Merged Unit 1-6 Papers
Jan 09 - June 16

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Sample Assessment Material
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

S45360A

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S 4 5 3 6 0 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following quantities, used in the calculation of the lattice energy of lithium oxide, Li_2O, has a negative value?

☒ **A** The enthalpy change of atomization of lithium.

☒ **B** The first ionization energy of lithium.

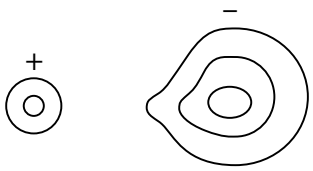
☒ **C** The first electron affinity of oxygen.

☒ **D** The second electron affinity of oxygen.

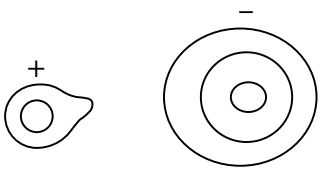
(Total for Question 1 = 1 mark)

2 Which of the diagrams below best represents the shapes of the electron contours in sodium fluoride?

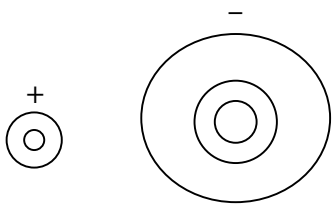
☒ **A**



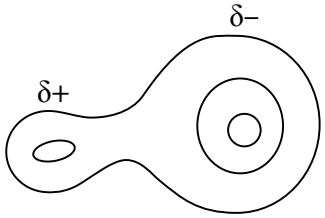
☒ **B**



☒ **C**



☒ **D**



(Total for Question 2 = 1 mark)

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3 Which of the equations below represents the first electron affinity for oxygen?

☒ **A** $O_2(g) + 2e^- \rightarrow 2O^-(g)$

☒ **B** $O_2(g) - 2e^- \rightarrow 2O^-(g)$

☒ **C** $\frac{1}{2}O_2(g) + e^- \rightarrow O^-(g)$

☒ **D** $O(g) + e^- \rightarrow O^-(g)$

(Total for Question 3 = 1 mark)

4 Which pair of ions is isoelectronic?

☒ **A** Ca^{2+} and O^{2-}

☒ **B** Na^+ and O^{2-}

☒ **C** Li^+ and Cl^-

☒ **D** Mg^{2+} and Cl^-

(Total for Question 4 = 1 mark)

5 A drop of sodium manganate(VII) solution is placed at the centre of a piece of moist filter paper on a microscope slide. The ends of the paper are clipped to a 30 V DC power supply. After a few minutes,

☒ **A** a purple colour has moved towards the positive terminal.

☒ **B** a purple colour has moved towards the negative terminal.

☒ **C** an orange colour has moved towards the positive terminal.

☒ **D** an orange colour has moved towards the negative terminal.

(Total for Question 5 = 1 mark)

6 How many moles of **ions** are present in 20 cm^3 of 0.050 mol dm^{-3} calcium chloride solution, $CaCl_2(aq)$?

☒ **A** 0.0050

☒ **B** 0.0030

☒ **C** 0.0020

☒ **D** 0.0010

(Total for Question 6 = 1 mark)

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7 The Avogadro constant is 6.0×10^{23} mol^{-1}. The number of **atoms** in 1 mol of dinitrogen tetroxide, N_2O_4, is

- ☒ **A** 3.6×10^{24}
- ☒ **B** 1.8×10^{24}
- ☒ **C** 6.0×10^{23}
- ☒ **D** 1.0×10^{23}

(Total for Question 7 = 1 mark)

8 The equation for the complete combustion of ethane is

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$$

What volume of oxygen, measured at room temperature and pressure, is needed to completely burn 0.1 mol of ethane?

[The volume of 1 mol of any gas measured at room temperature and pressure is 24 dm^3]

- ☒ **A** 2.4 dm^3
- ☒ **B** 4.8 dm^3
- ☒ **C** 8.4 dm^3
- ☒ **D** 16.8 dm^3

(Total for Question 8 = 1 mark)

9 A sample of swimming pool water contains 0.482 parts per million (ppm) of chlorine. This is equal to a percentage of

- ☒ **A** 0.000482
- ☒ **B** 0.0000482
- ☒ **C** 0.00000482
- ☒ **D** 0.000000482

(Total for Question 9 = 1 mark)

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10 Bromine has two isotopes with relative isotopic masses 79 and 81. Which of the following values for mass/charge ratio could correspond to a peak in the mass spectrum of bromine, Br_2? You should assume the ions detected have a single positive charge.

- ☒ **A** 79.9
- ☒ **B** 80
- ☒ **C** 159
- ☒ **D** 160

(Total for Question 10 = 1 mark)

11 The first five ionization energies of an element, **X**, are shown in the table.

Ionization energy	1st	2nd	3rd	4th	5th
Value / kJ mol^{-1}	631	1235	2389	7089	8844

What is the mostly likely formula of the oxide that forms when **X** burns in oxygen?

- ☒ **A** X_2O
- ☒ **B** XO
- ☒ **C** X_2O_3
- ☒ **D** XO_2

(Total for Question 11 = 1 mark)

12 Which of the following has the largest ionic radius?

- ☒ **A** S^{2-}
- ☒ **B** Cl^-
- ☒ **C** K^+
- ☒ **D** Ca^{2+}

(Total for Question 12 = 1 mark)

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13 Which of the following is a major effect caused by increased carbon dioxide levels arising from the burning of fossil fuels?

- ☒ **A** Melting of polar ice caps.
- ☒ **B** Damage to the ozone layer.
- ☒ **C** Increased acid rain.
- ☒ **D** Increased skin cancer.

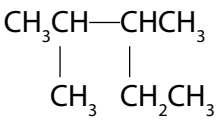
(Total for Question 13 = 1 mark)

14 Which of the following compounds shows geometric (*E-Z* or *cis-trans*) isomerism?

- ☒ **A** but-1-ene
- ☒ **B** 2-methylbut-1-ene
- ☒ **C** but-2-ene
- ☒ **D** 2-methylbut-2-ene

(Total for Question 14 = 1 mark)

15 What is the systematic name for the compound with the following formula?



- ☒ **A** 2-methyl-3-ethylbutane
- ☒ **B** 1,2,3-trimethylbutane
- ☒ **C** 2,3-dimethylpropane
- ☒ **D** 2,3-dimethylpentane

(Total for Question 15 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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16 This question is about the reaction of methane with bromine in sunlight.

(1)

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

(a) This reaction is best described as

☒ **A** electrophilic addition.

☒ **B** electrophilic substitution.

☒ **C** free radical addition.

☒ **D** free radical substitution.

(b) One of the steps in the mechanism of this reaction is

(1)

$\bullet CH_3 + Br\bullet \rightarrow CH_3Br$

This step is

☒ **A** initiation.

☒ **B** propagation.

☒ **C** termination.

☒ **D** reduction.

(c) This reaction produces a mixture of products.

Which of the following is most likely to form, as well as bromomethane?

(1)

☒ **A** ethane

☒ **B** propane

☒ **C** butane

☒ **D** pentane

(d) When human skin is overexposed to sunlight, it is likely to lead to skin cancer.

What is the radiation in sunlight that leads to skin cancer?

(1)

☒ **A** microwaves

☒ **B** infrared

☒ **C** visible light

☒ **D** ultraviolet

(Total for Question 16 = 4 marks)

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17 Which equation represents the reaction for which the enthalpy change, ΔH, is the mean bond energy of the C-F bond?

☒ **A** $CF_4(g) \rightarrow C(g) + 4F(g)$

☒ **B** $\frac{1}{4}CF_4(g) \rightarrow \frac{1}{4}C(g) + F(g)$

☒ **C** $C(g) + 4F(g) \rightarrow CF_4(g)$

☒ **D** $\frac{1}{4}C(g) + F(g) \rightarrow \frac{1}{4}CF_4(g)$

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 The radioactive isotope iodine-131, $^{131}_{53}I$, is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope, $^{127}_{53}I$.

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

(2)

Isotope	$^{131}_{53}I$	$^{127}_{53}I$
Number of protons		
Number of neutrons		

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

(1)

.....

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

(1)

.....

(d) Nuclear power stations are often proposed as suitable alternatives to those burning coal, gas or oil.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

(1)

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.....

(Total for Question 18 = 5 marks)

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19 This question is about the elements arsenic to rubidium which have atomic numbers 33 to 37.

The first ionization energies, E_{m1}, of these elements are given in the table.

Element	As	Se	Br	Kr	Rb
E_{m1} / kJ mol^{-1}	947	941	1140	1351	403

(a) Write the equation, with state symbols, which represents the first ionization energy of arsenic.

(2)

(b) Suggest the formulae of the hydrides of arsenic and selenium.

(2)

(c) (i) Complete the electronic configuration for an arsenic and a selenium atom using the electrons-in-boxes notation.

(2)

		4s	4p		
As	[Ar] 3d^{10}	↑↓			
Se	[Ar] 3d^{10}	↑↓			

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*(ii) Explain why the first ionization energy of selenium is lower than that of arsenic.

(2)

*(d) Explain why the first ionization energy of krypton is higher than that of selenium.

(2)

*(e) Explain why the first ionization energy of rubidium is lower than that of krypton.

(2)

(f) Which of the elements, arsenic to rubidium, is likely to have atoms with the smallest atomic radius?

(1)

(Total for Question 19 = 13 marks)

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20 Copper(II) sulfate solution, $CuSO_4(aq)$, can be made by adding an excess of solid copper(II) oxide, CuO, to boiling dilute sulfuric acid. This is an exothermic reaction.

The balanced equation for this reaction is

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

(a) (i) Complete the ionic equation for this reaction, including state symbols.

(2)

$$CuO(s) +$$

(ii) Calculate the mass of copper(II) oxide needed, if a 10% excess is required, when 0.020 mol of sulfuric acid is completely reacted.

[Relative atomic masses: Cu = 63.5 and O = 16.0]

(2)

(b) (i) Suggest, with a reason, how the copper(II) oxide should be added to the boiling sulfuric acid.

(2)

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(ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

To prepare crystals of copper(II) sulfate-5-water, $CuSO_4.5H_2O$, the resulting solution is boiled to remove excess water.

How would you know when sufficient water had been removed?

(1)

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.....

.....

.....

(iii) After cooling the solution, crystals form. State the colour of the crystals.

(1)

.....

(iv) The crystals all have the same shape. What does this indicate about the arrangement of the ions?

(1)

.....

.....

(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$. Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

(2)

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(ii) Calculate the percentage yield if 2.7 g of copper(II) sulfate-5-water is obtained from 0.020 mol of sulfuric acid.

(2)

(iii) What is the most likely reason for the yield being well below 100%?

(1)

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.....

(d) When the crystals are heated, they turn white. On adding water, they return to their original colour. Suggest a use for this reaction.

(1)

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(Total for Question 20 = 15 marks)

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21 Sodium hydrogencarbonate decomposes on heating to form sodium carbonate. It is difficult to measure the enthalpy change of this reaction directly.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

One method of determining this enthalpy change is to react known amounts of sodium hydrogencarbonate and sodium carbonate, separately, with excess dilute hydrochloric acid.

(a) 0.010 mol of solid sodium hydrogencarbonate was added to 25 cm^3 of dilute hydrochloric acid. A temperature rise of 11 °C was measured using a thermometer graduated at 1 °C intervals.

(i) Calculate the heat energy produced by this reaction using the equation:

Energy transferred in joules = mass × 4.18 × change in temperature

(1)

(ii) Calculate the standard enthalpy change for the reaction when one mole of sodium hydrogencarbonate reacts with hydrochloric acid.

Remember to include a sign and units with your answer which should be given to three significant figures.

(2)

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*(b) The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be

$\Delta H^{\ominus} = -321.6$ kJ mol^{-1}

Complete the Hess energy cycle below by adding the missing arrow and entities. Use it to calculate the standard enthalpy change for the decomposition of two moles of sodium hydrogencarbonate as in the equation below.

Remember to show your reasoning clearly.

(5)

$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$

2HCl(aq)

..... ( ) + ... ( ) + ... ( )

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(c) The uncertainty for each thermometer reading is ± 0.5 °C.
Calculate the percentage error in the temperature rise of 11 °C.

(1)

(d) Sodium hydrogencarbonate is used in cooking. Suggest what it is used for and how it works.

(2)

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(Total for Question 21 = 11 marks)

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22 This question is about ethene and its reactions.

Ethene is produced in industry by cracking.

(a) (i) Write the equation for the cracking of dodecane, $C_{12}H_{26}$, to produce one mole of ethene as the only alkene product.

(1)

(ii) Draw a labelled diagram of the apparatus and materials you would use to crack dodecane and collect a sample of the gaseous alkene in the laboratory.

(4)

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(b) Draw a diagram to show the regions of electron density in both parts of the double bond between the carbon atoms in ethene. Label each region with appropriate symbols.

(2)

(c) (i) Give the name and structural formula for the product of the reaction between ethene and bromine, $Br_2(l)$.

(2)

Name .....

Formula

(ii) Give the mechanism for the reaction between ethene and bromine.

(3)

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(d) Give the displayed formula for the organic product of the reaction between ethene and acidified potassium manganate(VII).

(1)

(e) (i) Write a balanced equation for the formation of poly(ethene) from ethene, showing the structure of the polymer clearly.

(2)

(ii) Comment on the atom economy of the reaction in (e)(i).

(1)

.....

.....

(Total for Question 22 = 16 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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S 4 5 3 6 0 A 0 2 4 2 4

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

PMT

Mark Scheme (SAM)

Pearson Edexcel International Advanced Subsidiary in Chemistry

Unit 1: The Core Principles of Chemistry

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General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

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Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected, it may still be creditworthy.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/	Means that the responses are alternatives and either answer should receive full credit.
()	Means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Bold	Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq	(error carried forward)(transfer error)(consequential) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions that involve the writing of continuous prose require candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where Quality of Written Communication is likely to be particularly important are indicated (Quality of Written Communication) in the mark scheme, but this does not preclude others.

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Section A

Question Number	Answer	Mark
1	C	(1)

Question Number	Answer	Mark
2	C	(1)

Question Number	Answer	Mark
3	D	(1)

Question Number	Answer	Mark
4	B	(1)

Question Number	Answer	Mark
5	A	(1)

Question Number	Answer	Mark
6	B	(1)

Question Number	Answer	Mark
7	A	(1)

Question Number	Answer	Mark
8	C	(1)

Question Number	Answer	Mark
9	B	(1)

Question Number	Answer	Mark
10	D	(1)

Question Number	Answer	Mark
11	C	(1)

Question Number	Answer	Mark
12	A	(1)

Question Number	Answer	Mark
13	A	(1)

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Question Number	Answer	Mark
14	C	**(1)**

Question Number	Answer	Mark
15	D	**(1)**

Question Number	Answer	Mark
16(a)	D	**(1)**

Question Number	Answer	Mark
16(b)	C	**(1)**

Question Number	Answer	Mark
16(c)	A	**(1)**

Question Number	Answer	Mark
16(d)	D	**(1)**

Question Number	Answer	Mark
17	B	**(1)**

Total for Section A = 20 Marks

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Section B

Question Number	Acceptable Answer	Mark
18(a)	<table><tr><td>Isotope</td><td>$^{131}I_{53}$</td><td>$^{127}I_{53}$</td></tr><tr><td>Number of protons</td><td>53</td><td>53</td></tr><tr><td>Number of neutrons</td><td>78</td><td>74</td></tr></table>	**(2)**

Question Number	Acceptable Answer	Reject	Mark
18(b)	Xenon/Xe/$_{54}$Xe/Xe_{54} $^{131}_{54}Xe$	$^{130}Xe_{54}$ Xe^- Iodine/I with or without numbers Hydrogen/H with or without numbers Te	**(1)**

Question Number	Acceptable Answer	Reject	Mark
18(c)	Potassium iodide/KI Accept any soluble, non-toxic iodide or iodate. Wrong name, correct formula. **(0)** Correct name, wrong formula. **(0)**	HI KI_3 Wrong formulae, e.g. CaI, MgI Wrong name, e.g. calcium idodate BaI_2 (toxic) AgI (insoluble) Potassium iodine	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
18(d)	Country /ALLOW state **and** justification Both needed for 1 mark For example, Japan/New Zealand/California etc. Country/state at risk from earthquake/tsunami/flooding. Further examples: Italy at risk from volcanoes. Afghanistan/middle eastern/African countries at risk from terrorist/(nuclear) weapon threat/war zone/political instability/abuse of nuclear power. USA/America/Jamaica at risk from hurricanes/tornadoes. California San Andreas Fault	Population density Landslide Too hot Surrounded by other countries Antarctica	**(1)**

Total for Question 18 = 5 Marks

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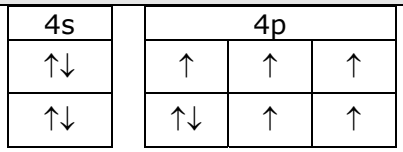
Question Number	Acceptable Answer	Reject	Mark
19(a)	**First mark:** $As(g) - e^{(-)} \rightarrow As^{+}(g)$ OR $As(g) \rightarrow As^{+}(g) + e^{(-)}$ **Second mark:** All species gaseous. A reasonable attempt at an ionization energy. Examples: $As(g) + e^{(-)} \rightarrow As^{+}(g)$ $As(g) - e^{(-)} \rightarrow As^{-}(g)$ $As^{2+}(g) - e^{(-)} \rightarrow As^{3+}(g)$ IGNORE state symbol of electron. ALLOW upper case/large AS in arsenic. ALLOW $As(g) + e^{(-)} \rightarrow As^{+}(g) + 2e^{(-)}$ **(2)**	$As(g) + e^{(-)} \rightarrow As(g)$ (electron affinity)	**(2)**

Question Number	Acceptable Answer	Reject	Mark
19(b)	**First mark:** AsH_3/H_3As **Second mark:** H_2Se/SeH_2 IGNORE charges. ALLOW upper case/large S in arsenic. **N.B.** if two or more answers are given for one element, mark that element on a plus/minus basis.	SE for selenium	**(2)**

Question Number	Acceptable Answer	Mark
19(c)(i)	 One mark for each row. Arrows may be half-headed. Arrows must be in same direction if in singly occupied boxes (can be down). ALLOW two arrows for Se in any 4p box. For selenium two arrows must show opposite spins.	(2)

Question Number	Acceptable Answer	Mark
*19(c)(ii) Quality of Written Communication	**For parts c(ii), d and e, it is important to keep in mind the two elements involved in each part: As and Se** **First mark:** EITHER In Se, (spin) pairing has occurred (for the first time in that p sub-shell). OR Electron removed from orbital containing two electrons. ALLOW sub-shell for orbital. **Second mark:** EITHER (Increase in) repulsion (so electron lost more easily). OR Half-filled (sub-) shell/allow orbital (particularly) stable (in As). ALLOW orbital for sub-shell. Mark each point independently. IGNORE reference to distance from nucleus and shielding.	(2)

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Question Number	Acceptable Answer	Reject	Mark
*19(d) Quality of Written Communication	**Se and Kr** **First mark:** EITHER The nuclear charge is increasing (nuclear must be stated or clearly implied). OR Number of protons/atomic number is increasing. **(1)** **Second mark:** (Outermost) electron is closer to the nucleus/electron is removed from the same (sub-)shell/electron experiences similar shielding/(atomic) radius is smaller/smaller **atom.** **(1)** ALLOW reverse arguments for selenium. IGNORE Kr has full outer shell.	Ionic radius molecule (unless monatomic)	**(2)**

Question Number	Acceptable Answer	Mark
*19(e) Quality of Written Communication	**Kr and Rb** Any two from: The **electron** (in Rb) (removed) is further from the nucleus. **(1)** The **electron** is in a higher/new/another/5s (energy quantum) shell/energy level. **(1)** **More** shielded. IGNORE any reference to stability of krypton or larger atomic radius of Rb/full outer shell of Kr. **(1)** It is possible that two answers may be offered together in one sentence, e.g. Rb outer electron is in another shell further from nucleus. **(2)**	**(2)**

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Question Number	Acceptable Answer	Reject	Mark
19(f)	Krypton/Kr	Anything else	**(1)**

Total for Question 19 = 13 marks

Question Number	Acceptable Answer	Reject	Mark
20(a)(i)	$CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$ Left-hand side **(1)**, right-hand side **(1)** If SO_4^{2-} are on both sides, maximum 1 mark. ALLOW correct entities and balancing with no or incorrect state symbols, for 1 mark. ALLOW multiples.	Charges within water molecule	**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(a)(ii)	1.749/1.75/1.7 with or without working scores. **(2)** If answer incorrect look for: Mass = 79.5 x 0.02 OR =1.59 **(1)** OR TE from incorrect mass for 1 mark. Their mass x 1.1= their correct answer to 2/3/4SF (g) **(1)** Accept crossed 7s. ALLOW both ways of writing 4 i.e. if 4 looks like 9.	1.74 1.8	**(2)**

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Question Number	Acceptable Answer	Reject	Mark
20(b)(i)	**First mark:** Add in small portions/use a spatula/use a **small** spoon/slowly/gradually. **Second mark:** To prevent (mixture/acid) boiling over/frothing/spilling/splashing/splash back. Mark independently. Bubbles are neutral. IGNORE add carefully/cautiously alone.	Spitting/violent reaction/fizzing Reaction is exothermic alone Bubbles of carbon dioxide	**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(ii)	Dip in glass rod. Remove and allow to cool. See if crystals form. ALLOW any workable suggestion. Examples: See crystals/salt forming around edge of beaker. Depth of colour of solution increases. Solution/colour becomes darker. Solution/colour becomes deeper blue. Dark blue solution. Reduce volume by at least half/until crystals form.	Solution thickens precipitate forming	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(iii)	Blue	Any mention of green or other colour	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(iv)	(The ions are arranged in a) regular (way)/lattice. OR The ions are arranged in the same way/have same arrangement/have uniform arrangement. The term 'structure' is neutral and should be ignored. IGNORE statements about ions attracting or repelling.	The ions are arranged in a similar/fixed way	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(c)(i)	249.6 g mol^{-1} ALLOW 249.5 g mol^{-1}. ALLOW 250 g mol^{-1} value **(1)** units **(1)** Common wrong values are 159.5/6, 185.5/6, 249. ALLOW unit mark with any or no value. ALLOW g/mol for unit.	g/mol^{-1}	**(2)**

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Question Number	Acceptable Answer		Mark
20(c)(ii)	Max yield = 249.6 x 0.02 = 4.992(g)	**(1)**	**(2)**
	Percentage yield = $\frac{2.7 \times 100}{4.992}$		
	= (54.0865) = 54%	**(1)**	
	If 249.5 is used = (54.1082) = 54%		
	OR		
	2.7/249.6 = 0.01082	**(1)**	
	Percentage yield = 0.01082 x 100/0.02 = 54%	**(1)**	
	ALLOW TE from any value in (i), and note:		
	159.6 gives 84.6%		
	185.6 gives 72.7%		
	IGNORE SF except one SF.		
	Correct answer, no working scores.	**(2)**	

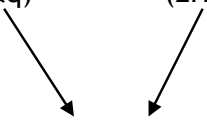
Question Number	Acceptable Answer	Reject	Mark
20(c)(iii)	(Copper(II) sulfate is soluble) so some remains in solution/some remains on the **filter paper.** IGNORE other transfer errors. Incomplete crystallization not all the crystals are formed.	Experimental error/ incomplete reaction Filtering alone Efflorescence	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(d)	This is a (chemical) test for (the presence of) water. Invisible ink. Moisture/humidity test. Test to see if solutions are aqueous.	Check to see if substance is hydrated Drying agent Quantitative measurements of water content	**(1)**

Total for Question 20 = 15 Marks

Question Number	Acceptable Answer	Reject	Mark
21(a)(i)	25 x 4.18 x 11 = 1149.5 (J) ALLOW 1.1495 **kJ** Otherwise ignore units even if incorrect. IGNORE sign. IGNORE SF except one or two SF.	1149.5 kJ	**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(a)(ii)	-115 kJ mol^{-1} ALLOW -115000 J mol^{-1} Sign with correct value. **(1)** Units and three significant figures. **(1)** Mark independently. ALLOW TE from (i) -114 kJ mol^{-1} (rounding error) scores 1 mark -115.0 kJ mol^{-1} scores 1 mark Values of -4600 and -3.86 are quite common. ALLOW K and j in any case in units.	J or kJ alone	**(2)**

Question Number	Acceptable Answer	Mark
***21(b) Quality of Written Communication**	$2NaHCO_3(s) \rightarrow Na_2CO_3(s)+CO_2(g)+H_2O(l)$ $2HCl(aq)$ $(2HCl(aq))$  $2NaCl(aq) + 2CO_2(g) + 2H_2O(l)$ **First mark:** Arrow from products in top line to lower line and correct entities. **(1)** $NaCl + CO_2 + H_2O$ **Second mark:** **2**$NaCl$**(aq)** + **2**CO_2**(g)** + **2**H_2O**(l)** Correct state symbols and balancing. **(1)** ΔH^o = **+**91.6 OR +91.7 (kJ mol^{-1}) ALLOW no positive sign only if correct working with correct signs given. **(3)**	**(5)**

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Question Number	Acceptable Answer	Mark
21(b) continued	**Third mark:** Correct use of Hess's Law (in numbers or symbols) consistent with arrow direction. **(1)** **Fourth mark:** **2 x** (-115) = ΔH^o -321.6 Correct multiples and numbers. ALLOW 2 x any number (including -4600 and -3.86) except 2 x +/- 321.6. **(1)** Notice third and fourth marks can be scored by: ΔH^o = 2(-115) - (-321.6) **Fifth mark:** ΔH^o = 2(−115) – (-321.6) = **+**91.6 (kJ mol^{-1}) OR ΔH^o = 2(−114.95) – (-321.6) = **+**91.7 (kJ mol^{-1}) Correct value for their calculation with correct sign. IGNORE SF except 1. ALLOW no positive sign only if correct working with correct signs given. **(1)** Omitting 2 x gives +206.6 (could get 4 marks) -4600 gives -598.4 -3.86 gives +313.88	

Question Number	Acceptable Answer	Reject	Mark
21(c)	((±) 0.5 x 2 x 100/11)= (±)9.09 (%) ALLOW at 9.0909/9.091/9.1 and 9.	9.10/9.0	**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(d)	**First mark:** It is used as a raising agent/self-raising flour/baking soda/baking powder. OR Causes cakes/(soda) bread to rise/expand. **Second mark:** Carbon dioxide (released on heating causes cakes/bread to rise). OR It reacts with acid to form carbon dioxide (in baking powder) providing bread/cake etc is mentioned. ALLOW Used in cooking green vegetables to keep green colour.	To make pastry rise Bicarbonate of soda Gas Air Neutralising acid foods	**(2)**

Total for Question 21 = 11 Marks

Question Number	Acceptable Answer	Mark
22(a)(i)	$C_{12}H_{26} \rightarrow C_{10}H_{22} + C_2H_4$ IGNORE state symbols even if incorrect. ALLOW displayed and structural formula for ethane.	**(1)**

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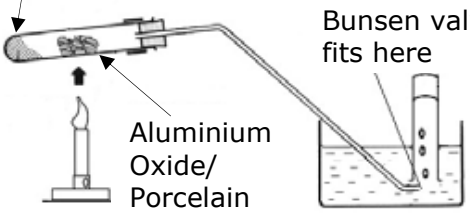
Question Number	Acceptable Answer	Reject	Mark
22 (a)(ii)	Collection over water or in gas syringe **(1)** IGNORE solid bung with delivery tube coming out/accidental sealing in drawing/clamps. This is the only stand-alone mark. **Dependent on diagram, including roughly horizontal tube:** Labelled ceramic fibre/any sort of wool (unless any named metal) (soaked in dodecane). **(1)** Aluminium oxide/porcelain pieces/catalyst/catalyst with incorrect name or incorrect formula/any named metal/anti-bump granules. **(1)** Heat under catalyst/under middle of test tube. **(1)** Ceramic fibre soaked in dodecane  	Delivery tube through glassware	**(4)**

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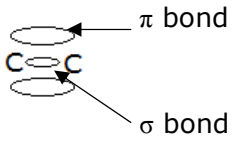
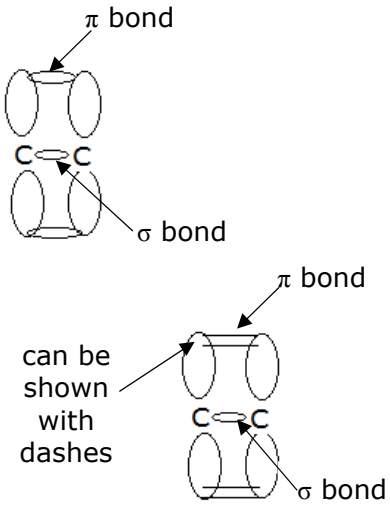
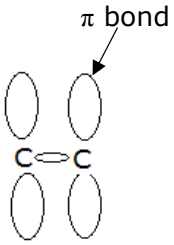
Question Number	Acceptable Answer	Reject	Mark
22(b)	 EITHER Diagram of bonds, the single bond must be shown as a region of space and not as a single or double straight line. **(1)** Labelled σ (sigma) and π (pi) in correct places on correctly drawn bonds, i.e. this mark can only be awarded if bonds correctly drawn. **(1)** OR  Labelled pi bond **(1)** Labelled sigma bond **(1)**		**(2)**

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Question Number	Acceptable Answer	Mark
22(b) continued	Bonds may be shown by overlap of appropriate orbitals, when any orbital or region of overlap may be labelled. Only one pi lobe/bond need be labelled. Carbons need not be shown. Bonds may be drawn on separate diagrams. IGNORE C-H bonds. IGNORE any additional electron density maps. IGNORE any partial charges.	

Question Number	Acceptable Answer		Reject	Mark
22(c)(i)	1, 2-dibromoethane	**(1)**	$C_2H_4Br_2$	**(2)**
	IGNORE punctuation.			
	CH_2BrCH_2Br	**(1)**		
	ALLOW displayed/skeletal formula.			
	Mark independently.			
	Bromoethane with CH_2BrCH_3	**(0)**		

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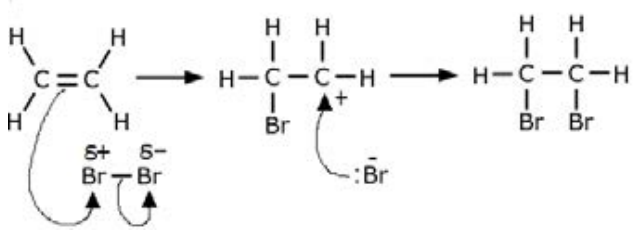
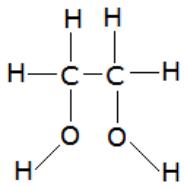
Question Number	Acceptable Answer	Mark
22 (c)(ii)	 **First mark:** Arrow from double bond towards nearest bromine atom and arrow from bond between bromine atoms to furthest bromine atom. **Second mark:** Correct formula of carbocation intermediate. **Third mark:** Arrow from anywhere on the brom**ide** ion to positive carbon. ALLOW missing hydrogens if bonds from carbons shown. ALLOW full marks for TE bromoethane formation using HBr and first arrow to H of HBr. ALLOW full marks for TE 1,2 –dibromopropane.	**(3)**

Question Number	Acceptable Answer	Reject	Mark
22(d)	 ALLOW O-H not displayed. ALLOW vertical C bond to any part of OH. Only penalise clear C-H-O/CH-O bond horizontally. IGNORE any name whether correct or not.	Skeletal formula or structural formula	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
22(e)(i)	$nCH_2=CH_2 \rightarrow (CH_2\text{-}CH_2)_n$ Left side **(1)** Right side extension bonds must be shown. **(1)** Mark independently. Accept $nC_2H_4 \rightarrow (CH_2\text{-}CH_2)_n$. Penalise omission of n only once. ALLOW $nCH_2=CH_2 + nCH_2=CH_2 \rightarrow (CH_2\text{-}CH_2)_n$ for two marks. ALLOW multiples of C_2H_4 in product.	$(CH_2=CH_2)_n$ N	**(2)**

Question Number	Acceptable Answer	Reject	Mark
22(e)(ii)	**100%** with one of the following: Only one product OR No by-products/no other product OR All reactants form the product OR As addition reaction IGNORE same empirical formula	No product lost/no side reaction(s) All reactants form the products	**(1)**

Total for Question 22 = 16 Marks

Total for Section B = 60 Marks

Total for Paper = 80 Marks

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Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Wednesday 3 June 2009 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/3/

H 3 4 4 7 1 A 0 1 2 8

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The nucleus of a $^{23}_{11}Na$ atom contains

☒ **A** 11 protons and 12 neutrons.

☒ **B** 11 protons and 12 electrons.

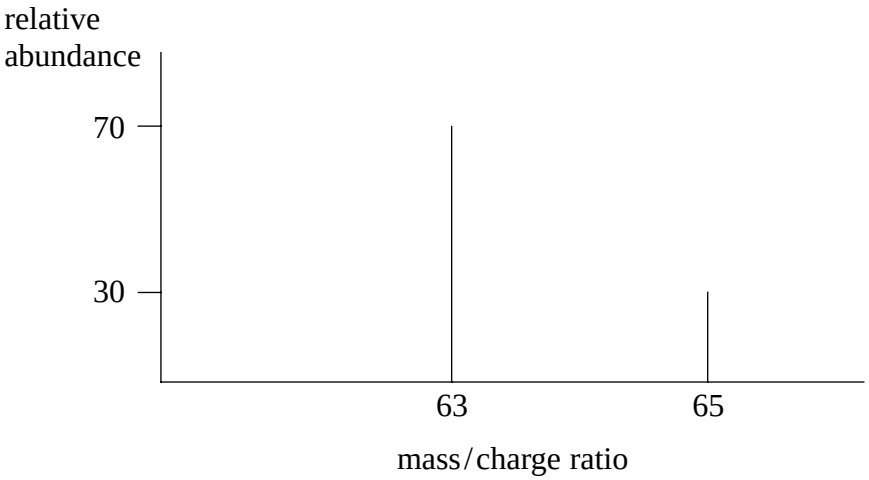
☒ **C** 23 protons and 11 neutrons.

☒ **D** 23 protons and 11 electrons.

(Total for Question 1 = 1 mark)

---

2 The mass spectrum for a sample of a metal is shown below.



The relative atomic mass of the metal is

☒ **A** 63.2

☒ **B** 63.4

☒ **C** 63.6

☒ **D** 64.0

(Total for Question 2 = 1 mark)

---

3 Some mean bond enthalpy values are given in the table below.

Bond	Mean bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

What is the enthalpy change for the reaction shown below in kJ mol^{-1}?

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

☒ **A** +436 + 151 – 299 = +288

☒ **B** –436 – 151 + 299 = –288

☒ **C** +436 +151 – (2 × 299) = –11

☒ **D** –436 – 151 + (2 × 299) = +11

(Total for Question 3 = 1 mark)

4 A compound was analysed and found to contain

1.45 g carbon 0.482 g hydrogen 1.69 g nitrogen

[Relative atomic masses: C = 12; H = 1; N = 14]

The empirical formula of the compound is

☒ **A** CH_3N

☒ **B** CH_4N

☒ **C** CH_5N

☒ **D** C_2H_4N

(Total for Question 4 = 1 mark)

5 17.1 g of aluminium sulfate, $Al_2(SO_4)_3$, was dissolved in water.

Calculate the number of sulfate ions, SO_4^{2-}, present in the solution formed.

[Assume the molar mass of $Al_2(SO_4)_3$ is 342 g mol^{-1} and the Avogadro Constant is 6×10^{23} mol^{-1}.]

☒ **A** 3×10^{21}

☒ **B** 1×10^{22}

☒ **C** 3×10^{22}

☒ **D** 9×10^{22}

(Total for Question 5 = 1 mark)

6 Calculate the mass of calcium hydroxide, $Ca(OH)_2$, present in 100 cm^3 of a 0.100 mol dm^{-3} solution.

[Assume the molar mass of $Ca(OH)_2$ is 74.0 g mol^{-1}.]

☒ **A** 0.570 g

☒ **B** 0.740 g

☒ **C** 1.85 g

☒ **D** 3.70 g

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 The first five successive ionization energies of an element, **X**, are shown in the table below.

Ionization energy	first	second	third	fourth	fifth
Value / kJ mol^{-1}	590	1100	4900	6500	8100

Which ion is **X** most likely to form when it reacts with chlorine?

☒ **A** X^{+}

☒ **B** X^{2+}

☒ **C** X^{3+}

☒ **D** X^{4+}

(Total for Question 7 = 1 mark)

8 Which of the following alkenes exhibits **E-Z** isomerism?

☒ **A** $H_3CCH{=}C(CH_3)_2$

☒ **B** $(CH_3)_2C{=}CH_2$

☒ **C** $H_2C{=}CHCH_2CH_3$

☒ **D** $H_3CCH{=}CHCH_3$

(Total for Question 8 = 1 mark)

9 Which of the following covalent bonds is the shortest?

☒ **A** H—F

☒ **B** H—Cl

☒ **C** H—Br

☒ **D** H—I

(Total for Question 9 = 1 mark)

10 Which of the following substances, obtained from the fractional distillation of crude oil, has the lowest boiling temperature?

☒ **A** refinery gas

☒ **B** kerosene

☒ **C** diesel oil

☒ **D** lubricating oil

(Total for Question 10 = 1 mark)

11 Sodium hydrogensulfate, $NaHSO_4$, reacts with sodium hydroxide, NaOH, as shown below.

$$NaHSO_4(aq) + NaOH(aq) \rightarrow Na_2SO_4(aq) + H_2O(l)$$

0.0100 mol of sodium hydrogensulfate is neutralized with dilute sodium hydroxide, concentration 0.200 mol dm^{-3}.

Calculate the volume of sodium hydroxide required.

☒ **A** 20.0 cm^3

☒ **B** 50.0 cm^3

☒ **C** 100 cm^3

☒ **D** 500 cm^3

(Total for Question 11 = 1 mark)

12 Which of the following ions would undergo the greatest deflection in a mass spectrometer?

☒ **A** $^{35}Cl^{2+}$

☒ **B** $^{35}Cl^{+}$

☒ **C** $^{37}Cl^{+}$

☒ **D** $^{35}Cl^{37}Cl^{+}$

(Total for Question 12 = 1 mark)

13 Which pair of atomic numbers represents elements which are both in the p-block of the Periodic Table?

☒ **A** 4, 8

☒ **B** 6, 12

☒ **C** 8, 16

☒ **D** 10, 20

(Total for Question 13 = 1 mark)

14 The electronic structure of an atom of an element in Group 6 of the Periodic Table could be

☒ **A** $1s^2\ 2s^2\ 2p^2$

☒ **B** $1s^2\ 2s^2\ 2p^4$

☒ **C** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^6\ 4s^2$

☒ **D** $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^{10}\ 4s^2\ 4p^6$

(Total for Question 14 = 1 mark)

15 Which of the following formulae for compounds of germanium, Ge, is unlikely to be correct, given the position of germanium in the Periodic Table?

☒ **A** GeF_3

☒ **B** GeS_2

☒ **C** GeO_2

☒ **D** GeH_4

(Total for Question 15 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

16 The electronic configurations of the atoms of four different elements are given below. For which element would you expect the value of the first ionization energy to be the largest?

☒ **A** $1s^1$

☒ **B** $1s^2$

☒ **C** $1s^2\ 2s^1$

☒ **D** $1s^2\ 2s^2$

(Total for Question 16 = 1 mark)

17 Which of the following gas samples occupies the greatest volume at the same temperature and pressure?

[Relative atomic masses: H = 1; C = 12; O = 16; F = 19; Ne = 20]

☒ **A** 1 gram of ethane

☒ **B** 1 gram of oxygen

☒ **C** 1 gram of fluorine

☒ **D** 1 gram of neon

(Total for Question 17 = 1 mark)

18 Which of the following has the smallest ionic radius?

☒ **A** F^-

☒ **B** Na^+

☒ **C** Mg^{2+}

☒ **D** O^{2-}

(Total for Question 18 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

19 Which of the following does **not** have exactly 10 electrons?

- ☒ **A** An ion of fluorine, F^-
- ☒ **B** A molecule of methane, CH_4
- ☒ **C** A molecule of nitrogen, N_2
- ☒ **D** An ion of sodium, Na^+

(Total for Question 19 = 1 mark)

20 Which of the following statements correctly describes an environmental problem caused by the burning of hydrocarbon fuels?

- ☒ **A** The carbon dioxide is toxic and kills plants.
- ☒ **B** The smoke produced reflects sunlight and leads to global warming.
- ☒ **C** The water produced results in a damaging increase in rainfall.
- ☒ **D** The carbon dioxide produced absorbs heat radiated from the Earth and leads to global warming.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

Use this space for any rough working. Anything you write in this space will gain no credit.

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 This question is about hydrocarbons.

(a) Liquefied petroleum gas (LPG) is a fuel sold as an alternative to petrol. It is a mixture of liquefied C_3 and C_4 alkanes.

(i) Suggest a reason why the alkanes are liquefied.

(1)

.....

.....

(ii) There are two C_4 alkanes.

Draw **skeletal** formulae of each of the C_4 alkanes in the spaces provided.

Name each alkane.

(4)

First skeletal formula	Second skeletal formula
Name:	Name: .....

(iii) Complete the following sentence.

(1)

Compounds with the same molecular formula but different structural formula are called .....

(b) Propane, C_3H_8, reacts with chlorine, Cl_2, in a substitution reaction.

$$C_3H_8 + Cl_2 \rightarrow C_3H_7Cl + HCl$$

The mechanism for this reaction is described in three stages.

(i) Give the **initiation step** for this reaction and state the condition necessary for this step to occur.

(2)

Initiation step

Condition .....

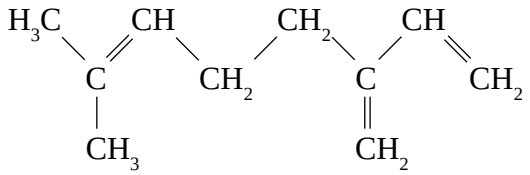
(ii) Give the TWO **propagation steps** for this reaction.

(2)

(iii) Give a possible **termination step** for this reaction.

(1)

(c) Myrcene, $C_{10}H_{16}$, is a naturally occurring compound which is used in perfumes.



Myrcene

(i) Name the functional group in myrcene.

(1)

.....

(ii) What colour change would you observe when bromine, dissolved in an organic solvent, is added to myrcene?

(1)

From ..... **To** .....

(iii) Classify the type and mechanism of the reaction that occurs when myrcene reacts with bromine, Br_2.

(2)

.....

.....

(iv) In an experiment, 1.36 g of myrcene (molar mass: 136 g mol^{-1}) was found to react with 0.72 dm^3 of hydrogen, H_2, in the presence of a nickel catalyst.

Use this information to draw the structural formula of the product of the reaction between myrcene and hydrogen.

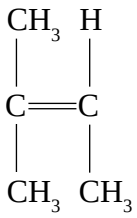
[Assume the molar volume of H_2 under the conditions of the experiment is 24 $dm^3 mol^{-1}$.]

(2)

Calculation

Hence structural formula of the product

(d) Myrcene is one of a group of compounds related to 2-methylbut-2-ene shown below.



2-methylbut-2-ene undergoes addition polymerization in a similar way to ethene.

Draw the structural formula of the repeat unit of the polymer formed.

(2)

(Total for Question 21 = 19 marks)

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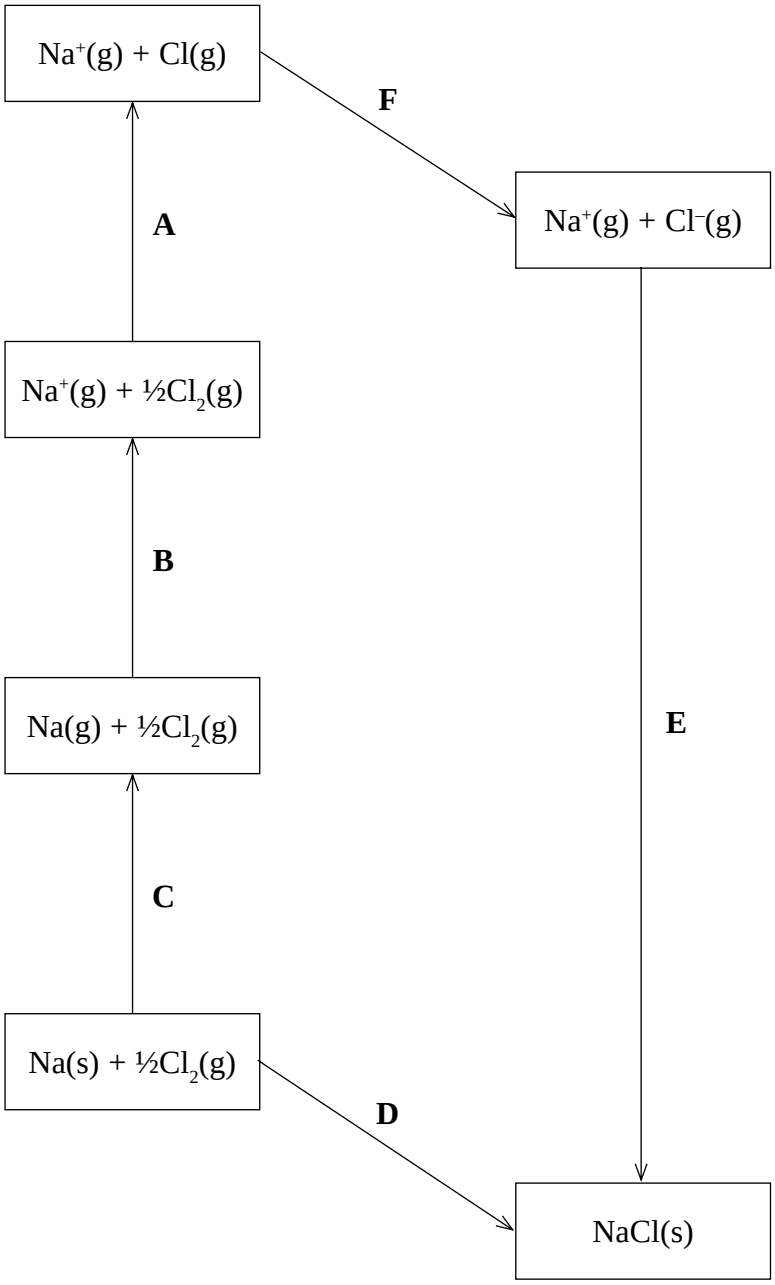
22 The Born-Haber cycle for the formation of sodium chloride from sodium and chlorine may be represented by a series of steps labelled **A** to **F** as shown.



(a) (i) Complete the table below by adding the letters **A** to **F** next to the corresponding energy changes.

(3)

Energy change	Letter	ΔH /kJ mol^{-1}
Lattice energy for sodium chloride		–775
Enthalpy change of atomization of sodium		+109
Enthalpy change of atomization of chlorine		+121
First ionization energy of sodium		+494
First electron affinity of chlorine		
Enthalpy change of formation of sodium chloride		–411

(ii) Calculate the first electron affinity of chlorine, in kJ mol^{-1}, from the data given.

(2)

(b) Lattice energies can be calculated from electrostatic theory (theoretical values) as well as by Born-Haber cycles (experimental values).

Compound	Experimental lattice energy / kJ mol^{-1}	Theoretical lattice energy / kJ mol^{-1}
NaCl	–770	–766
AgI	–889	–778

(i) Comment on the fact that there is close agreement between the values for sodium chloride, NaCl.

(1)

.....

.....

.....

*(ii) Explain, in terms of chemical bonding, why the experimental value for silver iodide, AgI, is more exothermic than the value calculated theoretically for the same compound.

(2)

.....

.....

.....

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.....

.....

*(c) Suggest why the first ionization energies of the Group 1 elements decrease down the group.

(2)

.....

.....

.....

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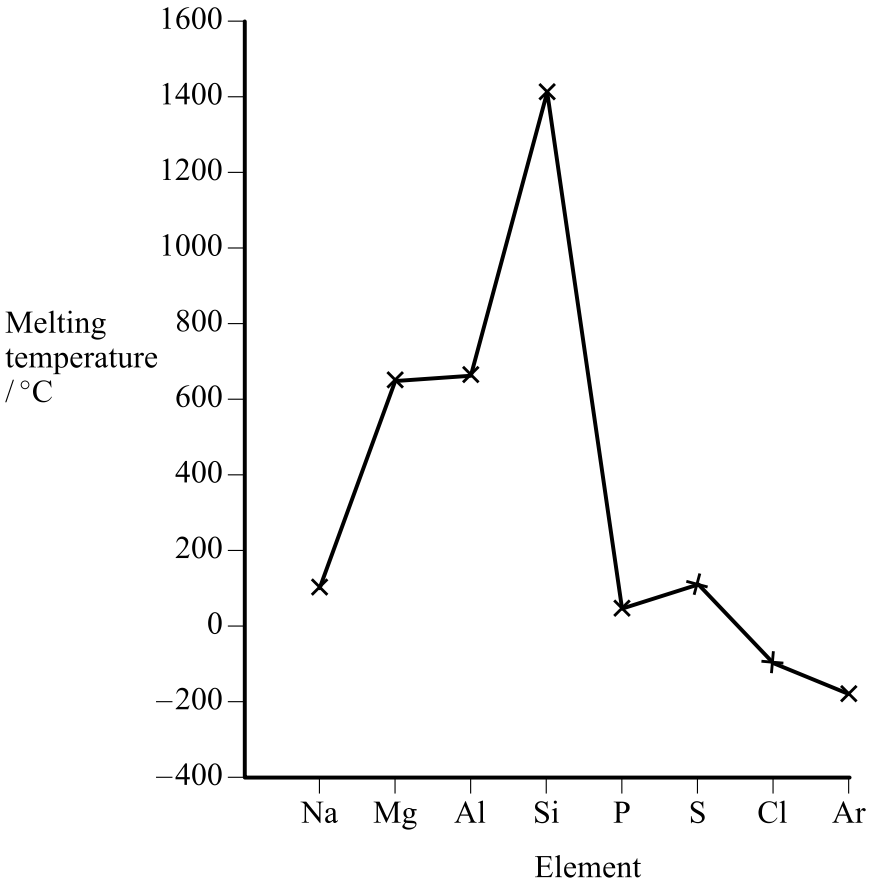
.....

(Total for Question 22 = 10 marks)

23 The graph shows the variation in melting temperatures of the elements across Period 3 (Na to Ar) of the Periodic Table.



(a) Complete the table below to show the type of structure and bonding for the elements shown.

(3)

Element	Structure	Bonding
sodium		
silicon		
sulfur		

(b) Explain why silicon has a much higher melting temperature than sulfur.

(2)

.....

.....

.....

.....

.....

*(c) Explain why the melting temperature increases from sodium to aluminium.

(2)

(d) Magnesium forms the basic oxide magnesium oxide, MgO. This oxide is almost insoluble in water. On gentle warming with dilute sulfuric acid, magnesium oxide reacts to form aqueous magnesium sulfate solution.

*(i) Describe how you would use the above reaction to prepare a pure sample of magnesium sulfate.

(5)

(ii) Suggest what action should be taken if a pupil spilt a small quantity of dilute sulfuric acid on a laboratory bench.

(1)

(e) The data in the table below will be useful when answering this question.

Soluble in water	Insoluble in water
$MgSO_4$	$MgCO_3$ $SrCO_3$ $SrSO_4$

Magnesium carbonate reacts with dilute sulfuric acid.

$$MgCO_3(s) + H_2SO_4(aq) \rightarrow MgSO_4(aq) + CO_2(g) + H_2O(l)$$

(i) Explain why the reaction between strontium carbonate and dilute sulfuric acid stops after a few seconds.

(1)

.....

.....

.....

(ii) Strontium sulfate is produced when aqueous sodium sulfate is added to aqueous strontium chloride.

Give the **ionic** equation for the reaction, including state symbols.

(2)

(Total for Question 23 = 16 marks)

24 Propanone, C_3H_6O, undergoes complete combustion to form carbon dioxide and water.

$$C_3H_6O(l) + 4O_2(g) \rightarrow 3CO_2(g) + 3H_2O(l)$$

(a) In an experiment to calculate the enthalpy change of combustion for propanone, 2.90 g of propanone was burned completely in oxygen.

The heat energy from this combustion raised the temperature of 200 g of water from 20.2 °C to 78.4 °C.

The specific heat capacity of water is 4.18 J g^{-1} °C^{-1}.

(i) Calculate the number of moles of propanone present in 2.90 g.

[The molar mass of propanone is 58 g mol^{-1}.]

(1)

(ii) Use the expression

$$\text{energy transferred (J)} = \text{mass} \times \begin{matrix}\text{specific heat}\\ \text{capacity}\end{matrix} \times \begin{matrix}\text{temperature}\\ \text{change}\end{matrix}$$

to calculate the heat energy transferred to raise the temperature of 200 g of water from 20.2 °C to 78.4 °C.

(2)

(iii) Use your answers to (a)(i) and (ii) to calculate a value for the enthalpy change of combustion of propanone. Give your answer to **three** significant figures and include a sign and units.

(3)

(b) In another experiment, the enthalpy change of combustion for butanone, C_4H_8O, was found to be –1300 kJ mol^{-1}.

A Data Book value for the standard enthalpy change of combustion for butanone is –2440 kJ mol^{-1}.

(i) Suggest a reason why the value obtained in the experiment is so different from the Data Book value.

(1)

.....

(ii) This Data Book value (–2440 kJ mol^{-1}) refers to the following equation.

$$C_4H_8O(l) + 6½O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l)$$

How would the value be different if it referred to the formation of water in the **gaseous** state? Justify your answer.

(2)

Difference .....

Justification .....

.....

.....

.....

(c) Standard enthalpy changes of combustion can be used to calculate the standard enthalpy change of formation of a compound.

(i) Define the term **standard enthalpy change of formation**, making clear the meaning of **standard** in this context.

(3)

.....

.....

.....

.....

.....

(ii) Use the standard enthalpy changes of combustion, $\Delta H_c^{\ominus}$, given in the table below to find the standard enthalpy change of formation for ethanoic acid, CH_3COOH, in kJ mol^{-1}.

Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s, graphite)	–394
$H_2(g)$	–286
$CH_3COOH(l)$	–870

$$2C(s, \text{graphite}) + 2H_2(g) + O_2(g) \rightarrow CH_3COOH(l)$$

(3)

(Total for Question 24 = 15 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

PMT

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Mark Scheme Summer 2009

GCE

GCE Chemistry (8CH01)

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Summer 2009

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General Marking Guidance

· All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.

· Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.

· Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.

· There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.

· All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.

· Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.

· When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.

· Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the mark scheme

1 / means that the responses are alternatives and either answer should receive full credit.

2 ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

3 [ ] words inside square brackets are instructions or guidance for examiners.

4 Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

5 OWTTE means or words to that effect

6 ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

· show clarity of expression

· construct and present coherent arguments

· demonstrate an effective use of grammar, punctuation and spelling.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated "QWC" in the mark scheme BUT this does not preclude others.

6CH01/01

Section A

Question Number	Correct Answer	Reject	Mark
1	A		**1**

Question Number	Correct Answer	Reject	Mark
2	C		**1**

Question Number	Correct Answer	Reject	Mark
3	C		**1**

Question Number	Correct Answer	Reject	Mark
4	B		**1**

Question Number	Correct Answer	Reject	Mark
5	D		**1**

Question Number	Correct Answer	Reject	Mark
6	B		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Correct Answer	Reject	Mark
8	D		**1**

Question Number	Correct Answer	Reject	Mark
9	A		**1**

Question Number	Correct Answer	Reject	Mark
10	A		**1**

Question Number	Correct Answer	Reject	Mark
11	B		**1**

Question Number	Correct Answer	Reject	Mark
12	A		**1**

Question Number	Correct Answer	Reject	Mark
13	C		**1**

Question Number	Correct Answer	Reject	Mark
14	B		**1**

Question Number	Correct Answer	Reject	Mark
15	A		**1**

Question Number	Correct Answer	Reject	Mark
16	B		**1**

Question Number	Correct Answer	Reject	Mark
17	D		**1**

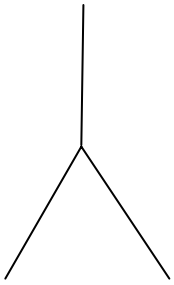
Question Number	Correct Answer	Reject	Mark
18	C		**1**

Question Number	Correct Answer	Reject	Mark
19	C		**1**

Question Number	Correct Answer	Reject	Mark
20	D		**1**

Section B

Question Number	Correct Answer	Reject	Mark
21 (a)(i)	Easier to transport / easier to store / less space / less volume needed for storage / easier to handle / easier to transfer *IGNORE* references to "safety" **Accept** Denser/cheaper to transport OWTTE	Just "cost"	**1**

Question Number	Correct Answer	Reject	Mark
21 (a)(ii)	**skeletal formula (1)**  **Name**: butane **(1)** Stand alone **skeletal formula (1)**  **Name**: methylpropane **OR** 2-methylpropane **(1)** *IGNORE* incorrect punctuation [e.g. extra/missing hyphens, etc.] Stand alone *IGNORE* displayed formulae if also given with skeletal formulae if 2 correct displayed formulae are given **max** 1 out of 2 for the structures		**4**

Question Number	Correct Answer	Reject	Mark
21 (a)(iii)	(Structural) isomers		**1**

Question Number	Correct Answer	Reject	Mark
21 (b)(i)	$Cl_2 \rightarrow Cl\cdot + Cl\cdot$ / $Cl_2 \rightarrow 2Cl\cdot$ **(1)** (U.V.) light / sunlight **(1)** Must show the dots · *IGNORE* any subsequent propagation steps in (b)(i)	 heat alone	**2**

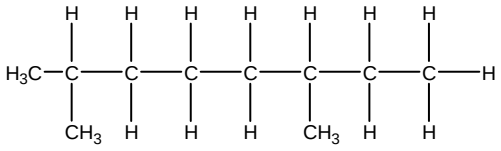
Question Number	Correct Answer	Reject	Mark
21 (b)(ii)	$C_3H_8 + Cl\cdot \rightarrow C_3H_7\cdot + HCl$ **(1)** $C_3H_7\cdot + Cl_2 \rightarrow C_3H_7Cl + Cl\cdot$ **(1)** Must show the dots ·		**2**

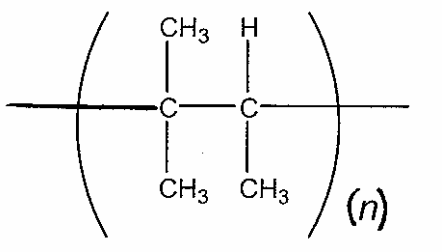
Question Number	Correct Answer	Reject	Mark
21 (b)(iii)	$C_3H_7\cdot + Cl\cdot \rightarrow C_3H_7Cl$ **OR** $Cl\cdot + Cl\cdot \rightarrow Cl_2$ **OR** $C_3H_7\cdot + C_3H_7\cdot \rightarrow C_6H_{14}$ Must show dots in termination step		**1**

Question Number	Correct Answer	Reject	Mark
21 (c)(i)	Alkene / triene **Accept** Diene Carbon-carbon double bond		**1**

Question Number	Correct Answer	Reject	Mark
21 (c)(ii)	**From:** Red / brown / orange / yellow or combinations of these colours **To:** colourless *both colours needed*	 "clear" instead of colourless	**1**

Question Number	Correct Answer	Reject	Mark
21 (c)(iii)	Electrophilic **(1)** addition **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
21 (c)(iv)	**Calculation:** 0.01 mol myrcene reacts with 0.03 mol H_2 **OR** 1 mol myrcene reacts with 3 mol H_2 **(1)** **Structural formula**: $(CH_3)_2CH(CH_2)_3CH(CH_3)CH_2CH_3$ **OR**  **(1)** **Accept** Fully displayed formula/skeletal formula Mark calculation and structural formula **independently**.		**2**

Question Number	Correct Answer	Reject	Mark
21 (d)	 repeat unit **(1)** continuation bonds shown (but these bonds do not have to cut through the brackets) **(1)** *n* **not essential** *IGNORE* the position of "*n*" relative to the repeat unit (e.g. can be written as a superscript)		**2**

Question Number	Correct Answer	Reject	Mark
22 (a)(i)			**3**

Energy change	**Letter**	**Δ*H*/kJ mol^{-1}**
Lattice energy for sodium chloride	**E**	-775
Enthalpy change of atomization of sodium	**C**	+109
Enthalpy change of atomization of chlorine	**A**	+121
First ionization energy of sodium	**B**	+494
First electron affinity of chlorine	**F**	
Enthalpy change of formation of sodium chloride	**D**	-411

6 correct letters **(3)**
5 or 4 correct letters **(2)**
3 or 2 correct letters **(1)**
1 or 0 correct letters **(0)**

Question Number	Correct Answer	Reject	Mark
22 (a)(ii)	Expression such as: D = C + B + A + F + E - 411 = + 109 + 494 + 121 + F + (- 775) F = - 411 - 109 - 494 - 121 + 775 **(1)** Answer: F = −360 (kJ mol^{-1}) **(1)** *Check empty box in 22(a)(i), as answer may be written there.* Answer must follow from working Correct answer only **(2)** Correct answer with some consistent working **(2)**		**2**

Question Number	Correct Answer	Reject	Mark
22 (b)(i)	(Bonding in NaCl) 100% ionic **OR** almost completely ionic **OR** no covalent character/(very) little covalent character	'Molecule' **(0)**	**1**

Question Number	Correct Answer	Reject	Mark
22 (b)(ii) QWC	AgI has (a degree of) covalent character **(1)** due to polarization or distortion (of the anion) **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
22 (c) QWC	Any **two** of the following: • (outermost) electron further from the nucleus/atoms get bigger/more shells • (outermost) electron more shielded (by inner shells of e^-) • (force of) attraction between nucleus and (outermost) electron decreases (down the Group) **OR** (outermost) electron held less strongly (down the Group) **OR** (outermost) electron becomes easier to remove (down the Group) *IGNORE* any references to(effective) nuclear charge or more protons.	**"ions"** get bigger (down Group)	**2**

Question Number	Correct Answer	Reject	Mark
23 (a)			**3**

element	structure	bonding
sodium	**Giant**	**metallic**
silicon	**Giant (atomic)/ macromolecular/ giant molecular**	**covalent**
sulfur	**simple / small molecules** **OR** **(simple) molecular** **OR** **S_8 molecules**	**covalent or van der Waals' forces/ London forces/ intermolecular forces/dispersion forces/induced-dipole forces**

IGNORE the word "lattice" **OR** "crystalline"

6 boxes correct (3)
5,4 boxes correct (2)
3,2 boxes correct (1)
1,0 boxes correct (0)

Question Number	Correct Answer	Reject	Mark
23 (b)	**Si** : covalent bonds / many bonds/ strong bonds (between atoms) **(1)** **S** : weak forces /van der Waals' forces/London forces/dispersion forces/intermolecular forces/induced-dipole forces **(1)** (need to be overcome)	any reference to **intermolecular forces in Si** suggestion that covalent bonds are broken	**2**

Question Number	Correct Answer	Reject	Mark
23 (c) **QWC**	Cations/ions decrease in size (from Na^+ to Al^{3+}) **OR** charge increases/charge density on (cat)ions increases/ "**effective** nuclear charge" increases (from Na^+ to Al^{3+}) **(1)** more e^- (per atom in 'sea' of delocalized electrons) / more delocalized electrons **OR** (force of) attraction between (cat)ions/nucleus and (delocalised) electrons increases (from Na to Al) **(1)** *IGNORE* "nuclear charge increases"/ "increasing no. of protons"	**atoms** decrease in size any mention of "molecules"/ "covalent bonds"/ "van der Waals' forces"/ "ionic bonds" **(0)** overall	**2**

Question Number	Correct Answer	Reject	Mark
23 (d)(i) QWC	• Add MgO to acid/react MgO with acid/dissolve MgO in acid **(1)** *[NOTE:* mention of heating not required. **IGNORE** water bath/reflux] • Filter **(1)** • **Heat/boil** filtrate /$MgSO_4$ solution (until volume reduced by half) **(1)** • Leave to cool/leave to crystallise/evaporate slowly/leave to evaporate **(1)** (decant / filter / pick out crystals, then) Leave to dry/pat dry/dry between filter papers/put in an oven/put in a desiccator/dry the crystals **(1)** *IGNORE* any washing of crystals immediately prior to drying them	Just **"warm"** the filtrate/$MgSO_4$ solution Use of a **desiccant** (added to crystals)	**5**

Question Number	Correct Answer	Reject	Mark
23 (d)(ii)	Rinse with (plenty of) water /use a damp cloth or damp (paper) towel / add a (named) weak alkali (e.g. solid or aqueous sodium hydrogencarbonate)	Any named strong alkali/just "strong alkali"	**1**

Question Number	Correct Answer	Reject	Mark
23 (e)(i)	**Insoluble strontium sulfate/insoluble $SrSO_4$** (forms on the strontium carbonate)		**1**

Question Number	Correct Answer	Reject	Mark
23 (e)(ii)	$Sr^{2+}(aq) + SO_4^{2-}(aq) \rightarrow SrSO_4(s)$ species **(1)** state symbols **(1)** **2nd mark is cq on first mark** $Sr^{2+}(aq) + 2Cl^-(aq) + 2Na^+(aq) + SO_4^{2-}(aq) \rightarrow SrSO_4(s) + 2Cl^-(aq) + 2Na^+(aq)$ scores **(1)** $SrCl_2(aq) + Na_2SO_4(aq) \rightarrow SrSO_4(s) + 2NaCl(aq)$ scores **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
24 (a)(i)	$\frac{2.90}{58} = 0.05(00)$ (mol) correct answer only **(1)**		**1**

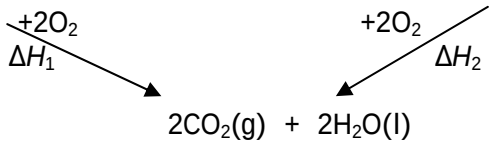
Question Number	Correct Answer	Reject	Mark
24 (a)(ii)	200 x 4.18 x **58.2** = 48655 (J) **OR** 48.655 kJ **(1)** for correct ΔT **(1)** *IGNORE* sf *IGNORE* signs at this stage		**2**

Question Number	Correct Answer	Reject	Mark
24 (a)(iii)	$-\frac{48655}{0.0500} = -973\ 100$ (J mol^{-1}) = −973 kJ mol^{-1} (3 s.f.) / −973000 J mol^{-1} (3 s.f.) answer **(1)** sign and units **(1)** [Do not award sign and units mark **if units given are just** "kJ" or **just** "J"] **three sig figs (1)** *CQ on (a)(i) & (ii)*		**3**

Question Number	Correct Answer	Reject	Mark
24 (b)(i)	Heat loss/energy loss **Accept** Incomplete combustion OWTTE *IGNORE* "experimental error"/ "departure from standard conditions"	Anything related to "average values" **(0)**	**1**

Question Number	Correct Answer	Reject	Mark
24 (b)(ii)	**Difference:** less exothermic / less negative *IGNORE* "higher" **if** written **with** less exothermic/less negative **Accept just "**lower"/ "less" **(1)** **Justification:** energy taken in to form gas/energy required to form gas/energy needed to form gas/takes heat in to form gas/heat required to form gas **Or reverse argument** **(1)** *Mark these two points independently*	**Just** "higher" (**0)** **Just** "$H_2O(g)$ is not water's standard state"	**2**

Question Number	Correct Answer	Reject	Mark
24 (c)(i)	Enthalpy / energy / heat (energy) change (when) one mole of a substance/one mole of a compound **(1)** is formed from its elements (in their most stable states) **(1)** 298K / 25°C / a stated temperature **AND** 1 atm pressure/100 kPa **(1)** *IGNORE* any references to concentration	"energy required" **OR** "energy released" "one mole of **product(s)**" is formed from its **reactants** room temperature/rtp	**3**

Question Number	Correct Answer	Reject	Mark
24 (c)(ii)	Cycle or formula expression  $\Delta H^{\theta}_{f} = \Delta H_1 - \Delta H_2$ = (2 x - 394) + (2 x - 286) - (- 870) = **−490** (kJ mol^{-1}) • correct expression or cycle **(1)** • evidence for doubling **both** ΔH^{θ}_{c} [C] **and** ΔH^{θ}_{c} [H_2] **(1)** • answer **(1)** Correct answer with no working scores full marks		**3**

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Section A

Question Number	Correct Answer	Reject	Mark
1	C		**1**

Question Number	Correct Answer	Reject	Mark
2	B		**1**

Question Number	Correct Answer	Reject	Mark
3	A		**1**

Question Number	Correct Answer	Reject	Mark
4	D		**1**

Question Number	Correct Answer	Reject	Mark
5	C		**1**

Question Number	Correct Answer	Reject	Mark
6	A		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Correct Answer	Reject	Mark
8	D		**1**

Question Number	Correct Answer	Reject	Mark
9	B		**1**

Question Number	Correct Answer	Reject	Mark
10 (a)	A		**1**

Question Number	Correct Answer	Reject	Mark
10 (b)	C		**1**

Question Number	Correct Answer	Reject	Mark
11	D		**1**

Question Number	Correct Answer	Reject	Mark
12	C		**1**

Question Number	Correct Answer	Reject	Mark
13	B		**1**

Question Number	Correct Answer	Reject	Mark
14	D		**1**

Question Number	Correct Answer	Reject	Mark
15	C		**1**

Question Number	Correct Answer	Reject	Mark
16	A		**1**

Question Number	Correct Answer	Reject	Mark
17	C		**1**

Question Number	Correct Answer	Reject	Mark
18	A		**1**

Question Number	Correct Answer	Reject	Mark
19	B		**1**

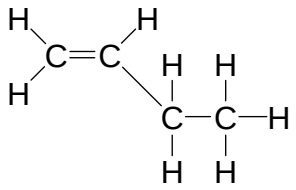
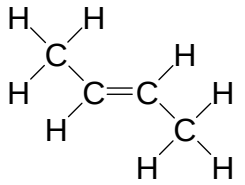
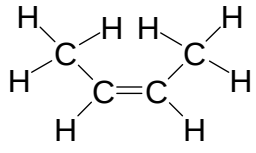
Section B

Question Number	Correct Answer	Reject	Mark
20 (a)(i)	**Reaction 1** – (nucleophilic) substitution **(1)** **Reaction 2** – elimination **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
20 (a)(ii) QWC	**Reaction 1** - Water can behave as a nucleophile /water can donate a lone pair (from oxygen)/water has a lone pair/water forms an $^{-}$OH ion **(1)** And attack (positive) carbon (originally attached to Cl)/bonds to the carbon/bonds to the carbocation **(1)** **Reaction 2** - behaves as a base **(1)** and accepts a hydrogen ion/proton / donates e^{-} pair to H/removes a proton/removes a hydrogen ion/removes a H^{+} **(1)** In each case a correctly drawn mechanism could get **(2)**	Removes a H **atom**	**4**

Question Number	Correct Answer	Reject	Mark
20 (b)(i)	Heterolytic (fission) **Notes** Accept phonetic/incorrect spelling as long as the word is recognisable		**1**

Question Number	Correct Answer	Reject	Mark
20 (b)(ii)	Butyl group less electron releasing/butyl group has less of a (positive) inductive effect **(1)** so less stable (positive charge on) carbocation **(1)** **0R** 1- chlorobutane is a primary halogenoalkane/the carbon only has 1 other C attached **(1)** So forms a less stable carbocation **(1)** **0R** Primary carbocation is less stable than a tertiary carbocation **(2)** **0R** Water/$^{-}$OH can attack C on 1˚ chloroalkane more easily (so no need to form cation) OWTTE / 1˚ chloroalkane reacts via SN2 mechanism/C–O bond forms before C–Cl breaks **(1)** As the carbon attacked is not surrounded by bulky groups OWTTE **(1)**	Negative inductive effect	**2**

Question Number	Correct Answer	Reject	Mark
20 (c)	Hydrogen (ion) can be eliminated from C on either side (of C attached to Cl)/double bond can form between 1st and 2nd or 2nd and 3rd carbon OWTTE **(1)** **OR** double bond can't rotate (so methyl group and hydrogens can be fixed in position) to form E and Z isomers / geometric isomers/cis and trans/stereoisomers/or named in diagrams OWTTE **(1)** allow descriptions in terms of cis and trans  **(1)**  **(1)**  **(1)** Methyl and ethyl groups do not need to be fully displayed Structural formulae/skeletal formulae For all 3 **(2)** For 2 **(1)** For 1 **(0)** For an incorrect haloalkane structure that can form 3 isomers including cis/trans **(2 max)** (eg 2-chloropentane)		**4**

Question Number	Correct Answer	Reject	Mark
20 (d)	(Slower) as C–F bond is stronger (than C-Cl)/fluorine bonds more strongly/fluorine holds the carbon more strongly **OR** Slower as **F^-** is a poorer leaving group (than Cl^-) **(1)** Use sodium hydroxide /NaOH/ potassium hydroxide /KOH/ hydroxide ions **(1)** As OH^- is a stronger nucleophile / OH^- has a full negative charge/ more strongly attracted to $C^{\delta+}$ /OH^- has more lone pairs (than water)/ OH^- is more negative than water **(1)**	Alkali Hydroxide	**3**

Question Number	Correct Answer	Reject	Mark
21 (a)(i)	Hydrogen bonding Hydrogen bond(s) H bonding H bond(s) **Notes** Accept phonetic/incorrect spelling as long as the word is recognisable	Not "hydrogen" on its own Dipole-dipole bond Permanent dipole-dipole bond Covalent bond van der Waals' (forces) Temporary dipole-dipole Induced dipole-dipole London forces Any correct answer in conjunction with an incorrect response, eg hydrogen dipole-dipole bond.	**1**

Question Number	Correct Answer	Reject	Mark
21 (a)(ii)	(Fluorine atom) is more electronegative **(1)** Because it has less shielding / (bonding) electrons closer to the nucleus/ smaller /has less shells (so greater pull from nucleus on bonding electrons) **(1)** so HF has a (greater) dipole moment/$H^{\delta+}$ on HF (greater than on HBr)/HF is (more) polar **(1)**		**3**

Question Number	Correct Answer	Reject	Mark
21 (a)(iii)	Between 150 – 180 (K) Accept a range within the range e.g. '150-170'	°C	**1**

Question Number	Correct Answer	Reject	Mark
21 (b)(i)	Because propanone has both polar and non polar characteristics/can form both London forces and H bonds/can form London forces and dipole-dipole forces OWTTE **(1)** London forces can be described as Van der Waals VDW Temporary dipole-dipole Instantaneous dipole-induced dipole		**1**

Question Number	Correct Answer	Reject	Mark
21 (b)(ii)	**Water**: Hydrogen bonds with the (oxygen of the) carbonyl group/H bonds to the oxygen **(1)** **Octane:** London forces with methyl groups/carbon chain/CH groups/ H atoms **(1)** Both forces given allow **(1)**	Carbon atoms	**2**

Question Number	Correct Answer	Reject	Mark
22 (a)(i)	Use of heat **(1)** To break down (a reactant)/one reactant into more than one product **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
22 (a)(ii)	$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$ Allow correct multiples		**1**

Question Number	Correct Answer	Reject	Mark
22 (a)(iii)	Group 2 carbonates are more (thermally) stable as you go down the group **(1)** as the cations get bigger/charge density gets less/cation has more shells **(1)** So have less of a polarising effect/distortion on the carbonate (ion)/less of a weakening effect on C–O **(1)** 2nd and 3rd marks cq on first	 Metal gets bigger/element gets bigger Carbonate molecule	**3**

Question Number	Correct Answer	Reject	Mark
22 (b)(i)	orange	Yellow Any colour in conjunction with orange	**1**

Question Number	Correct Answer	Reject	Mark
22 (b)(ii)	$(18.0/1000 \times 0.100) = 1.8 \times 10^{-3}$ /0.0018/2×10^{-3}/0.002 *IGNORE* sf and units even if incorrect		**1**

Question Number	Correct Answer	Reject	Mark
22 (b)(iii)	$(50/1000 \times 0.100) = 5 \times 10^{-3}$ **(1)** [If candidate fails to divide by 1000 in both (b)(ii) and b(iii) penalise only once] Moles HCl reacted = 3.2×10^{-3} (can get first mark here if 5×10^{-3} not shown above) So moles CaO = 1.6×10^{-3} **(1)** *IGNORE* sf Allow TE from b **(ii)**		**2**

Question Number	Correct Answer	Reject	Mark
22 (b)(iv)	Mass CaO = (1.6 x 10^{-3} x 56.1) = 0.0898 g **(1)** % purity = 0.0898/0.121 x100 = 74.2% **(1)** OR Allow % calculated in terms of moles e.g moles of CaO should be 0.121 x 56.1 = 0.0021568 (mol) **(1)** % purity = 0.0016/0.0021568 = 74.2% **(1)** **Accept** = (1.6 x 10^{-3} x 56) = 0.0896 g **(1)** % purity = 0.0896/0.121 x100 = 74.0% **(1)** Allow TE of incorrect moles of CaO from (b)(iii) Allow TE from incorrect mass of CaO if answer is ≤100% 0.09 g and 74.4% is 1 out of 2 (rounding too soon)	 Any % purity without 3 sf for second mark	**2**

Question Number	Correct Answer	Reject	Mark
22 (c)(i)	(Clean) nichrome/platinum wire/ceramic rod/silica/nickel/chrome rod **(1)** (In conc.) HCl/HCl(aq)/dilute HCl **(1)** Heat/place in (blue Bunsen) flame **(1)**	Metal loop/inoculating loop/glass rod/silver/spatula Place in yellow Bunsen flame/burn	**3**

Question Number	Correct Answer	Reject	Mark
22 (c)(ii)	Barium/Ba/Ba^{2+}		**1**

Question Number	Correct Answer	Reject	Mark
23 (a)	H bond between appropriate O and H atom **(1)** Angle of 180˚ between molecules **(1)** 2nd mark is dependent on first Compounds other than ethanol showing correct H bond and angle **(1 max)**	O---H-O if not in a straight line	**2**

Question Number	Correct Answer	Reject	Mark
23 (b)	Incorrect water flow through condenser **(1)** so takes longer to collect product / lower amount of product collected / inner tube in condenser could crack / backflow of water due to gravity/air bubbles/inefficient cooling/condenser does not fill up with water **(1)** Thermometer bulb too high **(1)** so incorrect boiling point reading/product collected at incorrect temp OWTTE **(1)** Sealed apparatus **(1)** so risk of explosion/pressure build up **(1)** 2nd mark in each pair dependent on 1st mark 1st mark can be obtained by circling correct point on diagram or by description Circle for 3rd error must cover joint to collection flask and/or delivery adaptor If the whole apparatus is circled to indicate sealed 2 marks could be awarded if the problem of the pressure build up is explained Circling the whole apparatus with no or incorrect explanation = 0 marks		**6**

Question Number	Correct Answer	Reject	Mark
23 (c)	(0.005 x 2)/20.10 x 100 = 0.05/0.04975 (%) *IGNORE* sf		**1**

Question Number	Correct Answer	Reject	Mark
23 (d)	Suitable drying agent e.g anhydrous magnesium sulfate/anhydrous sodium sulfate/calcium oxide **(1)** **Accept** anhydrous calcium chloride silica (gel) Add to ethanol (leave) and then filter/Add to ethanol (leave) and then decant **(1)** Mark independently	Concentrated sulfuric acid OR Sodium and potassium hydroxide Anhydrous copper sulfate Anhydrous cobalt chloride	**2**

Question Number	Correct Answer	Reject	Mark
23 (e)	Add PCl_5 /phosphorous(v)chloride/ phosphorous pentachloride (1) Misty fumes (of HCl) seen/steamy fumes/fumes that form white smoke with NH_3/fumes that turn blue litmus red **(1)** **OR** Add Na (to dried ethanol) **(1)** Bubbles (of H_2) seen/fizzing/effervescence **(1)** **OR** Add acidified (sodium) dichromate((VI))/$Cr_2O_7^{2-}$ and H^+ **(1)** Blue/green colour observed **(1)** **OR** Add acidified (potassium) manganate((VII))/MnO_4^- & H^+ **(1)** Loss of (purple) colour/colour fades/decolourises **(1)** 2nd mark dependent on sensible attempt at test reagent	PCl_3 White smoke on its own White fumes on its own	**2**

Question Number	Correct Answer	Reject	Mark
23 (f)(i) QWC	A fuel (derived from a plant) that takes in as much CO_2 (as it forms/grows) **(1)** as is released during its production /combustion/when used **(1)** **OR** A fuel (such as hydrogen) that produces no CO_2 when burnt **(1)** Nor in its production/processing **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
23 (f)(ii) QWC	**2 specific reasons** e.g • energy used to heat/distil (ethanol water mixture after fermentation) may require burning a fuel/energy • energy required to manufacture fertilisers (to grow plants for biofuels in good yield) • energy required to manufacture inseticides (to grow plants for biofuels in good yield) • energy required to transport fuel to the power plant • biofuels less effective at absorbing CO_2 than (rain)forests/trees **(2)** **2 well reasoned effects on society** e.g • use of food crops to produce biofuels reduces food supply • (use of land) for biofuels reduces biodiversity • use of land to grow biofuels leads to reduced food supply • leads to deforestation/leads to habitat loss • new jobs created to grow crops on new farmland • increased price of car/car service due to engine modifications • less CO_2 so less global warming • less SO_2 so less acid rain • less SO_2 so less respiratory illnesses e.g asthma **(2)** **Choice of most sustainable biofuel with appropriate reasoning** e.g • elephant grass as it requires little/no energy to process before it is burnt • elephant grass grows very quickly • elephant grass is a high yield crop • Any of the fuels can be burnt using existing technology **(1)**		**5**

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 14 January 2010 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/5/3/

N 3 5 1 3 1 A 0 1 2 4

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The isotopes of magnesium, $^{24}_{12}Mg$ and $^{25}_{12}Mg$, both form ions with charge 2+. Which of the following statements about these ions is true?

☐ **A** Both ions have electronic configuration $1s^2\ 2s^2\ 2p^6\ 3s^2$.

☐ **B** $^{25}_{12}Mg^{2+}$ has more protons than $^{24}_{12}Mg^{2+}$.

☐ **C** The ions have the same number of electrons but different numbers of neutrons.

☐ **D** The ions have the same number of neutrons but different numbers of protons.

(Total for Question 1 = 1 mark)

---

2 Chlorine has two isotopes with relative isotopic mass 35 and 37. Four *m/z* values are given below. Which will occur in a mass spectrum of chlorine gas, Cl_2, from an ion with a single positive charge?

☐ **A** 35.5

☐ **B** 36

☐ **C** 71

☐ **D** 72

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 The human body contains around 0.025 g of iodine molecules, I_2. Which of the following shows the number of iodine **atoms** in 0.025 g of I_2?

The Avogadro constant is $6.02 \times 10^{23}\,mol^{-1}$.

☒ **A** $\frac{0.025}{126.9} \times 6.02 \times 10^{23}$

☒ **B** $\frac{0.025}{253.8} \times 6.02 \times 10^{23}$

☒ **C** $\frac{253.8}{0.025} \times 6.02 \times 10^{23}$

☒ **D** $\frac{126.9}{0.025} \times 6.02 \times 10^{23}$

(Total for Question 3 = 1 mark)

---

4 Which equation represents the reaction for which the enthalpy change is the standard enthalpy change of formation, $\Delta H_f^{\ominus}$, of sodium nitrate, $NaNO_3$?

☒ **A** $2Na(s) + N_2(g) + 3O_2(g) \rightarrow 2NaNO_3(s)$

☒ **B** $Na(s) + ½N_2(g) + 1½O_2(g) \rightarrow NaNO_3(s)$

☒ **C** $Na(s) + N(g) + 3O(g) \rightarrow NaNO_3(s)$

☒ **D** $Na(g) + ½N_2(g) + 1½O_2(g) \rightarrow NaNO_3(g)$

(Total for Question 4 = 1 mark)

---

5 Which equation represents the reaction for which the enthalpy change, ΔH, is the mean bond enthalpy of the C–H bond?

☒ **A** $¼CH_4(g) \rightarrow ¼C(g) + H(g)$

☒ **B** $CH_4(g) \rightarrow C(s) + 2H_2(g)$

☒ **C** $CH_4(g) \rightarrow C(g) + 4H(g)$

☒ **D** $CH_4(g) \rightarrow C(g) + 2H_2(g)$

(Total for Question 5 = 1 mark)

---

6 The first ionization energies, in kJ mol^{-1}, of four elements with consecutive atomic numbers are shown below.

A 1680

B 2080

C 496

D 738

(a) Which element could be an inert gas?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which element could be X in a covalent compound with formula HX?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which element could be Y in an ionic compound with formula YH_2?

(1)

☒ **A**

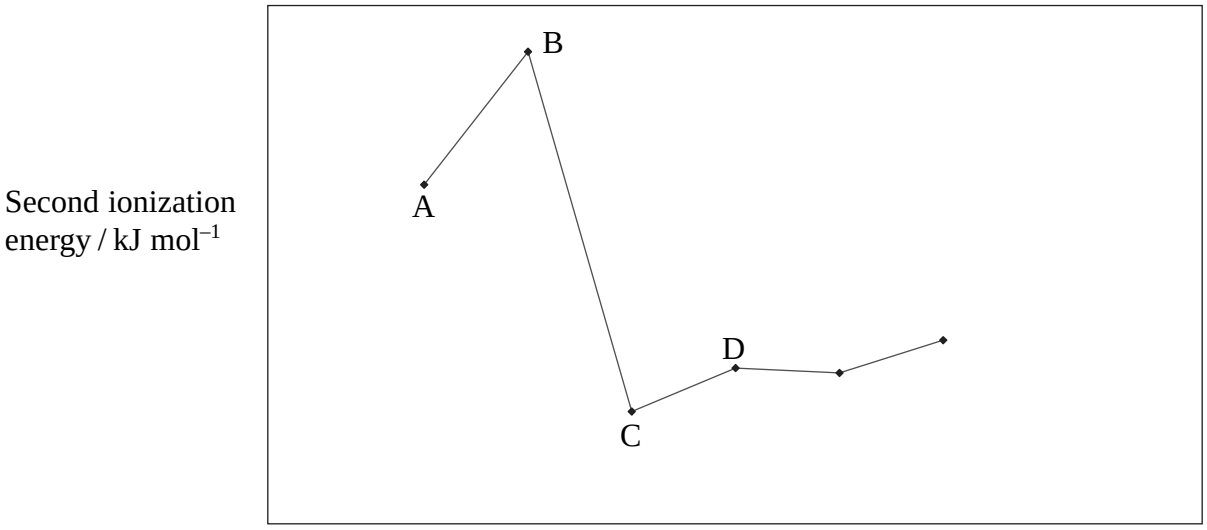
☒ **B**

☒ **C**

☒ **D**

(Total for Question 6 = 3 marks)

7 The graph below shows the **second** ionization energy of a series of elements with consecutive atomic numbers.



Which element could be lithium?

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 7 = 1 mark)

8 The first five ionization energies, in kJ mol^{-1}, of aluminium are

578 1817 2745 11 578 14 831

The orbitals from which the first five electrons are removed during ionization, starting with the first electron, are

- ☒ **A** 1s 2s 2p 3s 3p
- ☒ **B** 1s 1s 2s 2s 2p
- ☒ **C** 3p 3s 2p 2s 1s
- ☒ **D** 3p 3s 3s 2p 2p

(Total for Question 8 = 1 mark)

9 Going across the Periodic Table from sodium to aluminium,

☒ **A** the melting temperature increases.

☒ **B** the radius of the atom increases.

☒ **C** the radius of the metal ion increases.

☒ **D** the bonding in the element changes from metallic to covalent.

(Total for Question 9 = 1 mark)

10 Going down Group 1 from lithium to rubidium

☒ **A** the radius of the atom decreases.

☒ **B** the radius of the ion decreases.

☒ **C** the first ionization energy decreases.

☒ **D** the polarizing power of the ion increases.

(Total for Question 10 = 1 mark)

11 A drop of concentrated nickel(II) sulfate solution, which is green, is placed on moist filter paper on a microscope slide and the ends of the slide are connected to a 24 V DC power supply. After ten minutes,

☒ **A** a blue colour has moved towards the negative terminal and a yellow colour towards the positive terminal.

☒ **B** a blue colour has moved towards the positive terminal and a yellow colour towards the negative terminal.

☒ **C** a green colour has moved towards the negative terminal but there is no other visible change.

☒ **D** a green colour has moved towards the positive terminal but there is no other visible change.

(Total for Question 11 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

12 The bonding in magnesium oxide, MgO, is

- ☒ **A** ionic.
- ☒ **B** metallic and ionic.
- ☒ **C** ionic and covalent.
- ☒ **D** metallic and covalent.

(Total for Question 12 = 1 mark)

13 Which of the following mixtures could **not** form when octane, C_8H_{18}, is cracked?

- ☒ **A** propane + pentene
- ☒ **B** butane + butene
- ☒ **C** pentane + propene
- ☒ **D** heptane + ethene

(Total for Question 13 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

14 This question is about the organic compounds with skeletal formulae as shown:

A 

B 

C 

D 

(a) Which compound is 2-methylpropane?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which compound has the molecular formula C_5H_{12}?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which compounds are isomers?

(1)

☒ **A** compound **A** and compound **C**

☒ **B** compound **B** and compound **C**

☒ **C** compound **B** and compound **D**

☒ **D** compound **C** and compound **D**

(d) Which compound reacts with acidified potassium manganate(VII) to form a diol?

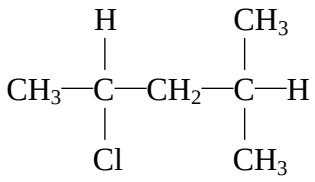
(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

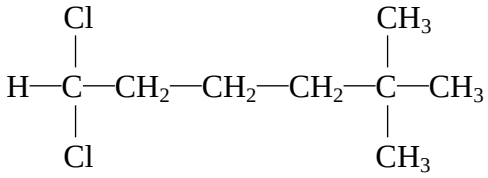
(Total for Question 14 = 4 marks)

15 The structural formula of 5-chloro-2,2-dimethylhexane is

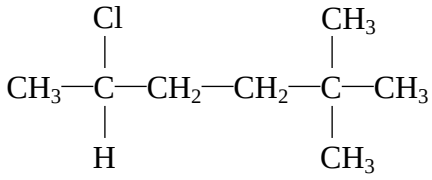
☒ **A**



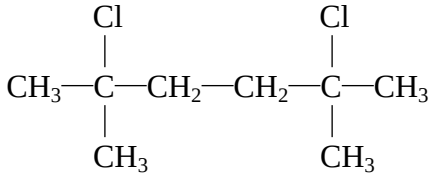
☒ **B**



☒ **C**



☒ **D**



(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

16 Magnesium chloride can be made by reacting solid magnesium carbonate, $MgCO_3$, with dilute hydrochloric acid.

(a) Write an equation for the reaction, including state symbols.

(2)

(b) Give TWO observations you would make when the reaction is taking place.

(2)

.....

.....

(c) In an experiment to make crystals of hydrated magnesium chloride, $MgCl_2.6H_2O$, magnesium carbonate was added to 25 cm^3 of hydrochloric acid with concentration 2.0 mol dm^{-3}. The molar mass of magnesium carbonate is 84.3 g mol^{-1}.

(i) How many moles of acid are used in the reaction?

(1)

(ii) What mass of magnesium carbonate, in grams, reacts with this amount of acid?

(1)

(iii) Suggest why slightly more than this mass of magnesium carbonate is used in practice.

(1)

.....

.....

(iv) How would you separate the magnesium chloride solution from the reaction mixture in (iii)?

(1)

.....

(v) The magnesium chloride solution was left to crystallise. The crystals were separated and dried carefully. A sample of 3.75 g of hydrated crystals, $MgCl_2.6H_2O$, which have molar mass 203.3 g mol^{-1}, was obtained. Calculate the percentage yield of this reaction.

(2)

(vi) Give ONE reason why the yield of crystals is less than 100%, even when pure compounds are used in the preparation.

(1)

.....

.....

.....

(d) Lattice energies can be measured using the Born-Haber cycle, or calculated from electrostatic theory. Lattice energies of magnesium chloride and magnesium iodide are shown below.

Salt	Lattice energy from Born-Haber cycle using experimental data / kJ mol^{-1}	Lattice energy from electrostatic theory / kJ mol^{-1}
$MgCl_2$	–2526	–2326
MgI_2	–2327	–1944

(i) What does this data indicate about the bonding in magnesium chloride?

(1)

.....

.....

.....

.....

*(ii) Explain why there is a greater difference between the experimental (Born-Haber) and theoretical lattice energies for magnesium iodide, MgI_2, compared with magnesium chloride.

(2)

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.....

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(e) Blood plasma typically contains 20 parts per million (ppm) of magnesium, by mass.

(i) Calculate the mass of magnesium, in grams, present in 100 g of plasma.

(1)

(ii) Magnesium chloride can be used as a supplement in the diet to treat patients with low amounts of magnesium in the blood. Suggest ONE property which makes it more suitable for this purpose than magnesium carbonate.

(1)

.....

.....

(Total for Question 16 = 16 marks)

17 Sulfamic acid is a white solid used by plumbers as a limescale remover.

(a) Sulfamic acid contains 14.42% by mass of nitrogen, 3.09% hydrogen and 33.06% sulfur. The remainder is oxygen.

(i) Calculate the empirical formula of sulfamic acid.

(3)

(ii) The molar mass of sulfamic acid is 97.1 g mol^{-1}. Use this information to deduce the molecular formula of sulfamic acid.

(1)

(b) A solution of sulfamic acid contains hydrogen ions. The hydrogen ions react with magnesium to produce hydrogen gas. In an experiment, a solution containing 5.5×10^{-3} moles of sulfamic acid was reacted with excess magnesium. The volume of hydrogen produced was 66 cm^3, measured at room temperature and pressure.

(i) Draw a labelled diagram of the apparatus you would use to carry out this experiment, showing how you would collect the hydrogen produced and measure its volume.

(2)

(ii) Calculate the number of moles of hydrogen, H_2, produced in this reaction.

[The molar volume of a gas is 24 $dm^3 mol^{-1}$ at room temperature and pressure]

(1)

(iii) Show that the data confirms that each mole of sulfamic acid produces one mole of hydrogen ions in solution.

(2)

(c) Plumbers use sulfamic acid powder for descaling large items such as boilers. Sulfamic acid acts as a descaler because the hydrogen ions react with carbonate ions in limescale.

(i) Write an ionic equation for the reaction of hydrogen ions with carbonate ions. State symbols are **not** required.

(1)

(ii) Suggest ONE reason why sulfamic acid is considered less hazardous than hydrochloric acid as a descaler.

(1)

.....

(Total for Question 17 = 11 marks)

18 This question is about hexane, C_6H_{14}, and hex-1-ene, C_6H_{12}.

(a) What test would you use to distinguish between hexane and hex-1-ene? Give the results of the test for each substance.

(2)

Test: .....

.....

Result with hexane: .....

.....

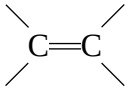
Result with hex-1-ene: .....

.....

(b) Hex-1-ene has a number of isomers, including two stereoisomers of hex-2-ene.

(i) Complete the formula to show the structure of *E*-hex-2-ene.

(1)



*(ii) Explain why stereoisomerism can occur in alkenes, and why hex-2-ene has stereoisomers but hex-1-ene does not.

(2)

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(c) The enthalpy change of combustion of hexane was measured using a spirit burner to heat a known mass of water in a calorimeter. The temperature rise of the water was measured. The results of the experiment are shown below.

Mass of hexane burnt	0.32 g
Mass of water in calorimeter	50 g
Initial temperature of water	22 °C
Final temperature of water	68 °C

The specific heat capacity of water is 4.18 J g^{-1} °C^{-1}.

(i) Calculate the energy in joules produced by burning the hexane. Use the expression

energy transferred = mass × specific heat capacity × temperature change.

(1)

(ii) Calculate the enthalpy change of combustion of hexane. The mass of 1 mole of hexane is 86 g.

Give your answer to TWO significant figures. Include a sign and units in your answer.

(3)

(iii) The value for the enthalpy change of combustion in this experiment is different from the value given in data books. Suggest TWO reasons for this difference.

(2)

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.....

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.....

(iv) A student suggested that the results would be more accurate if a thermometer which read to 0.1°C was used. Explain why this would **not** improve the accuracy of the result. A calculation is **not** required.

(1)

.....

.....

(d) Hex-1-ene can be converted to hexane in the following reaction.

$$C_6H_{12}(l) + H_2(g) \rightarrow C_6H_{14}(l)$$

(i) What catalyst is used in this reaction?

(1)

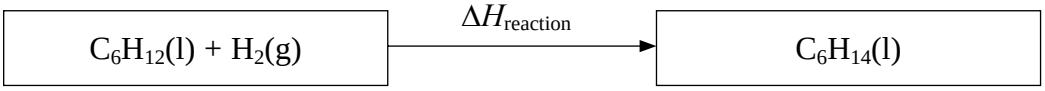
.....

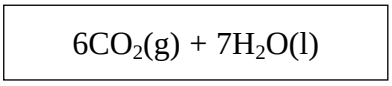
(ii) The enthalpy change of this reaction $\Delta H_{reaction}$ can be calculated from the following enthalpy changes of combustion.

Substance	Enthalpy change of combustion /kJ mol^{-1}
Hex-1-ene, C_6H_{12}	–4003
Hydrogen, H_2	–286
Hexane, C_6H_{14}	–4163

Complete the Hess cycle by adding labelled arrows. Use your cycle to calculate the enthalpy change $\Delta H_{reaction}$.

(3)





$\Delta H_{reaction}$ = ... kJ mol^{-1}

(iii) The enthalpy change for the reaction of some other alkenes with hydrogen is shown below.

Reaction	Standard enthalpy change / kJ mol^{-1}
$C_3H_6 + H_2 \rightarrow C_3H_8$	–125
$C_4H_8 + H_2 \rightarrow C_4H_{10}$	–126
$C_5H_{10} + H_2 \rightarrow C_5H_{12}$	–126

Explain why the values are so similar.

(1)

.....

.....

.....

(Total for Question 18 = 17 marks)

19 Chloroethane, C_2H_5Cl, can be made from either ethane or ethene.

(a) (i) What reagent and condition would be used to make chloroethane from **ethane**?

(2)

Reagent.....

Condition.....

(ii) State the type of reaction and mechanism by which this reaction occurs.

(2)

.....

(b) (i) What reagent would be used to make chloroethane from **ethene**?

(1)

.....

(ii) Show, in full, the mechanism for this reaction in which **ethene** is converted to chloroethane.

(3)

(c) Which method of making chloroethane has

(3)

- a higher atom economy? .....
- a higher percentage yield? .....

Explain your answers.

Higher atom economy .....

.....

Higher percentage yield .....

.....

(d) The compound chloroethene, $CH_2{=}CHCl$, forms an addition polymer.

(i) Draw a diagram, using dots or crosses, to show the arrangement of electrons in chloroethene. Only the outer shell electrons need be shown.

(2)

(ii) Chloroethene can form an addition polymer. Write the displayed formula of poly(chloroethene) showing two repeat units.

(1)

*(iii) Poly(chloroethene) is commonly known as PVC. Almost a quarter of the PVC which is manufactured is used to make water pipes, which were formerly made of metal.

Give TWO factors which have to be considered when deciding which material, PVC or metal, contributes to more sustainable uses of resources in the long term.

(2)

.....

.....

.....

.....

.....

.....

(Total for Question 19 = 16 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

N 3 5 1 3 1 A 0 2 4 2 4

PMT

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Mark Scheme (Results)
January 2010

GCE

GCE Chemistry (6CH01/01)

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January 2010

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

6CH01/01

Section A

Question Number	Correct Answer	Reject	Mark
1	C		**1**

Question Number	Correct Answer	Reject	Mark
2	D		**1**

Question Number	Correct Answer	Reject	Mark
3	A		**1**

Question Number	Correct Answer	Reject	Mark
4	B		**1**

Question Number	Correct Answer	Reject	Mark
5	A		**1**

Question Number	Correct Answer	Reject	Mark
6 (a)	B		**1**

Question Number	Correct Answer	Reject	Mark
6 (b)	A		**1**

Question Number	Correct Answer	Reject	Mark
6 (c)	D		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Correct Answer	Reject	Mark
8	D		**1**

Question Number	Correct Answer	Reject	Mark
9	A		**1**

Question Number	Correct Answer	Reject	Mark
10	C		**1**

Question Number	Correct Answer	Reject	Mark
11	C		**1**

Question Number	Correct Answer	Reject	Mark
12	A		**1**

Question Number	Correct Answer	Reject	Mark
13	D		**1**

Question Number	Correct Answer	Reject	Mark
14 (a)	A		**1**

Question Number	Correct Answer	Reject	Mark
14 (b)	D		**1**

Question Number	Correct Answer	Reject	Mark
14(c)	B		**1**

Question Number	Correct Answer	Reject	Mark
14 (d)	B		**1**

Question Number	Correct Answer	Reject	Mark
15	C		**1**

Section B

Question Number	Acceptable Answers	Reject	Mark
16 (a)	$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g)$ ALLOW $MgCO_3(s) + 2H^+(aq) \rightarrow Mg^{2+}(aq) + CO_2(g) + H_2O(l)$ All formulae and balancing (1) State symbols – mark independently; can be given even if eg $MgCl_2$ formula incorrect or for $H_2CO_3(aq)$(1) $CO_3^{2-}(s) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$ (1 mark max) ALLOW 1 missing/incorrect state symbol		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b)	Any two from Bubbles (of gas)/ fizzing/ effervescence (1) Solid disappears/ disintegrates /gets smaller /dissolves OR $MgCO_3$ disappears (if given as solid in (i)) (1) IGNORE clear solution forms Mixture gets warmer/cooler OR temperature change occurs/ heat change occurs(1)	 Carbon dioxide /gas given off Precipitate forms (no TE for $MgCl_2(s)$) Just "exothermic"	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (c) (i)	Moles acid = ((25 x 2/ 1000)) = 0.05/0.050 / $5x10^{-2}$ Ignore units and sf		**1**

Question Number	Acceptable Answers	Reject	Mark
16 (c) (ii)	Mass Mg CO_3 = ((0.05 x 84.3÷2)) = 2.1075/ 2.108 /2.11/2.1 (g) ALLOW TE from (c)(i) and (a) ALLOW Moles acid x 84.3 ÷2 for TE(from (i) (1) (4.2(15)) if factor of 2 missing for TE from (a)) Ignore sf except 1 sf Ignore units	2 / 2.12(g)	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (c) (iii)	To ensure all **acid** reacts/ all **acid** is used up / to ensure product is neutral/ it (HCl) is neutralised	All reactants used up To ensure reaction is complete (without reference to HCl) To ensure yield is high To ensure magnesium carbonate is in excess	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (c) (iv)	Filter ALLOW centrifuge/ decant/ pour off / (use) filter paper Ignore comments about heating solution first to concentrate it	Sieve Collect $MgCl_2$ in filter paper Use filter paper to dry crystals Evaporate	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (c) (v)	100% yield = (203.3 x 0.025) /5.08(25)g) (1) yield = $\left(\frac{3.75}{5.08} \times 100\right)$ = **74 %** (1) OR Mol magnesium chloride = $\frac{(3.75}{203.3)}$ = 0.018445/0.01845/0.0184/0.018 (1) yield = $\left(\frac{100 \text{ X } 0.01845)}{0.025}\right.$ = **74 %** (1) Second mark can be given as TE if expected yield or number of moles is wrong. ALLOW 73.82/73.78/73.8 /73.6 /other answers rounding to 74 % from earlier approximations /72 (from 0.018 moles) Allow TE from (a) and or (c)(i) and or (c)(ii) If the ratio HCl to $MgCl_2$ is 1:1 ans 37 % (2) If moles of HCl in (c)(i) are wrong (2) If (a) and (c)(i) are correct 37 % scores (1) If moles $MgCO_3$ = 0.05 allow TE giving 37/ 36.9% Ignore sf except 1 sf	70	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (c) (vi)	Some stays in solution / losses on transferring from one container to another/ loss on filtering /crystals left behind/some left on filter paper etc Any one ALLOW correct answers with other comments which are not incorrect eg "there may be some spillage and also ……."	Incomplete reaction/side reaction Lost as waste products Lost to environment Lost in manipulation? Hydrolysis Weighing errors Just "spillage"	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (d)(i)	Not 100% ionic /almost completely ionic OR (partial) covalent character/ almost no covalency OR Discrepancy in BH values indicates polarisation (of ions) (1) *Mark can be given if answer here refers to bond strength and the answer above is included in (ii)*	Magnesium chloride is covalent Magnesium chloride is partially ionic Just "polarity of ions"	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (d)(ii)	QWC I^- larger (than Cl^-) (1) so (ion) easier to polarise /distort (1) ALLOW for 2nd mark increases covalent character / more covalent than $MgCl_2$ / converse for $MgCl_2$ / description of polarisation instead of the term If clearly ions, allow reference to iodine instead of iodide ("iodine has a larger ion") Read in conjunction with (i). Direct comparison not needed if (i) covers bonding in chloride.	Size of atoms rather than ions I_2 is larger than Cl_2 I_2 molecules are polarised Mg^{2+} is polarised Iodine more electronegative than chlorine	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (e) (i)	$\frac{(100 \times 20)}{10^6} = 2 \times 10^{-3}$(g) ALLOW 0.002(g) 1/500 (g) 2×10^{-6} kg IGNORE % as unit	$2 \times 10^{-3} = 0.0002$	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (e) (ii)	(More) soluble (in water)/ (more) soluble in blood stream/ can be given as solution/ won't produce gas in stomach / won't react with stomach acid/ doesn't produce CO_2 Converse answers for $MgCO_3$ Or other valid answers ALLOW can be given in liquid form	$MgCl_2$ is a liquid $MgCO_3$ is too reactive	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a) (i)	Moles N $= \frac{14.42}{14} = 1.03$ Moles H = 3.09 Moles S $= \frac{33.06}{32.1} = 1.03$ (1) ALLOW Moles S $= \frac{33.06}{32} = 1.03$ Moles O $= \frac{49.43}{16} = 3.09$ (1) (Ratio 1:3:1:3) IGNORE sf/rounding for moles NH_3SO_3 any order (1) Correct answer, no working (3) If O omitted, giving NH_3S (2)		**3**

Question Number	Acceptable Answers	Reject	Mark
17 (a) (ii)	NH_3SO_3 (any order) since molar mass = empirical formula mass/ since empirical formula mass =97/ with some other justification TE from (i) $N_2H_6S_2$, as empirical formula mass =49, approx half molecular mass		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (i)	Look for workable method. Don't penalise lack of labels on simple equipment eg test tubes. Workable way of making and collecting gas eg flask or tube + connection/ below inverted funnel with tube of water above Labelling of reactants not needed (1) Suitable (labelled) apparatus for measuring volume eg Gas syringe/ inverted burette or measuring cylinder containing water (1)	Uncalibrated tubes	**2**

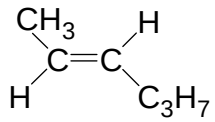
Question Number	Acceptable Answers	Reject	Mark
17 (b) (ii)	$\frac{66}{24\,000} = 2.75 \times 10^{-3}$ / 0.00275 / 0.0028	0.003	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (iii)	1 mol sulfamic acid $\rightarrow$ 0.5 mol H_2 OR ratio sulfamic acid : hydrogen gas = 2:1 OR 5.5 ($\times 10^{-3}$)(moles) = (2 x 2.75 ($\times 10^{-3}$)) (moles) OR TE using ratio calculated from (ii) (1) Each H_2 comes from 2 H^+ (So 1 sulfamic acid $\rightarrow$ 1 H^+) (1)	ratio sulfamic acid : hydrogen ions = 2:1	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (c) (i)	$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$ ALLOW $H^+ + CO_3^{2-} \rightarrow HCO_3^-$ $2H^+ + CO_3^{2-} \rightarrow H_2CO_3$		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c) (ii)	**Less** easy to spill solid (in storage) OR doesn't spread if spilt OR easy to sweep up if spilt OR **less** corrosive/ **less** strongly acidic than HCl ALLOW Weaker (acid) / HCl is a stronger acid	Just "it is a solid" Less reactive (unless with comment on acid strength) HCl produces poisonous gas / Cl_2 Less concentrated Has higher pH Just "HCl is harmful/irritant/corrosive" Just "sulfamic acid is not harmful/irritant/corrosive"	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a)	Allow formulae throughout instead of names **Test :** add bromine (water) /bromine solution ALLOW bromine gas /bromination (1) **Result:** no change with hexane / stays orange brown/ stays red brown/ stays yellow and goes colourless with hex-1-ene(1) 2nd mark cq on 1st OR **Test :** add (acidified) potassium manganate((VII)) (solution) (1) ALLOW potassium permanganate for potassium manganate(VII) **Result:** no change with hexane/stays purple and goes colourless / brown with hex-1-ene (1) OR **Test :** add alkaline potassium manganate((VII)) (solution) (1) ALLOW potassium permanganate for potassium manganate(VII) **Result:** no change with hexane/stays purple and goes green with hex-1-ene (1)	Smokiness of flame Bromide Iodine Goes clear	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (i)	 ALLOW Partially or fully displayed as long as the two H are trans Allow bonds which go closer to the H than to C of alkyl groups on l.h.s.		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	QWC C=C restricts rotation/ C=C prevents twisting /C=C can't rotate/ lack of free rotation round C=C (so the groups can't change position relative to the bond) (1) Hex–2-ene has different groups on the C at each end of C=C / hex-1-ene has 2 hydrogens on the C at one end of C=C / hex-1-ene doesn't have different groups on the C at one end of C=C / hex-1-ene has no group which takes priority on the C at one end of C=C (1) (answer can be considered from either hex –1-ene or hex-2-ene)	Alkenes can't rotate Double bond is fixed Bonds can't rotate Double bond is on first carbon (unless further explanation)	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (i)	ignore signs (50 x 46 x 4.18) = 9614(J)/ 9.614 kJ (if converted to kJ units must be stated) ALLOW 9610 / 9600 /9.61 kJ /9.6 kJ	(50.32 x 46 x 4.18) = 9676(J)	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (ii)	One mark each for moles of hexane energy change sign, units, 2 sig figs (for energy change calculated) Moles hexane = **0.32/86** = (3.72×10^{-3}) (1) ($9614 / 3.72 \times 10^{-3}$) = 2584000 J/ 2584 kJ (1) **ΔH = -2600 kJ mol^{-1}** /-2 600 000 J mol^{-1} / -2.6×10^{6} J mol^{-1} (1) Allow TE: **0.32g** in (i) (gives 61.53J), **ΔH = -17 kJ mol^{-1}** /-17 000 J mol^{-1} /-1.7×10^{4} J mol^{-1} **50.32g** in (i) (gives 9676J) **ΔH = -2600 kJ mol^{-1}** /-2 600 000 J mol^{-1} /-2.6×10^{6} J mol^{-1} **Rounding of moles to 4×10^{-3}** gives –**2400 kJ mol^{-1} or-15 kJ mol^{-1}** max 2 (loses moles mark) Answer alone (3) Max 2 if negative sign missing and/or more than 2 sf or error in units		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (iii)	Any 2 from: • Heat losses (from calorimeter)/ poor insulation • Incomplete combustion/burning • Incomplete transfer of heat/ loss by convection • Evaporation of fuel (after weighing) • Heat capacity of calorimeter (not included)/ heat absorbed by calorimeter • Measurements not carried out under standard conditions /H_2O is gas, not liquid, in this experiment	Just “energy losses” Not all hexane burns Data books give average values Hexane is impure Human error	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (iv)	Error in reading temperature is less than the effect of ignoring heat loss etc ALLOW Other errors are greater than error in temperature reading / Readings are within margins of error/ The accuracy with the thermometer is not significantly different from other measurement errors / 0.1°C is insignificant compared to temperature change / Using 0.1°C thermometer does not change significant figures in final answer / Using 0.1°C thermometer does not reduce errors	Using 0.1°C thermometer gives a more precise reading but does not improve accuracy	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (d) (i)	Nickel / Ni Finely divided nickel/ Raney nickel ALLOW Platinum /Pt Palladium/ Pd Rhodium/ Rh Accept one of the above answers combined with a comment such as “at high temperature”, “heat also needed”, “under pressure”, “lumps of”, “powdered” Accept combinations of above answers eg Pt and Pd	Zeolite Carbon Hydrogen Uv light	**1**

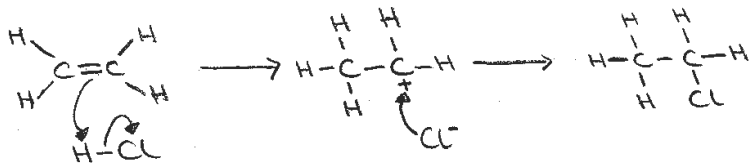
Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	Left hand arrow, pointing down, labelled ΔH_c hex-1-ene + ΔH_c hydrogen/ -4003-286/-4289 OR Pointing up with signs given above reversed (1) Right hand arrow pointing down labelled ΔH_c hexane / -4163 OR Pointing up with signs given above reversed (1) Ignore oxygen on both arrows Arrows may be labelled ΔH_1 etc if key given or use of numbers in calculation makes this obvious. ($\Delta H_{reaction}$ – 4163 = -4003 – 286 / or words applying Hess' law correctly) $\Delta H_{reaction}$ = **-126** however obtained(1) TE: If arrows point up and signs are **not** reversed $\Delta H_{reaction}$ = **+126** Max (1)		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (d) (iii)	Same (number and type of) bonds are broken and made in each reaction / one C=C (and one H-H) are broken and two C-H made ALLOW reaction is –CH=CH- + $H_2 \rightarrow$ -CH_2-CH_2- each time (Similar energy change) as in each case H_2 reacts with C=C	All are alkenes going to alkanes all have the same double bond which reacts in the same way	**1**

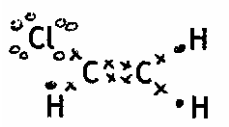
Question Number	Acceptable Answers	Reject	Mark
19 (a) (i)	Reagent: chlorine/ Cl_2 (1) Condition: uv/ sunlight (1) ALLOW light Mark independently Ignore reference to temp and pressure if given with uv light. If answers reversed/both on one line 1 out of 2	Cl Just "heat"	**2**

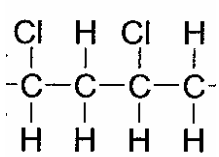
Question Number	Acceptable Answers	Reject	Mark
19 (a) (ii)	(free) radical (1) Substitution (1) Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b) (i)	Hydrogen chloride / HCl	Hydrochloric acid Chlorine HCl (aq) Cl_2	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b) (ii)	Curly (not half headed) arrow from C=C to H (1) Curly arrow from bond in H-Cl to Cl (1) Curly arrow from Cl^- to C^+ (1)  Partial charges on HCl not required Lone pairs on Cl^- not required It should be clear if arrows are to/ from a bond or an atom, but give allowance for precise position Correct intermediate without arrows (1) Correct addition of HBr max 2 Correct addition of HCl to propene max 2 Max 2 for addition of Cl_2 instead of HCl (forming 1,2 - dichloroethane) Max 1 for addition of Cl_2 instead of HCl forming chloroethane	Attack by $Cl^{\delta-}$ or $Cl\cdot$ loses 3rd mark only Correct free radical mechanism from ethane and chlorine scores 0	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (c)	Higher atom economy from ethene /by electrophilic addition Higher yield from ethene Both correct for (1) From ethene only one product / all atoms are used **making product** /no unwanted products (1) For ethene yield high as no di-, tri- etc substituted products form /only one product / no by-products OR no side reactions occur OR no C_4 compounds can form (1) [Or reverse argument]	Not much product is lost	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (d) (i)	 Double bond and electrons around C correct (1) Other electrons correct (1) Can be all dots or all crosses First mark can be given if C_2H_4 drawn correctly Second mark can be given if C_2H_5Cl drawn correctly Don't penalise if bonds shown as well as electrons		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (d) (ii)	 ALLOW H and Cl below C chain; Cl on C2 and C3 or C1 and C4; formula above with brackets at each end and n outside end bracket End bonds should be shown, but don't penalise if these don't go through brackets H atoms should be shown	Formula not displayed One monomer unit shown in bracket with the number 2 outside bracket Cl on C1 and C2 Cl onC3 and C4	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d) (iii)	QWC Any 2 Answers could consider the following factors: • energy for manufacture • availability / abundance of raw materials • lifetime of product/ how often will it need to be replaced /metal rusts/plastic more easily punctured etc • ease of recycling /steel an excellent recyclable material • consequences of disposal / is it biodegradable? • Is it from a non-renewable resource? • Atom economy in manufacture Allow answers comparing specific properties (if correct) illustrating the relevant property Examples PVC will last longer than iron due to lack of corrosion (1) PVC comes from oil which is non-renewable (1) PVC and metals come from non-renewable sources (1) Credit any two valid points	Ignore if other answers given: cost PVC biodegradable its carbon footprint Is it environmentally friendly? Pollution comments without reference to resources needed to clean up	**2**

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 21 May 2010 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The equations below show some reactions of magnesium and its compounds.

A $2Mg(s) + O_2(g) \rightarrow 2MgO(s)$

B $Mg(NO_3)_2(s) \rightarrow MgO(s) + 2NO_2(g) + O_2(g)$

C $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(1)$

D $Mg(s) + CuSO_4(aq) \rightarrow MgSO_4(aq) + Cu(s)$

(a) Which equation is **not** balanced?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which equation can be classified as a displacement reaction?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 2 marks)

---

2 Which of these equations represents the electron affinity of chlorine?

☒ **A** $Cl_2(g) + 2e^- \rightarrow 2Cl^-(g)$

☒ **B** $Cl_2(g) - 2e^- \rightarrow 2Cl^-(g)$

☒ **C** $\frac{1}{2}Cl_2(g) + e^- \rightarrow Cl^-(g)$

☒ **D** $Cl(g) + e^- \rightarrow Cl^-(g)$

(Total for Question 2 = 1 mark)

---

3 Which of these equations represents the second ionization of magnesium?

☒ **A** $Mg^{+}(g) \rightarrow Mg^{2+}(g) + e^{-}$

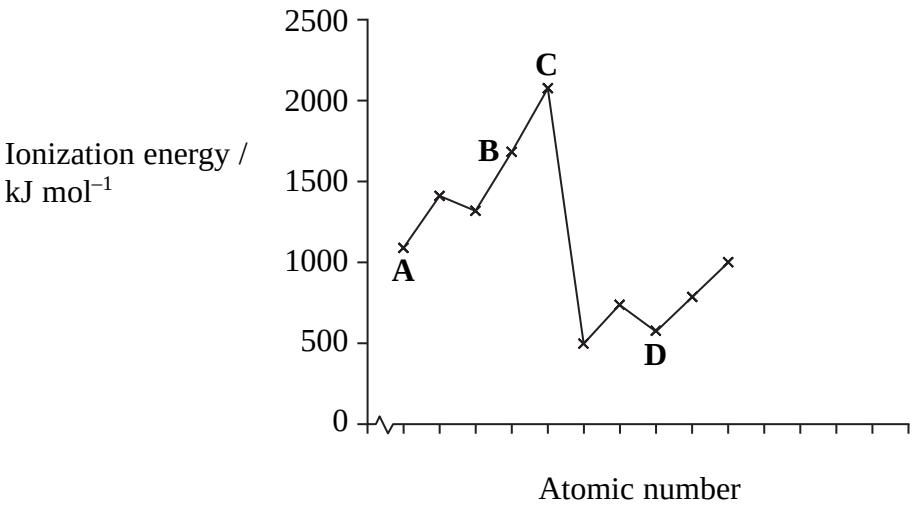
☒ **B** $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{-}$

☒ **C** $Mg^{+}(g) + e^{-} \rightarrow Mg^{2+}(g)$

☒ **D** $Mg(g) + 2e^{-} \rightarrow Mg^{2+}(g)$

(Total for Question 3 = 1 mark)

4 The sketch graph below shows the trend in first ionization energies for some elements in Periods two and three.



Select, from the elements **A to D**, the one that

(a) has atoms with five p electrons.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) is a member of Group 3.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) is likely to be very unreactive.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) normally forms four covalent bonds per atom.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 4 = 4 marks)

5 Which of these ions has the greatest ability to polarize an anion?

☒ **A** Ba^{2+}

☒ **B** Ca^{2+}

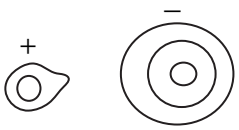
☒ **C** Cs^{+}

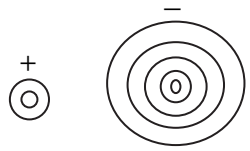
☒ **D** K^{+}

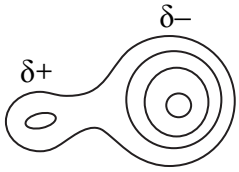
(Total for Question 5 = 1 mark)

6 Which of these electron density maps best represents the bonding in the compound lithium iodide, LiI?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 6 = 1 mark)

7 Which of these statements is **incorrect**?

☒ **A** The atomic radius of metals increases down a Group.

☒ **B** The trend in the melting temperature of successive elements across Period 2 is similar to that in Period 3.

☒ **C** A metallic structure is held together by attractions between metal atoms and delocalized electrons.

☒ **D** Na^+ and O^{2-} ions are isoelectronic.

(Total for Question 7 = 1 mark)

8 A sample of gas was prepared for use in helium-neon lasers. It contained 4 g of helium and 4 g of neon. What is the ratio of helium atoms to neon atoms in the sample?

☒ **A** 1 : 1

☒ **B** 2.5 : 1

☒ **C** 1 : 5

☒ **D** 5 : 1

(Total for Question 8 = 1 mark)

9 The overall equation for the reaction between sulfur and oxygen to form sulfur trioxide is shown below.

$$2S(s) + 3O_2(g) \rightarrow 2SO_3(g)$$

0.9 mol of $O_2(g)$ reacted completely with excess sulfur. What volume, in dm^3, of sulfur trioxide would form?

[Assume the molar gas volume = 24 dm^3 mol^{-1}]

☒ **A** $(0.9 \times 3/2) \times 24$

☒ **B** $(0.9 \times 3/2) \div 24$

☒ **C** $(0.9 \times 2/3) \times 24$

☒ **D** $(0.9 \times 2/3) \div 24$

(Total for Question 9 = 1 mark)

10 Which of these solutions does **not** contain the same total number of ions as the others?

☒ **A** 10.00 cm^3 of 0.100 mol dm^{-3} NaCl(aq)

☒ **B** 20.00 cm^3 of 0.050 mol dm^{-3} NaCl(aq)

☒ **C** 20.00 cm^3 of 0.050 mol dm^{-3} $MgCl_2$(aq)

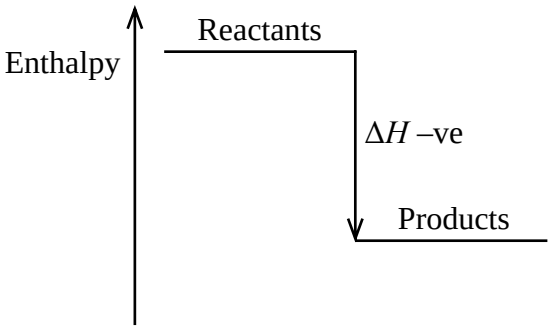
☒ **D** 13.33 cm^3 of 0.050 mol dm^{-3} $MgCl_2$(aq)

(Total for Question 10 = 1 mark)

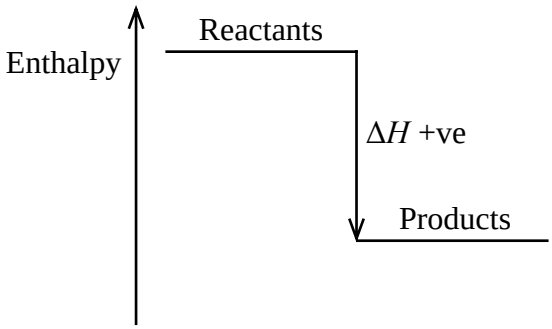
Use this space for any rough working. Anything you write in this space will gain no credit.

11 Which of these diagrams correctly represents an endothermic reaction?

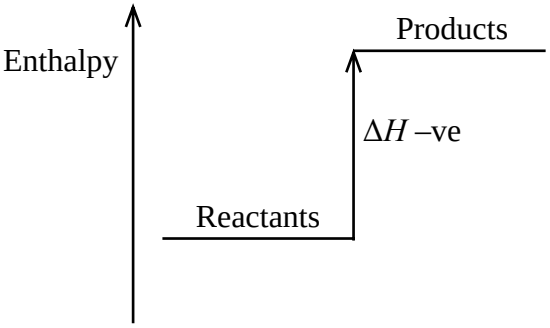
☒ **A**



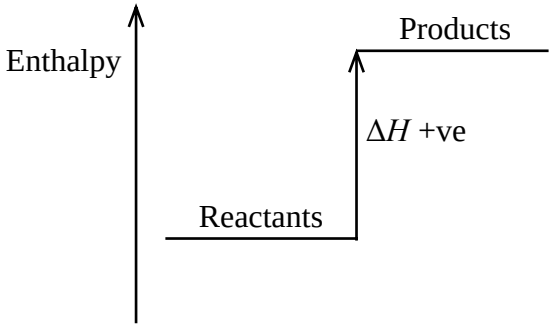
☒ **B**



☒ **C**



☒ **D**



(Total for Question 11 = 1 mark)

12 Which of these statements about carbon-carbon double bonds is **false**?

☒ **A** The two ends of a molecule cannot rotate relative to each other, about the axis of the double bond.

☒ **B** They are twice as strong as a carbon-carbon single bond.

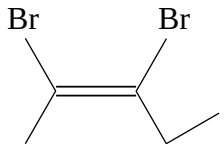
☒ **C** They have a higher electron density than a single bond.

☒ **D** They consist of a sigma bond and a pi bond.

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

13 What is the correct name for the compound below?



☒ **A** *E*-2,3-dibromopent-2-ene

☒ **B** *E*-2,3-dibromopent-3-ene

☒ **C** *Z*-2,3-dibromopent-3-ene

☒ **D** *Z*-2,3-dibromopent-2-ene

(Total for Question 13 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

14 The equations below show some of the processes that occur when methane and chlorine react.

A $Cl_2(g) \rightarrow 2Cl\bullet(g)$

B $Cl\bullet(g) + CH_4(g) \rightarrow CH_3\bullet(g) + HCl(g)$

C $CH_3\bullet(g) + CH_3\bullet(g) \rightarrow C_2H_6(g)$

D $Cl_2(g) + CH_4(g) \rightarrow CH_3Cl(g) + HCl(g)$

(a) Which equation shows a propagation step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which equation shows an initiation step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which equation shows a termination step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 14 = 3 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

15 This question is about the properties of ions and ionic compounds.

(a) Solid calcium carbonate, $CaCO_3$, has a giant ionic structure.

(i) Draw a diagram (using dots or crosses) for a calcium **ion**. Show **ALL** the electrons and the charge on the ion.

(2)

(ii) Complete the electronic configuration for a calcium **ion**.

(1)

$1s^2$ .....

(iii) Would you expect a calcium ion to be bigger, smaller or the same size as a calcium atom? Give TWO reasons to explain your answer.

(2)

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(iv) Explain why ionic compounds have relatively high melting temperatures.

(2)

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(b) Changes in the concentration of ions in a solution can be estimated by measuring the electrical conductivity of the solution.

(i) Explain why solutions of ions are able to conduct electricity.

(1)

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(ii) Suggest why aqueous solutions of calcium chloride, $CaCl_2(aq)$, and barium chloride, $BaCl_2(aq)$, of the same molar concentration, have different electrical conductivities.

(1)

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(iii) 1 kg of a solution contains 0.100 mol of calcium ions, Ca^{2+}.

What is the concentration of the calcium ions by mass in parts per million (ppm)?

[Assume the relative atomic mass of calcium is 40.]

(2)

..... ppm

*(c) Some buildings are made from limestone, which is mainly calcium carbonate. Gases in the atmosphere such as sulfur dioxide, SO_2, and nitrogen dioxide, NO_2, can be responsible for damaging these buildings.

Describe how these gases come to be present in the atmosphere and explain how they can damage a limestone building.

(3)

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(d) The lattice energy of calcium chloride, $CaCl_2$, is -2258 kJ mol^{-1} based on an experimental Born-Haber cycle and -2223 kJ mol^{-1} based on theoretical calculations.

Would you expect its bonding to match the ionic model? Justify your answer.

(1)

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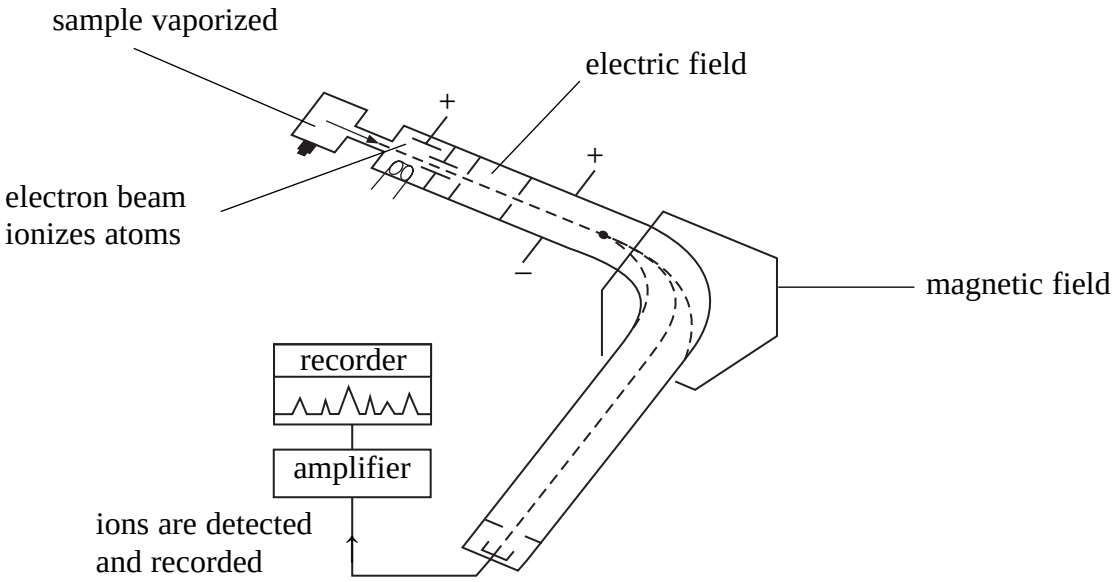
(Total for Question 15 = 15 marks)

16 The diagram below shows a mass spectrometer, which can be used to determine the percentage abundances of isotopes in an element.



(a) Explain, in terms of sub-atomic particles, what is meant by the term **isotopes**.

(2)

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(b) Describe the role of the following parts of the mass spectrometer.

(i) Electric field

(1)

.....

.....

(ii) Magnetic field

(1)

.....

.....

(c) A sample of the element barium is made up of four isotopes. The data below were taken from a mass spectrum of this sample.

Mass/charge ratio	% abundance
135	9.01
136	10.81
137	12.32
138	67.86

Calculate the relative atomic mass of the sample, giving your answer to **one** decimal place.

(2)

(d) The element bromine has two stable isotopes, ^{79}Br and ^{81}Br. How many peaks corresponding to Br_2^+ ions would be seen in the mass spectrum of bromine? Justify your answer.

(2)

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.....

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(e) Suggest another application of mass spectrometry, other than to determine the relative atomic mass of an element.

(1)

.....

.....

(Total for Question 16 = 9 marks)

17 This question is about methanol and the energy changes that accompany some of its reactions.

(a) Complete the diagram (using dots and crosses) to show the bonding in methanol, CH_3OH. You should show outer electrons only.

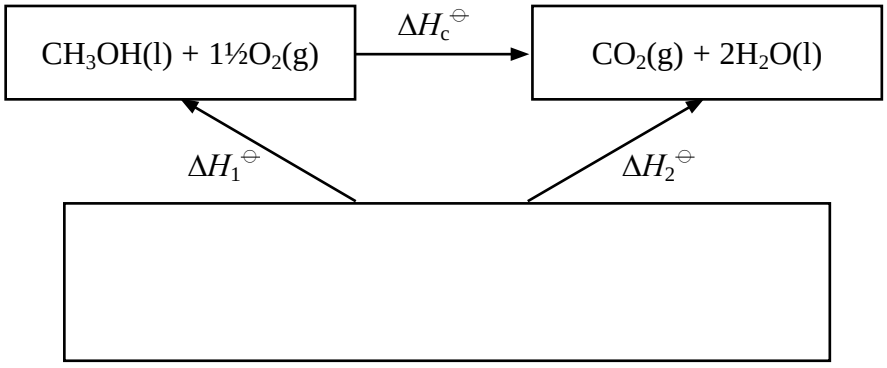
(2)

H

H C O H

H

(b) The Hess cycle below can be used to calculate the standard enthalpy change of combustion of methanol, using standard enthalpy changes of formation.



(i) Complete the cycle by filling in the empty box.

(2)

*(ii) Define the term **standard enthalpy change of formation** of a compound, making clear the meaning of **standard** in this context.

(3)

.....

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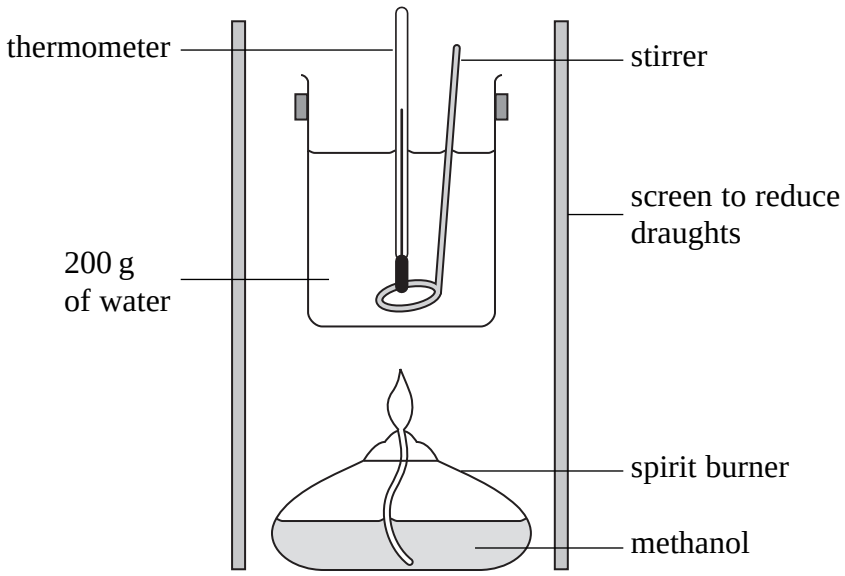
.....

(iii) Use your cycle and the data below to calculate the standard enthalpy change of combustion of methanol, $\Delta H_c^{\ominus}$.

	$\Delta H_f^{\ominus}$/kJ mol^{-1}
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8
$CH_3OH(l)$	–239.1

(2)

(c) An experiment was carried out, using the apparatus below, to estimate the standard enthalpy change of combustion of methanol.



After burning the methanol for a few minutes, the temperature of water in the beaker had risen by 20.7 °C and the mass of methanol burnt was 0.848 g.

(i) Calculate the amount of energy transferred to the water.

Energy transferred (J) = mass of water × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of methanol, CH_3OH, burnt during the experiment.

(1)

(iii) Use your answers to (c)(i) and (ii) to calculate the experimental value for the standard enthalpy change of combustion. Include a sign and units in your answer, which should be given to **three** significant figures.

(1)

(iv) Compare your answers to (b)(iii) and (c)(iii) and give TWO reasons to explain any differences.

(2)

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(Total for Question 17 = 14 marks)

18 This question is about ethene and related compounds.

(a) One way to manufacture ethene is by cracking hydrocarbon molecules such as liquid paraffin.

(i) Name a raw material from which liquid paraffin can be obtained.

(1)

.....

(ii) Describe what is meant by **cracking**.

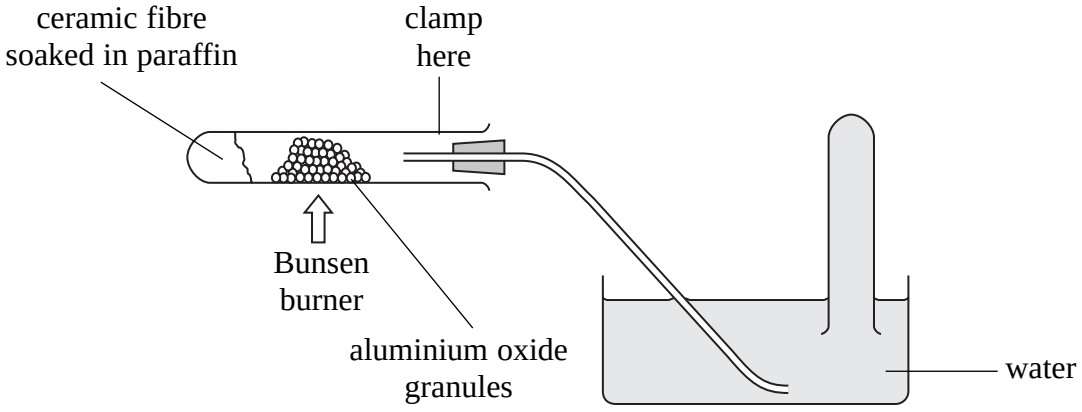
(2)

.....

.....

.....

(iii) It was proposed to set up the apparatus below on a laboratory bench, in order to crack paraffin.



State TWO of the **risks** of using the apparatus in this way and suggest how you would amend the set-up to minimise each risk.

(4)

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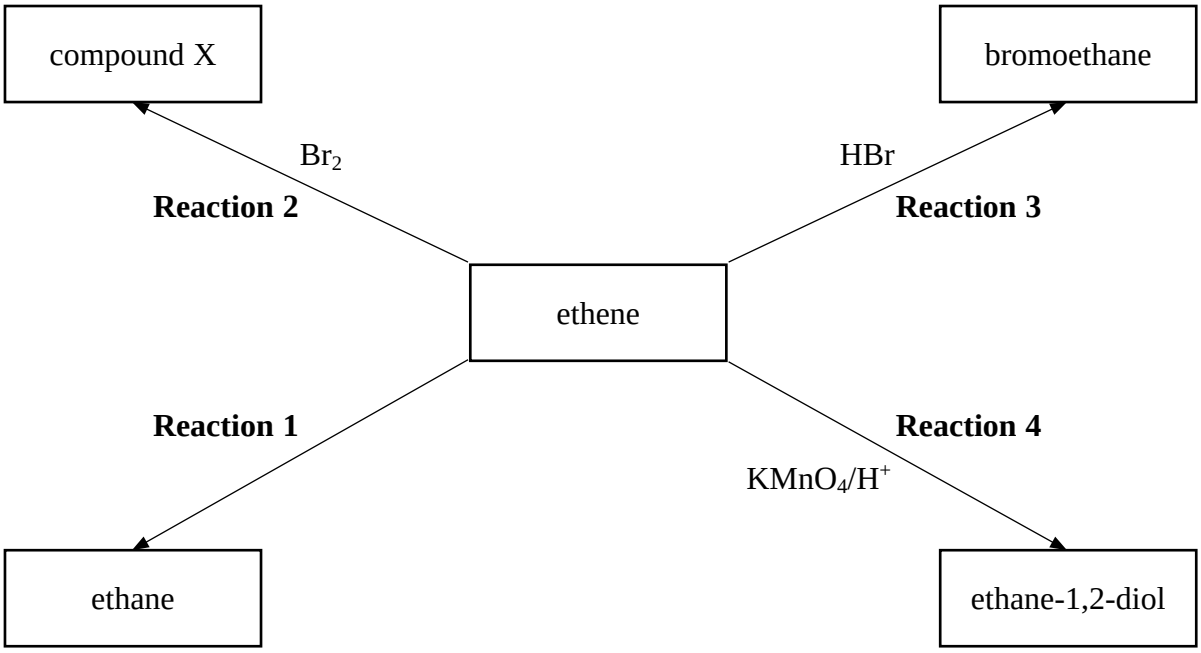
(b) Study the reaction scheme below and then answer the questions that follow.



(i) Name the reagent and catalyst needed for **Reaction 1**.

(2)

Reagent.....

Catalyst.....

(ii) Give the name and displayed formula of **compound X**.

(2)

Name.....

Displayed formula

(iii) Describe what colour change you would see during **Reaction 4** if a small amount of acidified $KMnO_4(aq)$ was shaken with ethene.

(1)

From..... **to**.....

(c) (i) Use displayed formulae to show the mechanism for **Reaction 3**.

(3)

(ii) Explain why the alkene, propene, could form two products when it reacts with hydrogen bromide in a similar way.

(1)

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.....

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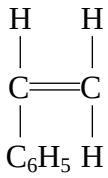
.....

(d) The formula of the alkene phenylethene, often called styrene, is shown below. It can be used to make the polymer poly(styrene).



phenylethene

Draw a section of the poly(styrene) polymer chain formed from **two** monomer units.

(2)

(e) The table below shows some data used in a life cycle analysis of polystyrene and paper drinking cups.

	Paper Cup	Polystyrene Cup
Raw Materials (per cup)		
Wood or bark	26 g	0 g
Petroleum fractions	2.2 g	3.4 g
Energy used (per tonne of material made)	980 kWh	280 kWh
Water released into environment (per tonne of material made)	120 m^3	2.5 m^3
Air emissions (per tonne of material made)		
Chlorine / chlorine dioxide	0.4 kg	0 kg
Sulfides / sulfur dioxide	11 kg	3.5 kg
Hydrocarbons	0 kg	40 kg

(i) Some people argue that using a polystyrene cup has less environmental impact than using a paper cup.

Choose TWO pieces of data to support this argument, explaining your choices.

(2)

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(ii) Suggest TWO further pieces of information, not given in the table, regarding the life cycle of the cups that would make any assessment of the environmental impact more reliable.

(2)

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(Total for Question 18 = 22 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
						1.0 H hydrogen 1											4.0 He helium 2
(1)	(2)		Key: relative atomic mass; atomic symbol; name; atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

N 3 5 6 9 1 A 0 2 8 2 8

PMT

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Mark Scheme (Results)
June 2010

GCE

GCE Chemistry (6CH01/01)

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Summer 2010

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1 (a)	B	**1**

Question Number	Correct Answer	Mark
1 (b)	D	**1**

Question Number	Correct Answer	Mark
2	D	**1**

Question Number	Correct Answer	Mark
3	A	**1**

Question Number	Correct Answer	Mark
4 (a)	B	**1**

Question Number	Correct Answer	Mark
4(b)	D	**1**

Question Number	Correct Answer	Mark
4 (c)	C	**1**

Question Number	Correct Answer	Mark
4 (d)	A	**1**

Question Number	Correct Answer	Mark
5	B	**1**

Question Number	Correct Answer	Mark
6	A	**1**

Question Number	Correct Answer	Mark
7	C	**1**

Question Number	Correct Answer	Mark
8	D	**1**

Question Number	Correct Answer	Mark
9	C	**1**

Question Number	Correct Answer	Mark
10	C	**1**

Question Number	Correct Answer	Mark
11	D	**1**

Question Number	Correct Answer	Mark
12	B	**1**

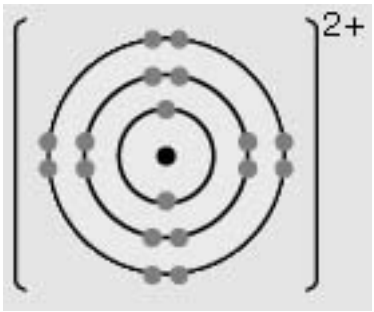
Question Number	Correct Answer	Mark
13	D	**1**

Question Number	Correct Answer	Mark
14 (a)	B	**1**

Question Number	Correct Answer	Mark
14 (b)	A	**1**

Question Number	Correct Answer	Mark
14 (c)	C	**1**

Section B

Question Number	Acceptable Answers	Reject	Mark
15 (a)(i)	 electrons **(1)** charge **(1)** square brackets not essential Mark independently Ignore (labelling of) nucleus unless incorrect		**2**

Question Number	Acceptable Answers	Reject	Mark
15 (a)(ii)	$1s^2 2s^2 2p^6 3s^2 3p^6$ Allow electron number as sub script Allow orbitals as capital letters Allow TE from (a) (i) if Ca atom or Ca^+ ion		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (a)(iii)	Smaller Because it has one less (sub) shell of electrons / orbital / energy level / less shielding **(1)** And the ratio of protons : electrons has increased / more protons than electrons / greater net force on remaining electrons (so remainder of electrons held more closely) / greater effective nuclear charge **(1)**	bigger scores zero greater nuclear charge /positive charge	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (a)(iv)	Any two from: Strong (electrostatic) forces / attractions / bonds (between ions) **(1)** (ions) held in giant lattice / **many** (ionic) attractions / forces / bonds **(1)** So large amount of energy needed (to break apart ions) **(1)**	Any mention of covalent or metallic bonds or atoms or molecules scores zero High temperature	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (b)(i)	Because the **ions** are free to move (when a potential difference is applied)	Electrons / particles are free to move	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b)(ii)	The cations / barium and calcium (ions) are different sizes Ignore any discussion of reasons (could select either the calcium ion because it has more water molecules associated with it OR the barium ion because it has more shells of electrons and so larger)	Atoms are different sizes	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b)(iii)	Mass of calcium ions in 1 kg = 0.100 x 40 (= 4.0) (g) **(1)** If mass quoted must be correct to score first mark Hence 4.0 g per 1000 g of solution So ppm = (4.0/1000) x 1000000 = 4000 (ppm) **(1)** OR Mass of calcium ions in 1 kg = 0.100 x 40.1 (= 4.01) (g) **(1)** Hence 4.01 g per 1000 g of solution So ppm = (4.01/1000) x 1000000 = 4010 (ppm) **(1)** Correct answer alone = 2 marks Allow TE for second mark from incorrect mass		**2**

Question Number	Acceptable Answers	Reject	Mark
15 (c)	(Sulfur / nitrogen oxides) form when (fossil) fuels are burnt / when petrol or diesel burn in vehicle engines / emissions from vehicle (engines) / volcanoes / lightning **(1)** They (react with water to) form sulfuric / sulfurous acid /nitric acid /acid rain / gases are acidic **(1)** Which **reacts** with limestone (to form soluble compounds) / limestone and acid take part in neutralisation / dissolves building / corrodes building **(1)** Allow correct equation for third mark but Ignore equations if mark already awarded. Ignore comments regarding erosion	from factories alone	**3**

Question Number	Acceptable Answers	Reject	Mark
15 (d)	**Either** Yes, as the values match closely (so little deviation from ionic model) **Or** no, as the values are (slightly) different so a degree of covalency / not fully ionic	100% ionic covalent	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (a)	Atoms (of an element) with the same number of protons **(1)** But with different number of neutrons **(1)** Same atomic number but different mass number only = **(1)** Element(s) with same number of protons but different number of neutrons = **(1)** max Ignore comments on electrons unless incorrect in which case award max 1		**2**

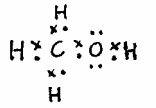
Question Number	Acceptable Answers	Reject	Mark
16 (b)(i)	(Electric field) **accelerates** ions		**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (ii)	(Magnetic field) **deflects** / changes direction of / bends the beam of ions if the term 'ions' is missing or an incorrect term is used e.g. 'atoms', penalise only once in parts b (i) and b (ii)	just bends ions	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (c)	% abundance = (135 x 9.01 + 136 x 10.81 + 137 x 12.32 + 138 x 67.86) /100 **(1)** = 137.4 **(1)** ignore units Allow TE for one slip in transfer of data from question Correct answer scores **(2)**	Just 137 as final answer 137.39 137.3903 137.390	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (d)	three peaks (caused by Br_2^+ ions) **(1)** because ions $(^{79}Br\text{-}^{79}Br)^{(+)}$ and $(^{81}Br\text{-}^{79}Br)^{(+)}$ / $(^{79}Br\text{-}^{81}Br)^{(+)}$ and $(^{81}Br\text{-}^{81}Br)^{(+)}$ **(1)** Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (e)	Any one analysis of material from space / drug testing in sport / identify breakdown products from drugs in body / quality control in pharmaceutical industry / identify molecules from sample with potential biological activity / radioactive dating with context e.g determine age of fossils / human remains The uses above must have a context / determining M_r of a molecule / evidence for structure from fragmentation pattern		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)	 **(1)** for around carbon and its hydrogens **(1)** for around oxygen and its hydrogen Allow all dots or all crosses Ignore circles around atoms		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(i)	$C(s)$ / (graphite) + $2H_2(g)$ + $2O_2(g)$ Correct species **(1)** Allow oxygen above arrows rather than in box Balancing and state symbols **(1)** Second mark dependent on correct species except as below with either hydrogen or oxygen or both as atoms e.g C(s) / (graphite) + 4H(g) + 4O(g) Scores second mark		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	Enthalpy / energy / heat(energy) change when one mole of a substance **(1)** Is formed from its elements (in their most stable / standard states) **(1)** Under standard conditions of 298K/ 25 °C / any **stated** temperature **AND** 1 atm pressure / 101 kPa / 100 kPa **(1)** Definitions based on lattice enthalpies may score third mark only	heat required / heat given out / heat taken in	**3**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iii)	$\Delta H^{\ominus}_c = -\Delta H_1^{\ominus} + \Delta H_2^{\ominus}$ **(1)** = (2 x −285.8 + −393.5) − (−239.1) = −726 **(1)** Ignore units Correct answer alone = 2 marks +726 = 1 -440.2 = 1 if omit multiply by 2		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(i)	20.7 x 200 x 4.18 = 17305(.2) (J) ignore sf except 1 sf i.e. 20000 **OR** 20.7 x 200 x 0.00418 = 17.305(2) kJ ignore sf except 1 sf i.e. 20 ignore signs ignore mol^{-1}		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c) (ii)	0.848/32 = 0.0265 (mol) ignore sf except 1 sf i.e. 0.03		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(iii)	17305.2/0.0265 = −653000 (J mol^{-1}) (3sf) **OR** −653 (kJ mol^{-1}) (3sf) Ignore missing units but penalise incorrect units Allow TE from (c)(i) & (ii)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)(iv)	Any two from As heat/energy absorbed by apparatus / heat/energy 'lost' to surroundings **(1)** methanol not completely burnt / incomplete combustion **(1)** methanol 'lost' by evaporation **(1)** cannot ensure all products are at standard conditions at end of reaction / water is produced as a gas / reaction not carried out in the standard conditions **(1)**	 just heat/energy loss just incomplete reaction	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(i)	**Crude** oil / petroleum / coal	Oil on its own / Natural gas / fossil fuels / any named fraction of crude oil	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	use of high temperatures / heat (in the absence of air) / thermal decomposition / catalysts **(1)** Either to break large molecules / to form smaller molecules / to break bonds in **large** molecules / to break carbon-carbon bonds **(1)** OR producing alkenes / producing carbon-carbon double bonds **(1)**		**2**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>18 (a)(iii)</td><td>Risks (2)
Amendments (2)

<table>
<tr><th>Risk</th><th>Amendment</th></tr>
<tr><td>exposure to harmful / toxic fumes</td><td>Set up in fume cupboard</td></tr>
<tr><td>Escape of flammable / harmful / toxic reactants or products from ill fitting bung</td><td>Correct fitting of bung</td></tr>
<tr><td>Escape of flammable / harmful /toxic reactants or products from poorly positioned delivery tube</td><td>Placement of delivery tube below mouth of test tube / use a longer delivery tube</td></tr>
<tr><td>suck back</td><td>Attach Bunsen valve / remove delivery tube from water before stopping heating etc</td></tr>
</table>

Mark all 4 points independently
If escaping gases linked to 2 amendments but no risk mentioned then allow 1 for risk</td><td>Dangerous

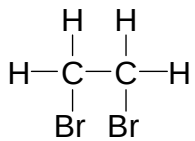
collect in syringe</td><td>4</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>18 (b)(i)</td><td>Reagent – Hydrogen/H_2 (1)
Catalyst –
Nickel/Ni/palladium/Pd/platinum/Pt (1)

Mark independently</td><td></td><td>2</td></tr>
</table>

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>18 (b)(ii)</td><td>1,2 – dibromoethane (1)

ignore punctuation

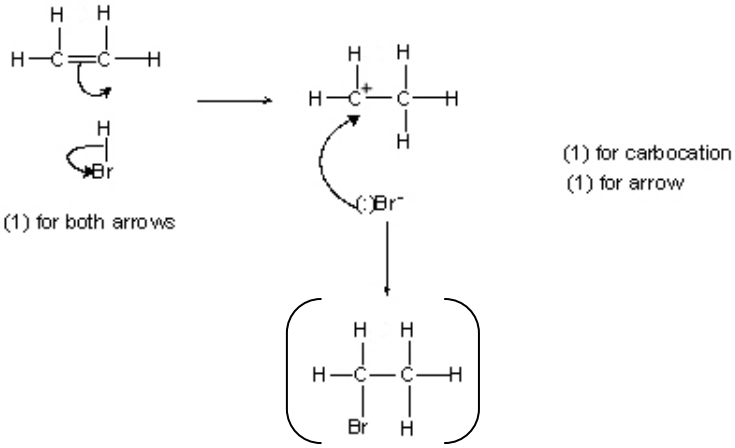
 
(1)

Mark independently
Allow CH_2BrCH_2Br</td><td>1,2 - bromoethane
dibromoethane

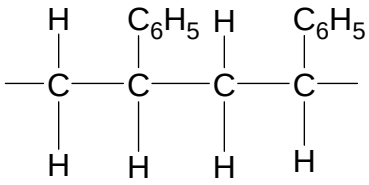
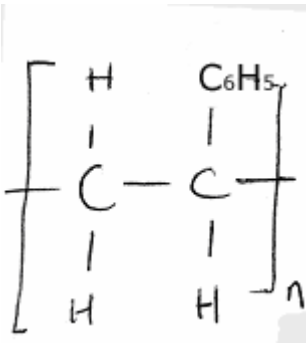
Skeletal formula

$C_2H_4Br_2$</td><td>2</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
18 (b)(iii)	From purple / pink → colourless	clear	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	 arrow from bromide ion can start from any part of the bromide ion and can go towards the C or the + sign on the intermediate bromide ion must show negative charge allow 2 max for addition of Br_2 and any other electrophilic additions half headed arrows used throughout penalise only once	δ- on bromide ion for third mark	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Bromine / bromide / hydrogen could add to either carbon (in the double bond) / bromide / bromine could add to either primary or secondary carbocation / (propene is unsymmetrical) so could form 1-bromopropane and / or 2-bromopropane. Allow correct structural or displayed formulae.	bromine could add to any of the three carbons	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (d)	 position of hydrogen atoms and phenyl groups **(1)** Allow phenyl groups on 2nd and 3rd carbon OR 1st and 4th OR 1st and 3rd carbon carbon single bonds and continuation bonds **(1)** second mark not awarded for incorrect monomer  **(1)** max with or without square brackets and n or numbers Do not penalise H from phenyl groups attaching to carbon chains Ignore extra square brackets, numbers and 'n' provided 2 monomer units shown		**2**

Question Number	Acceptable Answers	Reject	Mark
18 (e)(i)	Any two (raw material for) paper cup requires cutting down trees **(1)** polystyrene cup uses less energy (280 kWh rather than 980 kWh) to produce so less CO_2 released / less fossil fuels **(1)** polystyrene cup releases less sulfur based compounds into air so less chance of forming acid rain / less chance of damaging buildings / acidifying lakes (produces 3.5 kg rather than 11 kg) **(1)** polystyrene cup releases no chlorine compounds which damages ozone layer / poisonous (produce 0 kg rather than 0.4 kg) **(1)** 2 pieces of data chosen with no explanation allow 1 mark Ignore comments regarding water		**2**

Question Number	Acceptable Answers	Reject	Mark
18 (e)(ii)	2 additional factors e.g ease of recyclability whether cup is easy to reuse space taken up in landfill type and amount of gases formed if incinerated useful heat obtained if incinerated biodegradeability / how long they take to decompose management of gases produced during decomposition durability / how long the cup lasts method of disposal Ignore comments regarding atom economy Ignore comments regarding acid rain / ozone layer / greenhouse gases unless linked to gases produced during disposal		**2**

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Surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Thursday 13 January 2011 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

N37962A

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7/7/5/2/

N 3 7 9 6 2 A 0 1 2 4

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The compound butane has

☒ **A** the empirical formula C_4H_{10} and the molecular formula C_2H_5.

☒ **B** the empirical formula C_2H_5 and the molecular formula C_4H_{10}.

☒ **C** the empirical formula C_2H_5 and the molecular formula C_nH_{2n+2}.

☒ **D** the empirical formula C_nH_{2n+2} and the molecular formula C_4H_{10}.

(Total for Question 1 = 1 mark)

---

2 For the oxidation of ammonia

$$a\ NH_3 + b\ O_2 \rightarrow c\ NO + d\ H_2O$$

the values of the coefficients in the balanced equation are

☒ **A** a = 2, b = 3, c = 2 and d = 3

☒ **B** a = 4, b = 7, c = 4 and d = 4

☒ **C** a = 4, b = 5, c = 4 and d = 6

☒ **D** a = 6, b = 7, c = 6 and d = 9

(Total for Question 2 = 1 mark)

---

3 The Avogadro constant is 6.0×10^{23} mol^{-1}. Therefore the number of **atoms** in 1 mol of carbon dioxide is

☒ **A** 2.0×10^{23}

☒ **B** 6.0×10^{23}

☒ **C** 1.2×10^{24}

☒ **D** 1.8×10^{24}

(Total for Question 3 = 1 mark)

---

4 The equation for the complete combustion of octane is

$$2C_8H_{18} + 25O_2 \rightarrow 16CO_2 + 18H_2O$$

(a) The mass of 10 mol of octane is

(1)

☒ **A** 0.66 kg

☒ **B** 1.14 kg

☒ **C** 2.10 kg

☒ **D** 2.28 kg

(b) The volume of 1 mol of any gas (measured at room temperature and pressure) is 24 dm^3. Hence the volume of oxygen (measured at room temperature and pressure) required for the complete combustion of 10 mol of octane is

(1)

☒ **A** 240 dm^3

☒ **B** 300 dm^3

☒ **C** 3000 dm^3

☒ **D** 6000 dm^3

(Total for Question 4 = 2 marks)

5 The enthalpy change for the reaction

$$CH_4(g) \rightarrow C(g) + 4H(g)$$

is +1648 kJ mol^{-1}. Hence the mean bond enthalpy for the C–H bond is

☒ **A** +329.6 kJ mol^{-1}

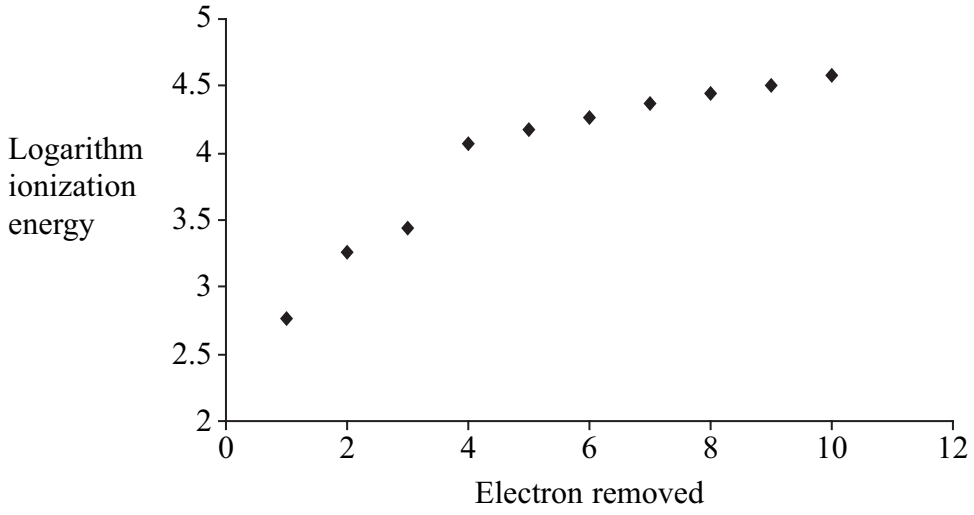
☒ **B** +412.0 kJ mol^{-1}

☒ **C** +1648 kJ mol^{-1}

☒ **D** +6592 kJ mol^{-1}

(Total for Question 5 = 1 mark)

6 The graph below represents the successive ionization energies of an element **X** plotted against the number of the electron removed. **X** is not the symbol for the element.



(a) From this graph it is possible to deduce the group in the Periodic Table to which **X** belongs. **X** is in

(1)

☒ **A** Group 1

☒ **B** Group 3

☒ **C** Group 5

☒ **D** Group 7

(b) From the graph it is possible to deduce that the most stable ion of **X** will be

(1)

☒ **A** X^{3+}

☒ **B** X^{+}

☒ **C** X^{-}

☒ **D** X^{3-}

(Total for Question 6 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 Element **R** is in Group 1 of the Periodic Table and element **T** is in Group 6. **R** and **T** are not the symbols for the elements.

(a) The compound of **R** and **T** will have the formula

(1)

☒ **A** RT

☒ **B** RT_6

☒ **C** RT_2

☒ **D** R_2T

(b) The compound of **R** and **T** will have bonding which is predominantly

(1)

☒ **A** ionic.

☒ **B** covalent.

☒ **C** dative covalent.

☒ **D** metallic.

(c) In terms of its electrical conductivity, the compound of **R** and **T** will

(1)

☒ **A** conduct when solid and liquid.

☒ **B** conduct when solid but not when liquid.

☒ **C** conduct when liquid but not when solid.

☒ **D** not conduct when solid or liquid.

(Total for Question 7 = 3 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

8 Ethane reacts with chlorine when the substances are exposed to UV radiation.

(a) The equation for this reaction is

(1)

☒ **A** $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

☒ **B** $C_2H_6 + Cl_2 \rightarrow C_2H_4Cl_2 + H_2$

☒ **C** $C_2H_6 + Cl_2 \rightarrow 2CH_3Cl$

☒ **D** $C_2H_4 + Cl_2 \rightarrow C_2H_4Cl_2$

(b) The role of the UV radiation in the reaction is to

(1)

☒ **A** break the Cl—Cl bond forming Cl• free radicals.

☒ **B** break the Cl—Cl bond forming Cl^+ and Cl^- ions.

☒ **C** break the C—C bond in ethane forming CH_3• free radicals.

☒ **D** break a C—H bond in ethane forming C_2H_5• free radicals.

(c) The overall reaction between ethane and chlorine is best described as

(1)

☒ **A** addition.

☒ **B** homolytic fission.

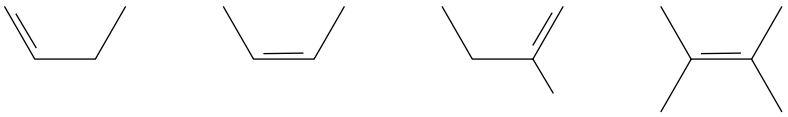
☒ **C** heterolytic fission.

☒ **D** substitution.

(Total for Question 8 = 3 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

9 This question concerns the following compounds



A **B** **C** **D**

Which of these compounds will show geometric (*E–Z* or *cis/trans*) isomerism?

☒ **A**

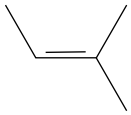
☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 1 mark)

10 The correct name for the compound shown below is



☒ **A** 2-methylbut-3-ene

☒ **B** 3-methylbut-2-ene

☒ **C** 3-methylbut-3-ene

☒ **D** 2-methylbut-2-ene

(Total for Question 10 = 1 mark)

11 Most compounds of lead are insoluble, an exception being lead(II) nitrate. Therefore a good method of preparing lead(II) sulfate is

☒ **A** adding dilute sulfuric acid to lead metal.

☒ **B** adding concentrated sulfuric acid to lead metal.

☒ **C** adding dilute sulfuric acid to lead(II) nitrate solution.

☒ **D** adding dilute sulfuric acid to solid lead(II) oxide.

(Total for Question 11 = 1 mark)

12 Metals usually have high melting temperatures and boiling temperatures because there are

- ☒ **A** strong attractions between the ions.
- ☒ **B** strong attractions between the delocalised electrons.
- ☒ **C** strong attractions between the ions and the delocalised electrons.
- ☒ **D** strong intermolecular forces.

(Total for Question 12 = 1 mark)

13 In 2006, the concentration of carbon dioxide in the atmosphere was 382 ppm. This is equivalent to

- ☒ **A** 0.00382%
- ☒ **B** 0.0382%
- ☒ **C** 0.382%
- ☒ **D** 3.82%

(Total for Question 13 = 1 mark)

14 A hazard that is particularly associated with alkanes is that they are

- ☒ **A** corrosive.
- ☒ **B** flammable.
- ☒ **C** toxic by inhalation.
- ☒ **D** toxic by skin absorption.

(Total for Question 14 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

BLANK PAGE

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

15 The relative atomic mass of an element is determined using a mass spectrometer.

(a) Define the term **relative atomic mass**.

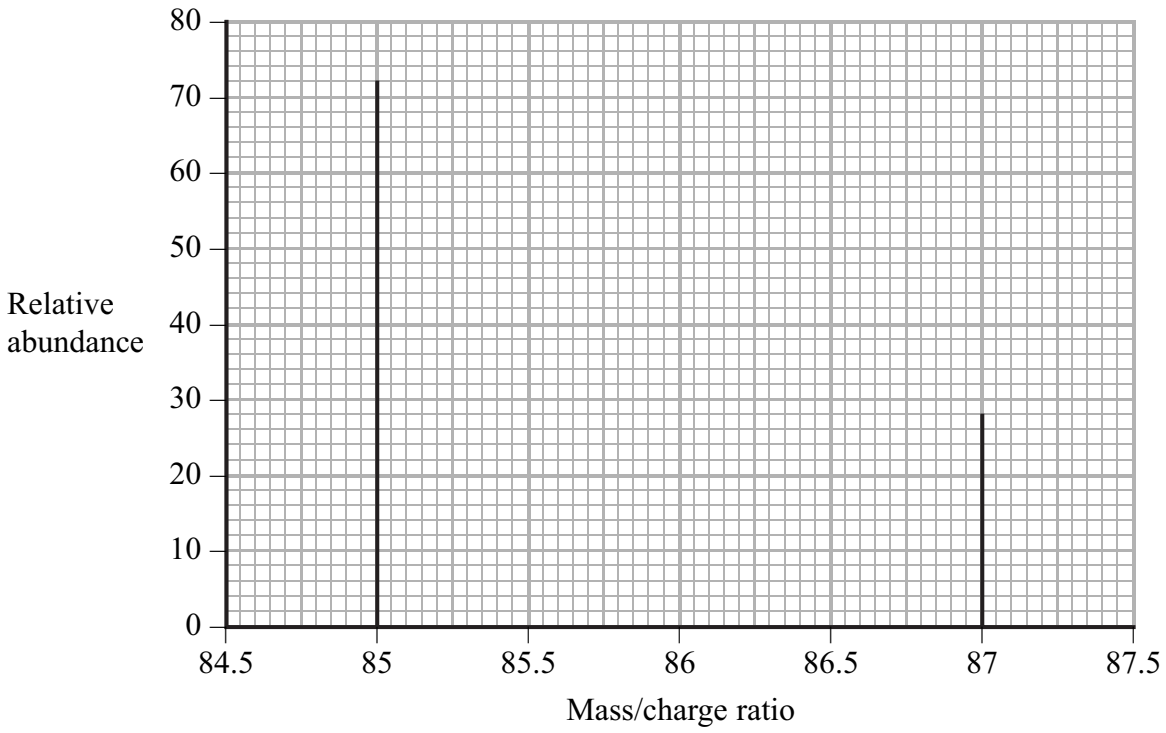
(2)

.....

.....

.....

(b) The mass spectrum of rubidium is shown below.



(i) Explain why there are two peaks in the spectrum.

(1)

.....

.....

(ii) Use the spectrum to calculate the relative atomic mass of rubidium.

(2)

(Total for Question 15 = 5 marks)

16 (a) Coral reefs are produced by living organisms and predominantly made up of calcium carbonate. It has been suggested that coral reefs will be damaged by global warming because of the increased acidity of the oceans due to higher concentrations of carbon dioxide.

(i) Write a chemical equation to show how the presence of carbon dioxide in water results in the formation of carbonic acid. State symbols are **not** required.

(1)

(ii) Write the **ionic** equation to show how acids react with carbonates. State symbols are **not** required.

(2)

(b) One method of determining the proportion of calcium carbonate in a coral is to dissolve a known mass of the coral in excess acid and measure the volume of carbon dioxide formed.

In such an experiment, 1.13 g of coral was dissolved in 25 cm^3 of hydrochloric acid (an excess) in a conical flask. When the reaction was complete, 224 cm^3 of carbon dioxide had been collected over water using a 250 cm^3 measuring cylinder.

(i) Draw a labelled diagram of the apparatus that could be used to carry out this experiment.

(2)

(ii) Suggest how you would mix the acid and the coral to ensure that no carbon dioxide escaped from the apparatus.

(1)

.....

.....

.....

(iii) Calculate the number of moles of carbon dioxide collected in the experiment.

[The molar volume of any gas is 24 000 $cm^3\ mol^{-1}$ at room temperature and pressure.]

(1)

(iv) Complete the equation below for the reaction between calcium carbonate and hydrochloric acid by inserting the missing state symbols.

(1)

$CaCO_3$(.....) + 2HCl(.....) → $CaCl_2$(.....) + H_2O(l) + CO_2(.....)

(v) Calculate the mass of 1 mol of calcium carbonate.

[Assume relative atomic masses: Ca = 40, C = 12, O = 16.]

(1)

(vi) Use your data and the equation in (iv) to calculate the mass of calcium carbonate in the sample and the percentage by mass of calcium carbonate in the coral. Give your final answer to **three** significant figures.

(2)

(vii) When this experiment is repeated, the results are inconsistent. Suggest a reason for this other than errors in the procedure, measurements or calculations.

(1)

.....

.....

(Total for Question 16 = 12 marks)

17 This question is about the element chlorine (atomic number = 17).

(a) Complete the electronic structure of chlorine.

(1)

$1s^2\ 2s^2$ .....

(b) Chlorine forms compounds with magnesium and with carbon.

(i) Draw a dot and cross diagram to show the electronic structure of the compound magnesium chloride (only the outer electrons need be shown).
Include the charges present.

(2)

(ii) Draw a dot and cross diagram to show the electronic structure of the compound tetrachloromethane (only the outer electrons need be shown).

(2)

*(iii) Suggest why the melting temperature of magnesium oxide is higher than that of magnesium chloride, even though both are almost 100% ionic.

(3)

(c) Magnesium chloride may be prepared from magnesium by reaction with chlorine or with hydrochloric acid. Compare these two preparations in terms of the atom economies of the reactions. No calculation is required.

(2)

(Total for Question 17 = 10 marks)

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18 Alkenes are unsaturated hydrocarbons which, because of their reactivity, are important industrial starting materials. Alkenes for industrial use are obtained by cracking alkanes.

(a) Write the equation for the cracking of decane ($C_{10}H_{22}$) to form 1 molecule of propene as the only alkene.

(1)

(b) The carbon–carbon double bond in alkenes consists of a σ and a π bond.

(i) Explain, using diagrams, the difference between the σ and the π bond in the carbon–carbon double bond of an alkene.

(4)

Diagrams

Explanation

.....

.....

.....

.....

(ii) State the type and mechanism involved in the typical reaction of alkenes.

(1)

.....

*(iii) By considering the strength and structure of the π bond, explain why alkenes are more reactive than alkanes.

(2)

.....

.....

.....

.....

.....

(c) When propene reacts with hydrogen bromide, there are two possible products.

(i) Draw a displayed formula of each of these products and label the major product.

(2)

(ii) Give the mechanism for the reaction of propene with hydrogen bromide which forms the major product.

(3)

(iii) Explain, by referring to the mechanism, why the major product is formed.

(2)

.....

.....

.....

.....

(d) The polymer poly(propene) is manufactured from propene.

(i) Write an equation for the polymerization, drawing the displayed formula of the repeat unit of poly(propene).

(3)

(ii) UV radiation causes poly(propene) to degrade. Suggest one advantage and one disadvantage of this.

(2)

Advantage .....

.....

Disadvantage .....

.....

(Total for Question 18 = 20 marks)

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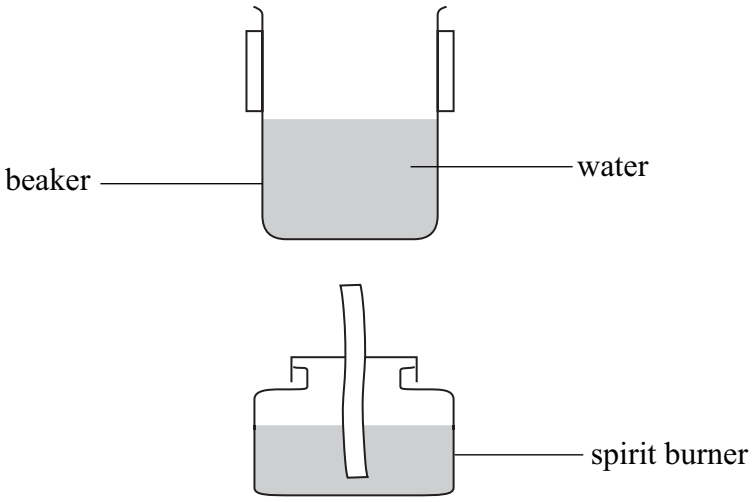
19 The enthalpy change of combustion of ethanol was determined using the apparatus shown in the diagram below. In the experiment, the temperature increase of the water in the beaker is measured when a known mass of the ethanol is burned.



(a) The results of the experiment are summarised in the table below.

Mass of water in the beaker	250.00 g
Mass of spirit burner + contents (initial)	63.21 g
Mass of spirit burner + contents (final)	62.47 g
Temperature of water (initial)	21.0 °C
Temperature of water (final)	31.5 °C

(i) Calculate the heat energy produced by the combustion of the alcohol using the equation

heat energy produced (J) = mass of water × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of ethanol burned in this experiment (the formula of ethanol is C_2H_5OH).

(3)

(iii) Use the equation below to calculate the enthalpy change of combustion of ethanol in kJ mol^{-1}. Give the value an appropriate sign.

$$\Delta H = \text{heat energy produced} \div \text{number of moles}$$

(2)

(b) The data book value for the enthalpy change of combustion of ethanol is –1370 kJ mol^{-1}.

(i) Calculate the percentage error in the value calculated in (a)(iii) in comparison with the data book value.

(1)

(ii) List **three** ways in which the design of the experiment causes the results to be so different from the data book value. (You should be specific but detailed explanations are not required.)

(3)

1 .....

.....

2 .....

.....

3 .....

.....

(iii) Use the data book values for enthalpy changes of combustion given in the table below to calculate the enthalpy change of formation of ethanol.

(3)

Substance	Enthalpy change of combustion / kJ mol^{-1}
C(s, graphite)	–394
$H_2(g)$	–286
$C_2H_5OH(l)$	–1370

(Total for Question 19 = 13 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

N 3 7 9 6 2 A 0 2 4 2 4

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Mark Scheme (Results)
January 2011

GCE

GCE Chemistry (6CH01/01)

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January 2011

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1	B	**1**

Question Number	Correct Answer	Mark
2	C	**1**

Question Number	Correct Answer	Mark
3	D	**1**

Question Number	Correct Answer	Mark
4 (a)	B	**1**

Question Number	Correct Answer	Mark
4 (b)	C	**1**

Question Number	Correct Answer	Mark
5	B	**1**

Question Number	Correct Answer	Mark
6 (a)	B	**1**

Question Number	Correct Answer	Mark
6 (b)	A	**1**

Question Number	Correct Answer	Mark
7 (a)	D	**1**

Question Number	Correct Answer	Mark
7 (b)	A	**1**

Question Number	Correct Answer	Mark
7 (c)	C	**1**

Question Number	Correct Answer	Mark
8 (a)	A	**1**

Question Number	Correct Answer	Mark
8 (b)	A	**1**

Question Number	Correct Answer	Mark
8 (c)	D	**1**

Question Number	Correct Answer	Mark
9	B	**1**

Question Number	Correct Answer	Mark
10	D	**1**

Question Number	Correct Answer	Mark
11	C	**1**

Question Number	Correct Answer	Mark
12	C	**1**

Question Number	Correct Answer	Mark
13	B	**1**

Question Number	Correct Answer	Mark
14	B	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

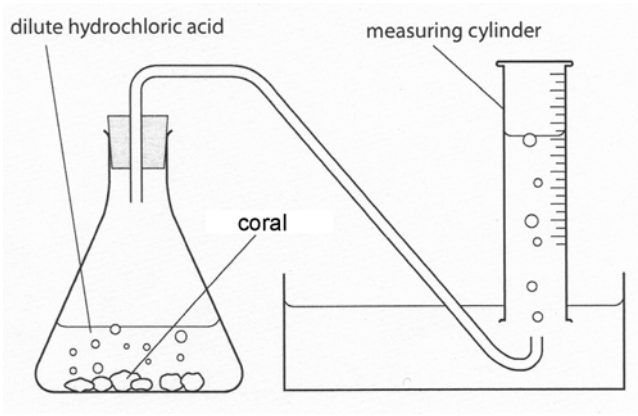
Question Number	Acceptable Answers	Reject	Mark
15 (a)	**Average/mean mass** of an atom/isotopes **(1)** (1/12 mass of an atom of) carbon–12 **(1)** **First mark:** mention of mean or average mass of either an atom/isotope**s** *IGNORE* "weighted" before average or mean *IGNORE* any mention of "moles" in definition **Second mark: any mention** of carbon-12 *IGNORE* any reference to "moles" or "1 mole" at any stage *IGNORE* 12 g with reference to carbon-12 **Mark the two points independently**	"weight" instead of mass mean or average mass **of an element**… without prior mention of either an atom or isotopes	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (i)	(Rubidium/it has) two **isotopes** *ALLOW* (Rubidium/it has) "different **isotopes**" *ALLOW* abbreviations such as formulae of rubidium atoms or cations with isotopic masses		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (ii)	$\frac{85 \times 72 + 87 \times 28}{100}$ **(1)** = 85.56 or 85.6 **(1)** Correct answer with no working **(2)** **NOTE**: Rounding error giving answer 85.5 scores **(1)** *IGNORE* **any** units (for example, g/g mol^{-1}/%) **NOTE:** If 71% abundance used for ^{85}Rb and 29% for ^{87}Rb, answer = 85.58 or 85.6 scores **(1)** Second mark awarded if answer CQ correct on wrong abundances and /or wrong isotopic masses.	Calculation of simple arithmetic mean of 85 + 87 = 86 scores zero	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (i)	$H_2O + CO_2 \rightarrow H_2CO_3$ (Allow atoms in H_2CO_3 in any order) Or $H_2O + CO_2 \rightarrow H^+ + HCO_3^-$ Or $H_2O + CO_2 \rightarrow 2H^+ + CO_3^{2-}$ Or H_3O^+ in place of H^+ *IGNORE STATE SYMBOLS EVEN IF INCORRECT*		**1**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (ii)	$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$ LHS **(1)** RHS **(1)** **OR** $2H_3O^+ + CO_3^{2-} \rightarrow 3H_2O + CO_2$ LHS **(1)** RHS **(1)** *IGNORE STATE SYMBOLS, EVEN IF INCORRECT* *IGNORE* ⇌ arrows	H_2CO_3 as a product $H^+ + CO_3^{2-} \rightarrow HCO_3^-$ Any other ions including spectator ions (e.g. Ca^{2+}, Cl^-) in the equation scores zero	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (i)	 Conical flask **and** a delivery tube leaving the conical flask **(1)** *IGNORE* "heat" beneath conical flask Inverted measuring cylinder with collection over water shown and cylinder above mouth of delivery tube **(1)** *ALLOW* collection over water to be shown/implied in the diagram without labels or other annotation	If collection **over water** is not somehow evident	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (ii)	Any method which is likely to bring the reactants into contact **after the apparatus is sealed**	Method suggesting mixing the reactants and then putting bung in flask very quickly	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (iii)	(224 ÷ 24000 =) 0.009333/9.333 x 10^{-3} (mol) **Ignore SF except 1 SF** **Ignore any incorrect units**	"0.009" as answer	**1**

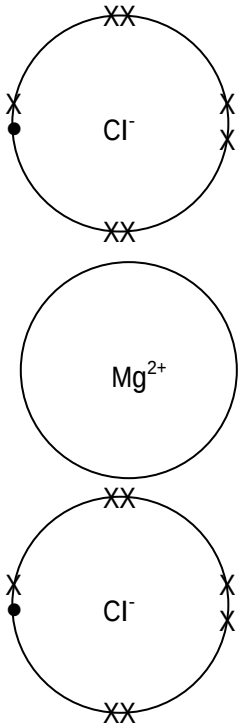
Question Number	Acceptable Answers	Reject	Mark
16 (b) (iv)	$CaCO_3$(**s**) + 2HCl(**aq**) → $CaCl_2$(**aq**) + H_2O(**l**) + CO_2 (**g/aq**) **ALL FOUR** state symbols must be correct for this mark		**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (v)	(Mass of 1 mol $CaCO_3$ = 40 + 12 + 3 x 16) = **100** g *ALLOW* just "100" *ALLOW* any incorrect units *ALLOW* "100.1 g " *OR* just "100.1" (Reason: this uses the Periodic Table value of A_r = 40.1 for Ca)		**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (vi)	(Mass of $CaCO_3$ = 100 x 0.009333) = 0.9333 (g) **(1)** *IGNORE* sig figs including 1 sf here **NOTE:** Moles of $CaCO_3$ consequential on answers to (b)(iii) and (b)(v) [**NOTE**: if A_r = 40.1 used for Ca, then the answer = 0.9339 (g)] Percentage of $CaCO_3$ in the coral = 100 x 0.9333 /1.13 = 82.6% **(1)** **NOTE:** If mass $CaCO_3$ used is 0.93, final answer is 82.3% [**NOTE***:* if A_r = 40.1 used for Ca, then the answers = 0.9339 (g) and **82.7**%]	Final **%** answer is **not given to 3 sf**	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (vii)	(Different samples of) coral have different amounts of **$CaCO_3$** /different proportions of **$CaCO_3$** / different "levels" of **$CaCO_3$** *ALLOW* "calcium carbonate" for **$CaCO_3$** OR Only one sample of coral (was) used	Answers that do not include any mention of $CaCO_3$ References to solubility of CO_2 in water References to repeating the experiment at a different temperature	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)	$(1s^2\ 2s^2)\ 2p^6\ 3s^2\ 3p^5$ (ignore repetition of $1s^2\ 2s^2$) *ALLOW* subscripts, correct use of p_x, p_y and p_z orbitals or normal font for electrons	2 8 7	**1**

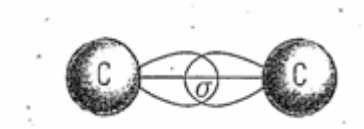
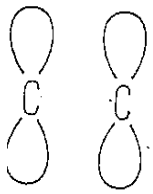
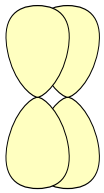
Question Number	Acceptable Answers	Reject	Mark
17 (b) (i)	 Correct number of outer electrons (ignore whether dots and / or crosses) drawn **and also** ratio of magnesium : chloride ions is 1:2 **(1)** Correct formulae and charges of the ions shown somewhere **(1)** **NOTE***:* Diagram for Mg^{2+} showing the outermost shell with $8e^-$ (dots and/or crosses) and/or Cl^- shown with a 2 in front or 2 as a subscript would also score both marks **Mark the two points independently**	Covalent bonding (0) Incorrect numbers of electrons in inner shells if drawn for first mark "MG^{2+}" and/or "CL^-" for second mark	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (ii)	4 shared pairs of electrons around the carbon labelled C **(1)** ALL outer electrons, including lone pairs, are correctly shown on each of the four chlorine atoms labelled Cl **(1)** *ALLOW* versions without circles *IGNORE* lines between the shared electrons **Mark two points independently**	Ionic bonding (0)	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (iii)	(Comparison of) charges: O^{2-} ions whereas Cl^- ions OR Statement to the effect that oxide ion has a greater (negative) charge / greater charge density than the chloride ion **(1)** (so the force of) attraction between **ions** is stronger in MgO (than $MgCl_2$) / stronger **ionic** bonding in MgO (than $MgCl_2$) **(1)** More **energy** is required to separate the ions in MgO (than $MgCl_2$) / more **energy** is required to break (ionic) bonds in MgO (than $MgCl_2$) / **(1)** **Mark the above three points independently** *NOTE ALTERNATIVE ANSWER WITH A MAXIMUM OF TWO MARKS:-* **O^{2-}** (ions) **smaller** (than Cl^- ions) **(1)** so (force of) attraction between **ions** is stronger in MgO (than $MgCl_2$) /stronger **ionic** bonding in MgO (than $MgCl_2$) **(1)** Ignore *ANY* references to polarization of ions / covalent character / degree of covalency. **Mark the above two points independently**	Use of term chlorine and/or oxygen "atoms" or "molecules" **(0) for answer overall** "More bonds need to be broken" **(0) for answer overall** if mentions "intermolecular forces"	**3**

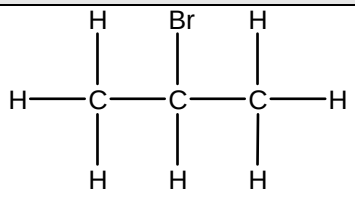
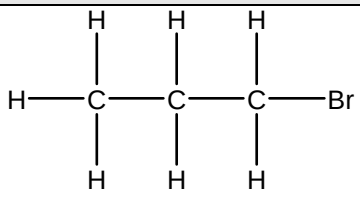
Question Number	Acceptable Answers	Reject	Mark
17 (c)	**First Mark:** *EITHER* Magnesium reacts with chlorine to form only magnesium chloride/ magnesium reacts with chlorine to form only one product / magnesium reacts with hydrochloric acid to form hydrogen (as well as magnesium chloride) / magnesium reacts with hydrochloric acid to form more than one product / magnesium reacts with hydrochloric acid to form a waste product *OR* **Both** equations $Mg + Cl_2 \rightarrow MgCl_2$ **and** $Mg + 2HCl \rightarrow MgCl_2 + H_2$ *IGNORE* state symbols, even if incorrect **(1)** **Second Mark:** *EITHER* The reaction with chlorine has an atom economy which is higher /100% ALLOW "high" *OR* Any mention of numbers comparing 100 % v. 97.9% **(1)** *IGNORE* any comments about **yield** **Mark the two points independently**		**2**

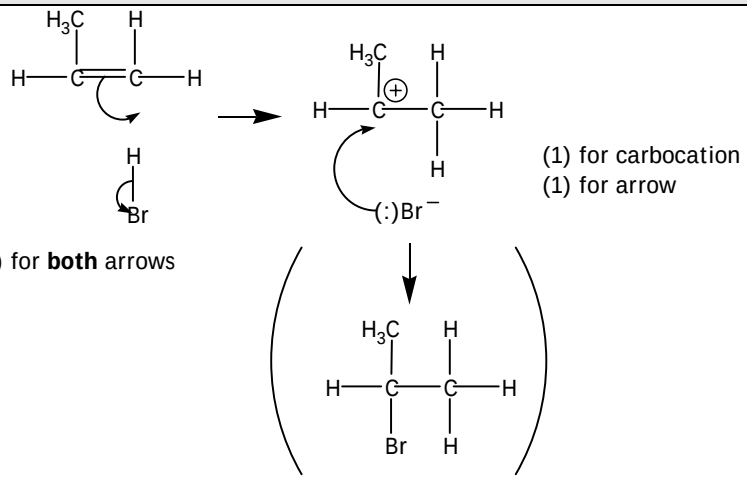
Question Number	Acceptable Answers	Reject	Mark
18 (a)	$C_{10}H_{22} \rightarrow C_7H_{16} + C_3H_6$ *ALLOW* structural or displayed formulae instead of molecular formulae *IGNORE* any state symbols, even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (i)	**diagram for the σ-bond** e.g.  **First Mark:** *EITHER* Diagram shows **overlap** of **any-shaped orbitals** along the line between the two nuclei *OR* Mentions/implies rotation around a sigma/single bond **(1)** **Second Mark:** Any written mention, or clear evidence from the diagram (e.g. shading), of the resultant (high) electron density (along the line) **between** the two nuclei **(1)** **diagram for the π-bond** e.g. *EITHER*  *OR*  **Third Mark:** *EITHER* Diagram shows two dumb-bell shaped (p-) orbitals(these can be separate dumb-bells or the diagram can show the p-orbitals overlapping sideways) *OR* Restricted /lack of /no rotation about a pi/double bond **(1)** **Fourth Mark:** Any written mention, or clear evidence from the diagram (e.g. shading), of the resultant (high) electron density **above and below (**the line between) the two nuclei **(1)**	Just a line between the two nuclei Just curved lines above and below the two nuclei	**4**

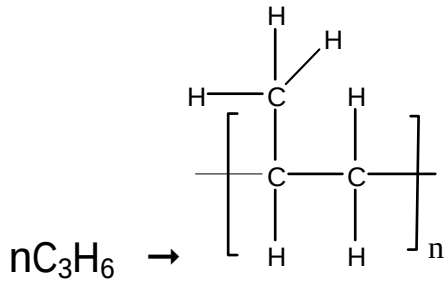
Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	Electrophilic addition *BOTH words needed* *ALLOW* "heterolytic" before electrophilic addition		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (iii)	π bond weaker than σ (bond) / less energy needed to break π bond *ALLOW* π bond weak(er) / π bond easy to break **(1)** π – electrons / π bonds (more) accessible (to electrophilic attack) *ALLOW* high/higher/more electron density in π bond (so alkenes more susceptible to electrophilic attack) **(1)** **Mark the two points independently**		**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (i)	 **and**  (main product) both DISPLAYED structures, with ALL bonds and atoms shown **(1)** major product identified or shown as product in (c)(ii) if NOT identified in (c)(i) **(1)** **NOTE**: if only one isomer of C_3H_7Br is named, assume this is the required "labelling" of the major product **Mark the two points independently**	CH_3 not fully displayed Incorrect name of isomer for 2nd mark	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (ii)	 **1st mark:** Curly arrows must start from the bonds NOT the atoms **3rd mark**: Bromide ion must clearly have a 1^- charge to get this mark **NOTE***:* The arrow from the bromide ion can start from anywhere on the Br^- ion (including the minus sign) or from a lone pair on Br^- if shown Curly arrow can go to the C or the + sign on the intermediate TE for mechanism on the isomer identified in (c)(i) or either mechanism if no major product has been identified in (c)(i) **Mark the three points independently**	**half** arrow-heads $Br^{\delta-}$	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (iii)	Secondary carbocation (named or described or drawn) **(1)** more stable (than primary) **(1)** **Mark the two points independently** **NOTE:** Zero awarded if primary carbocation thought to be more stable	Answers just in terms of Markownikoff's rule	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (d) (i)	 $nC_3H_6 \rightarrow$ **Two** "*n*'s" in the equation **and** a correct formula (molecular or structural) for propene on left hand side of the equation **(1)** Correct repeating unit, with a methyl branch shown **(1)** A*LLOW* CH_3 fully displayed or just as CH_3 Continuation bond at each end (with or without bracket shown in equation) **(1)** Unsaturated polymer scores max **(1)** **Mark the three points independently**	"x" instead of "n"	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	**(Advantage)**: polypropene will decompose (naturally) *ALLOW* "rot" or "break down" *OR* polypropene will not require landfill (as it can decompose in sunlight) *OR* no need to incinerate /burn *IGNORE* "good for environment" / "no pollution" **(1)** **(Disadvantage)**: poly(propene) cannot be used when exposed to (bright) sunlight / UV / outdoors *OR* cannot be recycled / cannot be reused **(1)** **Mark the two points independently**	"Can be recycled" (0) for first scoring point Biodegradable for 1st mark Answers which do not imply exposure to UV/sunlight Biodegradable for 2nd mark	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (a) (i)	(q = 250 x (31.5 – 21.0) x 4.18 =) **10972.5** (J) *IGNORE* sf except 1 sf *IGNORE* units even if incorrect *IGNORE* any sign at this stage *ALLOW* 10.97 (kJ)	10000 (J)	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a) (ii)	(M_r ethanol) = 46 **(1)** (Mass ethanol burned = 63.21 – 62.47 =) 0.74 (g) *ALLOW* 63.21 – 62.47 as alternative to 0.74 **(1)** (Amount of ethanol = 0.74 ÷ 46 =) 0.0161 (mol) **(1)** **NOTE***:* Moles of ethanol are CQ on molar mass and /or mass of ethanol burned *IGNORE* sf except 1 sf **NOTE***:* Correct answer with no working /limited working scores **(3)** **Mark the three points independently**	0.02 (mol) ethanol	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (a) (iii)	Answer (i) ÷ (1000 x answer (ii)) **(1)** **NOTE***:* Be aware of numbers held in calculator not corresponding to what is written in answer Value and negative sign **(1)** *IGNORE* sf except 1 sf **NOTE***:* Answer consistent with (a)(i) and (a)(ii) with no working scores **(2)** **E.g.** 10.9725 ÷ (0.74 ÷ 46) = – 682 (kJ mol^{-1}) *ALLOW* Just kJ as the units **NOTE***:* If correct answer is given in J mol^{-1}, the units of J mol^{-1} must be clearly given for the second mark to be awarded.	Correct answer in J instead of J mol^{-1}	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b) (i)	100 x (1370 – Answer to (iii)) ÷ 1370 = value e.g. 100 x (1370 – 682) ÷ 1370 = 50.2 %	Incorrect rounding of final answer **(0)**	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b) (ii)	Any **three** from: Heat loss (from the beaker)/beaker not insulated/heat loss as no lid on beaker (containing the water) /no stirring **(1)** Incomplete combustion (of the alcohol)/formation of soot (on beaker) **(1)** Not all of the energy from the flame is used to heat the beaker and/or the water OR Too large a distance between flame and beaker / no draught excluder **(1)** Heat capacity of the beaker is neglected/beaker absorbs heat/glass absorbs heat **(1)** Evaporation of the (hot) alcohol **(1)** Evaporation of the (hot) water **(1)**	More accurate thermometer **Just** "experimental /human error" Experiment carried out at a different (laboratory) temperature	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (b) (iii)	$2\ C(s) + 3H_2(g) + ½\ O_2(g) \rightarrow C_2H_5OH(l)$ $\downarrow \qquad\qquad \downarrow$ $2CO_2 + 3H_2O$ $\triangle H_f = 2 \times (-394) + 3 \times (-286) - (-1370)$ $= -276\ (kJ\ mol^{-1})$ Correct expression or cycle **(1)** Evidence for **both** doubling ΔH^{θ}_c [C] **and** trebling ΔH^{θ}_c [H_2] **(1)** Correct sign and answer **(1)** Correct answer with no working scores **(3)** Correct answer with an incorrect cycle **(3)** *IGNORE* units even if incorrect **Alternatively the following answers score as shown even with incorrect cycle or incorrect units** **NOTE***:* (+)276 with or without working scores **(2)** (+)690 with or without working scores **(2)** −690 with or without working scores **(1)** −552 with or without working scores **(2)** −1134 with or without working scores **(2)** (+)1134 with or without working scores **(1)** (+)10 with or without working scores **(2)** **REMINDER IF ANY OTHER ANSWER IS GIVEN: ALL WORKING MUST BE CHECKED TO SEE IF ANY MARKS CAN BE AWARDED**		**3**

TOTAL FOR SECTION B = 60 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Monday 23 May 2011 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P38433A

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7/7/5/2/

P 3 8 4 3 3 A 0 1 2 4

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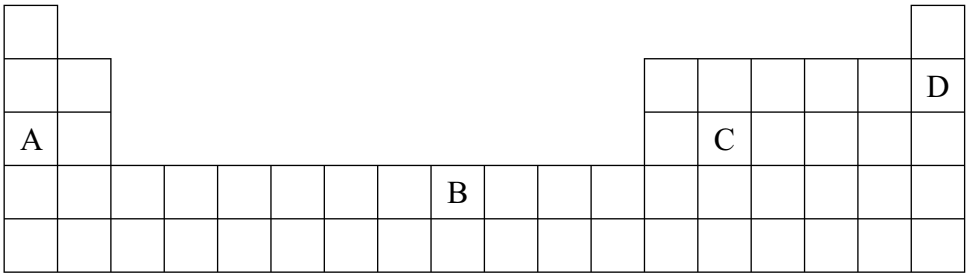
SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 In the following outline of the Periodic Table, the letters A to D are **not** the symbols of the elements.



Select from **A to D** the element which

(a) is a non-metal with a high melting temperature and boiling temperature.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) is in the d block of the Periodic Table.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) has a very stable electronic structure.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) is a metal with a high melting temperature and boiling temperature.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 4 marks)

2 The elements in Group 1 of the Periodic Table have very similar chemical properties. This is because

☒ **A** they have the same number of outer electrons.

☒ **B** they have the same number of filled shells of electrons.

☒ **C** their outer electrons are in the s sub-shell.

☒ **D** their outer electrons have very similar shielding.

(Total for Question 2 = 1 mark)

3 The European Union has set a limit (with effect from January 2010) of 3.13 ppm for the proportion of the toxic gas carbon monoxide in the air that we breathe. This is equivalent to

☒ **A** 3.13%

☒ **B** 0.0313%

☒ **C** 0.000313%

☒ **D** 0.00000313%

(Total for Question 3 = 1 mark)

4 For drivers in the UK, the legal limit of the concentration of ethanol (molar mass 46 g mol^{-1}) in the blood is 80 mg per 100 cm^3. This is equivalent to a concentration of

☒ **A** 17.4 mol dm^{-3}

☒ **B** 1.74 mol dm^{-3}

☒ **C** 0.0174 mol dm^{-3}

☒ **D** 0.00174 mol dm^{-3}

(Total for Question 4 = 1 mark)

5 An important reaction which occurs in the catalytic converter of a car is

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

In this reaction, when 500 cm^3 of CO reacts with 500 cm^3 of NO at 650 °C (the operating temperature of the catalyst) and at 1 atm, the **total** volume of gases produced at the same temperature and pressure is

☒ **A** 500 cm^3

☒ **B** 750 cm^3

☒ **C** 1000 cm^3

☒ **D** impossible to calculate without knowing the molar volume of gases under these conditions.

(Total for Question 5 = 1 mark)

---

6 When a solution of barium chloride is added to sulfuric acid, a white precipitate is formed. The ionic equation (including state symbols) for this reaction is

☒ **A** $H^+(aq) + Cl^-(aq) \rightarrow HCl(s)$

☒ **B** $Ba^+(aq) + SO_4^-(aq) \rightarrow BaSO_4(s)$

☒ **C** $Ba^{2+}(aq) + 2SO_4^-(aq) \rightarrow Ba(SO_4)_2(s)$

☒ **D** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

(Total for Question 6 = 1 mark)

---

7 The enthalpy change for the reaction between hydrochloric acid and sodium hydroxide is –56 kJ mol^{-1}. Therefore

☒ **A** the reaction is exothermic and the temperature rises.

☒ **B** the reaction is exothermic and the temperature falls.

☒ **C** the reaction is endothermic and the temperature rises.

☒ **D** the reaction is endothermic and the temperature falls.

(Total for Question 7 = 1 mark)

---

8 The standard enthalpy changes of formation of some sulfur species are:

Species	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$S_8(s)$	0
$S_8(g)$	+103
S(g)	+279

The enthalpy of atomization of sulfur is (in kJ mol^{-1})

☒ **A** 103 ÷ 8

☒ **B** 279 ÷ 8

☒ **C** 279

☒ **D** (103 ÷ 8) + 279

(Total for Question 8 = 1 mark)

9 For which of the following reactions is the enthalpy change equal to the bond enthalpy of H–I?

☒ **A** $HI(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}I_2(s)$

☒ **B** $HI(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g)$

☒ **C** $HI(g) \rightarrow H(g) + I(g)$

☒ **D** $HI(g) \rightarrow H^+(g) + I^-(g)$

(Total for Question 9 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

10 The equation for the complete combustion of pentane is

$$C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l) \qquad \Delta H_c^{\ominus} = -3509 \text{ kJ mol}^{-1}$$

The standard enthalpy change of formation of $CO_2(g)$ is –394 kJ mol^{-1} and that of $H_2O(l)$ is –286 kJ mol^{-1}.

The standard enthalpy change of formation of pentane (in kJ mol^{-1}) is

☒ **A** 5(–394) + 6(–286) + (–3509)

☒ **B** 5(–394) + 6(–286) – (–3509)

☒ **C** –5(–394) – 6(–286) + (–3509)

☒ **D** –5(–394) – 6(–286) – (–3509)

(Total for Question 10 = 1 mark)

11 All alkenes have

☒ **A** the same empirical formula and the same general formula.

☒ **B** the same molecular formula and the same general formula.

☒ **C** the same molecular formula and the same empirical formula.

☒ **D** the same empirical formula and the same structural formula.

(Total for Question 11 = 1 mark)

12 Covalent bonding results from the strong electrostatic attractions between

☒ **A** instantaneous dipoles.

☒ **B** electron clouds.

☒ **C** electrons in the bonding pair.

☒ **D** bonding pairs of electrons and nuclei.

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

13 This question concerns the reaction of hydrogen bromide with propene.

(a) This reaction requires

(1)

☒ **A** normal laboratory conditions.

☒ **B** the presence of UV light.

☒ **C** the presence of a suitable catalyst.

☒ **D** heating under reflux.

(b) The reaction is best described as

(1)

☒ **A** nucleophilic substitution.

☒ **B** electrophilic substitution.

☒ **C** nucleophilic addition.

☒ **D** electrophilic addition.

(c) The major product of the reaction will be

(1)

☒ **A** 1-bromopropane

☒ **B** 2-bromopropane

☒ **C** 1,2-dibromopropane

☒ **D** 2-bromopropene

(Total for Question 13 = 3 marks)

14 Many organic compounds have toxic vapours. For this reason

☒ **A** a naked flame should never be used when carrying out experiments with organic compounds.

☒ **B** gloves should usually be worn when carrying out experiments with organic compounds.

☒ **C** a fume cupboard should be used wherever possible when carrying out experiments with organic compounds.

☒ **D** most experiments with organic compounds are banned in schools and colleges.

(Total for Question 14 = 1 mark)

15 Ethanol (molar mass 46 g mol^{-1}) is manufactured by the hydration of ethene (molar mass 28 g mol^{-1}):

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

In a typical process 28 tonnes of ethene produces 43.7 tonnes of ethanol. The percentage yield of ethanol in this process is

☒ **A** 64%

☒ **B** 95%

☒ **C** 100%

☒ **D** 156%

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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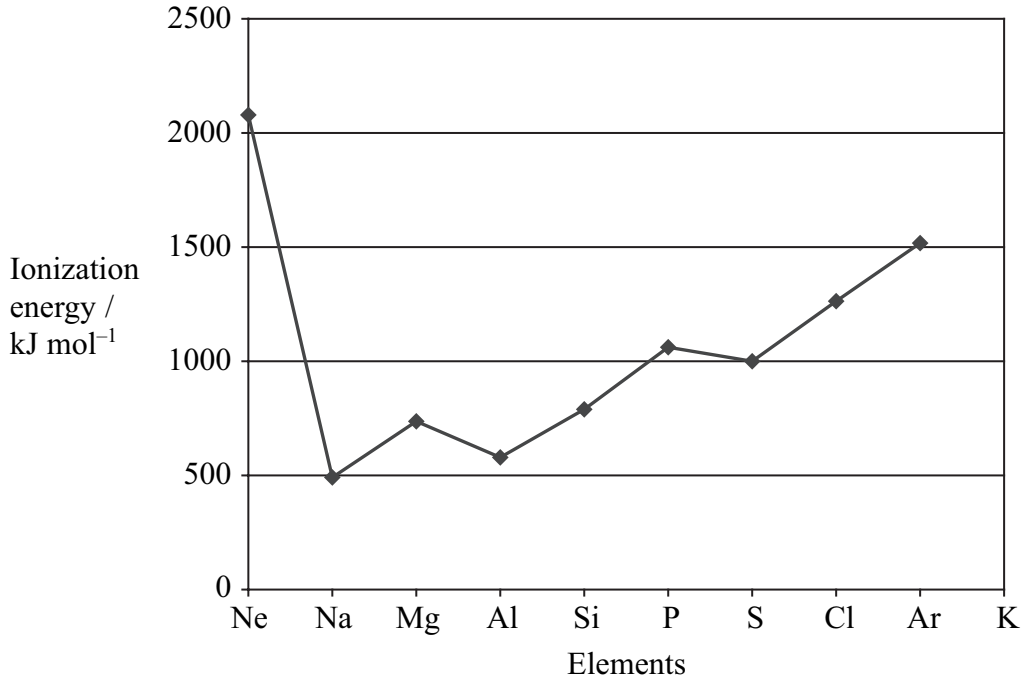
SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

16 The first ionization energy of each of the elements from neon to argon is shown on the graph below. The first ionization energy of potassium has been omitted.



(a) Define the term **first ionization energy**.

(3)

(b) Explain why, in moving from Na to Ar, the general trend is for the first ionization energy to increase.

(3)

(c) Explain why the first ionization energy decreases from P to S.

(2)

(d) Estimate the value of the first ionization energy of potassium, K, and write your answer below.

(1)

..... kJ mol^{-1}

(Total for Question 16 = 9 marks)

17 0.400 g of magnesium ribbon reacted with exactly 22.2 cm^3 of hydrochloric acid of concentration 1.50 mol dm^{-3}.

400 cm^3 of hydrogen gas was formed, the volume being measured at room temperature and pressure.

In the calculations that follow, use the following molar masses:

$$Mg = 24.0\ g\,mol^{-1}$$
$$Cl = 35.5\ g\,mol^{-1}$$

(a) Calculate the amount (in moles) of magnesium used.

(1)

(b) Calculate the amount (in moles) of hydrochloric acid used.

(1)

(c) Calculate the amount (in moles) of hydrogen produced.

[Molar volume of any gas at room temperature and pressure = 24 000 $cm^3\,mol^{-1}$]

(1)

(d) Show that the calculated amounts of magnesium, hydrochloric acid and hydrogen are consistent with the following equation for the reaction

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

(1)

(e) Calculate the maximum mass of magnesium chloride that would be formed in this reaction. Give your answer to **three** significant figures.

(3)

(Total for Question 17 = 7 marks)

18 Copper(II) sulfate exists as blue hydrated crystals and white anhydrous crystals. The enthalpy changes of solution for these two substances may be represented by the following simplified equations:

$$\underset{\text{blue}}{CuSO_4.5H_2O(s)} + aq \rightarrow CuSO_4(aq) \qquad \Delta H_1 = +11.5 \text{ kJ mol}^{-1}$$

$$\underset{\text{white}}{CuSO_4(s)} + aq \rightarrow CuSO_4(aq) \qquad \Delta H_2 = -66.1 \text{ kJ mol}^{-1}$$

(a) (i) Fill in the box and add labelled arrows to complete the Hess cycle to enable you to calculate $\Delta H_{reaction}$.

(3)

$$CuSO_4.5H_2O(s) \xrightarrow{\Delta H_{reaction}} CuSO_4(s) + 5H_2O(l)$$

(ii) Calculate a value for the enthalpy change $\Delta H_{reaction}$.

(2)

(b) Suggest why it is not possible to directly measure the enthalpy change for the conversion of the blue hydrated copper(II) sulfate crystals into the white anhydrous crystals.

(1)

.....

.....

.....

.....

*(c) (i) $CuSO_4.5H_2O(s) + aq \rightarrow CuSO_4(aq)$ $\Delta H_1 = +11.5$ kJ mol^{-1}

Describe briefly the experimental procedure that **you** would use to obtain the data necessary to calculate ΔH_1, given a known mass of hydrated copper(II) sulfate crystals, $CuSO_4.5H_2O(s)$.

You should state the apparatus that you would use and any measurements that you would make.

You are **not** required to calculate the amounts of substances or to explain how you would use the data obtained.

(4)

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.....

(ii) The value for the enthalpy change from (c)(i) obtained by experiments in a school laboratory is likely to be significantly different from a data book value.

List **three** possible reasons for this which do **not** relate to the quality of the apparatus or chemicals used or possible mistakes in carrying out the procedure.

(3)

1 .....

.....

2 .....

.....

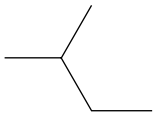
3 .....

.....

(Total for Question 18 = 13 marks)

19 This question is about alkanes.

(a) The skeletal formulae of two alkanes (**A** and **B**) are shown below.



A



B

(i) Write the general formula of the alkanes.

(1)

(ii) Compounds **A** and **B** are ..... of each other.

(1)

(iii) Draw the displayed formula of compound **A**.

(1)

(iv) Give the systematic name of compound **B**.

(1)

.....

(b) The largest use for alkanes is as fuels. However, there are problems associated with the combustion of alkanes, whether complete or incomplete.

(i) An incomplete combustion of methane, CH_4, results in the formation of carbon monoxide and water only.

Write the equation for this reaction. State symbols are **not** required.

(2)

(ii) When does incomplete combustion occur?

(1)

.....

.....

(iii) State **two** problems that result from the incomplete combustion of alkane fuels.

(2)

1 .....

.....

2 .....

.....

*(iv) State and explain the main environmental problem arising from the **complete** combustion of alkane fuels.

(3)

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(c) The reactions of organic compounds, including alkanes, may be broken down into a series of steps; this is the mechanism for the reaction. The reaction between methane and chlorine may be represented by a mechanism involving three stages – **initiation**, **propagation** and **termination**.

(i) Reaction mechanisms often involve the use of 'curly arrows'. Explain the meaning of the curly arrows shown below.

(2)



Arrow I



Arrow II

Arrow I .....

.....

Arrow II .....

.....

(ii) Using the curly arrow notation, show the **initiation** step of the reaction between methane and chlorine.

(2)

(iii) Give the two **propagation** steps of the reaction between methane and chlorine.

Curly arrows are **not** required.

(2)

(iv) Suggest why a small amount of UV light can result in the formation of a large amount of product.

(1)

.....

.....

(v) Ethane is a trace product of this reaction. By means of an equation, show how the ethane is formed.

(1)

(d) Scientists never detect molecular hydrogen, H_2, amongst the products of the chlorination of methane.

Use the data below to suggest why this is so.

The frequency of UV light used corresponds to an energy of about 400 kJ mol^{-1}.

Bond	Bond enthalpy / kJ mol^{-1}
C—H	435
Cl—Cl	243

(2)

.....

.....

.....

.....

(Total for Question 19 = 22 marks)

20 Metals are good conductors of heat and electricity and usually have high melting temperatures and boiling temperatures.

(a) (i) Describe the **structure** of a metal.

(2)

(ii) Describe the **bonding** in a metal.

(2)

(b) Explain why the melting temperature of magnesium (650 °C) is much higher than that of sodium (98 °C).

(3)

(c) Explain how metals conduct electricity.

(2)

.....

.....

.....

.....

(Total for Question 20 = 9 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12											27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 3 8 4 3 3 3 A 0 2 4 2 2 4

PMT

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Mark Scheme (Results)

June 2011

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear

- select and use a form and style of writing appropriate to purpose and to complex subject matter

- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1 (a)	C	**1**

Question Number	Correct Answer	Mark
1 (b)	B	**1**

Question Number	Correct Answer	Mark
1 (c)	D	**1**

Question Number	Correct Answer	Mark
1 (d)	B	**1**

Question Number	Correct Answer	Mark
2	A	**1**

Question Number	Correct Answer	Mark
3	C	**1**

Question Number	Correct Answer	Mark
4	C	**1**

Question Number	Correct Answer	Mark
5	B	**1**

Question Number	Correct Answer	Mark
6	D	**1**

Question Number	Correct Answer	Mark
7	A	**1**

Question Number	Correct Answer	Mark
8	C	**1**

Question Number	Correct Answer	Mark
9	C	**1**

Question Number	Correct Answer	Mark
10	B	**1**

Question Number	Correct Answer	Mark
11	A	**1**

Question Number	Correct Answer	Mark
12	D	**1**

Question Number	Correct Answer	Mark
13 (a)	A	**1**

Question Number	Correct Answer	Mark
13 (b)	D	**1**

Question Number	Correct Answer	Mark
13 (c)	B	**1**

Question Number	Correct Answer	Mark
14	C	**1**

Question Number	Correct Answer	Mark
15	B	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
16 (a)	**First mark** The energy (allow enthalpy / heat) required (allow change) per mole **(1)** **Second mark** to form (gaseous) singly charged positive ions Or to remove (1 mole of) electrons **(1)** **Third mark** from **gaseous** atoms (of the element) **(1)** $X(g) \longrightarrow X^{+}(g) + e^{(-)}$ scores last 2 marks Ignore standard conditions Per mole scores at any point	Energy / enthalpy produced Just gaseous element	**3**

Question Number	Acceptable Answers	Reject	Mark
16 (b)	Nuclear charge / effective nuclear charge / number of protons / atomic number increases **(1)** **Two of** (Outer) electrons in the **same** (quantum) shell / **same** number of electron shells **(1)** Shielding (of nucleus)(about) the same **(1)** Distance from nucleus/atomic radius less **(1)**	charge density orbitals, sub-shell	**3**

Question Number	Acceptable Answers	Reject	Mark
16 (c)	**Route 1** Electrons (in the p sub-shell) are **paired** (for the first time) (in S) / two electrons occupy the same (p) orbital / full orbital / electrons-in-boxes diagram **(1)** **repulsion** between the (paired) electrons (reduces IE) **(1)** **Route 2** P has a half-filled p sub-shell / half-filled p orbitals which is stable **(1)** (on ionization) S gains a half-filled p sub-shell / half-filled p orbitals **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (d)	200 – 490 (kJ mol^{-1})	Negative values	**1**

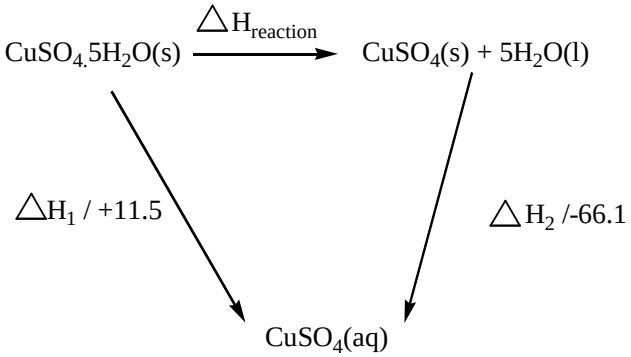
Question Number	Acceptable Answers	Reject	Mark
17 (a)	Do not penalize the use of A_r (Mg) = 24.3 at any stage in this question. Penalize SF errors (1 SF, incorrect SF (eg. 0.02) and incorrect rounding to 2 SF (e.g. 0.016)) only once in parts (a – d) Allow 0.0166 Allow fractions (e.g. 1/60) Amount Mg = (0.4 ÷ 24) = 0.016666 = 0.0167 (mol) Allow Amount Mg = (0.4 ÷ 24.3) = 0.016461 = 0.0165 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)	Amount HCl = 1.5 x 22.2/1000 = 0.033333 = 0.0333 (mol) Allow Amount HCl = 2 x answer in (a)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)	Amount of H_2 = 400 ÷ 24 000 = 0.016666 = 0.0167 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d)	Ratio mol Mg:HCl:H_2 = 0.0167 (0.165) : 0.0333 : 0.0167 = 1:2:1 Allow answers in which the mole ratios of the reactant and products are compared separately	Just stating the molar ratio	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (e)	M_r ($MgCl_2$) = 24 + 2 x 35.5 = 95 **(1)** Mol $MgCl_2$ = (mol Mg) = 0.0166666 (or 0.0167) **(1)** Mass $MgCl_2$ = 95 x 0.0166666 = 1.58 (g) **3 sf (1)** Or 95 x 0.0167 = 1.59 (g) 3sf Or 95.3 x 0.0166666 = 1.59 Or 95 x 0.0165 = 1.58 Or 95.3 x 0.0165 = 1.57 Correct answer with no working scores **(3)** TE on 17(a)		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (i)	Product in box: $CuSO_4$**(aq) (1)** **Either** Mark the arrows and then the labels: Two downward arrows **(1)** labelled with symbols or values with or without units **(1)** **OR** Mark each arrow and label separately Downward arrow & ΔH_1 or value **(1)** Downward arrow & ΔH_2 or value **(1)** Allow reversed arrows **with** reversed signs on ΔH Ignore any other labels on the arrows. Ignore $5H_2O$ in bottom product  		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	**Award higher mark from:** **Route 1** **Mark the calculation based on their cycle** TE from (a)(i) ignoring incorrect bottom product **Route 2** **Mark a calculation which is independent of the cycle** $\triangle H_{reaction} = \triangle H_1 - \triangle H_2$ stated or implied = +11.5 – (– 66.1) **(1)** = (+) 77.6 (kJ mol^{-1}) **(1)** Correct answer alone scores **(2)** **–**77.6 (kJ mol^{-1}) alone or from a correct addition scores **(1)**		**2**

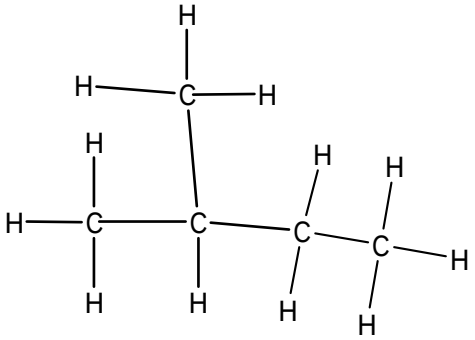
Question Number	Acceptable Answers	Reject	Mark
18 (b)	Dehydration reaction cannot be controlled OR temperature change (of dehydration reaction) cannot be measured OR $CuSO_4.5H_2O$ would need heating (so temperature change cannot be measured) OR impossible to add exact amount of water (to obtain value by reverse process) OR cannot mix solid with water to obtain perfect crystals	Temperature of solid / crystals cannot be measured	**1**

Question Number	Acceptable Answers	Reject	Mark
***18 (c)(i)**	First & second marks stand alone 1. Pipette/burette / measuring cylinder / balance to transfer (a known amount of) (water) **(1)** 2. to (expanded) polystyrene cup / calorimeter / any *insulated* container allow coffee / plastic cup **(1)** Third & fourth marks only awarded if correct chemicals **and** procedure used 3. add solid and **stir** (allow mix or shake) mixture **(1)** 4. measure initial **and** final temperature allow temperature change **(1)**	Just mass / volume measured Temperature **increase** unless exothermic penalised in (b)	**4**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Any three from: • heat transfer (from surroundings) (allow loss or gain) • approximation in (specific) heat capacity of solution • neglecting (specific) heat capacity of calorimeter/apparatus (allow energy absorbed by the apparatus) • reaction / dissolving may be incomplete/slow • temperature change is very small (and difficult to measure) • Density of solution is taken as the same as water • conditions not standard (allow)	Errors in calculation including adding mass of solid to mass of water loss of reagents / water incomplete combustion Just 'difficult to measure'	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	C_nH_{2n+2} or any symbol in place of n Ignore C_5H_{12}		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	(structural / chain) isomers		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	 (any orientation of this structure) Ignore non-displayed formulae	Structures in which **any** bonds or atoms are omitted Structures with CH_3 groups	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iv)	2,2-dimethylpropane **(1)** Allow dimethylpropane, 2-dimethylpropane 2,2 dimethylpropane, 2 dimethylpropane Ignore hyphens, commas, spaces		**1**

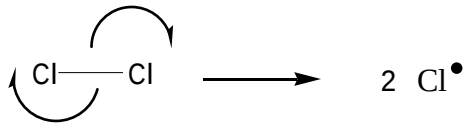
Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	$CH_4 + 1½O_2 \rightarrow CO + 2H_2O$ Formulae **(1)** balance **(1)** Or multiples Ignore state symbols No TE on **any** other species		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	Insufficient / not excess oxygen / air	Reactant does not react completely with oxygen Just 'methane in excess'	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	**Any two from** **CO** is toxic / poisonous (allow harmful) **(1)** Less energy is produced (allow (methane) becomes a less efficient fuel) **(1)** Unburned hydrocarbons react to form compounds which are toxic / harmful **(1)** Allow sooty deposits / carbon / particulates in atmosphere (ignore reference to global dimming) **(1)** Unburned hydrocarbons are toxic / harmful **(1)** If reference to damage to ozone layer, global warming and / or acid rain then max **(1)**	Explosive Reactants wasted Air pollution	**2**

Question Number	Acceptable Answers	Reject	Mark
***19 (b)(iv)**	Global warming / climate change **(1)** Due to (increase in concentration of) CO_2 in the atmosphere / CO_2 is a greenhouse gas **(1)** Traps the heat **from the earth** / IR radiation (re-radiating) **from the earth (1)** If reference to damage to ozone layer then max **(2)** Photochemical smog is formed **(0)** NO_x is produced (by reaction of nitrogen & oxygen) **(1)** and reacts with (volatile) organic compounds in sunlight **(1)** Ignore references to increase in (of concentration) of H_2O in the atmosphere Ignore references to the effects of climate change	(heat) from the sun Global dimming due to complete combustion of hydrocarbon fuels Effects (e.g. reactions of unburned hydrocarbons) due to *incomplete* combustion	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	The arrows show the movement of electrons **(1)** Single-headed/I denotes 1 electron and Double-headed/II denotes a pair of / 2 electrons /allow lone pair **(1)** Allow Explanations just in terms of electron movement in bond fission	Just stating homolytic and heterolytic fission	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	 Equation **(1)** two arrows correctly showing a homolytic fission **(1)** Here and in subsequent mechanisms the covalent bonds may be shown as lines or electron pairs or both The mechanism arrows may be shown on the same side or on different sides of the bond The single electrons need not be shown		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iii)	$CH_4 + Cl^{\bullet} \rightarrow CH_3^{\bullet} + HCl$ **(1)** $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ **(1)** Ignore state symbols and curly arrows. Ignore order of equations so these marks may be scored if an initiation step with fission of C – H bond in methane is given in c(ii)		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iv)	Because a (chlorine) radical is regenerated / reformed / reproduced / recycled (by the propagation reactions each time a molecule of product is formed) **(1)** Allow methyl radical regenerated if initiation step with fission of C – H bond in methane is given in c(ii) and propagation order reversed Ignore references to chain reaction	radical is regenerated by UV light (chlorine) radical is a catalyst	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(v)	$CH_3^{\bullet} + CH_3^{\bullet} \rightarrow C_2H_6$ / $2CH_3^{\bullet} \rightarrow C_2H_6$ Ignore state symbols The single electrons need not be shown		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)	UV light does not have enough energy to (ALLOW 'cannot') break the C-H bond **(1)** So no H free radicals / atoms are formed (therefore cannot combine to form H_2) **(1)**	Just 'hydrogen' Just 'so no H_2 formed	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)	**(i) Structure** Lattice /close-packed **(1)** (or a diagram with at least 3 rows) positive ions or cations (allow metal ions) **(1)** delocalized electrons / sea of electrons **(1)** **(ii) Bonding** (Electrostatic) **attraction** between positive ions / cations (allow metal ions) and delocalized electrons / sea of electrons **(1)**	layers protons 'free' electrons	**4**

Question Number	Acceptable Answers	Reject	Mark
20 (b)	Any three from 1. Magnesium ion / Mg^{2+} (allow magnesium) has a larger charge (density) than the sodium ion (allow sodium) / Na^{+} some comparison of the ions is required **(1)** 2. magnesium ions / Mg^{2+} smaller than sodium ions **(1)** 3. Magnesium / Mg^{2+} contributes two / more electrons (per atom) to the "sea" of electrons **(1)** 4. magnesium ions / Mg^{2+} have greater attraction for the delocalized "sea" of electrons **(1)** Ignore reference to number of outer electrons in Mg / Na Any references to the bonding being ionic, covalent or intermolecular (max 2) Reverse argument can gain full marks	Just Mg^{2+} and Na^{+} More bonds	**3**

Question Number	Acceptable Answers	Reject	Mark
20 (c)	The delocalized electrons / sea of electrons **(1)** Flow (allow move / free to move) **(1)** (When a potential difference/voltage is applied) 'Carry the current' is not sufficient for the mark	'free' electrons	**2**

TOTAL FOR SECTION B = 60 MARKS

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Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 13 January 2012 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39295A

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7/7/5/3/

P 3 9 2 9 5 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A molecule is

☒ **A** a group of atoms bonded by ionic bonds.

☒ **B** a group of atoms bonded by covalent bonds.

☒ **C** a group of ions bonded by covalent bonds.

☒ **D** a group of atoms bonded by metallic bonds.

(Total for Question 1 = 1 mark)

2 The relative atomic mass is defined as

☒ **A** the mass of an atom of an element relative to 1/12 the mass of a carbon-12 atom.

☒ **B** the mass of an atom of an element relative to the mass of a hydrogen atom.

☒ **C** the average mass of an element relative to 1/12 the mass of a carbon atom.

☒ **D** the average mass of an atom of an element relative to 1/12 the mass of a carbon-12 atom.

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 The definition of the mole is

☒ **A** the amount of any substance which occupies a volume of 24 dm^3 at room temperature and pressure.

☒ **B** the amount of any substance containing the same number of identical entities as there are in exactly 12 g of the carbon-12 isotope.

☒ **C** the number of atoms in exactly 12 g of the carbon-12 isotope.

☒ **D** the number of molecules in exactly 2 g of hydrogen at room temperature and pressure.

(Total for Question 3 = 1 mark)

4 The concentration of blood glucose is usually given in millimoles per dm^3 or mmol dm^{-3}. A reading of 5.0 mmol dm^{-3} is within the normal range. Glucose has a molar mass of 180 g mol^{-1}. What mass of glucose dissolved in 1 dm^3 of blood would give this normal reading?

☒ **A** 0.090 g

☒ **B** 0.18 g

☒ **C** 0.90 g

☒ **D** 9.0 g

(Total for Question 4 = 1 mark)

5 In an experiment performed to measure the enthalpy change for the reaction

$$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$$

3.0 g of zinc powder (an excess) was added to 30.0 cm^3 of copper(II) sulfate solution of concentration 1.00 mol dm^{-3}. The temperature rise of the mixture was 47.6 K. Assuming that the heat capacity of the solution is 4.2 J K^{-1} g^{-1}, the enthalpy change for the reaction is given by

☒ **A** $\Delta H = -(30 \times 4.2 \times 47.6) \div 0.03$

☒ **B** $\Delta H = -(33 \times 4.2 \times 47.6) \div 0.03$

☒ **C** $\Delta H = -(30 \times 4.2 \times 47.6) \times 0.03$

☒ **D** $\Delta H = -(33 \times 4.2 \times 47.6) \times 0.03$

(Total for Question 5 = 1 mark)

6 The enthalpy change of atomization of iodine is the value of ΔH for the process

☒ **A** $I_2(s) \rightarrow I_2(g)$

☒ **B** $I_2(s) \rightarrow 2I(g)$

☒ **C** $I_2(g) \rightarrow 2I(g)$

☒ **D** $\frac{1}{2}I_2(s) \rightarrow I(g)$

(Total for Question 6 = 1 mark)

7 The enthalpy change for the reaction

$$C(s, \text{graphite}) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

cannot be measured directly since some carbon dioxide is always formed in the reaction. It can be calculated using Hess's Law and the enthalpy changes of combustion of graphite and of carbon monoxide.

$$C(s, \text{graphite}) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -394 \text{ kJ mol}^{-1}$$

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \quad \Delta H = -283 \text{ kJ mol}^{-1}$$

The enthalpy change for the reaction of graphite with oxygen to give carbon monoxide is

☒ **A** -677 kJ mol^{-1}

☒ **B** $+111 \text{ kJ mol}^{-1}$

☒ **C** -111 kJ mol^{-1}

☒ **D** $+677 \text{ kJ mol}^{-1}$

(Total for Question 7 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

8 The molar enthalpy change of combustion of some alkanes is given below in kJ mol^{-1}.

C_3H_8	−2219
C_4H_{10}	−2877
C_5H_{12}	−3509
C_6H_{14}	−4163

Another alkane was found to have an enthalpy change of combustion of −6125 kJ mol^{-1}.
The alkane is

☒ **A** C_7H_{16}

☒ **B** C_8H_{18}

☒ **C** C_9H_{20}

☒ **D** $C_{10}H_{22}$

(Total for Question 8 = 1 mark)

9 If the mean C—H bond enthalpy is **+*x***, which of the following represents a process with an enthalpy change of **+4*x***?

☒ **A** $C(g) + 4H(g) \rightarrow CH_4(g)$

☒ **B** $CH_4(g) \rightarrow C(g) + 4H(g)$

☒ **C** $CH_4(g) \rightarrow C(s, \text{graphite}) + 2H_2(g)$

☒ **D** $C(s, \text{graphite}) + 2H_2(g) \rightarrow CH_4(g)$

(Total for Question 9 = 1 mark)

10 The first eight ionization energies of an element are (in kJ mol^{-1}):

789, 1577, 3232, 4356, 16091, 19785, 23787, 29253.

The element is in

☒ **A** Group 1

☒ **B** Group 2

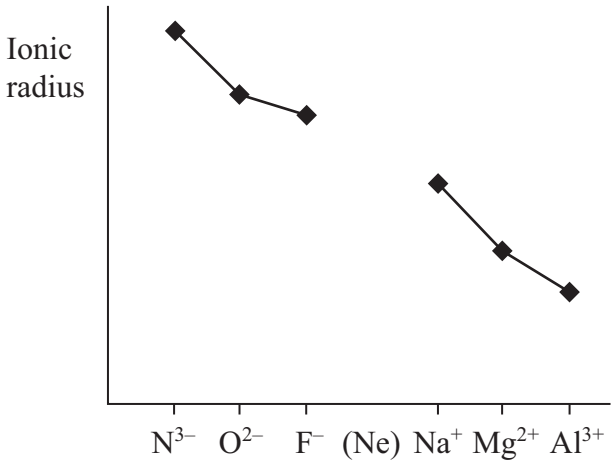
☒ **C** Group 3

☒ **D** Group 4

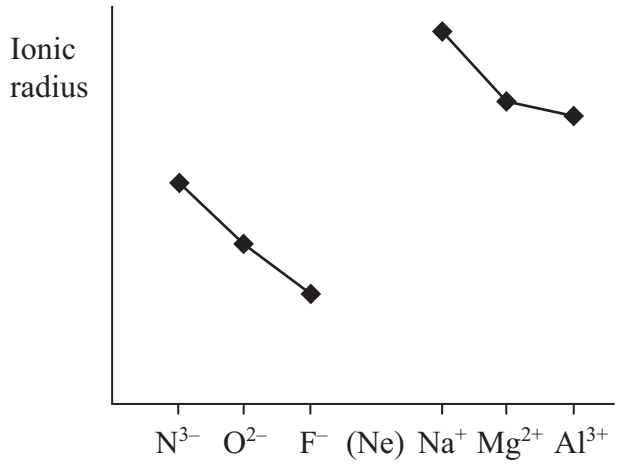
(Total for Question 10 = 1 mark)

11 Which of the graphs shows (from left to right) the trend in the ionic radius of the isoelectronic ions N^{3-}, O^{2-}, F^-, Na^+, Mg^{2+}, Al^{3+}?

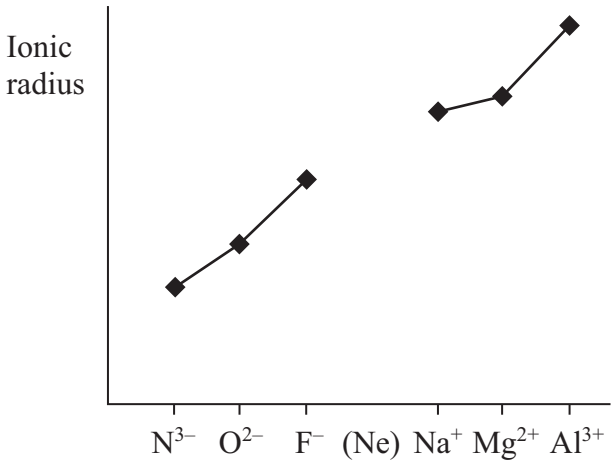
☒ **A**



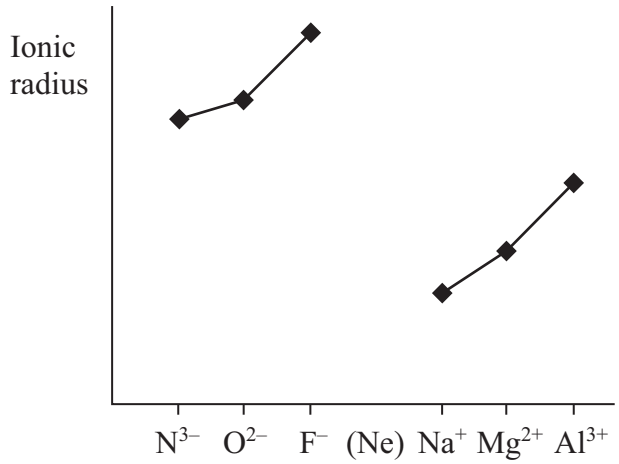
☒ **B**



☒ **C**



☒ **D**



(Total for Question 11 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

12 Oxygen can be prepared using several different reactions. Which of those given below has the highest atom economy by mass?

☒ **A** $NaNO_3 \rightarrow NaNO_2 + ½O_2$

☒ **B** $H_2O_2 \rightarrow H_2O + ½O_2$

☒ **C** $Cl_2 + H_2O \rightarrow 2HCl + ½O_2$

☒ **D** $PbO_2 \rightarrow PbO + ½O_2$

(Total for Question 12 = 1 mark)

13 The ionic radii in nm of some ions are given below.

Li^+	0.074	F^-	0.133
Ca^{2+}	0.100	Cl^-	0.180
		O^{2-}	0.140
		S^{2-}	0.185

(a) Which of the following compounds has the most exothermic lattice energy? They all have the same crystal structure.

(1)

☒ **A** LiF

☒ **B** LiCl

☒ **C** CaO

☒ **D** CaS

(b) Which of the following compounds will show the greatest difference between the experimental (Born-Haber) lattice energy and that calculated from a purely ionic model?

(1)

☒ **A** LiF

☒ **B** Li_2O

☒ **C** CaO

☒ **D** CaS

(Total for Question 13 = 2 marks)

14 Which of the following is the correct order for the processes used to obtain petrol from petroleum (crude oil)?

☒ **A** Petroleum → fractional distillation → reforming → cracking → petrol.

☒ **B** Petroleum → reforming → fractional distillation → cracking → petrol.

☒ **C** Petroleum → cracking → reforming → fractional distillation → petrol.

☒ **D** Petroleum → fractional distillation → cracking → reforming → petrol.

(Total for Question 14 = 1 mark)

15 In the reaction between ethene and bromine, the bromine molecule acts as an electrophile.

$$CH_2{=}CH_2 + Br_2 \rightarrow BrCH_2CH_2Br$$

Which of the following statements is true?

☒ **A** Ethene acts as a nucleophile because it is polar.

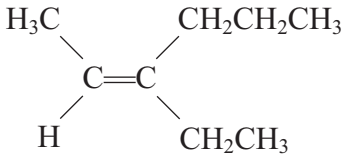
☒ **B** Ethene acts as a nucleophile because it can donate a pair of electrons to bromine.

☒ **C** Ethene is not a nucleophile in this reaction.

☒ **D** Ethene acts as a nucleophile because it donates a single electron to bromine.

(Total for Question 15 = 1 mark)

16 Name the alkene shown below.



☒ **A** *Z*-4-ethylhex-4-ene

☒ **B** *E*-3-ethylhex-2-ene

☒ **C** *Z*-3-ethylhex-2-ene

☒ **D** *E*-3-propylpent-2-ene

(Total for Question 16 = 1 mark)

17 If propene, $CH_3CH{=}CH_2$, is reacted with aqueous acidified potassium manganate(VII) the organic product is

☒ **A** $CH_3CH(OH)CH_2OH$

☒ **B** $CH_3CH(OH)CH_3$

☒ **C** $HOCH_2CH_2CH_2OH$

☒ **D** $CH_3CH_2CH_2OH$

(Total for Question 17 = 1 mark)

18 How many compounds have the formula C_5H_{12}?

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 18 = 1 mark)

19 An organic compound reacts with chlorine in the presence of ultraviolet light. The relative molecular mass of the product has increased by 34.5 compared with the original compound. What is the reaction mechanism?

☒ **A** Free radical substitution

☒ **B** Electrophilic substitution

☒ **C** Nucleophilic substitution

☒ **D** Free radical addition

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20 (a) An impure sample of sodium hydrogencarbonate, $NaHCO_3$, of mass 0.227 g, was reacted with an excess of hydrochloric acid. The volume of carbon dioxide evolved was measured at room temperature and pressure and found to be 58.4 cm^3.

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

The molar volume of any gas at the temperature and pressure of the experiment is 24 $dm^3\ mol^{-1}$. The molar mass of sodium hydrogencarbonate is 84 $g\ mol^{-1}$.

(i) Calculate the number of moles of carbon dioxide given off.

(1)

(ii) Calculate the mass of sodium hydrogencarbonate present in the impure sample.

(2)

(iii) Calculate the percentage purity of the sodium hydrogencarbonate. Give your answer to two significant figures.

(2)

(b) (i) The total error in reading the gas syringe is ±0.4 cm^3. Calculate the percentage error in measuring the gas volume of 58.4 cm^3.

(1)

(ii) Suggest why the carbon dioxide should not be collected over water in this experiment.

(1)

.....

.....

(Total for Question 20 = 7 marks)

21 (a) On strong heating, calcium carbonate decomposes to calcium oxide and carbon dioxide:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

Owing to the conditions under which the reaction occurs, it is not possible to measure the enthalpy change directly.

An indirect method employs the enthalpy changes when calcium carbonate and calcium oxide are neutralized with hydrochloric acid.

(i) Write the equation for the reaction of calcium carbonate with hydrochloric acid. State symbols are **not** required.

[$\boldsymbol{\Delta H}_1$ is the enthalpy change for this reaction]

(1)

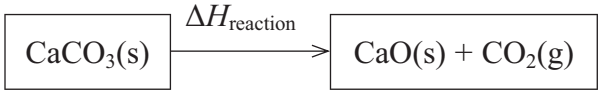
.....$\boldsymbol{\Delta H}_1$

(ii) The reaction of calcium oxide with hydrochloric acid is

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) \qquad \boldsymbol{\Delta H}_2$$

Use the equations in parts (i) and (ii) to complete the Hess's Law cycle below to show how you could calculate the enthalpy change for the decomposition of calcium carbonate, $\Delta H_{reaction}$. Label the arrows in your cycle.

(3)



(iii) Complete the expression for $\Delta H_{reaction}$ in terms of ΔH_1 and ΔH_2.

(1)

$\Delta H_{reaction}$ =

(b) Suggest **two** reasons why the value obtained by carrying out these two experiments and using the equation gives a value different to the data booklet value for the decomposition reaction of calcium carbonate.

(2)

1 .....

.....

2 .....

.....

(Total for Question 21 = 7 marks)

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22 (a) State how the following processes are achieved in a mass spectrometer.

(i) Ionization of the sample.

(1)

(ii) Acceleration of the ions.

(1)

(iii) Deflection of the ions.

(1)

(b) State how you could find the molecular mass of a substance from its mass spectrum.

(1)

(c) Living things take up the radioactive isotope carbon-14 from the atmosphere. In recent years a particular linen cloth was shown, using mass spectrometry, to have been made from flax grown in the early 14th century. Suggest how mass spectrometry can be used to estimate the age of the cloth.

(2)

(Total for Question 22 = 6 marks)

***23** The melting temperatures of the elements of Period 3 are given in the table below. Use these values to answer the questions that follow.

Element	Na	Mg	Al	Si	P (white)	S (monoclinic)	Cl	Ar
Melting temperature / K	371	922	933	1683	317	392	172	84

(a) Explain why the melting temperature of sodium is very much less than that of magnesium.

(3)

(b) Explain why the melting temperature of silicon is very much greater than that of white phosphorus.

(3)

(c) Explain why the melting temperature of argon is the lowest of all the elements of Period 3.

(1)

.....

.....

(d) Explain why magnesium is a good conductor of electricity whereas sulfur is a non-conductor.

(2)

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.....

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.....

(Total for Question 23 = 9 marks)

24 (a) Briefly describe an experiment, with a diagram of the apparatus you would use, which shows that there are oppositely charged ions in copper(II) chromate(VI), $CuCrO_4$. Describe what you would expect to see.

Formula of ion	Colour
$Cu^{2+}(aq)$	blue
$CrO_4^{2-}(aq)$	yellow

(4)

Diagram

(b) The ions in an ionic lattice are held together by an **overall** force of attraction.

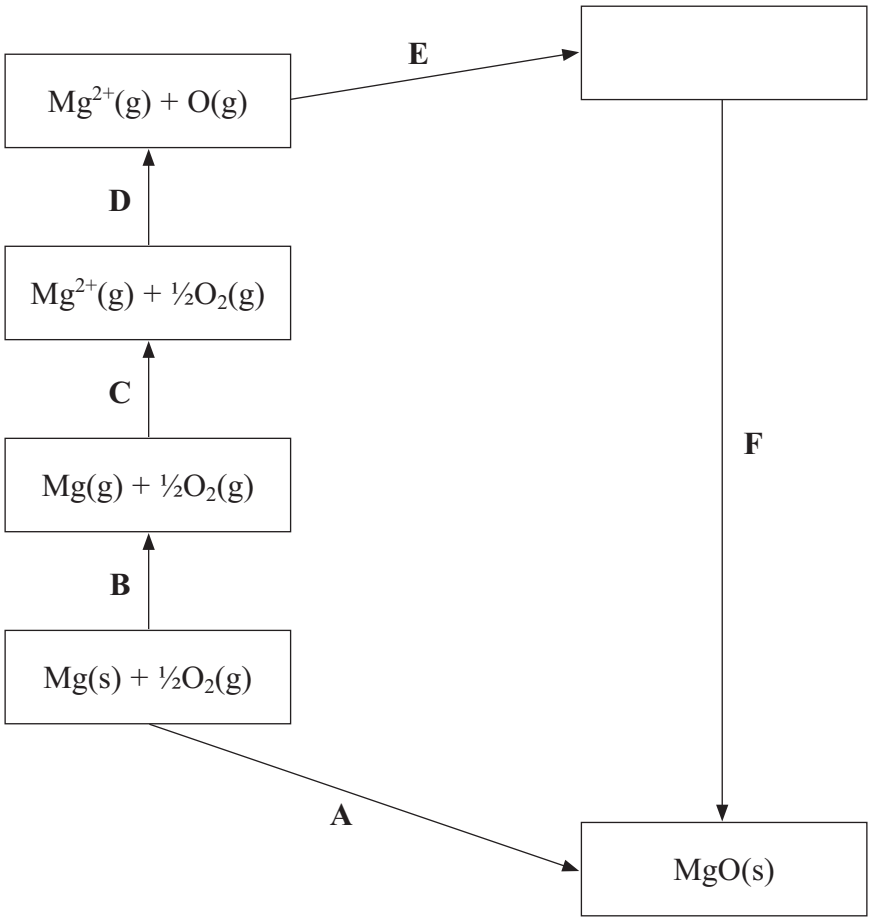
(i) Describe the forces of attraction in an ionic lattice.

(1)

(ii) Suggest **two** forces of repulsion which exist in an ionic lattice.

(2)

(c) Part of the Born-Haber cycle for magnesium oxide, MgO, is shown below.



(i) Complete the empty box with the appropriate formulae and state symbols.

(2)

(ii) Identify the enthalpy changes represented by the letters **A** and **C**.

(2)

A .....

C .....

(iii) Give the expression for the enthalpy change **F** in terms of the other enthalpy changes **A** to **E**.

(1)

F =

(d) The lattice composed of the ions Mg^{2+} and O^{2-} is stronger than a lattice composed of the ions Mg^{+} and O^{-}.

(i) Explain, in terms of the charges on the ions and the size of the cations, why this is so.

(2)

.....

.....

.....

.....

(ii) Suggest how the lattice energy of $Mg^{2+}O^{2-}$ would differ from that of $Mg^{+}O^{-}$.

(1)

.....

.....

(Total for Question 24 = 15 marks)

25 Chloroethane can be made from ethane and chlorine in the gas phase in the presence of ultraviolet light. The equation for the reaction is

$$CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$$

(a) Complete the mechanism for the reaction. Two of the steps have been given for you.

(4)

Initiation: $Cl_2 \rightarrow 2Cl\cdot$

Propagation (two steps)

(i)

(ii)

Termination (three steps)

$2Cl\cdot \rightarrow Cl_2$

(iii)

(iv)

(b) This reaction gives a poor yield of chloroethane. Give the structural formula and name of another organic product, not included in your mechanism for part (a), which could be produced in the reaction.

(2)

Formula

Name .....

(c) Chlorine gas is extremely toxic and is therefore a significant hazard. The preparation must be performed so as to minimise the risk to the experimenter.

(i) Explain the difference between **hazard** and **risk**.

(2)

.....

.....

.....

.....

(ii) Give one precaution that you would use in this experiment to minimise the risk, other than the use of a laboratory coat and safety goggles.

(1)

.....

.....

(Total for Question 25 = 9 marks)

26 (a) The alkenes have the general formula C_nH_{2n}. However, a compound with this general formula is not necessarily an alkene. Suggest why this is so.

(1)

.....

.....

.....

(b) Give the equation, using skeletal formulae, for the reaction of propene with each of the following.

(i) Hydrogen:

(1)

(ii) Hydrogen bromide to form the major product:

(2)

(c) Give the mechanism for the reaction of propene with hydrogen bromide, HBr, to form the major product.

(3)

(Total for Question 26 = 7 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 3 9 2 9 5 A 0 2 4 2 4

PMT

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Mark Scheme (Results)
January 2012

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		**1**

Question Number	Correct Answer	Reject	Mark
2	D		**1**

Question Number	Correct Answer	Reject	Mark
3	B		**1**

Question Number	Correct Answer	Reject	Mark
4	C		**1**

Question Number	Correct Answer	Reject	Mark
5	A		**1**

Question Number	Correct Answer	Reject	Mark
6	D		**1**

Question Number	Correct Answer	Reject	Mark
7	C		**1**

Question Number	Correct Answer	Reject	Mark
8	C		**1**

Question Number	Correct Answer	Reject	Mark
9	B		**1**

Question Number	Correct Answer	Reject	Mark
10	D		**1**

Question Number	Correct Answer	Reject	Mark
11	A		**1**

Question Number	Correct Answer	Reject	Mark
12	B		**1**

Question Number	Correct Answer	Reject	Mark
13(a)	C **(1)**		
13(b)	D **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
14	D		**1**

Question Number	Correct Answer	Reject	Mark
15	B		**1**

Question Number	Correct Answer	Reject	Mark
16	C		**1**

Question Number	Correct Answer	Reject	Mark
17	A		**1**

Question Number	Correct Answer	Reject	Mark
18	C		**1**

Question Number	Correct Answer	Reject	Mark
19	A		**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	(Amount CO_2 = 0.0584 dm^3 ÷ 24 dm^3 mol^{-1}) = 0.0024333/2.4333 x 10^{-3} (mol) IGNORE sf except 1 No working needed Mark final answer	0.002/2 x 10^{-3} or any other value WRONG units with correct numerical answer scores (0)	**1**

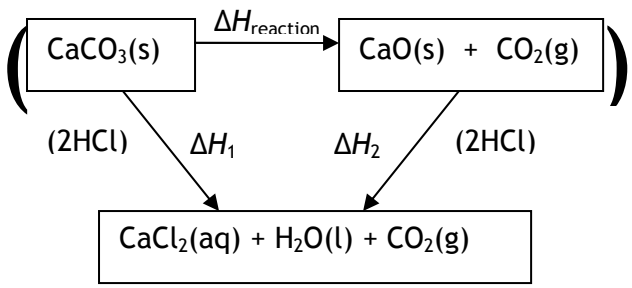
Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	**First mark:** amount CO_2 = amount $NaHCO_3$ **OR** use of candidate's answer to (a)(i) stated (or implied by final answer given) **(1)** **Second mark:** ∴ mass $NaHCO_3$ = 0.0024333 (mol) **x 84** (g mol^{-1}) = 0.2044 (g) ALLOW **0.2 (g)** This mark is for evidence of multiplying their moles of $NaHCO_3$ **by 84** **(1)** IGNORE sf including 1 sf Correct answer with no working scores **(2)** ALLOW consequentially from (i).		**2**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	**%** purity **=** (0.2044 g x 100) ÷ 0.227g = 90.04 **%** **(1)** = 90% **(1) (2 sf only)** ALLLOW consequentially from (i) and (ii) NOTE: The second mark to be awarded for 2sf answers less than a 100% (e.g. 10% scores **(1).** This is the percentage **impurity**) Correct answer with no working scores **(2)** Can score both marks via moles rather than masses	Answers not to 2 sf or answers incorrectly rounded up do not score 2nd mark Answers > 100% score **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	0.4 / 58.4 x 100 = (±) 0.68493(%) IGNORE sf (including 1 sf so (±) 0.7 (%) **is** OK here)	(±) 1.37 (%) etc., as the uncertainty should NOT be doubled Answers incorrectly rounded (e.g. 0.684 / 0.67 / 0.68492)	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	Any one of:- CO_2 dissolves /soluble (in water) CO_2 reacts (with water) / CO_2 forms carbonic acid / $CO_2 + H_2O \rightarrow H_2CO_3$ ALLOW CO_2 absorbed (by water) IGNORE suggestions to use a gas syringe	"CO_2 not the only gas given off" CO_2 diffuses/is lost/mixes with water "Water is also a product of the experiment" "Suck-back"	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ ALLOW multiples No other species to be allowed IGNORE state symbols even if incorrect	H_2CO_3 instead of "$H_2O + CO_2$" on right hand side of equation	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	 **Mark each point independently** **First mark:** All three formulae in box, ignoring state symbols (even if incorrect) **This mark is stand alone, NOT to be marked CQ on answer to (a)(i)** **(1)** **Second mark:** Two arrows, BOTH pointing downwards **(1)** **Third mark:** Left hand arrow labelled as ΔH_1 **AND** right hand arrow labelled ΔH_2 (whatever the direction of the arrows) **(1)**	Any other formulae	**3**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	$(\Delta H_{reaction}) = \mathbf{\Delta H_1 - \Delta H_2}$ This is a stand alone answer NOT to be marked CQ on (a)(ii) and/or (a)(i)	Any other expression	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)	**Any two from:** Heat /energy loss OR Heat /energy loss to surroundings OR Heat /energy loss to apparatus **(1)** Measured under non-standard conditions **(1)** Specific heat capacity of solutions is approximate **(1)** Density of solution assumed to be 1 g cm^{-3}/same as (pure) water **(1)** Large relative error in temperature measurement **(1)**	"Incomplete reaction" "Incomplete combustion" "Inaccuracy of equipment/apparatus" "Human error" CO_2 escapes Bond enthalpies Impurity of reactants Transfer losses Side-reactions	**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	**The mark is for the idea of impact by high energy electrons** **Any ONE of:** High-energy electrons Bombard with electrons Fast electrons (fired at sample) Accelerated electrons (fired at sample) (High-energy) electrons fired (at sample) (Sample) blasted with electrons Electron gun ALLOW "beam of electrons" IGNORE any comments (correct or incorrect) re subsequent ionization of the sample	High-**density** electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Electric field /electrostatic field / charged plates /voltage plates	**Positively-charged** plates /electronic field /electric current /(electro) magnetic field / electric coil	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Magnetic field/magnet / electromagnet /magnetic plates/ electromagnetic field	**"Negative** magnetic field"/ negatively-charged magnet	**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)	(Molecular mass of a substance is) that of the molecular ion/parent ion OR (m/e value for) peak/ion of largest mass OR (m/e value for) peak/ion furthest to the right ALLOW "last peak"/"peak at the end"	Highest peak/ tallest peak/ comments about determination of relative atomic mass	**1**

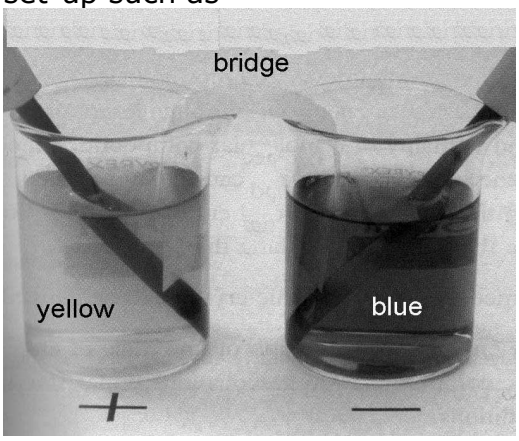
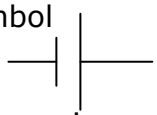
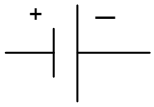
Question Number	Acceptable Answers	Reject	Mark
22(c)	**Mark independently:** **First mark:** Any mention of (determination of) amount /mass/abundance of ^{14}**C** (in cloth) ALLOW Any mention of (determination of) concentration/content/percentage of ^{14}**C** (in cloth) **OR** find proportion of ^{12}**C : ^{14}C** (in cloth) **(1)** **Second mark:** Any mention of any one of the following:- (Use) half-life of ^{14}**C** / mention that amount of ^{14}**C** (in cloth) decreases (over time) / ^{14}**C** decays over time / comparison of amount of ^{14}**C** in living systems / comparison of amount of ^{14}**C** in modern materials / compare with ^{12}**C : ^{14}C** in living systems **(1)**	amount of ^{14}**C** (in cloth) increases (over time)	**2**

Question Number	Acceptable Answers	Reject	Mark
***23(a)**	**ALLOW reverse arguments in each case** **Any three from:-** • **sodium atoms/sodium ions** are larger (than magnesium atoms/ions) **NOTE:** Allow symbols (eg Na or Na^+) **(1)** • sodium ions are Na^+ whereas magnesium ions are Mg^{2+} OR Na^+/sodium **ions** have smaller charge (density) than Mg^{2+}/ magnesium **ions** **(1)** **[NOTE:** It follows that the statement that "Na^+ ions are larger than Mg^{2+} ions" would score the first two scoring points above**]** • sodium has fewer **delocalized** electrons (than magnesium) **(1)** • attraction between the positive ions and (delocalized) electrons is weaker in sodium (than magnesium) **(1)** • sodium is not close-packed (but magnesium is close-packed) **(1)** • less energy needed (to break bonds) **(1)**	Attraction between **nucleus** and (delocalized) electrons Mention of **intermolecular forces/molecules** negates the energy mark **NOTE:** Arguments based on ionization energies **OR** suggestion of removal of outer shell electrons as part of the melting process scores **(0) overall**	**3**

Question Number	Acceptable Answers	Reject	Mark
***23(b)**	**First mark:** Idea of (breaking) **covalent bonds** in silicon **(1)** **Second and third marks:** **ANY TWO FROM** • Silicon is **giant** covalent / giant atomic/giant molecular/ macromolecular/giant structure/giant lattice IGNORE just "giant" **(1)** • Phosphorus made up of simple molecules /small molecules/ P_4 molecules /phosphorus is molecular covalent /molecular/simple covalent IGNORE just "simple"/"simple structure" **(1)** • Between phosphorus molecules: weak forces/weak intermolecular forces/weak London forces/weak van der Waals' forces/weak dispersion forces/weak induced-dipole forces **(1)** **[ALLOW** "weak bonds" if implies between phosphorus **molecules]** • More energy needed (to break bonds in silicon) **(1)**	Intermolecular forces broken in silicon/ covalent bonds broken in phosphorus "silicon giant ionic"/"silicon giant metallic" Weak bonds between phosphorus **atoms**	**3**

Question Number	Acceptable Answers	Reject	Mark
***23(c)**	**IGNORE any references to "energy" in this part of the question** Argon monatomic/argon (composed of) single atoms **NOTE:** This must be stated in words, not just by use of its symbol Ar IGNORE any comments about argon atoms having a full outer shell or argon being a noble gas IGNORE any comment about forces/bonds between argon particles	Any suggestion that argon is molecular Argon having a giant structure (of atoms)	**1**

Question Number	Acceptable Answers	Reject	Mark
***23(d)**	**First mark:** Mg has mobile electrons/delocalized electrons/free electrons/sea of electrons (to carry the charge) ALLOW Mg^{2+} instead of Mg or magnesium **(1)** **Second mark:** Sulfur's electrons are fixed (in covalent bonds)/sulfur's electrons are involved in bonding/sulfur's electrons are not free (to move)/no delocalized electrons in sulfur/no mobile electrons in sulfur **(1)**	Mg has free ions/Mg has mobile ions Sulfur has 'no free **ions**'/sulfur **has** delocalized electrons/just "sulfur has covalent bonds"/ just "sulfur is not a metal"	**2**

Question Number	Acceptable Answers	Reject	Mark
24(a)	**First mark:** **Diagram** showing U-tube OR filter paper on a microscope slide OR electrodes in a beaker OR other feasible set-up such as  **but a + and a — sign must be shown somewhere on the diagram by signs or words, positive and negative.** **NOTES** If set-up in the picture above is used, in addition to the + and — signs a bridge between the two beakers must also be shown. External circuits do not have to be complete (e.g. wires can be shown attached to a slide, provided the **+** and **—** labels included). **If** the words cathode and/or anode are included, for the first mark to be awarded the cathode must be shown as —ve and/or the anode as +ve **If** a battery symbol  shown, IGNORE any incorrect polarities, that is  **IGNORE** any electrode materials **EXCEPT** Cu^{2+} and/or CrO_4^{2-} **(1)**		4

	Second mark: Description to include the idea that the **ions move**/**ions** are **mobile**/**ions migrate** **MUST BE IN WORDS** ALLOW if description focuses on the movement of one of the ions to the oppositely-charged electrode **(1)** **Third mark:** Yellow ion/yellow (colour)/CrO_4^{2-} moves towards the/+ve (electrode)/ anode **(1)** **Fourth mark:** Blue ion/blue (colour)/Cu^{2+} moves towards cathode /—ve (electrode) **(1)** Mark CQ on candidate's cathode and anode signs for the **3rd** and **4th** marks	**Just** ions are attracted to the electrodes of opposite charge	

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	(Forces of attraction between) oppositely-charged ions/positive and negative ions/cations and anions IGNORE comments about electron transfer	Just ionic bonds/ Just "electrostatic forces of attraction"	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	**First mark:** Ions of the same charge (repel)/ positive ions (repel)/negative ions (repel) **(1)** **Second mark:** Nuclei (of the ions repel) ALLOW 'protons' (in the ions repel) OR Electron clouds OR electrons (in the ions repel) **(1)**	"**Magnetic** repulsion" negates first mark "Electrons repel nuclei"	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	$Mg^{2+}(g)$ **(1)** O^{2-} (g) **(1)** Penalise missing /incorrect state symbols once only Max 1 if include "$2e^-$"		**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	(**A** is enthalpy change of) **formation** (of MgO) **(1)** ALLOW just "ΔH_f" ALLOW (enthalpy change of) combustion **of magnesium** (**C** is) (sum of) first plus second ionization energies (of Mg) / $IE_1 + IE_2$ (for Mg) **(1)** ALLOW "first and second ionization energies (of Mg)" IGNORE references to "standard"	"(enthalpy change of) **reaction**" Just "ionization energy"/ "second ionization energy" (of Mg)	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	(**F** =) A – B – C – D – E NOTE: These letters may be in any order, but the signs MUST be correct ALLOW answers when the enthalpy changes are identified correctly in words or symbols in lieu of the letters		**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	**First mark:** **Mg^{2+} AND O^{2-}** higher charge / **Mg^{2+} AND O^{2-}** higher charge density (than Mg^{+} and O^{-}) NOTE: **both** ions needed **(1)** **Second mark:** Mg^{2+} smaller (than Mg^{+}) **(1)** IGNORE comparisons of the relative sizes of O^{-} with O^{2-} even if INCORRECT IGNORE any references to polarization (of ions) and/or covalent character	Any mention of 'intermolecular forces' scores **(0)** overall for this question	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	(Lattice energy of $Mg^{2+}O^{2-}$ is) more exothermic/more negative ALLOW greater/increased/higher/ more/larger/bigger IGNORE "stronger lattice"	"energy **required**" OR Lower/less/ smaller	**1**

N.B. Throughout, ALLOW C_2H_6 for CH_3CH_3 and C_2H_5Cl for CH_3CH_2Cl and $C_2H_5\bullet$ for $CH_3CH_2\bullet$ and C_4H_{10} for $CH_3CH_2CH_2CH_3$ etc

If CH_4 used instead of CH_3CH_3 max (1) mark overall for (a)(i) and (a)(ii) taken together
Then mark (a)(iii) and (a)(iv) CQ as for CH_4

IGNORE positions of the dots in free radicals; dots must be shown in each radical

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	$CH_3CH_3 + Cl\cdot \rightarrow CH_3CH_2\cdot + HCl$ OR $CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$		**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	$CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$ OR $CH_3CH_3 + Cl\cdot \rightarrow CH_3CH_2\cdot + HCl$ N.B. different answers for (i) and (ii) needed		**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	$2CH_3CH_2\cdot \rightarrow CH_3CH_2CH_2CH_3$ OR $CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$	$Cl\cdot + Cl\cdot \rightarrow Cl_2$	**1**

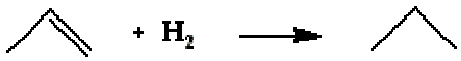
Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	$CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$ OR $2CH_3CH_2\cdot \rightarrow CH_3CH_2CH_2CH_3$ N.B. different answers for (iii) and (iv) needed		**1**

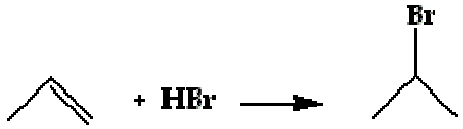
Question Number	Acceptable Answers	Reject	Mark
25(b)	**First mark:** Structural formula (enough to see the structure) **of any polyhalogenated ethane derivative** OR **any polyhalogenated methane derivative** ALLOW correct displayed or skeletal formula **(1)** **Second mark:** If first mark awarded the name must be consequentially correct IGNORE any missing or incorrect numbering in name (e.g. "dichloroethane" scores the mark) IGNORE missing or incorrect hyphens If first mark NOT awarded then only ALLOW correct name **of any polyhalogenated ethane or polyhalogenated methane derivative** **(1)**	Butane /C_4H_{10} / $CH_3CH_2CH_2CH_3$ / chlorobutane / hexane / chloromethane	**2**

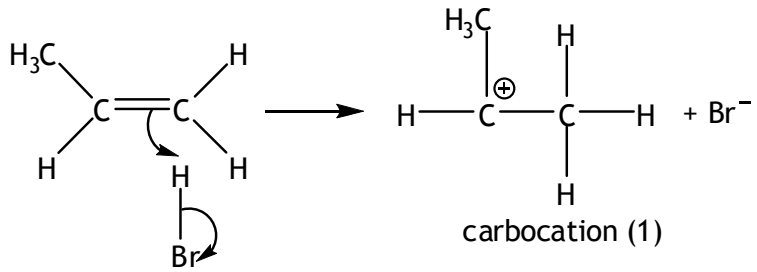
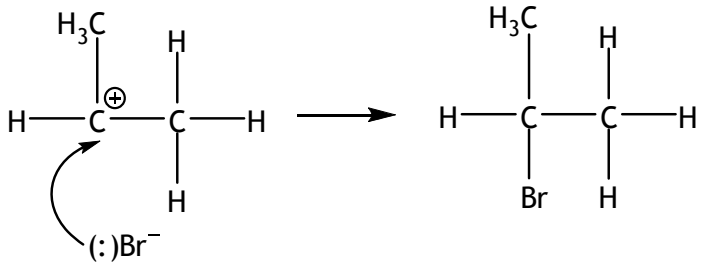
Question Number	Acceptable Answers	Reject	Mark
25(c)(i)	**1st mark for HAZARD:** This mark is for the idea of: (substance or procedure that) can cause harm/may cause harm/has the potential to do harm/can be dangerous ALLOW references to specific hazards such as toxic/flammable /harmful/ irritant /corrosive /oxidizing/ carcinogenic for the mark **(1)** **2nd mark for RISK:** This mark is for the idea of likelihood/probability/chance that harm will result (from the use of a substance or a procedure) **(1)**	**Just** "causes harm"/**just** "is a danger"	**2**

Question Number	Acceptable Answers	Reject	Mark
25(c)(ii)	fume cupboard OR gloves OR **u.v.** goggles	**Just** 'open windows'/**Just** well-ventilated lab/**Just** 'gas mask'/**Just** "use of smaller quantities"/closed system/closed experiment	**1**

Question Number	Acceptable Answers	Reject	Mark
26(a)	(C_nH_{2n} could be a) ring / cyclic (compound) ALLOW identification of any specific cyclic compound (e.g. cyclohexane) IGNORE any reference to "fewer hydrogen atoms"		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(i)	 All must be correct for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(ii)	 **First mark:-** An equation with the reactants shown correctly and EITHER 2-bromopropane OR 1-bromopropane shown as the product NOTE: The C-Br bond MUST be shown in the skeletal formula for the first mark **(1)** **Second mark (stand alone, even if no equation attempted or left-hand side of equation incorrect):-** Correct skeletal formula of **2-bromopropane** **(1)** Penalise lack of skeletal formulae once only in (b)(i) and (b)(ii) when taken together		**2**

Question Number	Acceptable Answers	Reject	Mark
26(c)	 both arrows (1) carbocation (1)  attack of bromide ion (1) **First mark:** Curly arrow from C=C to H (in H-Br) **AND** curly arrow from bond in H-Br to the Br IGNORE polarity of HBr even if incorrect **(1)** **Second mark:** Structure of correct secondary carbocation **(1)** **Third mark:** Curly arrow from anywhere on the bromide ion towards the C+ on the carbocation **NOTE:** The bromide ion must have a full negative charge, but the lone pair of electrons on the Br^- NEED NOT be shown **NOTE:** A correct mechanism leading to the formation of 1-bromopropane scores the **first** and **third** marks only (so max **(2)**) Skeletal formulae can be used	**Full** + and - charges on HBr Extra / spare bond dangling from the C+ carbon δ^- on bromide ion instead of Br^-	3

	If but-2-ene is the starting alkene, only 3rd mark can be awarded If but-1-ene is the starting alkene, 2nd and 3rd marks can be awarded ***If single-headed arrows used throughout but all else correct, then max (2) can be awarded for mechanism***		

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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Surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Tuesday 15 May 2012 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39306A

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7/7/5/5/5/

P 3 9 3 0 6 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A solution contains 66 ppm of a solute. The mass of the solute dissolved in 1 kg of this solution is

☒ **A** 66 g

☒ **B** 0.66 g

☒ **C** 0.066 g

☒ **D** 0.000066 g

(Total for Question 1 = 1 mark)

2 Complete combustion of 50 cm^3 of a hydrocarbon vapour gave 350 cm^3 of carbon dioxide, both gas volumes being measured at the same temperature and pressure. The formula of the hydrocarbon could be

☒ **A** C_8H_{18}

☒ **B** C_7H_{16}

☒ **C** C_6H_{14}

☒ **D** C_5H_{12}

(Total for Question 2 = 1 mark)

3 Which of the following statements is true? The Avogadro constant is the number of

☒ **A** grams of any element which contains 6.02×10^{23} atoms of that element.

☒ **B** atoms contained in one mole of any element.

☒ **C** atoms contained in one mole of any monatomic element.

☒ **D** particles (atoms, molecules or ions) required to make one gram of a substance.

(Total for Question 3 = 1 mark)

4 In an experiment to determine the enthalpy change of combustion of an alcohol, a spirit burner containing the alcohol was weighed, lit and placed under a copper can containing a known volume of water. The temperature rise of the water was measured and the burner re-weighed. The enthalpy change calculated from the results was much less exothermic than the value reported in the literature.

Which of the following factors is **most** likely to be the cause of this error?

☒ **A** Heat loss around the side of the copper can.

☒ **B** The use of a thermometer with a range of 0 – 110 °C rather than 0 – 50 °C.

☒ **C** The use of a measuring cylinder for measuring the water rather than a pipette.

☒ **D** Evaporation of the alcohol during the weighing.

(Total for Question 4 = 1 mark)

5 The standard enthalpy changes of formation of carbon dioxide and of methanoic acid are -394 kJ mol^{-1} and -409 kJ mol^{-1} respectively. Calculate the enthalpy change for the reaction

$$H_2(g) + CO_2(g) \rightarrow HCOOH(l)$$

☒ **A** -803 kJ mol^{-1}

☒ **B** -15 kJ mol^{-1}

☒ **C** $+803$ kJ mol^{-1}

☒ **D** $+15$ kJ mol^{-1}

(Total for Question 5 = 1 mark)

6 For which of the following changes is the value of ΔH negative?

☒ **A** $K(g) \rightarrow K^+(g) + e^-$

☒ **B** $K^+Cl^-(s) \rightarrow K^+(g) + Cl^-(g)$

☒ **C** $Cl(g) + e^- \rightarrow Cl^-(g)$

☒ **D** $Cl_2(g) \rightarrow 2Cl(g)$

(Total for Question 6 = 1 mark)

7 In which of the following cases would a cation be most polarizing?

		Radius	Charge
☒	**A**	small	small
☒	**B**	small	large
☒	**C**	large	small
☒	**D**	large	large

(Total for Question 7 = 1 mark)

8 Magnesium chloride, $MgCl_2$, has two lattice energy values quoted in the data booklet. The first is the experimental value, obtained from the Born-Haber cycle, -2526 kJ mol^{-1}; the second is the theoretical value, -2326 kJ mol^{-1}. Why are the two values different?

☒ **A** The cation polarizes the anion leading to some covalent bonding.

☒ **B** The anion polarizes the cation leading to some covalent bonding.

☒ **C** Magnesium chloride is a covalent substance.

☒ **D** The results from the Born-Haber cycle are too inaccurate to be reliable.

(Total for Question 8 = 1 mark)

9 Which of the following represents the process occurring when the enthalpy change of atomization of bromine is measured?

☒ **A** $\frac{1}{2}Br_2(l) \rightarrow Br(g)$

☒ **B** $\frac{1}{2}Br_2(g) \rightarrow Br(g)$

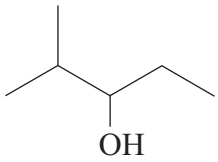
☒ **C** $Br_2(l) \rightarrow Br^+(g) + Br^-(g)$

☒ **D** $Br_2(g) \rightarrow Br^+(g) + Br^-(g)$

(Total for Question 9 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

10 An organic compound is represented by the skeletal formula shown below.



The compound is

☒ **A** $CH_3CH_2CH_2CH(OH)CH_2CH_3$

☒ **B** $(CH_3)_2CHC(OH)(CH_3)_2$

☒ **C** $(CH_3)_2CHCH_2CH(OH)CH_3$

☒ **D** $(CH_3)_2CHCH(OH)CH_2CH_3$

(Total for Question 10 = 1 mark)

11 How many structural isomers does the alkane C_5H_{12} have?

☒ **A** 4

☒ **B** 3

☒ **C** 2

☒ **D** 1

(Total for Question 11 = 1 mark)

12 When methane reacts with chlorine, a mixture of products forms. Which product provides the strongest evidence for a free radical mechanism?

☒ **A** C_2H_6

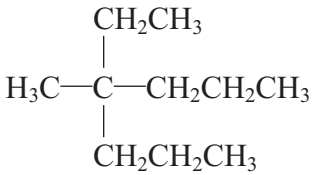
☒ **B** CH_3Cl

☒ **C** HCl

☒ **D** $CHCl_3$

(Total for Question 12 = 1 mark)

13 What is the IUPAC name of the compound shown below?



- ☒ **A** 2-ethyl-2-propylpentane
- ☒ **B** 3-methyl-3-propylhexane
- ☒ **C** 4-methyl-4-propylhexane
- ☒ **D** 4-ethyl-4-methylheptane

(Total for Question 13 = 1 mark)

14 The reaction of bromine with propene is an example of

- ☒ **A** electrophilic substitution.
- ☒ **B** free radical substitution.
- ☒ **C** electrophilic addition.
- ☒ **D** free radical addition.

(Total for Question 14 = 1 mark)

15 A compound **Z** contains, by mass, 26.7% carbon, 2.2% hydrogen, and 71.1% oxygen.
The empirical formula of **Z** is

- ☒ **A** CHO_2
- ☒ **B** $C_2H_2O_4$
- ☒ **C** CHO
- ☒ **D** $C_2H_2O_2$

(Total for Question 15 = 1 mark)

16 In which of the following series does the melting temperature of the element **increase** from left to right?

☒ **A** Li, Na, K

☒ **B** Al, Si, P

☒ **C** Si, P, S

☒ **D** Na, Mg, Al

(Total for Question 16 = 1 mark)

17 If **X** represents the element of atomic number 9 and **Y** the element of atomic number 20, the compound formed between these two elements is

☒ **A** covalent, $\mathbf{YX_2}$.

☒ **B** ionic, $\mathbf{YX_2}$.

☒ **C** covalent, **YX**.

☒ **D** ionic, **YX**.

(Total for Question 17 = 1 mark)

18 The equation representing the reaction between copper(II) oxide and dilute sulfuric acid is

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

The **ionic** equation for the reaction is

☒ **A** $Cu^{2+}(s) + SO_4^{2-}(aq) \rightarrow CuSO_4(aq)$

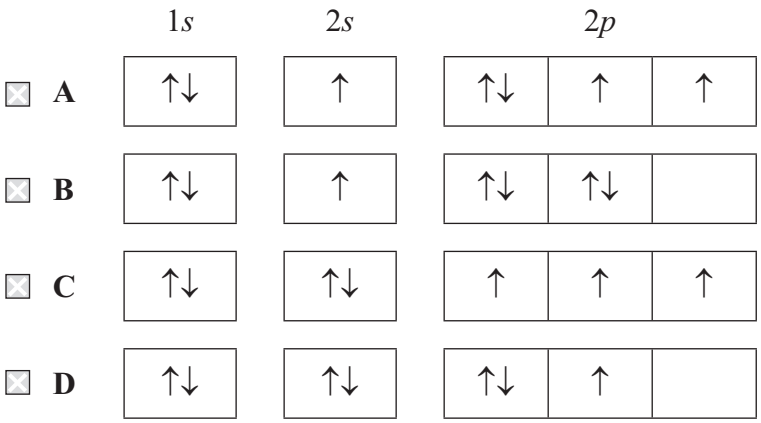
☒ **B** $O^{2-}(s) + H_2SO_4(aq) \rightarrow H_2O(l) + SO_4^{2-}(aq)$

☒ **C** $CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$

☒ **D** $CuO(s) + H_2SO_4(aq) \rightarrow Cu^{2+}SO_4^{2-}(aq) + H_2O(l)$

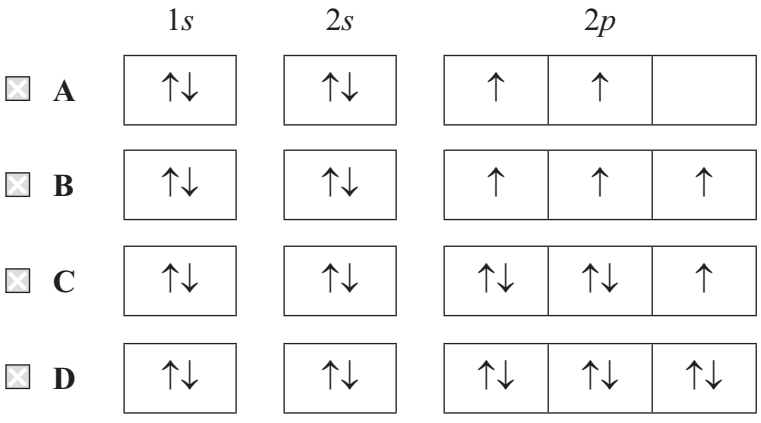
(Total for Question 18 = 1 mark)

19 Which of the following represents the electronic structure of a nitrogen atom?



(Total for Question 19 = 1 mark)

20 The electronic structures of four elements are given below. Which of these elements has the highest first ionization energy?



(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 (a) Define the term **relative isotopic mass**.

(2)

.....

.....

.....

.....

(b) Naturally occurring chlorine contains 75.53% of ^{35}Cl and 24.47% of ^{37}Cl.

(i) Calculate the relative atomic mass of chlorine to **four** significant figures.

(2)

(ii) Two of the peaks in the mass spectrum of chlorine, Cl_2, are at *m/e* 70 and 74. Identify the species giving rise to these peaks.

(2)

70 .....

74 .....

(iii) What is the *m/e* value of the other peak that you would expect to see in this region of the mass spectrum and the identity of the species giving rise to it?

(2)

Value .....

Species .....

(Total for Question 21 = 8 marks)

22 (a) Define the term **first ionization energy**.

(2)

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*(b) Explain why the first ionization energy of the elements down Group 1 decreases even though the atomic number increases.

(2)

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(c) The eleven successive ionization energies for sodium are given below.

Electron removed	1	2	3	4	5	6	7	8	9	10	11
Ionization energy / kJ mol^{-1}	496	4563	6913	9544	13352	16611	20115	24491	28934	141367	159079

(i) Explain why the successive ionization energies increase.

(1)

.....

.....

.....

*(ii) Explain how these ionization energies give evidence for the electronic structure of sodium. You may use a sketch graph if you wish.

(2)

(d) The first ionization energy of aluminium (element 13) is lower than that of magnesium (element 12).

(i) Give the electronic structures of magnesium and of aluminium in *s*, *p* and *d* notation.

(1)

Magnesium .....

Aluminium .....

*(ii) Explain the difference in the first ionization energies of the two metals.

(1)

(Total for Question 22 = 9 marks)

23 (a) State Hess's Law.

(1)

.....

.....

.....

(b) Methane burns in a limited supply of oxygen to give carbon monoxide and water.

$$CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(l)$$

The enthalpy change for this reaction cannot be determined directly, but can be found using the standard enthalpy changes of combustion of methane and carbon monoxide, together with Hess's Law.

The standard enthalpy changes of combustion needed are for CH_4, -890 kJ mol^{-1}, and for CO, -283 kJ mol^{-1}.

(i) Draw a Hess's Law diagram which would enable you to calculate the enthalpy change for the combustion of methane to carbon monoxide.

$$CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(l)$$

(2)

(ii) Calculate the enthalpy change for this reaction, in kJ mol^{-1}.

(2)

(iii) Explain why the enthalpy change for this reaction cannot be determined directly.

(1)

.....

.....

.....

(c) Explain why the calculation in part (b)(ii) would give an incorrect result for the enthalpy change for the reaction below.

$$CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(g)$$

(2)

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.....

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.....

(Total for Question 23 = 8 marks)

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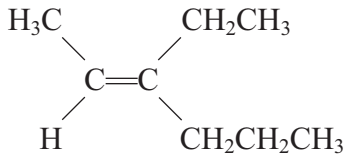
24 (a) Give the general formula for the homologous series of **alkenes**.

(1)

(b) What is meant by the term **unsaturated** as applied to alkenes?

(1)

(c) (i) Name the alkene below using *E-Z* nomenclature.



(2)

(ii) Suggest why this alkene cannot be named using the *cis-trans* naming system.

(1)

(d) Give the structural formula of the organic product of the reaction of ethene, $CH_2{=}{=}CH_2$, with

(i) hydrogen.

(1)

(ii) chlorine.

(1)

(iii) acidified aqueous potassium manganate(VII).

(1)

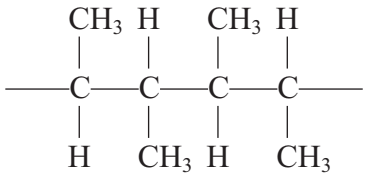
(iv) bromine **water**.

(1)

(e) Draw the mechanism for the reaction of **propene** with hydrogen bromide to give the major product.

(4)

(f) The structure below shows **two** repeat units of a polymer.



(i) Give the displayed formulae of **two** isomeric alkenes, either of which could have given rise to this polymer.

(2)

(ii) State why the empirical formula of a poly(alkene) is the same as that of the monomer from which it is produced.

(1)

(iii) State, with a reason, the atom economy for the production of a poly(alkene) from an alkene.

(1)

(Total for Question 24 = 17 marks)

25 Sodium burns in oxygen to give a pale yellow solid **X**.

(a) (i) 1.73 g of sodium reacts with 1.20 g of oxygen.

Calculate the empirical formula of **X**.

(2)

(ii) The molar mass of **X** is 78 g mol^{-1}. Give the molecular formula of **X**.

(1)

(iii) Write the equation, including state symbols, for the reaction of sodium with oxygen to produce **X**.

(2)

(iv) Calculate the volume of oxygen in dm^3 (at room temperature and pressure) which reacts with 1.73 g of sodium. (The molar volume of any gas at room temperature and pressure is 24 dm^3 mol^{-1}.)

(2)

(v) Calculate the number of oxygen **molecules** that react with 1.73 g of sodium. (The Avogadro constant = 6.02×10^{23} mol^{-1}.)

(1)

(b) If sodium is burnt in **air**, compound **X** is not the only product. Suggest why this is so.

(1)

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.....

(Total for Question 25 = 9 marks)

26 (a) Explain how the atoms are held together by the covalent bond in a molecule of hydrogen.

(1)

.....

.....

.....

(b) Draw the dot and cross diagrams for

(i) methane, CH_4

(1)

(ii) ethene, $CH_2{=}{=}CH_2$

(1)

(iii) nitrogen, N_2

(1)

(iv) the ammonium ion, NH_4^+

(1)

(c) Silicon exists in a giant covalent lattice.

(i) The electrical conductivity of pure silicon is very low. Explain why this is so in terms of the bonding.

(2)

(ii) Explain the high melting temperature of silicon in terms of the bonding.

(2)

(Total for Question 26 = 9 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 3 9 3 0 6 A 0 2 4 2 4

PMT

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Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		**1**

Question Number	Correct Answer	Reject	Mark
2	B		**1**

Question Number	Correct Answer	Reject	Mark
3	C		**1**

Question Number	Correct Answer	Reject	Mark
4	A		**1**

Question Number	Correct Answer	Reject	Mark
5	B		**1**

Question Number	Correct Answer	Reject	Mark
6	C		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Correct Answer	Reject	Mark
8	A		**1**

Question Number	Correct Answer	Reject	Mark
9	A		**1**

Question Number	Correct Answer	Reject	Mark
10	D		**1**

Question Number	Correct Answer	Reject	Mark
11	B		**1**

Question Number	Correct Answer	Reject	Mark
12	A		**1**

Question Number	Correct Answer	Reject	Mark
13	D		**1**

Question Number	Correct Answer	Reject	Mark
14	C		**1**

Question Number	Correct Answer	Reject	Mark
15	A		**1**

Question Number	Correct Answer	Reject	Mark
16	D		**1**

Question Number	Correct Answer	Reject	Mark
17	B		**1**

Question Number	Correct Answer	Reject	Mark
18	C		**1**

Question Number	Correct Answer	Reject	Mark
19	C		**1**

Question Number	Correct Answer	Reject	Mark
20	D		**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)	**First mark:** Mass of **an atom**/mass of **an isotope** (of an element) **(1)** IGNORE any references to average or (weighted) mean **Second mark:** relative to 1/12th the mass of a ^{12}C atom **(1)** NOTE: The second mark is awarded for **any mention of ^{12}C** IGNORE throughout the candidate's answer any references to 'moles' or '1 mol' or '12 g' Mark the two points independently	Mass of (all the) isotope**s** /atom**s** 'Mass of an element'	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	{(35 x 75.53) + (37 x 24.47)} ÷ 100 **(1)** = 35.4894 = 35.49 **(1)** **Answer to 4 s.f. only**. Correct answer no working **(2)** IGNORE units of any kind (e.g. 'g' 'g mol^{-1}' 'amu', etc.)		**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$^{35}Cl_2^+$/(^{35}Cl —$^{35}Cl)^+$ **(1)** $^{37}Cl_2^+$/(^{37}Cl —$^{37}Cl)^+$ **(1)** ALLOW (^{35}Cl + $^{35}Cl)^+$ and/or (^{37}Cl + $^{37}Cl)^+$ OR ($^{35}Cl^{35}Cl)^+$ and/or ($^{37}Cl^{37}Cl)^+$ OR (^{35}Cl and $^{35}Cl)^+$ and/or (^{37}Cl and $^{37}Cl)^+$ If the 'formal' charge is omitted on either ion (or both the ions), then award **(1)** mark only. NOTE: $^{35}Cl^+$ $^{35}Cl^+$ and $^{37}Cl^+$ $^{37}Cl^+$ scores **(1)** as each ion has an extra + charge. $2^{35}Cl^+$ and $2^{37}Cl^+$ scores **(1)** Accept mass number written as superscript to right of symbol.	$^{70}Cl_2^+$ $^{74}Cl_2^+$ $2^{35}Cl$ and/or $2^{37}Cl$ scores **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	**72** **(1)** ^{35}Cl —$^{37}Cl^{(+)}$ **(1)** ALLOW (^{35}Cl + $^{37}Cl)^{(+)}$ and/or (^{37}Cl + $^{35}Cl)^{(+)}$ OR ($^{37}Cl^{35}Cl)^{(+)}$ and/or ($^{37}Cl^{35}Cl)^{(+)}$ OR (^{35}Cl and $^{37}Cl)^{(+)}$ and/or (^{37}Cl and $^{35}Cl)^{(+)}$ NOTE: The + charge is not needed on **this ion** IGNORE extra + charges, so ALLOW $^{35}Cl^+$ $^{37}Cl^+$ and/or $^{37}Cl^+$ $^{35}Cl^+$		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)	**First mark:-** Makes mention of energy/enthalpy/(heat) energy/heat (change) AND to remove an electron AND one mole/1 mol **Second mark:** Makes mention of **gaseous atom(s)** **ALTERNATIVE ANSWER** Energy change per mole for **(1)** $X(g) \rightarrow X^{+}(g) + e^{(-)}$ **(1)** Mark the two points independently IGNORE any references to standard conditions	"Energy **given out**…" for first mark **Just** 'gaseous element'/ 'gaseous substance'	**2**

Question Number	Acceptable Answers	Reject	Mark
***22(b)**	**Any two from three:-** (Atomic) radius increases/there are more shells/(outermost) electron further from the nucleus **(1)** there is '**more** shielding' or '**more** screening' (down group) **(1)** the nuclear attraction decreases OR attraction between nucleus and (outermost) electron decreases OR the increased shielding/increased distance outweighs the increased nuclear charge **(1)** IGNORE any references to 'more protons' and/just 'increasing nuclear charge' IGNORE references to "effective nuclear charge"	**Ionic** radius increases	**2**

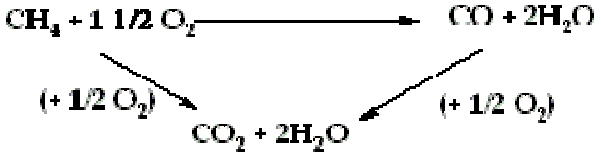
Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	**Any ONE from:** (Electrons are being removed from an) increasingly positive ion/ charge on the ion (successively) increases/ increasing proton : electron ratio/ same number of protons (attracting) fewer electrons / ions get smaller/ the electron repulsion decreases/ the shielding decreases/ electrons (being removed are) closer to the nucleus/ **effective** nuclear charge increases		**1**

Question Number	Acceptable Answers	Reject	Mark
***22(c)(ii)**	**First mark: <u>Two</u> jumps** **Two** (large) jumps (between 1st and 2nd and 9th and 10th IEs) **(1)** NOTE: A sketch graph with **two** (large) jumps can score this first mark Note if the jumps are specified, they must be between 1st and 2nd **and** 9th and 10th IEs **Second mark: Electronic configuration of Na** 2, 8, 1 mentioned in words, **annotated** on a sketch graph or drawn out in a diagram (e.g. electrons shown in orbits/shells around the centre of the atom) but NOT just inferred **(1)** ALLOW "1, 8, 2" OR $1s^2 2s^2 2p^6 3s^1$ Mark the two points independently	1st mark if the graph is sketched 'back to front'	**2**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	Credit any of the following representations (but need **BOTH** Mg **AND** Al to be correct) Mg $1s^2 2s^2 2p^6 3s^2$ **and** Al $1s^2 2s^2 2p^6 3s^2 3p^1$ Mg $1s_2 2s_2 2p_6 3s_2$ **and** Al $1s_2 2s_2 2p_6 3s_2 3p_1$ Mg $1S^2 2S^2 2P^6 3S^2$ **and** Al $1S^2 2S^2 2P^6 3S^2 3P^1$ Mg $1S_2 2S_2 2P_6 3S_2$ **and** Al $1S_2 2S_2 2P_6 3S_2 3P_1$		**1**

Question Number	Acceptable Answers	Reject	Mark
***22(d)(ii)**	NOTE: ALLOW an argument focusing on **either** the Al **or** the Mg atom **EITHER** **In Al**, (3p) **electron** (lost is) at higher energy/more shielded (by 3s electrons)/further from the nucleus IGNORE any reference to an unpaired electron in Al **OR** **In Mg**, (3s) **electron** (lost is) at lower energy/less shielded/ nearer to the nucleus/from a **full subshell**/from a full orbital/from (stable) $(3)s^2$ Any reference to an Al atom being **larger** in size than an Mg atom scores zero overall.	Al has one more **shell** than Mg **Just** (lost from) a new sub-shell Electron lost in Mg from a "full **shell**"	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)	The heat/enthalpy/energy change (for a reaction) is independent of the path(way)/route IGNORE any extra detail referring to "initial and final states"		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	 CO_2 + **2**H_2O **(1)** Both arrows in correct direction downwards **(1)** IGNORE state symbols, even if incorrect Mark the two points independently		**2**

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	ΔH = − 890 −(− 283) **(1)** = − 607 (kJ mol^{-1}) **(1)** Correct answer with no working scores **(2)** NOTE: **+**607 (kJ mol^{-1}) scores **(1)** only		**2**

Question Number	Acceptable Answers	Reject	Mark
***23 (b) (iii)**	Cannot stop the reaction at CO OR the reaction produces CO_2/complete combustion occurs OR may produce some carbon/soot OR cannot react exact amounts of methane to oxygen	non-standard conditions **Just** incomplete combustion occurs **Just** forming 'other products' /**just** a 'mixture of products' **Just** methane is 'very reactive'/ 'explosive' **Just** heat loss Cannot measure the temperature change	**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark: State of the H_2O** Water is in the gas phase/water is (formed) as steam/water is not in its standard state/water is not (formed as a) liquid **(1)** **Second mark: Idea of an energy change when there is a change of state** Change of state involves an energy change /energy change (for the reaction given) is less exothermic **(1)** ALLOW 'more endothermic' instead of 'less exothermic' IGNORE references to non-standard conditions	Energy change is more exothermic /less endothermic Heat loss 'Incomplete combustion'	**2**

Question Number	Acceptable Answers	Reject	Mark
24(a)	C_nH_{2n} ALLOW letters other than *n*		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)	A compound which contains (C=C) double bonds OR A compound that will undergo addition reactions OR Does not contain the maximum number of hydrogen atoms		**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	*E*-3-ethylhex-2-ene **(2)** **(1)** mark for 3-ethylhex-2-ene **(1)** mark for '**E'** IGNORE any missing hyphens or any hyphens replaced by commas Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	The four atoms/four groups around the C=C double bond are different OR No two groups are the same OR There are no common groups on either side of the C=C double bond OR There are two alkyl groups on one of the carbon atoms (in the C=C double bond) OR There are three alkyl groups around the double bond OR An indication of the existence of Priority Rules (for E-Z nomenclature) OR One of the carbon atoms (of the C=C double bond) is not bonded to a hydrogen atom ALLOW 'functional groups' for 'groups'	Each side is not symmetrical	**1**

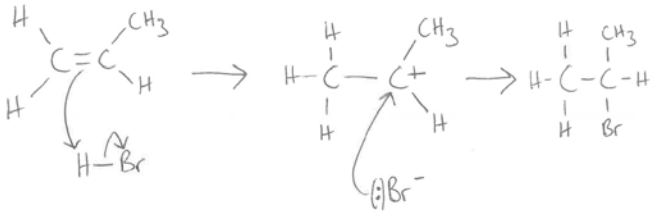
ALLOW displayed or skeletal formulae throughout 24(d)

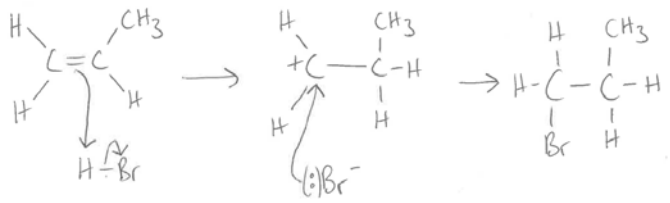
Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	CH_3CH_3 ALLOW displayed or skeletal formulae throughout 24(d)	C_2H_6	**1**

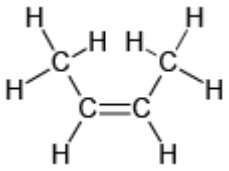
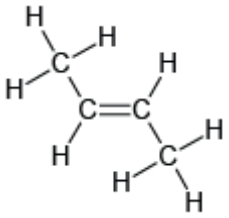
Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	$ClCH_2CH_2Cl$ / CH_2ClCH_2Cl	$C_2H_4Cl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	$HOCH_2CH_2OH$ / CH_2OHCH_2OH	$C_2H_6O_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iv)	$HOCH_2CH_2Br$ / CH_2OHCH_2Br	$BrCH_2CH_2Br$; C_2H_5OBr; $C_2H_4Br_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(e)	Major product route:  **First mark:** Curly arrow from C=C to the H (in H-Br) **AND** curly arrow from the bond in H—Br to the Br **(1)** **Second mark:** Structure of correct secondary carbocation **(1)** **Third mark:** Curly arrow from anywhere on the bromide ion towards the C+ on the carbocation **(1)** NOTE: The bromide ion must have a full negative charge, but the lone pair of electrons on the Br^- NEED NOT be shown **Fourth mark:** Choice of 2-bromopropane as major product **(1)** For showing the major product mechanism correctly **(4)** • both arrows **(1)** • carbocation intermediate **(1)** • attack by bromide ion **(1)** (Bromide ion must show a full negative charge. The lone pair of electrons need not be shown) • choice of 2-bromopropane as major product **(1)**		**4**

	Single-headed arrows used throughout **max (3)** Minor product route **max (3)**  If the minor product route is shown, the last mark is lost, but the first three marks can be scored consequentially as follows:- • both arrows **(1)** • carbocation intermediate **(1)** • attack of bromide ion **(1)** (NOTE: The bromide ion must show a full negative charge. The lone pair of electrons need not be shown) NOTE: If a correct mechanism for the electrophilic addition of HBr to **ethene** is shown then max **(2)** (i.e. the first and the third marks in the mechanism)		

Question Number	Acceptable Answers	Reject	Mark
24(f)(i)	 **(1)**  **(1)** NOTE: CH_3 group does not have to be displayed. IGNORE if any connectivity is shown from the **H_3** in a C**H_3** group IGNORE bond angles ALLOW one mark for just but-2-ene's structural formula		**2**

Question Number	Acceptable Answers	Reject	Mark
24(f)(ii)	**Any ONE of:-** • No atoms lost (or gained) • No elements lost (or gained) • (Only) one product (is formed) • (Produced by) an addition reaction • Addition polymer(ization) • Polymer is a repeat of the monomer • No small molecules (formed) • No co-products • No waste products • Same C:H ratio • Same ratio of carbon:hydrogen atoms • Same ratio of each element • Same ratio of atoms	(Monomer and polymer have) '**same number** of carbon and hydrogen atoms'	**1**

Question Number	Acceptable Answers	Reject	Mark
24(f)(iii)	**100% AND** some correct justification is needed **ONE answer from:-** 100% as addition reaction 100% because all the atoms are incorporated into the polymer 100% because (only) one product is formed 100% because (only) one desired product is formed 100% because no atoms are lost 100% because no waste products 100% because no small molecules (formed) 100% as no co-products 100% as no by-products	Statements such as 'the atom economy is **almost** 100%' OR **Just** "it has a high atom economy"	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	Amount Na = 1.73 (g) ÷ 23 (g mol^{-1}) = 0.075(22) (mol) Amount O = 1.20 (g) ÷ 16 (g mol^{-1}) = 0.075 (mol) **(1)** IGNORE sf, even if 1 sf NaO **(1)** Correct answer no working **(2)** NOTE: Correct answer can be obtained via incorrect working and all responses should be read carefully e.g. Amount Na = 23 ÷ 1.73 = 13.3 Amount O = 16 ÷ 1.20 = 13.3 scores second mark only for NaO if obtained by incorrect working OR e.g. Use of atomic numbers gives the Na : O ratio as 0.157 : 0.150 and an empirical formula of NaO. This scores (1) overall (i.e. the 2nd mark). OR e.g Use of atomic number ONLY for Na (i.e. Na = 11) gives the Na : O ratio as 0.157 : 0.075 and an empirical formula of Na_2O. This scores (1) overall (i.e. the 2nd mark). NOTE: Use of **O** = 32 gives Na_2O and scores second mark	 Na_2O_2	**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	(NaO = 39 hence molar mass twice that of NaO ∴) so **Na_2O_2**	'2NaO'	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	$2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$ All species correct **(1)** State symbols and balancing **(1)** NOTE: 2nd mark is conditional on correct species. NOTE: $2Na(s) + O_2(g) \rightarrow 2NaO(s)$ scores **(1)** $Na(s) + O_2(g) \rightarrow NaO_2(s)$ scores **(1)** $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$ scores **(2)**		**2**

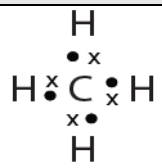
Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	Moles of O_2 = 0.075 ÷ 2 = 0.0375 OR 1.2 ÷ 32 = 0.0375 (mol) **(1)** 0.0375 mol x 24 dm^3 mol^{-1} = 0.9(0) (dm^3) **(1)** ALLOW 900 **cm^3 (units must be present here)** Correct answer no working **(2)** OR Moles of Na = 1.73 ÷ 23 = 0.075217 = moles of O Moles of O_2 = 0.075217 ÷ 2 = 0.0376085 0.0376085 x 24 = 0.903 (dm^3) or 903 **cm^3** IGNORE s.f., including ONE s.f. NOTE: If number of moles x 24 (dm^3 mol^{-1}) is clearly evident and correctly calculated in stated units, award second mark		**2**

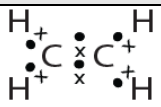
Question Number	Acceptable Answers	Reject	Mark
25(a)(v)	0.0375 x 6.02 x 10^{23} (= 2.2575 x 10^{22} (molecules)) = 2.26 x 10^{22} (molecules) IGNORE s.f. unless 1 s.f.		**1**

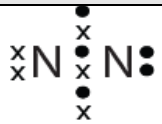
Question Number	Acceptable Answers	Reject	Mark
25(b)	Sodium might react with nitrogen in the air/sodium forms a nitride/ nitrogen (gas) is present in the air (which reacts with the sodium) OR sodium might form a different oxide (e.g. Na_2O or allow NaO_2) NOTE: If nitrogen / N_2 is mentioned as part of a 'list' of substances that can be present in air, award the mark	**Just** 'very reactive' OR 'very explosive' sodium forms Na_2O_2 alone References to hydrogen in the air **Just** 'reacts with other substances in the air' (as nitrogen not identified Sodium nitrate formation **Just** sodium hydroxide formation	**1**

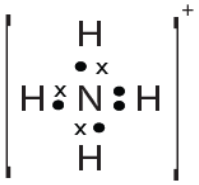
Question Number	Acceptable Answers	Reject	Mark
26(a)	(Electrostatic) attraction between (bonding) electrons and nuclei/protons	**Just** a 'shared pair of electrons'	**1**

- IGNORE ANY INNER SHELL ELECTRONS DRAWN
- ONLY THE TOTAL NUMBERS OF ELECTRONS IN OUTER SHELLS ARE BEING ASSESSED
- ALLOW ELECTRONS TO BE ALL DOTS OR ALL CROSSES OR BOTH

Question Number	Acceptable Answers	Reject	Mark
26(b)(i)			**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(ii)			**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(iii)	 NOTE: The lone pair of electrons on each N atom do not have to be shown as a pair		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(iv)	 The **+** sign can be shown anywhere Ignore missing brackets Ignore if the **+** is missing		**1**

Question Number	Acceptable Answers	Reject	Mark
26(c)(i)	IGNORE any references to 'molecules' in this part only **First mark: Location of silicon's electrons** Silicon's (outer) electrons are fixed (in covalent bonds)/ silicon's (outer) electrons are in fixed positions (in covalent bonds)/ silicon's (outer) electrons are involved in bonding **(1)** **Second mark: Lack of mobility of silicon's electrons** (therefore) silicon's electrons are not free (to move)/ silicon has no free electrons/ there are no mobile electrons in silicon/ silicon has no delocalized electrons/ silicon's electrons cannot flow **(1)** IGNORE references to **lack of** ions	'Silicon is ionic' scores **(0)** for the question 'silicon's **ions** are not free to move' scores **(0)** for the question	**2**

Question Number	Acceptable Answers	Reject	Mark
26(c)(ii)	(The covalent) bonds are **strong** (throughout the lattice) **(1)** (therefore) a lot of **energy** is required to break the bonds / a lot of **energy** is needed to overcome the attractions **(1)** IGNORE any references to 'giant molecular'	'(simple) molecular silicon' **(0)** /'molecules of silicon' **(0)** /'silicon has ions' **(0)** /'intermolecular forces' / 'van der Waals' forces'/ 'London forces' **(0)** ALL THE ABOVE SCORE **(0)** OVERALL	**2**

TOTAL FOR SECTION B = 60 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 10 January 2013 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41212A

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7/6/5/5/4/5/

P 4 1 2 1 2 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 When aqueous solutions of barium chloride and potassium sulfate are mixed, a white precipitate forms. The ionic equation for the reaction is

☒ **A** $K^+(aq) + Cl^-(aq) \rightarrow KCl(s)$

☒ **B** $K^{2+}(aq) + 2Cl^-(aq) \rightarrow KCl_2(s)$

☒ **C** $Ba^+(aq) + SO_4^-(aq) \rightarrow BaSO_4(s)$

☒ **D** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

(Total for Question 1 = 1 mark)

2 Which of the following processes has the highest atom economy?

☒ **A** Making poly(ethene) from ethene.

☒ **B** Making ethene from eicosane, $C_{20}H_{42}$.

☒ **C** Making chloromethane from methane.

☒ **D** Making magnesium chloride from magnesium and hydrochloric acid.

(Total for Question 2 = 1 mark)

3 How many molecules are present in 16 g of oxygen gas, $O_2(g)$?

[Avogadro constant = 6×10^{23} mol^{-1}]

☒ **A** 96×10^{23}

☒ **B** 12×10^{23}

☒ **C** 6×10^{23}

☒ **D** 3×10^{23}

(Total for Question 3 = 1 mark)

4 Nickel(II) sulfate is prepared by adding an excess of nickel(II) carbonate to 0.010 mol of dilute sulfuric acid.

$$NiCO_3(s) + H_2SO_4(aq) \rightarrow NiSO_4(aq) + H_2O(l) + CO_2(g)$$

Solid nickel(II) sulfate crystals are produced with a 20% yield. How many moles of nickel(II) sulfate crystals are obtained?

☒ **A** 0.001

☒ **B** 0.002

☒ **C** 0.010

☒ **D** 0.050

(Total for Question 4 = 1 mark)

5 When 0.635 g of copper (relative atomic mass, RAM = 63.5) is added to an excess of silver nitrate solution, 2.158 g of silver (RAM = 107.9) form. The ionic equation for the reaction is

☒ **A** $Cu(s) + Ag^{2+}(aq) \rightarrow Cu^{2+}(aq) + Ag(s)$

☒ **B** $Cu(s) + Ag^{+}(aq) \rightarrow Cu^{+}(aq) + Ag(s)$

☒ **C** $2Cu(s) + Ag^{2+}(aq) \rightarrow 2Cu^{+}(aq) + Ag(s)$

☒ **D** $Cu(s) + 2Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

(Total for Question 5 = 1 mark)

6 In an experiment to measure the enthalpy change of a reaction involving gases, which of the following conditions must always be kept constant?

☒ **A** Pressure

☒ **B** Temperature

☒ **C** Volume

☒ **D** Temperature and pressure

(Total for Question 6 = 1 mark)

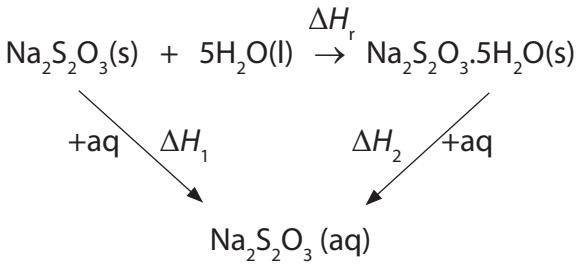
7 In an endothermic reaction in aqueous solution, which of the following is correct?

	Temperature	Sign of enthalpy change
☒ **A**	Increases	Positive
☒ **B**	Increases	Negative
☒ **C**	Decreases	Positive
☒ **D**	Decreases	Negative

(Total for Question 7 = 1 mark)

8 The enthalpy change for the reaction to form hydrated sodium thiosulfate crystals cannot be measured directly.

The following Hess cycle can be used.



The enthalpy change for the reaction, ΔH_r, is equal to

☒ **A** $\Delta H_1 + \Delta H_2$

☒ **B** $\Delta H_1 - \Delta H_2$

☒ **C** $-\Delta H_1 - \Delta H_2$

☒ **D** $-\Delta H_1 + \Delta H_2$

(Total for Question 8 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

9 When 10 cm^3 of 2 mol dm^{-3} hydrochloric acid is reacted with 10 cm^3 of 2 mol dm^{-3} sodium hydroxide solution, the temperature change is ΔT.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

When the reaction is repeated with 50 cm^3 of each solution, the temperature change is

☒ **A** ΔT

☒ **B** $5 \times \Delta T$

☒ **C** $\frac{1}{5} \times \Delta T$

☒ **D** $10 \times 2 \times \Delta T$

(Total for Question 9 = 1 mark)

10 An isotope of an element, atomic number z, has mass number 2z + 4. How many neutrons are in the nucleus of the element?

☒ **A** z + 4

☒ **B** z + 2

☒ **C** z

☒ **D** 4

(Total for Question 10 = 1 mark)

11 When an Al^{4+} ion is formed from an Al atom, the fourth electron is lost from the

☒ **A** 1s sub-shell.

☒ **B** 2s sub-shell.

☒ **C** 2p sub-shell.

☒ **D** 3s sub-shell.

(Total for Question 11 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

12 Metals are good conductors of electricity because

- ☒ **A** metal atoms are arranged in a regular lattice.
- ☒ **B** metal ions are very close to each other.
- ☒ **C** metal ions are free to move through the lattice.
- ☒ **D** electrons are free to move through the lattice.

(Total for Question 12 = 1 mark)

13 Which of the following statements is evidence for the existence of ions in ionic compounds?

- ☒ **A** Ionic compounds, in the solid state, conduct electricity.
- ☒ **B** When **any** ionic compound in solution is electrolysed, the migration of ions can be seen.
- ☒ **C** In electron density maps for ionic compounds, there is no single line representing electron density that surrounds both cations and anions.
- ☒ **D** In electron density maps for ionic compounds, there are some single lines representing electron density that surround both cations and anions.

(Total for Question 13 = 1 mark)

14 White phosphorus consists of

- ☒ **A** a giant structure of atoms.
- ☒ **B** a giant structure of ions.
- ☒ **C** small molecules.
- ☒ **D** single atoms.

(Total for Question 14 = 1 mark)

15 Isomers have different

- ☒ **A** empirical formulae.
- ☒ **B** molecular formulae.
- ☒ **C** skeletal formulae.
- ☒ **D** molar masses.

(Total for Question 15 = 1 mark)

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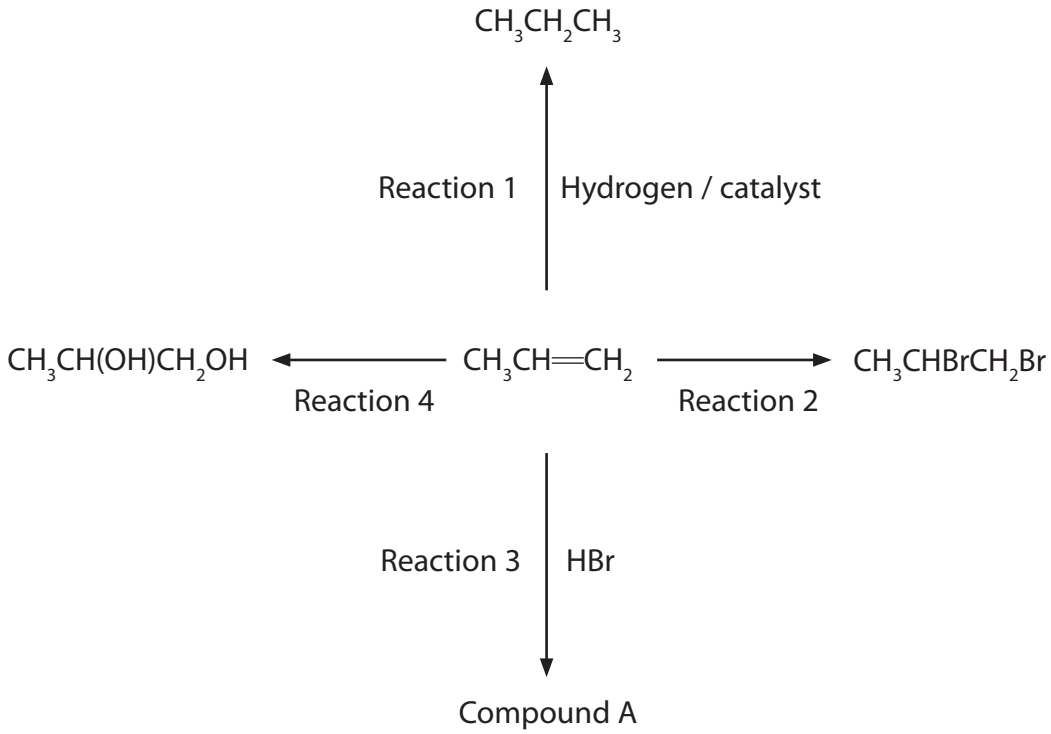
16 Four of the reactions of propene are shown on the diagram below.



(a) Nickel is often used as the catalyst for Reaction 1. Use your Periodic Table to select which of the following metals can be used instead of nickel to catalyse Reaction 1.

(1)

☒ **A** Potassium

☒ **B** Calcium

☒ **C** Gallium

☒ **D** Palladium

(b) The name of the reagent and the product for Reaction 2 are

(1)

	Reagent	Product
☒ **A**	bromine water	dibromopropane
☒ **B**	bromine	dibromopropane
☒ **C**	bromine water	1,2-dibromopropane
☒ **D**	bromine	1,2-dibromopropane

(c) What is formed in Reaction 3?

(1)

☒ **A** Only 1-bromopropane

☒ **B** Only 2-bromopropane

☒ **C** A mixture of bromopropanes containing mainly 2-bromopropane

☒ **D** A mixture of bromopropanes containing mainly 1-bromopropane

(d) A mixture of dilute sulfuric acid and which of the following reagents is needed for Reaction 4?

(1)

☒ **A** KOH

☒ **B** $KMnO_4$

☒ **C** H_2O_2

☒ **D** O_2

(e) The reaction of propene in Reaction 4 can be classified both as

(1)

☒ **A**	addition and reduction.
☒ **B**	addition and oxidation.
☒ **C**	free radical substitution and reduction.
☒ **D**	free radical substitution and oxidation.

(Total for Question 16 = 5 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

17 This question is about the preparation of the alum, potassium aluminium sulfate, $KAl(SO_4)_2 \cdot 12H_2O$. It is a double salt consisting of potassium ions, aluminium ions and sulfate ions, and water of crystallization.

(a) The first step of the preparation involves adding an excess of aluminium foil to 10 cm^3 of 2 mol dm^{-3} potassium hydroxide to form potassium aluminate.

The equation for this reaction is

$$2Al(s) + 2KOH(aq) + 2H_2O(l) \rightarrow 2KAlO_2(aq) + 3H_2(g)$$

(i) Write a balanced **ionic** equation for this reaction.

(1)

(ii) Calculate the number of moles of potassium hydroxide used.

(1)

(iii) Hence state the number of moles of aluminium that react with the potassium hydroxide.

(1)

(iv) Use your answer to (iii) to calculate the mass of aluminium that reacts with the potassium hydroxide. Use the Periodic Table as a source of data.

(1)

(v) Calculate the total mass of aluminium added to the potassium hydroxide if a 10% excess of aluminium is required.

(1)

(vi) Identify **two** hazards in this first step of the preparation.

(2)

Hazard 1 .....

.....

Hazard 2 .....

.....

(b) The second step of the reaction is the addition of a slight excess of 1 mol dm^{-3} sulfuric acid.

(i) Balance the following equation for the reaction

(1)

$$KAlO_2(aq) + H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + H_2O(l)$$

(ii) Calculate the volume of the 1 mol dm^{-3} sulfuric acid that reacts with the potassium aluminate.

(1)

(iii) State how you would show that the acid had been added in excess.

(2)

.....

.....

.....

.....

*(iv) State and explain the steps necessary to obtain pure, dry crystals from the mixture.

(4)

(v) Suggest the colour of the crystals.

(1)

(vi) Suggest the formula of another metal ion which could form an alum, in combination with potassium and sulfate ions.

(1)

(Total for Question 17 = 17 marks)

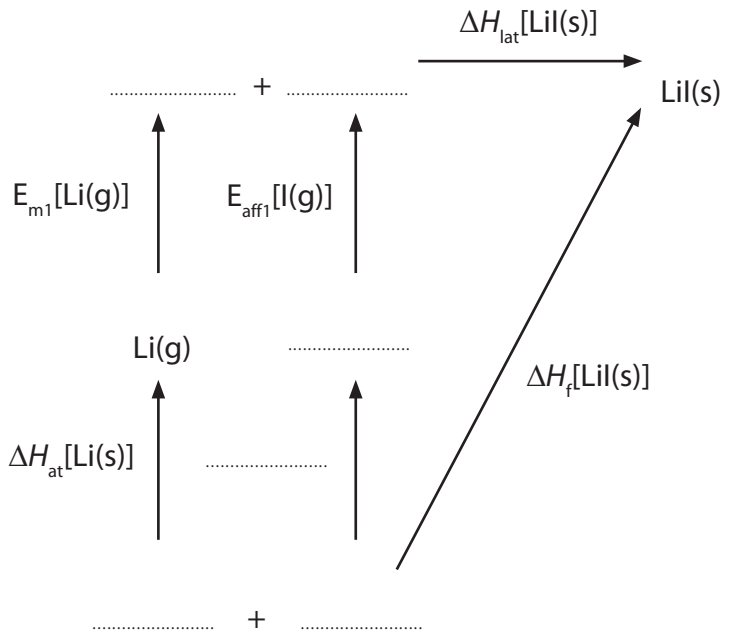
18 This question is about lithium iodide, an ionic salt.

(a) Draw dot and cross diagrams for the lithium and iodide ions. Show all the electrons in the lithium ion but only outer shell electrons in the iodide ion.

(2)

(b) On the Born-Haber cycle below, fill in the missing formulae (including state symbols) and the missing enthalpy change.

(3)



(c) Calculate the electron affinity of iodine, $E_{aff1}[I(g)]$, using the data below.

	ΔH/kJ mol^{-1}
Lattice energy for lithium iodide, ΔH_{lat}	–759
Enthalpy change of atomization of lithium, ΔH_{at}	+159
Enthalpy change of atomization of iodine, ΔH_{at}	+107
First ionization energy of lithium, E_{m1}	+520
Enthalpy change of formation of lithium iodide, ΔH_f	–270

(2)

(d) The experimental lattice energy for lithium iodide is –759 kJ mol^{-1}. The theoretical lattice energy is different from this value.

Will the experimental lattice energy be more negative or less negative than the theoretical lattice energy? Justify your answer.

(3)

(e) State and explain how electron affinity values change as you go down Group 7 from chlorine to iodine.

(2)

.....

.....

.....

.....

(Total for Question 18 = 12 marks)

19 Hydrogen has three isotopes, ^{1}H, known as protium, ^{2}H, deuterium, and ^{3}H, tritium.

(a) In terms of sub-atomic particles, give the similarities and differences between atoms of these three isotopes of hydrogen.

(3)

.....

.....

.....

(b) When a nitrogen atom collides with a high energy neutron, one atom of tritium and one atom of another element are formed. Complete the equation below.

(1)

$$^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{3}_{1}H + \text{.....}$$

(c) Tritium-deuterium gas, consisting of molecules each containing one deuterium atom and one tritium atom, is used in some nuclear warheads. Typically, each warhead has about 4.0 g of the gas added.

(i) Calculate the number of moles of tritium-deuterium in 4.0 g.

(2)

(ii) Calculate the volume, in cm^3, of 4.0 g of tritium-deuterium gas.

[Molar volume of a gas under these conditions = 24 000 $cm^3\ mol^{-1}$]

(1)

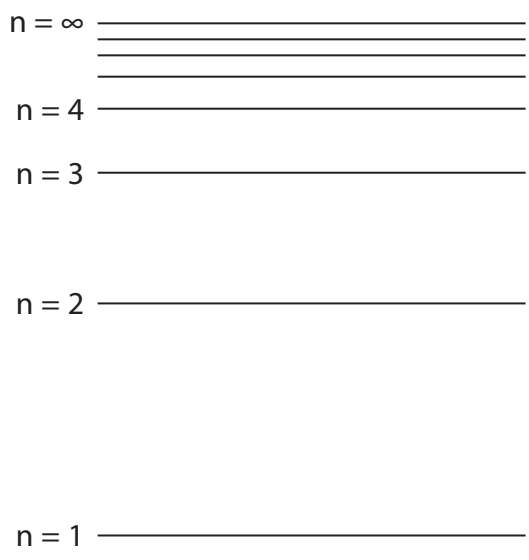
(d) Tritium is not usually included in calculations of the relative atomic mass of hydrogen, because it is radioactive and has a relatively short half-life.

Calculate the relative atomic mass of hydrogen with the following isotopic composition. Give your answer to four decimal places.

(2)

Isotope	Mass number	Relative abundance
^{1}H	1.0078	99.9850
^{2}H	2.0141	0.0150

(e) The electronic energy levels in hydrogen are shown below.



(i) Mark on the energy level diagram, with an arrow, the transition that represents the ionization energy of hydrogen.

(1)

(ii) In some versions of the Periodic Table, hydrogen is placed in the same group as sodium. Give the electronic configurations for both a hydrogen atom and a sodium atom, using the *s* and *p* notation.

Use these electronic configurations to suggest why this is a reasonable grouping.

(2)

H .....

Na .....

.....

.....

*(f) Which element in the Periodic Table has the highest first ionization energy? Justify your answer.

(3)

.....

.....

.....

.....

.....

.....

(Total for Question 19 = 15 marks)

20 This question is about the gas ethane, C_2H_6, and its reactions.

(a) Write the equation, including state symbols, which represents the reaction taking place when the standard enthalpy change of combustion of ethane is measured.

(2)

(b) Ethane can react with chlorine to form chloroethane and hydrogen chloride.

$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$$

Bond	Bond enthalpy/kJ mol^{-1}
C—H	413
C—C	347
C—Cl	346
H—Cl	432
Cl—Cl	243

Rewrite this equation using displayed formulae.

Use the equation you have written, together with the bond enthalpy data, to calculate the enthalpy change for the reaction.

(4)

(c) This reaction takes place in a number of steps, some of which are shown below.

Step 1 $Cl_2 \rightarrow 2Cl\bullet$

Step 2 $CH_3CH_3 + Cl\bullet \rightarrow HCl + CH_3CH_2\bullet$

(i) State the type of reaction occurring in step 1 and the conditions needed for this step.

(2)

Type .....

Conditions .....

(ii) Complete the equation below for the third step of the reaction, and show the movement of electrons using the appropriate arrows.

(3)

$CH_3CH_2\bullet + Cl—Cl \rightarrow$

(iii) Write equations for **two** termination steps in this reaction.

(2)

(d) Ethane can be cracked in industry. Write an equation for the cracking of ethane.

(1)

(e) Suggest **two** reasons why cracking of larger alkane molecules is important in industry.

(2)

Reason 1: .....

.....

Reason 2: .....

.....

(Total for Question 20 = 16 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 1 2 1 2 A 0 2 4 2 4

PMT

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Mark Scheme (Results)

January 2013

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	D	**1**

Question Number	Correct Answer	Mark
2	A	**1**

Question Number	Correct Answer	Mark
3	D	**1**

Question Number	Correct Answer	Mark
4	B	**1**

Question Number	Correct Answer	Mark
5	D	**1**

Question Number	Correct Answer	Mark
6	A	**1**

Question Number	Correct Answer	Mark
7	C	**1**

Question Number	Correct Answer	Mark
8	B	**1**

Question Number	Correct Answer	Mark
9	A	**1**

Question Number	Correct Answer	Mark
10	A	**1**

Question Number	Correct Answer	Mark
11	C	**1**

Question Number	Correct Answer	Mark
12	D	**1**

Question Number	Correct Answer	Mark
13	C	**1**

Question Number	Correct Answer	Mark
14	C	**1**

Question Number	Correct Answer	Mark
15	C	**1**

Question Number	Correct Answer	Mark
16(a)	D	**1**
(b)	D	**1**
(c)	C	**1**
(d)	B	**1**
(e)	B	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a) (i)	$2Al(s) + 2OH^-(aq) + 2H_2O(l) \rightarrow 2AlO_2^-(aq) + 3H_2(g)$	$2O_2^{2-}(aq)$	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	$\left(\frac{2 \times 10}{1000} = 0.02 / 2 \times 10^{-2}\right)$ Ignore trailing zeroes		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iii)	$0.02 / 2 \times 10^{-2}$ Accept TE answer to (ii)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iv)	$0.02 \times 27.0 = 0.54 / 5.4 \times 10^{-1}$ (g) TE answer to (iii) OR (ii) x 27.0 Ignore sf except 1	Other unit	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(v)	$(1.1 \times 0.54) = 0.59(4) / 5.9(4) \times 10^{-1}$(g) TE answer to (iv) x 1.1 Ignore sf except 1 Only penalise sf once		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(vi)	**Potassium hydroxide / KOH** (solution) is corrosive / burns / caustic **OR** **KOH** damages / harms / is harmful to / dissolves / reacts with **skin / eye(s)** **(1)** **OR** **KOH** in **eye(s)** **(1)** **Ignore** Harmful, irritant, highly reactive alone **Hydrogen / H_2** is flammable / explodes / explosive **(1)** Allow mention of both potassium hydroxide and hydrogen alone scores **(1)** Allow Al foil can cut your skin **(1)** Correct answer with additional incorrect chemistry e.g. KOH is oxidising so corrosive scores **(0)**	Toxic, carcinogenic, alone or in combination with correct answer Burns alone Additional chemicals	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(i)	$KAlO_2(aq) + \mathbf{2}H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + \mathbf{2}H_2O(l)$ Allow multiples		**1**

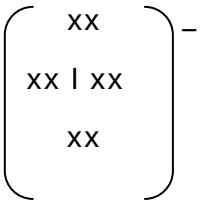
Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	$\frac{2 \times 1000 \times 0.02}{1} = 40\ (cm^3)$ Allow 0.04(0) **dm^3** TE answer to (a)(ii) x 2000 and TE from (b)(i)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iii)	Litmus (paper / solution) **(1)** Red / pink (in acid) **(1)** OR any other named acid-base indicator including universal indicator **(1)** with a correct acidic colour **(1)** NB phenolphthalein must be spelt correctly to score **(1)** and no mark for colour Notice that other indicators only require recognisable spellings Red litmus turns blue scores for the indicator **(1)** OR pH meter / universal indicator **(1)** with value < 7 **(1)** NB measure pH alone (0) pH < 7 **(1)** OR add a (metal) carbonate / suitable metal eg Mg **(1)** bubbles / fizzing **(1)** Calculation of amounts / moles of **both** reactants (1 maximum)		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iv)	**Each point must be made in full** **The second and final scoring points, which are asterisked, can only be gained through these statements. Two further marks can be scored for any two of the other four points.** 1 Filter (to remove any aluminium / impurities) **(1)** NB This mark can only be awarded if it is the first action **and** the mixture is subsequently heated. 2 *Boil / heat / evaporate to reduce the volume of water **(1)** NB boil / heat to remove water only gets the mark if it is clear, subsequently, that some solution is left 3 Cool / set aside / leave to allow crystals to form **(1)** 4 Filter OR pick out / remove / take out crystals (to separate) **(1)** 5 Wash with a **little / cold** water **(1)** 6 *Place between filter papers / dab with paper towel / use dessicator (to dry) **(1)**	Leave in the sun If boiled to dry stop marking here Heat in oven	**4**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(v)	White / colourless Ignore clear / transparent / cloudy / opaque e.g. accept clear and colourless	Any other colours with or without white	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(vi)	Cr^{3+}/ Fe^{3+}/ Sc^{3+} / Ga^{3+} Accept any feasible triply positive metal ion Allow B^{3+} Allow any name or symbol for a Group 3 element Allow named existing transition metal ions with (III) after the name (if they exist) Fully correct formula for an alum or intermediate starting entity Eg $KGa(SO_4)_2$ / $KGaO_2$	Al^{3+} and anything else Group 3 element with incorrect charge	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a)	$[:Li]^+$ (1)  (1) Accept all or mixture of dots and crosses **Check inner electrons present on lithium** If no element symbols but fully correct with Li first give **1 max** If no / incorrect charge(s) if the electrons are correct **1 max** If arrow drawn from third / outer shell electron on lithium to join electrons in iodine / iodide with correct charges scores **1 max** Brackets are not essential		**2**

Question Number	Acceptable Answers	Reject	Mark
18 (b)	$Li(s)$ **and** $Li^+(g)$ **and** $I^-(g)$ **(1)** $\frac{1}{2}I_2(s)$ **and** $I(g)$ **(1)** (ΔH_{at}) **[**$\frac{1}{2}I_2(s)$**]** **(1)** Notice the square brackets are essential for this mark If wrong state for iodine element ie if $\frac{1}{2}I_2(g/l)$ and consistent $(\Delta H_{at})[\frac{1}{2}I_2(g/l)]$ allow third mark If I(s) given for element and (ΔH_{at}) [I(s)] allow third mark If wrong state with monatomic iodine both the last two marks lost If $Li^+(g)$ + e appears ignore electron		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c)	**First mark for one of:** −270 = + 159 + 107 + 520 + electron affinity − 759 Or Electron affinity = −270 − (159 + 520 + 107 − 759) **(1)** OR Electron affinity = −270 - 159 - 520 - 107 + 759 **(1)** **Second mark for:** (Electron affinity =) −297 (kJ mol^{-1}) **(1)** −297 (kJ mol^{-1}) alone scores **(2)** NB providing method is recognisable with one transcription error eg 795 for 759 and the final answer is consistent **1 max** NB (+) 297 (kJ mol^{-1}) **1 max**	Wrong unit e.g. J	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (d)	(Experimental lattice energy is) more negative / exothermic **(1)** OR Theoretical lattice energy is less negative / exothermic **(1)** OR Recognition that more energy **released** **(1)** Irrespective of first answer then, any two from: Due to a degree of covalency **(1)** Deviation from pure ionic model (in experimental value) OR The theoretical model is pure ionic bonding **(1)** **Polarization / distortion** of the iod**ide** / negative ions (by the lithium ion). Can be shown by diagram **(1)** Iodine/ I / I_2 ion is not acceptable but iodine / I **anion** is allowed Note I_2 anion is not allowed	Greater / less Increase / decrease alone	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (e)	Electron affinities become less negative / less exothermic / more positive (going down Group 7) **(1)** As (added) **electron** further from the nucleus OR **More** shielding / shielded (from the nucleus) **(1)** Second mark stands alone Ignore larger (ionic) radius / atom / ion / charge density	Greater / less / Increase / decrease alone Any indication of ionization/ removing an electron	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (a)	All have the same number of electrons / all have one (s) electron / same electron configuration **(1)** All have the same number of protons / all have one proton **(1)** The first has no neutrons, the second one neutron and the third two neutrons Allow deuterium has one more neutron, tritium two more neutrons **(1)** Ignore references to same atomic number and different mass numbers	All have one p electron Different number of neutrons alone	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (b)	($^{14}_{7}N$ + $^{1}_{0}n$ → $^{3}_{1}H$ +) $^{12}_{6}C$ Numbers can be on either side or both sides		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	**Molar mass / M(r) / 3+2 / 2+3** = 5 (g mol^{-1}) (1) Number of moles = 4/5 = 0.8 **(1)** O.8 with correct working, with wrong working, or with no working **(2)** Allow internal TE if Molar mass clearly indicated and incorrect eg Molar mass / M(r) = 6 (g mol^{-1}) **(0)** Number of moles = 4/6 = 0.67 **(1)**	Penalise incorrect units	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	24 000 x 0.8 = 19 200 (cm^3) Allow 19.2 **dm^3** Allow TE from (c)(i)	Incorrect units	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)	$\frac{1.0078 \times 99.9850 + 2.0141 \times 0.0150}{100}$ OR $\frac{1.0078 \times 99.9850 + 2.0141 \times 0.0150}{99.9850 + 0.0150}$ **(1)** Notice this working must be shown in full to score first mark. (= 1.007951) = 1.0080 **(1)** 1.008 max 1 with or without working Correct answer no working **(2)** Only give second mark for correct answer to 4 decimal places Ignore g mol^{-1}	Incorrect units e.g. g	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (e)(i)	Single arrow **upwards** from lowest line to infinity line (allow above or very close below) Allow double headed arrow	More than one line	**1**

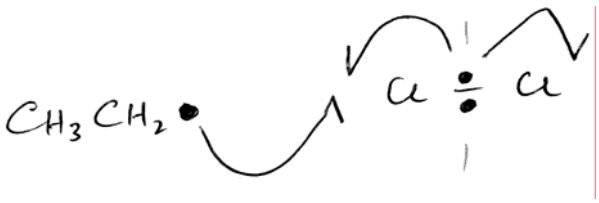
Question Number	Acceptable Answers	Reject	Mark
19 (e)(ii)	Hydrogen $1s^1$ **and** Sodium $1s^2\ 2s^2\ 2p^6\ 3s^1$ **(1)** Electron numbers may be on lines or subscript. Both have one (s) electron in the **outer** shell / orbital / sub shell OR same number of electrons / same electron(ic) configuration in **outer** shell / orbital / sub shell OR Both have an/one unpaired electron in their **outer** / **last** shell / orbital / sub shell **(1)** Second mark depends on one outer shell s electron shown for each electronic configuration	$1s^2\ 2s^1$ half filled s outer shell same electron(ic) configuration alone	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (f)	Helium **(1)** Any two from the following points: Electron removed is closest / close to the nucleus **(1)** Little shielding, allow no shielding **(1)** More protons / higher nuclear charge than hydrogen. Allow higher effective nuclear charge **(1)** **NB** second and third marks can be gained if **hydrogen** is given: Electron removed is close / closest to the nucleus **(1)** No shielding **(1)**	Any other elements	3

Question Number	Acceptable Answers	Reject	Mark
20(a)	$C_2H_6(g) + 3½O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ Formulae and states **(1)** Balancing of correct entities **(1)**	Multiples	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)	Notice the first mark is for the equation and there are 3 separate additional marks for the calculation H H H H | | | | H-C-C-H + Cl-Cl → H-C-C-Cl + H-Cl | | | | H H H H **(1)** Check all bonds displayed especially Cl-Cl and H-Cl **Calculation marks:** +413 + 243 **(1)** (−)(346 + 432) **(1)** OR 656 **(1)** (−) 778 **(1)** = −122 (kJ mol^{-1}) **(1)** Fully correct answer to calculation with no working **(3)** Extra 5x413 and 347 may be included on both sides, giving 3068 and (-)3190 Allow other same values(s) missing from both sides Bonds breaking **(1)** Bonds making **(1)** [Bonds breaking - bonds making] to give correct answer **with sign** **(1)**	Incorrect / no sign and / or incorrect units Incorrect units loses this mark	**4**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	Initiation **(1)** Allow homolysis / atomization / homolytic (fission) Ignore any reference to free radical substitution UV / (sun)light **(1)** Ignore reference to high temperature	Free radical substitution alone Photolysis	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	$CH_3CH_2\bullet$ + Cl-Cl → CH_3CH_2Cl + Cl• OR $CH_3CH_2\bullet$ + Cl-Cl → C_2H_5Cl + Cl• Both products correct including dot (1) Two half headed arrows showing homolytic breaking of Cl-Cl bond **(1)** Half headed arrow from radical to pair with a Cl arrow OR One arrow from chlorine bond clearly to ethyl radical **(1)** Arrows must be single-headed     The two dots in the covalent bond do not have to be shown		**3**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iii)	$Cl\bullet + Cl\bullet \rightarrow Cl_2$ **(1)** $\bullet CH_2CH_3 + \bullet CH_2CH_3 \rightarrow CH_3CH_2CH_2CH_3$ / C_4H_{10} **(1)** $\bullet CH_2CH_3 + Cl\bullet \rightarrow CH_3CH_2Cl$ **(1)** Penalise missing dots once Allow $\bullet C_2H_5$ for $\bullet CH_2CH_3$ Di and tri substitution steps	C_4H_{12} $CH_3CH_2CH_3CH_2$	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (d)	$C_2H_6 \rightarrow C_2H_4 + H_2$ Allow **2**$C_2H_6 \rightarrow C_2H_4 +$ **2**CH_4		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (e)	Any two from: (It) produces (more) petrol / gasoline / diesel / jet fuel / LPG / liquid petroleum gas / fuel **(1)** Short chain alkanes / lighter fractions are more useful products **(1)** Demand is greater for shorter chain alkanes / lighter fractions / smaller molecules OR converts surplus of low demand fractions **(1)** It produces ethane / short chain alkenes for making poly(ethene) / ethane-1,2-diol / ethanol / plastics / polymers **(1)** Smaller alkanes give less pollution/burn more efficiently **(1)** Recycles waste products **(1)** As a source of hydrogen **(1)** **NB** examiners need to look carefully at the vowel in the middle of alk**a**ne / alk**e**ne / eth**a**ne / eth**e**ne if not clear do not give BOD	Points based on atom economy / renewable fuels alone Easier to transport / store Short chain alkenes / ethene more useful alone Recycles alone	2

TOTAL FOR SECTION B = 60

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Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 23 May 2013 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41649A

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10/5/6/7/

P 4 1 6 4 9 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following quantities, used in the calculation of the lattice energy of lithium oxide, Li_2O, has a negative value?

☒ **A** The enthalpy change of atomization of lithium.

☒ **B** The first ionization energy of lithium.

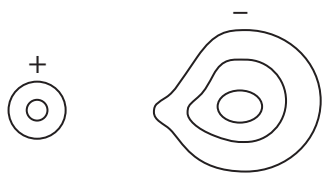
☒ **C** The first electron affinity of oxygen.

☒ **D** The second electron affinity of oxygen.

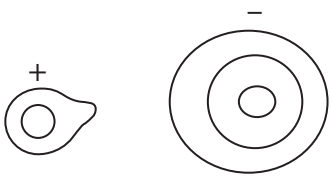
(Total for Question 1 = 1 mark)

2 Which of the diagrams below best represents the shapes of the electron contours in sodium fluoride?

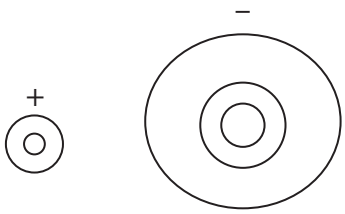
☒ **A**



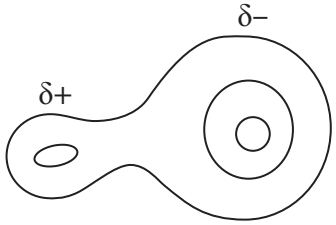
☒ **B**



☒ **C**



☒ **D**



(Total for Question 2 = 1 mark)

3 Which of the equations below represents the first electron affinity for oxygen?

☒ **A** $O_2(g) + 2e^- \rightarrow 2O^-(g)$

☒ **B** $O_2(g) - 2e^- \rightarrow 2O^-(g)$

☒ **C** $\frac{1}{2}O_2(g) + e^- \rightarrow O^-(g)$

☒ **D** $O(g) + e^- \rightarrow O^-(g)$

(Total for Question 3 = 1 mark)

4 Which pair of ions is isoelectronic?

☒ **A** Ca^{2+} and O^{2-}

☒ **B** Na^+ and O^{2-}

☒ **C** Li^+ and Cl^-

☒ **D** Mg^{2+} and Cl^-

(Total for Question 4 = 1 mark)

5 A drop of sodium manganate(VII) solution is placed at the centre of a piece of moist filter paper on a microscope slide. The ends of the paper are clipped to a 30 V DC power supply. After a few minutes,

☒ **A** a purple colour has moved towards the positive terminal.

☒ **B** a purple colour has moved towards the negative terminal.

☒ **C** an orange colour has moved towards the positive terminal.

☒ **D** an orange colour has moved towards the negative terminal.

(Total for Question 5 = 1 mark)

6 How many moles of **ions** are present in 20 cm^3 of 0.050 mol dm^{-3} calcium chloride solution, $CaCl_2(aq)$?

☒ **A** 0.0050

☒ **B** 0.0030

☒ **C** 0.0020

☒ **D** 0.0010

(Total for Question 6 = 1 mark)

7 The Avogadro constant is 6.0×10^{23} mol^{-1}. The number of **atoms** in 1 mol of dinitrogen tetroxide, N_2O_4, is

- ☒ **A** 3.6×10^{24}
- ☒ **B** 1.8×10^{24}
- ☒ **C** 6.0×10^{23}
- ☒ **D** 1.0×10^{23}

(Total for Question 7 = 1 mark)

8 The equation for the complete combustion of ethane is

$$2C_2H_6(g) + 7O_2(g) \rightarrow 4CO_2(g) + 6H_2O(l)$$

What volume of oxygen, measured at room temperature and pressure, is needed to completely burn 0.1 mol of ethane?

[The volume of 1 mol of any gas measured at room temperature and pressure is 24 dm^3]

- ☒ **A** 2.4 dm^3
- ☒ **B** 4.8 dm^3
- ☒ **C** 8.4 dm^3
- ☒ **D** 16.8 dm^3

(Total for Question 8 = 1 mark)

9 A sample of swimming pool water contains 0.482 parts per million (ppm) of chlorine. This is equal to a percentage of

- ☒ **A** 0.000482
- ☒ **B** 0.0000482
- ☒ **C** 0.00000482
- ☒ **D** 0.000000482

(Total for Question 9 = 1 mark)

10 Bromine has two isotopes with relative isotopic masses 79 and 81. Which of the following values for mass/charge ratio could correspond to a peak in the mass spectrum of bromine, Br_2? You should assume the ions detected have a single positive charge.

- ☒ **A** 79.9
- ☒ **B** 80
- ☒ **C** 159
- ☒ **D** 160

(Total for Question 10 = 1 mark)

11 The first five ionization energies of an element, **X**, are shown in the table.

Ionization energy	1st	2nd	3rd	4th	5th
Value / kJ mol^{-1}	631	1235	2389	7089	8844

What is the mostly likely formula of the oxide that forms when **X** burns in oxygen?

- ☒ **A** X_2O
- ☒ **B** XO
- ☒ **C** X_2O_3
- ☒ **D** XO_2

(Total for Question 11 = 1 mark)

12 Which of the following has the largest ionic radius?

- ☒ **A** S^{2-}
- ☒ **B** Cl^-
- ☒ **C** K^+
- ☒ **D** Ca^{2+}

(Total for Question 12 = 1 mark)

13 Which of the following is a major effect caused by increased carbon dioxide levels arising from the burning of fossil fuels?

☒ **A** Melting of polar ice caps.

☒ **B** Damage to the ozone layer.

☒ **C** Increased acid rain.

☒ **D** Increased skin cancer.

(Total for Question 13 = 1 mark)

14 Which of the following compounds shows geometric (*E-Z* or *cis-trans*) isomerism?

☒ **A** but-1-ene

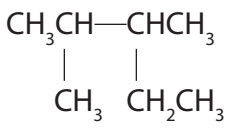
☒ **B** 2-methylbut-1-ene

☒ **C** but-2-ene

☒ **D** 2-methylbut-2-ene

(Total for Question 14 = 1 mark)

15 What is the systematic name for the compound with the following formula?



☒ **A** 2-methyl-3-ethylbutane

☒ **B** 1,2,3-trimethylbutane

☒ **C** 2,3-dimethylpropane

☒ **D** 2,3-dimethylpentane

(Total for Question 15 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

16 This question is about the reaction of methane with bromine in sunlight.

(1)

$$CH_4 + Br_2 \rightarrow CH_3Br + HBr$$

(a) This reaction is best described as

- ☒ **A** electrophilic addition.
- ☒ **B** electrophilic substitution.
- ☒ **C** free radical addition.
- ☒ **D** free radical substitution.

(b) One of the steps in the mechanism of this reaction is

(1)

$\bullet CH_3 + Br\bullet \rightarrow CH_3Br$

This step is

- ☒ **A** initiation.
- ☒ **B** propagation.
- ☒ **C** termination.
- ☒ **D** reduction.

(c) This reaction produces a mixture of products.

Which of the following is most likely to form, as well as bromomethane?

(1)

- ☒ **A** ethane
- ☒ **B** propane
- ☒ **C** butane
- ☒ **D** pentane

(d) When human skin is overexposed to sunlight, it is likely to lead to skin cancer.

What is the radiation in sunlight that leads to skin cancer?

(1)

- ☒ **A** microwaves
- ☒ **B** infrared
- ☒ **C** visible light
- ☒ **D** ultraviolet

(Total for Question 16 = 4 marks)

17 Which equation represents the reaction for which the enthalpy change, ΔH, is the mean bond energy of the C-F bond?

☒ **A** $CF_4(g) \rightarrow C(g) + 4F(g)$

☒ **B** $\frac{1}{4}CF_4(g) \rightarrow \frac{1}{4}C(g) + F(g)$

☒ **C** $C(g) + 4F(g) \rightarrow CF_4(g)$

☒ **D** $\frac{1}{4}C(g) + F(g) \rightarrow \frac{1}{4}CF_4(g)$

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 The radioactive isotope iodine-131, $^{131}_{53}I$, is formed in nuclear reactors providing nuclear power. Naturally occurring iodine contains only the isotope, $^{127}_{53}I$.

(a) Complete the table to show the number of protons and neutrons in these two isotopes.

(2)

Isotope	$^{131}_{53}I$	$^{127}_{53}I$
Number of protons		
Number of neutrons		

(b) When iodine-131 decays, one of its neutrons emits an electron and forms a proton. Identify the new element formed by name or symbol.

(1)

.....

(c) The problem with radioactive iodine is that it accumulates in humans in the thyroid gland. Its absorption can be reduced by taking an appropriate daily dose of a soluble iodine compound.

Suggest a suitable iodine compound which could be used.

(1)

.....

(d) Nuclear power stations are often proposed as suitable alternatives to those burning coal, gas or oil.

Suggest a country where, because of its location, the dangers of nuclear power may outweigh the advantages. Justify your answer.

(1)

.....

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.....

(Total for Question 18 = 5 marks)

19 This question is about the elements arsenic to rubidium which have atomic numbers 33 to 37.

The first ionization energies, E_{m1}, of these elements are given in the table.

Element	As	Se	Br	Kr	Rb
E_{m1} / kJ mol^{-1}	947	941	1140	1351	403

(a) Write the equation, with state symbols, which represents the first ionization energy of arsenic.

(2)

(b) Suggest the formulae of the hydrides of arsenic and selenium.

(2)

(c) (i) Complete the electronic configuration for an arsenic and a selenium atom using the electrons-in-boxes notation.

(2)

		4s	4p		
As	[Ar] 3d^{10}	↑↓			
Se	[Ar] 3d^{10}	↑↓			

*(ii) Explain why the first ionization energy of selenium is lower than that of arsenic.

(2)

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*(d) Explain why the first ionization energy of krypton is higher than that of selenium.

(2)

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*(e) Explain why the first ionization energy of rubidium is lower than that of krypton.

(2)

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.....

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(f) Which of the elements, arsenic to rubidium, is likely to have atoms with the smallest atomic radius?

(1)

.....

(Total for Question 19 = 13 marks)

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20 Copper(II) sulfate solution, $CuSO_4(aq)$, can be made by adding an excess of solid copper(II) oxide, CuO, to boiling dilute sulfuric acid. This is an exothermic reaction.

The balanced equation for this reaction is

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$

(a) (i) Complete the ionic equation for this reaction, including state symbols.

(2)

$CuO(s) +$

(ii) Calculate the mass of copper(II) oxide needed, if a 10% excess is required, when 0.020 mol of sulfuric acid is completely reacted.

[Relative atomic masses: Cu = 63.5 and O = 16.0]

(2)

(b) (i) Suggest, with a reason, how the copper(II) oxide should be added to the boiling sulfuric acid.

(2)

.....

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.....

.....

(ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

To prepare crystals of copper(II) sulfate-5-water, $CuSO_4.5H_2O$, the resulting solution is boiled to remove excess water.

How would you know when sufficient water had been removed?

(1)

.....

.....

.....

.....

(iii) After cooling the solution, crystals form. State the colour of the crystals.

(1)

.....

(iv) The crystals all have the same shape. What does this indicate about the arrangement of the ions?

(1)

.....

.....

(c) (i) Calculate the molar mass of copper(II) sulfate-5-water, $CuSO_4.5H_2O$. Remember to include the appropriate units in your answer. You will need to use the Periodic Table as a source of data.

(2)

(ii) Calculate the percentage yield if 2.7 g of copper(II) sulfate-5-water is obtained from 0.020 mol of sulfuric acid.

(2)

(iii) What is the most likely reason for the yield being well below 100%?

(1)

.....

.....

(d) When the crystals are heated, they turn white. On adding water, they return to their original colour. Suggest a use for this reaction.

(1)

.....

.....

(Total for Question 20 = 15 marks)

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21 Sodium hydrogencarbonate decomposes on heating to form sodium carbonate. It is difficult to measure the enthalpy change of this reaction directly.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

One method of determining this enthalpy change is to react known amounts of sodium hydrogencarbonate and sodium carbonate, separately, with excess dilute hydrochloric acid.

(a) 0.010 mol of solid sodium hydrogencarbonate was added to 25 cm^3 of dilute hydrochloric acid. A temperature rise of 11 °C was measured using a thermometer graduated at 1 °C intervals.

(i) Calculate the heat energy produced by this reaction using the equation:

Energy transferred in joules = mass × 4.18 × change in temperature

(1)

(ii) Calculate the standard enthalpy change for the reaction when one mole of sodium hydrogencarbonate reacts with hydrochloric acid.

Remember to include a sign and units with your answer which should be given to three significant figures.

(2)

*(b) The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be

$\Delta H^{\ominus} = -321.6$ kJ mol^{-1}

Complete the Hess energy cycle below by adding the missing arrow and entities. Use it to calculate the standard enthalpy change for the decomposition of two moles of sodium hydrogencarbonate as in the equation below.

Remember to show your reasoning clearly.

(5)

$2NaHCO_3(s) \longrightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$

2HCl(aq)

..... ( ) + ... ( ) + ... ( )

(c) The uncertainty for each thermometer reading is ± 0.5 °C.
Calculate the percentage error in the temperature rise of 11 °C.

(1)

(d) Sodium hydrogencarbonate is used in cooking. Suggest what it is used for and how it works.

(2)

.....

.....

.....

.....

(Total for Question 21 = 11 marks)

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22 This question is about ethene and its reactions.

Ethene is produced in industry by cracking.

(a) (i) Write the equation for the cracking of dodecane, $C_{12}H_{26}$, to produce one mole of ethene as the only alkene product.

(1)

(ii) Draw a labelled diagram of the apparatus and materials you would use to crack dodecane and collect a sample of the gaseous alkene in the laboratory.

(4)

(b) Draw a diagram to show the regions of electron density in both parts of the double bond between the carbon atoms in ethene. Label each region with appropriate symbols.

(2)

(c) (i) Give the name and structural formula for the product of the reaction between ethene and bromine, $Br_2(l)$.

(2)

Name .....

Formula

(ii) Give the mechanism for the reaction between ethene and bromine.

(3)

(d) Give the displayed formula for the organic product of the reaction between ethene and acidified potassium manganate(VII).

(1)

(e) (i) Write a balanced equation for the formation of poly(ethene) from ethene, showing the structure of the polymer clearly.

(2)

(ii) Comment on the atom economy of the reaction in (e)(i).

(1)

.....

.....

(Total for Question 22 = 16 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 1 6 4 9 A 0 2 4 2 4

PMT

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Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH01/01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Correct Answer	Reject	Mark
1	C		**1**

Question Number	Correct Answer	Reject	Mark
2	C		**1**

Question Number	Correct Answer	Reject	Mark
3	D		**1**

Question Number	Correct Answer	Reject	Mark
4	B		**1**

Question Number	Correct Answer	Reject	Mark
5	A		**1**

Question Number	Correct Answer	Reject	Mark
6	B		**1**

Question Number	Correct Answer	Reject	Mark
7	A		**1**

Question Number	Correct Answer	Reject	Mark
8	C		**1**

Question Number	Correct Answer	Reject	Mark
9	B		**1**

Question Number	Correct Answer	Reject	Mark
10	D		**1**

Question Number	Correct Answer	Reject	Mark
11	C		**1**

Question Number	Correct Answer	Reject	Mark
12	A		**1**

Question Number	Correct Answer	Reject	Mark
13	A		**1**

Question Number	Correct Answer	Reject	Mark
14	C		**1**

Question Number	Correct Answer	Reject	Mark
15	D		**1**

Question Number	Correct Answer	Reject	Mark
16a	D		**1**

Question Number	Correct Answer	Reject	Mark
16b	C		**1**

Question Number	Correct Answer	Reject	Mark
16c	A		**1**

Question Number	Correct Answer	Reject	Mark
16d	D		**1**

Question Number	Correct Answer	Reject	Mark
17	B		**1**

Total for Section A = 20 Marks

Question Number	Acceptable Answers	Reject	Mark
18(a)	<table><tr><td>Isotope</td><td>$^{131}I_{53}$</td><td>$^{127}I_{53}$</td></tr><tr><td>Number of protons</td><td>53</td><td>53</td></tr><tr><td>Number of neutrons</td><td>78</td><td>74</td></tr></table>		**2**

Question Number	Acceptable Answers	Reject	Mark
18(b)	Xenon / Xe / $_{54}Xe$ / Xe_{54} / $^{131}_{54}Xe$	Anything else including: $^{130}Xe_{54}$ Xe^- Iodine / I with or without numbers Hydrogen / H with or without numbers Te	**1**

Question Number	Acceptable Answers	Reject	Mark
18(c)	Potassium iodide / KI Accept any soluble, non-toxic iodide or iodate Wrong name, correct formula (0) Correct name, wrong formula (0)	HI KI_3 Wrong formulae like CaI, MgI Wrong name like calcium idodate BaI_2 (toxic) AgI (insoluble) Potassium iodine	**1**

Question Number	Acceptable Answers	Reject	Mark
18(d)	Country /ALLOW state **and** justification Both needed for one mark e.g. Japan / New Zealand / California etc Country / state at risk from Earthquake / tsunami / flooding Further examples: Italy with volcanoes Afghanistan / middle eastern / African countries terrorist / (nuclear) weapon threat / war zone / political instability / abuse of nuclear power. USA /America / Jamaica etc risk of hurricane / tornado California San Andreas fault	…population density …landslide …too hot … surrounded by other countries Antarctica	**1**

Total for Question 18 = 5 Marks

Question Number	Acceptable Answers	Reject	Mark
19(a)	$As(g) - e^{(-)} \rightarrow As^{+}(g)$ OR $As(g) \rightarrow As^{+}(g) + e^{(-)}$ Entities **(1)** All species gaseous **(1)** providing a reasonable attempt at an ionization energy Examples: $As(g) + e^{(-)} \rightarrow As^{+}(g)$ $As(g) - e^{(-)} \rightarrow As^{-}(g)$ $As^{2+}(g) - e^{(-)} \rightarrow As^{3+}(g)$ IGNORE state symbol of electron ALLOW upper case / large S in arsenic ALLOW $As(g) + e^{(-)} \rightarrow As^{+}(g) + 2e^{(-)}$ **(2)**	$As(g) + e^{(-)} \rightarrow As^{-}(g)$ (electron affinity)	**2**

Question Number	Acceptable Answers	Reject	Mark
19(b)	AsH_3 / H_3As **(1)** H_2Se / SeH_2 **(1)** IGNORE charges ALLOW upper case / large S in arsenic **NOTE:** If two or more answers given for one element mark that element on a plus minus basis	SE for Selenium	**2**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	**As** [Ar] $3d^{10}$ ↑↓ | ↑ ↑ ↑ **Se** [Ar] $3d^{10}$ ↑↓ | ↑↓ ↑ ↑ (4s | 4p) One mark for each row Arrows may be half-headed Arrows must be in same direction if in singly occupied boxes (can be down) ALLOW two arrows for Se in any 4p box Selenium two arrows must show opposite spins		**2**

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	**For parts c(ii),d and e it is important to keep in mind the two elements involved in each part** **As and Se** **First mark:** EITHER In Se, (spin) pairing has occurred (for the first time in that p sub-shell) OR electron removed from orbital containing two electrons **(1)** ALLOW sub-shell for orbital **Second mark:** EITHER (Increase in) repulsion (so electron lost more easily) OR Half-filled (sub-) shell/allow orbital (particularly) stable (in As) ALLOW orbital for sub-shell **(1)** Mark each point independently IGNORE reference to distance from nucleus and shielding		**2**

Question Number	Acceptable Answers	Reject	Mark
19(d)	**Se and Kr** **First mark:** EITHER The nuclear charge is increasing (Nuclear must be stated or clearly implied) OR number of protons / atomic number is increasing **(1)** **Second mark:** (Outermost) electron closer to nucleus / electron is removed from the same (sub)shell / electron experiences similar shielding / (atomic) radius is smaller/ smaller **atom** **(1)** ALLOW reverse arguments for selenium IGNORE Kr has full outer shell	Ionic radius Molecule (unless monatomic)	**2**

Question Number	Acceptable Answers	Reject	Mark
19(e)	**Kr and Rb** Any two from: The **electron** (in Rb) (removed) is further from the nucleus **(1)** The **electron** is in a higher / new / another / 5s (energy quantum) shell / energy level **(1)** **More** shielded **(1)** IGNORE any reference to stability of krypton or larger atomic radius of Rb / full outer shell of Kr It is possible that two answers may be offered together in one sentence e.g. Rb outer electron is in another shell further from nucleus (2)		**2**

Question Number	Acceptable Answers	Reject	Mark
19(f)	Krypton / Kr	Anything else	**1**

Total for Question 19 = 13 Marks

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	$CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$ Left hand side **(1)** right hand side **(1)** If SO_4^{2-} are on both sides max one mark ALLOW correct entities and balancing with no or incorrect state symbols for one mark. ALLOW multiples It is sometimes difficult to be sure of the '2' on the Cu^{2+}. Give BOD provided $2H^+$ on the left of the equation	Charges within water molecule	**2**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	1.749/1.75/1.7 with or without working scores 2 If answer incorrect look for Mass = 79.5 x 0.02 OR =1.59 (1) OR TE from incorrect mass for one mark Their mass x 1.1= their correct answer to 2/3/4SF (g) (1) Accept crossed 7's ALLOW both ways of writing 4 and be generous if 4 looks like 9	1.74 1.8	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	Add in small portions / use a spatula / use a **small** spoon / slowly / gradually **(1)** To prevent (mixture / acid) boiling over / frothing / spilling / splashing / splash back **(1)** Mark independently Bubbles are neutral IGNORE add carefully / cautiously alone	Spitting / violent reaction / fizzing Because reaction is exothermic alone Bubbles of carbon dioxide	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	Dip in glass rod. Remove and allow to cool. See if crystals form ALLOW any workable suggestion Examples: See crystals / salt forming around edge of beaker Depth of colour of solution increases Solution / colour becomes darker Solution / colour becomes deeper blue Dark blue solution Reduce volume by at least half / until crystals form	Solution thickens Precipitate forming	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	Blue	Any mention of green or other colour	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iv)	(The ions are arranged in a) regular (way) / lattice OR The ions are arranged in the same way / have same arrangement / have uniform arrangement The term structure is neutral and should be ignored IGNORE statements about ions attracting or repelling	The ions are arranged in a similar / fixed way	**1**

Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	249.6 g mol^{-1} ALLOW 249.5 g mol^{-1} ALLOW 250 g mol^{-1} value **(1)** units **(1)** Common wrong values are 159.5 / 6, 185.5 / 6, 249 ALLOW unit mark with any or no value. ALLOW g / mol for unit	g/mol^{-1}	**2**

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	Max yield = 249.6 x 0.02 = 4.992(g) **(1)** Percentage yield = $\frac{2.7 \times 100}{4.992}$ = (54.0865) = 54% **(1)** If 249.5 is used = (54.1082) = 54% OR 2.7 / 249.6 = 0.01082 **(1)** Percentage yield = 0.01082 x 100/0.02 = 54% **(1)** ALLOW TE from any value in (i), and note 159.6 gives 84.6% 185.6 gives 72.7% IGNORE SF except one SF Correct answer, no working scores (2)		**2**

Question Number	Acceptable Answers	Reject	Mark
20(c)(iii)	(Copper(II) sulfate is soluble) so some remains in solution / some remains on the **filter paper** IGNORE other transfer errors Incomplete crystallization / not all the crystals are formed	Experimental error/ incomplete reaction Filtering alone Efflorescence	**1**

Question Number	Acceptable Answers	Reject	Mark
20(d)	This is a (chemical) test for (the presence of) water Invisible ink Moisture / humidity test Test to see if solutions are aqueous	Check to see if substance is hydrated Drying agent Quantitative measurements of water content.	**1**

Total for Question 20 = 15 Marks

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	25 x 4.18 x 11 = 1149.5 (J) ALLOW 1.1495 **kJ** Otherwise ignore units even if incorrect IGNORE sign IGNORE SF except one or two SF	1149.5 **kJ**	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	-115 kJ mol^{-1} ALLOW -115000 J mol^{-1} Sign with correct value **(1)** Units and three significant figures **(1)** Mark independently ALLOW TE from (i) -114 kJ mol^{-1} (rounding error) scores 1 -115.0 kJ mol^{-1} scores 1 Values of -4600 and -3.86 are quite common ALLOW K and j in any case in units	J or kJ alone	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)	$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$ 2HCl(aq) (2HCl(aq)) $2NaCl(aq) + 2CO_2(g) + 2H_2O(l)$ **First mark** Arrow from products in top line to lower line and correct entities **(1)** $NaCl + CO_2 + H_2O$ **Second mark** **2**$NaCl$**(aq)** + **2**CO_2**(g)** + **2**H_2O**(l)** Correct state symbols and balancing **(1)** ΔH^o = **+**91.6 OR +91.7 (kJ mol^{-1}) ALLOW no positive sign only if correct Working with correct signs given **(3)** OR **Third mark** Correct use of Hess's Law (in numbers or symbols) consistent with arrow direction **(1)** **Fourth mark** **2x**(-115) = ΔH^o - 321.6 Correct multiples and numbers **(1)** ALLOW 2 x any number (including -4600 and -3.86) except 2 x +/- 321.6 Notice Third and Fourth marks can be scored by $\Delta H^o = 2(-115) - (-321.6)$		**5**

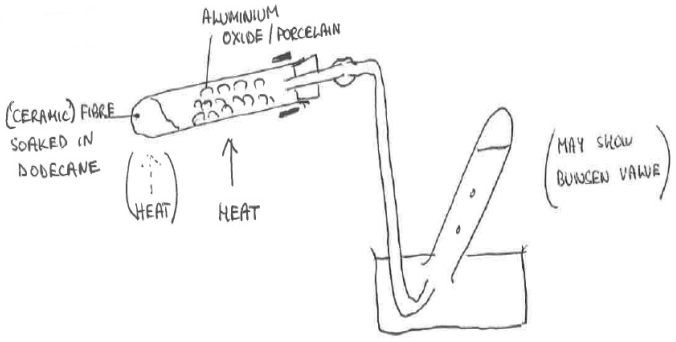
	Fifth mark ΔH^o = 2(–115) – (-321.6) = **+**91.6 (kJ mol^{-1}) OR ΔH^o = 2(–114.95) – (-321.6) = **+**91.7 (kJ mol^{-1}) Correct value for their calculation with correct sign IGNORE SF except 1 ALLOW no positive sign only if correct working with correct signs given **(1)** Omitting 2x gives +206.6 (could get 4 marks) -4600 gives -598.4 -3.86 gives +313.88		

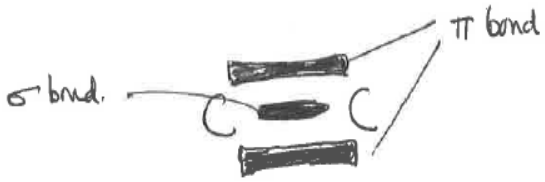
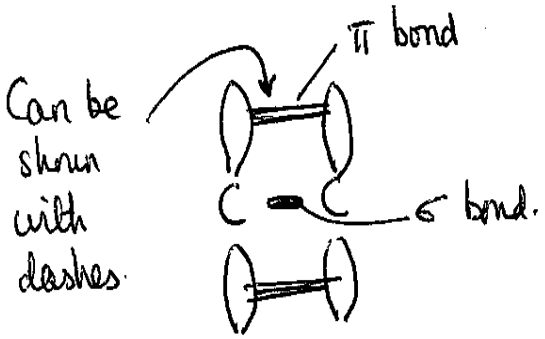
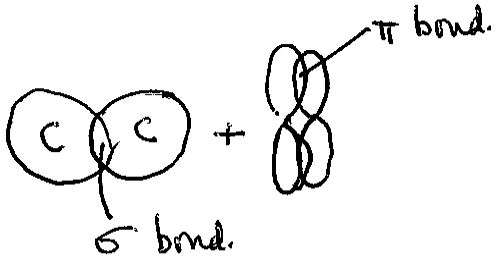
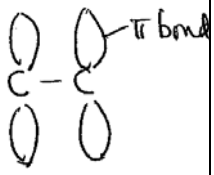
Question Number	Acceptable Answers	Reject	Mark
21(c)	((±) 0.5 x 2 x 100 /11) = (±)9.09 (%) ALLOW at 9.0909/9.091/9.1 and 9	 9.10/9.0	**1**

Question Number	Acceptable Answers	Reject	Mark
21(d)	**First mark** It is used as a raising agent / self raising flour / baking soda / baking powder OR Causes cakes / (soda) bread to rise / expand. **(1)** **Second mark** Carbon dioxide (released on heating causes cakes / bread to rise) OR It reacts with acid to form carbon dioxide (in baking powder) providing bread /cake etc is mentioned **(1)** ALLOW Used in cooking green vegetables To keep green colour	To make pastry rise Bicarbonate of soda Gas Air Neutralizing acid foods	**2**

Total for Question 21 = 11 Marks

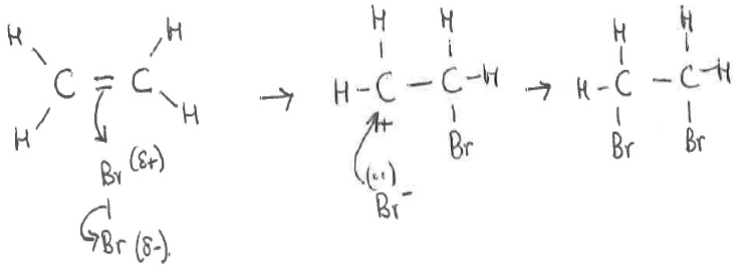
Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	$C_{12}H_{26} \rightarrow C_{10}H_{22} + C_2H_4$ IGNORE state symbols even if incorrect ALLOW displayed and structural formula for ethene		**1**

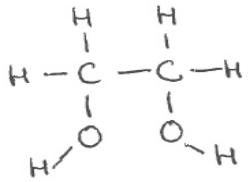
Question Number	Acceptable Answers	Reject	Mark
22 (a)(ii)	Collection over water or in gas syringe **(1)** IGNORE solid bung with delivery tube coming out / accidental sealing in drawing / clamps This is the only stand alone mark **Dependent on diagram including roughly horizontal tube:** Labelled ceramic fibre / any sort of wool (unless any named metal) (soaked in dodecane) **(1)** Aluminium oxide / porcelain pieces/catalyst / catalyst with incorrect name or incorrect formula / any named metal / anti-bump granules **(1)** Heat under catalyst/under middle of test tube **(1)**  	Delivery tube through glassware	**4**

Question Number	Acceptable Answers	Reject	Mark
22(b)	EITHER  Diagram of bonds, the single bond must be shown as a region of space and not as a single or double straight line **(1)** Labelled σ and π in correct places on correctly drawn bonds.ie this mark can only be awarded if bonds correctly drawn **(1)** OR   Labelled pi bond **(1)** Labelled sigma bond **(1)** Whichever scores more Bonds may be shown by overlap of appropriate orbitals, when any orbital or region of overlap may be labelled Only one pi lobe / bond need be labelled Carbons need not be shown Bonds may be drawn on separate diagrams	 	**2**

	IGNORE C-H bonds IGNORE any additional electron density maps IGNORE any partial charges		

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	1,2-dibromoethane **(1)** IGNORE punctuation CH_2BrCH_2Br **(1)** ALLOW displayed / skeletal formula Mark independently Bromoethane with CH_2BrCH_3 (0)	 $C_2H_4Br_2$	**2**

Question Number	Acceptable Answers	Reject	Mark
22 (c)(ii)	 Arrow from double bond towards nearest bromine atom and arrow from bond between bromine atoms to furthest bromine atom **(1)** Correct formula of carbocation intermediate **(1)** Arrow from anywhere on the brom**ide** ion to positive carbon **(1)** ALLOW missing hydrogens if bonds from carbons shown ALLOW full marks for TE bromoethane formation using HBr and first arrow to H of HBr ALLOW full marks for TE 1,2 – dibromopropane		**3**

Question Number	Acceptable Answers	Reject	Mark
22(d)	 ALLOW O-H not displayed ALLOW vertical C bond to any part of OH Only penalise clear C-H-O / CH-O bond horizontally IGNORE any name whether correct or not	Skeletal formula or structural formula	**1**

Question Number	Acceptable Answers	Reject	Mark
22(e)(i)	$nCH_2=CH_2 \rightarrow \text{(}CH_2\text{-}CH_2\text{)}_n$ Left side **(1)** Right side extension bonds must be shown **(1)** Mark independently Accept $nC_2H_4 \rightarrow \text{(}CH_2\text{-}CH_2\text{)}_n$ Penalise omission of n only once ALLOW $nCH_2=CH_2 + nCH_2=CH_2 \rightarrow \text{(}CH_2\text{-}CH_2\text{)}_n$ for (2) ALLOW multiples of C_2H_4 in product	$(CH_2=CH_2)_n$ N	**2**

Question Number	Acceptable Answers	Reject	Mark
22(e)(ii)	**100%** with one of the following: …only one product OR … no by-products / no other product OR …all reactants form the product OR …as addition reaction IGNORE…same empirical formula	 No product lost / No side reaction(s) All reactants form the product**s**	**1**

Total for Question 22 = 16 Marks

Total for Paper = 80 Marks

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Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 23 May 2013 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01R

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P42982A

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7/6/7/1/

P 4 2 9 8 2 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The first five ionization energies of an element, **X**, are

578, 1817, 2745, 11578 and 14831 kJ mol^{-1}, respectively.

In which group of the Periodic Table is **X** found?

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(Total for Question 1 = 1 mark)

---

2 Which of the following oxides would be expected to have the most exothermic lattice energy?

☒ **A** Na_2O

☒ **B** MgO

☒ **C** CaO

☒ **D** K_2O

(Total for Question 2 = 1 mark)

---

3 In which of the following compounds is the **anion** most polarized?

☒ **A** LiF

☒ **B** LiI

☒ **C** KF

☒ **D** KI

(Total for Question 3 = 1 mark)

---

4 In the Born-Haber cycle for potassium iodide, which of the following steps is **exothermic**?

☒ **A** $K(s) \rightarrow K(g)$

☒ **B** $K(g) \rightarrow K^+(g) + e^-$

☒ **C** $\frac{1}{2}I_2(s) \rightarrow I(g)$

☒ **D** $I(g) + e^- \rightarrow I^-(g)$

(Total for Question 4 = 1 mark)

5 Which of the following represents a pair of isotopes?

☒ **A** $^{14}_{6}C$ and $^{14}_{7}N$

☒ **B** $^{32}_{16}S$ and $^{32}_{16}S^{2-}$

☒ **C** O_2 and O_3

☒ **D** $^{206}_{82}Pb$ and $^{208}_{82}Pb$

(Total for Question 5 = 1 mark)

6 Which of the following equations represents the **second** ionization energy of chlorine?

☒ **A** $Cl^+(g) \rightarrow Cl^{2+}(g) + e^-$

☒ **B** $Cl(g) \rightarrow Cl^{2+}(g) + 2e^-$

☒ **C** $Cl(g) \rightarrow Cl^{2-}(g) - 2e^-$

☒ **D** $Cl^-(g) \rightarrow Cl^{2-}(g) - e^-$

(Total for Question 6 = 1 mark)

7 For Period 3 of the Periodic Table, from sodium to argon, what is the trend in the melting temperatures of the elements?

☒ **A** A steady decrease

☒ **B** A steady increase

☒ **C** A decrease to silicon then an increase

☒ **D** An increase to silicon then a decrease

(Total for Question 7 = 1 mark)

8 Given the following information

$$CH_4(g) \rightarrow C(g) + 4H(g) \qquad \Delta H = +Q \text{ kJ mol}^{-1}$$

the mean bond enthalpy for the C—H bond in methane is

☒ **A** $+Q$

☒ **B** $+Q/4$

☒ **C** $-Q$

☒ **D** $-Q/4$

(Total for Question 8 = 1 mark)

9 Consider the following information:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
I—I	+151
H—I	+299

For the reaction

$$H_2(g) + I_2(g) \rightarrow 2HI(g)$$

the enthalpy change, in kJ mol^{-1}, is

☒ **A** +288

☒ **B** +144

☒ **C** −11

☒ **D** −5.5

(Total for Question 9 = 1 mark)

10 The equation for the complete combustion of butanone, $C_2H_5COCH_3$, is

$$C_2H_5COCH_3(l) + 5\frac{1}{2}O_2(g) \rightarrow 4CO_2(g) + 4H_2O(l) \qquad \Delta H^{\ominus} = -2440 \text{ kJ mol}^{-1}$$

Substance	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CO_2(g)$	–394
$H_2O(l)$	–286

From the above data, the standard enthalpy change of formation of butanone, in kJ mol^{-1}, is

☒ **A** –280

☒ **B** +280

☒ **C** –1760

☒ **D** +1760

(Total for Question 10 = 1 mark)

11 A compound was found to contain 2.8 g of nitrogen and 8.0 g of oxygen.

What is the empirical formula of the compound?

Use the Periodic Table as a source of data.

☒ **A** NO

☒ **B** NO_2

☒ **C** N_2O_3

☒ **D** N_2O_5

(Total for Question 11 = 1 mark)

12 What is the total number of **atoms** in 1.8 g of water, H_2O?

DATA
- The molar mass of H_2O is 18 g mol^{-1}
- The Avogadro Constant is 6.0×10^{23} mol^{-1}

☒ **A** 6.0×10^{22}

☒ **B** 6.0×10^{23}

☒ **C** 1.8×10^{23}

☒ **D** 1.8×10^{24}

(Total for Question 12 = 1 mark)

13 Phosphorus(V) chloride, PCl_5, reacts with water according to the equation

$$PCl_5(s) + 4H_2O(l) \rightarrow H_3PO_4(aq) + 5HCl(aq)$$

If 1.04 g of phosphorus pentachloride (molar mass = 208 g mol^{-1}) is reacted completely with water and the solution made up to 1 dm^3, the concentration of the hydrochloric acid in mol dm^{-3} is

- ☒ **A** 0.001
- ☒ **B** 0.005
- ☒ **C** 0.025
- ☒ **D** 0.250

(Total for Question 13 = 1 mark)

14 A sample of sodium chlorate(V), $NaClO_3$, was heated and 120 cm^3 of oxygen gas was collected.

$$2NaClO_3(s) \rightarrow 2NaCl(s) + 3O_2(g)$$

Calculate the number of moles of sodium chlorate(V) that were decomposed in the above reaction.

[Molar volume of a gas under the conditions of the experiment = 24000 cm^3 mol^{-1}]

- ☒ **A** 2.50×10^{-3}
- ☒ **B** 3.33×10^{-3}
- ☒ **C** 5.00×10^{-3}
- ☒ **D** 7.50×10^{-3}

(Total for Question 14 = 1 mark)

15 In the ethene molecule, the C=C double bond is made up of

- ☒ **A** two sigma bonds.
- ☒ **B** one pi bond.
- ☒ **C** two pi bonds.
- ☒ **D** one sigma bond and one pi bond.

(Total for Question 15 = 1 mark)

16 3.0 dm^3 of sulfur dioxide reacts with 1.5 dm^3 of oxygen, under suitable conditions, according to the equation below.

$$2SO_2(g) + O_2(g) \rightarrow 2SO_3(g)$$

What is the maximum volume of sulfur trioxide that can be formed in the above reaction?

[The volumes of the gases are measured at the same temperature and pressure.]

☒ **A** 6.0 dm^3

☒ **B** 4.5 dm^3

☒ **C** 3.0 dm^3

☒ **D** 1.5 dm^3

(Total for Question 16 = 1 mark)

17 Which of the following alkenes exhibits *E/Z* isomerism?

☒ **A** But-1-ene

☒ **B** But-2-ene

☒ **C** 2-Methylpropene

☒ **D** Propene

(Total for Question 17 = 1 mark)

18 An electrophile is **defined** as a species that

☒ **A** is an electron pair acceptor.

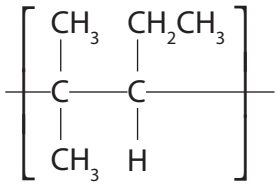
☒ **B** is an electron pair donor.

☒ **C** has a negative charge.

☒ **D** has a positive charge.

(Total for Question 18 = 1 mark)

19 The repeat unit of a polymer is shown below.



The systematic name of the alkene monomer that forms this polymer is

☒ **A** 2-methyl-3-ethylpropene

☒ **B** 2-methylpent-2-ene

☒ **C** 2-methylpent-3-ene

☒ **D** 4-methylpent-2-ene

(Total for Question 19 = 1 mark)

20 Cracking crude oil

☒ **A** separates the mixture into pure compounds.

☒ **B** separates the mixture into a number of fractions.

☒ **C** separates saturated compounds from unsaturated ones.

☒ **D** decreases the average number of carbon atoms per molecule.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

BLANK PAGE

Section B begins on the next page.

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 In atoms, electrons fill up the sub-shells in order of increasing energy.

(a) Fill in the last two boxes in the table below to show the order in which the next two sub-shells are filled.

1s	2s	2p	3s	3p	4s		

energy increases →

(2)

(b) Electrons in atoms occupy orbitals.

(i) Explain the term **orbital**.

(1)

.....

.....

.....

(ii) Draw diagrams below to show the shape of an s-orbital and of a p-orbital.

(2)

s-orbital

p-orbital

(c) State the **total** number of electrons occupying **all** the p-orbitals in one atom of chlorine.

(1)

.....

(d) State the number of electrons present in an ion of calcium, Ca^{2+}.

(1)

.....

*(e) Define the term **first ionization energy**.

(3)

.....

.....

.....

.....

.....

(f) The ionization energies of sodium, Na, are shown in the table below.

Show with a tick (✓), in the third row of the table below, **all** the ionization numbers that involve the removal of an electron from an s-orbital.

(2)

Ionization energy / kJ mol^{-1}	496	4563	6913	9544	13352	16611	20115	25491	28934	141367	159079
Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th

(Total for Question 21 = 12 marks)

22 (a) In a mass spectrometer being used to determine relative atomic masses, gaseous atoms are ionized. The ions are then accelerated and deflected before being detected.

(i) Explain how atoms are **ionized** in a mass spectrometer.

(1)

.....

.....

.....

.....

(ii) How are the ions **accelerated** in a mass spectrometer?

(1)

.....

.....

(iii) How are the ions **deflected** in a mass spectrometer?

(1)

.....

.....

(b) The following data were obtained from the mass spectrum of a sample of platinum.

Peak at *m/e*	%
194	32.8
195	30.6
196	25.4
198	11.2

Calculate the relative atomic mass of platinum in this sample. Give your answer to **one** decimal place.

(2)

(c) In which block of the Periodic Table is platinum found?

(1)

(d) Most solids exist as lattice structures.

(i) Complete the table, using a tick (✓) if the substance conducts electricity or a cross (✗) if the substance does not conduct electricity.

(2)

Substance	Conducts electricity in the SOLID state? (✓ or ✗)	Conducts electricity in the LIQUID state? (✓ or ✗)
Sodium, Na		
Sodium oxide, Na_2O		

*(ii) Explain the electrical conductivities of sodium and of sodium oxide in the solid and liquid states.

(3)

(Total for Question 22 = 11 marks)

23 Crude oil is a complex mixture of hydrocarbons. Initial separation is achieved by fractional distillation of the crude oil. The separate fractions are further refined to produce hydrocarbons such as decane, $C_{10}H_{22}$.

(a) Give the general formula of alkanes.

(1)

(b) Carbon monoxide, CO, is formed during the incomplete combustion of decane.

(i) Write an equation for the incomplete combustion of decane, forming carbon monoxide and water only.

(1)

(ii) Explain why incomplete combustion can occur.

(1)

.....

.....

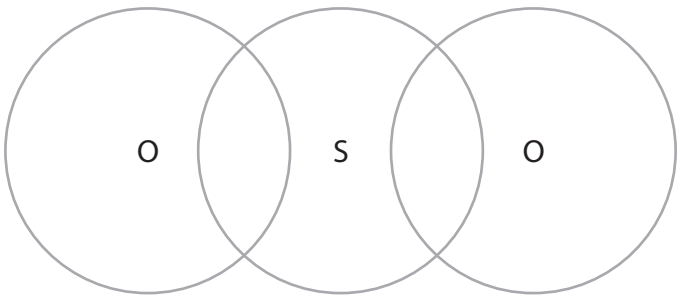
(c) 'Low-sulfur fuel' is now supplied to petrol stations. The removal of sulfur from diesel and petrol reduces the emission of toxic oxides of sulfur from vehicle exhausts. One such oxide is sulfur dioxide, SO_2.

The bonding in sulfur dioxide may be represented as shown below.

$$O = S \rightarrow O$$

Complete the dot and cross diagram below for the SO_2 molecule, showing only outer shell electrons. Use dots to represent the oxygen electrons and crosses to represent the sulfur electrons.

(3)



(d) Another alkane produced from crude oil is heptane, C_7H_{16}. The reforming of heptane produces methylcyclohexane and only one other product. A methylcyclohexane molecule is made from a ring of six carbon atoms bonded to a methyl group.

(i) Use the information given above to give the **skeletal** formula of methylcyclohexane.

(1)

(ii) Write a balanced equation, using **molecular** formulae, for the reforming of heptane into methylcyclohexane and one other product. State symbols are not required.

(1)

(iii) Suggest a reason why oil companies reform alkanes such as heptane.

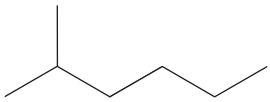
(1)

.....

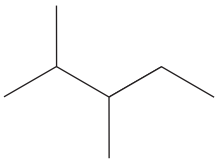
.....

(e) Five branched-chain isomers of heptane are shown in the boxes below.

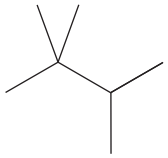
2-methylhexane



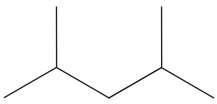
2,3-dimethylpentane



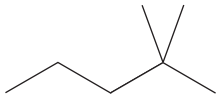
2,2,3-trimethylbutane



2,4-dimethylpentane



isomer **A**



(i) Give the systematic name of isomer **A**.

(1)

.....

(ii) In the empty boxes above, draw skeletal formulae for two other **branched-chain** isomers of C_7H_{16}, with no side-chain having more than one carbon atom.

(2)

(f) Butane, C_4H_{10}, reacts with chlorine, Cl_2, at room temperature and pressure.

$$C_4H_{10} + Cl_2 \rightarrow C_4H_9Cl + HCl$$

(i) What other condition is essential for this reaction?

(1)

.....

(ii) Write an equation for the initiation step of the mechanism for the above reaction. Curly arrows are not required.

(1)

(iii) State the type of bond fission involved in the initiation step.

(1)

.....

(iv) Write equations for the two propagation steps of this mechanism. Curly arrows are not required.

(2)

First propagation step:

Second propagation step:

(v) Write **one** equation for a reaction that would terminate this mechanism.

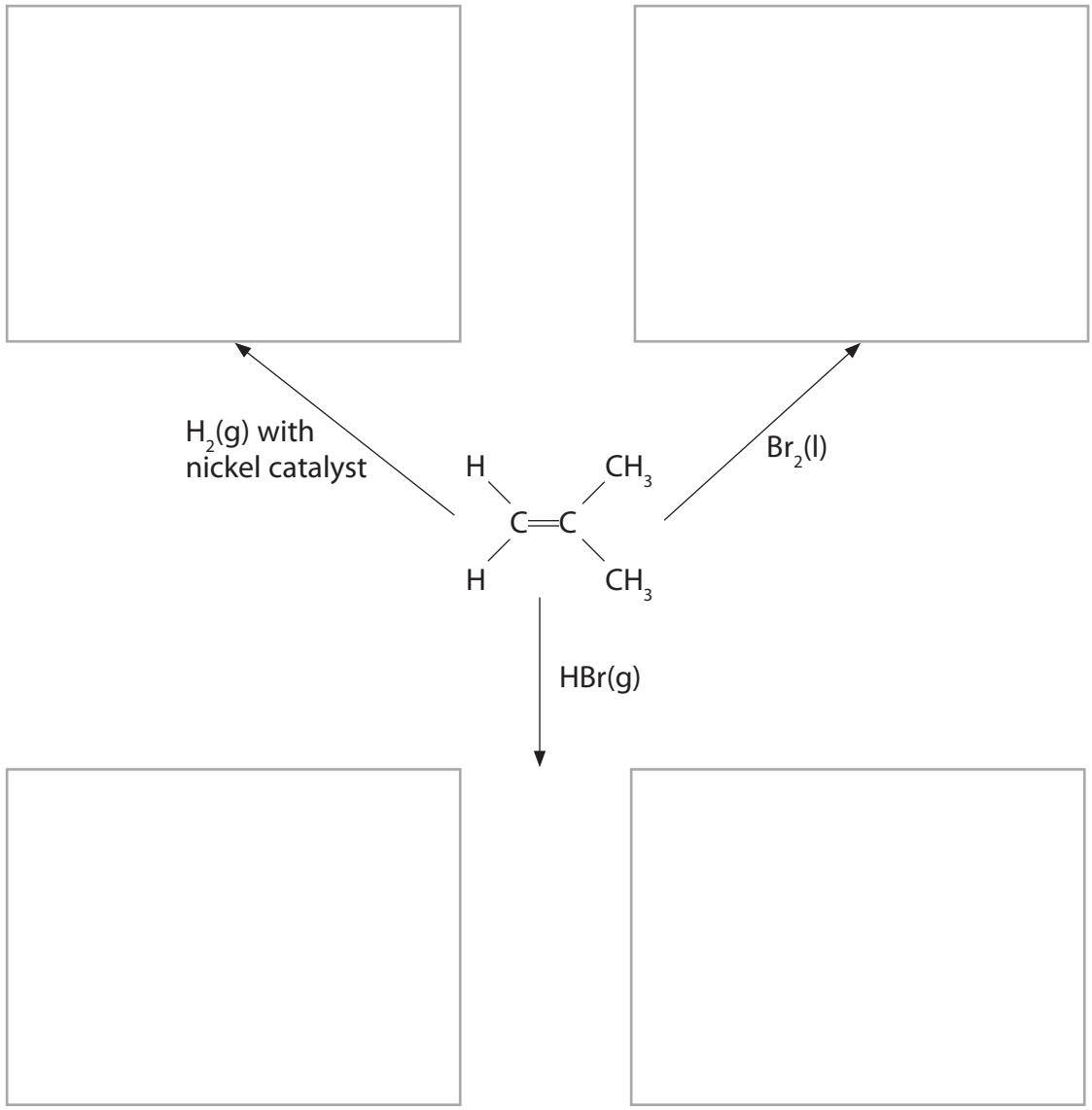
(1)

(Total for Question 23 = 18 marks)

24 Alkenes are unsaturated hydrocarbons. They are used in the industrial production of many organic compounds.

(a) Add structural formulae to the flowchart below to show the organic product formed in each addition reaction of 2-methylpropene.

(4)



mixture of isomers

(b) Suggest a mechanism for the reaction of 2-methylpropene with bromine, $Br_2(l)$.
Include curly arrows.

(3)

(c) Ethene, C_2H_4, was prepared from ethanol, C_2H_5OH, by the following reaction

$$C_2H_5OH \rightarrow C_2H_4 + H_2O$$

A chemist reacted 9.2 g of ethanol, C_2H_5OH, and obtained 4.2 g of ethene.

Calculate the percentage yield of ethene in the reaction.

(2)

(Total for Question 24 = 9 marks)

25 *(a) Define the term **enthalpy change of neutralization**.

(2)

.....

.....

.....

.....

(b) The enthalpy change of the neutralization reaction between hydrochloric acid, HCl(aq), and sodium hydroxide, NaOH(aq), can be determined by the following procedure.

Procedure:

- 50.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid is transferred to a polystyrene cup and its temperature recorded
- 50.0 cm^3 of 2.00 mol dm^{-3} sodium hydroxide solution is placed in another polystyrene cup and its temperature recorded
- The two solutions are mixed, with stirring, and the maximum temperature is recorded

Results:

Initial temperature of both the HCl(aq) and NaOH(aq) = 19.0 °C

Maximum temperature reached after mixing = 32.5 °C

Assumption:

- The specific heat capacity of all aqueous solutions is 4.18 J g^{-1} $°C^{-1}$
- The density of all aqueous solutions is 1.00 g cm^{-3}

(i) Calculate the heat energy released (in joules) on mixing the hydrochloric acid and the sodium hydroxide solutions.

Use the expression

energy released (J) = mass of solution $\times$ 4.18 $\times$ temperature change

(2)

(ii) Calculate the number of moles of hydrochloric acid used in the experiment.

(1)

(iii) Give the **ionic** equation, including state symbols, for the reaction between hydrochloric acid and sodium hydroxide solution.

(1)

(iv) Use your answers to (b)(i), (ii) and (iii) to calculate the enthalpy change of neutralization for the above reaction.
Include a sign and units in your answer.

(3)

(v) Explain why the enthalpy change of neutralization for the reaction between dilute nitric acid, $HNO_3(aq)$, and potassium hydroxide solution, KOH(aq), is predicted to be the same as the enthalpy change of neutralization for the reaction carried out in part (b).

(1)

.....

.....

.....

.....

(Total for Question 25 = 10 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 8 2 A 0 2 4 2 4

PMT



Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH01/01R
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear

  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter

  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.

( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear

- select and use a form and style of writing appropriate to purpose and to complex subject matter

- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Correct Answer	Mark
1	C	**1**

Question Number	Correct Answer	Mark
2	B	**1**

Question Number	Correct Answer	Mark
3	B	**1**

Question Number	Correct Answer	Mark
4	D	**1**

Question Number	Correct Answer	Mark
5	D	**1**

Question Number	Correct Answer	Mark
6	A	**1**

Question Number	Correct Answer	Mark
7	D	**1**

Question Number	Correct Answer	Mark
8	B	**1**

Question Number	Correct Answer	Mark
9	C	**1**

Question Number	Correct Answer	Mark
10	A	**1**

Question Number	Correct Answer	Mark
11	D	**1**

Question Number	Correct Answer	Mark
12	C	**1**

Question Number	Correct Answer	Mark
13	C	**1**

Question Number	Correct Answer	Mark
14	B	**1**

Question Number	Correct Answer	Mark
15	D	**1**

Question Number	Correct Answer	Mark
16	C	**1**

Question Number	Correct Answer	Mark
17	B	**1**

Question Number	Correct Answer	Mark
18	A	**1**

Question Number	Correct Answer	Mark
19	B	**1**

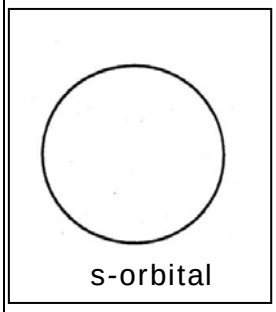
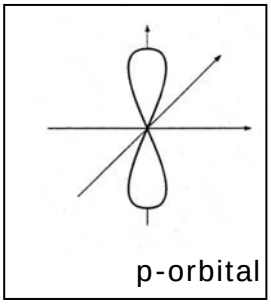
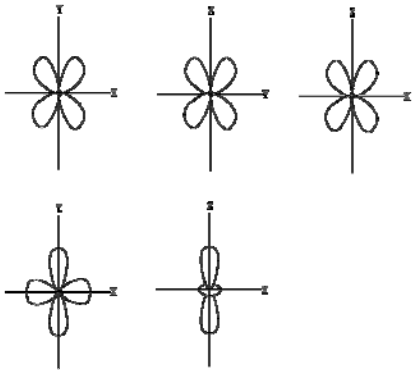
Question Number	Correct Answer	Mark
20	D	**1**

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a)	<table><tr><td>**1s**</td><td>**2s**</td><td>**2p**</td><td>**3s**</td><td>**3p**</td><td>**4s**</td><td>**3d**</td><td>**4p**</td></tr></table> 3d 4p **(2)** ALLOW 4p 3d scores 1 out of 2 4p 5s scores 1 out of 2 ALLOW use of capital letters e.g. "3D and/or 4P"	'4p 4d' or '4d 4p' gets 0	**2**

Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	A region / space / volume (around the nucleus / atom) where there is a high probability / chance / likelihood / of finding an electron ALLOW 'area' / 'sub-shell' as alternative for region OR A region where an electron is likely to be found	Just 'the path an electron takes orbiting around a nucleus' Just 'Position of electrons in an atom'	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)	 s-orbital **(1)**  p-orbital **(1)**	For s-orbital do not allow ellipse for first mark pi bond d-orbitals shown below 	**2**

Question Number	Acceptable Answers	Reject	Mark
21 (c)	11 / eleven ALLOW $2p^6 3p^5$	 $1s^2 2s^2 2p^6 3s^2 3p^5$	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (d)	18 / eighteen	$1s^2 2s^2 2p^6 3s^2 3p^6$	**1**

Question Number	Acceptable Answers	Reject	Mark
***21 (e)**	Enthalpy / energy / heat / heat energy per mole **required / needed** OR Enthalpy / energy / heat / heat energy **change** per mole **(1)** to remove one / an electron **(1)** from **gaseous atom(s)** **(1)** "Energy required to remove one mole of electrons from one mole of gaseous atoms" scores all **three** marks NOTE: The equation: $X(g) \rightarrow X^{+}(g) + e^{-}$ scores the last two marks NOTE: An incorrect equation given with a correct definition in words scores 2 out of 3 marks	"Energy **given out** …" for first mark	**3**

Question Number	Acceptable Answers												Mark
21 (f)	**Ionization energy / kJ mol^{-1}**	496	4563	6913	9544	13352	16611	20115	25491	28934	141367	159079	**2**
	Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th	9th	10th	11th	
		✓							✓	✓	✓	✓	

All five correct = **2** marks

Four/three correct = **1** mark

Two/one/none correct = **0** marks

Total for Question 21 = 12 marks

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Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	**The mark is for the idea of impact by high energy electrons** **Any ONE of:** High-energy **electrons** Bombard with **electrons** Fast **electrons** (fired at sample) Accelerated **electrons** (fired at sample) (High-energy) **electrons** fired (at sample) (Sample) blasted with **electrons** **Electron** gun ALLOW "beam of **electrons**" IGNORE any comments about ionization of the sample whether correct or incorrect IGNORE descriptions of vaporisation	High-**density** electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Electric field / (negatively) charged plates ALLOW voltage plates electrostatic field electrical field pushed by positively (charged) plate/ anode	**Positively** charged plates alone / electronic field / electric current / electricity / electrical charge / (electro) magnetic field / electric coil	**1**

Question Number	Acceptable Answers	Reject	Mark
22 (a)(iii)	Magnetic field /magnet / electromagnet /magnetic plates / electromagnetic field	**Negative** magnetic field/ negatively charged magnet	**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)	(194 x 32.8) + (195 x 30.6) + (196 x 25.4) + (198 x 11.2)) ÷ 100 **(1)** = 195.262 = 195.3 **(1 d.p.)** **(1)** Method **(1)** Answer must be to **1 d.p.** IGNORE g , g mol^{-1} or amu but other wrong units lose a mark Correct answer with no working **(2)** ALLOW TE for second mark if 1 numerical slip in transferring data from the table and answer to 1 d.p		**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)	d(-block) ALLOW D(-block) IGNORE Transition element(s) / transition metal(s)		**1**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	**(Na):** ✓ and ✓ **(1)** **(Na_2O):** **X** and ✓ **(1)**		**2**

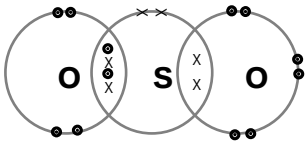
Question Number	Acceptable Answers	Reject	Mark
***22 (d) (ii)**	**Na:** conducts when **both** solid and molten due to (delocalized)**free / mobile electrons** **(1)** **Na_2O:** does not conduct when solid as no mobile **ions** / **ions** unable to move / **ions** in fixed position **(1)** **Na_2O:** conducts when molten as has mobile **ions** **(1)**	Ions with reference to either form of sodium metal electrons electrons	**3**

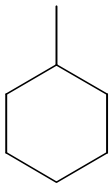
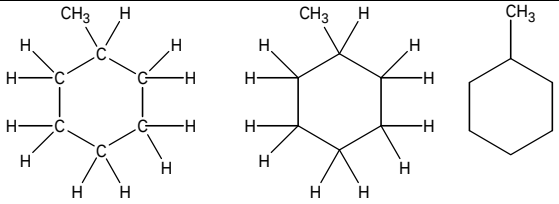
Total for Question 22 = 11 marks

Question Number	Acceptable Answers	Reject	Mark
23(a)	C_nH_{2n+2} IGNORE 'where n=1, 2, 3 etc' or 'where n is greater than 1'		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	$C_{10}H_{22} + 10½O_2 \rightarrow 10CO + 11H_2O$ ALLOW 21 / 2 O_2 ALLOW any correct multiples IGNORE state symbols, even if incorrect	21 [O]	**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	Any statement that makes it clear there is not enough air or oxygen e.g. Limited supply of air / limited supply of oxygen / not enough air / not enough oxygen / lack of oxygen / little amount of oxygen/ small amount of oxygen IGNORE "it is not completely oxidized"		**1**

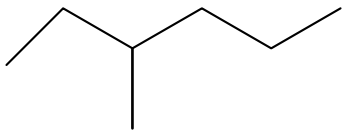
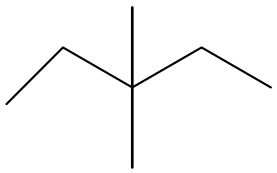
Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark** Dative pair of e^- between S and right-hand O **(1)** **Second mark** Two bond pairs between S and left-hand O **(1)** **Third mark** Two lone pairs on left-hand O, one lone pair on central S and three lone pairs on right-hand O atom **(1)** If 2 double bonds between sulfur and each oxygen then the third mark can be given for two lone pairs on both oxygens and one lone pair on central S  NOTE ALLOW dots and crosses that have been reversed Lone pair electrons can be shown as separated (rather than having to be paired up) – **it is the total number of electrons in each outer shell that matters** Stand alone marks If molecule shown as charged then 2 max		**3**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)		 benzene ring	**1**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	$C_7H_{16} \rightarrow C_7H_{14} + H_2$ ALLOW $C_6H_{11}CH_3$ IGNORE state symbols, even if incorrect	Formulae other than molecular formulae Any other structural or displayed formulae	**1**

Question Number	Acceptable Answers	Reject	Mark
23(d)(iii)	Any **ONE** of: (a cyclic alkane) has more efficient combustion allows smoother burning increases octane number reduces knocking / less likely to produce pre-ignition is a more efficient fuel burns better / easier to burn /combusts more easily / improves combustion IGNORE (a cyclic alkane): increases the volatility of a fuel "ignites more easily" "is a better fuel" "burns more cleanly" IGNORE (a cyclic alkane) has a lower boiling point mentions of viscosity safer fuel	Less pollution / reduce waste High atom economy Produces useful products / hydrogen Used to make polymers Produces substances in higher demand / more valuable	**1**

Question Number	Acceptable Answers	Reject	Mark
23(e)(i)	2,2-dimethylpent**ane** IGNORE missing hyphen/missing comma	2-dimethylpentane	**1**

Question Number	Acceptable Answers	Reject	Mark
23(e)(ii)	 **(1)**  **(1)** IGNORE names even if incorrect IGNORE different length bonds IGNORE direction of methyl groups		**2**

Question Number	Acceptable Answers	Reject	Mark
23(f)(i)	U.V. / U.V.light / light / sunlight ALLOW high temperature	 heat alone	**1**

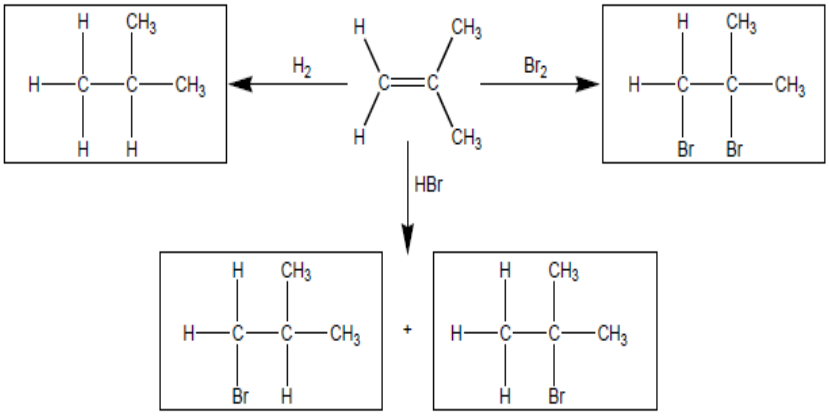
Question Number	Acceptable Answers	Reject	Mark
23(f)(ii)	$Cl_2 \rightarrow Cl\cdot + Cl\cdot$ / $Cl_2 \rightarrow 2Cl\cdot$ IGNORE any curly arrows, even if incorrect IGNORE C_4H_{10} given on both sides		**1**

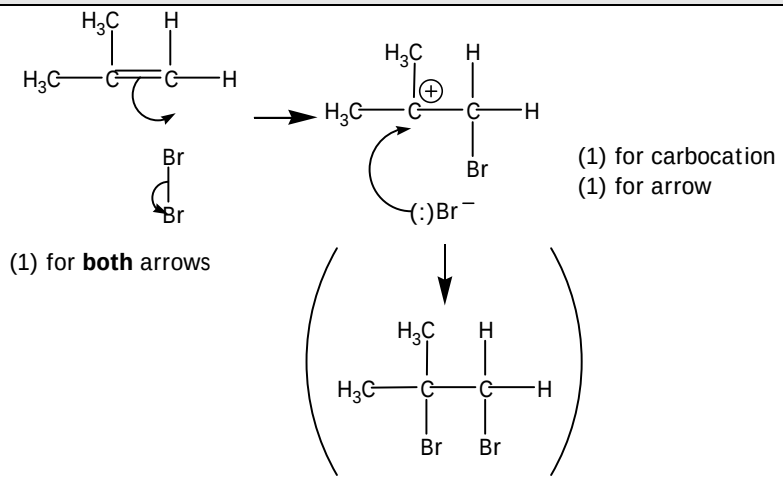
Question Number	Acceptable Answers	Reject	Mark
23(f)(iii)	Homolytic (fission) IGNORE any formulae and arrows	Photolysis (fission) / free radical (fission)	**1**

Question Number	Acceptable Answers	Reject	Mark
23(f)(iv)	**(First propagation step)** $C_4H_{10} + Cl\cdot \rightarrow C_4H_9\cdot + HCl$ **(1)** **(Second propagation step)** $C_4H_9\cdot + Cl_2 \rightarrow C_4H_9Cl + Cl\cdot$ **(1)** Formulae can be displayed 'dots' can be anywhere on free radical but no dots at all scores zero ALLOW in either order Incorrect alkane / halogenoalkane but two correct propagation steps scores 1 out of 2	Any reactions involving Hydrogen radicals scores zero Reverse of first reaction	**2**

Question Number	Acceptable Answers	Reject	Mark
23(f)(v)	Any **ONE** of: $C_4H_9\cdot + Cl\cdot \rightarrow C_4H_9Cl$ OR $Cl\cdot + Cl\cdot \rightarrow Cl_2$ OR $C_4H_9\cdot + C_4H_9\cdot \rightarrow C_8H_{18}$		**1**

Total for Question 23 = 18 marks

Question Number	Acceptable Answers	Reject	Mark
24(a)	 **(1)** for each correct product ALLOW correct displayed / skeletal / semi-skeletal / structural / semi-structural formula in each case ALLOW any order of symbols after or before each carbon ALLOW brackets or no brackets around Br/ CH_3 for example $CH_2BrCH_3CBrCH_3$		**4**

Question Number	Acceptable Answers	Reject	Mark
24(b)	 (1) for carbocation (1) for arrow (1) for **both** arrows **First mark** **Double-headed** arrow from alkene must start from somewhere on C=C bond Partial charge on Br_2 molecule must be correct if shown **Second mark** is for either correct primary or secondary carbocation and is a standalone mark **Third mark** **Double-headed** arrow from bromide ion can start from the minus sign, a lone pair on Br^-, or from the Br and can go to the C or the + sign on the intermediate The **negative charge** must be present on the **bromide ion** The final product, if shown, must be correct to gain third mark Mechanisms with other electrophiles (e.g. HBr, BrOH) can score 2nd and 3rd marks	Single-headed arrow Bromine / bromide free radicals Single-headed arrow (Penalise again)	**3**

Question Number	Acceptable Answers	Reject	Mark
24(c)	**First mark is for calculating the theoretical maximum mass of ethene from 9.2 g ethanol:-** (46 g C_2H_5OH gives 28 g C_2H_4 so 9.2 g C_2H_5OH gives maximum mass of) **5.6 g** C_2H_4 **(1)** **Second mark is for calculating the percentage yield from candidate's theoretical maximum mass:-** (4.2/5.6 x 100% =) **75** (%) IGNORE s.f. except 1 s.f. OR **First mark** Amount of ethene = 4.2/28 = 0.15 (mol) and amount of ethanol = 9.2/46 = 0.20 (mol) **(1)** **Second mark** % yield = 0.15/0.20 = 75 % **(1)** **NOTE** Correct answer with no working scores **(2)** % yield TE on candidate's theoretical mass / moles only if % yield ‹100% If molar masses are reversed, award one mark for 27.8%	**(0)** for $\frac{4.2}{9.2}$ x 100%	**2**

Total for Question 24 = 9 marks

Question Number	Acceptable Answers	Reject	Mark
***25(a)**	**First mark** The enthalpy change when **one mole of water** is produced **(1)** **Second Mark** as a result of the reaction between an acid and an alkali / a base **(1)** OR **First Mark** The enthalpy change when **one mole** of H^+ / H_3O^+ / oxonium / hydronium / hydroxonium (ions) **(1)** **Second Mark** Reacts with one mole of / excess / just enough OH^- **(1)** ALLOW **First mark** The enthalpy change when **one mole of acid** is (just) neutralized **(1)** **Second Mark** By (excess) alkali / base **(1)** ALLOW reverse argument i.e. base neutralising acid	"Energy **required**..." for 1st mark	**2**

Question Number	Acceptable Answers	Reject	Mark
25(b)(i)	5643 without working score 2 marks IGNORE any signs **First mark** Recognition that volume of solution / mass of solution is 100 (cm^3 / g) **(1)** **Second mark** ΔT = 13.5 ^oC (energy released) = 100 x 4.18 x 13.5 = 5643 (J) **(1)** ALLOW 5.643 **kJ** IGNORE s.f. except 1 s.f. IGNORE mol^{-1}	5643 kJ	**2**

Question Number	Acceptable Answers	Reject	Mark
25(b)(ii)	(Moles HCl = c_{HCl} x V_{HCl} / 1000=) $\frac{2.00 \times 50.0}{1000}$ = 0.1(00) (mol HCl) IGNORE s.f.		**1**

Question Number	Acceptable Answers	Reject	Mark
25(b) (iii)	$H^+(aq) + OH^-(aq) \rightarrow / \rightleftharpoons H_2O(l)$ NOTE: **ALL State symbols AND ALL species are required for the mark** ALLOW equations with the "spectator ions" crossed out		**1**

Question Number	Acceptable Answers	Reject	Mark
25(b) (iv)	— $\frac{5.643}{0.1(00)}$ = —56.43 **kJ mol^{-1}** **First mark:** Correct TE for calculations using answers to (b)(i) and (b)(ii) **(1)** **Second mark:** Minus sign **(1)** **Third mark:** Final answer in units of **kJ mol^{-1}** or **kJ/mol** ALLOW correct answer in J mol^{-1} if units given **(1)** IGNORE case of k and J IGNORE s.f. EXCEPT 1 s.f. NOTE*:* Correct answer, with or without working, scores **(3)**	Final answer to 1 s.f. kJ/mol^{-1} or just kJ just J	**3**

Question Number	Acceptable Answers	Reject	Mark
25(b)(v)	The **ionic equation** is the **same** OR number of moles of H^+ ions and OH^- is the same OR number of moles of H^+ ions and water is the same OR number of moles of OH^- ions and water is the same ALLOW Both acid and base are strong **and** produce 1 mol of water	Just 'forms one mole of water**(1)**'	**1**

Total for Question 25 = 10 marks

Total for Section B = 60 Marks

Total for Paper = 80 Marks

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Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Thursday 9 January 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P42986A

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6/6/6/6/2/2/

P 4 2 9 8 6 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following ions would be deflected **least** in a mass spectrometer?

☒ **A** $^{35}Cl^{+}$

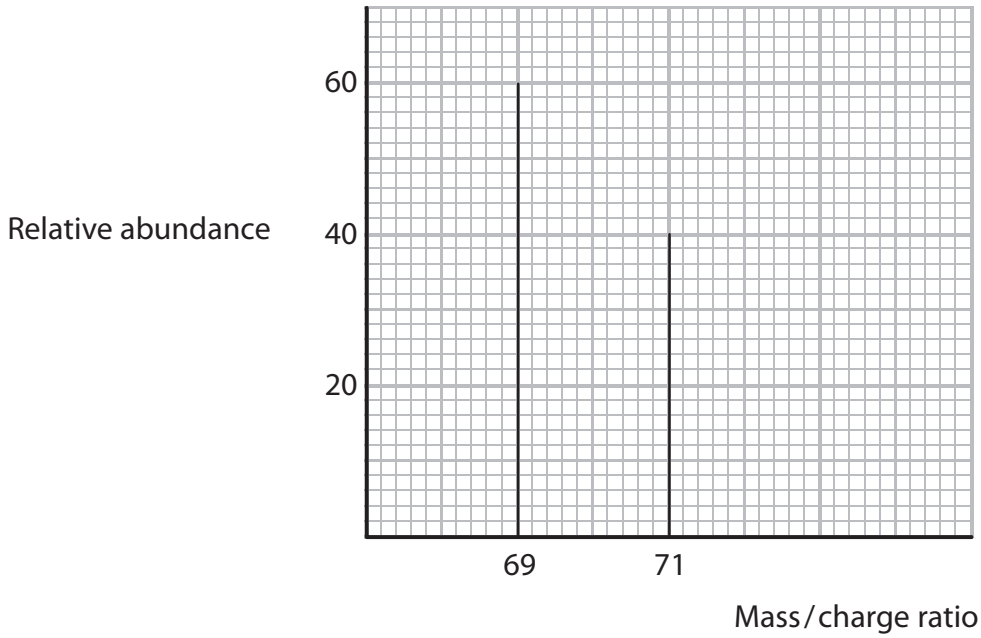
☒ **B** $^{35}Cl^{2+}$

☒ **C** $^{37}Cl^{+}$

☒ **D** $^{37}Cl^{2+}$

(Total for Question 1 = 1 mark)

2 The mass spectrum of an element is shown below.



The relative atomic mass of the element is

☒ **A** 69.4

☒ **B** 69.8

☒ **C** 70.0

☒ **D** 70.2

(Total for Question 2 = 1 mark)

3 In a mass spectrometer, positive ions are accelerated by

☒ **A** bombarding them with fast-moving electrons.

☒ **B** bombarding them with fast-moving protons.

☒ **C** passing them between charged plates.

☒ **D** passing them through a magnetic field.

(Total for Question 3 = 1 mark)

4 The number of unpaired electrons in a nitrogen atom in its ground state is

☒ **A** 0

☒ **B** 1

☒ **C** 2

☒ **D** 3

(Total for Question 4 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

5 Four sequences of ionization energies of elements, in kJ mol^{-1}, are shown below.

A 590 1145 4912 6474 8144

B 520 496 419 403 376

C 1000 1251 1521 419 590

D 631 658 650 653 717

(a) The sequence giving the first ionization energies of elements going down a Group in the Periodic Table is

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) The sequence showing the first five ionization energies of calcium is

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) The sequence showing the first ionization energy of successive elements, in which atomic number increases by one each time, starting with an element in Group 6 is

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 3 marks)

6 Which of the following ions has the **smallest** ionic radius?

☒ **A** Ca^{2+}

☒ **B** K^{+}

☒ **C** S^{2-}

☒ **D** Cl^{-}

(Total for Question 6 = 1 mark)

7 A liquid, which conducts electricity, continues to conduct when it is cooled and solidified. Which of the following could it be?

☒ **A** Mercury

☒ **B** Bromine

☒ **C** Molten sodium chloride

☒ **D** Tetrachloromethane

(Total for Question 7 = 1 mark)

8 Calculate the number of **atoms** in one mole of hydrogen peroxide, H_2O_2.

[The Avogadro constant, $L = 6.0 \times 10^{23}$ mol^{-1}]

☒ **A** 1.5×10^{23}

☒ **B** 6.0×10^{23}

☒ **C** 1.2×10^{24}

☒ **D** 2.4×10^{24}

(Total for Question 8 = 1 mark)

9 When 0.1 mol of atoms of an element reacts with chlorine, there is an increase in mass of 7.1 g.

The element could be

☒ **A** carbon.

☒ **B** sodium.

☒ **C** magnesium.

☒ **D** aluminium.

(Total for Question 9 = 1 mark)

10 Magnesium nitrate is decomposed by heat in the following reaction.

$$2Mg(NO_3)_2(s) \rightarrow 2MgO(s) + 4NO_2(g) + O_2(g)$$

In an experiment, 0.10 mol of magnesium nitrate was heated. What is the maximum volume of gas, measured in dm^3 at room temperature and pressure, which could be obtained?

[Molar volume of a gas = 24 $dm^3\ mol^{-1}$ at room temperature and pressure]

☒ **A** 0.24

☒ **B** 2.4

☒ **C** 4.8

☒ **D** 6.0

(Total for Question 10 = 1 mark)

11 Ammonia gas decomposes when heated.

$$2NH_3(g) \rightarrow N_2(g) + 3H_2(g)$$

In an experiment, a sample of 500 cm^3 of ammonia was heated and 20% decomposed.

The total volume of gas present at the end of the experiment, in cm^3, was

☒ **A** 200

☒ **B** 400

☒ **C** 600

☒ **D** 1000

(Total for Question 11 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

12 The standard enthalpy change for the formation of ethene, C_2H_4, is +52.2 kJ mol^{-1} and that of ethane, C_2H_6, is –84.7 kJ mol^{-1}.

Calculate the standard enthalpy change for the reaction below, in kJ mol^{-1}.

$$C_2H_4(g) + H_2(g) \rightarrow C_2H_6(g)$$

☒ **A** –32.5

☒ **B** –136.9

☒ **C** +136.9

☒ **D** This cannot be calculated using only the data above.

(Total for Question 12 = 1 mark)

13 Which of the following equations represents a reaction for which the enthalpy change is the standard enthalpy change of formation of water, $\Delta H^{\ominus}_{f,298}$?

☒ **A** $H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$

☒ **B** $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$

☒ **C** $H_2O(g) \rightarrow H_2O(l)$

☒ **D** $H_2O(s) \rightarrow H_2O(l)$

(Total for Question 13 = 1 mark)

14 Consider the following bond enthalpy values.

Bond	Bond enthalpy / kJ mol^{-1}
CO in carbon monoxide	+1077
O=O	+498
C=O in carbon dioxide	+805

The enthalpy change for the reaction

$$CO(g) + \frac{1}{2}O_2(g) \rightarrow CO_2(g)$$

in units of kJ mol^{-1} is

☒ **A** –284

☒ **B** +35

☒ **C** +521

☒ **D** +770

(Total for Question 14 = 1 mark)

15 (a) Which of the following represents the equation for the reaction between ethane and chlorine in the presence of UV radiation?

(1)

☒ **A** $C_2H_6 + Cl_2 \rightarrow C_2H_4Cl_2 + H_2$

☒ **B** $C_2H_6 + Cl_2 \rightarrow C_2H_5Cl + HCl$

☒ **C** $C_2H_6 + Cl_2 \rightarrow 2CH_3Cl$

☒ **D** $C_2H_6 + 2Cl_2 \rightarrow 2CH_3Cl + 2HCl$

(b) The UV radiation initially causes the formation of

(1)

☒ **A** Cl^- ions.

☒ **B** Cl^+ ions.

☒ **C** $Cl^\bullet$ free radicals.

☒ **D** $C_2H_5^\bullet$ free radicals.

(c) Once it has started, the reaction can proceed for a time without UV light because

(1)

☒ **A** a chain reaction is occurring.

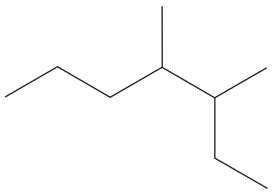
☒ **B** initiation is occurring.

☒ **C** a substitution reaction is occurring.

☒ **D** termination steps cannot occur without UV light.

(Total for Question 15 = 3 marks)

16 Which of the following is the systematic name for the hydrocarbon shown below?



☒ **A** 5-ethyl-4-methylhexane

☒ **B** 2-ethyl-3-methylhexane

☒ **C** 4,5-dimethylheptane

☒ **D** 3,4-dimethylheptane

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

17 This question is about some of the elements in Period 3 of the Periodic Table.

(a) (i) An atom of silicon has mass number 29. Complete the table below showing the numbers of sub-atomic particles in this atom of silicon. Use the Periodic Table as a source of data.

(1)

Sub-atomic particles present in one atom of ^{29}Si	Number
protons	
electrons	
neutrons	

(ii) Complete the electronic configuration of silicon.

(1)

$1s^2$.....

*(b) Explain the following, referring to differences in structure and bonding.

(i) Silicon has a higher melting temperature than phosphorus.

(3)

.....

.....

.....

.....

.....

.....

(ii) Magnesium has a higher melting temperature than sodium.

(2)

.....

.....

.....

.....

(c) Suggest why the atomic radius decreases going across the Periodic Table from sodium to silicon.

(2)

.....

.....

.....

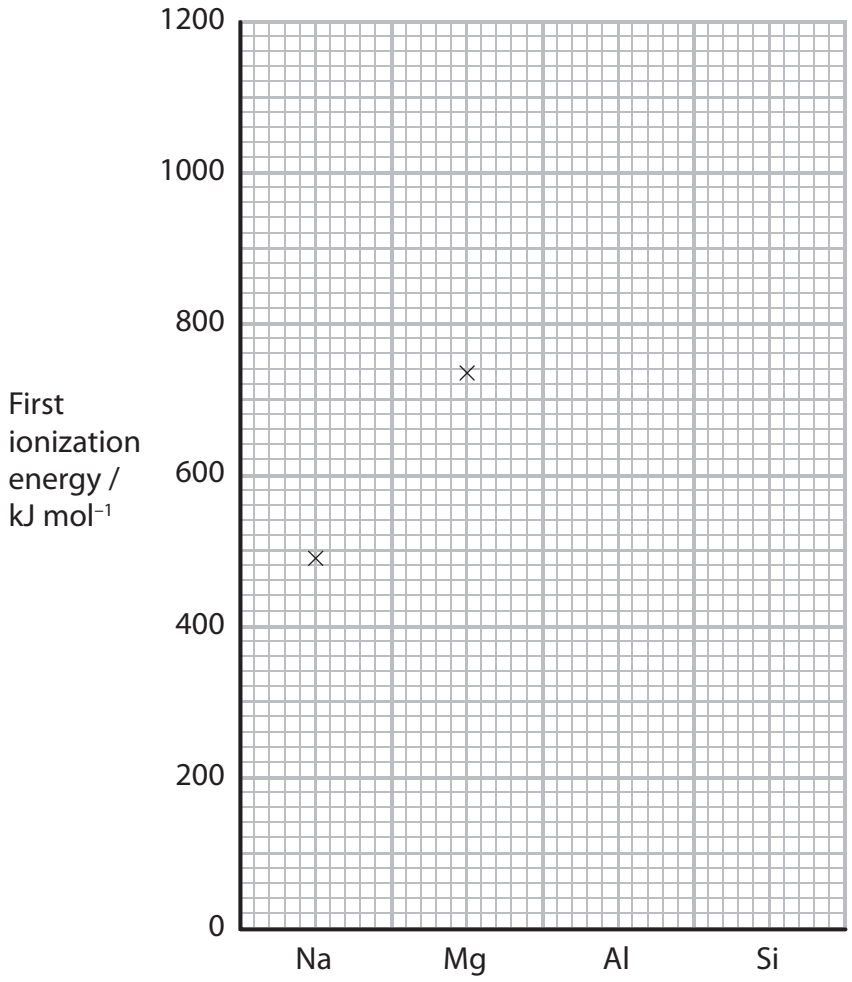
.....

(d) At room temperature, silicon tetrachloride, $SiCl_4$, is a liquid that does not conduct electricity.

Draw a dot and cross diagram illustrating the bonding in silicon chloride. Show only the outer electron shells of the atoms. Use crosses to represent the electrons from silicon and dots to represent the electrons from chlorine.

(2)

(e) The diagram below shows the values of the first ionization energies of sodium and magnesium.



(i) On the diagram, add crosses to mark the approximate positions for the values of the first ionization energies of the elements Al and Si.

(1)

*(ii) Justify your suggested values in terms of the atomic structure and electronic configuration of the elements.

(2)

Aluminium .....

.....

.....

Silicon .....

.....

.....

(Total for Question 17 = 14 marks)

18 Barium chloride can be made by reacting solid barium carbonate with dilute hydrochloric acid in the following reaction.

$$BaCO_3(s) + 2HCl(aq) \rightarrow BaCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) (i) Write the ionic equation for the reaction of solid barium carbonate with hydrogen ions from the hydrochloric acid. State symbols are not required.

(1)

(ii) State **two** observations you would make while the reaction is taking place. No change of colour occurs.

(2)

Observation 1 .....

Observation 2 .....

(b) In an experiment to prepare crystals of hydrated barium chloride, $BaCl_2.2H_2O$, a volume of 25.0 cm^3 of 2.00 mol dm^{-3} hydrochloric acid, HCl, was transferred to a beaker and solid barium carbonate, $BaCO_3$, was added until it was in excess.

(i) How many moles of acid were used in the reaction?

(1)

(ii) What mass of barium carbonate, in grams, reacts with this amount of acid?

The molar mass of barium carbonate is 197.3 g mol^{-1}.

(1)

(iii) Why was an **excess** of barium carbonate used in the experiment?

(1)

.....

.....

(iv) How would you separate the barium chloride solution from the reaction mixture in part (iii)?

(1)

.....

.....

(v) The barium chloride solution was left to crystallize. The crystals were separated and dried carefully. A sample of 5.35 g of hydrated crystals, $BaCl_2 \cdot 2H_2O$, which has molar mass 244 g mol^{-1}, was obtained. Calculate the percentage yield of this reaction.

(2)

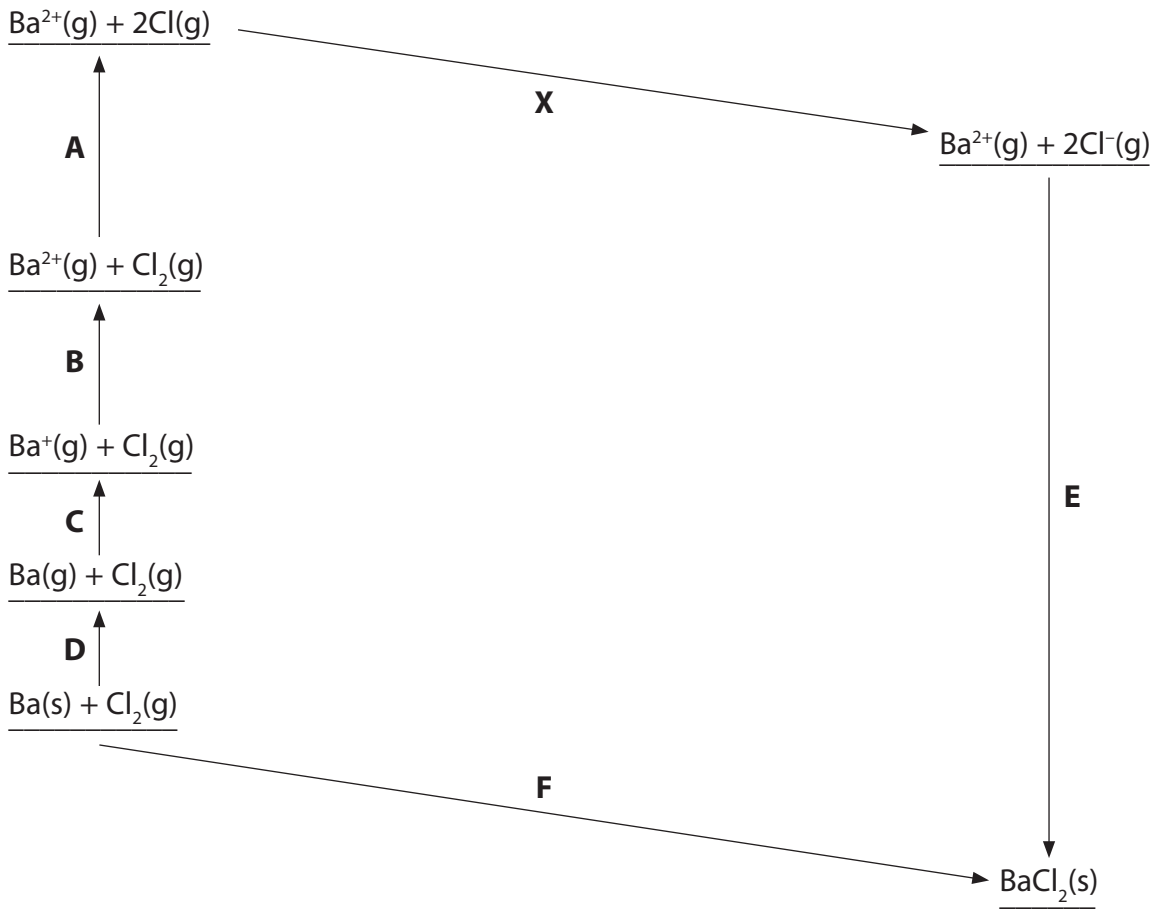
(vi) Give **one** reason why the yield of crystals is less than 100%, even when the reactants contain no impurities.

(1)

.....

.....

(c) The diagram below, which is not drawn to scale, shows how the lattice energy of barium chloride can be calculated using the Born-Haber cycle.



(i) Using the letters **A** to **F**, complete the table below by matching each letter to its corresponding energy change.

(3)

(ii) The energy change **X** is –697.6 kJ mol^{-1}.

In the table, add the name of the enthalpy change which is occurring in this stage of the cycle.

(1)

Energy change	Letter	ΔH / kJ mol^{-1}
Lattice energy of barium chloride		
Enthalpy change of atomization of barium		180.0
Enthalpy change of atomization of $Cl_2(g)$ to 2Cl(g)		243.4
First ionization energy of barium		503
Second ionization energy of barium		965
	X	$2 \times (-348.8)$ $= -697.6$
Enthalpy change of formation of barium chloride		–858.6

(iii) Use the data to calculate the lattice energy of barium chloride.

(2)

Answer = ... kJ mol^{-1}

*(iv) Lattice energies can be calculated from electrostatic theory (theoretical values) as well as by Born-Haber cycles (experimental values).

What can you deduce from the fact that the experimental and theoretical values for the lattice energy of barium chloride are very close?

(2)

.....

.....

.....

.....

(Total for Question 18 = 18 marks)

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19 This question is about the flammable liquid, methanol, CH_3OH.

(a) Methanol starts to have toxic effects when it is present in blood at levels of above 200 mg in 1000 g.

Express this concentration in parts per million.

(1)

(b) The enthalpy change of combustion of methanol was measured using a spirit burner to heat a known mass of water in a calorimeter. The temperature increase of the water in the calorimeter was measured when a known mass of methanol was burned.

(i) Write an equation for the complete combustion of methanol, CH_3OH, under standard conditions. Include state symbols in the equation.

(2)

(ii) Identify **two** other products that could form if the combustion was **incomplete**.

(1)

1 .....

2 .....

(c) The results of the experiment are summarised in the table below.

Mass of water in the calorimeter	150.0 g
Mass of spirit burner + contents (initial)	52.24 g
Mass of spirit burner + contents (final)	51.60 g
Temperature of water (initial)	21.4 °C
Temperature of water (final)	37.2 °C

(i) Calculate the heat energy produced in this experiment using the equation

Heat energy produced (J) = mass of water × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of methanol burned in this experiment.

(1)

(iii) Calculate the enthalpy change of combustion of methanol in kJ mol^{-1}. Give your answer to **three** significant figures.

(2)

(iv) The experimental result differs from the true value for the enthalpy change of combustion of methanol.

State **one** factor in the experimental method, other than heat losses or incomplete combustion, which causes the result to differ from the true value.

Explain the effect this factor has on the magnitude of the experimental value compared to the true value.

(2)

Factor .....

.....

.....

Explanation .....

.....

.....

(d) The value of the enthalpy change for the combustion of methanol can be calculated from the mean bond enthalpies of the substances in the reaction.

Give **two** reasons why this value differs from the value obtained in the experiment, even after corrections are made for experimental error.

(2)

Reason 1 .....

.....

Reason 2 .....

.....

(Total for Question 19 = 12 marks)

20 This question is about the chemistry of alkenes, which are unsaturated hydrocarbons.

(a) State what is meant by the term **unsaturated** as applied to a hydrocarbon.

(1)

.....

.....

(b) An organic compound, **X**, is an unsaturated hydrocarbon with molecular formula C_4H_8.

(i) Draw the displayed formulae and give the names of **two** unbranched molecules with molecular formula C_4H_8 which are *E/Z* isomers.

(3)

Isomer 1	Isomer 2
Name:	Name:

(ii) Both isomers react with a solution of acidified aqueous potassium manganate(VII).

State the colour change that you would observe when this reaction is carried out.

(1)

From ..... to .....

(iii) Draw the structure of the organic product of this reaction with either one of these isomers.

(1)

(iv) Compounds such as C_4H_8 are formed when fractions of crude oil are cracked.

State what is meant by the term **cracking** when applied to processing a fraction obtained from crude oil.

(1)

.....

.....

(v) Write an equation to show the cracking of the hydrocarbon octane into C_4H_8 and a saturated hydrocarbon as the only products.

(1)

(c) Another alkene is propene, C_3H_6.

Describe the mechanism for the addition reaction of propene with bromine, Br_2, to form $C_3H_6Br_2$.

In your answer you should include:

- the name for the type of addition which occurs
- the name of the product
- the mechanism using curly arrows to show the movement of electron pairs.

(5)

Type of addition .....

Name of product .....

Mechanism

(d) Propene can polymerize to form poly(propene).

(i) State, with a reason, the atom economy for this reaction.

(1)

.....

.....

(ii) Draw a section of this polymer, showing **two** repeat units.

(1)

(iii) Poly(propene) is used to make synthetic fibres which are extremely light and act as good insulators.

Comment on the sustainability of this use of poly(propene).

(1)

.....

.....

(Total for Question 20 = 16 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 8 6 A 0 2 4 2 4

PMT

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Mark Scheme (Results)

January 2014

IAL Chemistry (WCH01/01)
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		1

Question Number	Correct Answer	Reject	Mark
2	B		1

Question Number	Correct Answer	Reject	Mark
3	C		1

Question Number	Correct Answer	Reject	Mark
4	D		1

Question Number	Correct Answer	Reject	Mark
5(a)	B		1

Question Number	Correct Answer	Reject	Mark
5(b)	A		1

Question Number	Correct Answer	Reject	Mark
5 (c)	C		1

Question Number	Correct Answer	Reject	Mark
6	A		1

Question Number	Correct Answer	Reject	Mark
7	A		1

Question Number	Correct Answer	Reject	Mark
8	D		1

Question Number	Correct Answer	Reject	Mark
9	C		1

Question Number	Correct Answer	Reject	Mark
10	D		1

Question Number	Correct Answer	Reject	Mark
11	C		1

Question Number	Correct Answer	Reject	Mark
12	B		1

Question Number	Correct Answer	Reject	Mark
13	B		1

Question Number	Correct Answer	Reject	Mark
14	A		1

Question Number	Correct Answer	Reject	Mark
15(a)	B		

Question Number	Correct Answer	Reject	Mark
15(b)	C		1

Question Number	Correct Answer	Reject	Mark
15(c)	A		1

Question Number	Correct Answer	Reject	Mark
16	D		1

Section B

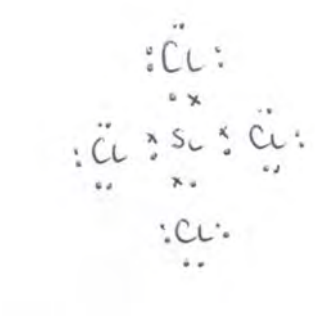
Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	14p,14e,15n All correct		**1**

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^2$ Fully correct ALLOW Subscripts rather than superscripts SPD in capitals $2p_x^2\ 2p_y^2\ 2p_z^2$ and $3p_x^1\ 3p_y^1$ for 2p and 3p IGNORE $1s^2$ written again before $2s^2$		**1**

Question Number	Acceptable Answers	Reject	Mark
***17(b)(i)**	**First mark: Structure of silicon** • Silicon is **giant** covalent / **giant** atomic / **giant** molecular / macromolecular / **giant** structure / **giant** lattice **(1)** IGNORE **JUST** 'GIANT' OR **JUST** 'LATTICE' **Second mark: Structure of phosphorus** • Small molecules / simple molecules / P_4 molecules / molecular covalent / simple covalent / molecular **(1)** IGNORE **JUST** 'SIMPLE' /'SIMPLE STRUCTURE' **Third mark: Interactions overcome on melting** **BOTH** • (Breaking strong) **covalent bonds** in silicon **AND** • Between phosphorus molecules: weak forces / (weak) intermolecular forces / (weak) London forces / (weak) van der Waals' forces / (weak) dispersion forces / (weak) induced-dipole forces **(1)** [ALLOW "weak bonds" **IF** implies between phosphorus **molecules**]	Silicon "giant ionic" / silicon "giant metallic" Intermolecular forces broken in silicon Covalent bonds broken in phosphorus / weak bonds between phosphorus **atoms** / weak **covalent** bonds	**3**

Question Number	Acceptable Answers	Reject	Mark
***17(b)(ii)**	**ALLOW** reverse arguments in each case **PENALISE** Omission of 'atoms' or 'ions' / mis-use of 'atom' or 'ion' ONCE only where relevant **ANY TWO FROM:** • Magnesium atoms / magnesium ions are smaller (than sodium atoms/ions) **(1)** **NOTE:** Allow symbols (e.g. Mg or Mg^{2+}) • Magnesium ions are Mg^{2+} whereas sodium ions are Na^{+} **OR** Mg^{2+} /magnesium **ions** have a higher charge (density) than Na^{+}/sodium ions **(1)** **IGNORE** References to (effective) nuclear charge • Magnesium has more delocalised electrons (than sodium) /magnesium has more electrons (than sodium) in its sea of electrons **(1)** • Attraction between positive ions and (delocalised) electrons is stronger in magnesium (than in sodium) **(1)** **IGNORE** References to **JUST** 'more energy needed' (to break bonds in magnesium)	Attraction "between **nucleus** and (delocalised) electrons" Mention of "intermolecular forces" or "molecules" scores **(0)** overall for this question	**2**

Question Number	Acceptable Answers	Reject	Mark
17(c)	**1st mark:** More protons / increasing nuclear charge / increasing effective nuclear charge **(1)** **IGNORE** 'increasing atomic number' **2nd mark:** Same shielding (of outermost electrons) / same number of (occupied) shells **OR** (Outermost) electrons in same shell **OR** Greater attraction between nucleus and (outermost) electrons **(1)**	'Increasing charge densities' (Outermost) electrons in same **sub-shell**	**2**

Question Number	Acceptable Answers	Reject	Mark
17(d)	 Outer shell of Si with total of 8 electrons **(1)** Each Si electron sharing with one electron from an outer shell of 7 in chlorine **(1)** Comment Do not penalise if dots and crosses are reversed **MAX 1** if all dots or all crosses		**2**

Question Number	Acceptable Answers	Reject	Mark
17(e)(i)	**Al:** level of cross between Na and Mg (actual value 578) **Si:** level of cross anywhere above Al <u>and</u> Mg (actual value 789) Both needed for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
17(e)(ii)	**Al:** (3p) **electron / e^-** (lost is) from higher energy (level) / (more) shielded (by 3s electrons) / further from nucleus / from p orbital / from $3p_x$ **(1)** **Si:** more protons / extra proton / greater nuclear charge (compared to Al) **(1)**	If e^- lost from a **2p** orbital / if states that Al has **higher** ionization energy than Mg	**2**

Total for Question 17 = 14 marks

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	$BaCO_3 + 2H^+ \rightarrow Ba^{2+} + CO_2 + H_2O$ IGNORE state symbols even if wrong IGNORE charges $Ba^{2+}CO_3^{2-}$	Cl^- remains on both sides of equation, unless crossed out / "Ba^{2+} **+** CO_3^{2-}" on left-hand side	**1**

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	Effervescence / fizzing / bubbles (of gas) **(1)** Solid disappears /dissolves **(1)** IGNORE Tests on gas / just 'vigorous reaction' / any references to temperature change	**Just** "Gas given off"	**2**

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)	$(25 \times 2.00/1000) = 0.05 / 5 \times 10^{-2}$ (mol) Ignore sf		**1**

Question Number	Acceptable Answers	Reject	Mark
18(b)(ii)	$(0.5 \times (5 \times 10^{-2} \times 197.3))$ = 4.9325 / 4.933 / 4.93 / 4.9 (g) TE from (b)(i) Ignore SF except 1		**1**

Question Number	Acceptable Answers	Reject	Mark
18(b)(iii)	So that **all acid** was neutralized / **all acid** reacted / **all acid** used up / **all H^+** used up	So that reaction is complete /to get maximum reaction / "So that all the **$BaCO_3$** is used up" / **Just** "to neutralize the acid" / "To make sure all the **solid** reacts"	**1**

Question Number	Acceptable Answers	Reject	Mark
18(b)(iv)	Filtration/ centrifuging	Decanting	**1**

Question Number	Acceptable Answers	Reject	Mark
18(b)(v)	Theoretical yield = (244 x 5 x 10^{-2} x 0.5) = 6.1(0) (g) **(1)** TE from (b)(i) (244 x ans to b(i) x 0.5) % yield = (5.35 x 100 /6.10) = 87.70492 = 87.7/88% **(1)** OR Moles of crystals = (5.35/244 =) 0.02193 **(1)** % yield = ((0.02193x100/0.025) =) 87.7049 = 87.7/88% [NB If use moles crystals 0.0219 ans=87.6%] **(1)** TE for mol crystals/answer to (b)(i), so 43.9% etc gets **(1)** Correct final answer with no working shown scores both marks Ignore SF except 1	$\frac{4.93}{5.35}$ x 100% = 92% **(0)** $\frac{197.3}{244}$ x 100% = 80.9% **(0)** 87% (as rounding error)	**2**

Question Number	Acceptable Answers	Reject	Mark
18(b)(vi)	**ANY ONE OF:** Not all solid/product crystallizes Some barium chloride/product remains in solution Product lost during filtration Product/crystals left on filter paper ALLOW 'Transfer losses' / 'loss during the process' Product left on apparatus / product left on glass rod / product left on beaker **IGNORE** Spillages / 'blunders' **NOTE:** 'Loss of products during transfer and incomplete reaction' scores **(0)** as +1 – 1 = 0	Incomplete reaction / Equilibrium reaction / 'side products' / 'side reactions' / 'loss of **reactants** during transfer' / '**reactants** left on apparatus' / 'vapourisation of $BaCl_2$'	**1**

Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	Lattice energy for barium chloride **E** Enthalpy change of atomization of barium **D** Enthalpy change of atomization of Cl_2 to 2Cl **A** First ionization energy of barium **C** Second ionization energy of barium **B** Enthalpy change of formation of barium chloride **F** All correct (3) 4 or 5 correct (2) 2 or 3 correct (1) **CHECK TO SEE IF ANSWERS ANNOTATED ON SCRIPT AT TOP OF PAGE 14**		**3**

Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	Twice the (first) electron affinity OR (First) electron affinity (of chlorine/Cl)	If mention of Cl_2 /chlor**ide** / Cl^-	**1**

Question Number	Acceptable Answers	Reject	Mark
18(c)(iii)	180 + 243.4 + 503 + 965 – 697.6 + lattice energy = −858.6 OR **F** = **D** + **C** + **B** + **A** + **X** + **E** OR **E** = **F** – **D** – **C** – **B** – **A** – **X** **(1)** Lattice energy = −2052.4/−2052/−2050 (kJ mol^{-1}) **(1)** Correct answer, with or without working scores 2 Correct method with incorrect final answer scores (1) +2052.4/+2052/+2050 (kJ mol^{-1}) **(1)**	335.2 / −335.2 / −162.5 score **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
18(c)(iv)	**1st mark:** Bonding is (almost) 100% ionic / bonding is (almost) purely ionic /there is no covalent character / little covalent character **(1)** **2nd mark:** (Chloride) **ion(s)** are not polarized / (both) ions are spherical / charge density of Ba^{2+} too low (to polarize anion) **(1)** **ALLOW** 'Very little distortion of (electron) cloud by Ba^{2+} ion' / 'Very little polarization of chloride (ion)'	**Just** "no polarization is taking place" / "no polarization of the bond" / "little distortion from electric cloud" / "barium and chlorine are not easy to polarize" / **just** "not much distortion" / use of **Ba** or **Cl** (as implies atoms)	**2**

Total for Question 18 = 18 marks

Question Number	Acceptable Answers	Reject	Mark
19(a)	200 / 2 x 10^2 (ppm)		**1**

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	$CH_3OH(l) + 3/2O_2(g) \rightarrow CO_2(g) + 2H_2O(l)$ Formulae **(1)** Balancing and state symbols **(1)** Allow multiples 2nd mark dependent on 1st	CH_3OH(**aq**) / (**g**) / $2H_2O$(**g**)	**2**

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	Carbon / C / soot AND carbon monoxide / CO **Both needed**	Graphite	**1**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	(150 x 4.18 x 15.8) = 9906.6 / 9907 / 9910 (J) / 9.9066 **kJ** Ignore sf except 1 sf / Ignore signs here	kJ **mol^{-1}**	**1**

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	(0.64/32) = 0.02(00) (mol)		**1**

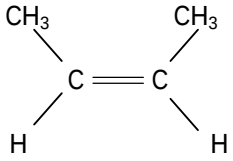
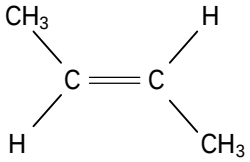
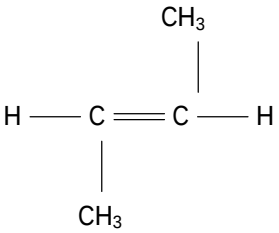
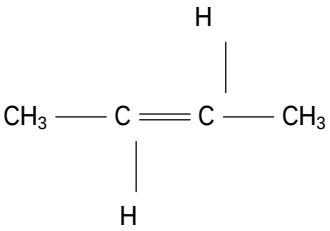
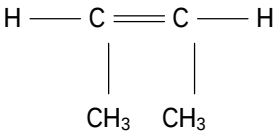
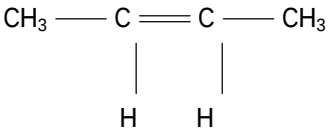
Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	(9.9066/0.0200) = 495.33 ΔH = -495 (kJ mol^{-1}) Value **(1)** Sign and 3sf **(1)** Allow TE from (c)(i) and / or (c)(ii) (answer to (c)(i) in kJ/ answer to (c)(ii)) No 2nd mark if units given are incorrect e.g. kJ mol or kJ/mol^{-1}		**2**

Question Number	Acceptable Answers	Reject	Mark
19(c)(iv)	Mark the two points **independently** **1st mark:** Evaporation of alcohol (from burner) / alcohol is volatile /CH_3OH is volatile ALLOW H_2O forms as steam, not water **IGNORE** Water evaporates (from apparatus) **(1)** **2nd mark:** (Actual) mass/moles (methanol) burned is less **and** (so) enthalpy change will be less negative/less exothermic / less / smaller **OR** Estimate of mass/moles (methanol) burned is too high **and** (so) enthalpy change will be less negative/less exothermic / less / smaller **OR** Temperature rise will be less than it should be **and** (so) enthalpy change will be less negative/less exothermic / less / smaller **(1)** **IGNORE** Any mention of specific heat capacity	Weighing errors / Other equipment errors (eg distance between calorimeter and spirit burner) Any answers that suggest lab value more exothermic / greater value of enthalpy change	**2**

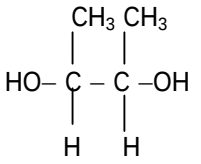
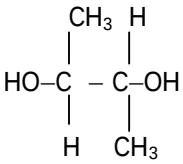
Question Number	Acceptable Answers	Reject	Mark
19(d)	**Mark each point independently** **1st mark:** **ANY ONE OF:** Bond enthalpies vary with environment Mean bond enthalpies do not equal actual bond enthalpies (for these reactants) / mean bond enthalpies are not exact values Bond enthalpies used are average values (from a range of compounds) **(1)** **2nd mark:** **ANY ONE OF:** Bond enthalpies refer to gases OR Bond enthalpies refer to gaseous bonds OR Methanol is a liquid OR Water is a liquid (under standard conditions) **(1)** IGNORE References to 'non-standard conditions' / 'incomplete combustion' / 'not in same state'		**2**

Total for Question 19 = 12 marks

Question Number	Acceptable Answers	Reject	Mark
20(a)	**Any ONE of :** Contains a carbon-carbon double bond / C=C OR Contains a carbon-carbon triple bond OR Does not contain the maximum number of hydrogen atoms/hydrogen(s) OR Can undergo addition reactions	Just 'carbon double bond' / Just 'contains a double bond' / 'contains a double bond between carbon **molecules**'/'contains **more than** one carbon-carbon double bond'	**1**

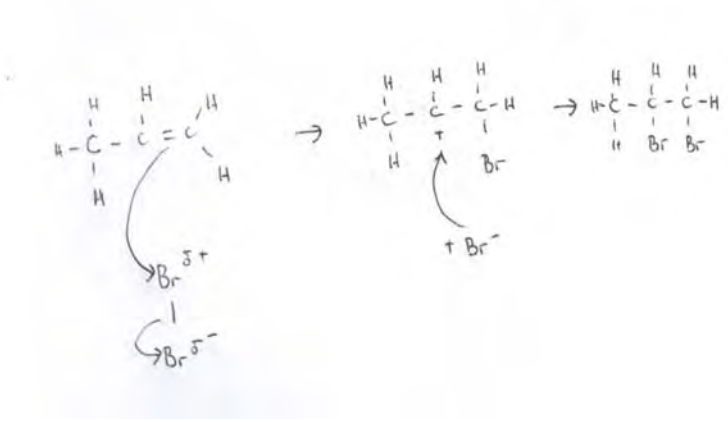
Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	 *Z*-but-2-ene  *E*-but-2-ene IGNORE references to *cis-trans* isomerism BOTH correct structures drawn **(1)** *E*-isomer **and** *Z*-isomer correctly identified **(1)** **but-2-ene** written for each isomer **(1)** **IGNORE** missing hyphens Allow angles shown as right angles **CH_3 does not have to be displayed in full** Allow for *E*:  OR  Allow for *Z*:  OR  H atoms must be shown	If propene is drawn **(0) overall**	**3**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	From purple/ (pale) pink to colourless Both needed Accept to brown	Clear for colourless/violet for purple	**1**

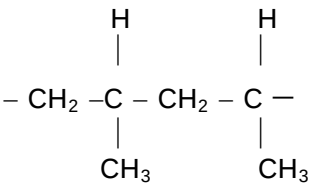
Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	 **OR**  Ignore bond angles and orientation		**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iv)	Breaking a C-C bond/ breaking the molecule into a smaller molecule/ breaking the hydrocarbon into a smaller hydrocarbon **ALLOW** **Any mention** of 'breaking' or 'splitting' (molecule or compound or hydrocarbon) or 'large to small' **IGNORE** **Just** '**cracking** to form an alkane and an alkene'	Any mention of 'breaking down into fractions' / forms **branched** molecules / splitting of **crude oil** (into smaller molecules)	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(v)	$C_8H_{18} \rightarrow C_4H_8 + C_4H_{10}$ **OR** Equations with correct structural or displayed formulae **IGNORE** State symbols, even if incorrect Names, even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
20(c)	Electrophilic (addition) **(1)** **IGNORE** 'heterolytic' Name of final product = 1,2-dibromopropane **(1)** No TE on naming a product shown incorrectly in equation.  Both curly arrows in first step **(1)** The structure of the intermediate carbocation $CH_3CH^+–CH_2Br$ **(1)** Allow $CH_3CHBr–CH_2^+$ as intermediate Curly arrow from $Br^–$ to C^+ **(1)** Partial (δ+ and δ-) charges are not required Lone pair on bromide ion not required	If curly arrow from $Br^–$ to a C^+ with a Br already attached to it	**5**

Question Number	Acceptable Answers	Reject	Mark
20(d)(i)	100% as only one product / 100% as no by product(s) / 100% as addition reaction / 100% as no waste product (formed)	**Just** "atom economy is **high**" / no mention of 100%	**1**

Question Number	Acceptable Answers	Reject	Mark
20(d)(ii)	 CH_3 groups may be on C2 and C4 OR C1 and C3 **IGNORE** brackets **IGNORE** 'n' **BOTH continuation bonds are essential**	**Just** repeating unit / one repeating unit drawn with an 'n' or a '2' next to it	**1**

Question Number	Acceptable Answers	Reject	Mark
20(d)(iii)	Not sustainable as poly(propene) not made from a renewable resource / Not sustainable as made from non-renewable resource / not sustainable as made from crude oil. Not sustainable as crude oil is not renewable/ Not sustainable as crude oil finite resource **ALLOW** Is sustainable if linked to recycling **IGNORE** References to non-biodegradability / long-lasting in use		**1**

Total for Question 20 = 16 marks

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Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Wednesday 7 January 2015 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P45041A

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6/6/6/6/2/

P 4 5 0 4 1 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 A solution contains 33 ppm of solute. The mass of solute dissolved in 1 kg of this solution is

☒ **A** 33 g

☒ **B** 0.33 g

☒ **C** 0.033 g

☒ **D** 0.000033 g

(Total for Question 1 = 1 mark)

2 The Avogadro constant is equal to the number of

☒ **A** grams of an element which contains 6.02×10^{23} atoms of that element.

☒ **B** atoms contained in one mole of any element.

☒ **C** atoms contained in one mole of any monatomic element.

☒ **D** particles (atoms, ions or molecules) required to make one gram of a substance.

(Total for Question 2 = 1 mark)

3 A hydrocarbon contains, by mass, 82.7% carbon and 17.3% hydrogen.

The **molecular** formula of the hydrocarbon is

☒ **A** CH_3

☒ **B** C_2H_6

☒ **C** C_2H_5

☒ **D** C_4H_{10}

(Total for Question 3 = 1 mark)

4 An ion, X^-, contains 36 electrons.

In which block of the Periodic Table would element **X** be found?

☒ **A** s

☒ **B** p

☒ **C** d

☒ **D** f

(Total for Question 4 = 1 mark)

5 Consider the following data:

$C(s) + O_2(g) \rightarrow CO_2(g)$ $\quad \Delta H^{\ominus} = -394 \text{ kJ mol}^{-1}$

$Pb(s) + \frac{1}{2}O_2(g) \rightarrow PbO(s)$ $\quad \Delta H^{\ominus} = -217 \text{ kJ mol}^{-1}$

$PbO(s) + CO(g) \rightarrow Pb(s) + CO_2(g)$ $\quad \Delta H^{\ominus} = -66 \text{ kJ mol}^{-1}$

Calculate the value of the enthalpy change, in kJ mol^{-1}, for the following reaction.

$$C(s) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

☒ **A** –243

☒ **B** –111

☒ **C** +111

☒ **D** +243

(Total for Question 5 = 1 mark)

6 Which of the following enthalpy changes cannot be measured **directly** by experiment?

The enthalpy change of

☒ **A** formation of methane.

☒ **B** combustion of hydrogen.

☒ **C** formation of carbon dioxide.

☒ **D** combustion of carbon monoxide.

(Total for Question 6 = 1 mark)

7 Which of the following equations represents a step that is **not** involved in the Born-Haber cycle for lithium iodide, LiI?

☒ **A** $Li(s) + \frac{1}{2}I_2(s) \rightarrow LiI(s)$

☒ **B** $\frac{1}{2}I_2(s) \rightarrow I(g)$

☒ **C** $Li(s) \rightarrow Li(g)$

☒ **D** $I(g) \rightarrow I^+(g) + e^-$

(Total for Question 7 = 1 mark)

8 Which of the following results in the most polarizing cation?

	Cation radius	Cation charge
☒ **A**	small	small
☒ **B**	small	large
☒ **C**	large	small
☒ **D**	large	large

(Total for Question 8 = 1 mark)

9 Calcium carbonate reacts with dilute nitric acid as follows:

$$CaCO_3(s) + 2HNO_3(aq) \rightarrow Ca(NO_3)_2(aq) + H_2O(l) + CO_2(g)$$

0.05 mol of calcium carbonate was added to a solution containing 0.08 mol of nitric acid.

Which of the following statements is true?

☒ **A** 0.05 mol of carbon dioxide is produced.

☒ **B** 0.08 mol of calcium nitrate is produced.

☒ **C** Calcium carbonate is in excess by 0.01 mol.

☒ **D** Nitric acid is in excess by 0.03 mol.

(Total for Question 9 = 1 mark)

10 In which of the following pairs does each gas occupy the same volume?

All volumes are measured at the same temperature and pressure.

☒ **A** 2 g of hydrogen and 14 g of nitrogen.

☒ **B** 32 g of methane and 88 g of carbon dioxide.

☒ **C** 7 g of carbon monoxide and 16 g of oxygen.

☒ **D** 10 g of hydrogen chloride and 10 g of sulfur dioxide.

(Total for Question 10 = 1 mark)

11 Consider the reaction below.

$$2NO(g) + O_2(g) \rightarrow 2NO_2(g)$$

What is the maximum volume, in dm^3, of nitrogen dioxide that could be obtained in the reaction occurring when 1 dm^3 of nitrogen monoxide is mixed with 2 dm^3 of oxygen, under suitable conditions?

All measurements are made at the same temperature and pressure.

☒ **A** 1

☒ **B** 2

☒ **C** 3

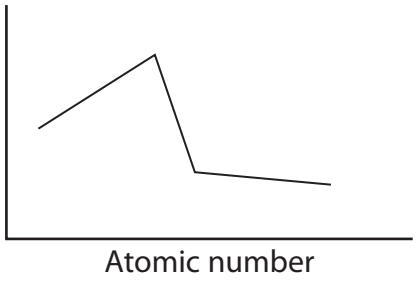
☒ **D** 4

(Total for Question 11 = 1 mark)

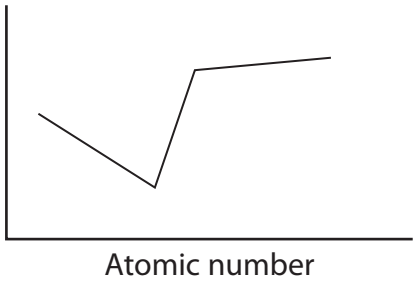
Use this space for any rough working. Anything you write in this space will gain no credit.

12 Which of the following graphs, not drawn to scale, best represents the trend in the melting temperatures of the elements across Period 3, from sodium to argon?

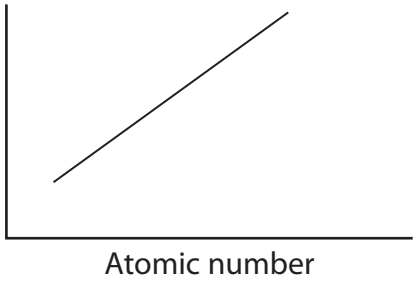
☒ **A**



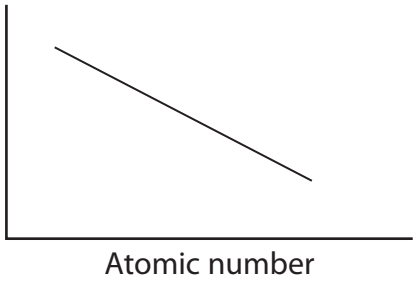
☒ **B**



☒ **C**



☒ **D**



(Total for Question 12 = 1 mark)

13 In an experiment, 3.425 g of lead oxide was reduced to form 3.105 g of lead.

The empirical formula of the lead oxide is

☒ **A** PbO

☒ **B** Pb_3O_2

☒ **C** Pb_3O_4

☒ **D** Pb_4O_3

(Total for Question 13 = 1 mark)

14 Which one of the following ions has the smallest radius?

☒ **A** F^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** O^{2-}

(Total for Question 14 = 1 mark)

15 Phenol, C_6H_5OH, is converted into trichlorophenol (known as TCP), $C_6H_2Cl_3OH$, according to the equation below.

$$C_6H_5OH + 3Cl_2 \rightarrow C_6H_2Cl_3OH + 3HCl$$

If 50.0 g of phenol produces 97.6 g of TCP, what is the percentage yield of the TCP?

[Molar masses: phenol = 94 g mol^{-1}; TCP = 197.5 g mol^{-1}]

☒ **A** 47.6%

☒ **B** 49.4%

☒ **C** 51.2%

☒ **D** 92.9%

(Total for Question 15 = 1 mark)

16 Which of the following contains a dative covalent bond?

☒ **A** N_2

☒ **B** NH_3

☒ **C** NH_2^-

☒ **D** NH_4^+

(Total for Question 16 = 1 mark)

17 If the price of one tonne (1000 kg) of sulfur, S, is £160, what is the cost (to the nearest pound) of the sulfur needed to make one tonne of sulfuric acid, H_2SO_4?

☒ **A** £52

☒ **B** £98

☒ **C** £160

☒ **D** £490

(Total for Question 17 = 1 mark)

18 Potassium combines with iodine to form potassium iodide.

Which of the following describes the bonding in the three substances?

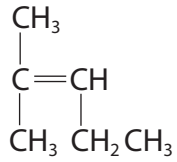
	Potassium	Iodine	Potassium iodide
☒ **A**	ionic	covalent	ionic
☒ **B**	metallic	ionic	covalent
☒ **C**	covalent	covalent	ionic
☒ **D**	metallic	covalent	ionic

(Total for Question 18 = 1 mark)

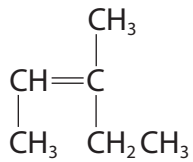
Use this space for any rough working. Anything you write in this space will gain no credit.

19 Which of the following does **not** represent the structure of the compound 2-methylpent-2-ene?

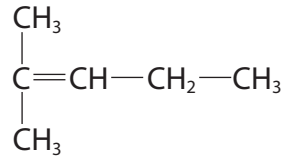
☒ **A**



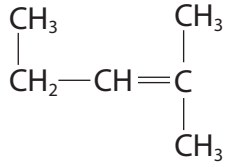
☒ **B**



☒ **C**



☒ **D**



(Total for Question 19 = 1 mark)

20 Ions with the same electronic configuration are said to be **isoelectronic**.

Which of the following compounds is made up of isoelectronic ions?

☒ **A** CaO

☒ **B** $CaBr_2$

☒ **C** Na_2O

☒ **D** LiF

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Crude oil is a source of alkanes.

(a) Name the process by which the hydrocarbons in crude oil are separated.

(1)

.....

(b) The alkane **X** is composed of straight-chain molecules, each with nine carbon atoms.

(i) Give the molecular formula of **X**.

(1)

.....

(ii) **Y** is a branched-chain isomer of **X**.
Y has eight carbon atoms in a straight-chain with **one** methyl group as a side-chain.

Draw the **skeletal formula** of **one** possible structure for **Y**.

Give the name of the structure that you have drawn.

(2)

Skeletal formula:

Name:

.....

(c) A reaction called cracking occurs when the alkane pentadecane, $C_{15}H_{32}$, is heated in the presence of a catalyst.

(i) Give an equation to show the cracking of one molecule of $C_{15}H_{32}$ to form one molecule of ethene and a molecule of **one** other product.
State symbols are not required.

(1)

(ii) In practice, cracking pentadecane forms a large number of products.

Suggest why this is so.

(1)

.....

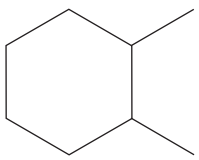
.....

(d) In the petroleum industry, some straight-chain alkanes are processed to form cyclic hydrocarbons.

When octane is processed, each molecule of octane produces one molecule of a cyclic hydrocarbon, C_8H_{12}, and three molecules of hydrogen as the only products.

(i) Complete the **skeletal** formula of one of the possible cyclic hydrocarbons.

(1)



(ii) Suggest why the petroleum industry processes straight-chain alkanes to form cyclic hydrocarbons.

(1)

.....

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.....

(Total for Question 21 = 8 marks)

22 For some reactions, the enthalpy change can be determined by experiment.

(a) Define the term **enthalpy change of reaction**.

(2)

.....

.....

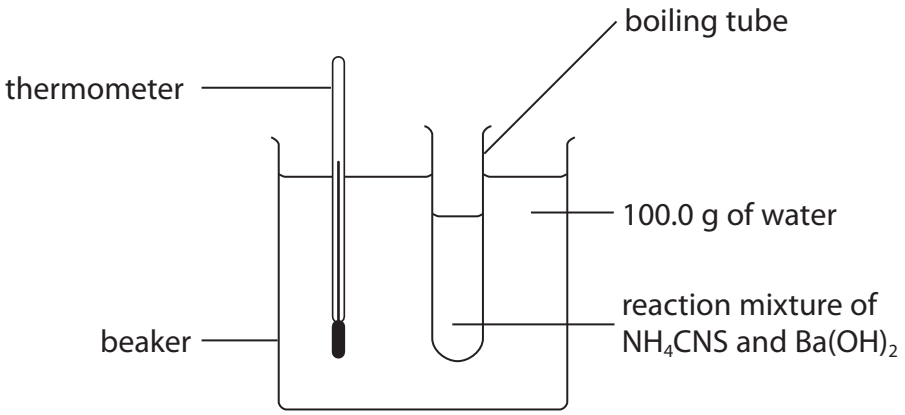
.....

.....

(b) An equation for the reaction between the two solids ammonium thiocyanate, NH_4CNS, and barium hydroxide, $Ba(OH)_2$, is shown below.

$$2NH_4CNS(s) + Ba(OH)_2(s) \rightarrow Ba(CNS)_2(s) + 2H_2O(l) + 2NH_3(g)$$

The following apparatus was set up in order to determine the enthalpy change for the reaction.



In the experiment, 15.22 g of NH_4CNS was reacted with an excess of $Ba(OH)_2$. The reaction absorbed heat energy from the surroundings. The temperature of the 100.0 g of water fell from 22.0 °C to 16.5 °C.

(i) Calculate the heat energy absorbed, in joules, during the reaction.

Use the equation

Heat energy absorbed (J) = mass of water × 4.2 × temperature change

(1)

(ii) Calculate the number of moles of NH_4CNS used in the experiment.

(1)

(iii) Calculate the enthalpy change of the reaction, in kJ mol^{-1}, to **two** significant figures. Include a sign in your answer.

$$2NH_4CNS(s) + Ba(OH)_2(s) \rightarrow Ba(CNS)_2(s) + 2H_2O(l) + 2NH_3(g)$$

(3)

(c) Standard enthalpy changes of reaction can also be calculated using mean bond enthalpies.

(i) What is meant by the term **mean bond enthalpy**?

(2)

(ii) Describe the bonding in a C═C double bond in terms of the different ways in which the orbitals overlap.

You may draw a diagram if you wish.

(2)

Space for diagram:

(iii) Suggest why the mean bond enthalpy of a C═C bond is less than twice the mean bond enthalpy of a C—C bond.

(1)

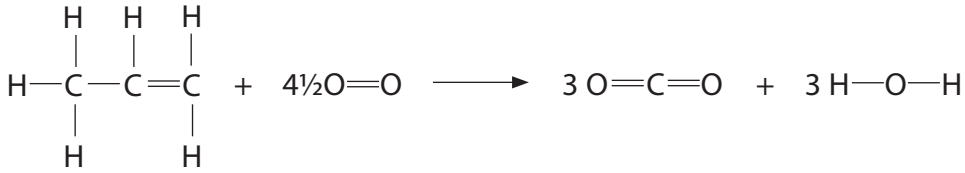
.....

.....

(iv) Use the mean bond enthalpy data in the table, and the equation given below, to calculate a value for the standard enthalpy change of combustion of propene.

(3)

Bond	Mean bond enthalpy / kJ mol^{-1}
C═C	612
C—C	347
C—H	413
O═O	498
C═O	805
O—H	464



Answer = ... kJ mol^{-1}

*(v) The Data Booklet value for the standard enthalpy change of combustion of propene is –2058 kJ mol^{-1}.

Explain why the value calculated in (c)(iv) is less exothermic than the Data Booklet value.

(2)

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(Total for Question 22 = 17 marks)

23 Iodine monochloride, ICl, is an interhalogen compound. Molecules of iodine monochloride have a permanent dipole. Alkenes react with ICl, under suitable conditions, in a similar way to the reaction of alkenes with hydrogen chloride, HCl.

(a) Propene reacts with ICl to form two possible organic products. One of these products is 2-chloro-1-iodopropane.

(i) Complete the mechanism below, by adding curly arrows and the intermediate species.

(3)



(ii) Classify the type and mechanism for the reaction in (a)(i).

(2)

.....

(iii) Draw the structure of the other possible organic product of the reaction of propene with ICl.

(1)

(b) Methane reacts with ICl, under suitable conditions, to form many products. Two of these products are iodomethane and hydrogen chloride.
The reaction between methane and ICl is similar to that between methane and chlorine, Cl_2.

(i) Suggest the essential condition needed for this reaction.

(1)

.....

*(ii) The mechanism for the reaction between methane and ICl involves three stages. One of these is the third and final stage, called termination.

Describe the mechanism of the reaction to form iodomethane and hydrogen chloride.

In your answer, include:

- the type of reaction and mechanism
- the type of bond fission occurring
- the name and equation for the **first** stage of the mechanism
- the name and equations for the **second** stage of the mechanism
- one equation for a termination step

Curly (half-) arrows and state symbols are **not** required in your equations.

(7)

Type of reaction and mechanism .....

Type of bond fission occurring .....

.....

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(Total for Question 23 = 14 marks)

24 A model of the atom describes a nucleus containing protons and neutrons surrounded by electrons in energy levels.

(a) Complete the table below.

(3)

Sub-atomic particle	Relative mass	Relative charge
proton		
neutron		
electron		

(b) State, in terms of the sub-atomic particles present, the meaning of the term **isotopes**.

(2)

.....

.....

(c) The element rubidium exists as the isotopes ^{85}Rb and ^{87}Rb.

(i) Explain how gaseous atoms of rubidium are ionized in a mass spectrometer.

(2)

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.....

(ii) In a sample of rubidium, the isotope ^{85}Rb has an abundance 2.5 times greater than that of ^{87}Rb.

Calculate the relative atomic mass of rubidium in this sample. Give your answer to **one** decimal place.

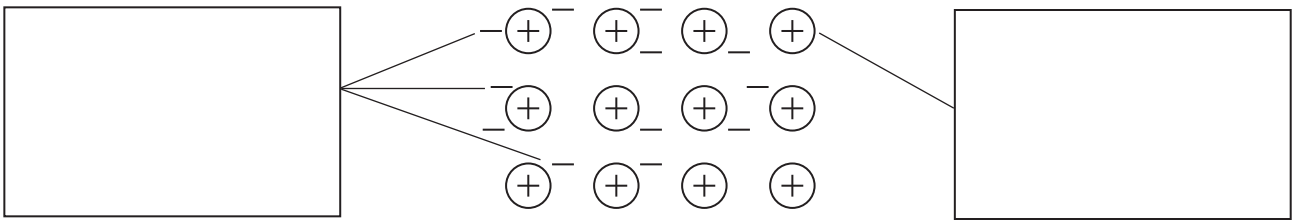
(3)

Relative atomic mass = ...

(d) The diagram below illustrates a model of the metallic bonding in rubidium.

Write appropriate labels in the two empty boxes in order to complete the diagram.

(2)



(Total for Question 24 = 12 marks)

25 Ionization energies provide evidence for the arrangement of electrons in atoms.

(a) (i) Write an equation, including state symbols, to show the **second** ionization energy of magnesium.

(2)

*(ii) Give **two** reasons why the second ionization energy of magnesium is greater than the first ionization energy of magnesium.

(2)

1 .....

.....

.....

2 .....

.....

.....

(iii) Complete the table by suggesting a value for the **third** ionization energy of magnesium.

(1)

Ionization number	First	Second	Third	Fourth	Fifth
Ionization energy / kJ mol^{-1}	738	1450		10 500	13 600

(b) (i) Give the electronic configurations of phosphorus and of sulfur in s, p and d notation.

(2)

Phosphorus (atomic number 15) .....

Sulfur (atomic number 16) .....

(ii) By reference to your answer in (b)(i), explain why the first ionization energy of sulfur is lower than that of phosphorus.

(2)

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(Total for Question 25 = 9 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 5 0 4 1 A 0 2 4 2 4

PMT

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Mark Scheme (Results)

January 2015

Pearson Edexcel International Advanced Subsidiary in Chemistry (WCH01) Paper 01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	C	**1**

Question Number	Correct Answer	Mark
2	C	**1**

Question Number	Correct Answer	Mark
3	D	**1**

Question Number	Correct Answer	Mark
4	B	**1**

Question Number	Correct Answer	Mark
5	B	**1**

Question Number	Correct Answer	Mark
6	A	**1**

Question Number	Correct Answer	Mark
7	D	**1**

Question Number	Correct Answer	Mark
8	B	**1**

Question Number	Correct Answer	Mark
9	C	**1**

Question Number	Correct Answer	Mark
10	B	**1**

Question Number	Correct Answer	Mark
11	A	**1**

Question Number	Correct Answer	Mark
12	A	**1**

Question Number	Correct Answer	Mark
13	C	**1**

Question Number	Correct Answer	Mark
14	B	**1**

Question Number	Correct Answer	Mark
15	D	**1**

Question Number	Correct Answer	Mark
16	D	**1**

Question Number	Correct Answer	Mark
17	A	**1**

Question Number	Correct Answer	Mark
18	D	**1**

Question Number	Correct Answer	Mark
19	B	**1**

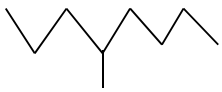
Question Number	Correct Answer	Mark
20	C	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

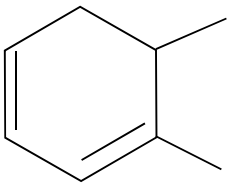
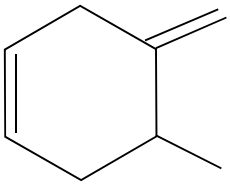
Question Number	Acceptable Answers	Reject	Mark
21(a)	Fractional distillation Both words needed		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	C_9H_{20}		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	Correct skeletal formula **(1)** Correct name for the structure drawn providing that the structure is a branched-chain isomer of C_9H_{20} **NO TE for name if skeletal formula is incorrect** **ALLOW** Correct name, even if structural or displayed formula has been drawn **(1)** EXAMPLES of correct skeletal formulae and names  2-methyloctane  3-methyloctane  4-methyloctane	Structural or displayed formula	**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	$C_{15}H_{32} \rightarrow C_{13}H_{28} + C_2H_4$ **IGNORE** State symbols, even if incorrect **ALLOW** Correct structural OR displayed OR skeletal OR mixture of these (as long as unambiguous)		**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	Any **carbon-carbon bond** (in the chain) can **break** OR The **carbon chain** can **break**/**split** in different places OR Carbon chain is cracked in many places / different places OR $C_{13}H_{28}$ / product will break down further **IGNORE** 'Molecule can break anywhere' / 'It breaks into smaller molecules' / 'large number of C atoms' / 'bonds break randomly' / 'hydrocarbon chain is long'		**1**

Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	Two double bonds anywhere on the RING (allow them to be adjacent). e.g.  **ALLOW** One triple bond (instead of two double bonds) BUT not adjacent to a methyl group **ALLOW:** (ie double bond(s) on side-chain) 	If any other incorrect structure is included with the final answer Any 5-valent C atom in structure scores **(0)** If the methyl groups are joined by a bond **(0)** Benzene ring **(0)**	**1**

Question Number	Acceptable Answers	Reject	Mark
21(d)(ii)	**NOTE** The answer must relate to combustion or burning To promote efficient combustion OR To increase octane number OR To reduce knocking OR Pre-ignition less likely **ALLOW** To allow smoother burning OR More efficient fuels OR Better burning / fuels easier to burn OR Combust more easily OR Improves combustion **ALLOW** Reverse argument for straight-chain hydrocarbons **IGNORE** References to: 'less pollution' / 'burning more cleanly' / 'better fuels' / 'to form alkenes' / 'to form more useful products' /'branched chains form' / boiling point / volatility / 'to form H_2'	'Ignition less likely' **(0)**	**1**

(Total for Question 21 = 8 marks)

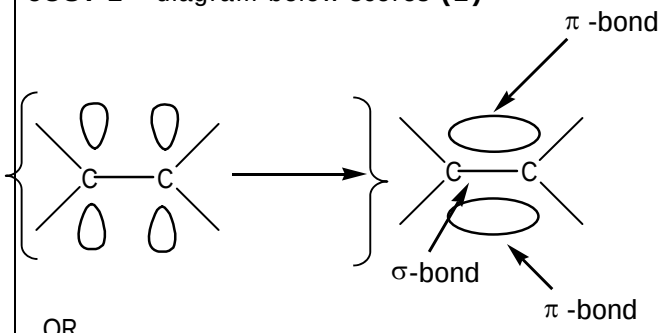
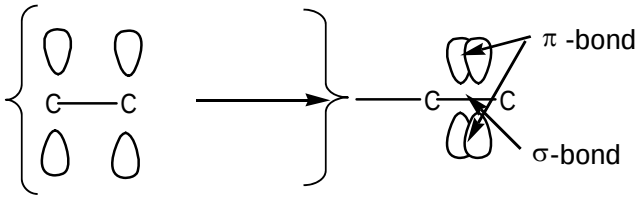
Question Number	Acceptable Answers	Reject	Mark
22(a)	**1st mark – idea of moles / amounts specified** (Enthalpy change when) the number of moles of reactants **ALLOW** (Enthalpy change when) the number of moles of products or substances / just molar quantities / just amounts / just moles **(1)** **2nd mark – idea of an equation** (react as specified in the balanced) **equation** **(1)** **IGNORE** references to (standard) conditions / just 'enthalpy change that occurs during a reaction'	**'One mole** of reactants' / **'One mole** of products' for 1st mark	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	(Heat energy absorbed = 100 x 4.2 x 5.5 =) 2310 (J) **ALLOW** 2.3(10) **kJ** IGNORE sign and sf except one sf		**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	(Moles NH_4CNS = $\frac{15.22}{76.1}$ =) 0.2(00) (mol) **IGNORE** sf **ALLOW** M_r = 76 for NH_4CNS to give 0.200(3) (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)(iii)	$\Delta H_{reaction}$ = +$\frac{2.3(10)}{0.2(00)}$ **x2** = +23.1 (kJ mol^{-1}) = **+**23 (kJ mol^{-1}) to 2 sf **First mark – correct computation of $\Delta H_{reaction}$:** **2 x** [answer to (b)(i) in kJ ÷ answer to (b)(ii) in mol] **(1)** **Second mark – stand alone, for correct rounding:** A final answer to **two** sf **(1)** **Third mark – stand alone, for giving a + sign for endothermic reaction:** **+** sign in front of final answer **(1)** NOTE: **+**12 (kJ mol^{-1}) scores **(2)** (i.e. the 2nd and 3rd marks)	Incorrect units given by the candidate (no 3rd scoring point)	**3**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	(Average amount of) energy/enthalpy required to **break one mole** of (covalent) **bonds** **ALLOW** Energy change/enthalpy change to **break one mole** of (covalent) **bonds** **(1)** (in the) **gas / gaseous** (state) **(1)**	Energy/enthalpy **released** OR 'Bonds **formed**/**made**' OR 1 mol of **compound** for 1st mark	**2**

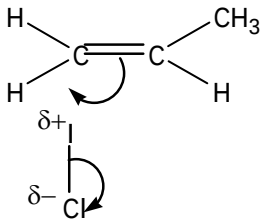
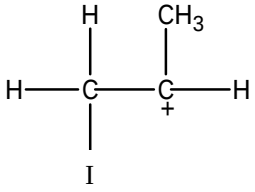
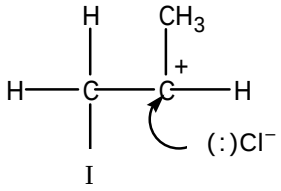
Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	For a pi/π-bond: Sideways overlap of p-orbitals / overlap of p-orbitals above and below stated or drawn on a diagram **(1)** For a sigma/σ-bond: Head-on overlap of any orbitals, stated or drawn on a diagram **(1)** **MAX (1)** if it is not specified/clear which type of overlap relates to which type of bond **IGNORE** Incorrect diagram **NOTE** **JUST 1st** diagram below scores **(1)** whereas **JUST 2nd** diagram below scores **(2)**  OR  **NOTE:** For the σ-bond, allow any form of 'end-on' overlap of orbitals **MAX (1)** if **only** an UNLABELLED but otherwise correct diagram is given (ie also no words)		**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	π-bond is weak(er) OR σ-bond is strong(er) OR The sideways overlap is less effective than the head-on overlap **ALLOW** The two bonds in the (C=C) double bond are not the same strength **IGNORE** References to C=C bond more reactive than C-C bond / 'restricted rotation'	π-bond is stronger than the σ-bond OR C=C bond weaker than C-C bond	**1**

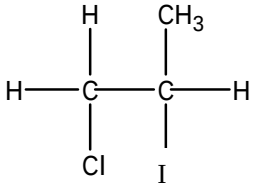
Question Number	Acceptable Answers	Reject	Mark
22(c)(iv)	[FIRST, check the answer on the answer line IF answer = **−1936** (kJ mol^{-1}) award **(3)** marks; **+1936** (kJ mol^{-1}) scores **(2)**] Bonds broken (6 x (C−H) = 6 x 413 + 1 x (C−C) = 1 x 347 + 1 x (C=C) = 1 x 612 + 4½ x (O=O) = 4½ x 498 =) (+)5678 **(1)** Bonds made (6 x (C=O) = 6 x −805 + 6 x (O−H) = 6 x −464 =) (−)7614 **(1)** $\Delta H_{reaction}$ = bonds broken + bonds made = (+)5678 + (−)7614 = −1936 (kJ mol^{-1}) **(1)** **NOTE** 3rd mark CQ on answers calculated for bonds broken and bonds made		**3**

Question Number	Acceptable Answers	Reject	Mark
22(c)*(v)	Under standard conditions/298 K water is a **liquid** OR (Calculations involving) bond energies refer to (water in) **gaseous** state **(1)** Energy released/given out on changing from gas to liquid OR Energy absorbed/taken in on changing from liquid to gas **(1)** **ALLOW max (1)** if state that 'bond energies are average values (from a range of compounds)' **IGNORE** References to 'heat losses' / 'incomplete combustion'		**2**

(Total for Question 22 = 17 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	Curly arrow from double bond towards iodine atom **AND** curly arrow from the I—Cl **bond** to the chlorine atom **(1)**  Carbocation intermediate **(1)**  Curly arrow from the chloride ion to the correct C^+ in the intermediate **(1)**  **NOTE** Curly arrow can originate from anywhere on the Cl^- ion in the final step. Do not have to have a lone pair of e^- on the Cl^- ion	δ^+ for + δ^- for – on Cl^-	**3**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	Electrophilic **(1)** Addition **(1)** ALLOW answers in either order IGNORE 'heterolytic'		**2**

Question Number	Acceptable Answers	Reject	Mark
23(a)(iii)	 ALLOW Correct structural OR displayed OR skeletal formula OR mixture of these (so long as unambiguous) Eg $CH_2ClCHICH_3$ IGNORE Any name given, even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	Ultraviolet / UV OR Sun (light) OR Light **ALLOW** **High** temperature / 300°C (minimum) IGNORE Just heat / just radiation / rays	Mention of a 'catalyst'	**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)*(ii)	**First mark:** (Free) radical substitution **(1)** **Second mark:** **Homolytic** (fission) **(1)** **Third mark:** **Initiation** **AND** $ICl \rightarrow I\bullet + Cl\bullet$ **(1)** BOTH needed for the 3rd mark **Fourth mark:** **Propagation** **(1)** **Fifth and sixth marks:** $CH_4 + Cl\bullet \rightarrow CH_3\bullet + HCl$ **(1)** $CH_3\bullet + ICl \rightarrow CH_3I + Cl\bullet$ **(1)** **IGNORE** $CH_4 + I\bullet \rightarrow CH_3\bullet + HI$ $CH_3\bullet + ICl \rightarrow CH_3Cl + I\bullet$ **Seventh mark:** $CH_3\bullet + I\bullet \rightarrow CH_3I$ OR $Cl\bullet + Cl\bullet \rightarrow Cl_2$ OR $CH_3\bullet + Cl\bullet \rightarrow CH_3Cl$ OR $CH_3\bullet + CH_3\bullet \rightarrow C_2H_6$ OR $I\bullet + Cl\bullet \rightarrow ICl$ ALLOW $I\bullet + I\bullet \rightarrow I_2$ **(1)** **IGNORE** **Any** INCORRECT termination step(s) **IGNORE** State symbols, even if incorrect Curly arrows / half curly arrows, even if incorrect	**Heterolytic** (fission) $H\bullet$ (the fifth and sixth marks cannot be awarded if $H\bullet$ appears in **either** propagation step)	**7**

(Total for Question 23 = 14 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>24(a)</td><td>
<table>
<tr><th>(Sub-atomic particle)</th><th>(Relative mass)</th><th>(Relative charge)</th></tr>
<tr><td>(proton)</td><td>1</td><td>+1/1+</td></tr>
<tr><td>(neutron)</td><td>1</td><td>0</td></tr>
<tr><td>(electron)</td><td>1/2000 to 1/1800
or
‘negligible’
or 0.0005 to 0.00056</td><td>—1/1—</td></tr>
</table>
(1) for each correct row

MAX (1) if only one COLUMN correct
IGNORE any masses in g or kg
IGNORE any charges in coulombs
</td><td>Just “+” for proton charge

Just “neutral” for neutron charge

Just “—” for electron charge

“Zero” /”0” for mass of an electron</td><td>3</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
24(b)	**Atoms** with the same number of protons **(1)** IGNORE same number of electrons (but) different numbers of neutrons **(1)** IGNORE References to atomic number / mass number / ‘nucleons’ / **JUST** ‘atoms of the same element’	“**Element(s)** with the same number of protons”	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	Electron gun / high-speed electrons / high-energy electrons / fast-moving electrons / bombardment with electrons **(1)** Knock-out / remove electron(s) **(1)** IGNORE References to ionizing / forming ions / **just** equations such as $Rb(g) \rightarrow Rb^{+}(g) + e^{-}$ / other stages in the process of mass spectrometry	**Just** ‘electrons’ / ‘Highly-charged’ electrons	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	[FIRST, check the answer on the answer line IF answer = 85.6 award **(3)** marks] **1st mark:** 85 x 2.5 + 87 x 1 OR 85 x 71.4 + 87 x 28.6 **(1)** **2nd mark:** ÷3.5 (can ÷7 if ratio given as 5:2) OR ÷100 ALLOW TE using incorrect % abundances or ratios **(1)** **3rd mark – stand alone for correct rounding (TE only if value calculated is between 85 and 87)** (= 85.57, but 'accurate' answer depends on rounding) Final answer rounded to **85.6** (ie 1 dp) Ignore units even if incorrect. **(1)** **NOTE** 85.5 without working scores **(0)**		**3**

Question Number	Acceptable Answers	Reject	Mark
24(d)	(Left-hand box) Delocalised electron(s) **BOTH these words needed** **(1)** (Right-hand box) Positive ion(s) / cation(s) / Rb^+ **ALLOW** metal ion(s) **(1)**	**Just** 'electrons' 'Negatively-charged ions' 'nuclei' / 'nucleus' / 'positive atoms' 'positively-charged lattice'	**2**

(Total for Question 24 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	$Mg^{+}(g) \rightarrow Mg^{2+}(g) + e^{(-)}$ OR $Mg^{+}(g) - e^{(-)} \rightarrow Mg^{2+}(g)$ OR $Mg^{+}(g) + e^{(-)} \rightarrow Mg^{2+}(g) + 2e^{(-)}$ **1st mark** Correct species for reactants **and** products **(1)** **2nd mark** Correct state symbols **This mark can only be awarded if first mark has already been awarded.** **(1)** **NOTE** Award state symbols mark if '$X^{+}(g)$' OR 'MG' used instead of 'Mg' $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{(-)}$ **scores (0)**	"MG" for first mark	**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)*(ii)	Any **TWO** from: Electron (in Mg^+) is being removed from a positive ion **(1)** Electron being removed is closer to the nucleus (in Mg^+) / Mg^+ is smaller (than Mg) **(1)** Proton: electron ratio greater (in Mg^+) / remaining e^- more tightly held (in Mg^+) **(1)** Greater (force of) attraction between nucleus and (outermost) electron (in Mg^+) **(1)** Electron repulsion is less in Mg^+ (than Mg) **(1)** **IGNORE** References to "effective nuclear charge (ENC)" / high charge-density in Mg^+ / references to shielding	"Mg^+ has more protons than Mg" scores **(0)** overall Electron is being removed from a new shell/different shell / 2nd shell scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	Any value in range 5000 to 9000 (kJ mol^{-1}) **NOTE** Actual value is 7730 (kJ mol^{-1})		**1**

Question Number	Acceptable Answers	Reject	Mark
25(b)(i)	(Phosphorus) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^3$ ALLOW p_x, p_y, p_z notation / upper case **(1)** (Sulfur) $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^4$ ALLOW p_x, p_y, p_z notation / upper case **(1)** ALLOW Noble gas core: [Ne] for $1s^2\ 2s^2\ 2p^6$		**2**

Question Number	Acceptable Answers	Reject	Mark
25(b)(ii)	**1st mark – idea of paired e^- in S** In sulfur, spin-pairing has occurred / two electrons in the same orbital / paired e^- Note: **Just** $3p^4$ stated for S does not gain this mark. **ALLOW** an 'electrons-in-box' diagram, showing two electrons in the same orbital **(1)** **2nd mark – idea of repulsion** (resultant increase in) **repulsion** **(1)** **ALLOW** **Just** phosphorus has a half-filled sub-shell which is more stable (max **(1)**)		**2**

(Total for Question 25 = 9 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 14 January 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P46937A

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6/6/6/6/

P 4 6 9 3 7 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which row in the table shows the number of protons, neutrons and electrons in a fluoride ion, F^-?

Use the Periodic Table as a source of data.

	Protons	Neutrons	Electrons
☒ **A**	8	9	9
☒ **B**	9	9	10
☒ **C**	9	10	9
☒ **D**	9	10	10

(Total for Question 1 = 1 mark)

2 A sample of oxygen contains the isotopes ^{16}O, ^{17}O, ^{18}O.

How many peaks would there be for the O_2^+ ions in the mass spectrum of this sample of oxygen?

☒ **A** 3

☒ **B** 5

☒ **C** 6

☒ **D** 9

(Total for Question 2 = 1 mark)

3 2000 g of a solution contains 0.015 g of solute.

In the solution, the concentration of the solute in parts per million (ppm) is

☒ **A** 3.0

☒ **B** 7.5

☒ **C** 30

☒ **D** 75

(Total for Question 3 = 1 mark)

DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA DO NOT WRITE IN THIS AREA

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DO NOT WRITE IN THIS AREA
DO NOT WRITE IN THIS AREA

4 What is the concentration, in mol dm^{-3}, of a solution of 10.6 g of sodium carbonate, Na_2CO_3, in 250 cm^3 of solution?

☒ **A** 0.40

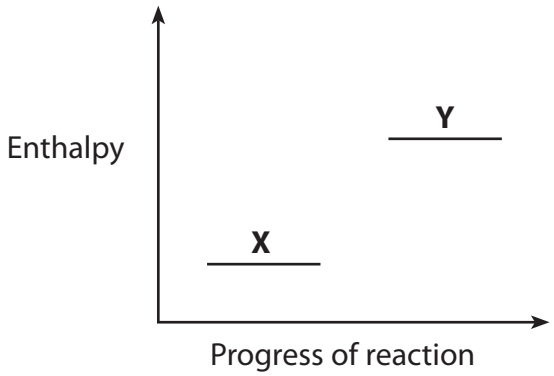
☒ **B** 0.25

☒ **C** 0.10

☒ **D** 0.025

(Total for Question 4 = 1 mark)

5 An enthalpy level diagram for a reaction is



Which row in the table shows the correct terms for **X** and **Y** and the enthalpy change for this reaction?

	X	Y	Enthalpy change
☒ **A**	products	reactants	endothermic
☒ **B**	products	reactants	exothermic
☒ **C**	reactants	products	endothermic
☒ **D**	reactants	products	exothermic

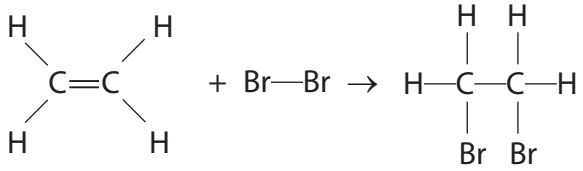
(Total for Question 5 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

6 The table shows the mean bond enthalpies for some covalent bonds.

Covalent bond	C—C	C═C	Br—Br	C—Br	C—H
Mean bond enthalpy / kJ mol^{-1}	347	612	193	290	413

What is the approximate enthalpy change, in kJ mol^{-1}, for the reaction shown?



☒ **A** −225

☒ **B** −122

☒ **C** +122

☒ **D** +225

(Total for Question 6 = 1 mark)

7 The first six ionization energies, in kJ mol^{-1}, of an element are

1086, 2353, 4621, 6223, 37832, 47278

In which group of the Periodic Table is this element?

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 5

(Total for Question 7 = 1 mark)

Use this space for rough working. Anything you write in this space will gain no credit.

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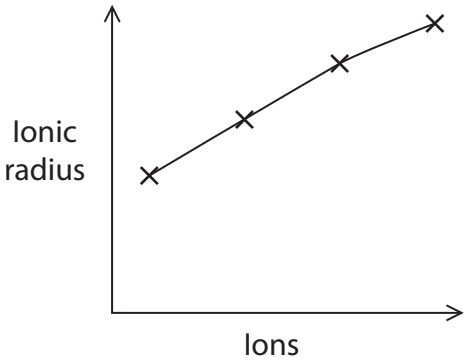
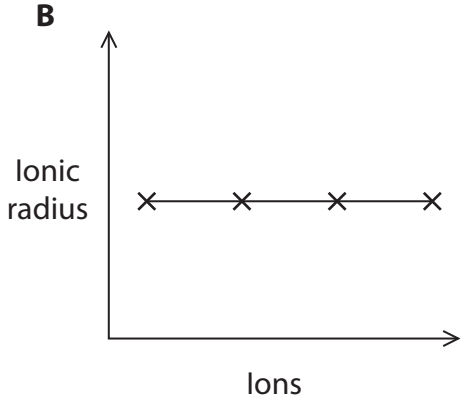
8 Each diagram shows the trend in the ionic radius for four sequences of ions.
The diagrams are not to scale.

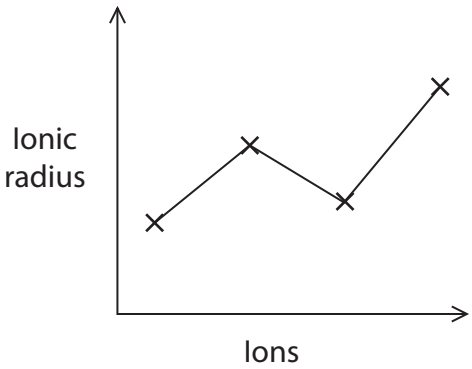
A



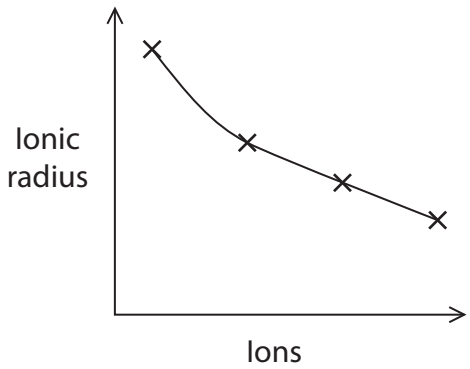
B



C



D



(a) Which diagram shows the trend in the ionic radius for the sequence Li^+, Na^+, K^+, Rb^+?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which diagram shows the trend in the ionic radius for the sequence Na^+, Mg^{2+}, Al^{3+}, Si^{4+}?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 8 = 2 marks)

9 Some energy changes involved in a Born-Haber cycle are

A electron affinity

B lattice energy

C standard enthalpy change of atomization

D standard enthalpy change of formation

(a) Which enthalpy or energy change is represented by **p**?

$$K(s) \rightarrow K(g) \qquad \Delta H^{\ominus} = \mathbf{p}$$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which enthalpy or energy change is represented by **q**?

$$K(s) + \tfrac{1}{2}Cl_2(g) \rightarrow KCl(s) \qquad \Delta H^{\ominus} = \mathbf{q}$$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which enthalpy or energy change is represented by **r**?

$$\tfrac{1}{2}Cl_2(g) \rightarrow Cl(g) \qquad \Delta H^{\ominus} = \mathbf{r}$$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 9 = 3 marks)

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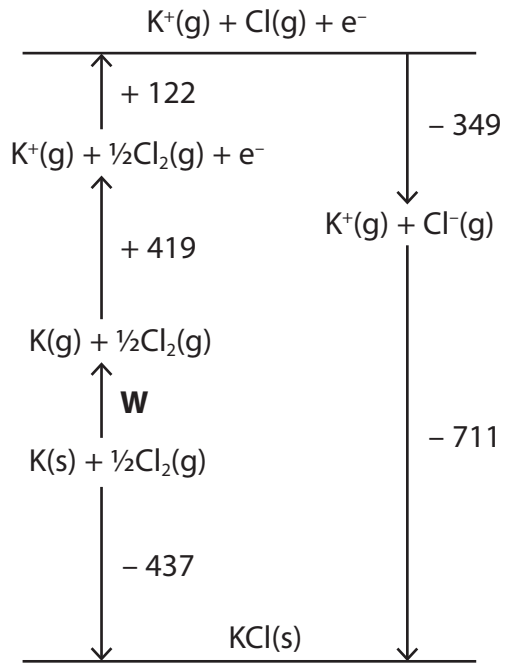
10 The diagram, which is not drawn to scale, shows the Born-Haber cycle for potassium chloride. The energy changes given are in kJ mol^{-1}.



What is the value for **W**, in kJ mol^{-1}?

- ☒ **A** −956
- ☒ **B** −82
- ☒ **C** +82
- ☒ **D** +956

(Total for Question 10 = 1 mark)

Use this space for rough working. Anything you write in this space will gain no credit.

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11 Which row in the table shows the lattice energies, in kJ mol^{-1}, of calcium fluoride, potassium fluoride and potassium iodide?

	Calcium fluoride	Potassium fluoride	Potassium iodide
☒ **A**	–2630	–817	–651
☒ **B**	–2630	–651	–817
☒ **C**	–651	–817	–2630
☒ **D**	–817	–2630	–651

(Total for Question 11 = 1 mark)

12 The experimental value for the lattice energy of beryllium iodide is −2800 kJ mol^{-1} and the theoretical value is –2653 kJ mol^{-1}.

The best explanation for the difference is that the

☒ **A** beryllium ion is large and polarizes the iodide ion.

☒ **B** beryllium ion is small and polarizes the iodide ion.

☒ **C** iodide ion is large and polarizes the beryllium ion.

☒ **D** iodide ion is small and polarizes the beryllium ion.

(Total for Question 12 = 1 mark)

13 Carbon (diamond) and oxygen both form covalent bonds between their atoms in the element.

What is the **best** reason for the fact that diamond has a much higher melting temperature than oxygen?

☒ **A** Diamond is a solid but oxygen is a gas at room temperature.

☒ **B** Diamond has a giant atomic structure but oxygen has a simple molecular structure.

☒ **C** The covalent bonds between carbon atoms in diamond are stronger than those between oxygen atoms.

☒ **D** There is a single covalent bond between carbon atoms in diamond but a double covalent bond between oxygen atoms.

(Total for Question 13 = 1 mark)

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14 The bonding in solid ammonium chloride is

☒ **A** ionic only.

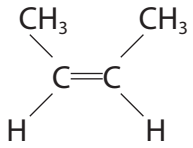
☒ **B** ionic and covalent only.

☒ **C** ionic and dative covalent only.

☒ **D** ionic, covalent and dative covalent only.

(Total for Question 14 = 1 mark)

15 One of the isomers with the formula C_4H_8 is



Possible names for this isomer are

☒ **A** *cis*-but-2-ene and *E*-but-2-ene.

☒ **B** *cis*-but-2-ene and *Z*-but-2-ene.

☒ **C** *trans*-but-2-ene and *E*-but-2-ene.

☒ **D** *trans*-but-2-ene and *Z*-but-2-ene.

(Total for Question 15 = 1 mark)

16 An electrophile is a species that

☒ **A** can accept a pair of electrons to form a covalent bond.

☒ **B** can donate a pair of electrons to form a covalent bond.

☒ **C** always has a negative charge.

☒ **D** always has a positive charge.

(Total for Question 16 = 1 mark)

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17 Alkenes react with hydrogen gas in the presence of a nickel catalyst.

0.2 mol of an alkene reacted completely with 19.2 dm^3 of hydrogen gas at room temperature and pressure.

How many C═C bonds are there in a molecule of this alkene?

[The molar volume of a gas is 24.0 dm^3 mol^{-1} at room temperature and pressure]

☒ **A** 4

☒ **B** 3

☒ **C** 2

☒ **D** 1

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 (a) The relative atomic masses of elements can be determined using a mass spectrometer.

(i) Define the term **relative atomic mass**.

(3)

(ii) Describe fully how positive ions are formed from gaseous atoms in a mass spectrometer.

(2)

(iii) The following data were obtained from the mass spectrum of a sample of strontium.

Mass / charge ratio	% abundance
84.0	0.56
86.0	9.86
87.0	7.02
88.0	82.56

Calculate the relative atomic mass of strontium in this sample.

Give your answer to **three** significant figures.

(2)

(b) In which block of the Periodic Table is strontium found?

(1)

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(c) Draw the dot and cross diagram for strontium chloride.

Show **outer** electrons only.

(2)

(d) A solution of strontium nitrate was prepared from strontium oxide and dilute nitric acid.

Write the equation for this reaction, including state symbols.

(2)

(e) A compound of strontium contains 49.9% strontium, 13.7% carbon and 36.4% oxygen, by mass.

Calculate the empirical formula for this compound.

[Use relative atomic masses: Sr = 87.6, C = 12.0, O = 16.0]

(3)

(Total for Question 18 = 15 marks)

19 The first ionization energies for the elements in Period 3 of the Periodic Table are

Element	Na	Mg	Al	Si	P	S	Cl	Ar
First ionization energy / kJ mol^{-1}	496	738	578	789	1012	1000	1251	1521

(a) (i) Complete the electronic configuration of phosphorus, using the electrons-in-boxes notation.

Write the symbols for the sub-shells on the dotted lines.

(2)



1s ....

*(ii) The first ionization energies generally increase from left to right across the period.

Explain why the first ionization energy of sulfur is **lower** than that of phosphorus.

(2)

.....

.....

.....

.....

.....

.....

(iii) Write an equation, with state symbols, to show the **third** ionization energy of phosphorus.

(2)

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*(b) (i) Explain why the first ionization energy of nitrogen is greater than the first ionization energy of phosphorus.

(3)

(ii) Draw a dot and cross diagram to show the bonding in a molecule of nitrogen.

Show **outer** electrons only.

(2)

(c) Solid white phosphorus exists as P_4 molecules.

Calculate the number of molecules in 24.8 g of white phosphorus.

[The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}]

(2)

(Total for Question 19 = 13 marks)

20 Compound **X** has the molecular formula C_5H_{12}.

(a) Draw the **displayed** formulae of the **three** structural isomers of C_5H_{12}.

(2)

(b) C_5H_{12} reacts with chlorine to form a mixture of products.

(i) Classify the type and mechanism of this reaction.

(2)

(ii) Write the equations for the two propagation steps for this mechanism. Use the molecular formula, C_5H_{12}, in your first equation. Curly arrows are not required.

(2)

(iii) Write the equation for **one** termination step for this mechanism. Curly arrows are not required.

(1)

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(c) An experiment was carried out to determine the enthalpy change of combustion of compound **X**, C_5H_{12}.

100.0 g of water was heated by burning 0.144 g of compound **X**.

The temperature rise of the water was 14.5 °C.

(i) Calculate the energy transferred, in **kJ**, in this experiment.

Use the equation

heat energy produced (J) = mass of water × 4.18 × temperature change

(1)

energy transferred = ... kJ

(ii) Calculate the number of moles of compound **X** used in this experiment.

(1)

moles of **X** = ...

(iii) Calculate the enthalpy change of combustion of compound **X**. Include a sign and units in your answer.

(2)

enthalpy change of combustion = ...

(iv) The Data Book values for the enthalpy changes of combustion of the three structural isomers with the formula C_5H_{12} are:

$-3509.1\ kJ\ mol^{-1}$

$-3503.4\ kJ\ mol^{-1}$

$-3492.5\ kJ\ mol^{-1}$

The experimental value calculated in (c)(iii) is very different from these values. Give **two** reasons, other than heat loss, for this large difference.

(2)

(v) Explain why it is **not** possible to deduce which of the isomers is compound **X** by comparing this experimental value and the Data Book values.

(1)

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*(d) Complete the Hess cycle and use it to calculate the enthalpy change of combustion of C_5H_{12} from the following data.

Show all of your working.

Standard enthalpy change of formation of $C_5H_{12}(l)$	–173.2 kJ mol^{-1}
Standard enthalpy change of combustion of $H_2(g)$	–285.8 kJ mol^{-1}
Standard enthalpy change of combustion of carbon(s, graphite)	–393.5 kJ mol^{-1}

(4)

$C_5H_{12}(l) + 8O_2(g) \longrightarrow 5CO_2(g) + 6H_2O(l)$

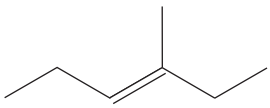
..... + ... + ...

(Total for Question 20 = 18 marks)

21 This question is about alkenes.

(a) (i) Give the molecular formula of this alkene.

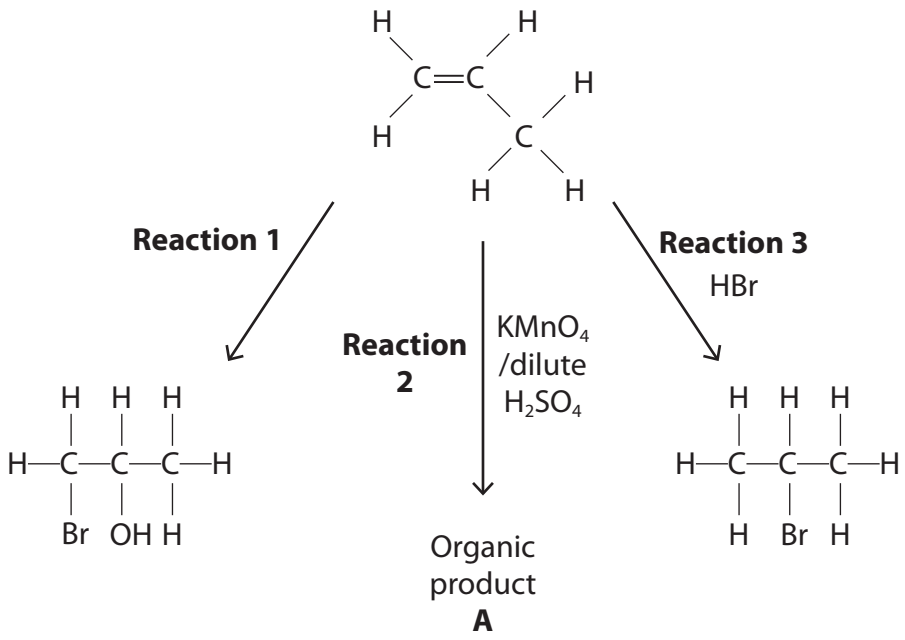
(1)



(ii) Explain why the alkene in (a)(i) exhibits geometric isomerism.

(2)

(b) Propene reacts with three different reagents.



(i) Give the reagent needed for **Reaction 1**.

(1)

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(ii) Identify, by name or formula, the organic product **A** formed in **Reaction 2**.

(1)

(iii) State the colour change that you would see when **Reaction 2** is carried out.

(1)

From ..... to .....

(iv) Give the mechanism for **Reaction 3**. Use curly arrows and show any relevant dipoles and lone pairs.

(4)

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(c) But-2-ene polymerizes to form poly(but-2-ene).

Draw a section of this polymer, showing **two** repeat units.

(1)

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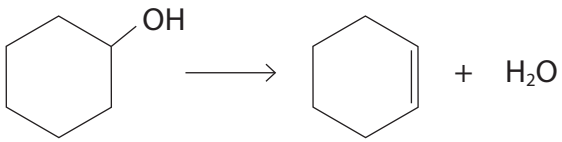
(d) Cyclohexanol forms cyclohexene in the following reaction.



(i) Calculate the percentage atom economy by mass for the production of cyclohexene.

(1)

(ii) Calculate the percentage yield if 10.20 g of cyclohexanol produced 6.15 g of cyclohexene.

(2)

(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

January 2016

Pearson Edexcel International
Advanced Level in Chemistry (WCH01)
Paper 01 – The Core Principles of
Chemistry.

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	D		**1**

Question Number	Correct Answer	Reject	Mark
2	B		**1**

Question Number	Correct Answer	Reject	Mark
3	B		**1**

Question Number	Correct Answer	Reject	Mark
4	A		**1**

Question Number	Correct Answer	Reject	Mark
5	C		**1**

Question Number	Correct Answer	Reject	Mark
6	B		**1**

Question Number	Correct Answer	Reject	Mark
7	C		**1**

Question Number	Correct Answer	Reject	Mark
8(a)	A		**1**

Question Number	Correct Answer	Reject	Mark
8(b)	D		**1**

Question Number	Correct Answer	Reject	Mark
9(a)	C		**1**

Question Number	Correct Answer	Reject	Mark
9(b)	D		**1**

Question Number	Correct Answer	Reject	Mark
9(c)	C		**1**

Question Number	Correct Answer	Reject	Mark
10	C		**1**

Question Number	Correct Answer	Reject	Mark
11	A		**1**

Question Number	Correct Answer	Reject	Mark
12	B		**1**

Question Number	Correct Answer	Reject	Mark
13	B		**1**

Question Number	Correct Answer	Reject	Mark
14	D		**1**

Question Number	Correct Answer	Reject	Mark
15	B		**1**

Question Number	Correct Answer	Reject	Mark
16	A		**1**

Question Number	Correct Answer	Reject	Mark
17	A		**1**

(Total for Section A = 20 marks)

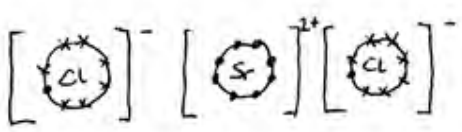
Section B

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	**First mark** Weighted mean mass ALLOW (Weighted) average (atomic) mass **(1)** **Second mark** (Mass) of atom(s) (of an element) ALLOW (Mass of all) the isotopes (of an element) **(1)** **Third mark** Divided by / compared with 1/12th the **mass** of (an atom of) ^{12}C / C-12 OR On a scale in which ^{12}C / C-12 = 12 (g) **(1)**	average weight atom of an isotope Mole(s) of atoms	**3**

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	(Beam of) high energy electrons / accelerated electrons / electrons from electron gun / high speed electrons / ALLOW Electron beam OR Electrons bombard / hit / blast the (gaseous) atoms OR Electrons are fired at the (gaseous) atoms **(1)** Knock off / liberates an electron(s) / leads to loss/removal of electron(s) (from the gaseous atoms) **(1)** IGNORE References to ionising / forming (positive) ions / just an equation e.g. $M(g) \rightarrow M^+(g) + e$	Just 'electron gun' / 'electron(s)' highly charged electrons Just 'takes an electron(s)'	**2**

Question Number	Acceptable Answers	Reject	Mark
18(a)(iii)	Correct answer with or without working scores both marks ((84.0 x 0.56) + (86.0 x 9.86) + (87.0 x 7.02) +(88.0 x 82.56))/100 **(1)** = 87.7 (must be to 3 SF) **(1)** NOTE 87.71/ 87.710/87.7102 score **(1)** with or without working IGNORE g or g mol^{-1}, but wrong units, eg %, lose the second mark		**2**

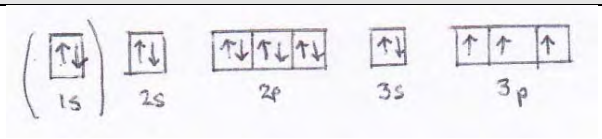
Question Number	Acceptable Answers	Reject	Mark
18(b)	s (block) ALLOW S (block) IGNORE group 2 / period 5	Any number in front of the s e.g. 4s Any other group number / period number	**1**

Question Number	Acceptable Answers	Reject	Mark
18(c)	 **First mark** Correct dot and cross diagrams with 2+ charge on Sr and – charge on Cl **(1)** ALLOW no electrons or 8 electrons on outer shell of Sr ALLOW dots or crosses for electrons ALLOW diagrams without square brackets **Second mark** Ratio of 1 strontium and 2 chloride (ions) ALLOW this shown as 2 in front of a chloride ion or subscript 2 after the ion **(1)** IGNORE any inner shell electrons ALLOW max 1 for incorrect symbol(s)	covalent bonding **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
18(d)	$SrO(s) + 2HNO_3(aq) \rightarrow Sr(NO_3)_2(aq) + H_2O(l)$ **OR** $SrO(s) + 2H^+(aq) \rightarrow Sr^{2+}(aq) + H_2O(l)$ Correct formulae and balancing ALLOW multiples **(1)** State symbols **(1)** If no other mark awarded, ALLOW Ionic equation given as $O^{2-}(s) + 2H^+(aq) \rightarrow H_2O(l)$ **(1)**	H_2 scores **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
18(e)	SrC_2O_4 with or without working scores 3 marks Sr C O % 49.9 13.7 36.4 **(1)** A_r 87.6 12.0 16.0 divide 0.57 1.14 2.28 by 0.57 0.57 0.57 smaller ratio 1 2(.004) 4/3.993 **(1)** empirical formula SrC_2O_4 **(1)** ALLOW symbols in any order ALLOW use of 87.7 instead of 87.6 ALLOW TE for MP2 and 3, if one slip in MP1 or MP2	If all A_r/%, scores **(0)** overall If all %/atomic number, scores **(0)** overall Incorrect symbol(s)	**3**

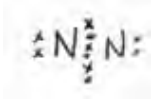
(Total for Question 18 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	 Arrows correct ALLOW half-headed arrows/ 3p electrons all pointing downwards **(1)** Labels correct OR $2p_x$, $2p_y$, $2p_z$ and $3p_x$, $3p_y$, $3p_z$ **(1)** IGNORE numbers as superscripts		**2**

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	Mark independently **First mark** (idea of paired electrons in S) In sulfur: spin-pairing has occurred (in the 3p orbital / sub-shell)/ there are paired electrons (in a 3p orbital / sub-shell) OR there are two electrons in the same (3p) orbital **/** there is a full (3p) orbital **(1)** **Note** – Just stating $3p^4$ does not get this mark **Second mark** (idea of repulsion) (Resultant increase in) repulsion (allows electron to be removed more easily) **(1)** **Note** – if no correct reference to sulfur ALLOW Phosphorus has a half-filled sub-shell which is (more) stable **(1)** IGNORE any reference to nuclear attraction / atomic radius / shielding	Sub-shell / shell	**2**

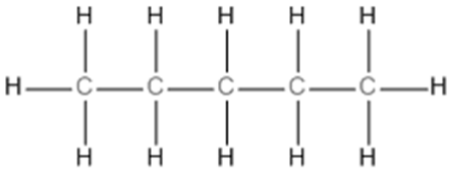
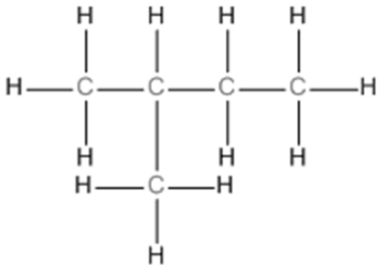
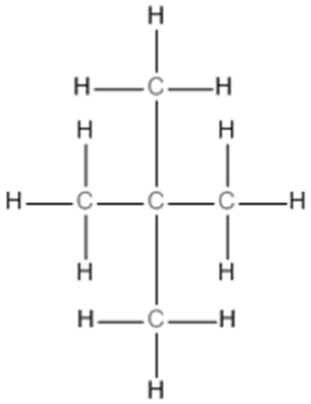
Question Number	Acceptable Answers	Reject	Mark
19(a)(iii)	$P^{2+}(g) \rightarrow P^{3+}(g) + e^{(-)}$ ALLOW $P^{2+}(g) — e^{(-)} \rightarrow P^{3+}(g)$ ALLOW +2/+3 for 2+/3+ or additional electrons provided the equation balances Correct symbols **(1)** Both (g) **(1)** Mark independently IGNORE state symbol on the electron / IE in equation	Incorrect symbol for first mark only	**2**

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	Mark independently **First mark** (number of shells) N has fewer (electron) shells than P ALLOW The outer electron is in a shell closer to the nucleus in N OR In N the atomic radius/size is less **(1)** **Second mark** (shielding) (Outermost electron in N) has less shielding **(1)** **Third mark** (attraction) (Even though N has a lower nuclear charge/ fewer protons) (there is a) greater (force of) attraction between the nucleus and the (outer) electron/ greater effective nuclear charge OR outer electron is held more strongly by the nucleus **(1)** IGNORE N has a greater charge density ALLOW Reverse argument for phosphorus / trend down the group	Mention of molecules Just 'lower atomic number' / 'N is smaller than P' Ionic radius N has a higher nuclear charge than P	**3**

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	 OR  ALLOW all dots, all crosses or any other symbol for the electrons **First Mark** Three pairs of electrons between the nitrogen atoms ALLOW Two or three of the 3 pairs of electrons circled to show sharing as part of triple bond **(1)** **Second Mark** Lone pair on each nitrogen atom ALLOW 2 unpaired electrons **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
19(c)	Correct answer with or without working scores both marks Number of moles = $\frac{24.8}{31.0 \times 4}$ **(1)** $= 0.2(00)$ (mol) Number of molecules of P_4 $= 0.2 \times 6.02 \times 10^{23}$ $= 1.204 \times 10^{23}$ / 1.20×10^{23} / 1.2×10^{23} **(1)** TE on number of moles IGNORE SF except 1SF		**2**

(Total for Question 19 = 13 marks)

Question Number	Acceptable Answers	Reject	Mark
20(a)	   All 3 correct **(2)** Any 2 correct **(1)** ALLOW CH_3 groups If no other marks are scored, ALLOW 3 correct isomers as structural, skeletal or any other combination of formulae except molecular for **(1)** mark IGNORE bond angles and bond lengths IGNORE structural or skeletal formulae in addition to displayed formulae / names, even if incorrect If 4 or more isomers drawn, max 1	Missing H once only Only structural or skeletal formulae once only	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	(Free) radical **(1)** Substitution **(1)** IGNORE homolytic fission/ initiation / propagation /termination	Heterolytic /electrophilic /nucleophilic	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	$C_5H_{12} + Cl\bullet \rightarrow C_5H_{11}\bullet + HCl$ **(1)** $C_5H_{11}\bullet + Cl_2 \rightarrow C_5H_{11}Cl + Cl\bullet$ **(1)** ALLOW equations in either order / displayed formulae / structural formulae NO TE on incorrect free radical IGNORE size and position of dot / any type of curly arrows	Missing dots once only in (b)(ii) and (b)(iii) Additional incorrect equations once only Formation of H• scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	Any one from $Cl\bullet + Cl\bullet \rightarrow Cl_2$ $Cl\bullet + C_5H_{11}\bullet \rightarrow C_5H_{11}Cl$ $C_5H_{11}\bullet + C_5H_{11}\bullet \rightarrow C_{10}H_{22}$ IGNORE any type of curly arrows	Additional incorrect equation	**1**

Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	Correct answer with or without working scores the mark 100.0 x 4.18 x 14.5 (**=** 6061 J) **=** 6.061/6.06/6.1 (kJ) ALLOW 6061 **J** IGNORE sign (+/-) / kJ mol^{-1}	6 / 6061 (kJ)	**1**

Question Number	Acceptable Answers	Mark
20(c)(ii)	Correct answer with or without working scores the mark number of moles = $\frac{0.144}{72}$ = 0.002 / $2x10^{-3}$ ALLOW correct working with no answer written	**1**

Question Number	Acceptable Answers	Reject	Mark
20(c)(iii)	Correct answer with or without working scores both marks enthalpy change of combustion = $\frac{\text{answer to (c)(i)}}{\text{answer to (c)(ii)}}$ = −3030.5/−3031 kJ mol^{-1} Or −3030500/−3.0305 x 10^6/−3031000/−3.031 x 10^6 J mol^{-1} Correct number **(1)** Correct sign and units consistent with number **(1)** Mark independently ALLOW −3030/−3050 kJ mol^{-1} and equivalent answers in J mol^{-1} score both marks ALLOW units as kJ/mol or $\frac{kJ}{mol}$ or J/mol or $\frac{J}{mol}$ IGNORE SF except 1SF ALLOW TE from (c)(i) and (c)(ii)	Incorrect unit e.g. kJ/mol^{-1} or kJ mol^{-}	**2**

Question Number	Acceptable Answers	Reject	Mark
20(c)(iv)	**First mark** Incomplete combustion ALLOW incomplete reaction **(1)** IGNORE not enough oxygen / not all the fuel has reacted **Second mark** Evaporation of the alkane / fuel / reactant / compound ALLOW alkane is volatile / heat capacity of/heat absorbed by container/apparatus was not included **(1)** IGNORE Heat loss to the surroundings / Not measured at standard conditions / Mention of heat capacity/density of water / Evaporation of water / Error in thermometer/balance / Alkane is impure If average bond enthalpies is mentioned, max (1)		**2**

Question Number	Acceptable Answers	Reject	Mark
20(c)(v)	The experimental errors are greater than the differences in the Data Book values OR The experimental value is much lower than all the Data Book values/ the Data Book values are all much more exothermic than the experimental value ALLOW The three Data Book values are (too) close together IGNORE Answer to (c)(iii)/ experimental value is very different to the Data Book values	Average bond enthalpies	**1**

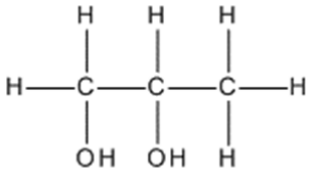
Question Number	Acceptable Answers	Reject	Mark
20(d)	$C_5H_{12}(l) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l)$  $5C(s, graphite) + 6H_2(g) + 8O_2(g)$ **Cycle** 2 marks $5C(s, graphite) + 6H_2(g) + 8O_2(g)$ **OR** $5C(s) + 6H_2(g) + 8O_2(g)$ Correct species, multiples and all state symbols needed **(1)** Both arrows upwards ALLOW two arrows from elements to products of combustion /downward arrows provided they are labelled with correct value or symbol **(1)** IGNORE additional curved arrows as part of working **Calculation** 2 marks Mark independently of arrows on cycle Correct answer with or without working scores both marks $\Delta H_c = (5x-393.5) + (6x-285.8) -(-173.2)$ **(1)** $= -3509.1/-3509$ (kJ mol^{-1}) **(1)** IGNORE kJ as unit ALLOW TE from incorrect multiple of C and H_2	Other incorrect unit	**4**

(Total for Question 20 = 18 marks)

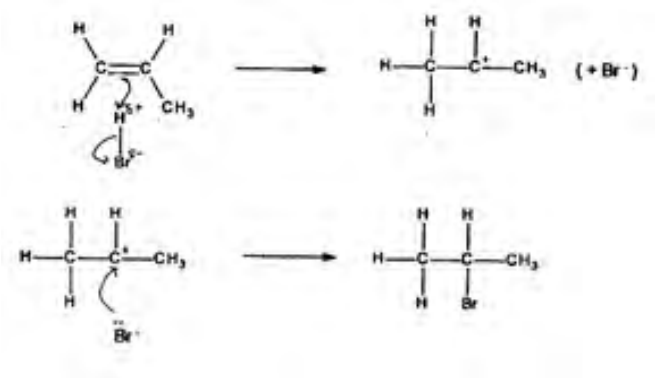
Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	C_7H_{14} ALLOW $H_{14}C_7$ IGNORE any working/ names	C^7H^{14}	**1**

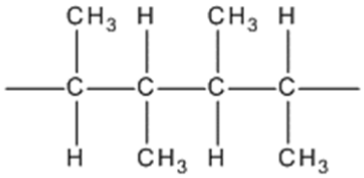
Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	**First mark** Restricted/barrier to rotation (around C=C/ pi bond) ALLOW no rotation (around C=C/ pi bond/ the double bond) **(1)** IGNORE Just 'groups/atoms attached to C=C are in fixed positions ' **Second mark** (Two) different groups/atoms (with different priorities/masses) on both/each of the carbon atoms (of C=C) OR (Two) different groups on either side of C=C OR There are three different groups/atoms around the C=C bond ALLOW two clear diagrams/structures showing the two different groups in each isomer **(1)**	the molecule/ hydrocarbon cannot rotate compounds/ molecules/ branches for groups 4 different groups/atoms	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	bromine water/ aqueous bromine /Br_2(aq)	Just 'bromine/Br_2'/ Br_2(l)/ BrOH	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	propane-1,2-diol ALLOW propan-1,2-diol/ 1,2-propanediol/ 1,2-propandiol IGNORE missing/ additional hyphens in name **OR**  ALLOW Structural formula, skeletal formula or a combination of these IGNORE Molecular formula/ $C_3H_8O_2$	1,2-dipropanol Correct name with incorrect formula or vice versa O-H-C... OH-C... OHC... ...C-H-O ... C-HO ...CHO	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	(From) purple/ pink (to) colourless Both colours correct for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)		Clearly half-headed arrows once only Missing H on structures once only	**4**
	Correct dipole on HBr **(1)** Curly arrow from C=C to H of HBr **and** curly arrow from H-Br bond to Br **(1)** Correct intermediate with + charge **(1)** (At least one) lone pair on Br^- **and** curly arrow from Br^- to C^+ **(1)** ALLOW curly arrow from anywhere on Br, including the – sign If mechanisms are given for 1-bromopropane and 2-bromopropane, ignore the mechanism for 1-bromopropane If final product is 1-bromopropane only, mechanism can score marks 1, 2 and 4	δ+ $Br^{\delta-}$	

Question Number	Acceptable Answers	Reject	Mark
21(c)	 ALLOW CH_3 groups above or below the chain ALLOW fully displayed formula IGNORE brackets and n/ 2 IGNORE bond angles and bond lengths IGNORE working before final structure		**1**

Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	Correct answer with no working scores the mark (percentage atom economy) = $\frac{82.0}{100.0} \times 100$ = 82(.0) (%)	82.4(%) (incorrect M_rs of 84 and 102 used 80 (1 SF)	**1**

Question Number	Acceptable Answers	Reject	Mark
21(d)(ii)	Correct answer with no working scores both marks **First mark** moles of cyclohexanol = 10.2 / 100.0 = 0.102 ALLOW TE on incorrect M_r in (i) **(1)** **Second mark** **EITHER** moles of cyclohexene produced = 6.15 / 82.0 = 0.075 % yield = 0.075 / 0.102 x 100 = 73.529/ 73.53/ 73.5/ 74 (%) **(1)** ALLOW TE on incorrect mol of cyclohexanol and cyclohexene or incorrect M_r in (i) **OR** theoretical mass of cyclohexene = 0.102 x 82.0 = 8.364 g % yield = 6.15 / 8.364 x 100 = 73.529/ 73.53/ 73.5/ 74 (%) **(1)** ALLOW TE on mol of cyclohexanol, mass of cyclohexene or incorrect M_r IGNORE SF except 1 SF	6.15 / 10.2 x 100 = 60.3% scores **(0)** 70 for the second mark	**2**

(Total for Question 21 = 14 marks)

TOTAL FOR PAPER = 80 MARKS

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 23 May 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P42976A

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6/6/6/6/

P 4 2 9 7 6 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following species has 50 neutrons?

☒ **A** $^{50}_{23}V$

☒ **B** $^{86}_{37}Rb^-$

☒ **C** $^{89}_{39}Y^+$

☒ **D** $^{91}_{40}Zr^+$

(Total for Question 1 = 1 mark)

2 Which of the following statements is correct about **all** isotopes of an element? They have

☒ **A** the same mass number.

☒ **B** the same number of neutrons.

☒ **C** more protons than neutrons.

☒ **D** the same electronic configuration.

(Total for Question 2 = 1 mark)

3 The element rhenium has two naturally-occurring isotopes, ^{185}Re and ^{187}Re. The relative atomic mass of rhenium is 186.2.

From this information, the percentage abundances of these two isotopes are

☒ **A** 12% ^{185}Re and 88% ^{187}Re

☒ **B** 40% ^{185}Re and 60% ^{187}Re

☒ **C** 60% ^{185}Re and 40% ^{187}Re

☒ **D** 88% ^{185}Re and 12% ^{187}Re

(Total for Question 3 = 1 mark)

4 In which of the following pairs does the second element have a **lower** 1st ionization energy than the first element?

	First element	Second element
☒ **A**	Si	C
☒ **B**	Na	Mg
☒ **C**	Be	B
☒ **D**	Ar	Ne

(Total for Question 4 = 1 mark)

5 An oxide of nitrogen contains 2.8 g of nitrogen and 8.0 g of oxygen.
What is the empirical formula of this oxide?

☒ **A** NO

☒ **B** NO_3

☒ **C** N_2O_3

☒ **D** N_2O_5

(Total for Question 5 = 1 mark)

6 Calculate the total number of **atoms** present in 1.8 g of water, H_2O.

DATA

- The molar mass of H_2O is 18 g mol^{-1}
- The Avogadro constant is 6.0×10^{23} mol^{-1}

☒ **A** 6.0×10^{22}

☒ **B** 6.0×10^{23}

☒ **C** 1.8×10^{23}

☒ **D** 1.8×10^{24}

(Total for Question 6 = 1 mark)

7 Calculate the mass of hydrated sodium thiosulfate, $Na_2S_2O_3.5H_2O$, required to prepare 200 cm^3 of a 0.100 mol dm^{-3} solution.

[Assume that the molar mass of $Na_2S_2O_3.5H_2O$ is 248 g mol^{-1}]

☒ **A** 0.124 g

☒ **B** 4.96 g

☒ **C** 24.8 g

☒ **D** 4960 g

(Total for Question 7 = 1 mark)

8 A 27.0 g sample of an unknown hydrocarbon, C_xH_y, was burned completely in excess oxygen to form 88.0 g of carbon dioxide and 27.0 g of water.

[Molar masses / g mol^{-1}: $CO_2 = 44$; $H_2O = 18$]

Which of the following is a possible formula of the unknown hydrocarbon?

☒ **A** CH_4

☒ **B** C_2H_6

☒ **C** C_4H_6

☒ **D** C_6H_6

(Total for Question 8 = 1 mark)

9 The Avogadro constant is equal to the number of

☒ **A** grams of any element which contains 6.0×10^{23} atoms of that element.

☒ **B** atoms contained in one mole of any element in its standard state.

☒ **C** particles (atoms, ions or molecules) required to make one gram of a substance.

☒ **D** atoms contained in one mole of any monatomic element.

(Total for Question 9 = 1 mark)

10 Nitrogen monoxide, NO, can be made by the catalytic oxidation of ammonia, NH_3.

$$4NH_3 + 5O_2 \rightarrow 4NO + 6H_2O$$

In an experiment, 8.5 g of ammonia reacted to form 15.0 g of nitrogen monoxide. The percentage yield of nitrogen monoxide in this experiment is

☒ **A** 50%

☒ **B** 57%

☒ **C** 100%

☒ **D** 176%

(Total for Question 10 = 1 mark)

11 Calculate the mass, in grams, of silver chloride, AgCl, formed when excess silver nitrate solution is added to 55.0 cm^3 of a 0.200 mol dm^{-3} solution of potassium chloride.

[The molar mass of AgCl = 143.4 g mol^{-1}]

$$AgNO_3(aq) + KCl(aq) \rightarrow AgCl(s) + KNO_3(aq)$$

☒ **A** 1.10 g

☒ **B** 1.58 g

☒ **C** 7.89 g

☒ **D** 11.0 g

(Total for Question 11 = 1 mark)

12 Element X is in Group 3 and element Y is in Group 6 of the Periodic Table. Which of the following is the most likely formula of the compound formed when X and Y react together?

☒ **A** X_2Y_3

☒ **B** X_3Y_2

☒ **C** X_2Y

☒ **D** XY_2

(Total for Question 12 = 1 mark)

13 Metallic bonding is **best** described as the electrostatic attraction between

- ☒ **A** positive ions and delocalized electrons.
- ☒ **B** protons and electrons.
- ☒ **C** positive and negative ions.
- ☒ **D** nuclei and shared pairs of electrons.

(Total for Question 13 = 1 mark)

14 Which of the following molecules contains a double bond?

- ☒ **A** F_2
- ☒ **B** F_2O
- ☒ **C** C_2F_4
- ☒ **D** C_2F_6

(Total for Question 14 = 1 mark)

15 Which of the following statements is true?

- ☒ **A** Breaking covalent bonds requires energy and making ionic bonds requires energy.
- ☒ **B** Bond breaking is endothermic whereas bond making is exothermic.
- ☒ **C** Bond breaking is exothermic whereas bond making is endothermic.
- ☒ **D** Breaking ionic bonds releases energy whereas making covalent bonds requires energy.

(Total for Question 15 = 1 mark)

16 Consider the two equations given below.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(l) \qquad \Delta H = -572 \text{ kJ mol}^{-1}$$

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g) \qquad \Delta H = -484 \text{ kJ mol}^{-1}$$

From this information, calculate the enthalpy change for the following process

$$H_2O(g) \rightarrow H_2O(l)$$

☒ **A** –44 kJ mol^{-1}

☒ **B** +44 kJ mol^{-1}

☒ **C** –88 kJ mol^{-1}

☒ **D** +88 kJ mol^{-1}

(Total for Question 16 = 1 mark)

17 How many structural isomers have the molecular formula C_6H_{14}?

☒ **A** Four

☒ **B** Five

☒ **C** Six

☒ **D** Seven

(Total for Question 17 = 1 mark)

18 In addition to water, which of the following could be formed during the **incomplete** combustion of a hydrocarbon?

☒ **A** Carbon, carbon monoxide and hydrogen

☒ **B** Carbon and hydrogen

☒ **C** Carbon monoxide and hydrogen

☒ **D** Carbon and carbon monoxide

(Total for Question 18 = 1 mark)

19 Poly(ethene) is a plastic material made by polymerizing the hydrocarbon ethene. Which of the following is **not** true?

Pure poly(ethene) is

☒ **A** solidified ethene.

☒ **B** composed of carbon and hydrogen only.

☒ **C** a long-chain compound.

☒ **D** non-biodegradable.

(Total for Question 19 = 1 mark)

20 Which of the following statements correctly describes an environmental problem caused by the burning of hydrocarbon fuels?

☒ **A** The carbon dioxide produced is toxic and kills plants.

☒ **B** The smoke produced obscures sunlight and leads to global warming.

☒ **C** The water produced results in a damaging increase in rainfall.

☒ **D** The carbon dioxide produced traps heat radiated from the Earth and leads to global warming.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Bromine, Br_2, can react with both alkanes and alkenes. The type of reaction that occurs depends on whether the Br—Br bond breaks by homolytic or heterolytic fission.

(a) (i) Write an equation to show the **homolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

(ii) Write an equation to show the **heterolytic** fission of the Br—Br bond. Do **not** include curly arrows or state symbols.

(1)

(iii) Choosing from the products you have given in (a)(i) and (a)(ii), write the formula of a free radical and an electrophile.

(2)

Free radical .....

Electrophile .....

(b) The compound hexane, C_6H_{14}, can react with bromine, in the presence of UV light, according to the equation

$$C_6H_{14} + Br_2 \rightarrow C_6H_{13}Br + HBr$$

(i) Give the displayed formulae of the three structural isomers of $C_6H_{13}Br$ that could be formed in the above reaction.

(3)

First isomer

Second isomer

Third isomer

(ii) The bromoalkanes and the hydrogen bromide formed in this reaction are hazardous.

The bromoalkanes would be labelled as 'flammable'. Suggest a suitable hazard warning for the hydrogen bromide.

(1)

.....

(iii) Calculate the percentage atom economy by mass for the formation of $C_6H_{13}Br$.

Give your answer to **three** significant figures.

Use the expression

$$\text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\%$$

(2)

(c) Fluorine, F_2, and chlorine, Cl_2, react with **methane**, CH_4, by a similar mechanism, although the rates of reaction are very different.

(i) Write an equation for the reaction between **methane** and fluorine, assuming they react in a 1:1 mole ratio. State symbols are not required.

(1)

*(ii) On the basis of comparing the relative sizes of the fluorine and chlorine atoms, it might be predicted that the F—F bond energy would be greater than the Cl—Cl bond energy.
Suggest an explanation for this prediction.

(2)

(iii) Draw a dot and cross diagram to show the arrangement of the outermost electrons in a fluorine molecule, F_2.

(2)

(iv) The actual bond energies are shown below.

Bond	Bond energy / kJ mol^{-1}
F—F	158
Cl—Cl	243

By referring to your dot and cross diagram in your answer to (c)(iii), suggest an explanation for the fact that the F—F bond energy is **less** than that of the Cl—Cl bond energy.

(2)

(v) Suggest why a mixture of methane and chlorine requires exposure to UV light, or heat, before a reaction occurs, whereas methane reacts rapidly with fluorine at room temperature in the absence of UV light or heat.

(1)

(d) The alkene hex-3-ene reacts with bromine to produce 3,4-dibromohexane. Complete the mechanism below by adding curly arrows to show the movement of electron pairs in both steps and by giving the structural formula of the intermediate carbocation.

(3)



3,4-dibromohexane

(e) The mechanism shown in (d) shows *Z*-hex-3-ene reacting with bromine. *E*-hex-3-ene also reacts with bromine to form 3,4-dibromohexane.

(i) Draw the structure of *E*-hex-3-ene.

(1)

(ii) Explain why both *Z*-hex-3-ene and *E*-hex-3-ene react with bromine to produce the **same** structural isomer.

(1)

.....

.....

(Total for Question 21 = 23 marks)

22 Lattice energy can be used as a measure of ionic bond strength. Born-Haber cycles can be used to determine experimental values of lattice energies.

The table below shows the energy changes that are needed to determine the lattice energy of lithium fluoride, LiF.

Energy change	ΔH / kJ mol^{-1}
Enthalpy change of atomization of lithium	+159
First ionization energy of lithium	+520
Enthalpy change of atomization of fluorine, $\frac{1}{2}F_2$	+79
First electron affinity of fluorine	−328
Enthalpy change of formation of lithium fluoride	−616

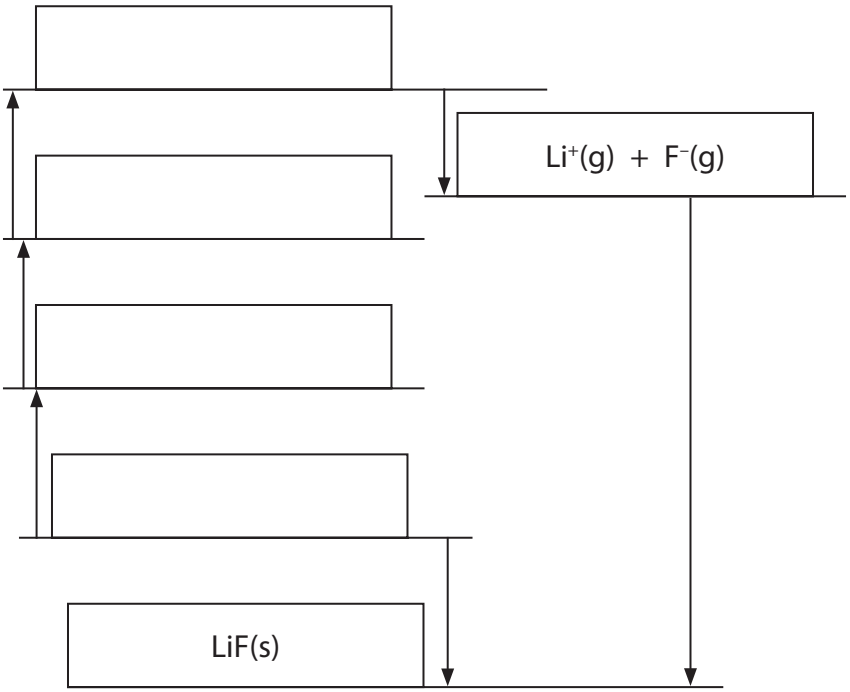
(a) Define the term **lattice energy**.

(2)

(b) The diagram below shows an incomplete Born-Haber cycle for the formation of lithium fluoride from lithium and fluorine.

(i) Complete the diagram by writing the formulae of the correct species, including state symbols, in the four empty boxes.

(4)



(ii) Calculate the lattice energy of lithium fluoride, in kJ mol^{-1}.

(2)

lattice energy = ... kJ mol^{-1}

*(c) The lattice energies of sodium fluoride, sodium chloride and magnesium fluoride are shown in the table below.

Compound	Lattice energy / kJ mol^{-1}
Sodium fluoride, NaF	–918
Sodium chloride, NaCl	–780
Magnesium fluoride, MgF_2	–2957

Explain, in terms of the sizes and charges of the ions involved, the differences between the lattice energy values of

(i) NaF and NaCl

(2)

.....

.....

.....

.....

.....

(ii) NaF and MgF_2

(2)

.....

.....

.....

.....

.....

(Total for Question 22 = 12 marks)

23 Alkanes are used as fuels in homes and in industry. It is, therefore, important that the enthalpy changes involving alkanes are known.

(a) Define the term **standard enthalpy change of formation** of a compound.

Give the conditions of temperature and pressure that are used when measuring a **standard** enthalpy change.

(3)

Definition .....

.....

.....

.....

Standard temperature is .....

Standard pressure is .....

(b) Write the equation, with state symbols, that accompanies the enthalpy change of formation of hexane, $C_6H_{14}(l)$.

(2)

(c) Enthalpy changes can be calculated using enthalpy changes of combustion. Values for some standard enthalpy changes of combustion are shown in the table below.

Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s)	–394
$H_2(g)$	–286
$CH_4(g)$	–890

Use these data to complete the Hess cycle below for the reaction and then calculate the standard enthalpy change for the reaction, in kJ mol^{-1}.

C(s)	+	$2H_2(g)$	→	$CH_4(g)$

(3)

Space for working

standard enthalpy change for the reaction = ... kJ mol^{-1}

(d) The equations for the combination of gaseous carbon atoms and gaseous hydrogen atoms to form methane, CH_4, and ethane, C_2H_6, are shown below.

$$C(g) + 4H(g) \rightarrow CH_4(g) \qquad \Delta H = -1652 \text{ kJ mol}^{-1}$$

$$2C(g) + 6H(g) \rightarrow C_2H_6(g) \qquad \Delta H = -2825 \text{ kJ mol}^{-1}$$

Use these data to calculate

(i) the mean bond enthalpy of a C—H bond in methane, in kJ mol^{-1}.

(1)

(ii) the bond enthalpy of a C—C bond, in kJ mol^{-1}, clearly showing your working.

(2)

(Total for Question 23 = 11 marks)

24 This question is about atomic structure.

(a) Draw diagrams to show the shape of an s-orbital and of a p-orbital.

(2)

s-orbital	p-orbital

(b) Complete the table to show the number of electrons that **completely** fill the following regions.

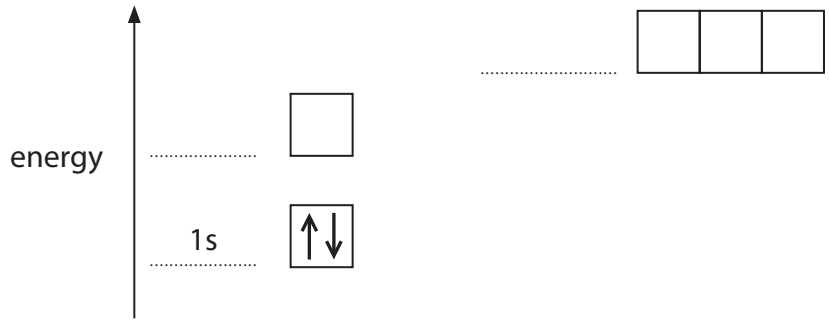
(3)

Region	Number of electrons present when completely filled
a d-orbital	
a p sub-shell	
the third shell (n = 3)	

(c) The energy diagram below is for the eight electrons present in an oxygen atom. Complete the diagram for an oxygen atom by adding

- labels to identify the other occupied sub-shells
- arrows to show how the remaining six electrons are arranged in the orbitals.

(2)



(d) Successive ionization energies provide evidence for the arrangement of electrons in atoms. The eight successive ionization energies of oxygen are shown in the table below.

Ionization number	1st	2nd	3rd	4th	5th	6th	7th	8th
Ionization energy / kJ mol^{-1}	1314	3388	5301	7469	10989	13327	71337	84080

(i) Define the term **first ionization energy**.

(3)

(ii) Write an equation, with state symbols, to show the **third** ionization energy of oxygen.

(2)

*(iii) Explain how the data in the table provide evidence that there are two occupied electron shells in an oxygen atom.

(2)

(Total for Question 24 = 14 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 7 6 A 0 2 4 2 4

PMT

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Mark Scheme (Results)

Summer 2014

IAL Chemistry (WCH01/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to

complex subject matter

- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Correct Answer	Mark
1	C	**1**

Question Number	Correct Answer	Mark
2	D	**1**

Question Number	Correct Answer	Mark
3	B	**1**

Question Number	Correct Answer	Mark
4	C	**1**

Question Number	Correct Answer	Mark
5	D	**1**

Question Number	Correct Answer	Mark
6	C	**1**

Question Number	Correct Answer	Mark
7	B	**1**

Question Number	Correct Answer	Mark
8	C	**1**

Question Number	Correct Answer	Mark
9	D	**1**

Question Number	Correct Answer	Mark
10	C	**1**

Question Number	Correct Answer	Mark
11	B	**1**

Question Number	Correct Answer	Mark
12	A	**1**

Question Number	Correct Answer	Mark
13	A	**1**

Question Number	Correct Answer	Mark
14	C	**1**

Question Number	Correct Answer	Mark
15	B	**1**

Question Number	Correct Answer	Mark
16	A	**1**

Question Number	Correct Answer	Mark
17	B	**1**

Question Number	Correct Answer	Mark
18	D	**1**

Question Number	Correct Answer	Mark
19	A	**1**

Question Number	Correct Answer	Mark
20	D	**1**

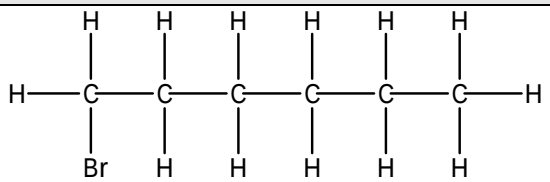
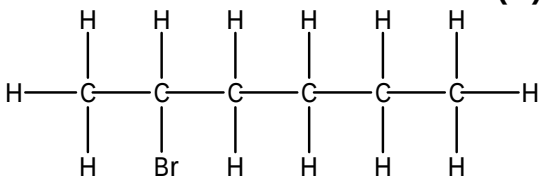
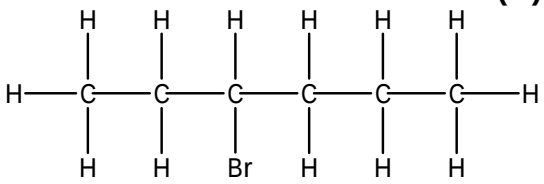
SECTION A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	Penalise use of chlorine once only in Q21(a)(i), (ii) and (iii) IGNORE lone pairs of electrons, even if incorrect in Q21(a)(i), (ii) and (iii) ALLOW one slip in the formula of the element if it is correctly given elsewhere in the answer e.g B for Br $Br_2 \rightarrow Br\bullet + Br\bullet$ / $Br_2 \rightarrow 2Br\bullet$ Ignore position of dot Ignore state symbols and curly arrows even if incorrect	Br	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	$Br_2 \rightarrow Br^+ + Br^-$ Ignore state symbols and curly arrows even if incorrect	$\boldsymbol{\delta^+}$ / $\boldsymbol{\delta^-}$ for the + or –	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iii)	(free radical) Br$\cdot$ NOTE: No TE, except Cl$\cdot$ **(1)** Penalise omission of the dot only once in (a)(i) and (a)(iii) (electrophile) $\boldsymbol{Br^+}$ NOTE: No TE, except Cl^+ **(1)**	Br	**2**

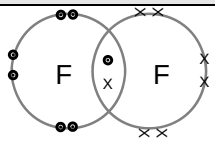
Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	 **(1)**  **(1)**  **(1)** Isomers can be in any order ALLOW skeletal or structural formulae	Any branched-chain isomers	**3**

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)	Corrosive / toxic / poisonous Allow correct symbols for corrosive or toxic / poisonous   IGNORE harmful / dangerous / irritant / acidic / volatile / any references to state of HBr IGNORE Any precautions taken, EXCEPT those related to flammability	Flammable / 'naked flames'	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (b)(iii)	**First mark** Calculation of the $C_6H_{13}Br$ M_r value and the total of the product Mr EXPECTED 164.9 **AND** 245.8 ALLOW 165 **AND** 246 **(1)** **Second mark** EXPECTED $\frac{164.9}{245.8}$ (x 100%) = 67.08706265(%) **= 67.1(%) to 3 s.f.** ALLOW $\frac{165}{246}$ (x 100%) = 67.07317073 (%) = **67.1(%) to 3 s.f.** ALLOW TE from any incorrect M_r value(s) provided answer is not greater than 100% **(1)** Answer **MUST** be rounded correctly to 3 s.f. for the second mark Correct answer with no working **(2)**		**2**

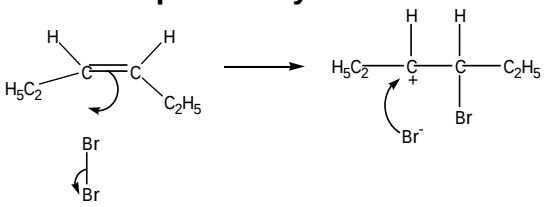
Question Number	Acceptable Answers	Reject	Mark
21 (c)(i)	$CH_4 + F_2 \rightarrow CH_3F + HF$ IGNORE state symbols, even if incorrect	Cl_2 "Fl" if used more than once	**1**

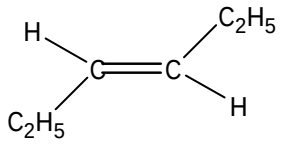
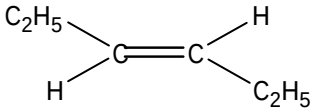
Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	NOTE Allow reverse argument throughout **1st Mark** Fluorine / F (atom is) **smaller** (than a Cl atom) **(1)** **2nd Mark** Any ONE of:- (so expect) F—F **bond** to be shorter (than the Cl—Cl bond) OR F—F **bonding** electrons / **bond** pair / / **shared** pair closer to (both) nuclei OR (so) attraction between nuclei and **bonding** electrons / **bond** pair / **shared** pair expected to be stronger **(1)** IGNORE Any references to the strengths of the F-F and/or Cl-Cl bonds Any references to the 'repulsion between nuclei' Any references to 'shielding' / 'Charge density' / 'Electronegativity' / outer electrons	F_2 / 'fluorine **molecule**' Mention of 'Intermolecular forces' (no **2nd** mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
21 (c)(iii)	 Shared pair of electrons shown **(1)** The remaining six electrons on each F atom **(1)** NOTE Can be dots or crosses – only total number of electrons matters Circles not required IGNORE Two inner-shell electrons ALLOW 'Fl' or F symbol missing		**2**

Question Number	Acceptable Answers	Reject	Mark
21 (c)(iv)	**'Repulsion** between electrons' scores (1) BUT **'Repulsion** between lone pairs (of electrons)' scores (2) ALLOW 'Non-bonding electrons' for lone pairs	Just repulsion between bonding / shared electrons	**2**

Question Number	Acceptable Answers	Reject	Mark
21 (c)(v)	UV (light) / (sun) light / heat / energy required to break Cl—Cl bond OR UV (light) / (sun) light / heat / energy required to form Cl· OR F—F requires less energy to break OR F—F requires less energy to form F· IGNORE **Just** F_2 more reactive (than Cl_2) **Just** F—F bond is weaker (than Cl—Cl) **Just** F—F bond energy is lower (than Cl—Cl)		**1**

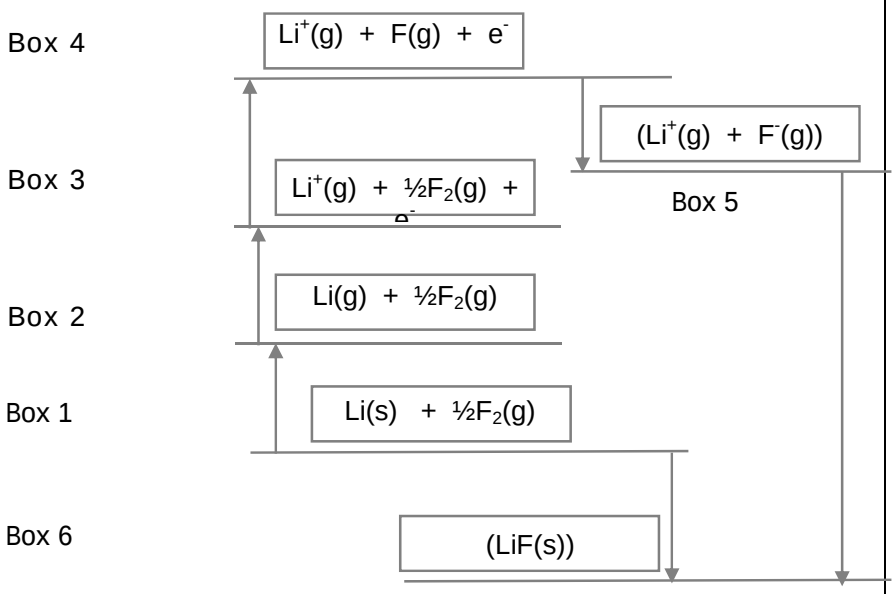
Question Number	Acceptable Answers	Reject	Mark
21 (d)	**Mark independently**  **First mark:** For **both arrows** in initial step Allow upper arrow as in diagram or directly to Br atom **(1)** **Second mark:** Carbocation intermediate **(1)** **Third mark:** Arrow from anywhere on the bromide ion to the C or to the + sign on the intermediate **(1)** Lone pair(s) on Br^- not required	**Half-arrow(s)** **Incorrect polarities** **Full**-charges on Br_2 **Half-arrow(s)** **δ**$^-$ instead of the full **–** sign on the Br^-	**3**

Question Number	Acceptable Answers	Reject	Mark
21(e)(i)	 OR  Diagram **clearly shows** that H atoms are diagonal to each other in the *E*-isomer/correct relative positions of hydrogen atoms and ethyl groups ALLOW Skeletal or displayed formula		**1**

Question Number	Acceptable Answers	Reject	Mark
21(e)(ii)	EITHER **Rotation** around C—C bond (in product molecule) OR Double bond is broken so **rotation** (is now possible) ALLOW Same carbocation / intermediate formed (so product is the same) IGNORE Comments about optical isomerism		**1**

(Total for Question 21 = 23 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)	(The energy / enthalpy change / released that accompanies the formation of) **one mole** of a(n ionic) compound **(1)** ALLOW as alternative for compound: lattice /crystal / substance / solid / product / salt from (its) **gaseous ions** **(1)** IGNORE References to 'standard conditions' or any incorrect standard conditions **ALTERNATIVE RESPONSE** If no mark(s) already awarded from above, can answer by giving:- energy change **per mole** / enthalpy change **per mole** **(1)** Li^+(**g**) + F^-(**g**) → LiF(s) **(1)** **NOTE** If lattice energy of dissociation is given (e.g. "energy required to break down 1 mol of an ionic lattice into its gaseous ions") max (1) for the 2nd scoring point 'gaseous ions'	'energy required' / 'energy needed' / 'energy it takes' 'from **one mole of gaseous ions**' (no 2nd mark) Just 'from gaseous **elements**' (no 2nd mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	 IGNORE missing electrons / e^- **First mark (Box 1):** **$Li(s) + ½F_2(g)$** **(1)** **Second mark (Box 4):** **$Li^+(g) + F(g)$** $(+e^-)$ **(1)** **Third and Fourth marks (if box 1 is correct):** 'Box 2' as above i.e. $Li(g) + ½F_2(g)$ as above **(1)** 'Box 3' as above i.e. $Li^+(g) + ½F_2(g)$ $(+ e^-)$ as above **(1)** OR 'Box 2' Li(s) + F (g) **(1)** 'Box 3' Li(g) + F(g) **(1)** OR 'Box 2' $Li(g) + ½F_2(g)$ **(1)** 'Box 3' Li(g) + F(g) **(1)**		**4**

	Penalise use of 'Fl' instead of 'F' once only If Box 1 is INCORRECT max (2) for correct transitions e.g if use F(g) or F_2(g) instead of ½F_2(g), then 2 marks available for two correct transitions involving lithium.		

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	**FIRST, CHECK THE FINAL ANSWER** **IF answer = −1046 (kJ mol^{-1}) then** **award (2) marks, with or without working** Otherwise look for −616 = (+159) + (+520) + (+79) + (−328) + ΔH_{LE} **OR** ΔH_{LE} = −616 − [(+159) + (+520) + (+79) + (−328)] **(1)** = −616 − 430 = −**1046** (kJ mol^{-1}) **(1)** NOTE **ALLOW** for **1 mark**: (+)1046 (wrong sign) −186 (+430 instead of −430) (+)186 (+616 instead of −616) −1006.5 (+79 halved to +39.5) −1702 (wrong sign for 328)		**2**

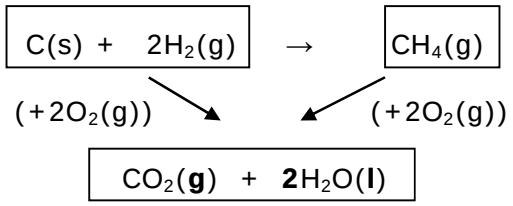
Question Number	Acceptable Answers	Reject	Mark
***22(c)(i)**	ALLOW reverse argument where appropriate (NaF more negative than NaCl because) **First mark** F^- smaller (than Cl^-) ALLOW 'fluorine **ion** is smaller (than a chlorine **ion**') OR F^- larger **charge density** (than Cl^-) **(1)** **Second mark:** F^- (forms) stronger (electrostatic) **attractions** (than Cl^-) IGNORE just 'stronger (ionic) bonds' **(1)** **Penalise ONCE ONLY in (c)(i) and (c)(ii)** the use of the word 'atom(s)' or 'molecule(s)'/ use of **just formulae** such as 'Mg', 'Na', 'F', 'F_2', 'Cl', 'Cl_2', etc. OR **Penalise ONCE ONLY in (c)(i) and (c)(ii)** the use of **words** such as **just '**magnesium' (instead of magnesium ions/Mg^{2+}) and/or **just '**fluorine' (instead of fluoride ions/F^-) /and or **just** 'chlorine' (instead of chloride ions/Cl^-) IGNORE Any comments about polarization of the anion (by the cation) / covalent character	"**NaF** is smaller than **NaCl**" F^- has a smaller **atomic** radius than Cl^-	**2**

Question Number	Acceptable Answers	Reject	Mark
***22(c)(ii)**	ALLOW reverse argument where appropriate (NaF less negative than MgF_2 because) **First mark - size:** Mg^{2+} smaller (than Na^+) OR 'Magnesium ion' is smaller (than Na^+) **(1)** **Second mark - charge:** Mg^{2+} has a greater charge (density) (than Na^+) OR 'Magnesium ion' has a greater charge (density) (than Na^+) **(1)** **[NOTE:** It follows that the statement that "Mg^{2+} ions are smaller than Na^+ ions" would score BOTH marks**]** IGNORE Any comments about polarization of the anion (by the cation) / covalent character	"**MgF_2** is smaller than **NaF**" Mg^{2+} has a smaller **atomic** radius than Na^+	**2**

(Total for Question 22 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)	(Enthalpy/energy change when) **one mole** of a compound / **one mole** of a substance IGNORE Statements such as "energy released" or "energy required" here **(1)** is formed from its elements (in their standard states, under standard conditions) **(1)** (Standard temperature is) 298 K / $25^{o}C$ ALLOW '^{o}K' IGNORE References to room temperature (Standard pressure is) 1 atm / 101 kPa / 100 kPa **(1)**	'is formed from its **gaseous** elements'	**3**

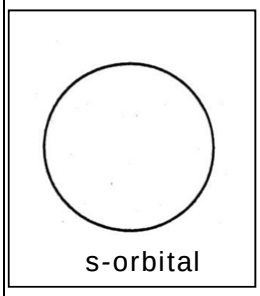
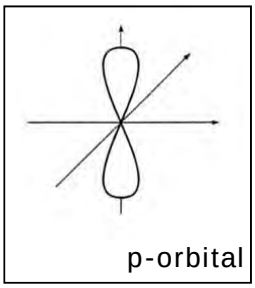
Question Number	Acceptable Answers	Reject	Mark
23(b)	$6C(s, graphite) + 7H_2(g) \rightarrow C_6H_{14}(l)$ **ALLOW** 6C(s) / 6C(graphite) Species **and** balancing correct **(1)** State symbols correct **(1)** State symbols mark is dependent on correct species but allow this mark if 14H used instead of $7H_2$ **NOTE** $C_6H_{14}(l) \rightarrow 6C(s, graphite) + 7H_2(g)$ scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
23(c)	 **First mark:** Both arrows point downwards **(1)** **Second mark:** CO_2(**g**) + **2**H_2O(**l**) **(1)** **Third mark:** ((1 x −394) + (2 x −286) − (1 x −890) =) **−76** (kJ mol^{-1}) No TE from cycle arrows **(1)**	**2**H_2O(**g**) If incorrect units with a final answer, no 3rd mark	**3**

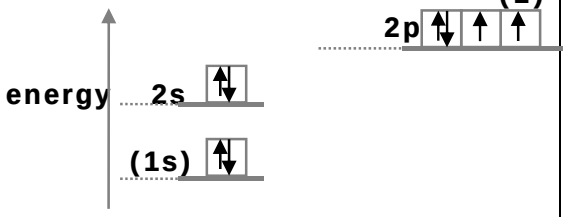
Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	(+1652÷4 =) (+)**413** (kJ mol^{-1})	**−**413	**1**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	**First mark:** (+2825 − 6 x answer to (d)(i)) ALLOW TE only from a **positive** value given as answer to (d)(i) **(1)** **Second mark:** = (+)347 (kJ mol^{-1}) **(1)** Second mark is CQ on first mark Correct answer with or without working scores **(2)** **NOTE** **−**347 (kJ mol^{-1}) **scores (1)**		**2**

(Total for Question 23 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
24(a)	 s-orbital  p-orbital **(s-orbital)** Circle drawn ALLOW Concentric circles drawn **(1)** **(p-orbital)** Figure of '8' / 'dumb-bell' drawn NOTE: p-orbital can be drawn along any axis (axis does not have to be shown) **(1)** ALLOW If one, two or three p-orbitals of correct shapes are shown If **overlapping** orbitals are shown of correct shape in both cases, award **(1)** mark		**2**

Question Number	Acceptable Answers	Reject	Mark
24(b)	**(region)** **(no. of electrons)** (a d-orbital) **2** **(1)** (a p sub-shell) **6** **(1)** (the third shell) **18** **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
24(c)	**First mark: BOTH** 2s and 2p labelled ALLOW $2s^2$ and $2p^4$ **(1)** **Second mark: ALL** eight e^- shown correctly **(1)**  ALLOW Half-arrows or full arrows for each electron Paired arrows in any one of the 2p orbitals NOTE Single arrows must be orientated in same direction Paired arrows must have opposite spins	$2p^6$	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	**First mark:** Makes mention of energy/enthalpy/(heat) energy/heat (change/required) AND to remove an electron **(1)** **Second mark:** one mole/1 mol **(1)** **Third mark:** Makes mention of **gaseous atom(s)** **(1)** **ALTERNATIVE ANSWER** Energy change per mole / kJ mol^{-1} for **(1)** $X(g) \rightarrow X^{+}(g) + e^{(-)}$ **(2)** One mark for species One mark for correct state symbols Mark independently IGNORE any references to standard conditions	“Energy **given out**…” for first mark **Just** ‘gaseous element’/ ‘gaseous substance’	**3**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	$O^{2+}(g) - e^{-} \rightarrow O^{3+}(g)$ OR $O^{2+}(g) \rightarrow O^{3+}(g) + e^{-}$ All species and balancing correct **(1)** State symbols correct **(1)** 2nd mark is dependent on 1st mark ALLOW 'e' for 'e^{-}' IGNORE (g) on the e^{-}	Reverse equation scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	**First mark:** **Big** 'jump' / **large** increase **(1)** **Second mark:** between **6th** and **7th** (IE) OR after the **6th** OR to the **7th** OR from 13327 to 71337 OR of 58010 **IGNORE** Additional jump identified between **4th** and **5th** (IE) if justified in terms of a change of **sub-shell** OR Additional jump identified between **4th** and **5th** (IE) if justified in terms of NOT being a change of shell **(1)**	Any other ionization jumps mentioned	**2**

(Total for Question 24 = 14 marks)
SECTION B = 60 marks
TOTAL FOR PAPER = 80 marks

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Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 23 May 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01R

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P42990A

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6/6/6/6/

P 4 2 9 9 0 A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following diagrams represents the electrons in the ground state of a boron atom?

	1s	2s	$2p_x$	$2p_y$	$2p_z$
☒ **A**	↑↓	↑↓	↑		
☒ **B**	↑	↑↓	↑	↑	
☒ **C**	↑↓	↑	↑	↑	
☒ **D**	↑	↑	↑	↑	↑

(Total for Question 1 = 1 mark)

2 Which of the following species contains the same number of electrons as neutrons?

☒ **A** $^{11}_{5}B$

☒ **B** $^{23}_{11}Na^{+}$

☒ **C** $^{24}_{12}Mg^{2+}$

☒ **D** $^{19}_{9}F^{-}$

(Total for Question 2 = 1 mark)

3 The recommended limit for safe exposure to sulfur dioxide in the air is 0.000025 %. What is this concentration in parts per million, ppm?

☒ **A** 25

☒ **B** 0.25

☒ **C** 0.025

☒ **D** 0.0025

(Total for Question 3 = 1 mark)

4 For which of the following pairs of elements does the second have a **higher** 1st ionization energy than the first?

	First element	Second element
☒ **A**	Mg	Al
☒ **B**	N	O
☒ **C**	Ne	Na
☒ **D**	K	Na

(Total for Question 4 = 1 mark)

5 In which of the following series of elements is there an **increase** in the melting temperatures from left to right?

☒ **A** Na Mg Al

☒ **B** Li Na K

☒ **C** B C N

☒ **D** Si P S

(Total for Question 5 = 1 mark)

6 What is the number of **atoms** in 2.8 g of ethene, C_2H_4?

DATA

- The molar mass of C_2H_4 is 28 g mol^{-1}
- The Avogadro constant is 6.0×10^{23} mol^{-1}

☒ **A** 1.0×10^{22}

☒ **B** 6.0×10^{22}

☒ **C** 1.2×10^{23}

☒ **D** 3.6×10^{23}

(Total for Question 6 = 1 mark)

7 A compound has the following percentage composition by mass.

C 61.0% H 15.3% N 23.7%

The empirical formula of the compound is

☒ **A** CH_3N

☒ **B** C_3H_9N

☒ **C** $C_6H_9N_2$

☒ **D** $C_8H_2N_3$

(Total for Question 7 = 1 mark)

8 Carbon monoxide and oxygen react together as follows.

$$2CO(g) + O_2(g) \rightarrow 2CO_2(g)$$

If all volumes of gas are measured at the same temperature and pressure, the volume of carbon dioxide produced after 50 cm^3 of carbon monoxide react with 25 cm^3 of oxygen is

☒ **A** 100 cm^3

☒ **B** 75 cm^3

☒ **C** 50 cm^3

☒ **D** 25 cm^3

(Total for Question 8 = 1 mark)

9 Potassium chlorate(V), $KClO_3$, decomposes on heating as follows.

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

What is the maximum volume of oxygen, measured in dm^3 at room temperature and pressure, which could be obtained by heating 0.50 mol potassium chlorate(V)?

[Molar volume of a gas = 24 $dm^3\,mol^{-1}$ at room temperature and pressure.]

☒ **A** 8

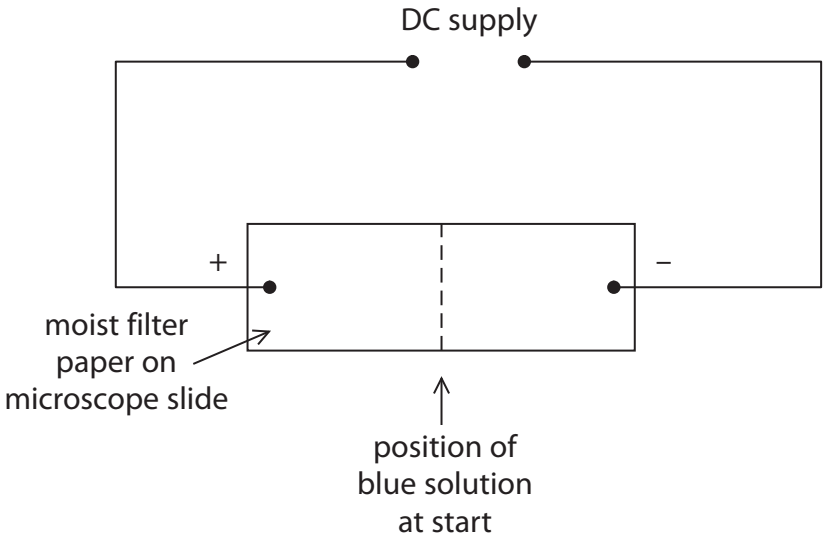
☒ **B** 18

☒ **C** 36

☒ **D** 72

(Total for Question 9 = 1 mark)

10 A spot of blue solution was placed in the centre of a piece of moist filter paper supported on a microscope slide and the following experiment was carried out.



After some time, a blue colour moved towards the negative terminal, but no change was visible in the region of the positive terminal. This is because

☒ **A** the negative ions in the solution were colourless and the positive ions were blue.

☒ **B** the positive ions in the solution were colourless and the negative ions were blue.

☒ **C** the negative ions in the solution had not moved but the positive ions had moved.

☒ **D** the positive ions in the solution had not moved but the negative ions had moved.

(Total for Question 10 = 1 mark)

11 The reaction for which the enthalpy change is the standard enthalpy change of formation of water, $\Delta H^{\ominus}_{f,298}$, is

☒ **A** $H_2(g) + ½O_2(g) \rightarrow H_2O(l)$

☒ **B** $H_2(g) + ½O_2(g) \rightarrow H_2O(g)$

☒ **C** $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$

☒ **D** $2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$

(Total for Question 11 = 1 mark)

12 Which of the following molecules does **not** contain a double bond?

- ☒ **A** CO_2
- ☒ **B** C_2Cl_4
- ☒ **C** C_3F_8
- ☒ **D** $C_2H_2Cl_2$

(Total for Question 12 = 1 mark)

13 The bonding in lithium iodide has some covalent character because

- ☒ **A** the lithium ion polarizes the iodide ion.
- ☒ **B** the iodide ion polarizes the lithium ion.
- ☒ **C** there is a very large difference in electronegativity between lithium and iodine.
- ☒ **D** there is a very small difference in electronegativity between lithium and iodine.

(Total for Question 13 = 1 mark)

14 Which of the following data is **not** needed to calculate the lattice energy of sodium chloride when using a Born-Haber cycle?

- ☒ **A** Enthalpy change of formation of sodium chloride.
- ☒ **B** Enthalpy change of atomization of sodium.
- ☒ **C** First ionization energy of chlorine.
- ☒ **D** Electron affinity of chlorine.

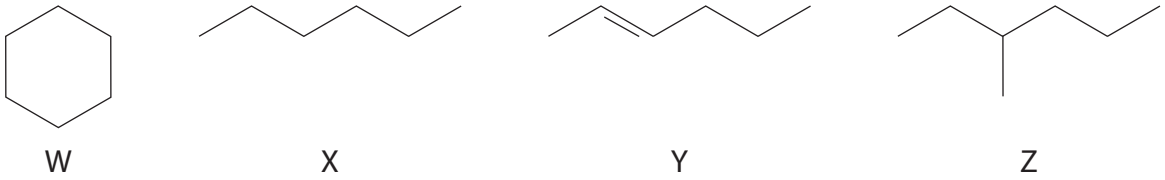
(Total for Question 14 = 1 mark)

15 The lattice energy of magnesium oxide is more negative than the lattice energy of magnesium fluoride because

- ☒ **A** oxide ions are larger than fluoride ions.
- ☒ **B** oxide ions are larger than magnesium ions.
- ☒ **C** oxide ions are more highly charged than fluoride ions.
- ☒ **D** there is only one oxide ion but two fluoride ions per magnesium ion.

(Total for Question 15 = 1 mark)

16 This question is about the organic compounds shown below.



W X Y Z

(a) The compounds which are isomers are

(1)

☒ **A** W and X

☒ **B** W and Y

☒ **C** W and Z

☒ **D** X and Z

(b) Which compound can react with chlorine to form $C_6H_{12}Cl_2$ as the **only** product?

(1)

☒ **A** Compound W

☒ **B** Compound X

☒ **C** Compound Y

☒ **D** Compound Z

(c) Which compound is reformed in the oil industry, producing one mole of a compound with formula C_6H_6 and four moles of hydrogen, H_2, only?

(1)

☒ **A** Compound W

☒ **B** Compound X

☒ **C** Compound Y

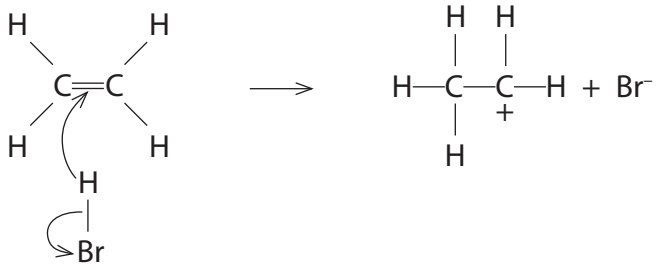
☒ **D** Compound Z

(Total for Question 16 = 3 marks)

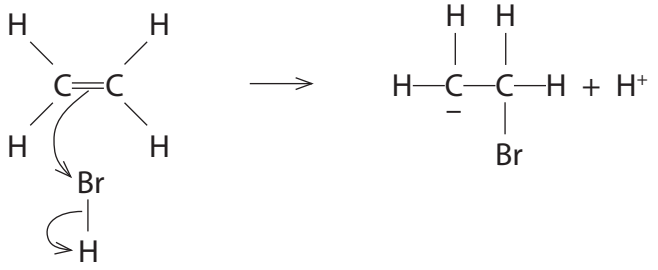
Use this space for any rough working. Anything you write in this space will gain no credit.

17 Which of the following equations shows the first step in the mechanism for the reaction between hydrogen bromide and ethene?

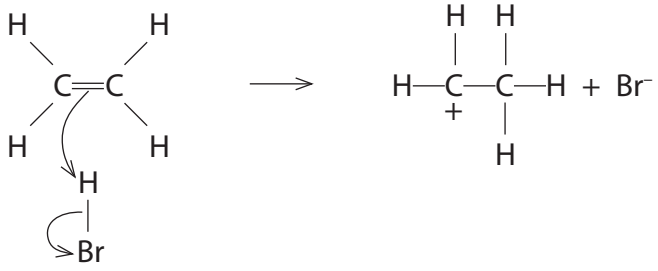
☒ **A**



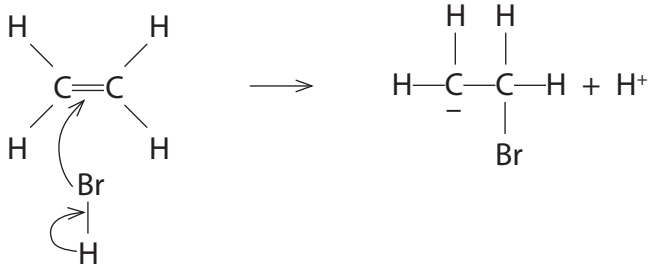
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

18 Scientists are developing sources of energy as alternatives to fuels produced from crude oil. Which of the following reasons for doing this is **incorrect**?

☒ **A** Crude oil is being used up faster than it is being formed.

☒ **B** Burning hydrocarbons affects global carbon dioxide levels.

☒ **C** Hydrocarbons from crude oil are a source of essential chemicals other than fuels.

☒ **D** Carbon dioxide produced by burning hydrocarbons is toxic to plants.

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

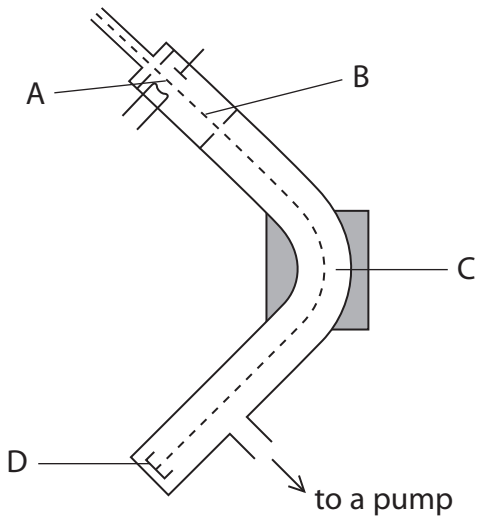
SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

19 Naturally occurring samples of potassium contain three isotopes, ^{39}K, ^{40}K and ^{41}K.

(a) The isotopes can be separated in a mass spectrometer.

(i) In the diagram below, particles are ionized at A and detected at D.



Name the **processes** occurring in the mass spectrometer at B and C.

(2)

B .....

C .....

(ii) A sample of potassium has the following composition.

Isotope	^{39}K	^{40}K	^{41}K
% abundance	93.22	0.12	6.66

Calculate the relative atomic mass of this sample of potassium, giving your answer to **two** decimal places.

(2)

(iii) Complete the table below to show the numbers of sub-atomic particles in an atom of each of the isotopes ^{39}K and ^{41}K.

(1)

Isotope	Electrons	Protons	Neutrons
^{39}K			
^{41}K			

(iv) Complete the electronic configuration for an atom of ^{39}K.

(1)

$1s^2$ .....

(v) Why is potassium placed after argon in the Periodic Table, even though it has a smaller relative atomic mass?

(1)

.....

.....

.....

.....

*(vi) Explain why a potassium ion is smaller than a potassium atom.

(2)

.....

.....

.....

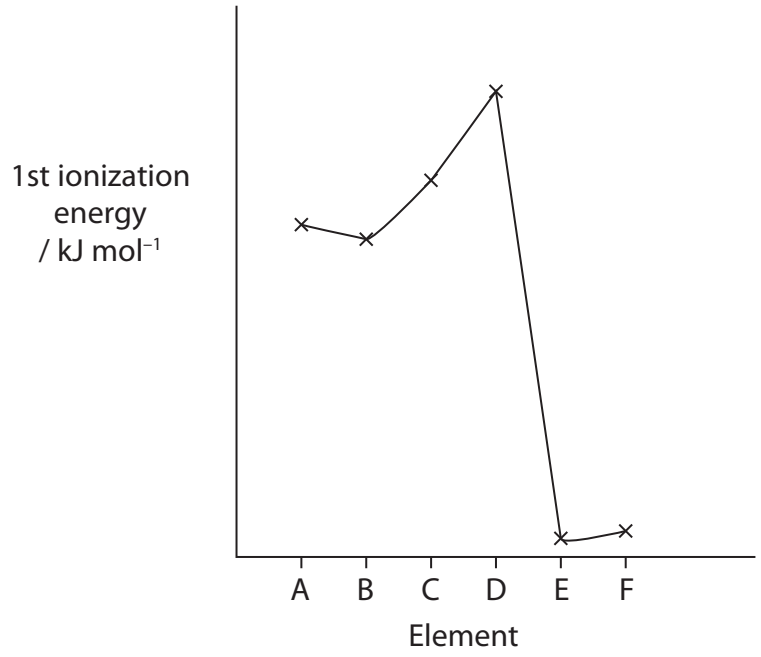
.....

(b) The type of bonding in potassium is metallic.

Draw a labelled diagram to illustrate the metallic bonding in potassium.

(2)

(c) The graph shows the variation of first ionization energy with atomic number for six successive elements in the Periodic Table, including potassium. The letters used to label the elements are not their symbols.



(i) Define the term **first ionization energy**.

(3)

(ii) Identify, with a reason, which element is potassium.

(2)

(Total for Question 19 = 16 marks)

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20 In an experiment to make crystals of hydrated copper(II) nitrate, a sample of 5.60 g of copper(II) oxide was added to 50 cm^3 of 2.50 mol dm^{-3} nitric acid. The following reaction occurred.

$$CuO(s) + 2HNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + H_2O(l)$$

(a) Calculate the number of moles of each reactant present, and use this to show that the copper(II) oxide was in excess.

The molar mass of copper(II) oxide, CuO, is 79.5 g mol^{-1}.

(3)

Moles of copper(II) oxide added

Moles of nitric acid used

The copper(II) oxide is in excess because .....

.....

.....

.....

(b) The copper(II) nitrate solution was heated gently to concentrate it, and then left to crystallize. The mass of hydrated copper(II) nitrate crystals, $Cu(NO_3)_2.6H_2O$, obtained was 12.52 g.

Calculate the percentage yield.

The molar mass of $Cu(NO_3)_2.6H_2O$ is 295.6 g mol^{-1}.

(3)

(c) Give **one** reason why the percentage yield is less than 100%, even though the nitric acid was completely reacted.

(1)

.....

.....

*(d) (i) The nitrate ion, NO_3^-, contains both covalent and dative covalent bonds.

What is the difference between these types of bond?

(2)

.....

.....

.....

.....

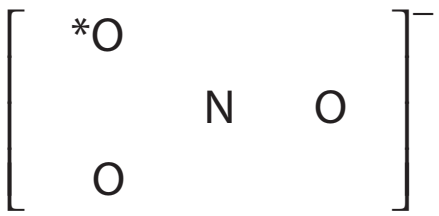
.....

.....

(ii) Complete the dot and cross diagram to show the bonding in the nitrate ion. Only the outer electron shells for each atom need to be shown.

Represent the nitrogen electrons with crosses (×), and oxygen electrons with dots, (•). The symbol * on the diagram represents the extra electron giving the ion its charge.

(3)



(Total for Question 20 = 12 marks)

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21 Propane is a saturated hydrocarbon with molecular formula C_3H_8.

*(a) Explain the meaning of the terms **saturated** and **hydrocarbon**.

(2)

Saturated .....

.....

Hydrocarbon .....

.....

(b) Propane is sold in small cylinders for use as a fuel in camping stoves. The enthalpy change of combustion of propane can be measured by experiment using one of these cylinders.

A known mass of propane is burned to heat a container of water, and the temperature rise of the water is measured.

The results of the experiment are shown below.

Mass of propane burned	0.33 g
Temperature of water at start	18.0 °C
Final temperature of water	45.1 °C
Mass of water in container	100 g

(i) How would the mass of propane which was burned be measured?

(1)

.....

.....

(ii) Calculate the energy transferred in the experiment, using the results above and the following expression.

Energy transferred (J) = mass × specific heat capacity × temperature change

The specific heat capacity of water is 4.18 J g^{-1} $°C^{-1}$.

(1)

(iii) Calculate the enthalpy change of combustion of propane, ΔH_c, in kJ mol^{-1}.

Give your answer to **three** significant figures and include a sign.

(3)

(iv) The results of this experiment are inaccurate due to heat loss.

Suggest **one** other source of error, other than measurement errors and limitations of the equipment.

(1)

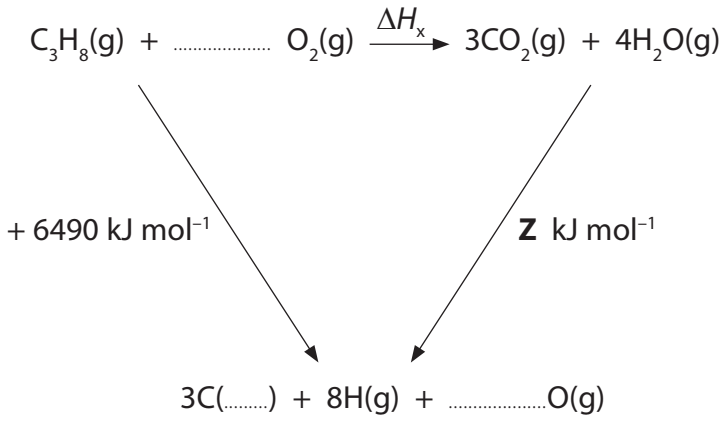
.....

.....

(c) Another way of calculating the enthalpy change of combustion for propane is to use mean bond enthalpy data.

(i) Complete the equations in the Hess cycle below. The enthalpy change of +6490 kJ mol^{-1} is the total energy required to break the bonds in propane and in oxygen.

(1)



(ii) Use the data in the table to calculate the enthalpy change, **Z**, in kJ mol^{-1}.

Bond	Mean bond enthalpy / kJ mol^{-1}
C═O	805
H—O	464

(1)

(iii) Use the cycle in (c)(i), and your answer to (c)(ii), to calculate the enthalpy change, ΔH_x, in kJ mol^{-1}, for the combustion of propane.

(1)

(iv) The data book value for the standard enthalpy change of combustion, $\Delta H_c^{\ominus}$, for propane is –2219.2 kJ mol^{-1}. This value is more exothermic than that calculated using mean bond enthalpy data. Give **one** reason for this.

(1)

.....

.....

(Total for Question 21 = 12 marks)

22 When trichloromethane, $CHCl_3$, reacts with chlorine, the organic product is tetrachloromethane, CCl_4. The reaction proceeds by free radical substitution.

The equation for this reaction is

$$CHCl_3 + Cl_2 \rightarrow CCl_4 + HCl$$

(a) State the essential condition for this reaction to occur at room temperature.

(1)

.....

(b) The reaction mechanism involves free radicals. Explain what is meant by the term **free radical**.

(1)

.....

.....

(c) The reaction takes place in a series of steps.

(i) The initiation step is

$$Cl_2 \rightarrow 2Cl\bullet$$

Suggest why this initiation step is more likely than

$$CHCl_3 \rightarrow CCl_3\bullet + H\bullet$$

(1)

.....

.....

(ii) Write equations for the two propagation steps.

(2)

First propagation step

Second propagation step

(iii) Write an equation for the termination step in which tetrachloromethane is formed.

(1)

(d) Tetrachloromethane can be manufactured using the by-products of chlorination reactions.

$$C_2Cl_6 + Cl_2 \rightarrow 2CCl_4$$

Compare the atom economy of this process with that of the reaction which produces tetrachloromethane from trichloromethane and chlorine. A calculation is not required.

(1)

.....

.....

(Total for Question 22 = 7 marks)

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23 This question is about isomers of C_4H_8.

(a) (i) Alkenes contain a carbon-carbon double bond, which consists of a σ bond and a π bond.

Show, and clearly label, the σ and π bonds on the diagram below.

(2)

C C

*(ii) Explain why the σ bond is stronger than the π bond.

(2)

(b) (i) Draw the structural formula of *E*-but-2-ene.

(1)

(ii) Explain why but-1-ene does not exhibit *E-Z* isomerism.

(1)

(iii) Describe the result of the test for the presence of a C═C bond in *E*-but-2-ene using bromine water. Give the displayed formula of the organic product.

(2)

Test result .....

.....

Displayed formula of organic product:

(c) Another test for C═C bonds is the reaction with acidified potassium manganate(VII).

Describe the result of this test using **but-1-ene** and give the displayed formula of the organic product.

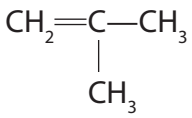
(2)

Test result .....

.....

Displayed formula of organic product:

(d) Another isomer of C_4H_8 has the structure shown below.



(i) Name this isomer.

(1)

.....

(ii) This isomer forms an addition polymer. Show the structure of this polymer by drawing **two** repeat units.

(1)

(e) 'Polybutene' is the name used by cosmetic companies for a mixture of poly(but-1-ene) and poly(but-2-ene).

An American "eco-cosmetics" company says that though 'polybutene' is considered a safe ingredient in lip gloss, it is non-sustainable to use it.

Suggest **one** reason to justify this statement.

(1)

.....

.....

(Total for Question 23 = 13 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 9 0 A 0 2 8 2 8

PMT



Mark Scheme (Results)

June 2014

International GCE Chemistry (6CH01/01R)
Unit 1: The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

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Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	A		1

Question Number	Correct Answer	Reject	Mark
2	D		1

Question Number	Correct Answer	Reject	Mark
3	B		1

Question Number	Correct Answer	Reject	Mark
4	D		1

Question Number	Correct Answer	Reject	Mark
5	A		1

Question Number	Correct Answer	Reject	Mark
6	D		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	C		1

Question Number	Correct Answer	Reject	Mark
9	B		1

Question Number	Correct Answer	Reject	Mark
10	A		1

Question Number	Correct Answer	Reject	Mark
11	A		1

Question Number	Correct Answer	Reject	Mark
12	C		1

Question Number	Correct Answer	Reject	Mark
13	A		1

Question Number	Correct Answer	Reject	Mark
14	C		1

Question Number	Correct Answer	Reject	Mark
15	C		1

Question Number	Correct Answer	Reject	Mark
16(a)	B		1

Question Number	Correct Answer	Reject	Mark
16(b)	C		1

Question Number	Correct Answer	Reject	Mark
16(c)	B		1

Question Number	Correct Answer	Reject	Mark
17	C		1

Question Number	Correct Answer	Reject	Mark
18	D		1

Section B

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	B **acceleration** **(1)** C **deflection** **(1)** Allow B ions are accelerated/ accelerating C ions are (being) deflected	B just electric field C just magnetic field	2

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	(A_r for K) = (39 x 0.9322) + (40 x 0.0012) + (41 x 0.0666) or a correct fraction using percentages **(1)** = 39.1344 = 39.13 **(1)** Correct answer without working scores 2 Max 1 if not to 2 decimal places Second mark dependent on first IGNORE Units of any kind (e.g. 'g', 'g mol^{-1}', 'amu', etc.)		2

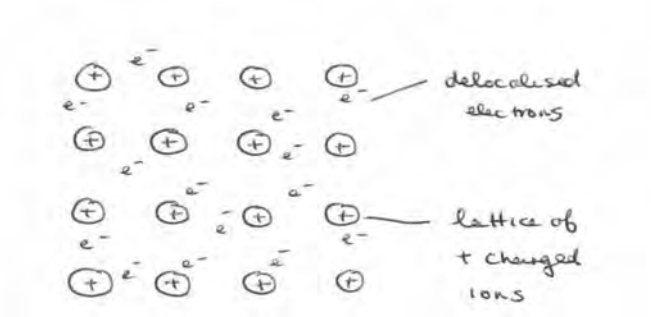
Question Number	Acceptable Answers	Reject	Mark
19(a)(iii)			1

Isotope	Electrons	Protons	Neutrons
^{39}K	19	19	20
^{41}K	19	19	22

Question Number	Acceptable Answers	Reject	Mark
19(a) (iv)	$(1s^2)\ 2s^2 2p^6\ 3s^2 3p^6\ 4s^1$ Fully correct Ignore additional $1s^2$		1

Question Number	Acceptable Answers	Reject	Mark
19(a)(v)	(Position in the Periodic Table) depends upon atomic number / proton number OR Ar (atom) has (one) fewer proton(s) (than K atom) OR K (atom) has (one) more proton(s) (than Ar atom) OR K has atomic number 19 (whereas) Ar has atomic number 18 OR Ar has 18 protons, K has 19 protons IGNORE 'Elements are not arranged in order of (relative) atomic mass' IGNORE Mention of numbers of electrons / numbers of shells (of electrons) IGNORE Arranged in vertical groups in accordance to properties / argon is a noble gas		1

Question Number	Acceptable Answers	Reject	Mark
19(a) (vi)	One fewer shell of electrons **(1)** Electrons in the ion are held more tightly OR Same number of protons attracting fewer electrons OR Less repulsion between (remaining) electrons **(1)** IGNORE References to effective nuclear charge / charge density		2

Question Number	Acceptable Answers	Reject	Mark
19(b)	Regular lattice of singly-positively charged (potassium) ions **(1)** Delocalised electrons / sea of electrons / mobile electrons **(1)** e.g.  Accept other regular arrangements Unlabelled diagram max (1)		2

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	**First mark:-** Makes mention of energy/enthalpy/(heat) energy/heat (change) AND to remove an electron **(1)** **Second mark:** one mole/1 mol **(1)** **Third mark:** Makes mention of **gaseous atom(s)** **(1)** **ALTERNATIVE ANSWER** Energy change per mole for **(1)** $X(g) \rightarrow X^{+}(g) + e^{(-)}$ **(2)** One mark for species One mark for correct state symbols Mark independently IGNORE any references to standard conditions	"Energy **given out**…" for first mark **Just** 'gaseous element'/ 'gaseous substance'	3

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Potassium is E **(1)** Alkali metals always have the lowest first ionization energy in their period OR It follows a noble gas/ an element with very high first ionization energy OR Ionization energy falls (significantly) at the start of a (new) period / Ionization energy falls (significantly) after **D** **(1)**		2

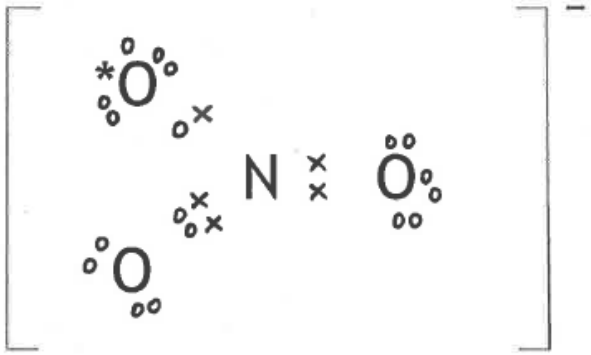
Total for Q19 = 16 marks

Question Number	Acceptable Answers	Reject	Mark
20(a)	**1st Mark** Mol CuO = (5.60/79.5) = 0.07044 / 0.0704 / 0.070 / 0.07 **(1)** **2nd Mark** Mol of nitric acid = (50 x 2.50/1000) = 0.125 **(1)** **3rd Mark** Reacting ratio =2:1 and nitric acid less than double moles of copper oxide/ Reacting ratio =2:1 and copper oxide more than half of moles of nitric acid OR moles acid needed to react with all CuO = (2 x 0.070 =) 0.140 which is more than 0.125 OR 0.125 mol nitric acid can only react with 0.0625 mol CuO **(1)**		3

Question Number	Acceptable Answers	Reject	Mark
20(b)	**1st Mark** Moles product = 0.5 x 0.125 =0.0625 **(1)** Allow TE from moles HNO_3 **2nd Mark** Theoretical yield = (0.0625 x 295.6 =) 18.475 g **(1)** Allow ECF on multiplying moles product by 295.6 **3rd Mark** % yield = (12.52/18.475 x 100) = 67.767 / 67.8 / 68 **(1)** **Alternative route for 2nd and 3rd Marks** mol product = (12.52 / 295.6) = 0.04235 **(1)** % yield = (0.04235/0.0625 x 100 = 67.767 / 67.8/ 68 **(1)** TE from (a) If moles of product taken as 0.125, final answer = 33.88% which scores **(2)** TE for calculation based on moles of copper(II) oxide which gives an answer between 60.128% and 60.506% **max(2)**	4.24% scores **(0)** overall	3

Question Number	Acceptable Answers	Reject	Mark
20(c)	Some product remains in solution/ some product does not crystallize Allow loss of material on transferring, if explained, such as Crystals remain in / on filter paper 'Spitting' (of solution on heating) IGNORE References to impure reactants	Incomplete reaction Just experimental error 'solution evaporates'	1

Question Number	Acceptable Answers	Reject	Mark
20(d)(i)	Covalent bond: (shared pair of electrons using) one electron from each atom **(1)** Dative covalent bond: (shared pair of electrons using) two electrons from same atom **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
20(d)(ii)	Double bond between N and one oxygen atom **(1)** Single bond **between N and O*** **(1)** Dative single bond between N and one O atom **(1)**  **Max 2 if any lone pair electrons are missing from any of the three oxygen atoms.**		3

Total for Q20 = 12 marks

Question Number	Acceptable Answers	Reject	Mark
21(a)	(Contains) **only** (C—C) single bonds/ **only** σ bond(s) OR (Contains) no (C=C) double bond(s)/no triple bond(s) OR Cannot undergo addition (reactions) ALLOW Has maximum number of hydrogen atoms / has maximum amount of hydrogen /can form no more bonds / no pi-bonds. IGNORE references to alkanes **(1)** (Compound of) carbon and hydrogen **ONLY / ENTIRELY / PURELY** **(1)**	"**Mixture** of carbon and hydrogen only"	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	Measure mass (of cylinder) before and after (burning)		1

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	Energy transferred = (100 x 4.18 x 27.1 =) 11327.8 (J) / 11.328 **kJ** Ignore SF except 1 SF		1

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	Mol propane = 0.33/ 44 = 0.0075 **(1)** ΔH_c = (– 11.3278/ 0.0075) = (– 1510.4) = –1510 (kJ mol^{-1}) **(1)** Sign and 3SF **(1)** Allow TE from b(ii)		3

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Incomplete combustion Allow carbon monoxide forms soot forms Ignore references to specific heat capacity of the apparatus or evaporation **of propane**	Evaporation of water Transfer losses Not under standard conditions Not all the fuel burns	1

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	$C_3H_8(g) + \mathbf{5}O_2(g) \rightarrow 3CO_2(g) + 4H_2O(g)$ + 6490 kJ mol^{-1} $3C\mathbf{(g)} + 8H(g) + \mathbf{10}\ O\ (g)$ Balancing **and** state symbol required		1

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	Z = (6x C=O + 8xO-H = 4830 + 3712) = (+)8542 (kJ mol^{-1})		1

Question Number	Acceptable Answers	Reject	Mark
21(c)(iii)	ΔH_X = 6490 - 8542 = -2052 (kJ mol^{-1}) Allow TE from 21(c)(ii)		1

Question Number	Acceptable Answers	Reject	Mark
21(c)(iv)	Bond energy calculation based on $H_2O(g)$ OR $\Delta H_c^{\ominus}$ based on $H_2O(l)$ Allow Bond energy varies with environment/ mean bond energies do not equal actual bond energies for these reactants Ignore reference to standard conditions		1

Total for Q21 = 12 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)	UV light/ ultraviolet light/ (sun) light / UV radiation IGNORE References to heat and or pressure.		1

Question Number	Acceptable Answers	Reject	Mark
22(b)	Species/ particle with **unpaired electron** Allow atom	Single electron	1

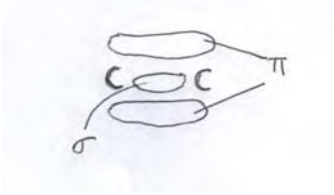
Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	Cl-Cl bond is weaker than a C-H bond / breaks more easily than a C-H bond OR Reverse argument		1

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	$CHCl_3 + \bullet Cl \rightarrow \bullet CCl_3 + HCl$ **(1)** $\bullet CCl_3 + Cl_2 \rightarrow CCl_4 + \bullet Cl$ **(1)** Max (1) if 2 equations based on methane.		2

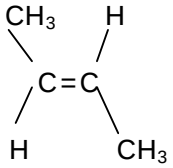
Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	$\bullet CCl_3 + \bullet Cl \rightarrow CCl_4$		1

Question Number	Acceptable Answers	Reject	Mark
22(d)	100% as only one product / 100% as no by product(s) / 100% as no waste product (formed)	**Just** "atom economy is **high(er)**" / no mention of 100%	1

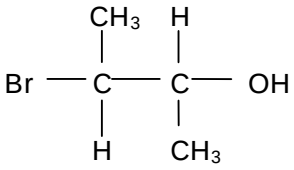
Total for Q22 = 7 marks

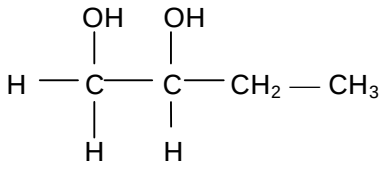
Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	σ bond between C atoms **(1)** π bond above and below σ bond **(1)**  Max (1) if diagram is unlabelled.		2

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	Good overlap of s orbitals in sigma bonds (1) p orbitals are parallel so poor overlap when π bonds form (1) OR Overlap of orbitals in sigma bond is along the line between the two nuclei (1) whereas, in the π bond, there is sideways overlap (1) Can be shown on a diagram		2

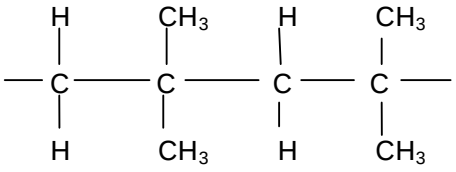
Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	 *E*-but-2-ene Allow angles of 90° between C=C and other bonds. Allow displayed or skeletal formula		1

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	One C on the double bond has two of the same atoms/ two hydrogen atoms attached to it OR C on one end of double bond is not attached to two different atoms or groups Ignore references to restricted rotation about the C=C double bond		1

Question Number	Acceptable Answers	Reject	Mark
23(b)(iii)	(Bromine water goes from brown/ red-brown / yellow/ orange to) colourless OR (Bromine water is) decolorised **(1)**  Accept any orientation Allow addition of two Br atoms Allow un-displayed CH_3 and OH groups Allow skeletal or structural formula **(1)**	To 'clear' Molecular formula	2

Question Number	Acceptable Answers	Reject	Mark
23(c)	(Colour change purple/ purple-pink / pink to) colourless OR ($KMnO_4$ is) decolorised **(1)**  Accept any orientation Allow un-displayed CH_2CH_3 and OH groups, skeletal or structural formula **(1)**	To clear Molecular formula	2

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	(2-) methylprop(-1)ene	2- methylprop-**2**-ene	1

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	 Allow methyl groups on C2 and C3 Allow complete polymer formula with square brackets and n		1

Question Number	Acceptable Answers	Reject	Mark
23(e)	Not sustainable as (polybutene) not made from a renewable resource / Not sustainable as made from non-renewable resource / not sustainable as made from crude oil / Not sustainable as crude oil is not renewable / Not sustainable as crude oil finite resource **IGNORE** References to non-biodegradability / long-lasting in use		1

Total for Q23 = 13 marks

TOTAL FOR PAPER = 80 MARKS

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Surname	Other names

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Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 23 May 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P42970A

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6/6/6/5/

P 4 2 9 7 0 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The correct sequence for the processes that occur in a mass spectrometer is

☒ **A** vaporization, ionization, acceleration, deflection and detection.

☒ **B** vaporization, acceleration, ionization, deflection and detection.

☒ **C** ionization, vaporization, acceleration, deflection and detection.

☒ **D** ionization, vaporization, deflection, acceleration and detection.

(Total for Question = 1 mark)

2 Which of the following ions would be deflected **most** in a mass spectrometer?

☒ **A** $^{35}Cl^{+}$

☒ **B** $^{37}Cl^{+}$

☒ **C** $^{37}Cl^{2+}$

☒ **D** $(^{35}Cl —^{37}Cl)^{+}$

(Total for Question 2 = 1 mark)

3 A particle with a **single** positive charge and with the electronic configuration $1s^2\ 2s^2\ 2p^6$ is

☒ **A** a sodium ion.

☒ **B** a fluoride ion.

☒ **C** an oxide ion.

☒ **D** a potassium ion.

(Total for Question 3 = 1 mark)

4 In which of the following electronic configurations are only two of the electrons unpaired?

☒ **A** $1s^2\ 2s^2$

☒ **B** $1s^2\ 2s^2\ 2p^3$

☒ **C** $1s^2\ 2s^2\ 2p^4$

☒ **D** $1s^2\ 2s^2\ 2p^5$

(Total for Question 4 = 1 mark)

5 Which of the following contains a dative covalent bond?

☒ **A** N_2

☒ **B** NH_3

☒ **C** NH_2^-

☒ **D** NH_4^+

(Total for Question 5 = 1 mark)

6 Which of the following ions has the **largest** ionic radius?

☒ **A** F^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** O^{2-}

(Total for Question 6 = 1 mark)

7 Which of the following observations provides the best evidence for the presence of ionic bonding in an unknown substance?

The substance conducts electricity

☒ **A** in the solid state.

☒ **B** in the solid state and in aqueous solution.

☒ **C** in the solid state and when molten.

☒ **D** when molten but not in the solid state.

(Total for Question 7 = 1 mark)

8 Which of the following can be determined, for an unknown alkene, using **only** percentage composition by mass data?

☒ **A** Molecular formula

☒ **B** Empirical (simplest) formula

☒ **C** Both the molecular formula and the empirical (simplest) formula

☒ **D** Structural formula

(Total for Question 8 = 1 mark)

9 1.12 g of iron reacts with oxygen to form 1.60 g of an oxide of iron.
Use relative atomic masses: Fe = 56, O = 16.

What is the formula of this oxide of iron?

☒ **A** FeO_5

☒ **B** Fe_2O_{10}

☒ **C** Fe_3O_2

☒ **D** Fe_2O_3

(Total for Question 9 = 1 mark)

10 In an experiment, 1.226 g of potassium chlorate(V), $KClO_3$, was heated. A mass of 0.320 g of oxygen gas, O_2, was collected.

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

Use the molar mass of $KClO_3$ = 122.6 g mol^{-1} and relative atomic mass O = 16.

The percentage yield of oxygen in this experiment is

☒ **A** 17.4%

☒ **B** 26.1%

☒ **C** 66.7%

☒ **D** 100%

(Total for Question 10 = 1 mark)

11 Oxygen gas, O_2, can be converted into ozone, O_3, by passing it through an electric discharge.

$$3O_2(g) \rightarrow 2O_3(g)$$

In an experiment, a volume of 300 cm^3 of oxygen was used but only 10% of the oxygen was converted into ozone. All volumes were measured at the same temperature and pressure.

The **total** volume of gas present at the end of the experiment, in cm^3, was

☒ **A** 200

☒ **B** 210

☒ **C** 290

☒ **D** 300

(Total for Question 11 = 1 mark)

12 1.40 g of an alkene gave 3.77 g of a dichloroalkane on reaction with chlorine.

What is the molecular formula of the alkene?

☒ **A** C_2H_4

☒ **B** C_3H_6

☒ **C** C_4H_8

☒ **D** C_6H_{12}

(Total for Question 12 = 1 mark)

13 The standard enthalpy change for the combustion of graphite is –393.5 kJ mol^{-1} and that of diamond is –395.4 kJ mol^{-1}.

What is the standard enthalpy change for the reaction below, in kJ mol^{-1}?

$$C(s, \text{graphite}) \rightarrow C(s, \text{diamond})$$

☒ **A** –1.9

☒ **B** +1.9

☒ **C** –788.9

☒ **D** +788.9

(Total for Question 13 = 1 mark)

14 The standard enthalpy change of neutralization when an acid reacts with an alkali is the number of kilojoules released by the

☒ **A** formation of one mole of salt.

☒ **B** formation of one mole of water.

☒ **C** neutralization of one mole of acid.

☒ **D** neutralization of one mole of alkali.

(Total for Question 14 = 1 mark)

15 Consider the following bond enthalpy values.

Bond	Bond enthalpy / kJ mol^{-1}
O—O	+146
O—H	+463
O═O	+496

For the reaction

$$H—O—O—H(g) \rightarrow H—O—H(g) + \tfrac{1}{2}O═O(g)$$

the enthalpy change, in kJ mol^{-1}, is

☒ **A** –102

☒ **B** +102

☒ **C** +350

☒ **D** +394

(Total for Question 15 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

16 Using the data in the table below, calculate the standard enthalpy change, in kJ mol^{-1}, for the reaction between carbon disulfide, CS_2, and oxygen shown in the following equation.

$$CS_2(g) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

Substance	Standard enthalpy change of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CS_2(g)$	+110
$CO_2(g)$	–390
$SO_2(g)$	–290

☒ **A** –570

☒ **B** –790

☒ **C** –860

☒ **D** –1080

(Total for Question 16 = 1 mark)

17 (a) Which of the following represents a step in the mechanism during the reaction between ethene and hydrogen bromide?

(1)

☒ **A** $C_2H_4 + Br^+ \rightarrow C_2H_4Br^+$

☒ **B** $C_2H_4 + HBr \rightarrow C_2H_5^+ + Br^-$

☒ **C** $C_2H_4 + HBr \rightarrow C_2H_5^{\bullet} + Br^{\bullet}$

☒ **D** $C_2H_4 + HBr \rightarrow C_2H_4Br^- + H^+$

(b) The mechanism of the reaction between ethene and hydrogen bromide is

(1)

☒ **A** electrophilic addition.

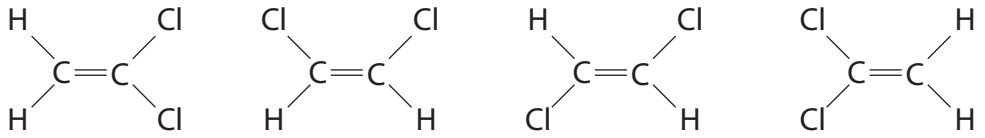
☒ **B** electrophilic substitution.

☒ **C** nucleophilic addition.

☒ **D** nucleophilic substitution.

(Total for Question 17 = 2 marks)

18 Which of the following pairs are *cis-trans* isomers?



1 **2** **3** **4**

☒ **A** **1** and **2**

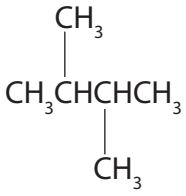
☒ **B** **1** and **4**

☒ **C** **2** and **3**

☒ **D** **3** and **4**

(Total for Question 18 = 1 mark)

19 What is the systematic name for the hydrocarbon shown below?



☒ **A** 1,4-dimethylbutane

☒ **B** 2,3-dimethylbutane

☒ **C** 2,3-dimethylhexane

☒ **D** 1,1,2,2-tetramethylethane

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

BLANK PAGE

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20 Crude oil is composed mainly of alkanes, which are saturated hydrocarbons.

(a) (i) Define the term **hydrocarbon**.

(1)

(ii) State what is meant by the term **saturated**, as applied to a hydrocarbon.

(1)

(b) Crude oil can be separated into fractions.

(i) What property allows crude oil to be separated by fractional distillation?

(1)

(ii) Many chemists are of the opinion that we should use fuels such as biodiesel rather than petrol and diesel.

Suggest **one** reason to support this opinion.

(1)

(c) A molecule of a hydrocarbon, **X**, can be cracked to form one molecule of pentane, C_5H_{12}, and two molecules of ethene only.

(i) Deduce the molecular formula of **X**.

(1)

(ii) Give **one** reason why cracking reactions are carried out in industry and suggest why high temperatures are used in this process other than to speed up the reaction.

(2)

(d) Butane, C_4H_{10}, is a hydrocarbon which is used as a fuel. It is a gas under standard conditions.

(i) Explain what is meant by the term **fuel**.

(1)

(ii) Write an equation for the **complete** combustion of butane under standard conditions. Include state symbols in your answer.

(2)

(iii) Write an equation for the **incomplete** combustion of butane to form carbon monoxide and water only. State symbols are not required.

(1)

(iv) Under what conditions would you expect incomplete combustion to occur?

(1)

.....

.....

(e) Butane can react with bromine, in the presence of ultraviolet radiation, according to the following equation.

$$C_4H_{10} + Br_2 \rightarrow C_4H_9Br + HBr$$

(i) Calculate the atom economy by mass for the formation of C_4H_9Br.
Use the expression

$$\text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\ \%$$

Use the Periodic Table as a source of data.

(2)

Final answer.....%

*(ii) Describe the mechanism of the reaction between butane and bromine that forms the products given in the equation below.

$$C_4H_{10} + Br_2 \rightarrow C_4H_9Br + HBr$$

In your answer you should include

- equations for each step of the mechanism (curly arrows are **not** required)
- the name of each step occurring in the mechanism.

(7)

(Total for Question 20 = 21 marks)

21 Lattice energies can be calculated from experimental data using Born-Haber cycles.

In the table below are the enthalpy changes needed to calculate the lattice energy of sodium oxide, Na_2O.

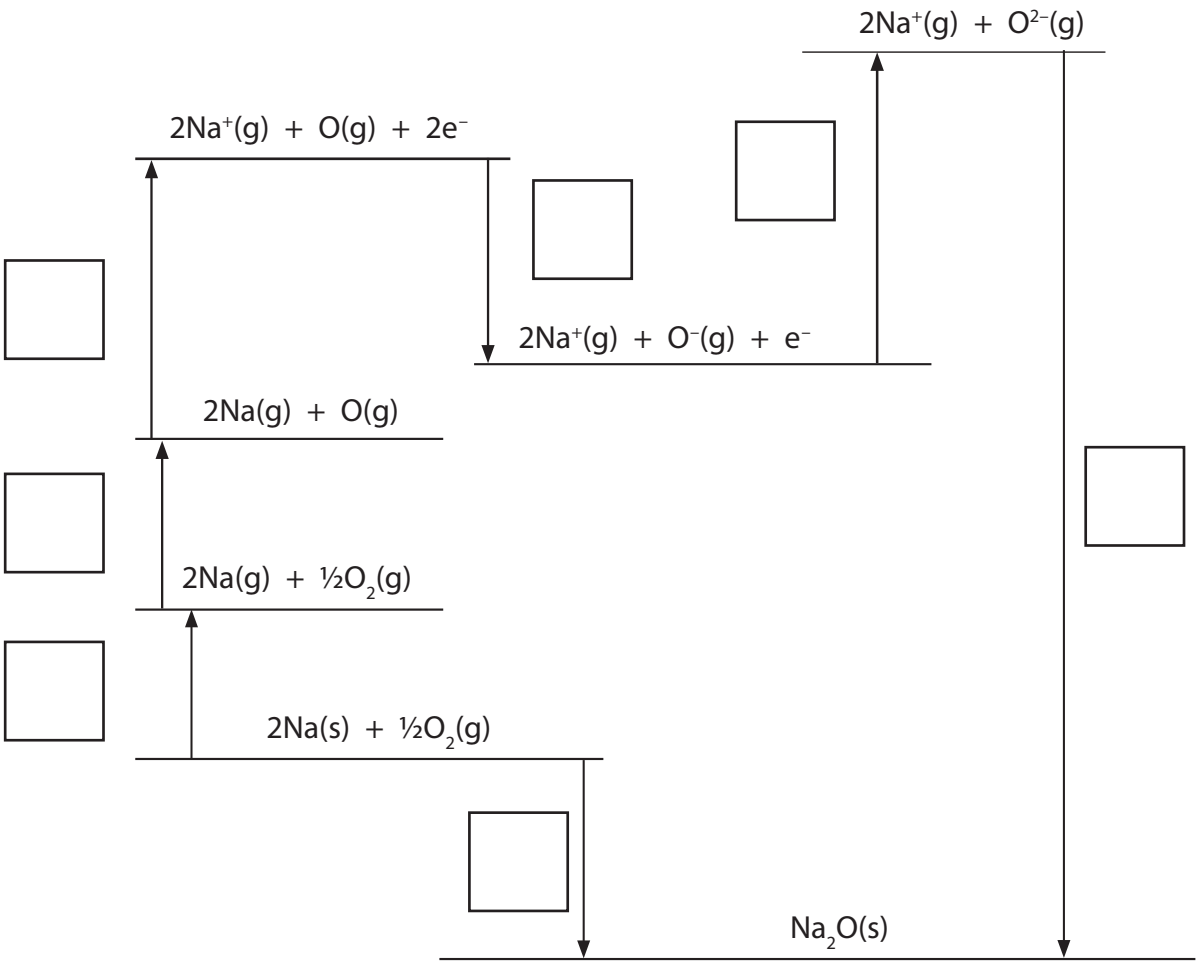
Letter	Enthalpy change	Value / kJ mol^{-1}
A	1st electron affinity of oxygen	–141
B	2nd electron affinity of oxygen	+790
C	1st ionization energy of sodium	+496
D	enthalpy change of atomization of sodium	+108
E	enthalpy change of atomization of oxygen, $\frac{1}{2}O_2(g)$	+249
F	enthalpy change of formation of sodium oxide	–414
G	lattice energy of sodium oxide	

(a) Define the term **lattice energy**.

(2)

(b) (i) Write the correct letters from the table of data to label the Born-Haber cycle below.

(3)



(ii) Calculate the lattice energy of sodium oxide, enthalpy change **G**, in kJ mol^{-1}.

(2)

Answer = ... kJ mol^{-1}

*(c) Predict whether the lattice energy of magnesium oxide, MgO, is more or less exothermic than the lattice energy of magnesium sulfide, MgS.

Justify your answer in terms of the sizes and the charges of the ions involved.

(4)

(Total for Question 21 = 11 marks)

22 Nickel is an element in the d-block of the Periodic Table.

(a) Complete the electronic configuration of a nickel atom using the s, p, d notation.

(1)

$1s^2$ .....

(b) A sample of nickel is made up of three isotopes. The percentage abundances are shown in the table below.

Isotope	Percentage abundance
^{58}Ni	69.02
^{60}Ni	27.32
^{62}Ni	3.66

Calculate the relative atomic mass of nickel. Give your answer to **two** decimal places.

(2)

(c) Nickel reacts with carbon monoxide, CO, to give the compound nickel carbonyl, $Ni(CO)_4$.

$$Ni(s) + 4CO(g) \rightarrow Ni(CO)_4(g)$$

(i) Calculate the volume of carbon monoxide, in dm^3, measured at room temperature and pressure, that is required to react completely with 5.87 g of nickel.

[Relative atomic mass: Ni = 58.7
Molar volume of a gas = 24 dm^3 mol^{-1} at room temperature and pressure.]

(3)

(ii) Calculate the **number** of carbon monoxide molecules present in the volume of gas you have calculated in (c)(i).

[The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}]

(1)

(d) Nickel(II) nitrate, $Ni(NO_3)_2$, can be made by several different methods.

Method 1

Nickel(II) oxide, NiO, was reacted with dilute nitric acid according to the equation

$$NiO(s) + 2HNO_3(aq) \rightarrow Ni(NO_3)_2(aq) + H_2O(l)$$

(i) Calculate the volume of 2.00 mol dm^{-3} dilute nitric acid, in cm^3, that was required to exactly neutralize 1.494 g of nickel(II) oxide.

Use the relative atomic masses: Ni = 58.7, O = 16.0

(3)

Method 2

A volume of 25.0 cm^3 of 2.00 mol dm^{-3} nitric acid, HNO_3, was transferred to a beaker. Solid nickel(II) carbonate, $NiCO_3$, was added until it was in excess.

(ii) Why was **excess** nickel(II) carbonate used?

(1)

.....

.....

(iii) Why must the beaker be **much** larger than the volume of acid used?

(1)

.....

.....

.....

(iv) Write a balanced equation for the reaction between nickel(II) carbonate and dilute nitric acid, including state symbols.

(2)

*(v) For **Method 2**, describe the practical steps that you would take to obtain pure dry crystals of hydrated nickel(II) nitrate, $Ni(NO_3)_2.6H_2O$, from a mixture of nickel(II) nitrate solution and unreacted solid nickel(II) carbonate.

(4)

(Total for Question 22 = 18 marks)

23 This question concerns the Periodic Table.

(a) An atom of argon has mass number 40. Complete the table below showing the numbers of sub-atomic particles in this atom of argon. Use the Periodic Table as a source of data.

(1)

Sub-atomic particles present in one atom of ^{40}Ar	Number
protons	
electrons	
neutrons	

(b) An atom of potassium has mass number 39. Explain why argon is placed before potassium in the modern Periodic Table.

(1)

.....

.....

.....

.....

(c) In the context of the Periodic Table, explain what is meant by the term **periodicity**.

(2)

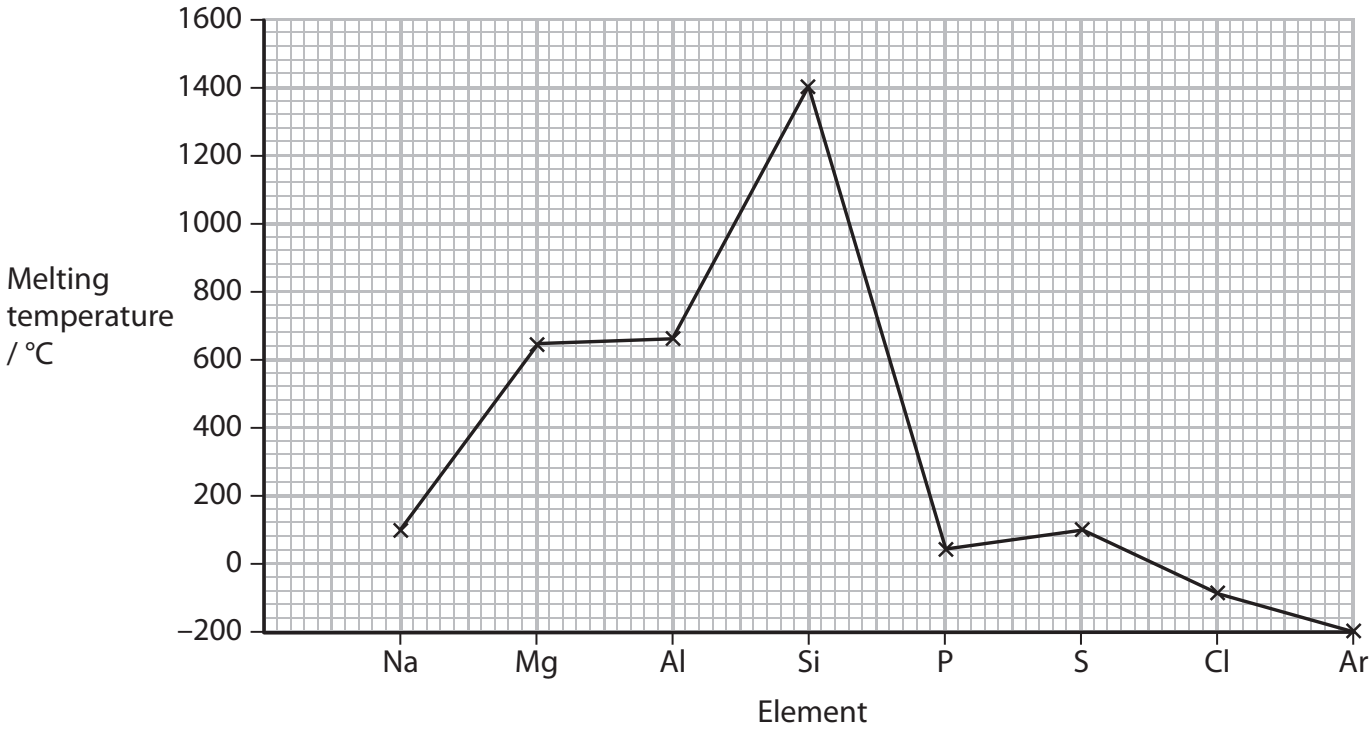
.....

.....

.....

.....

(d) The graph shows the variation in melting temperatures of the elements across Period 3 (Na to Ar) of the Periodic Table.



(i) Name **one** of the elements above that is composed of **simple molecules** at room temperature and pressure.

(1)

.....

(ii) Silicon has a giant atomic structure. Explain how this structure results in the high melting temperature shown on the graph.

(2)

.....

.....

.....

.....

(iii) Explain why the melting temperature of magnesium is higher than that of sodium.

(3)

(Total for Question 23 = 10 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 7 0 A 0 2 4 2 4

PMT

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Mark Scheme (Results)
Summer 2014

GCE Chemistry (6CH01/01)
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Correct Answer	Mark
1	A	**1**

Question Number	Correct Answer	Mark
2	C	**1**

Question Number	Correct Answer	Mark
3	A	**1**

Question Number	Correct Answer	Mark
4	C	**1**

Question Number	Correct Answer	Mark
5	D	**1**

Question Number	Correct Answer	Mark
6	D	**1**

Question Number	Correct Answer	Mark
7	D	**1**

Question Number	Correct Answer	Mark
8	B	**1**

Question Number	Correct Answer	Mark
9	D	**1**

Question Number	Correct Answer	Mark
10	C	**1**

Question Number	Correct Answer	Mark
11	C	**1**

Question Number	Correct Answer	Mark
12	B	**1**

Question Number	Correct Answer	Mark
13	B	**1**

Question Number	Correct Answer	Mark
14	B	**1**

Question Number	Correct Answer	Mark
15	A	**1**

Question Number	Correct Answer	Mark
16	D	**1**

Question Number	Correct Answer	Mark
17(a)	B	**1**

Question Number	Correct Answer	Mark
17(b)	A	**1**

Question Number	Correct Answer	Mark
18	C	**1**

Question Number	Correct Answer	Mark
19	B	**1**

Total for Section A: 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	(Compound of) carbon and hydrogen **ONLY / ENTIRELY / PURELY**	"**Mixture** of carbon and hydrogen only"	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	(Contains) **only** (C—C) single bonds/ **only** σ bond(s) OR (Contains) no (C=C) double bond(s)/no triple bond(s) OR Cannot undergo addition (reactions) ALLOW Has maximum number of hydrogen atoms / has maximum amount of hydrogen /can form no more bonds IGNORE references to alkanes		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(i)	**Boiling** point(s) / **boiling** temperatures / **boiling** ranges ALLOW Different sizes of molecules / different chain lengths / different numbers of carbon atoms IGNORE References to melting points / melting temperatures / condensing	**Just** 'different temperatures' Breaking of hydrocarbon chains	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(ii)	Save fossil fuels / saves finite resources / saves petrol / saves diesel OR More sustainable OR Uses renewable resources / biodiesel made from 'natural resources' OR Biodiesel is a renewable fuel OR Plants (more) carbon neutral / use of plants improves carbon footprint (of fuel) OR Biodiesel has smaller carbon footprint / zero carbon footprint OR Biodiesel (more) carbon neutral ALLOW Reverse argument for petrol / 'normal' diesel (eg crude oil is non-renewable) IGNORE Less impact on the environment / references to 'environmentally friendly' / less polluting / acid rain IGNORE References to 'global warming' or 'Greenhouse Effect' or 'climate change'.		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	**C_9H_{20}** IGNORE Any structures drawn out		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	**First mark:** Any ONE of:- (Greater) demand for smaller molecules / (Greater) demand for smaller alkanes / (Greater) demand for alkenes / To make more useful products / To make more reactive product / To make smaller molecules / To make shorter molecules / To make alkenes / To make shorter chains NOTE: ALLOW 'To produce fuel(s)' **(1)** **Second mark:** (High temperatures needed to) **break** (the C-C and / or C-H) **bonds** OR To break (down) the (hydrocarbon) chain(s) / To break (down) the molecule(s) / To split the molecule(s) / To break the hydrocarbon OR (Reaction is) endothermic ALLOW To overcome the (high) activation energy / the reaction has a high activation energy / provide activation energy IGNORE C-C bond is stable References to increasing rate (of reaction) References to yield / equilibrium References to efficiency / producing less CO **(1)** **Marks are stand-alone**	**No 2nd mark if any of the following are mentioned:** **Separation** of molecules Breaking **intermolecular** forces References to (high) boiling temperatures / (high) boiling points References to (high) melting temperatures / (high) melting points	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(i)	(Substance that) produces **energy** or produces **heat** IGNORE:- References to 'power' References to **just** 'exothermic' References to burning or combustion or heating the fuel or reference to oxygen		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(ii)	$C_4H_{10}(g) + 6½O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ OR $C_4H_{10}(g) + 6.5O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ OR $C_4H_{10}(g) + \frac{13}{2} O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ OR $2C_4H_{10}(g) + 13\ O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$ OR Any other correct multiples Correct species **(1)** Balancing and state symbols correct **(1)** 2nd mark is dependent on the 1st mark	H_2O(**g**) C_4H_{10}(**l**)	**2**

Question Number	Acceptable Answers	Reject	Mark
20(d)(iii)	$C_4H_{10} + 4½O_2 \rightarrow 4CO + 5H_2O$ OR $C_4H_{10} + 4.5\ O_2 \rightarrow 4CO + 5H_2O$ OR $C_4H_{10} + \frac{9}{2} O_2 \rightarrow 4CO + 5H_2O$ OR $2C_4H_{10} + 9\ O_2 \rightarrow 8CO + 10H_2O$ OR Any other correct multiples IGNORE State symbols even if incorrect		**1**

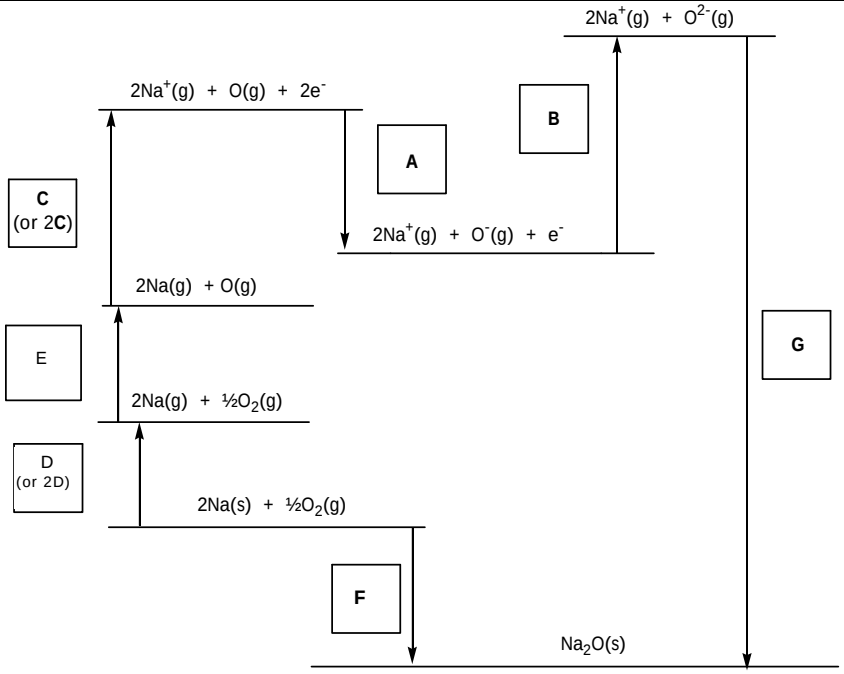
Question Number	Acceptable Answers	Reject	Mark
20(d)(iv)	Limited (supply of) air / oxygen OR insufficient (supply of) air / oxygen OR Oxygen / air not in excess OR Not enough air / not enough oxygen ALLOW 'Lack of oxygen' / lack of ventilation IGNORE "It is not completely oxidized"	'**no** air' / '**no** oxygen'	**1**

Question Number	Acceptable Answers	Reject	Mark
20(e)(i)	**First mark** Calculation of the sum of the M_r values of all the products = **217.8** If using Br = 80, M_r = 218 **(1)** **Second mark** Calculation of % atom economy using value of total M_r **[** = $\frac{136.9}{217.8}$ (x 100%) **]** = 62.856 (%) **(1)** NOTE If using Br = 80, final answer = 62.844 (%) ALLOW ECF for the 2nd mark on an incorrect total M_r value IGNORE sf except 1 sf Correct answer with no working **(2)** **Check rounding of answer** **NOTE** **If one error only is made, (1) mark awarded**	For M_r = **217.8**, **62.8**% (no 2nd mark, as this is a rounding error)	**2**

Question Number	Acceptable Answers	Reject	Mark
***20(e)(ii)**	**First mark:** **Initiation** (step) **(1)** **Second mark:** Br—Br → Br● + Br● / Br_2 → 2Br● **(1)** **Third mark:** **Propagation** (steps) **(1)** **Fourth and fifth marks:** Br● + C_4H_{10} → C_4H_9● + HBr **(1)** Br_2 + C_4H_9● → C_4H_9Br + Br● **(1)** Allow in either order **Sixth mark:** **Termination (**step(s) **(1)** **Seventh mark:** **Any one of** Br● + Br● → Br_2 OR C_4H_9● + Br● → C_4H_9Br OR C_4H_9● + C_4H_9● → C_8H_{18} **(1)**	H● (the fourth and fifth marks cannot be awarded if H● appears in **either** propagation step)	**7**

(Total for Question 20 = 21 marks)

Question Number	Acceptable Answers	Reject	Mark
21(a)	(The energy / enthalpy change that accompanies the formation of) **one mole** of a(n ionic) compound **(1)** ALLOW as alternative for compound: lattice /crystal / substance / solid / product / salt from (its) **gaseous ions** **(1)** IGNORE References to 'standard conditions' or any incorrect standard conditions **ALTERNATIVE RESPONSE** If no mark(s) already awarded from above, can answer by giving:- energy change / enthalpy change **per mole** **(1)** $2Na^{+}(g) + O^{2-}(g) \rightarrow Na_2O(s)$ **(1)** **NOTE** If lattice energy of dissociation is given (e.g. "energy required to break down 1 mol of an ionic lattice into its gaseous ions") max (1) for the 2nd scoring point 'gaseous ions'	'energy required' / 'energy needed' / 'energy it takes' 'from **one mole of gaseous ions**' (no 2nd mark) 'from gaseous **elements**' (no 2nd mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	 All seven letters correct **(3)** Five **OR** six letters correct **(2)** Three **OR** four letters correct **(1)** ALLOW Either D or 2D Either C or 2C ALLOW Correct numerical values (see question paper) may be given as an alternative to the correct letters		**3**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	**FIRST, CHECK THE FINAL ANSWER** **IF answer = −2520 (kJ mol^{-1})** **then** **award (2) marks, with or without working** Otherwise look for −414 = (2 × 108) + 249 + (2 × 496) + (−141) + 790) + ΔH_{LE} **OR** ΔH_{LE} = −414 − [(2 × 108) + 249 + (2 × 496) + (−141) + 790] **OR** A correct expression using letters e.g. F = (2)D + E + (2)C + A + B + G **(1)** (=−414 − 2106) = **−2520** (kJ mol^{-1}) **(1)** NOTE **ALLOW** for **1 mark**: −1692 (wrong sign for 414) −1916 (2 × 108 and 2 × 496 not used for Na^+) −2412 (2 × 108 not used for Na^+) −2024 (2 × 496 not used for Na^+) +2520 (wrong sign for final answer) −2802 (sign changed for 1st electron affinity of oxygen) −2395.5 (atomization of oxygen halved) NOTE Penalise incorrect units (e.g. kJ mol) ONCE only **NO ECF** from incorrect answers to (b)(i)	−1088 (kJ mol^{-1}) scores **(0)** overall (as two errors) (+)1088 (kJ mol^{-1}) also scores **(0)** overall (as several errors)	**2**

Question Number	Acceptable Answers	Reject	Mark
***21(c)**	ALLOW reverse argument where appropriate **First mark** MgO more exothermic (than MgS) IGNORE 'greater' / 'higher' / 'larger' **(1)** **Second mark** S^{2-} larger than O^{2-} **(1)** **Third mark** Charges on O^{2-} and S^{2-} same OR Charges on (all) ions same OR S^{2-} smaller **charge density** than O^{2-} NOTE This mark is awarded if both formulae for the ions O^{2-} and S^{2-} are mentioned **(1)** **Fourth mark** O^{2-} (forms) **stronger** (electrostatic) **attractions** (than S^{2-}) IGNORE just 'stronger (ionic) bonds' **(1)** **Penalise ONCE ONLY** the use of the word 'atom(s)' or 'molecule(s)'/ use of **formulae** such as 'Mg' 'O' 'O_2', etc. AND/OR **Penalise ONCE ONLY** use of **words** such as **just '**magnesium' (instead of magnesium ions/Mg^{2+}) and/or **just '**oxygen' (instead of oxide ions/O^{2-}) **Mark each point independently**	"**MgS** is larger than **MgO**" S^{2-} has a larger **atomic** radius than O^{2-}	**4**

(Total for Question 21 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$ OR $(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8$ ALLOW capital S P D Allow subscripts (e.g. $(1s^2)\ 2s_2\ 2p_6\ 3s_2\ 3p_6\ 4s_2\ 3d_8$)		**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)	(A_r for Ni) = (58 x 0.6902) + (60 x 0.2732) + (62 x 0.0366) or a correct fraction using percentages **(1)** (= 58.6928) [calculator value] = 58.69 (**must be to 2 dp**) **(1)** 2nd mark CQ on numbers transcribed Correct answer with no working **(2)** IGNORE Units of any kind (e.g. 'g', 'g mol^{-1}', 'amu', etc.)	58.68 (as rounding error)	**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	Moles of nickel = $\frac{5.87}{58.7}$ = 0.1(00) (mol) **(1)** Moles CO = 0.1(00) x 4 = 0.4(00) (mol) Answer CQ on 4 x mol Ni **(1)** Volume of CO = 0.4(00) x 24 (dm^3) = 9.6 (dm^3) ALLOW 9600 **cm^3** Answer CQ on 24 x mol CO **(1)** Correct answer with no working scores **(3)**	9.6 dm^3 **mol^{-1}** (no 3rd mark) 9.6 dm^{-3} (no 3rd mark) OR Any other incorrect units (no 3rd mark)	**3**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	(Number of CO molecules = 0.400 x 6.02 x 10^{23}) = 2.408 x 10^{23} Answer CQ on moles / volume of CO in (c)(i) IGNORE sf except 1 sf IGNORE Any units, even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	Moles of NiO = $\frac{1.494}{74.7}$ = 0.02(00) (mol) **(1)** Moles HNO_3 = 0.02(00) x 2 = 0.04(00) (mol) Answer CQ on 2 x mol NiO **(1)** Volume of HNO_3 = $\frac{0.04(00) \times 1000}{2.00}$ = 20(.0) (cm^3) ALLOW 0.02(00) **dm^3** Answer CQ on mol HNO_3 **(1)** Correct answer with no working scores **(3)** Penalise wrong units ONCE only		**3**

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	To ensure all the **acid** reacts / all the **acid** is used up / all the **acid** is neutralized IGNORE References to 'yield' / reaction going to completion / just 'acid is the limiting reagent'	To ensure all the **reactants** are used up	**1**

Question Number	Acceptable Answers	Reject	Mark
22(d)(iii)	Fizzing / effervescence / frothing / bubbles / gas released IGNORE spilling (over) / spillage References to 'vigorous', 'exothermic', 'violent' / **just** 'safety'	(Mixture) **boils** Quantity of reagents / 'displacement' of solution on adding solid	**1**

Question Number	Acceptable Answers	Reject	Mark
22(d) (iv)	$NiCO_3$(**s**) + $2HNO_3$(**aq**) → $Ni(NO_3)_2$(**aq**) + H_2O(**l**) + CO_2(**g**) ALLOW correct ionic equation $NiCO_3$(**s**) + $2H^+$(**aq**) → Ni^{2+}(**aq**) + H_2O(**l**) + CO_2(**g**) All species correct **(1)** Balancing and all state symbols correct **(1)** 2nd mark is dependent on 1st mark (ie all species correct)	H_2CO_3(aq) scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
***22(d)(v)**	**First mark:** **Filter** (off the excess nickel(II) carbonate / solid) **(1)** **Second mark:** **Boil / heat** (to drive off some of the water) **(1)** **IGNORE** just 'evaporation' (as the technique of boiling / heating is required here) **Third mark:** Leave to cool / leave to crystallize / evaporate (water) slowly / leave (for water) to evaporate **(1)** **Fourth mark:** **Dry** (the crystals) **(1)** IGNORE Any washing of the crystals immediately prior to drying them NOTE If heat **to dryness** in the second stage, award (1) mark if filtration is **first** stage If filtration is not the first stage, award (1) mark for **steps 2, 3 and 4 all correct**	**Just** "warm" the filtrate / solution OR 'heat the filtrate **to dryness**' (Adding to a) drying agent Use of Bunsen burner or direct heating to dry crystals	**4**

(Total for Question 22 = 18 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)	(Protons) **18** (Electrons) **18** (Neutrons) **22** All three numbers correct for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)	(Position in the Periodic Table) depends upon atomic number / proton number OR Ar (atom) has (one) fewer proton(s) (than K atom) OR K (atom) has (one) more proton(s) (than Ar atom) OR K has atomic number 19 (whereas) Ar has atomic number 18 OR Ar has 18 protons, K has 19 protons IGNORE 'Elements are not arranged in order of (relative) atomic mass' IGNORE Mention of numbers of electrons / numbers of shells (of electrons) IGNORE Arranged in vertical groups in accordance to properties / Argon is a noble gas		**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark** Property / trend / pattern ALLOW Any named property (e.g. atomic radius, ionization energy, melting temperature) **(1)** **Second mark** **Repeated** (across each period) OR **Regular** (across each period) OR **Re-occurring** (across each period) **(1)** NOTE Statement such as: "A repeating trend across a period / across each period" scores **(2)**		**2**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	Phosphorus / P / P_4 OR Sulfur / S / S_8 OR Chlorine / Cl / Cl_2 IGNORE Argon / Ar		**1**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	(The covalent) **bonds** are **strong** (throughout the lattice) **(1)** (therefore) a lot of **energy** is required to break the bonds / a lot of **energy** is needed to overcome the attractions (between atoms) / 'more **energy**' is required to break the bonds /'more **energy**' is needed to overcome the attractions (between atoms) / 'greater amount of **energy**' is required to break the bonds /'greater amount of **energy**' is needed to overcome the attractions (between atoms) **(1)**	**MENTION OF ANY OF THE FOLLOWING SCORES (0) OVERALL** '(simple) molecular silicon' **(0)** 'molecules of silicon' **(0)** 'silicon has ions' / 'silicon is ionic' **(0)** 'intermolecular forces' / 'van der Waals' forces' / 'London forces' / 'forces between the molecules' **(0)** 'metallic bonding' **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
23(d)(iii)	**ALLOW reverse arguments in each case** **Any two from four:-** ● magnesium ions / magnesium atoms are small**er** (than sodium ions / sodium atoms) **(1)** **NOTE:** Allow symbols (e.g. Mg or Mg^{2+}) ● magnesium **ions** are Mg^{2+} whereas sodium **ions** are Na^{+} OR Mg^{2+} / magnesium **ions** have a larg**er** charge (density) (than Na^{+} /sodium **ions**) **(1)** **[NOTE:** It follows that the statement that "Mg^{2+} ions are smaller than Na^{+} ions" would score the first two scoring points above**]** ● magnesium has more **delocalised** electrons (than sodium) **(1)** IGNORE 'free electrons' IGNORE just 'sea of electrons' ● magnesium is close-packed (but sodium is not close-packed) **(1)** **Third mark (stand-alone):** · more / a lot of (heat) energy is needed to break (metallic) bonds in Mg (than in Na) OR · attraction between the positive ions and (delocalised) electrons is strong**er** in magnesium (than in sodium) **(1)**	attraction between **nucleus** and (delocalised) electrons (no third mark) mention of **intermolecular forces / molecules** (no third mark)	**3**

	IGNORE Just ‘metallic bonding in Mg stronger than that in Na’	ionic bonding (no third mark) attraction between Mg^{2+} ions (no third mark) **NOTE:** arguments based on ionization energies scores **(0) overall** **OR** any suggestion of removal of outer shell electrons as part of the melting process scores **(0) overall**	

(Total for Question 23 = 10 marks)

TOTAL FOR SECTION B = 60 marks

TOTAL FOR PAPER = 80 marks

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Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 22 May 2015 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P44880A

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6/6/6/5/1/

P 4 4 8 8 0 A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 In which order do the electrons fill the orbitals of an atom?

☒ **A** 1s 2s 2p 3s 3p 4s 4p 3d

☒ **B** 1s 2s 2p 3s 3d 3p 4s 4p

☒ **C** 1s 2s 2p 3s 3p 3d 4s 4p

☒ **D** 1s 2s 2p 3s 3p 4s 3d 4p

(Total for Question 1 = 1 mark)

2 Ions are separated in the mass spectrometer by

☒ **A** a vacuum pump.

☒ **B** a magnetic field.

☒ **C** an ionization chamber.

☒ **D** electron bombardment.

(Total for Question 2 = 1 mark)

3 Which of the following contains one mole of neutrons?

☒ **A** 1 g of $^{1}_{1}H$

☒ **B** 1 g of $^{12}_{6}C$

☒ **C** 2 g of $^{24}_{12}Mg$

☒ **D** 2 g of $^{22}_{10}Ne$

(Total for Question 3 = 1 mark)

4 Solutions of barium chloride and silver nitrate are mixed together.
The reaction that takes place is an example of

☒ **A** displacement.

☒ **B** neutralization.

☒ **C** oxidation.

☒ **D** precipitation.

(Total for Question 4 = 1 mark)

5 The Avogadro constant is numerically equal to the number of

☒ **A** ions in 1 mol of sodium chloride, NaCl

☒ **B** atoms in 1 mol of hydrogen gas, H_2

☒ **C** electrons in 1 mol of helium gas, He

☒ **D** molecules in 1 mol of oxygen gas, O_2

(Total for Question 5 = 1 mark)

6 10 g of magnesium is added to 1 dm^3 of 1 mol dm^{-3} copper(II) sulfate solution and the mixture is stirred until no further reaction occurs.

Which of the following is a result of this reaction?

☒ **A** The resulting solution is colourless.

☒ **B** 10 g of copper is displaced.

☒ **C** 63.5 g of copper is displaced.

☒ **D** All the magnesium reacts.

(Total for Question 6 = 1 mark)

7 Which of the following gas samples has the same volume as 7.0 g of carbon monoxide?

All volumes are measured at the same temperature and pressure.

☒ **A** 1.0 g of hydrogen

☒ **B** 3.5 g of nitrogen

☒ **C** 10.0 g of argon

☒ **D** 35.5 g of chlorine

(Total for Question 7 = 1 mark)

8 Which of the following aqueous solutions contains the greatest number of **negative** ions?

☒ **A** 500 cm^3 of 0.10 mol dm^{-3} $Na_2SO_4(aq)$

☒ **B** 250 cm^3 of 0.12 mol dm^{-3} $BaCl_2(aq)$

☒ **C** 250 cm^3 of 0.15 mol dm^{-3} $KI(aq)$

☒ **D** 500 cm^3 of 0.10 mol dm^{-3} $Zn(NO_3)_2(aq)$

(Total for Question 8 = 1 mark)

9 In an experiment carried out at 200 °C and 1 atm pressure, 20 cm^3 of ammonia gas reacted with an excess of heated copper(II) oxide.

$$3CuO(s) + 2NH_3(g) \rightarrow 3Cu(s) + 3H_2O(g) + N_2(g)$$

If all measurements were made at 200 °C and 1 atm pressure, what would be the total volume, in cm^3, of gaseous products?

☒ **A** 10

☒ **B** 20

☒ **C** 30

☒ **D** 40

(Total for Question 9 = 1 mark)

10 Ammonia is manufactured from hydrogen and nitrogen in the Haber process.

$$3H_2(g) + N_2(g) \rightleftharpoons 2NH_3(g)$$

If 60 tonnes of hydrogen produces 80 tonnes of ammonia, what is the percentage yield in the reaction?

☒ **A** $\frac{80}{170} \times 100\%$

☒ **B** $\frac{80}{340} \times 100\%$

☒ **C** $\frac{30}{80} \times 100\%$

☒ **D** $\frac{60}{80} \times 100\%$

(Total for Question 10 = 1 mark)

11 Which of the following compounds has the greatest ionic character?

☒ **A** Caesium fluoride

☒ **B** Caesium iodide

☒ **C** Potassium fluoride

☒ **D** Potassium iodide

(Total for Question 11 = 1 mark)

12 Which species has a dative covalent bond?

☒ **A** H_3O^+

☒ **B** H_2O

☒ **C** OH^-

☒ **D** O_2

(Total for Question 12 = 1 mark)

13 The atomic radius of potassium is larger than that of sodium because potassium has

☒ **A** a larger nuclear charge.

☒ **B** a larger nucleus.

☒ **C** more occupied electron shells.

☒ **D** a smaller first ionization energy.

(Total for Question 13 = 1 mark)

14 Consider the following data.

$S(s)$	+	$H_2(g)$	→	$H_2S(g)$	$\Delta H^{\ominus} = a$
$H_2(g)$	+	$½O_2(g)$	→	$H_2O(l)$	$\Delta H^{\ominus} = b$
$S(s)$	+	$O_2(g)$	→	$SO_2(g)$	$\Delta H^{\ominus} = c$
$H_2S(g)$	+	$1½O_2(g)$	→	$H_2O(l) + SO_2(g)$	$\Delta H^{\ominus} = d$

What is the relationship between a, b, c and d?

☒ **A** $a = b + c - d$

☒ **B** $a = d - b - c$

☒ **C** $a = b - c - d$

☒ **D** $a = d + c - b$

(Total for Question 14 = 1 mark)

15 In which of the following does **X** represent the mean bond enthalpy for the O–H bond in water?

☒ **A** $H_2O(g) \rightarrow O(g) + H_2(g)$ $\Delta H = 2\mathbf{X}$

☒ **B** $H_2O(g) \rightarrow O(g) + 2H(g)$ $\Delta H = 2\mathbf{X}$

☒ **C** $H_2O(g) \rightarrow O(g) + H_2(g)$ $\Delta H = \mathbf{X}$

☒ **D** $H_2O(g) \rightarrow O(g) + 2H(g)$ $\Delta H = \mathbf{X}$

(Total for Question 15 = 1 mark)

16 Which of the following is a step in the propagation stage of the chlorination of methane?

☒ **A** $Cl_2 \rightarrow Cl^{\bullet} + Cl^{\bullet}$

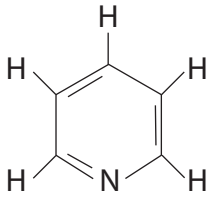
☒ **B** $CH_3^{\bullet} + Cl^{\bullet} \rightarrow CH_3Cl$

☒ **C** $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$

☒ **D** $CH_4 + Cl^{\bullet} \rightarrow CH_3Cl + H^{\bullet}$

(Total for Question 16 = 1 mark)

17 A molecule of **Z** has the following structure:



Molecule of **Z**

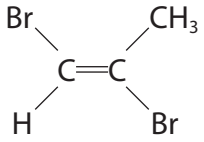
What are the total numbers of σ-bonds and π-bonds in a molecule of **Z**?

	Number of σ-bonds	Number of π-bonds
☒ **A**	3	11
☒ **B**	8	3
☒ **C**	11	3
☒ **D**	14	6

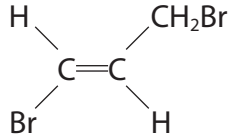
(Total for Question 17 = 1 mark)

18 Which is the structure of *Z*-1,2-dibromoprop-1-ene?

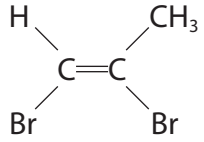
☒ **A**



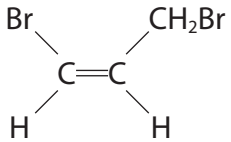
☒ **B**



☒ **C**

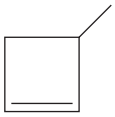


☒ **D**



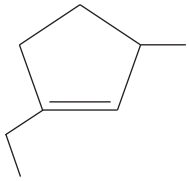
(Total for Question 18 = 1 mark)

19 The skeletal formula of 3-methylcyclobut-1-ene is shown below.

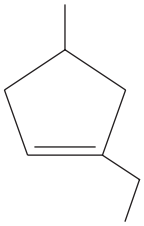


What is the skeletal formula of 1-ethyl-3-methylcyclopent-1-ene?

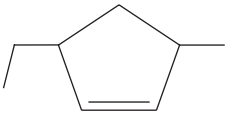
☒ **A**



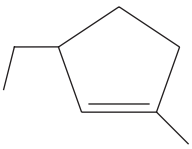
☒ **B**



☒ **C**



☒ **D**



(Total for Question 19 = 1 mark)

20 Which of the following fuels, when burned, would make no significant contribution to climate change?

☒ **A** Hydrogen

☒ **B** Methane

☒ **C** Petrol

☒ **D** Coal

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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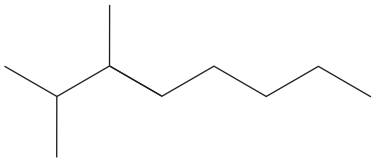
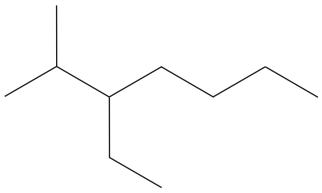
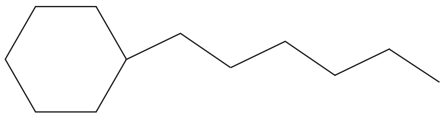
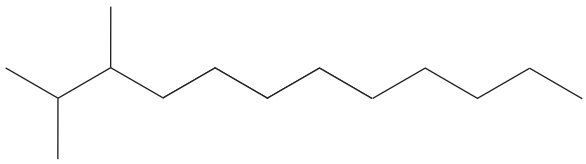
SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 A propellant for a rocket consists of a fuel, kerosene, and an oxidizer, liquid oxygen.

(a) The formulae of some hydrocarbons present in kerosene are shown in the table below.

Hydrocarbon	Formula
A	
B	$CH_3(CH_2)_{10}CH_3$
C	
D	
E	

(i) Name the homologous series to which the compounds **A**, **B**, **C** and **E** belong.

(1)

.....

(ii) Name the compound **A**.

(1)

.....

(iii) Explain the term **structural isomers**, by reference to two molecules selected from the table in part (a).

(3)

.....

.....

.....

.....

.....

.....

.....

(iv) Give the **molecular** formula of the compound **D**.

(2)

(b) In the petrochemical industry, other fuels are obtained by the cracking and reforming of kerosene.

Using appropriate letters, **A** to **D**, identify a molecule listed in the table that could be formed from **E** by

(i) cracking alone

(1)

.....

(ii) cracking and then reforming

(1)

.....

(c) Suggest how engine performance is improved by using a fuel containing the molecule that you have identified in (b)(ii).

(1)

.....

.....

(d) The **energy density** of a fuel is defined as the energy produced per kilogram of fuel.

Calculate the energy density of dodecane, $C_{12}H_{26}$, in kJ kg^{-1}. Give your answer to **two** significant figures.

The enthalpy change of combustion of dodecane is −8086 kJ mol^{-1}.

[Molar mass: $C_{12}H_{26}$ = 170 g mol^{-1}]

(3)

energy density = ... kJ kg^{-1}

(Total for Question 21 = 13 marks)

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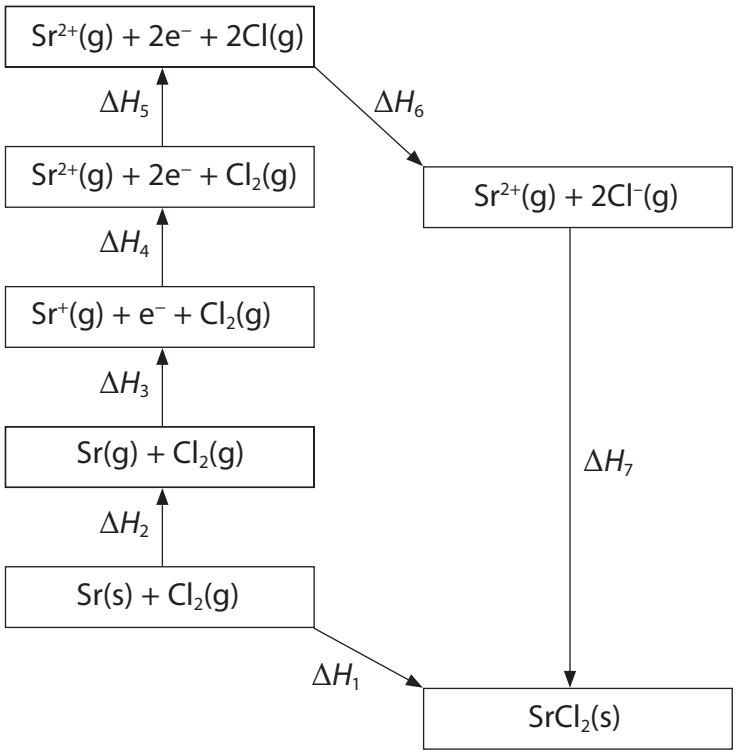
22 Born-Haber cycles can be used to determine experimental values of lattice energies.

(a) The diagram below shows a Born-Haber cycle for the formation of strontium chloride from strontium and chlorine.



Using symbols from ΔH_1 to ΔH_7 as appropriate, identify the

(i) enthalpy change of atomization of strontium

(1)

.....

(ii) bond enthalpy of chlorine

(1)

.....

(iii) first electron affinity of chlorine

(1)

.....

(iv) enthalpy change of formation of strontium chloride

(1)

.....

(b) The table below shows the energy changes that are needed to determine the lattice energy of strontium chloride, $SrCl_2$.

Energy change	ΔH / kJ mol^{-1}
enthalpy change of atomization of strontium	+164
first ionization energy of strontium	+550
second ionization energy of strontium	+1064
enthalpy change of atomization of chlorine, $\frac{1}{2}Cl_2$	+122
first electron affinity of chlorine	−349
enthalpy change of formation of strontium chloride	−829

(i) Define the term **lattice energy**.

(2)

.....

.....

.....

.....

(ii) Calculate the lattice energy of strontium chloride, in kJ mol^{-1}.

(2)

lattice energy = ... kJ mol^{-1}

*(c) The lattice energies of sodium fluoride and magnesium fluoride are shown in the table below.

Compound	Lattice energy / kJ mol^{-1}
Sodium fluoride, NaF	–918
Magnesium fluoride, MgF_2	–2957

Explain, in terms of the sizes and charges of the ions involved, why the lattice energy of MgF_2 is more negative than that of NaF.

(3)

(Total for Question 22 = 11 marks)

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23 This question is about alkenes.

(a) Give the general formula for the homologous series of alkenes.

(1)

.....

(b) Give the **structural** formula of the organic product formed when **ethene**, $CH_2=CH_2$, reacts with

(i) hydrogen

(1)

(ii) chlorine

(1)

(iii) acidified aqueous potassium manganate(VII)

(1)

(iv) bromine **water**

(1)

(c) When **propene**, $CH_3CH=CH_2$, reacts with hydrogen chloride, there are **two** possible products, a major product and a minor product.

(i) Draw the **displayed** formulae of these products.

(2)

Major product	Minor product

(ii) Give the mechanism for the reaction of **propene** with hydrogen chloride which forms the major product.

(3)

(d) Propene can be polymerized.

(i) Write a balanced equation for the polymerization of propene to form poly(propene), drawing the **displayed** formula of the repeat unit of poly(propene).

(3)

(ii) State a problem associated with the disposal of waste poly(propene).

(1)

(e) Standard enthalpy changes of combustion can be used to calculate the standard enthalpy change of formation of propene.

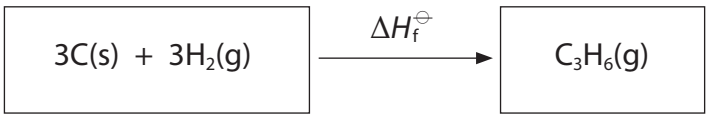
$$3C(s) + 3H_2(g) \longrightarrow C_3H_6(g)$$

Values for some standard enthalpy changes of combustion, $\Delta H_c^{\ominus}$, are shown in the table below.

Substance	$\Delta H_c^{\ominus}$ / kJ mol^{-1}
C(s)	−394
$H_2(g)$	−286
$C_3H_6(g)$	−2058

(i) Complete the Hess cycle below to enable you to calculate $\Delta H_f^{\ominus}$ from combustion data.

(1)



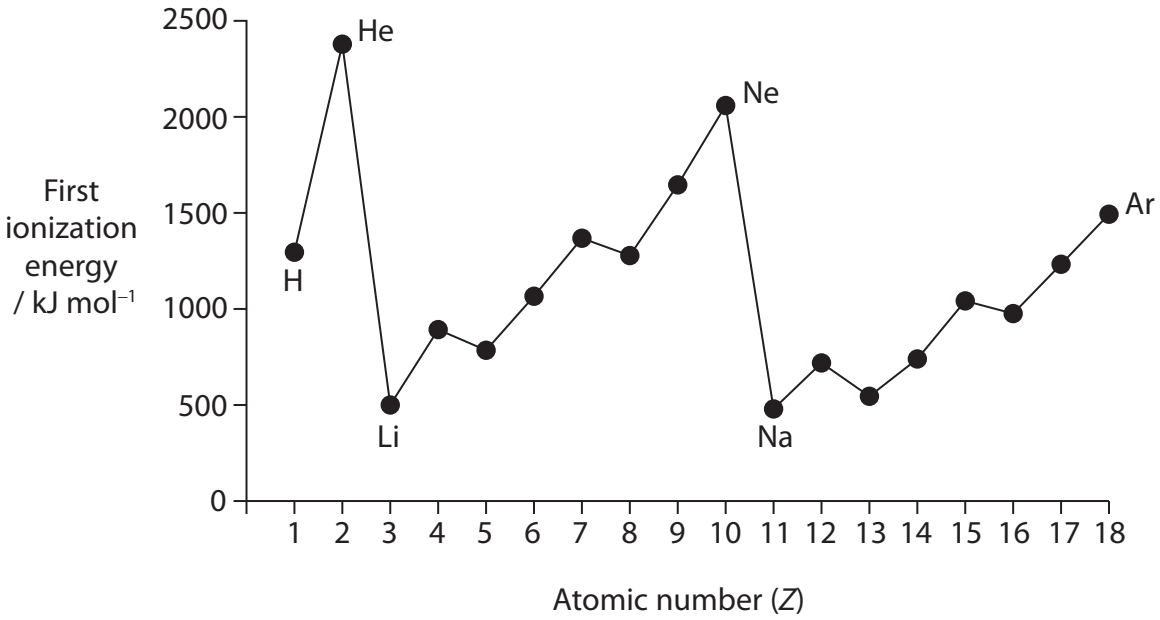
(ii) Calculate $\Delta H_f^{\ominus}$, in kJ mol^{-1}.

(2)

standard enthalpy change of formation of propene = ... kJ mol^{-1}

(Total for Question 23 = 17 marks)

24 The diagram below shows the pattern in the first ionization energies of the first 18 elements.



(a) Give the equation, including state symbols, for the first ionization energy of fluorine.

(2)

*(b) Explain why there is a **general** increase in the first ionization energies from sodium to argon.

(3)

(c) *(i) Explain why the first ionization energy of aluminium ($Z = 13$) is less than that of magnesium ($Z = 12$).

(2)

.....

.....

.....

.....

*(ii) Explain why the first ionization energy of sulfur ($Z = 16$) is less than that of phosphorus ($Z = 15$).

(2)

.....

.....

.....

.....

(d) The table below, which is incomplete, refers to the elements sodium to sulfur.

Element	Na	Mg	Al	Si	P	S
Melting temperature	low	high				
Structure		giant				
Electrical conductivity		high				

(i) Complete the **melting temperature** row by using only the words 'high' or 'low'.

(2)

(ii) Complete the **structure** row by using only the words 'giant' or 'molecular'.

(2)

(iii) Complete the **electrical conductivity** row by using only the words 'high' or 'low'.

(1)

(e) In an experiment, 2.76 g of sodium completely reacted with water to form 500 cm^3 of aqueous sodium hydroxide.

$$2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g)$$

(i) Calculate the number of moles of sodium that reacted.

(1)

(ii) Calculate the maximum volume, in dm^3, of hydrogen that can be formed at room temperature and pressure.

[1 mol of any gas occupies 24 dm^3 at room temperature and pressure.]

(2)

(iii) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide solution, NaOH(aq), formed in the experiment.

(2)

(Total for Question 24 = 19 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 4 8 8 0 A 0 2 8 2 8

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Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH01/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	D	**1**

Question Number	Correct Answer	Mark
2	B	**1**

Question Number	Correct Answer	Mark
3	C	**1**

Question Number	Correct Answer	Mark
4	D	**1**

Question Number	Correct Answer	Mark
5	D	**1**

Question Number	Correct Answer	Mark
6	D	**1**

Question Number	Correct Answer	Mark
7	C	**1**

Question Number	Correct Answer	Mark
8	D	**1**

Question Number	Correct Answer	Mark
9	D	**1**

Question Number	Correct Answer	Mark
10	B	**1**

Question Number	Correct Answer	Mark
11	A	**1**

Question Number	Correct Answer	Mark
12	A	**1**

Question Number	Correct Answer	Mark
13	C	**1**

Question Number	Correct Answer	Mark
14	A	**1**

Question Number	Correct Answer	Mark
15	B	**1**

Question Number	Correct Answer	Mark
16	C	**1**

Question Number	Correct Answer	Mark
17	C	**1**

Question Number	Correct Answer	Mark
18	C	**1**

Question Number	Correct Answer	Mark
19	A	**1**

Question Number	Correct Answer	Mark
20	A	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Alkane(s) **IGNORE** Any references to 'branched' / 'aliphatic' / 'hydrocarbons'		**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	2,3-**di**methyloctane **IGNORE** Incorrect or missing punctuation		**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	**1st mark:** (Isomers) **A and C** **(1)** **NOTE** If no isomers or isomers other than A & C have been chosen, then award one mark max providing both 2nd and 3rd marking points are evident. **2nd mark:** (They/A and C) have the same **molecular formula** / $C_{10}H_{22}$ / same number of C and H (atoms) **(1)** **3rd mark:** (They/A and C) have different structural formulae/displayed formulae / skeletal formulae / different structures/different arrangement of atoms **IGNORE** Any references to 'in space' / 'spatial' Any references to names Any references to general formulae **(1)**	'Different chemical formulae'	**3**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iv)	$C_{12}H_{24}$ **1st mark:** C_{12} **(1)** **2nd mark:** H_{24} **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	**A** OR **B** **ALLOW** lower case letters **IGNORE** any names or formulae		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	**C** OR **D** **ALLOW** lower case letters **IGNORE** any names or formulae		**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)	Any **one** of: (It improves engine performance by) Promoting efficient combustion OR Allowing smoother burning OR Increasing octane number OR Reduces knocking / prevents knocking OR Pre-ignition being less likely OR Being (more) efficient (fuels) OR Better burning / fuels easier to burn OR Combusting more easily OR Improving combustion / complete combustion OR Burns more cleanly OR More miles per gallon **IGNORE** any references to energy density / boiling temperature / volatility		**1**

Question Number	Acceptable Answers	Reject	Mark
21(d)	[FIRST, check the answer on the answer line IF answer = 48000 (kJ kg^{-1}) award **(3)** marks] **1st two marks** $\frac{1000}{170}$ **(1)** x 8086 **(1)** **OR** $\frac{8086}{170}$ **(1)** x 1000 **(1)** NOTE: second mark in both cases dependent on first mark unless one minor transcription error in first mark e.g. use of 110 rather than 170 **3rd mark** = 47564.70588 = 48000 **(1)** Answer must be to 2 sf **Ignore signs and / or incorrect units at any stage** 48 scores **(2)** 47.56 scores **(1)** 1374.6 scores **(0)** even if rounded to 2SF		**3**

(Total for Question 21 = 13 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	ΔH_2 **ALLOW** ΔH_2 = ...		**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	ΔH_5 **ALLOW** ΔH_5 = ...	$\frac{\Delta H_5}{2}$	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	$\frac{\Delta H_6}{2}$ OR ΔH_6 / 2 OR $\Delta H_6 \div 2$ OR 0.5 ΔH_6	ΔH_6	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iv)	ΔH_1 **ALLOW** ΔH_1 = ...	ΔH_7	**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	(The energy change / enthalpy change that accompanies / energy released / enthalpy released) the formation of **one mole** of a(n ionic) compound **(1)** ALLOW as alternative for compound: lattice /crystal / substance / solid / product from its **gaseous ions** **(1)** *NOTE* 'one mole of gaseous ions' scores max **(1)** (ie 2nd mark only available) *IGNORE* References to 'constituent elements' References to 'standard conditions' **ALTERNATIVE RESPONSE** If no mark(s) already awarded from above, can answer by giving:- energy change / enthalpy change **per mole** **(1)** $Sr^{2+}(g) + 2Cl^{-}(g) \rightarrow SrCl_2(s)$ **ALLOW** Any correct 'generic' equation with state symbols included **(1)**	'Energy / enthalpy **required**' **/ 'used'** 'molecule' **no 1st mark** 'gaseous atoms' **no 2nd mark**	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	[FIRST, check the answer on the answer line IF answer = **—2153** (kJ $mol^{—1}$) then award **(2)** marks, with or without working] **1st Mark:** $\Delta H_1 = \Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6 + \Delta H_7$ OR $\Delta H_7 = \Delta H_1 - [\Delta H_2 + \Delta H_3 + \Delta H_4 + \Delta H_5 + \Delta H_6]$ OR $\Delta H_7 = -829 - [164 + 550 + 1064 + (122 \times 2) + (2 \times -349)]$ **(1)** **2nd Mark:** $\Delta H_7 = -2153$ (kJ mol^{-1}) **(1)** **NOTE:** **The following answers score (1) mark with or without working** **+**2153 (kJ mol^{-1}) −2031 (kJ mol^{-1}) −2502 (kJ mol^{-1}) −2380 (kJ mol^{-1}) **NO OTHER TEs are allowed on an incorrect expression involving** ΔH_7		**2**

Question Number	Acceptable Answers	Reject	Mark
22*(c)	(Lattice energy of MgF_2 more exothermic than that of NaF because) **1st mark:** Mg^{2+} is smaller (than Na^+) **ALLOW** "Magnesium / Mg is smaller (than sodium / Na)" **(1)** **2nd mark:** Mg^{2+} higher charge / higher charge density (than Na^+) **ALLOW** Any reference to Mg^{2+} **and** Na^+ in answer for the 2nd mark, unless nuclear charge mentioned **(1)** **3rd mark:** (So electrostatic forces of) **attraction** between **ions** stronger in MgF_2 (than in NaF) **ALLOW** Strong**er** ionic bonds in MgF_2 / strong**er** ionic bonding in MgF_2 **(1)** OR reverse arguments	**No 1st mark** if only mention Mg **atom** or **atomic** radius "Mg^{2+} higher **nuclear** charge"	**3**

(Total for Question 22 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)	C_nH_{2n} ALLOW Letters other than *n*		**1**

ALLOW: (partially) displayed or skeletal formulae throughout **Q23(b)**
IGNORE: additional incorrect non-organic products

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	CH_3CH_3	C_2H_6	**1**

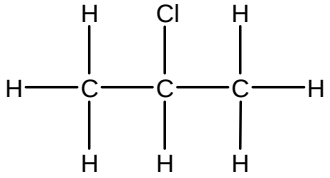
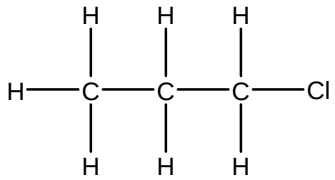
Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	$ClCH_2CH_2Cl$ / CH_2ClCH_2Cl	$C_2H_4Cl_2$	**1**

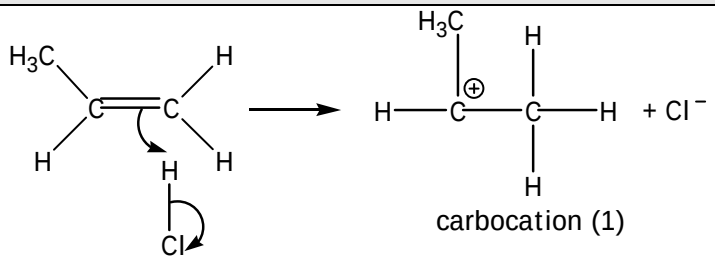
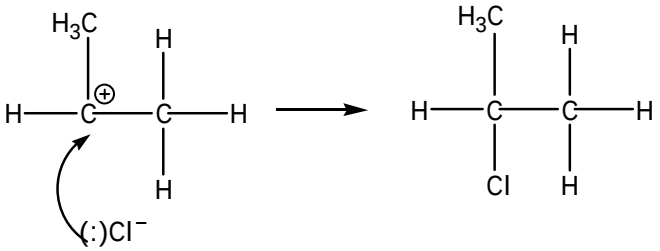
ONLY PENALISE <u>ONCE ONLY</u> in (b)(iii) & (b)(iv) THE CONNECTIVITY BETWEEN C and OH if CLEARLY a C to H covalent bond has been drawn

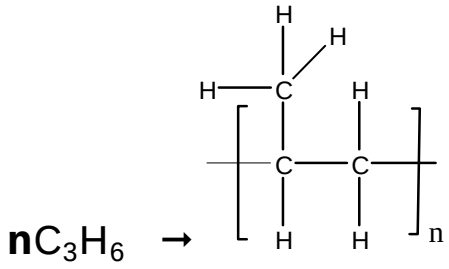
Question Number	Acceptable Answers	Reject	Mark
23(b)(iii)	**HO**CH_2CH_2OH / CH_2OHCH_2OH	$C_2H_6O_2$ / **OH**CH_2CH_2OH	**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(iv)	$HOCH_2CH_2Br$ / CH_2OHCH_2Br	$BrCH_2CH_2Br$ / C_2H_5OBr / $C_2H_4Br_2$	**1**

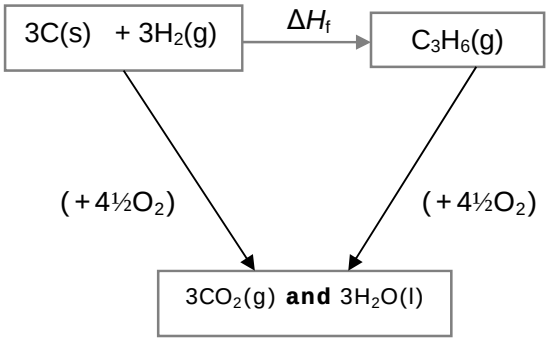
PENALISE USE OF Br instead of Cl once only in parts (c)(i) & (c)(ii)
PENALISE missing H atoms from displayed formulae once only in parts (c)(i) & (c)(ii)

Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	 (Major product) **(1)**  (Minor product) **(1)** Both DISPLAYED structures, with all bonds and atoms shown but in the wrong boxes scores **(1)** **PENALISE** CH_3 not fully displayed **ONCE** only **So** $CH_3CH(Cl)CH_3$ and $CH_3CH_2CH_2Cl$ scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
23(c)(ii)	 both arrows (1) carbocation (1)  attack of chloride ion (1) **1st mark:** Curly arrow from C=C to H (in H—Cl) **AND** curly arrow from bond in H—Cl to the Cl (dipole not reqd) Curly arrows must start from the bonds **NOT** the atoms **(1)** **2nd mark:** Structure of correct secondary carbocation **(1)** **3rd mark:** Curly arrow from anywhere on the chloride ion (including the minus sign) towards the C+ on the carbocation **(1)** **NOTE:** The chloride ion must have a full negative charge, but the lone pair of electrons on the Cl^- need not be shown **ALLOW:** TE on major product given in (c)(i) Skeletal formulae can be used **Mark the three points independently**	**Full +** and **-** charges on HCl **Incorrect** polarity on HCl Extra / spare bond dangling from the C+ carbon δ- on chloride ion instead of Cl^-	**3**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	 **n**C_3H_6 → TWO 'n' in the equation and a correct formula (molecular or structural) for propene on the left-hand side of the equation **(1)** **One** correct repeating unit, with the methyl branch shown **(1)** **ALLOW** CH_3 fully displayed or just as CH_3 **BOTH** continuation bonds (with or without bracket shown) **(1)** If C=C bond left in polymer on right-hand side, then max (1) **Mark the three points independently**		**3**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	Non-biodegradable IGNORE References to toxicity of poly(propene) / flammability IGNORE Litter / pollution / waste of resources / costs **ALLOW** People are reluctant to recycle OR Harmful to marine life / harmful to wildlife OR References to 'landfill' OR References to 'incineration' producing toxic fumes/toxic gases / CO_2 / Greenhouse gases OR References to use of **energy**/**fuel** used in transport (of waste) OR It takes a long time to degrade		**1**

Question Number	Acceptable Answers	Reject	Mark
23(e)(i)	 Both arrows in the correct direction **AND** $3CO_2$ **and** $3H_2O$ in lowest box IGNORE state symbols, even if incorrect IGNORE extra O_2 molecules in box or alongside arrows		**1**

Question Number	Acceptable Answers	Reject	Mark
23(e)(ii)	**1st mark** (−394 x 3) + (−286 x 3) OR = −2040 (kJ mol^{-1}) **(1)** **2nd mark:** ΔH_f = −2040 – (−2058) = (+)18 (kJ mol^{-1}) **(1)** **NOTE:** **The following answers score (1) mark** **with or without working** **−**18 (kJ mol^{-1}) (+)1378 (kJ mol^{-1}) (+)806 (kJ mol^{-1}) (+)590 (kJ mol^{-1}) −4098 (kJ mol^{-1}) IGNORE units even if incorrect		**2**

(Total for Question 23 = 17 marks

Question Number	Acceptable Answers	Reject	Mark
24(a)	$F(g) \rightarrow F^+(g) + e^{(-)}$ OR $F(g) - e^{(-)} \rightarrow F^+(g)$ Species **(1)** State symbols IGNORE Any state symbols on electrons **(1)** 2nd mark is dependent on the first **NOTE:** $F(g) + e^{(-)} \rightarrow F^+(g) + 2e^{(-)}$ Use of 'Fl' **max (1)**	Electron affinity equation (0) overall Equations with $F_2(g)$ score **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
24*(b)	**1st mark:** Number of protons increases / increasing nuclear charge / increasing effective nuclear charge **IGNORE** Just 'the atomic number increases' **(1)** **2nd mark:** Same shielding / same number of (occupied) shells / electron removed from the same shell / atomic radius decreases **(1)** **3rd mark:** Greater (electrostatic) attraction between nucleus / protons and (outermost) electron **(1)**	'Shielding increases' **(0)** for 2nd mark	**3**

Question Number	Acceptable Answers	Reject	Mark
24(c)*(i)	For aluminium **1st mark:** (Electron lost from) (3)**p**-subshell / (3)**p**-orbital ALLOW Correct electron configuration for Al: $1s^2 2s^2 2p^6 3s^2 3p^1$ or $[Ne]3s^2 3p^1$ or drawn as electrons-in-boxes **(1)** **NOTE** First mark must refer to aluminium **2nd mark:** at higher energy / further from the nucleus / (more) shielded (by 3s) OR Magnesium electron is at lower energy / closer to the nucleus / less shielded **(1)** **IGNORE** References to stability of $3s^2$ or full s-orbitals / full s sub-shell in Mg	Mention of **2**p, no 1st mark	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)*(ii)	For sulfur **1st mark:** (Electron lost from a) pair of electrons / an orbital with electrons (spin-) paired / a full (p) orbital **ALLOW** Mention of (3)p^4 OR Correct electron configuration for S:$1s^2 2s^2 2p^6 3s^2 3p^4$ or [Ne]$3s^2 3p^4$ or drawn as electrons-in-boxes **(1)** **2nd mark:** (increase in) **repulsion** (allows e^- to be removed more easily) **(1)** If no correct reference to Sulfur, then allow one mark for P (atom) has half-filled p sub-shell / p^3 (arrangement) is stable.		**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	(Al) (Si) (P) (S) high high low low Four correct **(2)** Three correct **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	(Na) (Al) (Si) (P) (S) giant (giant) giant giant molecular molecular ALLOW 'giant molecular' for Si ALLOW 'simple molecular' for P and/or S Five correct **(2)** Four correct **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	(Na) (Al) (Si) (P) (S) high (high) high **X** low low All four must be correct **IGNORE** Any word written over **X** in the Si box		**1**

Question Number	Acceptable Answers	Reject	Mark
24(e)(i)	($\frac{2.76}{23.0}$) = 0.12(0) (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
24(e)(ii)	Moles H_2 = ½ x mol Na **(1)** Volume H_2 = 0.06(0) x 24 = 1.44 (dm^3) **(1)** ALLOW ECF from moles of Na in (e)(i) ALLOW Both marks if answer given 1440 **cm^3** Correct answer, no working scores **(2)** **NOTE:** **The following answers score (1) mark with or without working** 2.88 (dm^3) / 2880 **cm^3** 5.76 (dm^3) / 5760 **cm^3** However, check as 2.88 could score 2 as a TE of 0.24 mol from (e)(i) IGNORE SF except 1 SF		**2**

Question Number	Acceptable Answers	Reject	Mark
24(e)(iii)	**1st mark:** Moles NaOH = moles of Na **(1)** Can be implied by use of value from (e)(i) **2nd mark:** (0.12) = 0.24(0) (mol dm^{-3}) 0.500 **(1)** ALLOW TE from moles of Na in (e)(i) Correct answer, no working scores **(2)** IGNORE SF except 1 SF NOTE: TE from first mark to second mark only if answer from (e)(i) has been used in some way e.g. answer to (e)(i) × 2 would not score mark 1, but could then be used to score mark 2 as a TE	No 2nd mark if give wrong units, e.g "mol/dm^{-3}" "dm^3/mol"	**2**

(Total for Question 24 = 19 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 22 May 2015 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P44879A

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6/6/6/6/

P 4 4 8 7 9 A 0 1 2 4

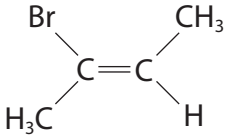
PEARSON

SECTION A

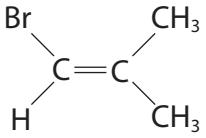
Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which molecule does **not** exhibit *E* / *Z* isomerism?

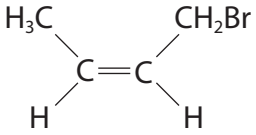
☒ **A**



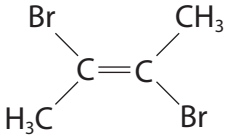
☒ **B**



☒ **C**

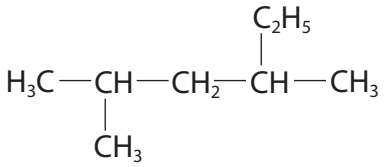


☒ **D**



(Total for Question 1 = 1 mark)

2 What is the systematic name for the compound with the following formula?



☒ **A** 2-methyl-4-ethylpentane

☒ **B** 2-ethyl-4-methylpentane

☒ **C** 2,4-dimethylhexane

☒ **D** 3,5-dimethylhexane

(Total for Question 2 = 1 mark)

3 Which of the following molecules is formed on adding bromine **water** to ethene?

☒ **A** ethanol

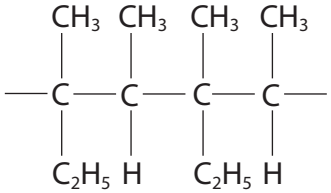
☒ **B** ethane-1,2-diol

☒ **C** bromoethane

☒ **D** 2-bromoethanol

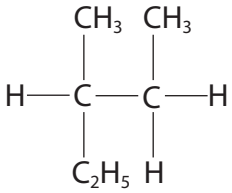
(Total for Question 3 = 1 mark)

4 A section of a polymer is shown below.

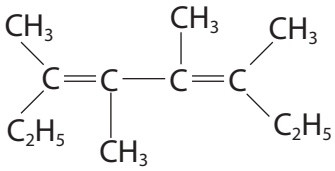


What is the monomer for this polymer?

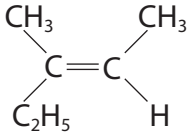
☒ **A**



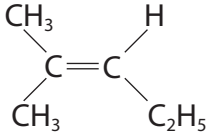
☒ **B**



☒ **C**



☒ **D**



(Total for Question 4 = 1 mark)

5 Which of the following equations has the correct state symbols for the reaction of dilute hydrochloric acid with magnesium oxide?

☒ **A** MgO**(s)** + $2HCl$**(aq)** → $MgCl_2$**(s)** + H_2O**(l)**

☒ **B** MgO**(s)** + $2HCl$**(aq)** → $MgCl_2$**(aq)** + H_2O**(l)**

☒ **C** MgO**(s)** + $2HCl$**(l)** → $MgCl_2$**(s)** + H_2O**(l)**

☒ **D** MgO**(s)** + $2HCl$**(l)** → $MgCl_2$**(aq)** + H_2O**(l)**

(Total for Question 5 = 1 mark)

6 This question is about the reaction between sodium carbonate solution and dilute nitric acid.

$$Na_2CO_3(aq) + 2HNO_3(aq) \rightarrow 2NaNO_3(aq) + CO_2(g) + H_2O(l)$$

(a) What is the **ionic** equation for this reaction?

(1)

☒ **A** $Na_2CO_3(aq) + 2H^+(aq) \rightarrow 2Na^+(aq) + CO_2(g) + H_2O(l)$

☒ **B** $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(aq)$

☒ **C** $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$

☒ **D** $CO_3^{2-}(aq) + 2HNO_3(aq) \rightarrow 2NO_3^-(aq) + CO_2(g) + H_2O(l)$

(b) What is the volume of carbon dioxide produced from the complete reaction of 0.10 mol of nitric acid at room temperature and pressure?

[1 mol of any gas occupies 24 dm^3 at room temperature and pressure.]

(1)

☒ **A** 1.2 dm^3

☒ **B** 1.8 dm^3

☒ **C** 2.4 dm^3

☒ **D** 3.6 dm^3

(c) What volume of sodium carbonate solution of concentration 0.500 mol dm^{-3}, would be needed to completely react with 25.0 cm^3 of nitric acid of concentration 0.250 mol dm^{-3}?

(1)

☒ **A** 6.25 cm^3

☒ **B** 12.50 cm^3

☒ **C** 18.75 cm^3

☒ **D** 25.00 cm^3

(Total for Question 6 = 3 marks)

7 Lithium reacts with water to produce hydrogen.

$$Li(s) + H_2O(l) \rightarrow LiOH(aq) + \tfrac{1}{2}H_2(g)$$

(a) In an experiment, 0.069 g (0.01 mol) of lithium produced 90 cm^3 of hydrogen at room temperature and pressure. What is the percentage yield of hydrogen?

[1 mol of any gas occupies 24 dm^3 at room temperature and pressure.]

(1)

☒ **A** 45%

☒ **B** 60%

☒ **C** 75%

☒ **D** 90%

(b) Which of the following is **not** a possible reason for the yield being less than 100%?

(1)

☒ **A** Some oil remained on the surface of the lithium.

☒ **B** Hydrogen gas is very soluble in water.

☒ **C** A layer of oxide was present on the surface of the lithium.

☒ **D** Some of the hydrogen gas escaped collection.

(Total for Question 7 = 2 marks)

8 How many moles of **atoms** are present in 240 cm^3 of carbon dioxide at room temperature and pressure?

[1 mol of any gas occupies 24 dm^3 at room temperature and pressure.]

☒ **A** 0.010

☒ **B** 0.020

☒ **C** 0.024

☒ **D** 0.030

(Total for Question 8 = 1 mark)

9 What is the percentage by mass of nitrogen in ammonium nitrate, NH_4NO_3?

[Molar masses/g mol^{-1}: N = 14.0; H = 1.0; O = 16.0]

☒ **A** 14.0%

☒ **B** 17.5%

☒ **C** 28.0%

☒ **D** 35.0%

(Total for Question 9 = 1 mark)

10 The first five successive ionization energies for an element J, in kJ mol^{-1}, are

1st	2nd	3rd	4th	5th
738	1450	7733	10543	13630

The formula of the compound of chlorine with element J is

☒ **A** JCl

☒ **B** JCl_2

☒ **C** JCl_3

☒ **D** J_2Cl_3

(Total for Question 10 = 1 mark)

11 Which of the following is the correct order of increasing melting temperature of elements of Period 3?

☒ **A** Na, Mg, Al, Si

☒ **B** Na, Mg, Si, Al

☒ **C** Si, Na, Mg, Al

☒ **D** Si, Al, Mg, Na

(Total for Question 11 = 1 mark)

12 Which one of the following elements undergoes the change in electronic configuration shown when it forms the stated ion?

Atom $1s^2 2s^2 2p^6 3s^2 3p^3$ Ion $1s^2 2s^2 2p^6 3s^2 3p^6$

☒ **A** B to B^{3+}

☒ **B** Al to Al^{3+}

☒ **C** N to N^{3-}

☒ **D** P to P^{3-}

(Total for Question 12 = 1 mark)

13 Which of the following compounds has the most polarized **anion**?

☒ **A** Na_2O

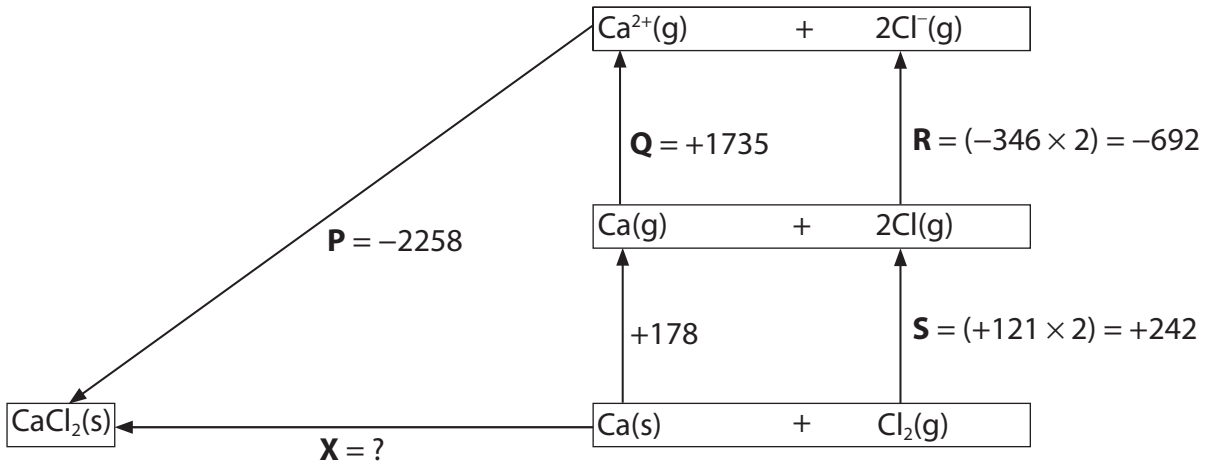
☒ **B** MgO

☒ **C** K_2O

☒ **D** CaO

(Total for Question 13 = 1 mark)

14 The diagram shows a Born-Haber cycle for calcium chloride. It is not drawn to scale. All units are in kJ mol^{-1}.



(a) Which enthalpy change is correctly labelled on the diagram?

(1)

☒ **A** Enthalpy change for the formation of calcium chloride (**P**).

☒ **B** First ionization energy of calcium (**Q**).

☒ **C** Electron affinity of chlorine (**R**).

☒ **D** Twice the enthalpy change of atomization of chlorine (**S**).

(b) What is the value of **X**, in kJ mol^{-1}?

(1)

☒ **A** +795

☒ **B** −795

☒ **C** +3721

☒ **D** −3721

(Total for Question 14 = 2 marks)

15 Calculate the enthalpy change, in kJ mol^{-1}, for the reaction

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(g)$$

DATA:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
O=O	+498
H—O	+464

☒ **A** −243

☒ **B** −6

☒ **C** +6

☒ **D** +221

(Total for Question 15 = 1 mark)

16 The chemical properties of an element are determined by its

☒ **A** electronic structure.

☒ **B** number of neutrons.

☒ **C** relative atomic mass.

☒ **D** number of protons plus neutrons.

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

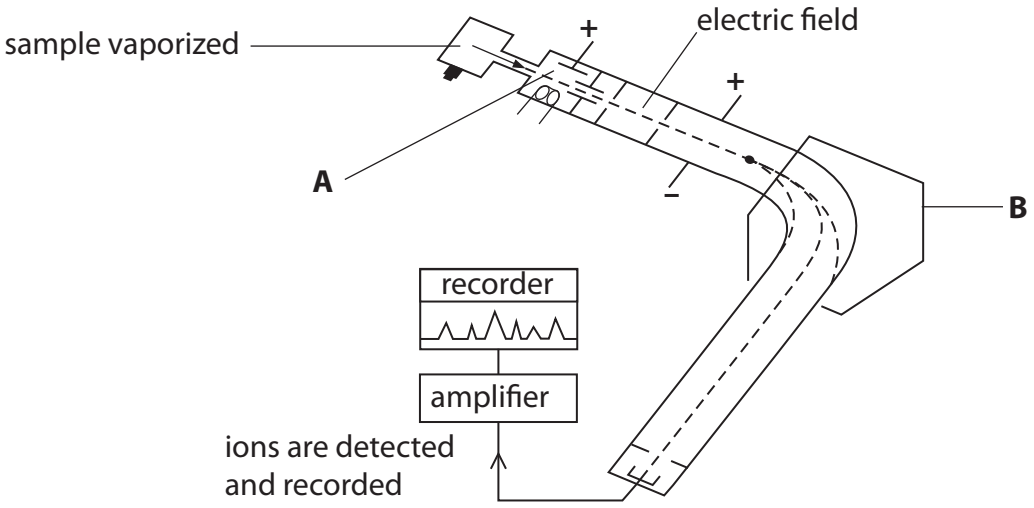
Answer ALL the questions. Write your answers in the spaces provided.

17 This question is about the use of mass spectrometers.

(a) Bromine has two isotopes, ^{79}Br and ^{81}Br. Explain the term **isotopes**, by reference to sub-atomic particles.

(1)

(b) The presence and abundance of these isotopes can be determined by using a mass spectrometer such as that shown in the diagram below.



(i) Explain how ions are produced in the area labelled **A**.

(2)

(ii) State what is used to deflect the ions moving through the mass spectrometer in the area labelled **B**.

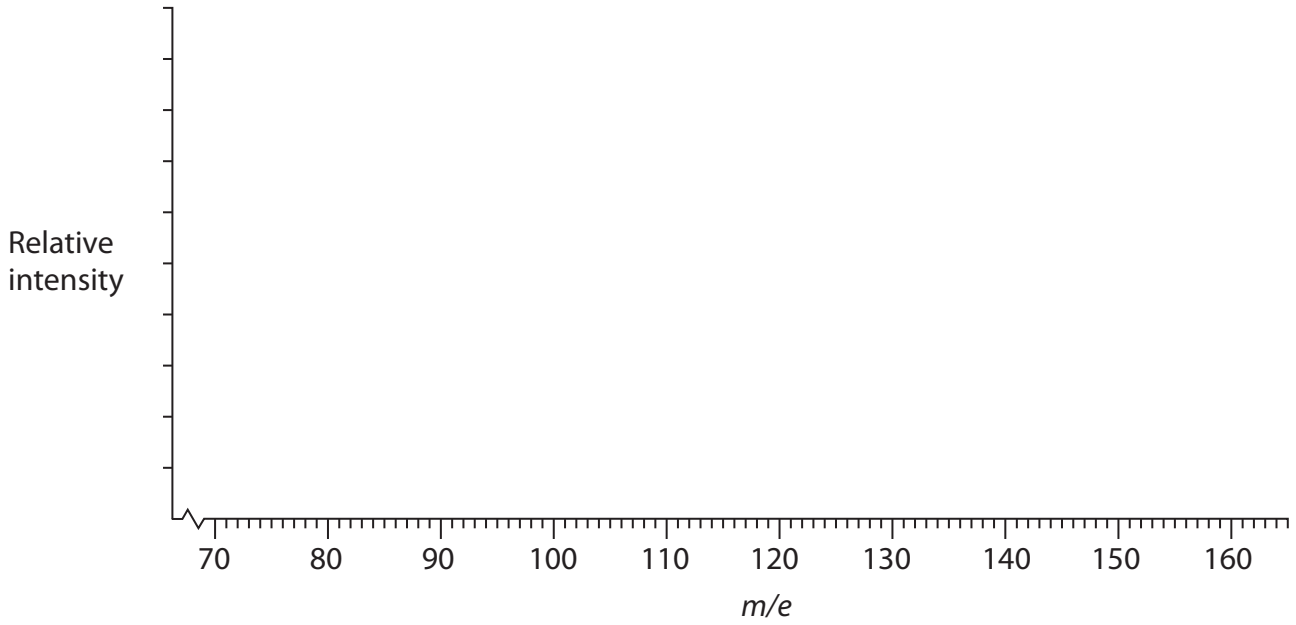
(1)

(iii) Explain why there is a vacuum in a mass spectrometer.

(1)

(c) Complete the mass spectrum below for a sample of bromine **gas** that contains approximately half ^{79}Br isotope and half ^{81}Br isotope.

(4)



(d) Calculate the relative atomic mass of bromine for a sample which was found to contain 47.0% ^{79}Br and 53.0% ^{81}Br.

Give your answer to **three** significant figures.

(2)

(e) What would be the effect, if any, on the *m/e* value of the peak if the ion detected had lost two electrons rather than one electron?

(1)

.....

.....

*(f) One of the uses of mass spectrometers is for the detection of banned substances, such as anabolic steroids, in a blood or urine sample taken from competitors in sports events.

(i) Suggest **two** precautions that are necessary to ensure that the result of any analysis would be valid.

(2)

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(ii) These substances can give competitors an unfair advantage. Suggest why the use of these substances may be of concern to the user.

(1)

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(g) Suggest **one** other use for mass spectrometers.

(1)

.....

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(Total for Question 17 = 16 marks)

18 Alkenes and cycloalkanes have the same general formula, but react very differently with halogens.

(a) Give the general formula that applies to both alkenes and cycloalkanes.

(1)

(b) Using structural formulae, complete the overall equation for the reaction of an alkene of your own choice, containing fewer than four carbon atoms, with liquid bromine.

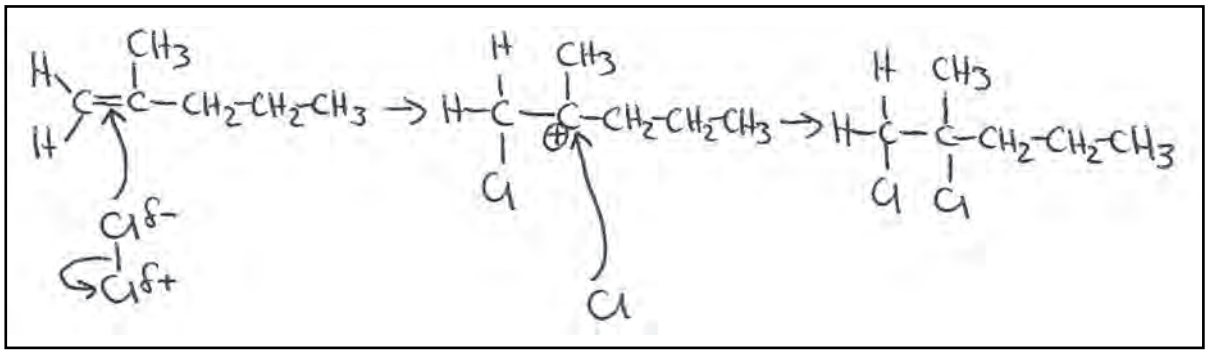
Name the product.

(3)

$+ \quad Br_2 \quad \rightarrow$

Name: .....

*(c) An example of an alkene with six carbon atoms is 2-methylpent-1-ene. It reacts with chlorine by means of an electrophilic addition reaction. The diagram below shows a student's attempt at drawing the mechanism for this reaction.



(i) Identify the three errors in this student's drawing of the mechanism.

(3)

Error 1 .....

.....

Error 2 .....

.....

Error 3 .....

.....

(ii) The structure of the carbocation intermediate is correctly drawn. Explain why the positive charge is on the carbon atom shown.

(1)

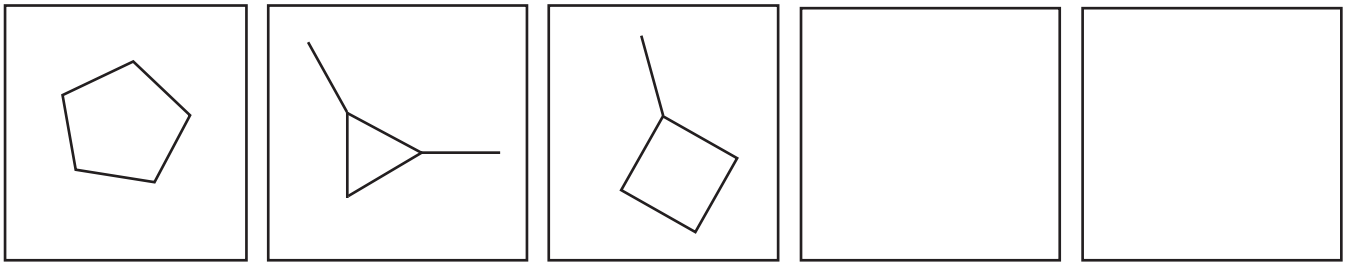
.....

.....

.....

(d) There are five possible cycloalkanes, each containing five carbon atoms. Three of the isomers are given below. Complete the other two boxes, by adding the skeletal formulae of the other two structural isomers.

(2)



(e) Define the term **structural isomerism**.

(1)

.....

.....

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(f) Another example of a cycloalkane is cyclobutane. This compound, like other cycloalkanes, can also react with chlorine.

The overall reaction of cyclobutane with chlorine is as follows:

$$C_4H_8 + Cl_2 \rightarrow C_4H_7Cl + HCl$$

(i) This reaction can occur at room temperature and pressure.
What further condition is needed for this reaction to take place?

(1)

.....

(ii) Using the appropriate arrows, complete the equation for the initiation step of the reaction mechanism for the reaction of chlorine with cyclobutane.

(2)

Cl — Cl →

(iii) Using molecular formulae, write equations for the **two** propagation steps of this mechanism.

(2)

First propagation step:

Second propagation step:

(iv) Name the type of bond fission which occurs in these propagation steps.

(1)

.....

(v) There are also termination steps in this mechanism. Explain how these differ from the other steps in the mechanism and why these result in the reaction ending.

(2)

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(g) If the reaction with cyclobutane is carried out with an excess of chlorine, how are the products of the reaction affected?

(1)

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.....

(Total for Question 18 = 20 marks)

19 Sodium and chlorine react together to produce sodium chloride. The bonding in the product is different from that in both of the reactants. Evidence for the type of bonding present can be obtained in a number of different ways.

(a) Draw the electron density map for a chlorine molecule to show covalent bonding.

(1)

(b) Sodium chloride is ionically bonded. What is meant by the term **ionic bond**?

(1)

.....

.....

.....

(c) Electrolysis is an experiment which you could carry out in a school or college laboratory on an aqueous solution of sodium chloride, to provide evidence for the presence of ionic bonding.

Draw a labelled diagram of the apparatus that you would use for this experiment, indicating how your results would show that the bonding was ionic.

(3)

(d) Chlorine gains an electron when it reacts with sodium to form sodium chloride.

(i) Draw the dot and cross diagram of a chloride ion showing outer electrons only.

(1)

(ii) Give the formula of an ion from **Period 3** that is isoelectronic with the chloride ion.

(1)

.....

(e) Sodium and sodium chloride can both be good conductors of electricity.

Under what conditions do these substances conduct electricity?

Compare the method of conductivity in each case.

(3)

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(Total for Question 19 = 10 marks)

20 The reaction of calcium oxide with hydrochloric acid is an exothermic reaction.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

In an experiment to investigate this reaction, the following procedure was carried out.

1. 50.0 cm^3 of hydrochloric acid, concentration 2.0 mol dm^{-3} (an excess), was pipetted into a polystyrene cup and the initial temperature measured using a thermometer with 0.5 °C graduations.

2. 1.46 g of calcium oxide powder was weighed out and added to the acid. The mixture was stirred and the maximum temperature measured.

Maximum temperature / °C	35.0
Initial temperature / °C	19.5

(a) Calculate the enthalpy change, in joules, for the quantities in this experiment. Assume that the specific heat capacity of the solution is 4.18 J g^{-1} C^{-1}.

Use the expression:

energy transferred in joules = 50.0 × specific heat capacity × temperature change

(1)

(b) Using your answer from (a), calculate the molar enthalpy change for the reaction between calcium oxide and hydrochloric acid. Include a sign and units in your answer.

(2)

(c) The standard molar enthalpy change for the reaction between calcium oxide and hydrochloric acid is −196.8 kJ mol^{-1}.

(i) Suggest **three** reasons why the calculated value in part (b) is different from this value.

(3)

Reason 1 .....

.....

Reason 2 .....

.....

Reason 3 .....

.....

(ii) Using the standard enthalpy change of −196.8 kJ mol^{-1}, calculate the minimum mass of calcium oxide that would be needed to raise the temperature of 250 cm^3 of hydrochloric acid (an excess) by 25.0 °C.

(3)

(d) The reaction of calcium carbonate with hydrochloric acid has the following standard molar enthalpy change.

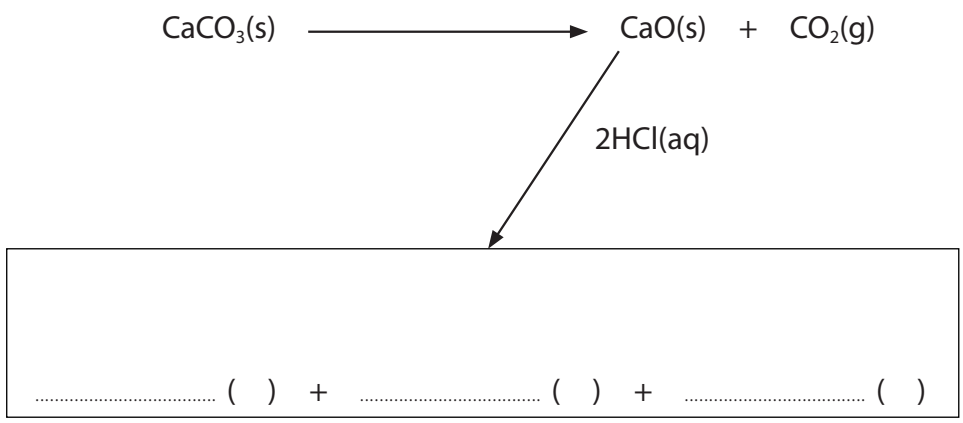
$$\Delta H^{\ominus} = -18.8 \text{ kJ mol}^{-1}$$

This value can be used, with the enthalpy change for the reaction of calcium oxide with hydrochloric acid, to determine the enthalpy change for the thermal decomposition of calcium carbonate. This cannot be measured directly.

(i) Complete the Hess energy cycle below by adding the missing arrow and entities.

Use the cycle, and the standard enthalpy change for the reaction of calcium oxide and hydrochloric acid (−196.8 kJ mol^{-1}), to determine the standard enthalpy change for the decomposition of calcium carbonate.

(4)

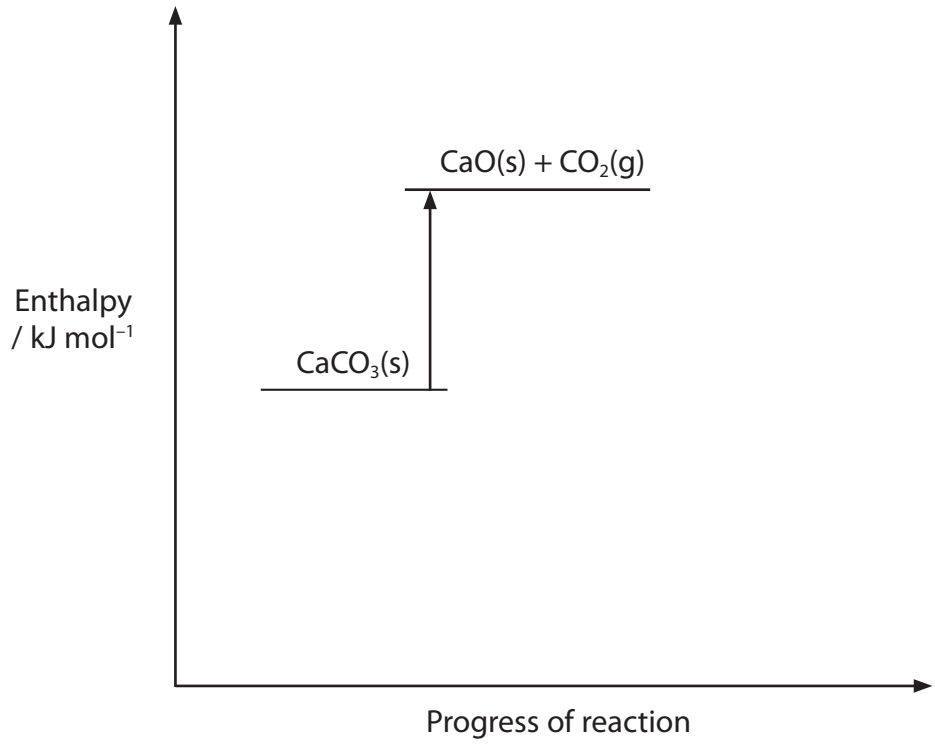


Enthalpy change = ... kJ mol^{-1}

(ii) Complete and label the enthalpy level diagram below, for the series of reactions in (d)(i).

Your diagram does not have to be to scale.

(1)



(Total for Question 20 = 14 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 4 8 7 9 A 0 2 4 2 4

PMT

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Mark Scheme (Results)

Summer 2015

GCE Chemistry (6CH01/01)
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		1

Question Number	Correct Answer	Reject	Mark
2	C		1

Question Number	Correct Answer	Reject	Mark
3	D		1

Question Number	Correct Answer	Reject	Mark
4	C		1

Question Number	Correct Answer	Reject	Mark
5	B		1

Question Number	Correct Answer	Reject	Mark
6(a)	C		1

Question Number	Correct Answer	Reject	Mark
6(b)	A		1

Question Number	Correct Answer	Reject	Mark
6(c)	A		1

Question Number	Correct Answer	Reject	Mark
7(a)	C		1

Question Number	Correct Answer	Reject	Mark
7(b)	B		1

Question Number	Correct Answer	Reject	Mark
8	D		1

Question Number	Correct Answer	Reject	Mark
9	D		1

Question Number	Correct Answer	Reject	Mark
10	B		1

Question Number	Correct Answer	Reject	Mark
11	A		1

Question Number	Correct Answer	Reject	Mark
12	D		1

Question Number	Correct Answer	Reject	Mark
13	B		1

Question Number	Correct Answer	Reject	Mark
14(a)	D		1

Question Number	Correct Answer	Reject	Mark
14(b)	B		1

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	A		1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17(a)	(Atoms/elements/isotopes with) the same number of protons (and electrons) **and** different numbers of neutrons ALLOW answers in terms of bromine isotopes, 35 protons **and** 44 or 46 neutrons. IGNORE different number of nucleons IGNORE same atomic number but different mass number		1

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	(High energy) **electrons** are 'fired' at/ **Electrons** bombard/Use of an '**electron** gun' (1) (result in) loss of electron/electrons (thus forming an ion) This can be shown in an equation $X + e \rightarrow X^+ + 2e$ OR $X \rightarrow X^+ + e$ (1) Stand alone marks	Magnetic field (0) Forms an anion	2

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	Magnet/Magnetic field/Electromagnet	Electric field Magnetic shield Magnetic radiation	1

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	Particles (of gas/air) will interfere with the movement of the **ions**/collide with the **ions**/deflect **ions** OR Additional peaks will be detected/peaks at incorrect m/e IGNORE references to chemical reactions	Atoms for ions	1

Question Number	Acceptable Answers	Reject	Mark
17(c)	**Marking point 1** Twin peaks of about the same height at 79 and 81 (1) **Marking point 2** Twin peaks of about the same height at 158 and 162 (1) **Marking point 3** Peak at 160 (1) **Marking point 4** Peak at 160 approximately twice the height of the peaks at 158 and 162 (1) IGNORE **Small** peak at 80 which could be due to Br_2^{2+} (79-81) In MPs 1 and 2 penalise height difference once only		4

Question Number	Acceptable Answers	Reject	Mark
17(d)	$\left(\frac{47 \times 79 + 53 \times 81}{100}\right) = 80.06$ (1) (answer =) 80.1 (1) Correct final answer without working scores (2) No TE on incorrect expression	Incorrect units of mass/%	2

Question Number	Acceptable Answers	Reject	Mark
17(e)	The (m/e) value would be **halved**	Peak half as high	1

Question Number	Acceptable Answers	Reject	Mark
17(f)(i)	Any two from: Sample kept sealed/ tamper-proof (1) Sample stored and labelled clearly (1) Sample stored in preservative/sample tested immediately after being taken (1) Sample kept under temperature control (1) Monitor sample is being taken from named competitor (1) Check that other non-banned substances do not give similar mass spectrometry result (1) Analysis repeated (to confirm result)/ Multiple samples taken/ Sample divided into two and tested at different times/ locations (1) Container/equipment sterile/cleaned (1) Run a control sample/ compare to a sample without drugs (1) Sampling to take place immediately after event (1) Precautions need to be **actions/activities** that are carried out and not just a statement that something must or must not happen but **how** this is ensured or prevented There will likely be other suggestions in addition to those given above which can be given credit if they are reasonable actions	References to medication being taken Just 'no contamination'	2

Question Number	Acceptable Answers	Reject	Mark
17(f)(ii)	Health concerns/depression/bursts of anger/ acts of violence/heart attack/strokes/liver damage/masculine features in women/ harmful side effects Allow any suitable health concern	Just 'Fear of being banned/prosecuted' Just 'side effects'	1

Question Number	Acceptable Answers	Reject	Mark
17(g)	Any suitable use such as: RAM/RMM calculations/Relative isotopic mass calculations/Space probes/ Pharmaceutical purity/testing of new pharmaceuticals/Age of rocks from Helium content/ Identification of unknown substances/ Carbon dating/Radioactive dating	Alcohol testing C-12 dating	1

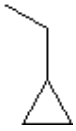
TOTAL FOR QUESTION 17 = 16 MARKS

Question Number	Acceptable Answers	Reject	Mark
18(a)	C_nH_{2n} ALLOW any letter for n	C_2H_{2n} C_nH_{2n+2}	1

Question Number	Acceptable Answers	Reject	Mark
18(b)	Either one of the following options: $CH_2CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$ 1,2-dibromoethane OR $CH_3CHCH_2 + Br_2 \rightarrow CH_3CHBrCH_2Br$ 1,2-dibromopropane **Marking Point 1** Correct reactant – ethene or propene (1) **Marking Point 2** Correct product from the number of carbon atoms in the reactant (1) **Marking Point 3** Correct name from the number of carbon atoms in the reactant (1) IGNORE punctuation on product ALLOW displayed/ skeletal formulae Penalise molecular formula of product only No TE on name if product incorrect		3

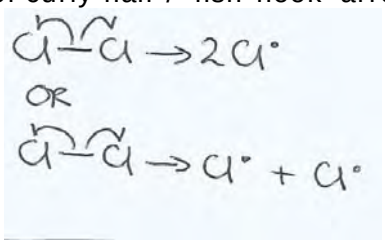
Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	(Error 1) the dipole on the chlorine molecule should be the other way round (1) (Error 2) the arrow should be going from the double bond (to the chlorine)/electrons move from the double bond to the chlorine (1) (Error 3) the chlorine should have a **negative** charge (and a lone pair) (1)	Chlorine molecule	3

Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	Because **tertiary** carbocation is more stable (than a primary carbocation) OR the positive carbon has more **positively-inductive**/ **electron-releasing** alkyl groups (to help stabilization than the other carbon of the double bond) IGNORE references to carbon only having three bonds or being electron deficient	Just Secondary carbocation	1

Question Number	Acceptable Answers	Reject	Mark
18(d)	 OR  (1)  (1)		2

Question Number	Acceptable Answers	Reject	Mark
18(e)	Same molecular formula/same number of atoms/same amount of each element but different (Structural) arrangement (of atoms)/ structure/ structural formulae/ displayed formulae/ skeletal formulae	 'in space'	1

Question Number	Acceptable Answers	Reject	Mark
18(f)(i)	Ultraviolet (radiation)/ UV (radiation) / (Sun) light	High temperature	1

Question Number	Acceptable Answers	Reject	Mark
18(f)(ii)	Cl-Cl →2Cl● OR Cl-Cl →Cl● + Cl● (1) Correct use of curly half / 'fish-hook' arrows (1)  Curly half arrows can start from anywhere on the bond and extend beyond the Cl The half arrows can be above or below the bond or a combination of the two.		2

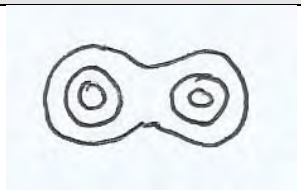
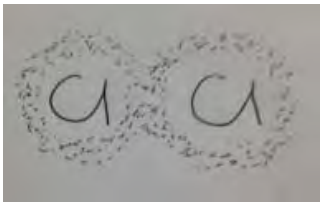
Question Number	Acceptable Answers	Reject	Mark
18(f)(iii)	(First propagation step) $C_4H_8 + Cl\bullet \rightarrow HCl + C_4H_7\bullet$ (1) (Second propagation step) $C_4H_7\bullet + Cl_2 \rightarrow C_4H_7Cl + Cl\bullet$ (1) The position of ● is not essential Penalise lack of ● once only	Reference to H/ H● scores (0)	2

Question Number	Acceptable Answers	Reject	Mark
18(f)(iv)	Homolytic/ homolytic fission/ homolytic bond fission		1

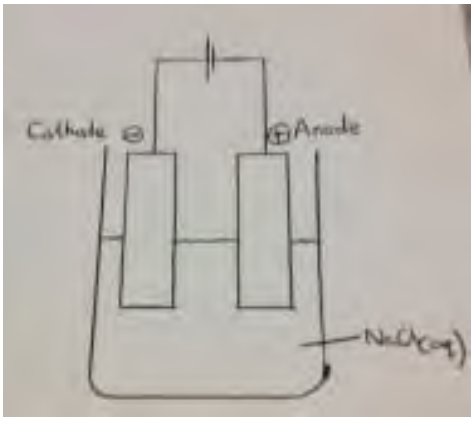
Question Number	Acceptable Answers	Reject	Mark
18(f)(v)	**Marking point 1** **Two** free radicals are combining/reacting with each other/suitable termination equation (1) **Marking point 2** The product is a stable species/No free radicals produced/ The product is not a free radical/ Concentration of free radicals decreases / lowers the number of radicals (1)		2

Question Number	Acceptable Answers	Reject	Mark
18(g)	Further substitution/polysubstitution can occur OR Other products such as $C_4H_6Cl_2$/ $C_4H_5Cl_3$ **COMMENT:** ALLOW Forms C_4Cl_8		1

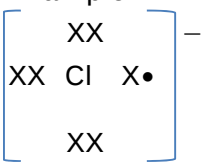
(TOTAL FOR QUESTION 18 =20 MARKS)

Question Number	Acceptable Answers	Reject	Mark
19(a)	 Drawing must have at least 1 circle around each chlorine atom OR  Random dots to indicate electron density around both chlorine atoms and a concentrated area between the atoms		**1**

Question Number	Acceptable Answers	Reject	Mark
19(b)	(Electrostatic) **attraction** between oppositely charged ions IGNORE comments on the formation of ions		**1**

Question Number	Acceptable Answers	Reject	Mark
19(c)	**Marking point 1** Either Diagram of U-tube / beaker with electrodes and sodium chloride solution OR Diagram of microscope slide with electrodes attached and either filter paper soaked in sodium chloride solution or dampened/wet filter paper on the top of the slide with the sample added (in the centre) (1) **Marking point 2** Suitable circuit (1) If electrodes labelled ± or named they must be consistent with the cell For example the following would not score this marking point:  **Marking point 3** Ammeter/ light bulb showing conductivity OR Chlorine (gas) evolved/ Test for chlorine/hydrogen (gas) evolved/Test for hydrogen (1) ALLOW any other reasonable electrolysis apparatus that would work to show ionic bonding. For MP3 if the electrode at which the gas is	Sodium electrode Sodium formed	**3**

	evolved is stated then it must have the correct sign or charge, although it is not necessary to name or give a sign for the electrode, ie chlorine at the electrode with a positive sign and hydrogen at the electrode with a negative sign. Use of other ionic compounds can only score MP2		

Question Number	Acceptable Answers	Reject	Mark
19(d)(i)	Correct dot and cross diagram with charge Example  ALLOW all dots or all crosses IGNORE any sodium dot and cross diagram		**1**

Question Number	Acceptable Answers	Reject	Mark
19(d)(ii)	(Isoelectronic example) $S^{2-}/S^{-2}/P^{3-}/P^{-3}$	$Si^{4-}/K^{+}/Ca^{2+}/Ar$	**1**

Question Number	Acceptable Answers	Reject	Mark
19(e)	**Marking point 1** Sodium conducts when solid (and liquid/molten) (1) **Marking point 2** Sodium chloride conducts when molten (and in solution but not as a solid) (1) **Marking point 3** Charge carriers in sodium are (delocalised) electrons but ions in sodium chloride OR Conductivity in sodium due to the movement of (delocalised) electrons but the movement of ions in sodium chloride (1)	Sodium in solution/dissolved	**3**

(TOTAL FOR QUESTION 19 = 10 MARKS)

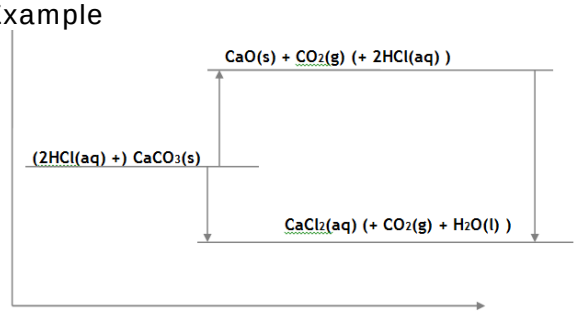
Question Number	Acceptable Answers	Reject	Mark
20(a)	(50 x 4.18 x 15.5 =) 3239.5 (J) IGNORE any sign given ALLOW 3.2395 kJ (units are essential for this answer)		**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)	(1.46 ÷ 56.1 =) 0.026025.. (mol) (1) (ΔH = 3.2395 ÷ 0.026025 = −124.47…) −124 kJ mol^{-1} (1) OR (1.46 ÷ 56.1 =) 0.0260 (mol) (1) (ΔH = 3.2395 ÷ 0.0260 = −124.596154) −125 kJ mol^{-1} (1) ALLOW the use of CaO = 56 = (−124.255 kJ mol^{-1}) −124 kJ mol^{-1} ALLOW TE from answer to (a)	+ sign	**2**

Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	Any three reasons from: Heat/energy loss (to the surroundings / to the apparatus)/ Lack of lid/no lid/ heat capacity of the cup not taken into account/heat capacity of the cup is not zero (1) Inaccuracy of thermometer/temperature readings (1) Impure CaO/Absorbed moisture from the air (1) Heat capacity is not 4.18/ the mass of solution is not 50 g/ density of solution is not 1 g cm^{-3} (1) IGNORE non-standard conditions/ stirring/human error/incomplete transfer of solid	Incomplete reaction Just 'heat lost to the thermometer'	**3**

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	**Marking point 1** (Q=(250 x 4.18 x 25) = 26125(J) OR (26125 ÷ 1000 =) 26.125 (kJ) (1) **Marking point 2** (n = 26.125 ÷ 196.8 =) 0.132749 (mol) (1) **Marking point 3** Mass = (0.132749 x 56.1 =) 7.4472189 = 7.45 (g) (1) ALLOW (0.132749 x 56 =) 7.433944 = 7.43 (g) Correct answer alone scores 3 marks	7.5	3

Question Number	Acceptable Answers	Reject	Mark
20(d)(i)	**Marking point 1** Arrow downwards from $CaCO_3$ to the box, with 2HCl((aq)) alongside (1) **Marking point 2** Correct entities and states in box $CaCl_2(aq) + H_2O(l) + CO_2(g)$ (1) **Marking point 3** Correct use of Hess' Law ($\Delta H = \Delta H_{CaCO3} - \Delta H_{CaO}$) e.g. $-18.8 - -196.8 =$ (1) **Marking point 4** $\Delta H = +178$(kJ mol^{-1}) (1)		4

Question Number	Acceptable Answers	Reject	Mark
20(d)(ii)	Products on line below $CaCO_3(s)$ with both arrows going down from $CaCO_3$ and CaO Example  ALLOW the word 'products' for formulae		1

(Total for Question 20 = 14 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 27 May 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/6/5/

P 4 6 6 6 2 A 0 1 2 0

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Cold water fish require a minimum of 8 parts per million by mass (ppm) of oxygen dissolved in water.

The minimum mass of oxygen required in 1 kg of water is

☒ **A** 8×10^{-6} g

☒ **B** 8×10^{-3} g

☒ **C** 8×10^{-2} g

☒ **D** 8×10^{-1} g

(Total for Question 1 = 1 mark)

2 Calculate the total number of **atoms** in 8.5 g of CH_2Cl_2.

DATA: Molar mass of CH_2Cl_2 = 85 g mol^{-1}.

Avogadro constant = 6.0×10^{23} mol^{-1}

☒ **A** 1.8×10^{23}

☒ **B** 2.4×10^{23}

☒ **C** 3.0×10^{23}

☒ **D** 3.0×10^{24}

(Total for Question 2 = 1 mark)

3 50 cm^3 of hydrogen is mixed with 25 cm^3 of chlorine. The gases react as shown in the equation below.

$$H_2(g) + Cl_2(g) \rightarrow 2HCl(g)$$

What is the total volume of gas present at the end of the reaction?

[All gas volumes are measured at the same temperature and pressure.]

☒ **A** 75 cm^3

☒ **B** 100 cm^3

☒ **C** 125 cm^3

☒ **D** 150 cm^3

(Total for Question 3 = 1 mark)

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4 Sodium hydrogencarbonate decomposes on heating.

$$2NaHCO_3(s) \rightarrow Na_2CO_3(s) + CO_2(g) + H_2O(l)$$

What is the maximum volume of carbon dioxide, in dm^3, which could be obtained by heating 0.25 mol sodium hydrogencarbonate?

The gas volume is measured at room temperature and pressure when the molar volume of a gas = 24 $dm^3\,mol^{-1}$.

☒ **A** 3

☒ **B** 6

☒ **C** 12

☒ **D** 24

(Total for Question 4 = 1 mark)

5 An experiment was carried out to measure the enthalpy change of the following reaction.

$$NaOH(aq) + HCl(aq) \rightarrow NaCl(aq) + H_2O(l)$$

50 cm^3 of hydrochloric acid was mixed with 50 cm^3 of sodium hydroxide solution. Each solution contained 0.10 mol solute. The temperature rise was 12 °C.

Energy transferred (J) = mass of solution × 4.2 × change in temperature

Assume the density of all solutions is 1.0 g cm^{-3}.

What is the enthalpy change of the reaction in kJ mol^{-1}?

☒ **A** $-\frac{50 \times 4.2 \times 12}{0.1 \times 1000}$

☒ **B** $-\frac{50 \times 4.2 \times 12}{0.2 \times 1000}$

☒ **C** $-\frac{100 \times 4.2 \times 12}{0.1 \times 1000}$

☒ **D** $-\frac{100 \times 4.2 \times 12}{0.05 \times 1000}$

(Total for Question 5 = 1 mark)

6 In the synthesis of ammonia, 56.0 g nitrogen was reacted with excess hydrogen.

$$N_2(g) + 3H_2(g) \rightarrow 2NH_3(g)$$

The mass of ammonia produced was 6.00 g.

What is the percentage yield of ammonia?

☒ **A** 5.66

☒ **B** 8.82

☒ **C** 9.10

☒ **D** 10.7

(Total for Question 6 = 1 mark)

7 Which of the following has the smallest ionic radius?

☒ **A** O^{2-}

☒ **B** F^-

☒ **C** Na^+

☒ **D** Mg^{2+}

(Total for Question 7 = 1 mark)

8 Magnesium chloride crystals were prepared using the following reaction.

$$2HCl(aq) + MgO(s) \rightarrow MgCl_2(aq) + H_2O(l)$$

(a) The ionic equation for this reaction is

(1)

☒ **A** $2Cl^-(aq) + Mg^{2+}(s) \rightarrow MgCl_2(aq)$

☒ **B** $2Cl^-(aq) + MgO(s) \rightarrow MgCl_2(aq) + O^{2-}(l)$

☒ **C** $2H^+(aq) + 2Cl^-(aq) + MgO(s) \rightarrow Mg^{2+}(Cl^-)_2(aq) + H_2O(l)$

☒ **D** $2H^+(aq) + MgO(s) \rightarrow Mg^{2+}(aq) + H_2O(l)$

(b) The amount of hydrochloric acid used was 0.10 mol. Which of the following solutions of hydrochloric acid contains this amount of HCl?

(1)

☒ **A** 100 cm^3 of 0.10 mol dm^{-3}

☒ **B** 40 cm^3 of 0.25 mol dm^{-3}

☒ **C** 25 cm^3 of 0.40 mol dm^{-3}

☒ **D** 20 cm^3 of 5.00 mol dm^{-3}

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(c) An **excess** of magnesium oxide was reacted with the 0.10 mol of hydrochloric acid.

Which of the following is the **smallest** mass which would provide an excess of magnesium oxide?

Molar mass of MgO = 40.3 g mol^{-1}

(1)

☒ **A** 1.50 g

☒ **B** 2.50 g

☒ **C** 3.00 g

☒ **D** 5.00 g

(d) What is the first step in obtaining pure hydrated crystals of magnesium chloride from the resulting reaction mixture?

(1)

☒ **A** Heating the mixture to concentrate it.

☒ **B** Allowing the mixture to evaporate slowly.

☒ **C** Filtering the mixture.

☒ **D** Distilling the mixture.

(e) Use the data below to calculate the number of moles of water of crystallization in each mole of hydrated magnesium chloride.

Substance	Molar mass / g mol^{-1}
Magnesium chloride	95.1
Hydrated magnesium chloride	203.1

(1)

☒ **A** 2

☒ **B** 4

☒ **C** 6

☒ **D** 8

(Total for Question 8 = 5 marks)

9 What is the equation for the lattice energy of magnesium chloride?

- ☒ **A** $Mg(s) + Cl_2(g) \rightarrow MgCl_2(s)$
- ☒ **B** $Mg^{2+}(s) + 2Cl^-(g) \rightarrow MgCl_2(s)$
- ☒ **C** $Mg^{2+}(g) + 2Cl^-(g) \rightarrow MgCl_2(s)$
- ☒ **D** $Mg^{2+}(g) + 2Cl^-(g) \rightarrow MgCl_2(g)$

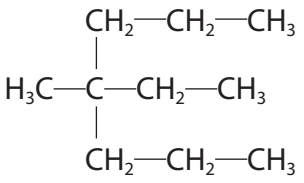
(Total for Question 9 = 1 mark)

10 A compound has the composition by mass of 54.5% C, 9.1% H and 36.4% O.
What is its empirical formula?

- ☒ **A** C_2H_2O
- ☒ **B** C_2H_4O
- ☒ **C** C_4H_9O
- ☒ **D** C_6HO_4

(Total for Question 10 = 1 mark)

11 What is the IUPAC name of the following hydrocarbon?



- ☒ **A** 2,2-dipropylbutane
- ☒ **B** 4-methyl-4-propylhexane
- ☒ **C** 2-ethyl-2-propylpentane
- ☒ **D** 4-ethyl-4-methylheptane

(Total for Question 11 = 1 mark)

12 Which of the following shows geometric isomerism?

- ☒ **A** propene
- ☒ **B** but-1-ene
- ☒ **C** but-2-ene
- ☒ **D** 2,3-dimethylbut-2-ene

(Total for Question 12 = 1 mark)

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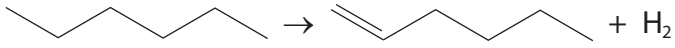
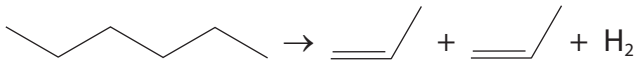
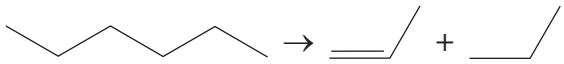
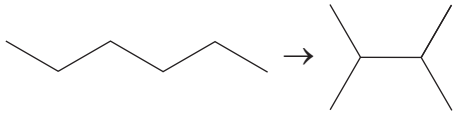
13 Which of the following is a reforming reaction?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 13 = 1 mark)

14 In the reaction of methane with chlorine, ultraviolet light causes

☒ **A** homolytic fission of the Cl—Cl bond in chlorine molecules.

☒ **B** heterolytic fission of the Cl—Cl bond in chlorine molecules.

☒ **C** homolytic fission of the C—H bond in methane molecules.

☒ **D** heterolytic fission of the C—H bond in methane molecules.

(Total for Question 14 = 1 mark)

15 In the mechanism of the reaction of methane with chlorine to form chloromethane, which of the following is a propagation step?

☒ **A** $\bullet CH_3 + \bullet Cl \rightarrow CH_3Cl$

☒ **B** $\bullet CH_3 + Cl_2 \rightarrow CH_3Cl + \bullet Cl$

☒ **C** $CH_4 + \bullet Cl \rightarrow CH_3Cl + \bullet H$

☒ **D** $\bullet CH_3 + Cl_2 \rightarrow \bullet CH_2Cl + HCl$

(Total for Question 15 = 1 mark)

16 The empirical formula of poly(ethene) is

☒ **A** CH

☒ **B** CH_2

☒ **C** C_2H_4

☒ **D** C_nH_{2n}

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

17 A mass spectrometer can be used to measure relative isotopic masses.

(a) State the meaning of the term **isotopes**.

(1)

.....

.....

(b) (i) In a mass spectrometer, a sample of the vapour of an element is ionized. State how this ionization is carried out.

(1)

.....

.....

(ii) Complete the equation showing the simplest ionization of a vaporised element **M**.

(1)

M(g) $\rightarrow$

(iii) How are the ions accelerated in the mass spectrometer?

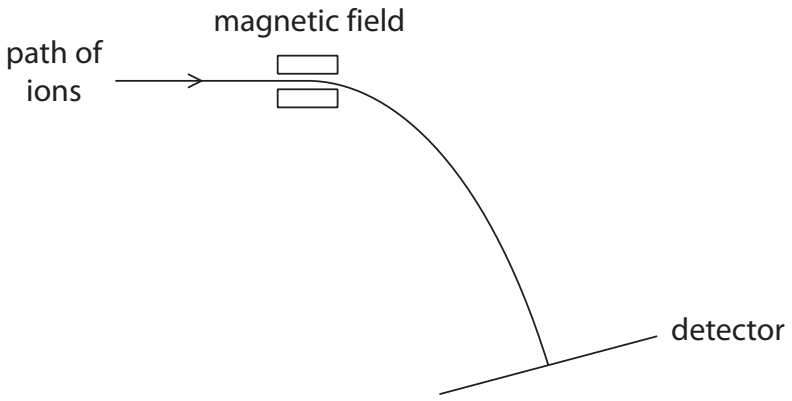
(1)

.....

.....

(iv) Ions with the same charge and travelling with the same velocity are then passed through a magnetic field.

(1)



The path of one ion is shown.
Add a line to the diagram to show the path of a **lighter** ion as it passes through the magnetic field and travels to the detector.

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(c) A sample of silicon is analysed in a mass spectrometer.

Relative isotopic mass	Relative abundance
28	92·17
29	4·71
30	3·12

Calculate the relative atomic mass of silicon, showing your working.
Give your answer to **four** significant figures.

(2)

(d) A high resolution mass spectrometer measures masses to **four** decimal places.
The relative molecular mass of a compound is found to be 84.0581.

The relative atomic mass of an oxygen atom, ^{16}O, is 15.9949

The relative atomic mass of a hydrogen atom, ^{1}H, is 1.0079

Use these data to deduce whether the compound is C_6H_{12} or C_5H_8O. Show your working, and state the assumption you make.

(3)

Assumption

.....

.....

(e) A helium mass spectrometer is an instrument used to detect leaks in containers.

A sealed container filled with helium is placed in a vacuum chamber. Any helium leaking out of the container is detected by the mass spectrometer.

Suggest **one** reason that makes helium suitable for this purpose, other than its lack of reactivity.

(1)

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(Total for Question 17 = 11 marks)

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18 This question is about the elements aluminium and magnesium.

(a) Complete the electronic configuration for an **atom** of aluminium.

(1)

$1s^2$.....

(b) Complete the table to show the composition of an aluminium ion, Al^{3+}.

(1)

Subatomic particle	Number of particles in Al^{3+}
proton	
neutron	
electron	

(c) The table below shows the first four ionization energies of aluminium.

(i) Complete the table by identifying the orbital from which each electron is removed.

(2)

	First ionization energy	Second ionization energy	Third ionization energy	Fourth ionization energy
Ionization energy / kJ mol^{-1}	578	1817	2745	11 578
Orbital				

(ii) Write the equation, including state symbols, which represents the second ionization energy of aluminium.

(2)

*(iii) Explain why the second ionization energy of an element is always greater than the first ionization energy.

(2)

*(iv) Explain why the difference between the third and fourth ionization energies of aluminium is much larger than the difference between the first and second ionization energies.

(2)

(d) Aluminium is a silvery metal with a melting temperature of 933 K.

(i) Draw a labelled diagram of the bonding in aluminium.

(2)

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(ii) The atomic number of magnesium is one less than aluminium. Would you expect magnesium to have a higher or lower melting temperature than aluminium? Justify your answer.

(2)

(iii) Draw the dot and cross diagram for magnesium chloride, $MgCl_2$.

Show the outer electrons only.

(2)

*(iv) Aluminium chloride has more covalent character than magnesium chloride.

Explain what this statement means. By considering the physical properties of these two chlorides, suggest **one** piece of evidence showing that aluminium chloride has more covalent character than magnesium chloride.

(3)

(Total for Question 18 = 19 marks)

19 Cordless hair-styler use 2-methylpropane as a fuel. The 2-methylpropane reacts with oxygen on the surface of a heated catalyst.

$$C_4H_{10}(g) + 6½O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$$

(a) Draw the **skeletal** formula of 2-methylpropane.

(1)

(b) When the hair-styler is switched on, the catalyst is heated using a battery. Suggest why the battery is not needed after the catalyst has been heated initially.

(2)

(c) The standard enthalpy changes of formation for the three compounds are:

Compound	Standard enthalpy of formation / kJ mol^{-1}
$C_4H_{10}(g)$	–134.5
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8

(i) The standard enthalpy change of formation of $H_2O(g)$ is –241.8 kJ mol^{-1}. Explain why this is less negative than the standard enthalpy change of formation of $H_2O(l)$.

(1)

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(ii) Use the data in the table to calculate the standard enthalpy change of combustion of 2-methylpropane in kJ mol^{-1}.

Show your method, which may involve the use of a Hess cycle.

Include a sign and units in your answer.

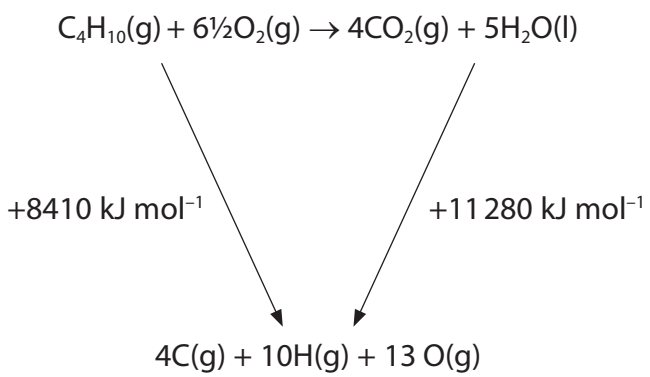
(3)

(iii) A refill canister for the cordless hair-styler holds 15 g of 2-methylpropane.

Calculate the energy in kJ which can be obtained from one canister.

(2)

(d) The enthalpy change of the reaction can also be calculated using the cycle below.



(i) Calculate the enthalpy change of the reaction using this cycle.

(1)

(ii) The enthalpy change of vaporization of water was one piece of data used to calculate the enthalpy changes shown beside the arrows in the cycle. What other information was needed?

(1)

.....

.....

(Total for Question 19 = 11 marks)

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20 Propene is an alkene which can be produced by cracking some of the hydrocarbons in crude oil.

(a) Draw a dot and cross diagram showing the bonding in propene.
Show outer electrons only.

(2)

(b) (i) Propene is one product of the cracking of decane, $C_{10}H_{22}$.

Write the equation for the reaction in which one mole of decane is cracked to produce one mole of ethene, one mole of propene and one other product.
State symbols are not required.

(1)

(ii) A synthetic rubber can be made by polymerizing a mixture of ethene and propene.

Draw the structural formula of the repeat unit of this polymer which forms from one molecule of each alkene.

(2)

(c) Propene is also used to make propane-1,2-diol. Give the reagents and colour change when this product is made at room temperature.

(3)

Reagents .....

Colour change from ..... to .....

(d) The reaction of propene with bromine **water** is used as a test for the carbon-carbon double bond.

State the colour change in this test.

Draw the displayed formula of the organic product and give its name.

(3)

Colour change from ..... to .....

Displayed formula of product

Name .....

(e) Write the mechanism for the reaction of propene with **hydrogen bromide** to give the major product. Include relevant dipoles.

(4)

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*(f) Molecules of the element bromine, Br_2, are not polar. Explain how **bromine** acts as an electrophile when it reacts with propene.

(2)

(g) In the United States of America, large deposits of shale gas have been discovered. This gas is trapped in rocks and can be extracted by "fracking" which involves breaking up the rock with water under pressure.

Shale gas typically contains about 90% methane, mixed with about 3% ethane, 0.6% propane, 0.2% butane and 0.2% pentane. The rest is hydrogen, nitrogen and carbon dioxide.

Suggest how the use of shale gas may affect the relative amounts of poly(ethene) and poly(propene) which are produced in the USA and justify your answer.

(2)

(Total for Question 20 = 19 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

Summer 2016

Pearson Edexcel
International Advanced Level
in Chemistry (WCH01) Paper 01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

WCH01 June 2016 Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		**(1)**

Question Number	Correct Answer	Reject	Mark
2	C		**(1)**

Question Number	Correct Answer	Reject	Mark
3	A		**(1)**

Question Number	Correct Answer	Reject	Mark
4	A		**(1)**

Question Number	Correct Answer	Reject	Mark
5	C		**(1)**

Question Number	Correct Answer	Reject	Mark
6	B		**(1)**

Question Number	Correct Answer	Reject	Mark
7	D		**(1)**

Question Number	Correct Answer	Reject	Mark
8a	D		**(1)**

Question Number	Correct Answer	Reject	Mark
8b	D		**(1)**

Question Number	Correct Answer	Reject	Mark
8c	B		**(1)**

Question Number	Correct Answer	Reject	Mark
8d	C		**(1)**

Question Number	Correct Answer	Reject	Mark
8e	C		**(1)**

Question Number	Correct Answer	Reject	Mark
9	C		**(1)**

Question Number	Correct Answer	Reject	Mark
10	B		**(1)**

Question Number	Correct Answer	Reject	Mark
11	D		**(1)**

Question Number	Correct Answer	Reject	Mark
12	C		**(1)**

Question Number	Correct Answer	Reject	Mark
13	D		**(1)**

Question Number	Correct Answer	Reject	Mark
14	A		**(1)**

Question Number	Correct Answer	Reject	Mark
15	B		**(1)**

Question Number	Correct Answer	Reject	Mark
16	B		**(1)**

(Total for Section A = 20 marks)

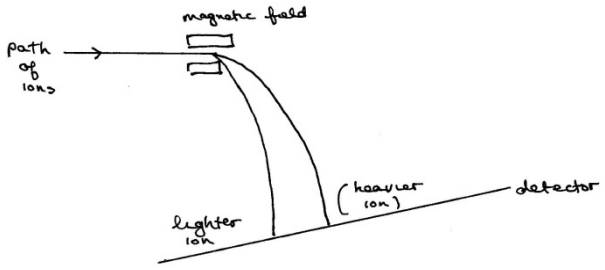
Section B

Question Number	Acceptable Answers	Reject	Mark
17(a)	Atoms of the **same** element / atomic number / proton number **and different** mass number / neutron number / nucleon number ALLOW Elements / they / isotopes have the same atomic number …etc Atomic mass for mass number IGNORE references to electrons	Molecule for atom Atomic mass number	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	High energy/fast moving/high speed electrons hit atoms/molecules/elements/sample (and knock electrons out.) ALLOW (Use) an electron gun/beam/stream Bombard with electrons IGNORE References to ionizing / forming (positive) ions Just an equation, e.g., $M(g) \rightarrow M^{+}(g) + e$		**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	$M(g) + e^- \rightarrow M^+(g) + 2e^-$ ALLOW $M(g) \rightarrow M^+(g) + e^-$ $M(g) - e^- \rightarrow M^+(g)$ ALLOW Use of $Mg^+(g)$ for $M^+(g)$ IGNORE omission of minus sign on electron state symbol on electron Rewritten M(g) on LHS Leading '1' before any charges e.g. $M(g)^{1+}$		**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	(With an) electric field / (negatively) charged plates (with slits in them) ALLOW Oppositely/alternatively charged plates IGNORE Electric plates	(Electro)magnetic field Positively charged plates Charged slits	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iv)	Curved path showing lighter ion deflected more  ALLOW dotted line additional parallel path entering the magnet with correct deflection lines that do not reach but would extrapolate to detector on left of original beam	Straight line Lines originating from the magnet Lines deflected before passing through the magnet Lines which would not hit the detector	**(1)**

Question Number	Acceptable Answers	Reject	Mark
17(c)	$\frac{((28\times92.17) + (29\times4.71) + (30\times3.12))}{100}$ (1) (= 28.1095) = **28.11** (1) Final answer without working scores (2) IGNORE units	Answers not to 4sf (second mark)	**(2)**

Question Number	Acceptable Answers	Reject	Mark
17(d)	**MP2 cannot be awarded without any attempt to do a calculation for MP1** **MP1** (6x12 + 12x1.0079) = 84.0948 OR (5x12 + 8x1.0079 + 15.9949) = 84.0581 (1) **MP2** So mass matches for C_5H_8O / doesn't match for C_6H_{12} (1) OR **MP1** Mass of 12H =12.0948 (1) **MP2** Remaining mass = 71.9633, so not exactly equal to 6C (1) OR **MP1** Mass of H_8O = 24.0581 (1) **MP2** Remaining mass = 60.0000 so exactly equal to 5C (1) **MP3** Assumption: (one atom of) C=12(.0000) / has mass (exactly) 12 ALLOW Other isotopes of H and/or O are not present (1) IGNORE Any units in calculations	Just use of C = 12 without indicating as an assumption	**(3)**

Question Number	Acceptable Answers	Reject	Mark
17(e)	Small atomic radius / small atom ALLOW Diffuses easily Not (significantly) present in air/ low density / less dense than air Non-toxic IGNORE Low mass / lighter than air / light(weight) / references to inertness or non-flammability / availability / gas at room temperature / monatomic / no isotopes / answers relating to cost	Small molecule	**(1)**

(Total for question 17 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
18(a)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^1$ ALLOW Upper case, subscripts, P orbitals divided into x, y, z eg: $2s^2\ 2p_x^2\ 2p_y^2\ 2p_z^2\ 3s^2\ 3p_x^1$ IGNORE $1s^2$ if written again		**(1)**

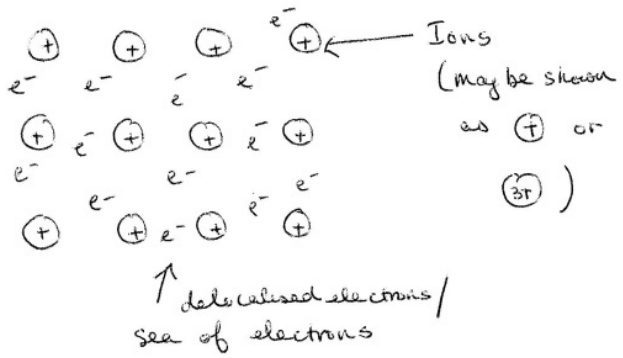
Question Number	Acceptable Answers		Reject	Mark
18(b)	protons	13		**(1)**
	neutrons	14		
	electrons	10		
	All three numbers needed for mark IGNORE any working out in table			

Question Number	Acceptable Answers				Reject	Mark
18(c)(i)	First IE	Second IE	Third IE	Fourth IE		**(2)**
	578	1817	2745	11578		
	3p	3s	3s	2p		
	$3p/\ 3p_x$ and **both** 3s (1) $2p/\ 2p_x / 2p_y / 2p_z$ (1) ALLOW p s s p for (1) mark					
	$3p^1$	$3s^2$	$3s^1$	$2p^6$		
	for (2) marks					

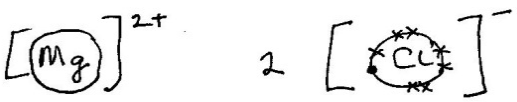
Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	Al^{+} (g) $\rightarrow$ Al^{2+}(g) + e^{-} OR Al^{+} (g) — e^{-} $\rightarrow$ Al^{2+}(g) **MP1** Balanced equation (1) **MP2** (g) symbols This is dependent on the equation involving aluminium even if electrons/charges are wrong (1) NOTE If correct equation for a second ionization using the wrong symbol is given with correct state symbols allow (1) max IGNORE lack of minus sign on electron / any state symbols for electron		**(2)**

Question Number	Acceptable Answers	Reject	Mark
***18(c)(iii)**	**MP1** Second electron is closer (to nucleus) / electron is removed from a positive ion / 1+ ion is smaller than atom ALLOW More protons than electrons (in ion) Effective nuclear charge greater (in ion) (1) **MP2** So greater attraction between electron and nucleus/protons OR More energy required to overcome attraction between electron and nucleus OR Less repulsion between electrons (1) IGNORE References to high charge-density in 1+ ion References to shielding / last electron / paired electrons / electron shell stability	Just 'more energy required to remove electron' / 'harder to remove electron' NOTE "Second I.E. loses 2 electrons" - scores **(0)** overall 1+ ion has more protons than atom - scores **(0)** overall	**(2)**

Question Number	Acceptable Answers	Reject	Mark
***18(c)(iv)**	**MP1 for** similarity between first and second electrons lost; 1st and 2nd (electrons are removed) from the same/3rd **shell** OR First (electron lost from) **3**p (subshell/orbital) **and** second (electron lost from) **3**s (subshell/orbital) **(1)** **MP2 for** difference between third and fourth electrons lost; Third (electron lost from) **3**s (subshell/orbital) **and** fourth (electron lost from) **2**p (subshell/orbital) OR (compared with the 3rd electron) the 4th electron is removed from a **shell** closer to the nucleus / from a new/lower/different **shell** / from a **shell** with less shielding **(1)** **If no other mark awarded**, allow **(1)** for: three electrons in the 3rd **shell** of Al **and** the fourth electron is removed from 2nd **shell** IGNORE References to charges on ion	1st and 2nd from same subshell	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(d)(i)	 Regular lattice of + OR 3+ (can be written in ions or labelled) ALLOW Ions which touch (1) Delocalised electrons/sea of electrons including some between ions, shown and labelled (1)	Protons / nucleus / atoms	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(d)(ii)	(Mg) lower (melting temperature) because *(no mark for this alone)* **and** any **two** from: (Mg) ion charge is less / (Mg) ion (radius) is larg**er** / (Mg) ion charge density is less / (any mention of) Mg^{2+} **and** Al^{3+} (1) (Mg) few**er** delocalised/free electrons / small**er** sea of electrons / one less electron donated (1) (Mg) weak**er** (forces of) attraction between (+ve) **ions** and (delocalised/free electrons / sea of electrons) / (Mg) **ions** are held less tightly to the sea of electrons / metallic bond is weaker (1)	"Mg has a higher melting point" scores **(0)** overall Atomic radius (of Mg) is larger References to ionic bonds / covalent bonds / intermolecular forces score (0) overall	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(d)(iii)	 **First mark** Correct dot and cross diagrams with 2+ on Mg and – / 1- / -1 charge on (both if drawn) Cl (1) ALLOW No electrons or 8 electrons on outer shell of Mg Dots or crosses or other valid symbols for electrons Paired or unpaired electrons Diagrams without brackets **Second mark** Ratio of one Mg to two Cl (ions) **(1)** ALLOW Number of Cl shown as 2 in front of a Cl, or as a subscript after the Cl The ratio mark even if no charges are shown (penalised in 1st mark) IGNORE any inner electrons ALLOW max 1 for incorrect symbols if charges and ratio are correct	Covalent bonding – scores (0) overall	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(d)(iv)	**MP1** Al (cat)ion polarises chloride / distorts chloride electron cloud OR Al (cat)ion has a greater polarising ability (than Mg ion) OR Chloride ion/anion **in $AlCl_3$** is distorted (by aluminium (ion)) **(1)** **MP2** EITHER Electrons are partly shared (by Al and Cl) OR (In $AlCl_3$) orbital overlap occurs OR (aluminium and chloride) ions are not totally discrete/separate **(1)** IGNORE fully shared electrons References to ionic size and charge References to atomic radius Ionic bond strength/stability Polarisation of $AlCl_3$ / polarisation power of $AlCl_3$ **MP3** Melting/boiling temperature (of $AlCl_3$) is lower (than that of $MgCl_2$) OR ($AlCl_3$) sublimes / **Molten** salt/$AlCl_3$ does not conduct electricity / cannot be electrolysed ALLOW BH cycle / experimental LE value greater / more negative / more exothermic than theoretical LE value of $AlCl_3$ ($AlCl_3$) forms a dimer ($AlCl_3$) forms dative covalent/coordinate bonds (with electron pair donors) Magnesium chloride solution is a better conductor than aluminium chloride solution (1)	References to Al / Mg or Cl atoms / chlorine	**(3)**

(Total for question 18 = 19 marks)

Question Number	Acceptable Answers	Reject	Mark
19(a)	 ALLOW Any orientation IGNORE bond angles, displayed formulae		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(b)	Combustion reaction is exothermic/ evolves heat/ releases energy (1) This keeps catalyst hot (1) IGNORE Activation energy		**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	The change $H_2O(g) \rightarrow H_2O(l)$ releases energy/ is exothermic / forms hydrogen bonds OR Extra heat is evolved when $H_2O(l)$ forms ALLOW reverse argument weaker intermolecular forces between $H_2O(g)$ than $H_2O(l)$		**(1)**

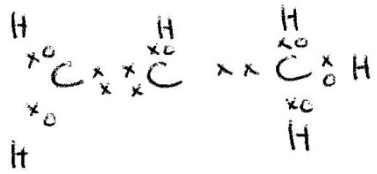
Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Look at final answer Correct answer scores 3 ((4x—393.5 + 5x —285.8) —(—134.5)) = —2868.5/ —2869/ —2870 / —2900 (kJ mol^{-1}) (3) ALLOW Correct value with incorrect sign and /or incorrect unit (2) Correct expression written but calculator error for final value (2) Incorrect answer with correct Hess cycle $C_4H_{10}(g) + 6½O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ Elements / $4C(s) + 5H_2(g) + 6½O_2(g)$ (1) IGNORE SF except 1 NOTE -544.8 (kJ mol^{-1}) scores 1 mark (misses x5 and x4 in expression) -2648.5 (kJ mol^{-1}) scores 2 marks (uses -241.8 instead of -285.8) Answers worth (2) because of one error: (+)279.5 —10.5 —3137.5 —1688.0 —1725.3	-3000	**(3)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	ALLOW TE from 19c(ii) **First mark** – amount of 2-methylpropane (=15/ 58) = 0.2586206/ 0.259 (mol) (1) **Second mark** - energy produced = (0.2586206 x 2868.5) =741.85345 (kJ) OR (0.259 x 2868.5) =742.94 (kJ) (1) IGNORE SF except 1 SF – sign. ALLOW TE from first to second mark Use of rounded values of amount or ΔH for example use of 0.26 mol gives 750 (kJ). Final answers may need to be checked individually.	0.3 / 0.25	**(2)**

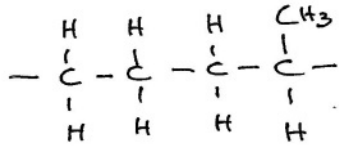
Question Number	Acceptable Answers	Reject	Mark
19(d)(i)	ΔH = (-11280 –(-8410)) = **–**2870 (kJ mol^{-1}) IGNORE units		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19d(ii)	Bond enthalpies / bond energies (of any or all of C-C, C-H, O=O, C=O, H-O) ALLOW Enthalpy change of bond breaking Enthalpy changes of atomization (of any or all of methylpropane / carbon dioxide/water/oxygen)	Bond enthalpies of compounds Enthalpy change of: Formation Combustion Specific heat capacity	**(1)**

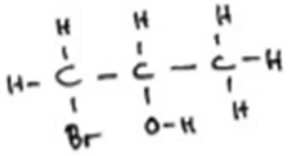
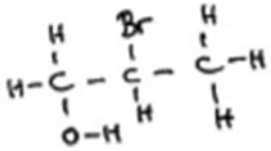
(Total for question 19 = 11 marks)

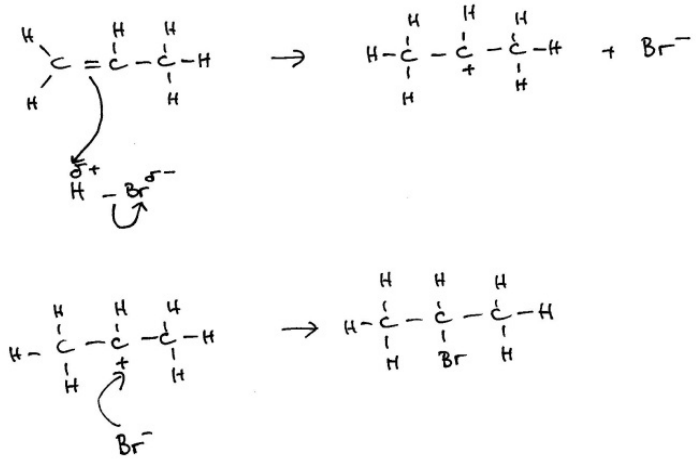
Question Number	Acceptable Answers	Reject	Mark
20(a)	 Electrons in C=C double bond within a hydrocarbon (1) Rest of molecule correct (1) ALLOW All dots / crosses		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	$C_{10}H_{22} \rightarrow C_2H_4 + C_3H_6 + C_5H_{12}$ ALLOW Other types of correct formulae IGNORE state symbols even if incorrect any suggested conditions	H_2	**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	 OR —$CH_2CH_2CH_2CH(CH_3)$— **One** Methyl side-group on a carbon chain (1) **4**-Carbon backbone complete with hydrogens and continuation bonds (1) IGNORE Square brackets and n ALLOW (1) mark for both correct repeat units drawn separately for poly(ethene) **and** poly(propene) if no other marks awarded	Just poly(propene) Just poly(ethene)	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(c)	**MP1** Potassium manganate((VII)) / potassium permanganate / $KMnO_4$ (1) **MP2 depends on mention of manganate** H_2SO_4 ALLOW Acidified / acid / H^+ (1) **MP3 depends on mention of manganate** (Colour change from) purple / pink (to) colourless (1) OR **MP2 depends on mention of manganate** KOH / NaOH (1) **MP3 depends on mention of manganate and alkali** Colour change from purple to green/brown (ppt) (1)	Incorrect oxidation numbers HCl To brown Just ‘alkaline’	**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(d)	Observation: (colour change from) brown/ yellow/orange/red-brown (to) colourless (1) **EITHER**  (1) 1-bromopropan-2-ol / 1-bromo-2-hydroxypropane (1) OR  (1) 2-bromopropan-1-ol / 2-bromo-1-hydroxypropane (1) ALLOW Skeletal or structural formula for 2nd mark TE in third mark for "1,2-dibromopropane" if this has been drawn, but this compound does not score the second mark	Red Bond directly from C to H in OH if displayed	**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(e)	 **MP1** Dipole on H-Br (1) **MP2** Curly arrow from double bond to H **and** curly arrow from H—Br bond to Br or just beyond (1) **MP3** Correct carbocation intermediate (1) **MP4** Arrow from anywhere on Br^- to C+ **and** product (1) ALLOW formation of 1-bromopropane following from + on C1 if other arrows correct (max 3) A fully correct electrophilic addition mechanism using Br_2 scores (2) marks Electrophilic addition mechanism using Br_2 with 1 error scores (1) mark	C+ with 4 bonds drawn Br●	**(4)**

Question Number	Acceptable Answers	Reject	Mark
20(f)	**MP1** (Pi electrons in) double bond repel electrons in Br-Br / bromine ALLOW Region of high electron density repels, etc (1) **MP2** EITHER Produces a dipole / produces δ+ (and δ-) / polarises molecule ALLOW Diagram showing the dipole OR So electron pair (from C=C) / electrons can be accepted (1)	brom**ide** / partial positive brom**ide**	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(g)	MP1 EITHER Production of both polymers will increase (as shale gas supplies more ethane and propane) OR (Relatively) more poly(ethene) than poly(propene) will be produced because there is more ethane in the shale gas (than propane) (1) MP2 EITHER More ethene is produced than propene (by cracking alkanes in shale gas) OR Ethene can be produced from ethane/propane/butane/pentane OR Propene can be produced from propane/butane/pentane/fewer alkanes OR Propene cannot be produced from ethane (1)		**(2)**

(Total for question 20 = 19 marks)

TOTAL FOR PAPER = 80 MARKS

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Write your name here

Surname	Other names

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Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 27 May 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P46656A

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3/6/6/3/1/

P 4 6 6 5 6 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The mass of magnesium ions in 1 kg of sea water is 1.3 g.
The concentration in parts per million (ppm) is

☒ **A** 1.3×10^{6}

☒ **B** 1.3×10^{3}

☒ **C** 1.3×10^{-3}

☒ **D** 1.3×10^{-6}

(Total for Question 1 = 1 mark)

2 Calculate the total number of **ions** in 7.41 g of calcium hydroxide, $Ca(OH)_2$.

The molar mass of calcium hydroxide is 74.1 g mol^{-1}.

The Avogadro constant is 6.0×10^{23} mol^{-1}.

☒ **A** 6.0×10^{22}

☒ **B** 1.2×10^{23}

☒ **C** 1.8×10^{23}

☒ **D** 3.0×10^{23}

(Total for Question 2 = 1 mark)

3 Which of the following has the highest melting temperature?

☒ **A** Hg

☒ **B** K

☒ **C** $C_{10}H_{22}$

☒ **D** SiO_2

(Total for Question 3 = 1 mark)

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4 Which of these has a dative covalent bond?

☒ **A** NH_3

☒ **B** OH^-

☒ **C** H_2O

☒ **D** H_3O^+

(Total for Question 4 = 1 mark)

5 What is the equation for the first electron affinity of sulfur?

☒ **A** $S(s) + e^- \rightarrow S^-(g)$

☒ **B** $S(g) + e^- \rightarrow S^-(g)$

☒ **C** $S(s) \rightarrow S^+(g) + e^-$

☒ **D** $S(g) \rightarrow S^+(g) + e^-$

(Total for Question 5 = 1 mark)

6 100 cm^3 of hydrogen is mixed with 25 cm^3 of oxygen at a temperature of 150 °C.
The gases react as shown in the equation below.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

The total volume of gas present at the end of the reaction is

☒ **A** 50 cm^3

☒ **B** 100 cm^3

☒ **C** 125 cm^3

☒ **D** 150 cm^3

(Total for Question 6 = 1 mark)

Use this space for rough working. Anything you write in this space will gain no credit.

7 Sodium nitrate decomposes on heating.

$$2NaNO_3(s) \rightarrow 2NaNO_2(s) + O_2(g)$$

What is the maximum volume of oxygen, measured in dm^3 at room temperature and pressure, which could be obtained by heating 0.50 mol of sodium nitrate?

[Molar volume of a gas = 24 dm^3 mol^{-1} at room temperature and pressure]

☒ **A** 3

☒ **B** 6

☒ **C** 12

☒ **D** 24

(Total for Question 7 = 1 mark)

8 An excess of copper(II) oxide is mixed with 40.0 cm^3 of 2.50 mol dm^{-3} hydrochloric acid.

$$CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$$

(a) If the mass of copper(II) chloride produced is 5.50 g, what is the percentage yield of copper(II) chloride?

[Molar mass of copper(II) chloride = 134.4 g mol^{-1}]

(1)

☒ **A** 81.8%

☒ **B** 67.2%

☒ **C** 40.9%

☒ **D** 20.4%

(b) The ionic equation for the reaction is

(1)

☒ **A** $Cu^{2+}(s) + 2Cl^-(aq) \rightarrow CuCl_2(aq)$

☒ **B** $CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$

☒ **C** $CuO(s) + 2H^+(aq) + 2Cl^-(aq) \rightarrow Cu^{2+}(Cl^-)_2(aq) + H_2O(l)$

☒ **D** $CuO(s) + 2Cl^-(aq) \rightarrow CuCl_2(aq) + O^{2-}(l)$

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(c) Some facts about copper(II) chloride are given below.

Which of these gives the **best** evidence that the bonding in copper(II) chloride is ionic?

(1)

☒ **A** It has a melting temperature of 620 °C.

☒ **B** It does not conduct electricity as a solid.

☒ **C** It decomposes before it reaches its boiling temperature.

☒ **D** In the electron density map, there are no contour lines around more than one nucleus.

(Total for Question 8 = 3 marks)

9 The melting temperature of sodium is lower than the melting temperature of magnesium. The **best** explanation for this is

☒ **A** sodium atoms are smaller than magnesium atoms.

☒ **B** sodium ions have a larger charge density than magnesium ions.

☒ **C** the repulsion between the ions in sodium is less than in magnesium.

☒ **D** the number of delocalised electrons per atom is fewer in sodium than in magnesium.

(Total for Question 9 = 1 mark)

10 A trend going down Group 1 is that the

☒ **A** first ionization energy of the element decreases.

☒ **B** lattice energy of the chloride becomes more negative.

☒ **C** radius of the atom decreases.

☒ **D** melting temperature of the element increases.

(Total for Question 10 = 1 mark)

11 Which of the following ions has the biggest radius?

☒ **A** S^{2-}

☒ **B** Cl^{-}

☒ **C** K^{+}

☒ **D** Ca^{2+}

(Total for Question 11 = 1 mark)

12 When 0.1 mol of aqueous potassium hydroxide was added to 0.1 mol of nitric acid, 5200 J were transferred to the surroundings. What is the enthalpy change, in kJ mol^{-1}, for this reaction?

$$KOH(aq) + HNO_3(aq) \rightarrow KNO_3(aq) + H_2O(l)$$

☒ **A** –52

☒ **B** –26

☒ **C** +26

☒ **D** +52

(Total for Question 12 = 1 mark)

13 A compound has the composition 62.1% C, 10.3% H and 27.6% O.

What is its empirical formula?

☒ **A** CH_2O

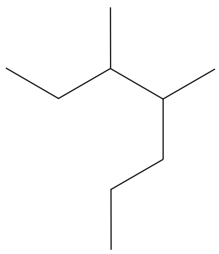
☒ **B** C_6H_2O

☒ **C** C_6H_3O

☒ **D** C_3H_6O

(Total for Question 13 = 1 mark)

14 What is the systematic name of the following?



☒ **A** 3-methyl-2-propylpentane

☒ **B** 3-methyl-4-propylpentane

☒ **C** 3,4-dimethylheptane

☒ **D** 4,5-dimethylheptane

(Total for Question 14 = 1 mark)

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15 Which of the following shows geometric isomerism?

☒ **A** prop-1-ene

☒ **B** but-1-ene

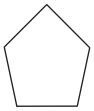
☒ **C** 1,1-dichloroethene

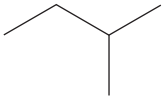
☒ **D** 1,2-dichloroethene

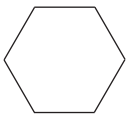
(Total for Question 15 = 1 mark)

16 This question is about the organic compounds with skeletal formulae as shown.

1 

2 

3 

4 

(a) Which compounds are isomers?

(1)

☒ **A** 1 and 2

☒ **B** 1 and 3

☒ **C** 1 and 4

☒ **D** 2 and 3

(b) Which compound has the same molecular formula and empirical formula?

(1)

☒ **A** 1

☒ **B** 2

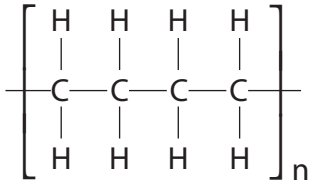
☒ **C** 3

☒ **D** 4

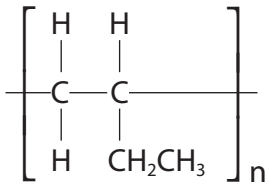
(Total for Question 16 = 2 marks)

17 What is the formula of poly(but-1-ene)?

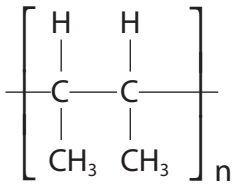
☒ **A**



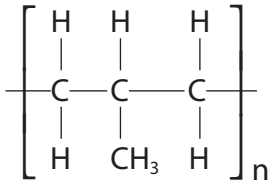
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

18 A mass spectrometer was used to analyse a sample of oxygen gas in which the most abundant isotope was ^{16}O. The oxygen was ionized and the ions were accelerated by an electric field.

(a) (i) Suggest the formulae of **two** different ions containing only the ^{16}O isotope, which might be formed in the mass spectrometer.

(2)

.....

.....

(ii) Which part of the mass spectrometer separates ions of different mass?

(1)

.....

(iii) For the two ions you have chosen in (a)(i), sketch their paths in the mass spectrometer after leaving the electric field and as they approach the detector region. Label each path with the formula of the ion.

(2)



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(b) The following results were obtained for the atoms of oxygen in the sample.

Relative isotopic mass	Relative abundance
16	99.759
17	0.037
18	0.204

Calculate the relative atomic mass of oxygen atoms. Show your working and give your answer to **three** decimal places.

(2)

(c) In the first half of the twentieth century, oxygen was used as the standard for relative atomic mass. The unit of atomic mass was defined as 1/16 the mass of an oxygen atom. This was based on samples of oxygen obtained from the air which consisted of a mixture of oxygen isotopes.

Suggest **one** reason why the use of this standard was discontinued.

(1)

.....

.....

.....

(d) Would you expect the first electron affinities of ^{16}O and ^{18}O to differ? Justify your answer.

(1)

.....

.....

.....

.....

(Total for Question 18 = 9 marks)

19 This question is about elements in Period 3 of the Periodic Table.

(a) Write the equation, including state symbols, which represents the first ionization energy of magnesium.

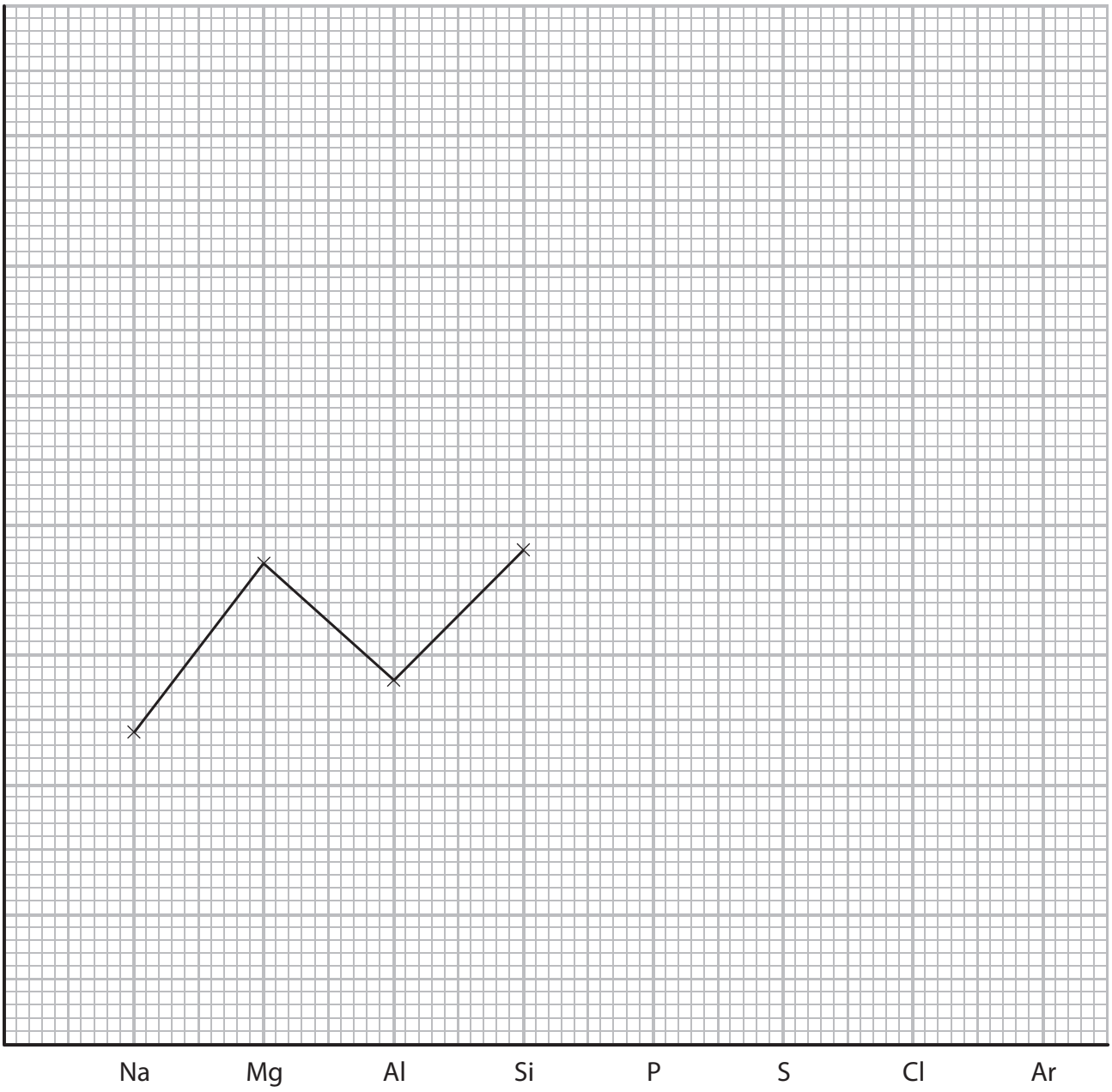
(2)

(b) Complete the electronic configuration for aluminium using s, p notation.

(1)

$1s^2$.....

(c) The sketch graph below shows the first ionization energies of some of the elements in Period 3.



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*(i) Explain why the values shown on the graph go down from magnesium to aluminium, and then rise again going from aluminium to silicon.

(3)

(ii) Complete the sketch graph for the elements from phosphorus to argon. Explain why one of these elements does not follow the general trend.

(3)

(d) Draw a dot and cross diagram for silicon tetrachloride, $SiCl_4$, showing outer shell electrons only. Use a cross (×) for silicon electrons and a dot (●) for chlorine electrons.

(2)

(e) Sodium and magnesium are both in Period 3. In sodium iodide, the ions are not polarized but in magnesium iodide some polarization occurs.

*(i) Explain the term **polarization** as it applies to magnesium iodide, and state how it arises.

(3)

(ii) State how thermochemical data could be used to show that there is polarization in magnesium iodide.

(1)

(Total for Question 19 = 15 marks)

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20 Fractional distillation is used in industry to obtain alkanes from crude oil.

(a) (i) On what physical property of alkanes does this process depend?

(1)

.....

(ii) The alkanes are then processed by **cracking** or **reforming** to produce other hydrocarbons.

Explain the meaning of these terms.

(2)

Cracking

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Reforming

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(iii) The equation for a cracking reaction of butane is

$$C_4H_{10} \rightarrow C_3H_6 + CH_4$$

Use the following standard enthalpy changes of combustion to calculate the enthalpy change of this cracking reaction. Show your method, which may involve the use of a Hess cycle. Include a sign and units in your answer.

Compound	Standard enthalpy change of combustion / kJ mol^{-1}
butane	–2877
propene	–2058
methane	–890

(3)

(iv) Butane can also be cracked to form products other than propene and methane. Write an equation for this reaction.

(1)

(b) (i) The enthalpy change of combustion of a liquid hydrocarbon, pentane, was determined in an experiment.

A sample of pentane was burned in a spirit burner and the energy produced used to heat water in a calorimeter.

The results of the experiment are as follows:

Mass of spirit burner and pentane at start	85.6 g
Mass of spirit burner and pentane after burning	84.6 g
Mass of water in calorimeter	200 g
Initial temperature of water	22.0 °C
Final temperature of water	56.0 °C
Mass of 1 mole of pentane	72.0 g

Heat energy transferred (J) = mass of water × temperature change × 4.18

Calculate the enthalpy change of combustion of pentane. Include a sign and units in your answer.

(3)

(ii) Give **one** reason, other than heat loss, why the enthalpy change determined in this experiment differs substantially from the Data Booklet value.

(1)

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(iii) Suggest a reason why this experiment would be too hazardous to carry out in a school laboratory.

(1)

.....

.....

(c) (i) Write an equation for the complete combustion of pentane. State symbols are not required.

(1)

(ii) Identify the type and number of bonds broken and formed during the combustion of a molecule of pentane.

(2)

(iii) Explain why the enthalpy change of combustion of pentane is exothermic.

(1)

.....

.....

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(Total for Question 20 = 16 marks)

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21 This question is about ethane and ethene.

(a) Ethane reacts with chlorine by a free radical mechanism.

(i) Explain what is meant by the term **free radical**.

(1)

.....

.....

(ii) Complete the equation for the formation of free radicals from one molecule of chlorine. Use appropriate curly arrows to show electron movements.

(1)

Cl—Cl →

(iii) Write an equation for the reaction between ethane and a chlorine free radical, and name the type of step in the mechanism where this occurs. Curly arrows are not required.

(2)

Type of step .....

(iv) Give an equation for a termination step in this mechanism in which an **organic** compound other than chloroethane is formed.

(1)

(b) Ethene contains a carbon-carbon double bond.

(i) Complete the diagram below showing the σ and π bonds in the carbon-carbon double bond in ethene.

(2)

C C

*(ii) Describe and explain what happens to the σ and π bonds in ethene in an addition reaction.

(3)

.....

.....

.....

.....

.....

.....

(iii) One test for a carbon-carbon double bond is the reaction with acidified potassium manganate(VII), $KMnO_4$.

Give the colour change if this reaction was carried out with ethene. Draw the **displayed** formula of the product.

(2)

From ..... to .....

Displayed formula

(iv) Describe another test for a carbon-carbon double bond and give the colour change for the positive result.

(2)

Test.....

From ..... to .....

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(v) Ethene reacts with hydrogen bromide. Write the mechanism for this reaction, showing any relevant dipoles.

(4)

Mechanism:

(c) But-1-ene is an alkene with properties similar to ethene.

Write an equation, using **skeletal** formulae for the organic compounds, showing the conversion of but-1-ene to butane. State the essential condition needed.

(2)

Condition.....

(Total for Question 21 = 20 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE
in Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		**(1)**

Question Number	Correct Answer	Reject	Mark
2	C		**(1)**

Question Number	Correct Answer	Reject	Mark
3	D		**(1)**

Question Number	Correct Answer	Reject	Mark
4	D		**(1)**

Question Number	Correct Answer	Reject	Mark
5	B		**(1)**

Question Number	Correct Answer	Reject	Mark
6	B		**(1)**

Question Number	Correct Answer	Reject	Mark
7	B		**(1)**

Question Number	Correct Answer	Reject	Mark
8a	A		**(1)**

Question Number	Correct Answer	Reject	Mark
8b	B		**(1)**

Question Number	Correct Answer	Reject	Mark
8c	D		**(1)**

Question Number	Correct Answer	Reject	Mark
9	D		**(1)**

Question Number	Correct Answer	Reject	Mark
10	A		**(1)**

Question Number	Correct Answer	Reject	Mark
11	A		**(1)**

Question Number	Correct Answer	Reject	Mark
12	A		**(1)**

Question Number	Correct Answer	Reject	Mark
13	D		**(1)**

Question Number	Correct Answer	Reject	Mark
14	C		**(1)**

Question Number	Correct Answer	Reject	Mark
15	D		**(1)**

Question Number	Correct Answer	Reject	Mark
16a	C		**(1)**

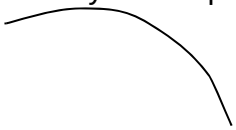
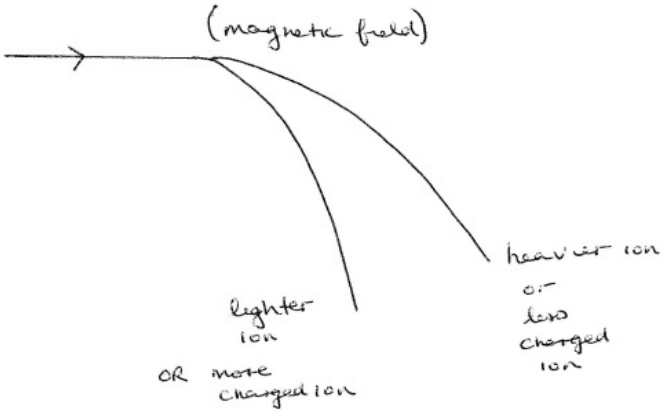
Question Number	Correct Answer	Reject	Mark
16b	C		**(1)**

Question Number	Correct Answer	Reject	Mark
17	B		**(1)**

Section B

Question Number	Acceptable Answers	Reject	Mark
18a(i)	Any two of O^+, O^{2+}, O_2^+, O_2^{2+} (1) for each correct ion ALLOW $^{16}O^+$, $^{16}O^{2+}$, $(^{16}O)_2^+$, $(^{16}O)_2^{2+}$ $^{16}O_2^+$, $^{16}O_2^{2+}$ $O=O^+$/ $O=O^{2+}$ for O_2 ions Added mass numbers which describe a diatomic ion eg $^{32}O_2^+$ Added round or square brackets	O^- O^{2-} Ions of O_3 Incorrect mass numbers eg $^{32}O^+$ Added incorrect atomic numbers Eg $^{16}_{9}O^+$	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18a(ii)	The magnetic field/ electromagnet/ electromagnetic field OR Deflection by magnetic field ALLOW Deflection and magnetic field	Gravitational field Just deflector/deflection Electric field Vacuum and magnetic field Detector/ detection	**(1)**

Question Number	Acceptable Answers	Reject	Mark
18a(iii)	**Two curved** lines going towards the detector region with at least one hitting the detector ALLOW Section of straight line before curve starts if magnetic field position is not shown Line may go up very slightly before it curves down, probably to keep it clear of lower line. ---------  (1) Labelling of paths depends on ions chosen: **Heavier ion** shown as **less deflected** OR O^{2+} more deflected than O_2^+ OR Ion with **lower charge** shown as **less deflected** ALLOW Ions with negative charges (as already penalised in (i)) (1) If chosen ions are O^+ and O_2^{2+} they will not be separated – answer must make this clear 	Straight lines Curvature away from detector/ concave curvature Line turning back upwards Species which are not ions of oxygen	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(b)	**Look at final answer** **16. 004 scores (2)** **16.00445 scores (1)** Correct expression with incorrect final answer scores (1) (16x99.759 + 17x0.037 + 18x0.204)/100 OR (16x0.99759 + 17x0.00037 + 18x0.00204) (1) =16.00445 =16.004 (1) Ignore units	 16.005	**(2)**

Question Number	Acceptable Answers	Reject	Mark
18(c)	Isotopic composition of oxygen in air varies ALLOW The abundance of the isotopes of oxygen varies OR Oxygen standard was introduced before existence of oxygen isotopes was known OR Some scientists used a standard based on one isotope while others used a value based on mixture in natural abundance OR The answer is inaccurate unless a specified isotope is used OR 12C standard used because there are many 12C compounds which can be used to calibrate the mass spectrometer ALLOW It was difficult to obtain pure oxygen from air.	Air contains other gases Air contains many isotopes Oxygen has many isotopes Just ‘12C standard is better’ 12C standard gives a whole number	**(1)**

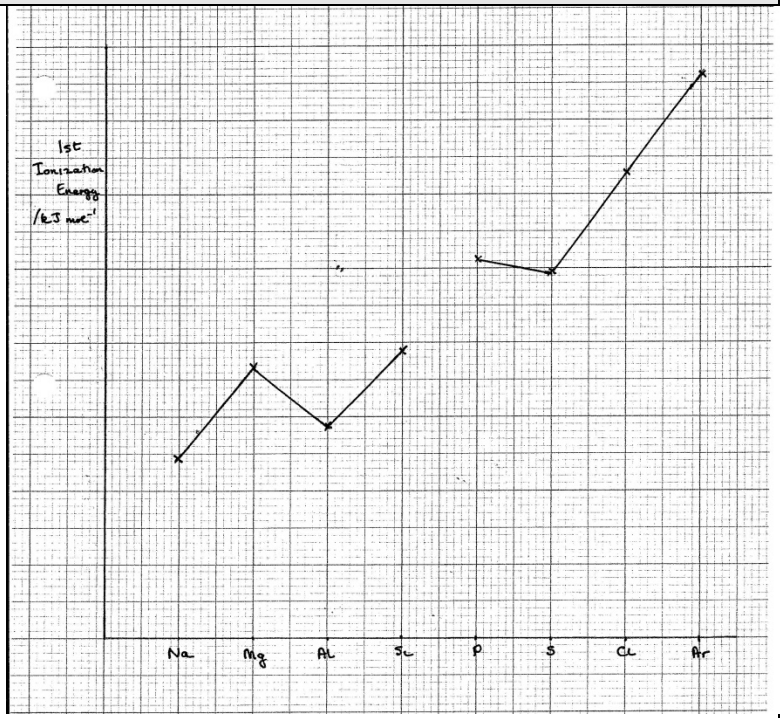
Question Number	Acceptable Answers	Reject	Mark
18(d)	No difference as both isotopes have the same number of protons (and electrons)/ the same nuclear charge IGNORE Same electronic configuration OR No difference as **only** number of neutrons is different		**(1)**

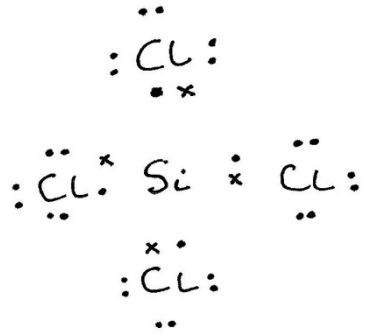
(Total for Question 18 = 9 marks)

Question Number	Acceptable Answers	Reject	Mark
19(a)	$Mg(g) \rightarrow Mg^{+}(g) + e^{(-)}$ ALLOW $Mg(g) - e^{(-)} \rightarrow Mg^{+}(g)$ Loss of electron to form Mg^{+} (1) IGNORE (g) sign on electron State symbols ALLOW Provided the equation involves magnesium, even if electron is added to the wrong side. (1)	Formation of Mg^{2+}	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(b)	$(1s^2)\ 2s^2 2p^6\ 3s^2 3p^1$ ALLOW Capital s and/or p, subscripts $2p_x^2\ 2p_y^2\ 2p_z^2\ 3p_x^1$ $3p_y^1$ / $3p_z^1$ for $3p_x^1$		**(1)**

Question Number	Acceptable Answers	Reject	Mark
***19(c)(i)**	**MP1** Mg to Al: Electron removed from Al is from a higher energy level (3p rather than 3s) ALLOW Electron removed in Al is (more) shielded (by 3s) IGNORE Outer electron is further from nucleus Full sub-shell is more stable than part filled sub-shell (1) **MP2** Al to Si: Si has one more proton than Al/ has greater nuclear charge, **and** electrons removed in both cases are 3p / same sub-shell / are equally shielded (1) **MP3** EITHER The attraction of the extra proton in Al is less than the effect of the higher energy level/ the shielding OR Electron removed from Si is closer to nucleus (than Al) ALLOW Silicon is smaller in size (1)		**(3)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	 **MP1** S does not follow trend (P is above Si followed by dip in graph from P to S rising again to Cl and Ar) (1) **MP2** S has one (3)p orbital which has two electrons/ paired electrons/ is fully occupied OR S has $3p_x^2$, $3p_y^1$, $3p_z^1$ OR Electron in box diagram for S ALLOW S has **a pair of** electrons in the (3)p subshell (1) **MP3** A paired electron is easier to remove OR paired electrons repel each other ALLOW half filled sub-shell (in P) is stable (1)	Just "S has $3p^4$" d orbital P has **a** half filled orbital	**(3)**

Question Number	Acceptable Answers	Reject	Mark
19(d)	Four x round Si sharing one ● with each Cl (1) Seven ● round each Cl sharing one x with each Si (1)  ALLOW Reversed symbols		**(2)**

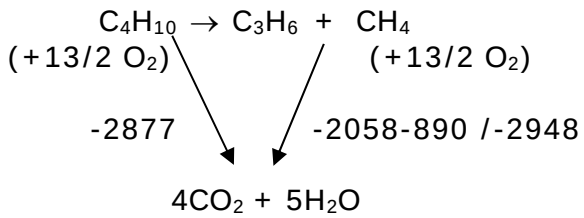
Question Number	Acceptable Answers	Reject	Mark
***19(e)(i)**	**MP1** I^- / anion becomes distorted / not spherical. May be shown in a diagram (1) **MP2** Mg^{2+} has high(er) charge **and** small(er) radius/ Mg^{2+} has high charge density (1) **MP3** Bonding in magnesium iodide has some covalent character OR Orbitals of Mg^{2+} and I^- overlap/ Mg^{2+} shares some of the I^- electrons OR Mg^{2+} and I^- ions are not completely separate (1)	Iodine becomes distorted Just “electrons in outer shell are attracted” Atoms of Mg have a small (atomic) radius	**(3)**

Question Number	Acceptable Answers	Reject	Mark
19(e)(ii)	Experimental/ Born Haber cycle and theoretical/ calculated lattice energies are **different** OR Experimental/ Born Haber cycle lattice energy is more exothermic/ more negative than theoretical/ calculated lattice energy ALLOW Greater for more negative IGNORE Comments about melting temperature	Just "Compare Experimental/ Born Haber cycle and theoretical/ calculated lattice energies" Use of electron density map	**(1)**

(Total for Question 19 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	(Different) boiling temperatures/ boiling points ALLOW Range of boiling temperatures		**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	**Cracking**: breaking of carbon chain (in a hydrocarbon/ alkane) to give shorter chain hydrocarbon(s)/ smaller molecules OR breaking a hydrocarbon/ alkane to give smaller molecules OR Breaking an alkane to give an alkene **and** (a smaller) alkane/ hydrogen (1) **Reforming**: converting straight chain to a (more) branched chain/ ring/ arene / aromatic compound ALLOW Specific examples (1) IGNORE Makes more useful compounds Converting low octane (fuels) into high octane (fuels)	Just “Breaking a hydrocarbon” Just “Breaking a molecule” Breaking a hydrocarbon to form branched chains or ring structures	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	Look at final answer: **+71** (kJ mol^{-1}) scores **3** marks **-71 / 71** (kJ mol^{-1}) scores **2** marks **-5825** (kJ mol^{-1}) scores **1** mark Method:  **MP1** Labelled cycle OR use of $\Delta H = \Sigma\Delta H_{combustion}$ reactants - $\Sigma\Delta H_{combustion}$ products (1) **MP2** ΔH = (-2877 -(-2058+ (-890)) (1) **MP3** =**+**71 (kJ mol^{-1}) (1)	Incorrect units	**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iv)	$C_4H_{10} \rightarrow C_2H_6 + C_2H_4$ OR $C_4H_{10} \rightarrow C_4H_8 + H_2$ OR $C_4H_{10} \rightarrow 2C_2H_4 + H_2$ ALLOW Breakdown of multiple butanes Ignore state symbols, even if incorrect	$C_4H_{10} \rightarrow C_3H_6 + CH_4$ Charged products eg $C_2H_5^+$ Free radicals eg $C_2H_5^{\bullet}$	**(1)**

Question Number	Acceptable Answers	Reject	Mark
20b(i)	Look at final answer: **-2050** (kJ mol^{-1}) or anything correctly rounded from −2046.528 **(-2047, -2046.5, -2046.53)** scores **3** marks **+2050 / 2050** (kJ mol^{-1}) scores **2** marks Incorrect rounding scores 2 marks Correct value without sign scores 2 marks Energy transferred = (200 x 4.18 x 34.0) =28424 (J) IGNORE Sign if given (1) Mol pentane =(1.0/72) = 0.01389 / 0.0139 (1) ΔH = − (-28424 ÷ (1/72 x 1000)) = −2046.528 (kJ mol^{-1}) ALLOW TE from MP 1 and 2 provided moles of pentane is not taken as 1 (1) NOTE Use of 0.0139 mol gives -2044.9 (kJ mol^{-1}) giving 3 marks Use of 0.0138 mol gives -2059.7 (kJ mol^{-1}) giving 2 marks Use of 0.014 mol gives -2030.29 (kJ mol^{-1}) giving 2 marks Ignore SF except one or two		**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	Incomplete combustion OR Loss of pentane by evaporation ALLOW Volume of water too large to heat evenly Water not stirred evenly Small change in mass inaccurate Heat capacity of /energy needed to heat calorimeter not included	Incomplete reaction Loss of water by evaporation Heat losses Conditions not standard Measuring errors Pentane impure	**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	Pentane is **very** volatile/ has low boiling temperature so risk of explosion OR Has **high** flammability IGNORE Reaction is very exothermic	 Just "it is flammable" Vapour is toxic Combustion products/ CO toxic	**(1)**

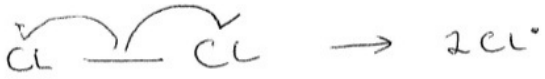
Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	$C_5H_{12} + 8O_2 \rightarrow 5CO_2 + 6H_2O$ Allow multiples Ignore state symbols even if incorrect		**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	Bonds broken are four C-C twelve C-H eight O=O (1) Bonds made are ten C=O twelve O-H (1) ALLOW TE from (c)(i) If all five bonds are named but formulae not given eg oxygen-oxygen bonds, max 1 If all five bonds are correctly identified by formula but numbers are incorrect or missing, max 1	O-O single bonds C-O single bonds	**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(c)(iii)	The (total) bond energy of the bonds formed is greater than the bond energy of the bonds broken OR Energy released forming new bonds > energy needed to break old bonds OR The sum of the bond energies of the products is greater than the sum of the bond energies of the reactants.	Just"more bonds are made than broken" Answers referring to energy needed to make bonds Energy contained by bonds in reactants> energy contained by bonds in products	**(1)**

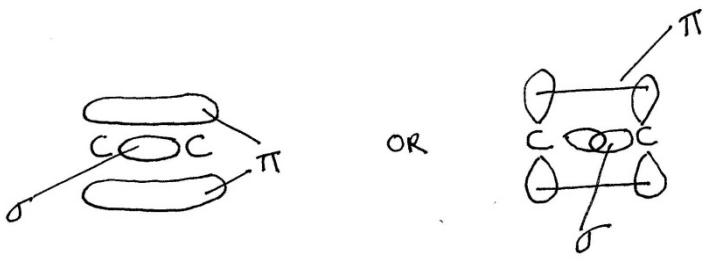
(Total for question 20 = 16 marks)

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Species/ atom/ molecule/ particle with an **unpaired electron** ALLOW An element with an **unpaired electron** IGNORE Reference to neutral species /lack of charge	Just "with a single electron" A lone electron Charged particle with an unpaired electron	**(1)**

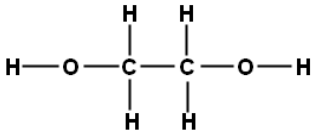
Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	 Half arrows going from bond to Cl or just beyond **and** product 2Cl• / Cl• + Cl•	Cl without •	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21a(iii)	$C_2H_6 + Cl\bullet \rightarrow C_2H_5\bullet + HCl$ ALLOW Structural formulae e.g. CH_3CH_3 OR displayed IGNORE Production of C_2H_5Cl from $C_2H_5\bullet$ if first step is correct (1) Propagation (1) The second mark is independent of the first	$C_2H_5^+$	**(2)**

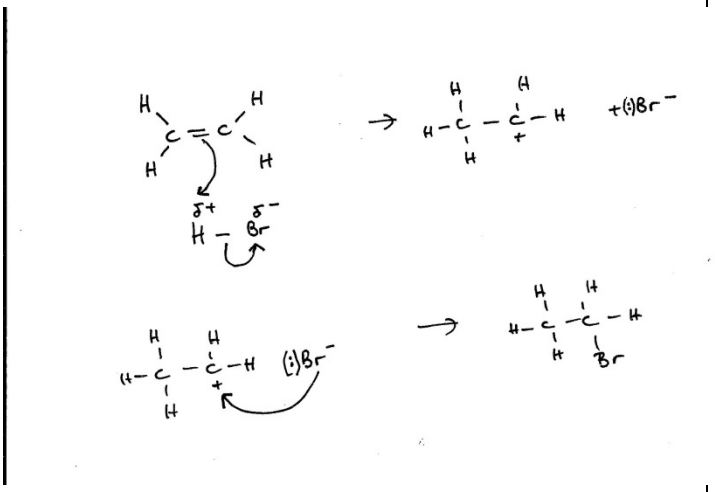
Question Number	Acceptable Answers	Reject	Mark
21a(iv)	$C_2H_5\bullet + C_2H_5\bullet \rightarrow C_4H_{10}$ ALLOW Structural formulae e.g. $CH_3CH_2\bullet$ / $\bullet CH_3CH_2$ OR displayed IGNORE $Cl\bullet + Cl\bullet \rightarrow Cl_2$	Methyl or propyl radicals	**(1)**

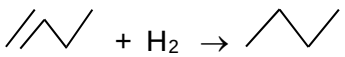
Question Number	Acceptable Answers	Reject	Mark
21b(i)	 σ bond between C atoms shown as 2 overlapping orbitals/ one electron cloud/ single bond (1) π bond above and below σ bond shown as two electron clouds/ overlapping p orbitals/ p orbitals linked by a line / a curved line above and below single bond (1) Both bonds must be labelled for 2 marks.		**(2)**

Question Number	Acceptable Answers	Reject	Mark
***21b(ii)**	**MP1** σ bond remains ALLOW The product contains σ bonds only (1) **MP2** π bonds break because they are weaker (than σ bonds) ALLOW π bonds break because σ bonds are stronger (1) **MP3** Breaking the π bond results in carbocation intermediate / positively charged carbon forming OR π orbital overlap is lateral/ sideways /between parallel orbitals (making π bonds break/ weak) OR The σ bonds are much stronger (than the π bond) because of more effective (orbital) overlap (1)		**(3)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	From: Purple/ pink (solution) To: colourless (1)  (1) Any orientation Don't penalise undisplayed OH Don't penalise bonds going to middle of undisplayed OH	To brown Molecular/ structural/ skeletal formulae C bonded to H of OH	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Second mark depends on use of bromine/ solution of bromine for test. EITHER Test: add bromine water / Br_2**(aq)** ALLOW Add bromine in organic solvent/ bromine dissolved in hexane/ bromine in 1,1,1-trichloroethane (1) From: brown/ red-brown/orange/ yellow To: colourless (1) OR Add bromine / Br_2 (1) From: brown/ red-brown To: colourless (1)		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(v)	 Dipole on HBr (1) Curly arrow from C=C double bond to $H^{\delta+}$ of HBr **and** curly arrow from H-Br bond to Br (1) Correct intermediate with + charge (1) Curly arrow from Br^- to C^+ and formula of product ALLOW Curly arrow from anywhere on Br, including the − sign or lone pair (which is optional) (1)	Half arrows	**(4)**

Question Number	Acceptable Answers	Reject	Mark
21(c)	 (1) Suitable catalyst nickel/ platinum/ palladium (1) Ignore references to temperature, pressure, uv light	Use of H, H^+ Zeolite catalyst	**(2)**

(Total for Question 21 = 20 marks)

TOTAL FOR PAPER = 80 MARKS

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Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 13 October 2016 – Morning
Time: 1 hour 30 minutes

Paper Reference
WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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4/6/6/5/

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Mohr's salt, $(NH_4)_2Fe(SO_4)_2.6H_2O$, is a blue-green crystalline solid usually made by dissolving equimolar amounts of iron(II) sulfate and ammonium sulfate in dilute sulfuric acid and then crystallising.

The reaction may be represented by the equation

	$FeSO_4.7H_2O$	+	$(NH_4)_2SO_4$	→	$(NH_4)_2Fe(SO_4)_2.6H_2O$	+	H_2O
Molar masses /g mol^{-1}	278		132		392		18

(a) What mass of Mohr's salt would be produced from 2.78 g of iron(II) sulfate with excess ammonium sulfate, if the yield in the reaction was 80%?

(1)

☒ **A** 2.22 g

☒ **B** 2.78 g

☒ **C** 3.14 g

☒ **D** 3.92 g

(b) How many **cations** are there in e[illegible] mole of Mohr's salt?

[Avogadro constant, L = [illegible] × 10^{23} mol^{-1}]

(1)

☒ **A** 6.0 × 10^{23}

☒ **B** 1.2 × $10^{[illegible]}$

☒ **C** 1.8 × $10^{[illegible]}$

☒ **D** 3.0 × 10^{24}

(c) What is the percentage by mass of water in Mohr's salt?

(1)

☒ **A** [illegible]%

☒ **B** 18%

☒ **C** 28%

☒ **D** 72%

(Total for Question 1 = 3 marks)

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2 Magnesium carbonate reacts with hydrochloric acid.

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) What mass of magnesium carbonate would react with excess hydrochloric acid to produce 240 cm^3 of carbon dioxide, measured at room temperature and pressure?

Data: 1 mol of any gas occupies 24.0 dm^3 at room temperature and pressure

Molar mass of magnesium carbonate = 84.3 g mol^{-1}

(1)

☒ **A** 0.843 g

☒ **B** 8.43 g

☒ **C** 84.3 g

☒ **D** 843 g

(b) What is the **minimum** mass of magnesium carbonate needed to neutralise 50.0 cm^3 of 0.250 mol dm^{-3} hydrochloric acid?

(1)

☒ **A** 0.423 g

☒ **B** 0.527 g

☒ **C** 1.05 g

☒ **D** 2.11 g

(c) What would be seen at the end of the reaction with excess acid?

(1)

☒ **A** A colourless solution

☒ **B** A coloured solution

☒ **C** A white precipitate

☒ **D** A coloured precipitate

(Total for Question 2 = 3 marks)

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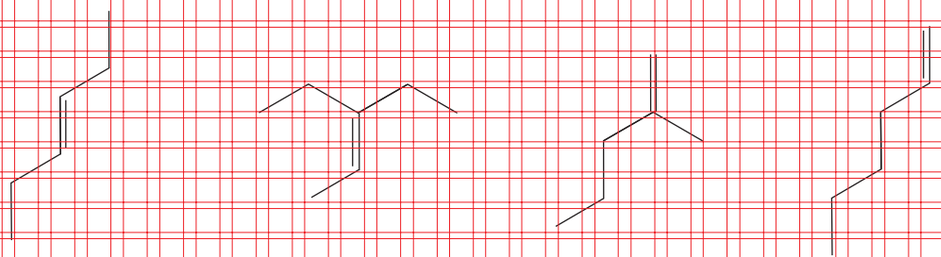
3 The following molecules are alkenes.



P Q R S

(a) Which molecule has a geometric isomer?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(b) Which molecule would produce 2-bromohexane as the **major** product on addition of hydrogen bromide?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(c) Which molecule has 14 hydrogen atoms?

(1)

☒ **A** P

☒ **B** Q

☒ **C** R

☒ **D** S

(Total for Question 3 = 3 marks)

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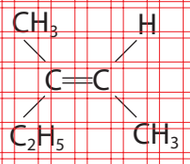
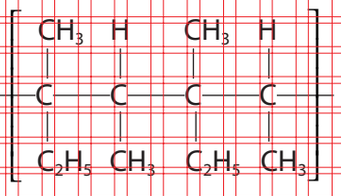
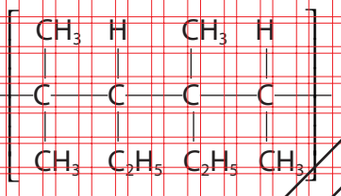
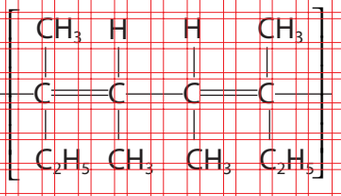
4 The structure of *Z*-3-methylpent-2-ene is

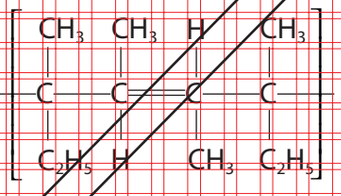


Which of the following shows **two** repeat units of the polymer made from *Z*-3-methylpent-2-ene?

☒ **A** 

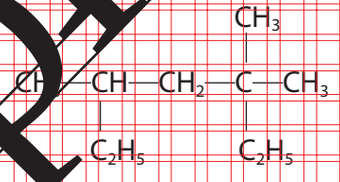
☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 4 = 1 mark)

5 What is the systematic name for the following molecule?



☒ **A** 2,4-diethyl-2-methylpentane

☒ **B** 2,4-diethyl-4-methylpentane

☒ **C** 3,5,5-trimethylheptane

☒ **D** 3,5,5-trimethylheptane

(Total for Question 5 = 1 mark)

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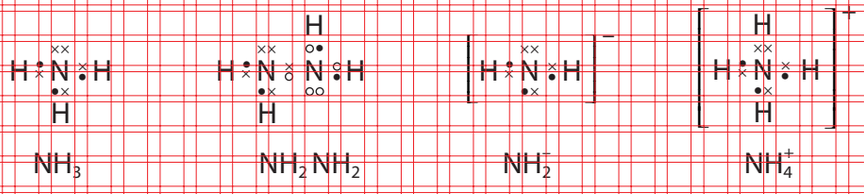
6 Nitrogen can form the following species with hydrogen:



NH_3 NH_2NH_2 NH_2^- NH_4^+

Which of these species has a dative covalent bond?

- ☒ **A** NH_3
- ☒ **B** NH_2NH_2
- ☒ **C** NH_2
- ☒ **D** NH_4^+

(Total for Question 6 = 1 mark)

7 Which of these elements in Period 3 has the highest melting temperature?

- ☒ **A** Na
- ☒ **B** Al
- ☒ **C** Si
- ☒ **D** P

(Total for Question 7 = 1 mark)

8 The conduction of electricity by a solution is evidence that ions are present in the solution.

What co[illegible] formed w[illegible] an electric current is passed through **aqueous** sodium [illegible]?

- ☒ **A** Chlo[illegible] at the anode
- ☒ [illegible]ydr[illegible] at the anode
- ☒ **C** [illegible]um at the cathode
- ☒ [illegible]Oxygen at the cathode

(Total for Question 8 = 1 mark)

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9 An example of an equation to illustrate the cracking of an alkane from crude oil is

$$\underset{\text{pentadecane}}{C_{15}H_{32}} \rightarrow \underset{\text{ethene}}{2C_2H_4} + \underset{\text{propene}}{C_3H_6} + \underset{\text{octane}}{C_8H_{18}}$$

Molar masses / g mol^{-1} 28 42 114

(a) What is the atom economy for this reaction in terms of production of alkenes?

Use the expression

$$\text{Atom economy} = \frac{\text{Total mass of desired product(s)}}{\text{Total mass of all products}} \times 100\%$$

(1)

☒ **A** 26%

☒ **B** 33%

☒ **C** 38%

☒ **D** 46%

(b) The chemical industry uses cracking in the processing of crude oil because

(1)

☒ **A** fractional distillation is too slow and expensive.

☒ **B** crude oil contains insufficient quantities of desired compounds.

☒ **C** reforming requires a catalyst.

☒ **D** cracking separates crude oil components.

(Total for Question 9 = 2 marks)

10 Scientists are developing alternatives to fossil fuels.

Which of the following is **not** a result of carbon dioxide emissions?

☒ **A** The increase in global warming.

☒ **B** The melting of the ice caps.

☒ **C** The increase in pH of the oceans.

☒ **D** The rise in sea level.

(Total for Question 10 = 1 mark)

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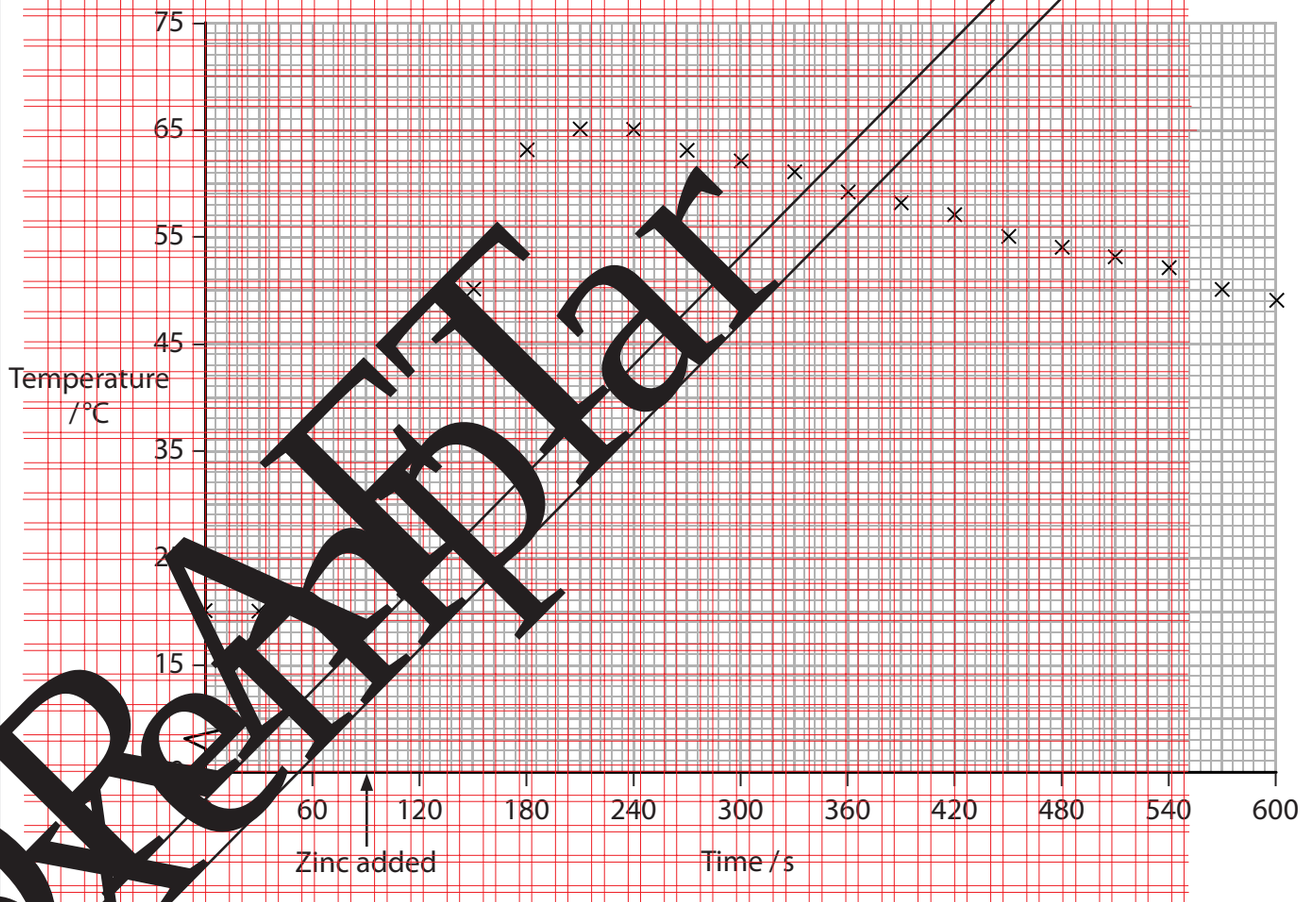
11 Which of the following is isoelectronic with the chloride ion, Cl^-?

- ☒ **A** F
- ☒ **B** Br
- ☒ **C** Na^+
- ☒ **D** Ar

(Total for Question 11 = 1 mark)

12 An excess of zinc powder was added to 50 cm^3 of 1.0 $mol\,dm^{-3}$ copper(II) sulfate in a polystyrene cup. The temperature of the copper(II) sulfate solution was measured at 30 s intervals. The zinc was added after 90 s. The results are shown on the graph.



What temperature change should be used when calculating the energy transfer?

- ☒ **A** 45 °C
- ☒ **B** 52 °C
- ☒ **C** 65 °C
- ☒ **D** 72 °C

(Total for Question 12 = 1 mark)

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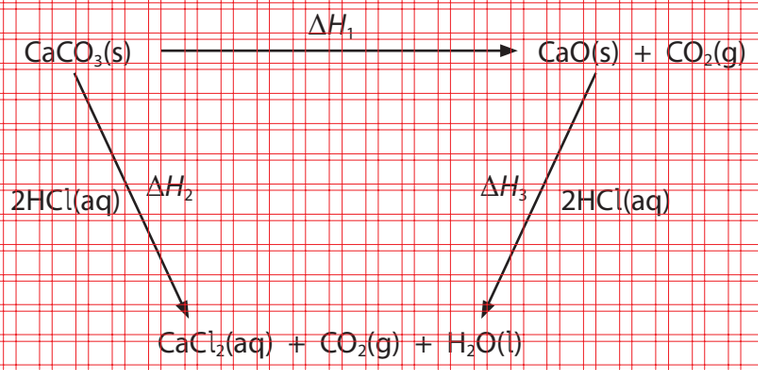
13 Hess's law can be used to determine enthalpy changes which cannot be measured directly, such as the thermal decomposition of calcium carbonate.



Using Hess's law, the expression to determine ΔH_1 is

☒ **A** $\Delta H_1 = \Delta H_2 - \Delta H_3$

☒ **B** $\Delta H_1 = \Delta H_2 + \Delta H_3$

☒ **C** $\Delta H_1 = 2\Delta H_2 - 2\Delta H_3$

☒ **D** $\Delta H_1 = 2\Delta H_2 + 2\Delta H_3$

(Total for Question 13 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

14 This question is about isotopes, and the use of mass spectrometry to detect their presence and measure their abundance.

(a) Boron has two naturally occurring isotopes, ^{10}B and ^{11}B.

(i) A sample of boron contained 13.9% of isotope ^{10}B and 86.1% of isotope ^{11}B. Calculate the relative atomic mass of boron in this sample. Give your answer to **three** significant figures.

(2)

(ii) Complete the following definition of relative atomic mass.

(1)

The relative atomic mass is the weighted mean mass of an atom of an element

.....

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(iii) Boron-12 is a short-lived radioactive isotope.
Name the subatomic particles in an atom of boron-12 and give the number of each.

(2)

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(b) (i) A mass spectrometer operates under a vacuum. Suggest the effect on the ions in a mass spectrometer if particles from the air were present.

(1)

(ii) Suggest how, if at all, the electric field in the mass spectrometer would affect molecules that are **not** ionised.

(1)

*(iii) The reaction of ethene with aqueous potassium manganate(VII), $KMnO_4$, produces ethane-1,2-diol, CH_2OHCH_2OH.

Data: molar mass of ethane-1,2-diol = 62 g mol^{-1}

In an experiment, $KMnO_4$ containing only ^{18}O reacts with ethene. Suggest how the mass spectrum of ethane-1,2-diol data could be used to decide whether the oxygen atoms in ethane-1,2-diol came from the manganate(VII) ion, water, or a combination of the two.

(2)

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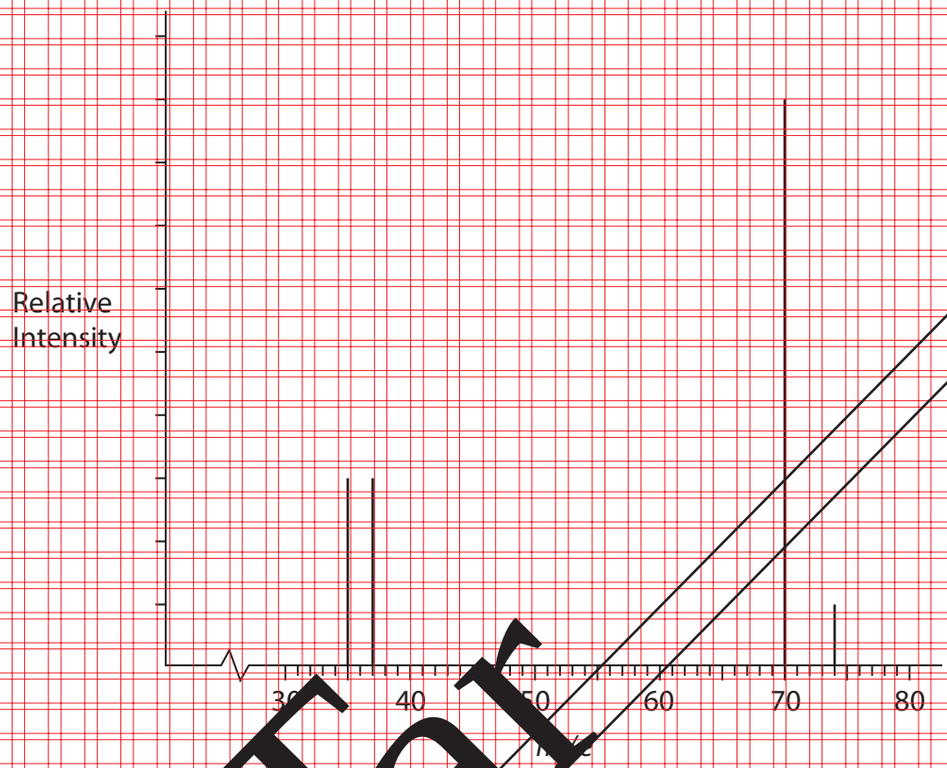
(c) A student sketched the mass spectrum of chlorine gas which contained 75% of the ^{35}Cl isotope and 25% of the ^{37}Cl isotope.



(i) Identify and correct the **two** errors made by the student in this sketch.

(2)

Error 1 .....

Correction 1 .....

Error 2 .....

Correction 2 .....

(ii) Give the formula of the ion responsible for the peak with $m/e = 74$, showing the isotope(s) present.

(1)

.....

(Total for Question 14 = 12 marks)

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15 Alkanes react with halogens in the presence of ultraviolet (UV) light.

(a) Write the equation for the overall reaction of bromine with methane to form bromomethane. State symbols are not required.

(1)

(b) Propane reacts with chlorine to produce C_3H_7Cl. There are two possible isomers with this molecular formula.

Draw the **skeletal** formulae of these two isomers and give their systematic names.

(4)

Name:

Name:

(c) Ethane reacts with chlorine in UV light by a free radical substitution mechanism involving a number of steps.

(i) Explain why ethane does not react with electrophiles.

(1)

(ii) Explain why ethane undergoes substitution and not addition reactions.

(1)

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(iii) The first step of the reaction of chlorine with ethane in UV light involves homolytic fission.

Write the equation for this fission and state the name of this reaction step.

Curly half-arrows are not required.

(2)

Equation:

Name of reaction step .....

(iv) The ethyl free radical is an intermediate in the propagation stage of the reaction. Draw the dot-and-cross diagram of this free radical.

Use dots (•) for the hydrogen electrons, crosses (x) for the electrons of one of the carbon atoms and asterisks (*) for the electrons of the other carbon atom. Show only outer shell electrons.

(2)

(v) What change to the reaction mixture of ethane and chlorine would increase the proportion of polychlorinated alkanes such as 1,1-dichloroethane and 1,2-dichloroethane?

(1)

.....

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(Total for Question 15 = 12 marks)

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16 This is a question about ionisation energies.

(a) Define **in words** the term 'first ionisation energy'.

(3)

(b) Write the equation for the **second** ionisation energy of lithium.

(1)

(c) Why is it not possible to determine the **third** ionisation energy for helium?

(1)

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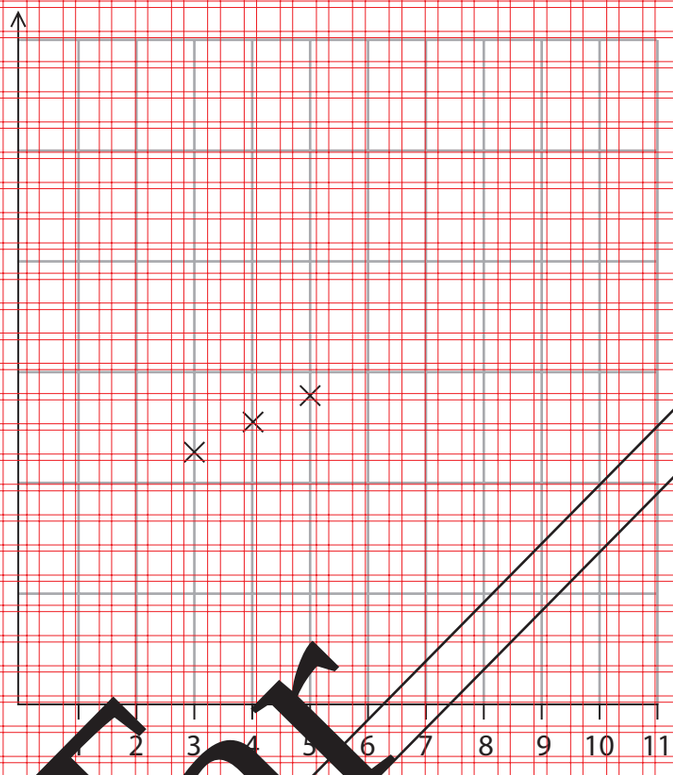
(d) Complete the sketch of the log (ionisation energy) of sodium.

(4)



*(e) Explain why there is a general decrease in the values of the first ionisation energy on descending a group in the Periodic Table.

(3)

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*(f) Explain why the first ionisation energy of sulfur is less than that of phosphorus.

(2)

*(g) The first ionisation energy for sodium is +496 kJ mol^{-1} and for magnesium is +738 kJ mol^{-1}.
Hence suggest a value for the first ionisation energy of aluminium and justify your choice.

(3)

Ionisation Energy Value: .....

Justification .....

(Total for Question 16 = 17 marks)

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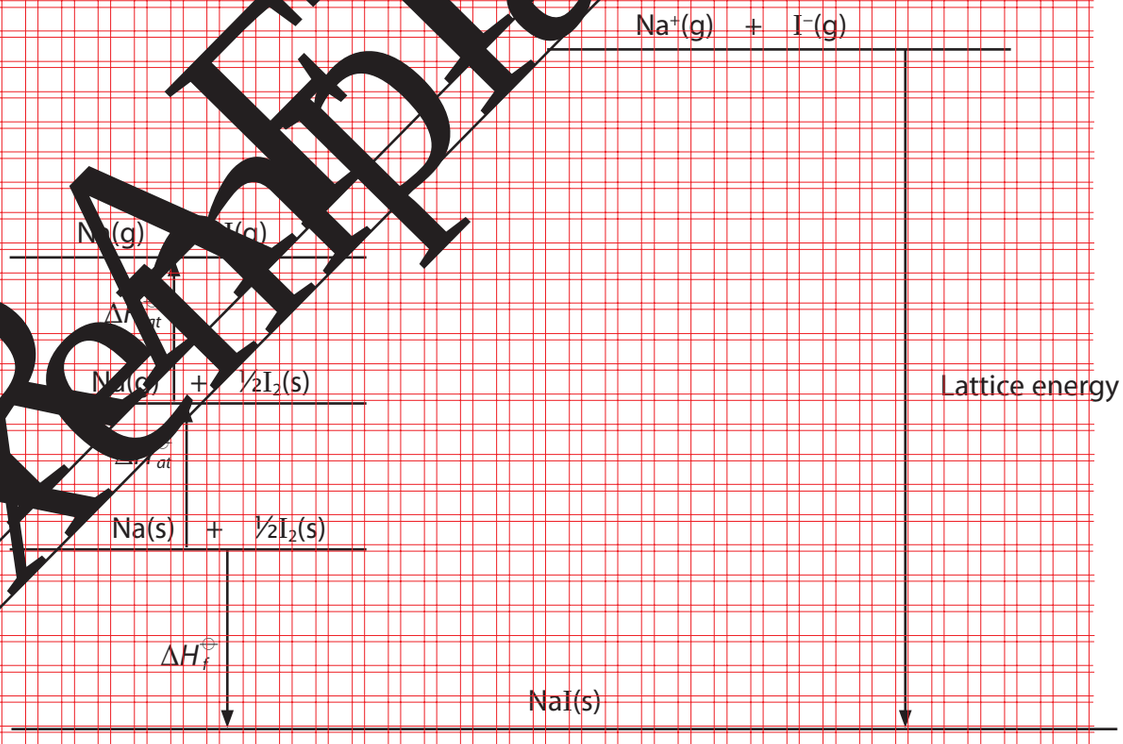
17 The following data can be used in the Born-Haber cycle for sodium iodide, NaI.

Energy change	ΔH / kJ mol^{-1}
Enthalpy change of atomisation of iodine	+107
Enthalpy change of atomisation of sodium	+107
First ionisation energy of sodium	+496
First electron affinity of iodine	−295
Enthalpy change of formation of sodium iodide	−288

(a) Complete the Born-Haber cycle diagram for sodium iodide by adding the first ionisation energy of sodium and the first electron affinity of iodine. Include any relevant entities and arrow directions.

(3)



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(b) Calculate the lattice energy for sodium iodide.

Give a sign and units in your answer.

(1)

(c) Explain why the enthalpy changes of atomisation of sodium and of iodine are endothermic. For each substance, state the type of bonding present in the solid.

(3)

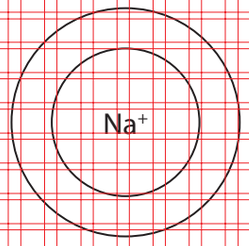
(d) The numerical value for the lattice energy of sodium iodide obtained from the Born-Haber cycle is more negative than the theoretical value.

(i) Explain why the Born-Haber value is more negative than the theoretical value.

(2)

(ii) Draw an electron density map for the iodide ion in sodium iodide showing any effect the sodium ion has on the iodide ion.

(1)



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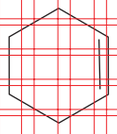
18 The reaction of liquid bromine is a standard test for alkenes.

(a) (i) Complete the equation for the reaction of cyclohexene with liquid bromine, using a skeletal formula.

(1)



$+ Br_2 \rightarrow$

(ii) What colour change would you see when this reaction occurs?

(1)

From ..... to .....

(b) Gaseous but-1-ene is another alkene that readily reacts with liquid bromine.

Using molecular formulae, the equation for the reaction is

$$C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$$

(i) Using the bond enthalpy values in the table, calculate the enthalpy change for this reaction.

(2)

Bond	Bond enthalpy / kJ mol^{-1}
C—H	413
C—C	347
C=C	612
C—Br	290
Br—Br	193

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(ii) Give **one** reason why the value calculated for the reaction in part (b)(i) using bond enthalpies is different from the true value.
Do **not** consider experimental error, mean bond enthalpy values or non-standard conditions.

(1)

.....

.....

(iii) Using appropriate curly arrows, write the mechanism of the reaction between but-1-ene and bromine.

(3)

(iv) Identify, by name or by displayed formula, the product formed when bromine **water** is added to but-1-ene.

(1)

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(Total for Question 18 = 9 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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Example

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Mark Scheme (Results)

October 2016

Pearson Edexcel International GCE in Chemistry (WCH01) Paper 1

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1(a)	C		1
	Incorrect Answers: A – This is 80% of the starting material and not the product B - Same mass as the starting material & not the product D- This is 100% yield and not 80%		

Question Number	Correct Answer	Reject	Mark
1(b)	C		1
	Incorrect Answers: A – This is only for one mole not three B - This is for two moles not three D- This is for five moles not three		

Question Number	Correct Answer	Reject	Mark
1(c)	C		1
	Incorrect Answers: A – This is for one water molecule not six B - This is the M_r value of water just as a percentage D- This is the percentage of the salt which is not water		

Question Number	Correct Answer	Reject	Mark
2(a)	A		1
	Incorrect Answers: B– Ten times too big C - 100 times too big D- Thousand times too big		

Question Number	Correct Answer	Reject	Mark
2(b)	B		1
	Incorrect Answers: A – Incorrect M_r and ratio used C - The 2:1 ratio has not been used D- The 2:1 ratio has been used the wrong way round		

Question Number	Correct Answer	Reject	Mark
2(c)	A		1
	Incorrect Answers: B – There are no coloured compounds C - There is no white precipitate D- There are no coloured precipitates		

Question Number	Correct Answer	Reject	Mark
3(a)	A		1
	Incorrect Answers: B – Two groups attached to one of the carbons in the double bond are the same C - Two groups attached to one of the carbons in the double bond are the same D- Two groups attached to one of the carbons in the double bond are the same		

Question Number	Correct Answer	Reject	Mark
3(b)	D		1
	Incorrect Answers: A – The major product is 3-bromohexane B - The major product is 3-bromo-3-methylpentane C- The major product is 2-bromo-2-methylpentane		

Question Number	Correct Answer	Reject	Mark
3(c)	B		1
	Incorrect Answers: A – There are 12 hydrogen atoms C - There are 12 hydrogen atoms D- There are 12 hydrogen atoms		

Question Number	Correct Answer	Reject	Mark
4	A		1
	Incorrect Answers: B – The methyl groups are bonded to the same carbon C - The double bonds are still present D- The double bond has moved and results in pentavalent carbons		

Question Number	Correct Answer	Reject	Mark
5	C		1
	Incorrect Answers: A – The longest consecutive chain is 7 not 5 B - The longest consecutive chain is 7 not 5 D- The numbering of the longest chain is wrong		

Question Number	Correct Answer	Reject	Mark
6	D		1
	Incorrect Answers: A – There is no dative covalent bond B - There is no dative covalent bond C- There is no dative covalent bond		

Question Number	Correct Answer	Reject	Mark
7	C		1
	Incorrect Answers: A – Melting temperatures increase across the period with a peak at group IV not Group I B - Melting temperatures increase across the period with a peak at group IV not Group III D- Melting temperatures increase across the period with a peak at group IV not Group V		

Question Number	Correct Answer	Reject	Mark
8	A		1
	Incorrect Answers: B– Hydrogen ions do not go to the anode C - Sodium would not be formed in water D- Oxygen ions do not go to the cathode		

Question Number	Correct Answer	Reject	Mark
9(a)	D		1
	Incorrect Answers: A – Atom economy of ethene, not all alkenes B - Ethene not doubled in numerator but doubled in denominator C- Atom economy where ethene not doubled		

Question Number	Correct Answer	Reject	Mark
9(b)	B		1
	Incorrect Answers: A – Incorrect reason for use of cracking C - Incorrect reason for use of cracking D- Incorrect reason for use of cracking		

Question Number	Correct Answer	Reject	Mark
10	C		1
	Incorrect Answers: A – Carbon dioxide does cause global warming B - Carbon dioxide does cause ice caps to melt D- Carbon dioxide does cause sea levels to rise		

Question Number	Correct Answer	Reject	Mark
11	D		1
	Incorrect Answers: A – Electron configuration lacks energy level 3 electrons B - Electron configuration has an extra 18 electrons C- Electron configuration lacks energy level 3 electrons		

Question Number	Correct Answer	Reject	Mark
12	B		1
	Incorrect Answers: A – The change is not to the extrapolated peak C - The change starts at zero and not 20 and goes to only the observed peak D- The change starts at zero and not 20		

Question Number	Correct Answer	Reject	Mark
13	A		1
	Incorrect Answers: B – The enthalpy changes are added and not subtracted C - The enthalpy changes are incorrectly doubled D- The enthalpy changes are doubled and added both incorrectly		

(TOTAL FOR SECTION A = 20 MARKS)

Section B

Question Number	Acceptable Answers	Reject	Mark
14(a)(i)	(RAM = $\frac{(13.9 \times 10) + (86.1 \times 11)}{100}$) = 10.861 (1) = 10.9 IGNORE amu / g mol^{-1} (1) Correct answer without working scores (2)	g/% answers not to 3sf	2

Question Number	Acceptable Answers	Reject	Mark
14(a)(ii)	compared to one twelfth the mass of a carbon-12 (atom/isotope) ALLOW where (one atom of) carbon-12 has a mass of exactly 12		1

Question Number	Acceptable Answers	Reject	Mark
14(a)(iii)	5 protons and 5 electrons (1) 7 neutrons (1) ALLOW use of letters p, e and n for sub-atomic particles		2

Question Number	Acceptable Answers	Reject	Mark
14(b)(i)	Any one from • deflect the ions from their normal path • additional/false peaks from particles in the air • ions would collide with particles in the air IGNORE Reference to chemical reactions/anomalous results/decreased speed of ions/ wrong percentage abundance given	Air molecules	1

Question Number	Acceptable Answers	Reject	Mark
14(b)(ii)	No effect / unaffected / they would not be accelerated/Only affects charged particles IGNORE Reference to detection/deflection/magnetic field		1

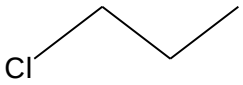
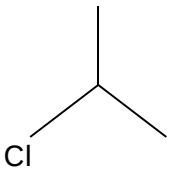
Question Number	Acceptable Answers	Reject	Mark
14(b)(iii)	Any one correct statement scores (1) Three correct statements scores (2) both oxygen atoms from the manganate(VII) ion gives a (molecular / parent ion) peak at **66** one oxygen atom from the manganate(VII) ion / one from water gives a (molecular / parent ion) peak at **64** both oxygen atoms from the water gives a (molecular / parent ion) peak at **62** IGNORE ^{18}O peak ALLOW Both oxygen atoms from the magnagate(VII) ion gives a (molecular/parent ion) peak **four** more	Reference to peaks at 32,34,36 or 63 or 65	2

Question Number	Acceptable Answers	Reject	Mark
14(c)(i)	(Error 1) peaks at 35 and 37 should be in 3:1 ratio/the peak at 35 should be three times the height of the peak at 37 ALLOW Reference to the height of the peak at 35 being at 75% compared to the height of the peak at 37 being at 25% (1) (Error 2) there should be a peak at 72 IGNORE Reference to the height/intensity of the peak at 72 (1)	Just 'greater'	2

Question Number	Acceptable Answers	Reject	Mark
14(c)(ii)	$(^{37}Cl—^{37}Cl)^+$ OR $[^{37}Cl—^{37}Cl]^+$ OR $(^{37}Cl^{37}Cl)^+$ OR $^{37}Cl—^{37}Cl^+$ OR $^{37}Cl_2^+$	$(^{37}Cl+^{37}Cl)^+$ $2\ ^{37}Cl^+$	1

(Total for Question 14 = 12 marks)

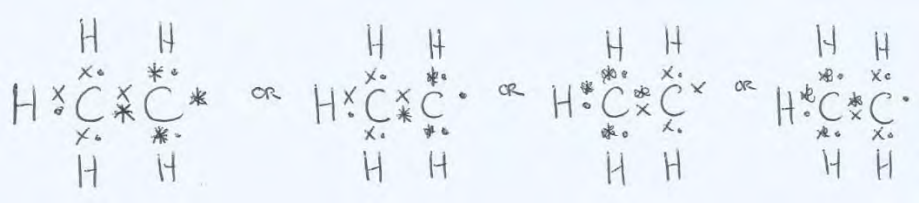
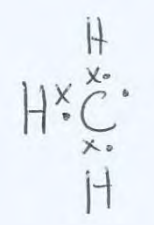
Question Number	Acceptable Answers	Reject	Mark
15(a)	$CH_4 + Br_2 \rightarrow CH_3Br + HBr$ IGNORE State symbols even if incorrect Reference to uv light	C_2H_6	1

Question Number	Acceptable Answers	Reject	Mark
15(b)	The names must correspond to the formulae but there is no TE on incorrect formulae  (1) Name: 1-chloropropane (1)  (1) Name: 2-chloropropane (1) IGNORE bond angles, bond lengths, bond orientations, punctuation		4

Question Number	Acceptable Answers	Reject	Mark
15(c)(i)	(Ethane) has no electron-rich area/no electron-dense area/ has no delta negative centre/no δ− (for the electrophile to react with) IGNORE No double bonds / no ∏ bonds but this can be credited in (c)(ii) Has maximum number of hydrogen atoms	Charge density/ No lone pair	1

Question Number	Acceptable Answers	Reject	Mark
15(c)(ii)	(Ethane) has no multiple bonds/ has no double bond / has no π bond / has only single / has only σ bonds ALLOW Ethane is saturated NOTE This may be explained in the answer to (c)(i) IGNORE Ethane is an alkane	Incorrect chemistry, e.g. donates protons	1

Question Number	Acceptable Answers	Reject	Mark
15(c)(iii)	(Equation) $Cl_2 \rightarrow 2Cl\bullet$ (1) IGNORE curly arrows even if incorrect (Name of reaction step) Initiation (1) IGNORE Free radical substitution/Homolytic fission Mark independently		2

Question Number	Acceptable Answers	Reject	Mark
15(c)(iv)	Carbon with only two hydrogens has single electron (1) Dot and cross of C−C and all C−H bonds correct (1) Example:  ALLOW One mark for ethane dot and cross diagram One mark for methyl free radical, example 	Missing H's	2

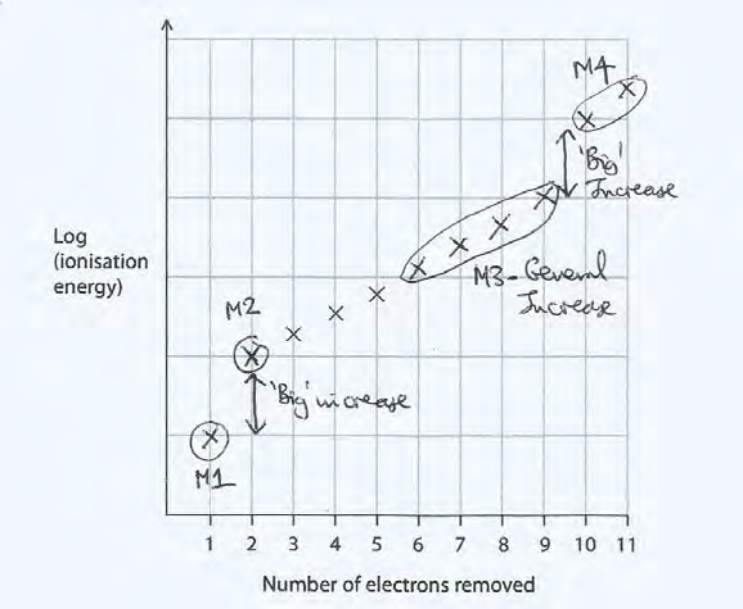
Question Number	Acceptable Answers	Reject	Mark
15(c)(v)	Increase the proportion of chlorine/ Use excess / more chlorine ALLOW decrease proportion of ethane OR Use less ethane Ignore references to temperature, pressure and uv light	Chloride Cl	1

(Total for Question 15 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
16(a)	The energy required ALLOW energy / enthalpy change/endothermic (1) to remove one electron from each atom in one mole of atoms ALLOW to remove one mole of electrons from one mole of atoms **Or** to produce one mole of singly charged positive ions from one mole of atoms (1) (all species) in the gaseous state (1) IGNORE equation even if correct	Energy given out / energy produced/ exothermic	3

Question Number	Acceptable Answers	Reject	Mark
16(b)	$Li^{+}(g) \rightarrow Li^{2+}(g) + e^{(-)}$ OR $Li^{+}(g) - e^{(-)} \rightarrow Li^{2+}(g)$ IGNORE missing (g) if gaseous is in part (a) DO NOT penalise missing gaseous state symbol if omission of gaseous is already penalised in part (a)		1

Question Number	Acceptable Answers	Reject	Mark
16(c)	Helium only has two electrons/ Helium does not have a third electron to lose IGNORE Helium only has two valence electrons/ only has two electrons in its outer shell		1

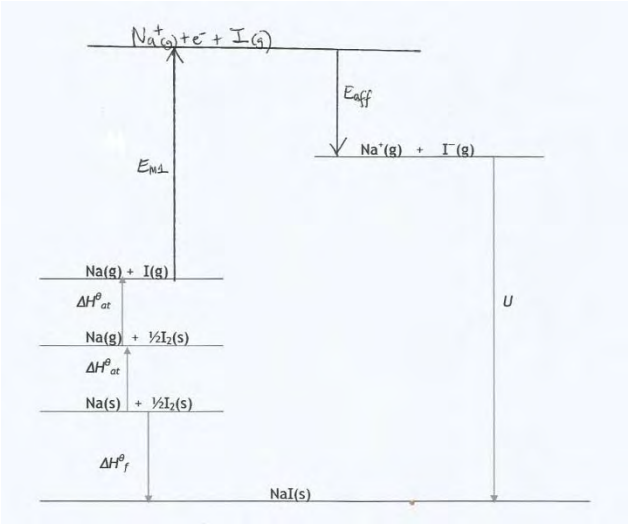
Question Number	Acceptable Answers	Reject	Mark
16(d)	**Marking point 1** One cross for electron 1 significantly below those already present (1) **Marking point 2** One cross for electron 2 slightly below the three crosses already present (1) **Marking point 3** Crosses for electrons 6 to 9 on an approximately straight line upwards continuing from electrons 3 to 5 (1) **Marking point 4** Cross for electron 10 significantly above the cross for electron 9 **and** cross for electron 11 slightly above the cross for electron 10 (1) Mark Independently IGNORE Lines drawn between crosses Example  	‘big’ increase anywhere between crosses 6 to 9 ‘big’ increase from cross 10 to cross 11	4

Question Number	Acceptable Answers	Reject	Mark
16(e)	Any three from Increased shielding (by inner electron shells) / greater repulsion between inner shell electrons (1) More shells (1) Greater distance from nucleus (to outermost electron) / increased (atomic) radius (1) These outweigh the increased nuclear attraction from the greater number of protons (1)	Reference to molecule, max 2 Ionic radius	3

Question Number	Acceptable Answers	Reject	Mark
16(f)	(For sulfur) the outermost electron is paired in the p orbital (1) Repulsion between (paired) electrons (reduces ionisation energy) (1) If no correct reference to sulfur then allow one mark for phosphorus (atom) having more stable p^3/half-filled p sub-shell	4p	2

Question Number	Acceptable Answers	Reject	Mark
16(g)	(Ionisation energy value) Any value in the range of (+)520-700 (kJ mol^{-1}) [Actual value (+)578] ALLOW Any range within the values given above (1) The outermost electron for aluminium is in a **p** orbital / subshell (1) Which has higher energy (than the **s** orbital) ALLOW is further away from the nucleus (and requires less energy to remove) than the 3s electrons (of aluminium) **Or** Shielded by the 3s electrons (1) ACCEPT Reverse arguments	 2p Higher energy **level / shell**	3

(Total for Question 16 = 17 marks)

Question Number	Acceptable Answers	Reject	Mark
17(a)	Diagram similar to:  **Marking point 1** Arrow upwards for first ionisation energy of sodium and correct label on arrow (from correct entities) (1) **Marking point 2** Arrow downwards for electron affinity of iodine and correct label on arrow (from correct entities) (1) **Marking point 3** Correct entities with states (on horizontal line) Ignore missing electron (1) ALLOW Numerical values for labels on arrows Recognisable symbols for labels on arrows, such as ΔH_{IE}, ΔH_{EA}		3

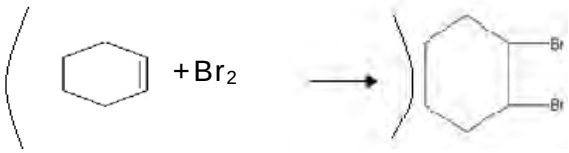
Question Number	Acceptable Answers	Reject	Mark
17 (b)	(LE = 107+107+496+288-295=) —703 kJ mol^{-1}		1

Question Number	Acceptable Answers	Reject	Mark
17 (c)	Energy is required to break bonds (1) In sodium these are metallic bonds/(electrostatic) attractions between metallic cations and the sea of delocalised electrons (1) In iodine these are covalent bonds (between the iodine atoms and London forces) (1) Mark independently		3

Question Number	Acceptable Answers	Reject	Mark
17(d)(i)	(Sodium iodide has) some covalent character / some covalency/some polarisation ALLOW the electron cloud of the iodide ion is distorted Ignore references to NaI being not 100% ionic/ NaI being just 'covalent' (1) which results in stronger bonding (than purely ionic) (1) Ignore References to standard conditions/expt. error		2

Question Number	Acceptable Answers	Reject	Mark
17(d)(ii)	Diagram with distorted electron density cloud towards the sodium ion Example  Ignore the size difference between the ions	Iodine contour line overlaps with sodium contour line	1

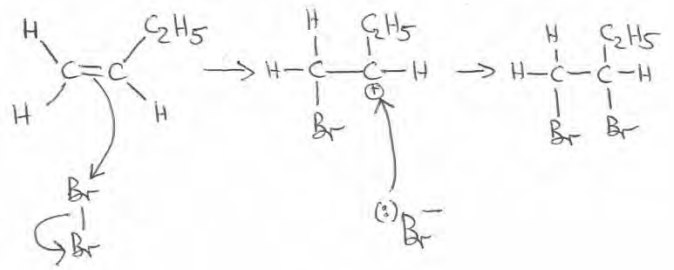
(Total for question 17 = 10 marks)

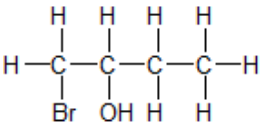
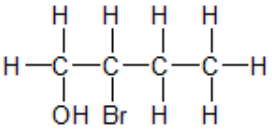
Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	 IGNORE bond angles, bond lengths, bond orientations	+ H_2	1

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	From red-brown / red / brown to colourless	Clear/white Orange/yellow/ Orange-brown	1

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)	(Bonds broken =) 612 + 193 = (+)805 (Bonds made=) 347 + (290x2)=(-) 927 (1) Enthalpy of reaction =(805 — 927=) —122 (kJ mol^{-1}) Correct answer with no working scores two marks ALLOW (All bonds broken=)+4803 (All bonds made =)-4925 (1) Enthalpy of reaction = (+4803 – 4925=) -122 (kJ mol^{-1}) (1) Award one mark for (+) 122 (kJ mol^{-1}) Award one mark for a correct subtraction using one of the correct values above, example 4538 – 4925 = –387 (kJ mol^{-1})		2

Question Number	Acceptable Answers	Reject	Mark
18(b)(ii)	Bond enthalpies are for gaseous compounds **and** bromine is a liquid / 1,2 dibromobutane is a liquid IGNORE Reference to just ‘different states’		1

Question Number	Acceptable Answers	Reject	Mark
18(b)(iii)	Mechanism drawn similar to  **Marking point 1** Curly arrow from double bond to Br **and** curly arrow from Br-Br bond to the Br (dipoles not required) (1) **Marking point 2** Correct carbocation structure (1) **Marking point 3** Curly arrow from anywhere on the bromide ion (including the minus sign) towards the carbocation **and** the correct product ALLOW TE on primary carbocation (1) Note the bromide ion must have a full negative charge but the lone pair of electrons need not be shown	Incorrect dipole $^{\delta-}$Br	3

Question Number	Acceptable Answers	Reject	Mark
18(b)(iv)	1-bromobutan-2-ol / $CH_3CH_2CHOHCH_2Br$/  ALLOW 2-bromobutan-1-ol / $CH_3CH_2CHBrCH_2OH$/  ALLOW 2-bromo-1-butanol ALLOW skeletal or structural formulae Penalise contradictory names/formulae	Missing H's	1

TOTAL FOR QUESTION 18 = 9 MARKS

(TOTAL FOR SECTION B = 60 MARKS)

TOTAL FOR PAPER = 80 MARKS

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Edexcel Chemistry – AS Grade Boundaries

6CH01 – The Core Principles of Chemistry

Season	Full UMS	A	B	C	D	E
IAL - June 2015	80	67	60	53	47	41
June 2015	76	62	55	49	43	37
IAL - Jan 2015	73	61	55	50	45	40
June 2014	78	66	60	54	48	42
IAL - June 2014	80	66	59	52	46	40
R - June 2014	80	66	58	50	42	35
IAL - Jan 2014	70	58	52	46	41	36
June 2013	73	59	52	45	39	33
R - June 2013	80	69	62	56	50	44
Jan 2013	63	53	48	43	39	35
June 2012	78	66	60	54	48	42
Jan 2012	66	54	48	42	36	30
June 2011	75	61	54	48	42	36
Jan 2011	67	55	49	43	37	32
June 2010	74	62	56	50	44	39
Jan 2010	62	48	41	35	29	23
June 2009	≈68	57	51	45	39	34
Jan 2009	≈63	53	46	40	34	28

6CH02 – Application of Core Principles of Chemistry

Season	Full UMS	A	B	C	D	E
IAL - June 2015	69	57	51	45	39	34
June 2015	72	60	54	48	42	37
IAL - Jan 2015	71	59	53	47	42	37
June 2014	76	64	58	52	47	42
IAL - June 2014	74	62	56	50	45	40
R - June 2014	74	60	53	47	41	35
IAL - Jan 2014	68	58	53	48	43	38
June 2013	75	61	54	47	40	34
R - June 2013	76	64	58	52	46	41
Jan 2013	77	65	59	54	49	44
June 2012	75	63	57	51	45	39
Jan 2012	73	61	55	49	44	39
June 2011	70	58	52	46	40	34
Jan 2011	72	60	54	48	42	36
June 2010	72	60	54	48	42	36
Jan 2010	63	51	45	39	33	27
June 2009	≈61	49	43	37	32	27
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Edexcel Chemistry – AS Grade Boundaries

6CH01 – The Core Principles of Chemistry

Season	Full UMS	A	B	C	D	E
IAL - June 2015	80	67	60	53	47	41
June 2015	76	62	55	49	43	37
IAL - Jan 2015	73	61	55	50	45	40
June 2014	78	66	60	54	48	42
IAL - June 2014	80	66	59	52	46	40
R - June 2014	80	66	58	50	42	35
IAL - Jan 2014	70	58	52	46	41	36
June 2013	73	59	52	45	39	33
R - June 2013	80	69	62	56	50	44
Jan 2013	63	53	48	43	39	35
June 2012	78	66	60	54	48	42
Jan 2012	66	54	48	42	36	30
June 2011	75	61	54	48	42	36
Jan 2011	67	55	49	43	37	32
June 2010	74	62	56	50	44	39
Jan 2010	62	48	41	35	29	23
June 2009	≈68	57	51	45	39	34
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6CH02 – Application of Core Principles of Chemistry

Season	Full UMS	A	B	C	D	E
IAL - June 2015	69	57	51	45	39	34
June 2015	72	60	54	48	42	37
IAL - Jan 2015	71	59	53	47	42	37
June 2014	76	64	58	52	47	42
IAL - June 2014	74	62	56	50	45	40
R - June 2014	74	60	53	47	41	35
IAL - Jan 2014	68	58	53	48	43	38
June 2013	75	61	54	47	40	34
R - June 2013	76	64	58	52	46	41
Jan 2013	77	65	59	54	49	44
June 2012	75	63	57	51	45	39
Jan 2012	73	61	55	49	44	39
June 2011	70	58	52	46	40	34
Jan 2011	72	60	54	48	42	36
June 2010	72	60	54	48	42	36
Jan 2010	63	51	45	39	33	27
June 2009	≈61	49	43	37	32	27
Jan 2009	≈68	56	50	44	39	34

Merged Unit 3s
Jan 09 - June 16

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Sample Assessment Material
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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PEARSON

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Answer ALL the questions. Write your answers in the spaces provided.

1 Tests were carried out on compounds **X**, **Y** and **Z**. Complete the tables below.

(a) Compound **X** is a white, water-soluble solid.

	Test	Observation	Inference (Name or formula)	
(i)	Flame test	Lilac flame	.....	**(1)**
(ii)	To a solution of **X**, add barium chloride solution and acidify with hydrochloric acid	....	Sulfate ions absent	**(1)**
(iii)	To a solution of **X**, add dilute nitric acid followed by	.....	Iodide ions present	**(2)**
(iv)	Add concentrated aqueous ammonia solution to the mixture remaining from test (iii)	.....	Confirms presence of iodide ions	**(1)**

(v) The **formula** of **X** is: .....

(1)

(b) Compound **Y** is a white solid that is insoluble in water.

	Test	Observation	Inference (Name or formula)	
(i)	Flame test	Yellow-red (brick red) flame	.....	**(1)**
(ii)	Add dilute hydrochloric acid to **Y** ..... Bubble the gas through	The mixture fizzed and the solid ..... It turned milky	CO_2 evolved	**(2)**

(iii) The **formula** of **Y** is: .....

(1)

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(c) **Z** is a colourless organic liquid with only one functional group. **Z** is completely miscible with water to form a neutral solution.

	Test	Observation	Inference
(i)	Add bromine water to **Z**	No colour change	..... (1)
(ii)	Add solid phosphorus(V) chloride, PCl_5, to **Z**	Misty fumes (of hydrogen chloride)	..... (1)
(iii)	Warm **Z** with potassium dichromate(VI) solution and dilute sulfuric acid	Colour changes from orange to green	**Z** could be ..... or ..... (2)

(d) The composition by mass of **Z** is C 60.0%, H 13.3%, O 26.7%.

(i) Calculate the empirical formula of **Z**.

(2)

(ii) The molecular formula of **Z** is the same as its empirical formula. Give the **displayed** formulae of the two possible isomers of **Z**.

(2)

(Total for Question 1 = 18 marks)

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2 An experiment to determine the enthalpy change of reaction between aqueous copper(II) sulfate and zinc was carried out as follows.

1. 50.0 cm^3 of copper(II) sulfate solution, of concentration 1.00 mol dm^{-3}, was placed in a polystyrene cup.
2. The temperature of the solution was measured with a 0 – 110 °C thermometer and was found to be 23.0 °C.
3. Zinc powder with a mass of 5 g (an excess) was added to the solution with vigorous stirring and the highest temperature recorded was 69.5 °C.

(a) (i) Write the **ionic** equation for the reaction between zinc and aqueous copper(II) ions, including state symbols.

(2)

(ii) Calculate the quantity of heat energy produced in the experiment above, giving your answer in J. (Assume that the heat capacity of the mixture is 4.18 J g^{-1} $°C^{-1}$ and its density is 1.00 g cm^{-3}.) Use the expression

energy transferred in joules = mass × specific heat capacity × temperature change

(2)

(iii) Calculate the number of moles of copper(II) sulfate used in the experiment.

(1)

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(iv) Use your answers from (a)(ii) and (a)(iii) to calculate the enthalpy change for the reaction in kJ mol^{-1}. Give your answer to **three** significant figures and include the appropriate sign.

(2)

(b) The thermometer used in this experiment gave an uncertainty in each temperature reading of ±0.5 °C.

(i) State the maximum temperature difference in this experiment that could have been obtained using this thermometer.

(1)

(ii) What is the percentage error in the temperature change using this thermometer?

(1)

(c) **Using the same equipment**, together with a stop clock, suggest a procedure that would improve the accuracy of this experiment by obtaining a more accurate temperature change. You must use the same mass of zinc powder and the same volume of 1.00 mol dm^{-3} copper(II) sulfate solution.

(4)

(Total for Question 2 = 13 marks)

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3 Chloroalkanes and bromoalkanes can be made from alcohols by reaction of the alcohol with sodium chloride or bromide, in the presence of 50% aqueous sulfuric acid.

Iodoalkanes cannot be made from sodium iodide and sulfuric acid; red phosphorus and iodine can be used instead as the halogenating agent.

(a) (i) What would you **see** if concentrated sulfuric acid was added to solid sodium iodide? Give **two** observations.

(2)

1.....

.....

2.....

.....

(ii) Explain why sodium iodide and sulfuric acid cannot be used to make iodoalkanes from alcohols.

(2)

.....

.....

.....

.....

(b) Give the equation for the reaction between phosphorus and iodine to form phosphorus(III) iodide. State symbols are not required.

(1)

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(c) A preparation of 1-iodobutane is given in outline below.

Procedure

1. Suitable quantities of red phosphorus and butan-1-ol are placed in a round-bottomed flask fitted with a reflux condenser.
2. The mixture is heated until it boils gently and then the heat source is removed.
3. A suitable quantity of powdered iodine is added in small portions down the condenser at a rate which just maintains gentle boiling. The reaction should be allowed to subside after each addition.
4. After the addition of iodine is complete, the mixture is heated under reflux for 30 – 60 minutes, until little or no iodine is visible.
5. The apparatus is allowed to cool and the condenser rearranged for distillation.
6. The crude 1-iodobutane is distilled off until the residue in the distilling flask is about one-fifth of its original volume. Double its volume of water is added and the distillation continued until no more oily drops condense into the receiver.
7. The crude 1-iodobutane is separated and washed with dilute sodium thiosulfate solution and then with dilute sodium carbonate solution.
8. The organic layer is separated and allowed to stand over anhydrous calcium chloride.

(i) What does the manner in which the iodine is added in **step 3** suggest about the nature of the reaction?

(1)

.....

(ii) Completion of **step 4** requires that 'little or no iodine is visible'. State what you would look for in this step to ensure that this is true.

(1)

.....

.....

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(iii) Draw the apparatus that is used in **step 6** for distillation.

(3)

(iv) Suggest why the first washing of the product in **step 7** is with dilute sodium thiosulfate solution rather than with water alone.

(1)

(v) State why calcium chloride used in **step 8** must be anhydrous.

(1)

(vi) To complete the preparation, after decanting the mixture from the calcium chloride, there should be a **step 9**. What is this step?

(1)

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(d) Chloroalkanes can be made from an alcohol and phosphorus(V) chloride, PCl_5.
The equation for the reaction of butan-1-ol with PCl_5 is

$$CH_3CH_2CH_2CH_2OH + PCl_5 \rightarrow CH_3CH_2CH_2CH_2Cl + HCl + POCl_3$$

This reaction is not suitable for the manufacture of 1-chlorobutane on a large scale.

(i) In a laboratory preparation of 1-chlorobutane, 95.0 g of butan-1-ol was used. Calculate the maximum mass of 1-chlorobutane that could be obtained.

(Assume the molar masses are, in g mol^{-1}, butan-1-ol = 74.0, 1-chlorobutane = 92.5)

(2)

(ii) In practice, 95.3 g of 1-chlorobutane was obtained. Calculate the percentage yield.

(1)

(iii) Give **one** reason why the actual yield is lower than the maximum possible yield.

(1)

.....

.....

(iv) Give **two** reasons why this reaction would not be used industrially to make 1-chlorobutane.

(2)

.....

.....

.....

.....

(Total for Question 3 = 19 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

PMT

Mark Scheme (SAM)

Pearson Edexcel International Advanced Subsidiary in Chemistry

Unit 3: Chemistry Laboratory Skills I

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General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

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Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected, it may still be creditworthy.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/	Means that the responses are alternatives and either answer should receive full credit.
()	Means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Bold	Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq	(error carried forward)(transfer error)(consequential) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

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Question Number	Acceptable Answer	Reject	Mark
1(a)(i)	Potassium (ions)/K^+	K/incorrect formula Name with incorrect formula, e.g. 'Potassium, K'	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(ii)	No precipitate forms/no change/no reaction/colourless **solution.** ALLOW clear for colourless.	White precipitate dissolves. Just 'dissolves'	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(iii)	Silver nitrate (solution)/$AgNO_3$ ALLOW acidified silver nitrate. **(1)** Yellow precipitate/solid ALLOW yellow suspension. **(1)** Second mark depends on first mark (use of silver nitrate).	Pale yellow precipitate	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(iv)	(Precipitate) does not dissolve/(precipitate) is insoluble/(precipitate) becomes paler in colour. ALLOW 'no change/no reaction'. ALLOW mark for insoluble even if wrong reagent is used in (a)(iii) to form a **precipitate** regardless of colour. Mark can only be given if there is a **precipitate** in (a)(iii).	Grey solid	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
1(a)(v)	KI Consequential on cation other than K^+ in (a)(i). ALLOW K^+I^-	Just potassium iodide Formula based on cation with incorrect charge or anion other than iodide	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(i)	Calcium (ions)/Ca^{2+} ALLOW +2 for 2+.	Ca/incorrect formula Name with incorrect formula, e.g. 'Calcium, Ca'	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(ii)	Dissolved/disappeared **(1)** Limewater/calcium hydroxide (solution) /$Ca(OH)_2$ ((aq)) **(1)**	Melted	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(iii)	$CaCO_3$ ALLOW $Ca(HCO_3)_2$. TE on incorrect metal ion in b(i) if correct formula given e.g $SrCO_3$, Na_2CO_3.	Name Formula based on cation with incorrect charge, e.g Ca_2CO_3 or anion other than carbonate or hydrogencarbonate	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
1(c)(i)	No double bonds between C atoms /C=C absent/not an alkene/**Z** is saturated/only single bonds between C atoms. ALLOW not an alkene or alkyne.	Just 'no double bonds' Just 'single bond(s)' alkane or any other functional group stated even if alcohol	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(c)(ii)	Alcohol/(−)OH/ROH/hydroxyl group present. ALLOW (−)COH.	OH^-/hydroxide for hydroxyl CHO Carboxylic acid Phenol	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
1(c)(iii)	Primary/1° alcohol **(1)** Secondary/2° alcohol **(1)** ALLOW **Not** a tertiary alcohol for 1 mark. ALLOW propan-1-ol **(1)** propan-2-ol **(1)**	Just 'alcohol' Tertiary alcohols Other specific examples Alcohol and carboxylic acid	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(d)(i)	<table><tr><td>C 60.0 ÷ 12</td><td>= 5.0</td><td>3</td></tr><tr><td>H 13.3 ÷ 1</td><td>= 13.3</td><td>8</td></tr><tr><td>O 26.7 ÷ 16</td><td>= 1.67</td><td>1</td></tr></table> Ratio 5.0: 13.3: 1.67 **(1)** C_3H_8O **(1)** Correct answer without working scores 2 marks. Correct answer with incorrect working (e.g. mole calculations inverted) scores 1 mark. No TE on incorrect ratios.	C_3H_7OH	**(2)**

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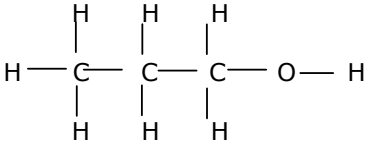
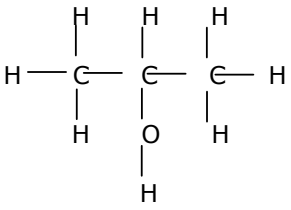
Question Number	Acceptable Answer	Reject	Mark
1(d)(ii)	 **(1)**  **(1)** ALLOW – OH for the hydroxyl group, but bond should go from C to O in propan-1-ol. IGNORE poorly placed OH in propan-2-ol. ALLOW skeletal formulae/structural formulae both correct – 1 mark. ALLOW TE from 1(d)(i), e.g. if a different number of carbon atoms is given in 1di then allow 2 different isomers drawn displayed correctly.	C-H-O C_3H_7OH	**(2)**

Total for Question 1 = 18 Marks

Question Number	Acceptable Answer	Reject	Mark
2(a)(i)	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ First mark for correct species in a balanced equation. ALLOW hexaqua ions providing the equation is balanced. IGNORE reversible arrows. **(1)** Second mark for states. Consequential on a reasonable attempt at the equation, including for a full equation or unbalanced equation. For example, ALLOW as reasonable Zn with 1+ instead of 2+ Sulfate ions shown correctly but not cancelled out. **(1)**	Sulfate ions not cancelled out Reversed equation Zn and Cu metal both shown as ions	**(2)**

Question Number	Acceptable Answer	Reject	Mark
2(a)(ii)	q = 50.0 x 4.18 x 46.5 **(1)** = 9718.5 (J)/9.7185 kJ **(1)** **Correct answer with no working scores (2)** IGNORE sf except 1 (i.e. allow 9719/9720 /9700 or 9.719/9.72/9.7 **kJ**) IGNORE sign of q if given. If mass used 55.0g and q = 55.0 x 4.18 x 46.5 = 10690.35 (J) **(1)** If mass used is 5g and q = 5 x 4.18 x 46.5 = 971.85(J) **(1)**	9718	**(2)**

Question Number	Acceptable Answer	Mark
2(a)(iii)	$\frac{50.0 \times 1}{1000}$ = 0.05 (mol) Mark is for final answer.	**(1)**

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Question Number	Acceptable Answer	Mark
2(a)(iv)	ΔH = -9718.5 ÷ (0.050 x 1000) = -194.370 (kJ mol^{-1}) = **-194** (kJ mol^{-1}) ALLOW = -194000 **J mol^{-1}** **First mark:** Value, ignore sign and sf. Only penalise units if value is in J (mol^{-1}) without stating this **(1)** TE (a)(ii) ÷ ((a)(iii) x 1000) Using 10690.5 gives - 2138810J = **-214** kJ mol^{-1}. **Second mark:** Sign and 3 sf. **(1)** **This mark depends on a correct calculation method.**	**(2)**

Question Number	Acceptable Answer	Mark
2(b)(i)	47.5 (^{o}C)	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(b)(ii)	(1.0 x 100) ÷ 46.5 = 2.1505376 = (±) **2.15/2.2/2** (%) IGNORE sf. ALLOW answer with 47.5 in the denominator which gives 2.1052631 = (±) **2.11/2.1/2** (%). ALLOW TE on value (b)(i).	2.0 and 2.1 2.0 and 2.2	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
2(c)	**First mark:** Measure the temperature (of copper(II) sulfate) every minute/at realistic time interval (15 seconds to 1 minute) for, e.g., 2-4 minutes before adding zinc. OR measure temperature (of copper(II) sulfate) before adding zinc. **(1)** **Second mark:** Measure temperature each minute/at realistic time intervals (after adding zinc) for several minutes. **(1)** **N.B.** these readings may be started after the maximum temperature is reached/after reaction has stopped and taken until the mixture has cooled to room temperature. Intervals should be chosen to allow at least 4 readings on cooling section of curve. **Third mark:** Plot a temperature – time graph/plot a graph using measurements (of temp and time) obtained. **(1)** This mark can be awarded if first two marks are insufficient for credit. **Fourth mark:** **Extrapolate** to find ΔT/ maximum temperature (at the time of mixing). OR use properly described intersecting lines to find maximum temperature. **(1)** ALLOW third and fourth marking points to be shown on annotated diagrams/graph. **If zinc is added in small portions or over a period of time only first and third marks can be awarded.** (since measurements of cooling will be incorrect and there is no definite time when reaction starts.)	Readings more often than every 15 s	**(4)**

Total for Question 2 = 13 Marks

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Question Number	Acceptable Answer	Reject	Mark
3(a)(i)	Any two from: Misty/steamy fumes **(1)** Purple/violet fumes **(1)** ALLOW purple gas/vapour. Brown or black solution/liquid/solid OR grey/grey-black solid **(1)** Yellow solid/deposit **(1)** ALLOW yellow precipitate. IGNORE effervescence, bubbles, colour change, coloured fumes, solid disappears, description of smells, identification of products even if incorrect, follow-on tests, e.g. effect on potassium dichromate paper.	White fumes Steamy white Smoke Yellow fumes Yellow liquid	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(ii)	There is little/no HI formed (which is the reagent needed). **(1)** Because HI is **oxidized** (to iodine)/because iodide ions are **oxidized** (to iodine)/sulfuric acid is oxidizing/HI **reduces** sulfuric acid/iodide ions **reduce** sulfuric acid. **(1)** Must mention oxidation or reduction correctly for second mark. IGNORE 'an elimination reaction would occur'. ALLOW 'HI is oxidized to iodine' for both marks.	Iodide **ions** react with sulfuric acid Sulfuric acid oxidizes **iodine** HI is **reduced** to iodine	**(2)**

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Question Number	Acceptable Answer	Reject	Mark
3(b)	$2P + 3I_2 \rightarrow 2PI_3$ OR $P + 3/2I_2 \rightarrow PI_3$ OR $P_4 + 6I_2 \rightarrow 4PI_3$ ALLOW reversible sign. IGNORE state symbols even if incorrect.	Equations with ions I for I_2	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(i)	Exothermic ALLOW fast/vigorous/violent.	Dangerous Reactive (In)flammable Volatile	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(ii)	(Very) pale purple/yellow/straw coloured OR Colourless mixture/is decolourised OR Co purple colour	Clear for colourless No (grey) solid remains Add starch	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
3(c)(iii)	Diagram to show: Distillation flask and still-head and heat. **(1)** (no need for a thermometer) ALLOW appropriate tubing as alternative to still head. ALLOW heating with electrical, water bath, Bunsen or just arrow. IGNORE thermometer and position, tap funnel in still head, absence of reagents in flask Condenser sloping downwards **(1)** With water entering at the bottom and suitable receiver (e.g. flask or beaker) **(1)**	Conical flask	**(3)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(iv)	This removes/reacts with (any residual) iodine. OR Removes excess iodine/I_3^-.	Removes acid Removes impurities Removes iodide Removes ions (other than I_3^-) Just reduces iodine to iodide	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(v)	Anhydrous calcium chloride/it is drying agent OR anhydrous salt needed to remove water/hydrated salt will not remove water Allow moisture for water and absorb for remove.	Just 'calcium chloride is a drying agent'	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
3(c)(vi)	Distillation/re-distillation (over a narrow range of temperature) (either side of the boiling temperature of 1-iodobutane). ALLOW fractional distillation. IGNORE filtering before distillation and any temperatures given.	Recrystallisation Just 'purification'	**(1)**

Question Number	Acceptable Answer	Mark
3(d)(i)	(95.0 ÷ 74.0) x 92.5 g **(1)** = 118.75/118.8/119 g **(1)** ALLOW 118.77 (from use of 1.284) 3, 4 or 5 sf in final answer Correct final answer scores 2 marks. OR Rounding errors by dividing 95.0 ÷ 74.0 as a first step: e.g. (95.0 ÷ 74.0)=1.28, followed by 1.28 x 92.5 = 118.4/118 **(1)** e.g. (95.0 ÷ 74.0) = 1.3 followed by 1.3 x 92.5 = 120.25/120.3/120 **(1)**	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3d(ii)	95.3 ÷ 3(d)(i) (95.3 ÷ 118.75) x 100 = 80.2563 = **80.25/80.3** % Many candidates give the answer to 3 d(i) to 3sf, e.g. 119 but keep the full answer in their calculator, resulting in an answer of 80.25 which is correct and should be allowed. TE from 3(d)(i).	80.2	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
3d(iii)	**One** of: Handling/transfer losses Competing reactions/(unwanted) side reaction/by-products form Incomplete reaction	Just 'losses'/spillage Impure reagents Loss by evaporation Other products form Not enough PCl_5 to react	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3d(iv)	**Two** of: Low atom economy IGNORE 'low percentage/80% yield'. Phosphorus(V) chloride expensive. Disposal of unwanted materials expensive or difficult. No (large scale) use for $POCl_3$. Difficult/expensive to separate required product. No credit for: Slow/time consuming Exothermic Not efficient High energy use Competing reactions Non-renewable reactants HCl toxic/acidic Unwanted products	Just Atom economy not 100% Just 'It' would be expensive Anything to do with environmental friendliness or the ozone layer or the end of life on Earth.	**(2)**

Total for Question 3 = 19 Marks

Total for Paper = 50 Marks

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Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Friday 15 May 2009 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/7/3/

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Answer ALL the questions. Write your answers in the spaces provided.

1 (a) A student carries out a series of tests on **X**, a white powder known to be either calcium carbonate or magnesium carbonate. Complete the table below.

(6)

	Test	Observation	Inference
(i)	Carry out a flame test on **X**.	....	Cation is magnesium.
(ii)	Add dilute hydrochloric acid to **X**.	.... **and** a solution **Y** is formed.	A gas is evolved.
(iii)	Pass the gas evolved in test (ii) through limewater.	....	Gas evolved in (ii) is ....
(iv)	Add dilute sodium hydroxide to solution **Y** until there is no further change.	....	The **new** substance observed is ....

(b) A student carries out a series of tests on a white solid **Z** which contains one cation and one anion. Complete the table below.

(6)

	Test	Observation	Inference
(i)	Carry out a flame test on **Z**.	Red flame	Cation is either ..... or .....
(ii)	Acidify an aqueous solution of **Z** with dilute nitric acid. Then add a few drops of aqueous silver nitrate followed by **concentrated** aqueous ammonia until there is no further change.	Cream precipitate which	Anion is probably bromide.
(iii)	Add concentrated sulfuric acid to solid **Z**.	Steamy fumes **and** ..... vapour seen.	Probably hydrogen bromide **and** ..... formed. Bromide confirmed.
(iv)	Test the gases formed in (iii) with a piece of filter paper soaked in potassium dichromate(VI) solution.	Colour change from ..... to	Sulfur dioxide present.

(v) Explain, in terms of the redox processes occurring, how sulfur dioxide is produced in (b)(iii).

(2)

.....

.....

.....

(Total for Question 1 = 14 marks)

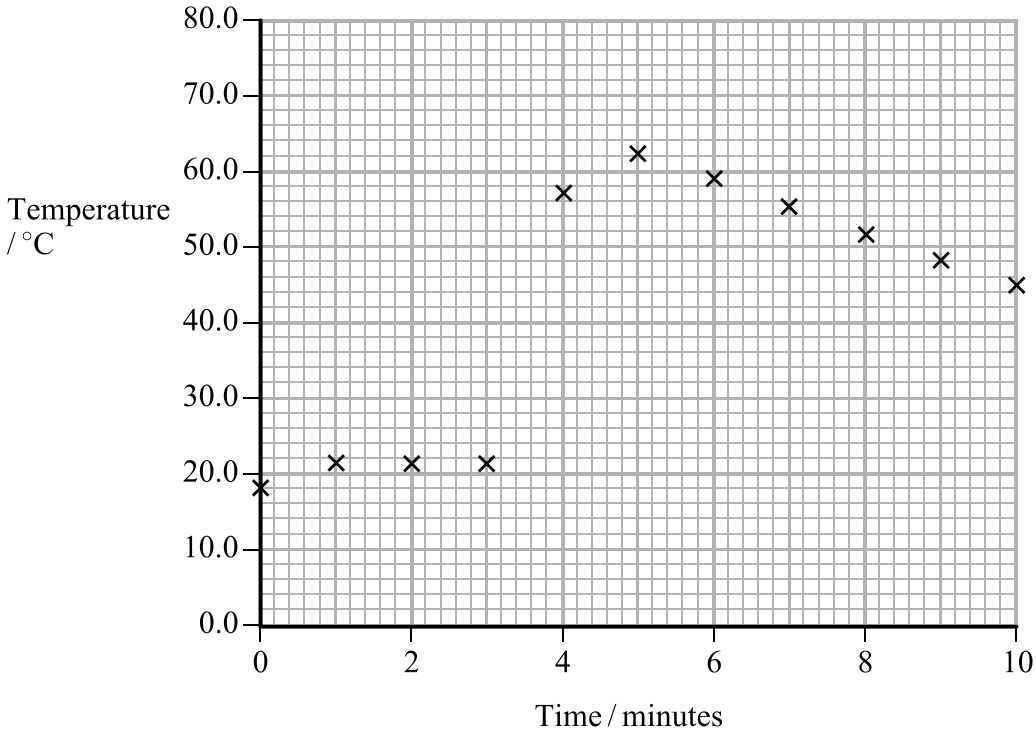
2 The enthalpy change for the reaction between zinc and copper(II) sulfate solution was determined using the procedure below. The ionic equation for the reaction is

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

Procedure

1. Weigh about 5 g of zinc powder.
2. Measure 50.0 cm^3 of 1.00 mol dm^{-3} copper(II) sulfate solution into a polystyrene cup.
3. Stir the solution continuously with a thermometer and measure the temperature of the solution each minute for 3 minutes.
4. At **exactly** 3.5 minutes add the zinc powder to the copper(II) sulfate solution.
5. Continue to stir the solution and read the temperature each minute from 4 to 10 minutes.

The results obtained are shown in the graph below.



(a) (i) Use the graph to estimate the maximum temperature change, ΔT, for the reaction. Show your working on the graph.

(2)

ΔT = ... °C

(ii) Calculate the number of moles of copper(II) sulfate in 50.0 cm^3 of 1.00 mol dm^{-3} solution.

(1)

(iii) The 5 g of zinc powder used is an excess. Calculate the mass of zinc that reacts exactly with 50.0 cm^3 of 1.00 mol dm^{-3} copper(II) sulfate solution.

(1)

(iv) Explain why the mass of zinc is **not** used in the calculation of the heat energy for the reaction.

(1)

.....

.....

(v) Use the value you have obtained for ΔT to calculate the heat energy produced in the reaction between zinc and copper(II) sulfate. Include units with your answer.

Use the expression

$$\text{energy produced (J)} = \text{mass of solution} \times \text{specific heat capacity of solution} \times \text{temperature rise}$$

[Assume the specific heat capacity of the solution to be 4.18 J g^{-1} °C^{-1} and the density of the solution to be 1.00 g cm^{-3}.]

(2)

(vi) Calculate the enthalpy change, ΔH, for this reaction. Your answer should be in units of kJ mol^{-1}, expressed to **two** significant figures and include a sign.

(2)

ΔH = ... kJ mol^{-1}

(b) (i) Explain why the temperature of the solution is measured for 3 minutes **before** adding the zinc.

(1)

.....

.....

(ii) Explain why the temperature of the solution is measured over a period of time **after** adding the zinc.

(1)

.....

.....

(iii) A polystyrene cup is used, rather than a glass beaker, to reduce heat loss. Explain why a polystyrene cup is a good choice.

(1)

.....

.....

.....

(iv) Explain why the solutions are **continuously** stirred in this experiment.

(1)

.....

.....

.....

(v) Suggest a piece of apparatus suitable for measuring the 50.0 cm^3 of copper(II) sulfate solution in this experiment.

(1)

.....

(vi) Suggest ONE change in the apparatus used (other than using more accurate measuring equipment) that would improve the accuracy of the results.

(1)

.....

.....

(c) In two further experiments, using more accurate equipment and an improved method, the ΔH for the reaction between zinc and copper(II) sulfate was determined to be -216.8 kJ mol^{-1} while that for the reaction between zinc and lead(II) nitrate was found to be -154.0 kJ mol^{-1}.

Place the three metals (copper, lead and zinc) in order of **decreasing** reactivity and justify your answer by using these ΔH values.

(2)

.....

.....

.....

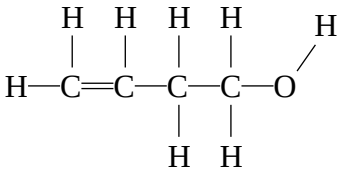
.....

.....

.....

(Total for Question 2 = 17 marks)

3 An organic compound **A** has the structure shown below.



(a) Give the observations that you would expect to make when each of the tests below is carried out. Give a brief chemical explanation of each reaction that occurs. Mechanisms are **not** required.

(i) A small amount of phosphorus(V) chloride is added to 2 cm^3 of **A** in a test tube.

(2)

Observation .....

Explanation .....

.....

(ii) A few drops of potassium manganate(VII) solution and 2 cm^3 of dilute sulfuric acid are added to 2 cm^3 of **A** in a test tube and the mixture is gently warmed.

(2)

Observation .....

Explanation .....

.....

(iii) A few drops of bromine water are added to 2 cm^3 of **A** in a test tube and the mixture is shaken.

(2)

Observation .....

Explanation .....

.....

(b) In the box below, draw the displayed formula of the product formed in (a)(iii).

(1)

(Total for Question 3 = 7 marks)

4 2-chloro-2-methylbutane may be prepared by reacting 2-methylbutan-2-ol with concentrated hydrochloric acid:

$$(CH_3)_2C(OH)CH_2CH_3 + HCl \rightarrow (CH_3)_2C(Cl)CH_2CH_3 + H_2O$$

The steps of the experimental procedure are as follows.

1. Place 5.00 cm^3 of 2-methylbutan-2-ol and about 20 cm^3 of concentrated hydrochloric acid into a separating funnel.
2. Continuously shake the mixture for 10 minutes.
3. Remove the aqueous layer and slowly add about 10 cm^3 of dilute sodium hydrogencarbonate solution to the separating funnel.
4. Shake the mixture gently, inverting the separating funnel and opening the tap at regular intervals.
5. Remove the aqueous layer and transfer the organic layer to a conical flask.
6. Add a few pieces of anhydrous calcium chloride to the conical flask and shake the mixture.
7. Decant the liquid into a distillation flask and distil it to collect the pure 2-chloro-2-methylbutane.

Data

	2-methylbutan-2-ol	2-chloro-2-methylbutane
Density / g cm^{-3}	0.805	0.866
Molar mass / g mol^{-1}	88	106.5
Boiling temperature / °C	102	85.5

(a) Draw a diagram of the separating funnel, clearly labelling the 2-methylbutan-2-ol and the concentrated hydrochloric acid layers (step 1).
[The density of concentrated hydrochloric acid is 1.18 g cm^{-3}.]

(2)

(b) (i) Why is it necessary to **continuously** shake the 2-methylbutan-2-ol and the concentrated hydrochloric acid for the reaction to occur (step 2)?

(1)

.....

.....

(ii) Explain the purpose of the sodium hydrogencarbonate solution (step 3).

(1)

.....

.....

(iii) Why is the tap of the separating funnel opened at regular intervals (step 4)?

(2)

.....

.....

.....

(iv) What is the purpose of the calcium chloride (step 6)?

(1)

.....

.....

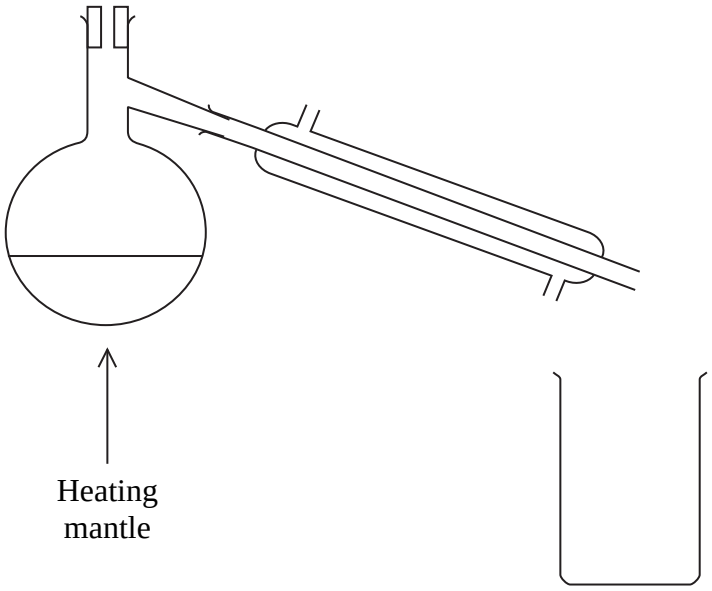
(v) What is meant by **decant** the liquid (step 7)?

(1)

.....

.....

(c) An incomplete diagram of the distillation apparatus is shown below.



(i) Draw a thermometer in the diagram, showing clearly where the bulb of the thermometer is placed.

(1)

(ii) Draw clearly labelled arrows on the diagram to show the flow of water into and out of the condenser.

(1)

(d) The typical yield from this preparation is 70 %. Calculate the mass of 2-chloro-2-methylbutane that would be formed from 5.00 cm^3 of 2-methylbutan-2-ol if a 70 % yield were obtained.

The equation for the reaction and the table of data are repeated below.

$$(CH_3)_2C(OH)CH_2CH_3 + HCl \rightarrow (CH_3)_2C(Cl)CH_2CH_3 + H_2O$$

	2-methylbutan-2-ol	2-chloro-2-methylbutane
Density / g cm^{-3}	0.805	0.866
Molar mass / g mol^{-1}	88	106.5
Boiling temperature /°C	102	85.5

(2)

(Total for Question 4 = 12 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

N 3 4 4 7 3 A 0 1 6 1 6

PMT

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Mark Scheme Summer 2009

GCE

GCE Chemistry (8CH07)
International Supplement 2

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Summer 2009

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Contents

1. 6CH07/01 Mark Scheme 5

6CH07/01

Question Number	Correct Answer	Reject	Mark
1 (a)(i)	No (colour) change (to flame) OR no flame colour **Accept** No colour	White flame	**1**

Question Number	Correct Answer	Reject	Mark
1 (a)(ii)	Effervescence / bubbling / fizzing *IGNORE* hissing		**1**

Question Number	Correct Answer	Reject	Mark
1 (a)(iii)	**Observation:** (Lime water) turns milky / cloudy or white precipitate (formed) (1) **Accept** White solid (formed) / chalky **Inference:** carbon dioxide / CO_2 (1)	Turns white	**2**

Question Number	Correct Answer	Reject	Mark
1 (a)(iv)	**Observation:** White precipitate (formed) (1) **Accept** White solid / crystal (formed) *IGNORE* references to heat given out and to precipitate insoluble in excess **Inference:** Magnesium hydroxide / $Mg(OH)_2$ (1)	White substance Confirms magnesium present	**2**

Question Number	Correct Answer	Reject	Mark
1 (b)(i)	Lithium / Li^+ (1) Strontium / Sr^{2+} (1) **Accept** Calcium / Ca^{2+} (1)	Rubidium Li, Sr, Ca (penalise use of element symbol once only)	**2**

Question Number	Correct Answer	Reject	Mark
1 (b)(ii)	Dissolves (in the ammonia) (to form a colourless solution) **Accept** Soluble *IGNORE* references to dilute ammonia	Partially dissolves	**1**

Question Number	Correct Answer	Reject	Mark
1 (b)(iii)	**Observation:** Brown or red-brown or orange (1) **Inference:** Bromine / Br_2 (1)	Red Bromide (for bromine)	**2**

Question Number	Correct Answer	Reject	Mark
1 (b)(iv)	**From:** Orange or yellow To: blue or green or blue-green		**1**

Question Number	Correct Answer	Reject	Mark
1 (b)(v)	**Mark two points independently** (Hydrogen) bromide oxidized / bromine oxidation number increased (from −1 to 0) / changes from -1 to 0 /Bromide loses an electron / (hydrogen) bromide is a reducing agent (1) sulfuric acid reduced / sulfur oxidation number decreases (from (+)6 to (+)4) / changes from (+)6 to (+)4 / sulfate gains electrons / sulfuric acid is an oxidizing agent (1) **Accept** (+)VI to (+)IV sulfate reduced		**2**

Question Number	Correct Answer	Reject	Mark
2 (a)(i)	**Vertical** line at 3.5 minutes intersects extrapolated top line (1) **Horizontal** extrapolated lower line and 66-69 minus 20-22 = $\triangle T$ (1)	incorrect or no extrapolation line joining points at 3 & 4 minutes & extrapolated to intersect top line (0)	**2**

Question Number	Correct Answer	Reject	Mark
2 (a)(ii)	$(1 \times 50 \times 10^{-3}) = 0.0500$ *IGNORE* sf		**1**

Question Number	Correct Answer	Reject	Mark
2 (a)(iii)	65.4 x 0.05 = 3.27 (g) / 3.3 (g) **Accept** 65 x 0.05 = 3.25 (g) / 3.3 (g)		**1**

Question Number	Correct Answer	Reject	Mark
2 (a)(iv)	Heat capacity negligible **Accept:** low specific heat capacity or zinc absorbs less heat than solution	Mass negligible No heat absorbed by zinc All heat absorbed by solution	**1**

Question Number	Correct Answer	Reject	Mark
2 (a)(v)	50 x 4.18 x $\triangle T$ (1) ($\triangle T$ CQ on (a)(i)) Penalise use of incorrect mass here only. *IGNORE* c = 4.2 $Jg^{-1}℃^{-1}$ (units if given must be consistent) (1) *IGNORE* sf except 1 sf		**2**

$\triangle T$	Heat energy (kJ)
44	9.20
45	9.41
46	9.61
47	9.82
48	10.0(3)
49	10.2(4)

Question Number	Correct Answer	Reject	Mark
2 (a)(vi)	= − answer to (a)(v) ÷ answer to (a)(ii) (1) For 0.05 mol: CQ on moles from 2 (a)(ii) Sign **and** 2 sf (1) [this mark may be awarded for any **calculated** value]		**2**

$\triangle T$	Heat energy (kJ)	$\triangle H$ / kJ mol^{-1}
44	9.20	-180
45	9.41	-190
46	9.61	-190
47	9.82	-200
48	10.0(3)	-200
49	10.2(4)	-200

Question Number	Correct Answer	Reject	Mark
2 (b)(i)	Ensure equilibration or steady temperature or same temperature (as surroundings)	More accurate temperature	**1**

Question Number	Correct Answer	Reject	Mark
2 (b)(ii)	To allow for cooling / a cooling correction / to compensate for heat loss	Temperature correction To determine maximum temperature change More accurate temperature / $\triangle T$	**1**

Question Number	Correct Answer	Reject	Mark
2 (b)(iii)	Low heat capacity Good insulator Poor heat conductor Low mass Absorbs less heat	Low **specific** heat capacity	**1**

Question Number	Correct Answer	Reject	Mark
2 (b)(iv)	Ensure uniform temperature **Accept** to spread out heat (uniformly) *IGNORE* references to mixing reagents, increasing reaction rate, enabling reactants to react and temperature accuracy.		**1**

Question Number	Correct Answer	Reject	Mark
2 (b)(v)	Burette / pipette / measuring cylinder /volumetric or graduated flask	Beaker /conical flask	**1**

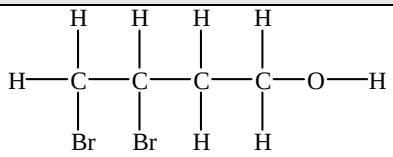
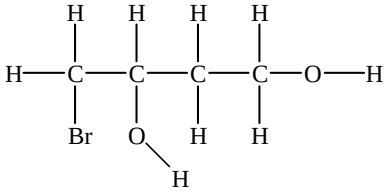
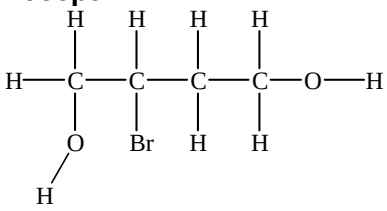
Question Number	Correct Answer	Reject	Mark
2 (b)(vi)	Lid on polystyrene cup/ Increase insulation **Accept** Put cup in a beaker	Magnetic stirrer	**1**

Question Number	Correct Answer	Reject	Mark
2 (c)	Zn>Pb>Cu OR Zinc **displaces** both so is most reactive (1) The more exothermic / negative (**accept** 'the larger') the $\triangle H$ the greater the difference in reactivity (so lead more reactive than copper) (1) If the order of reactivity is reversed maximum 1	Answers in **just** terms of reactivity or electrochemical series Generalised answers References to energy or enthalpy **required** for the reaction	**2**

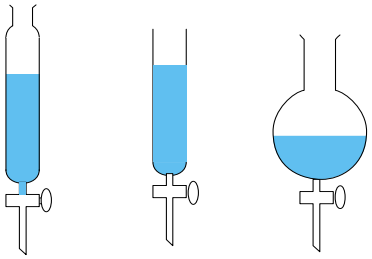
Question Number	Correct Answer	Reject	Mark
3 (a)(i)	**Observation:** Steamy/misty /white fumes (1) **Explanation:** Hydrogen chloride / HCl formed OR chloroalkene / chloro- compound formed OR Substitution reaction with OH (1)	Smoke or solid Hydrochloric acid Chloroalkane Just OH / alcohol group reacts (with PCl_5)	**2**

Question Number	Correct Answer	Reject	Mark
3 (a)(ii)	**Observation:** Purple to colourless or brown (1) **Explanation:** Addition to C=C /alkene **OR** oxidation of C=C /alkene **OR** OH / alcohol group oxidised (1) **Accept** Reacts with C=C to form diol or with OH to form an aldehyde or a carboxylic acid **OR** manganate(VII) / permanganate / MnO_4^- to MnO_2 (if brown) or Mn(II) / Mn^{2+} (if decolourized)	Just 'decolourized' 'Reacts' alone instead of addition or oxidation 'Due to the presence of C=C /alkene / OH' A oxidised	**2**

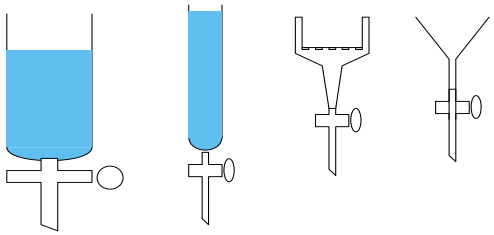
Question Number	Correct Answer	Reject	Mark
3 (a)(iii)	**Observation:** Orange or yellow or brown (**accept** red-brown) to colourless (1) **Explanation:** (Bromine) addition to C=C /alkene (Bromine) reacts with C=C /alkene to form dibromoalkanol / dibromo compound (1)	'pink' instead of purple 'clear' instead of colourless Just 'decolourized' Reaction alone instead of addition dibromoalkane	**2**

Question Number	Correct Answer	Reject	Mark
3 (b)	 OR  **Accept**  **Accept** OH for O—H		**1**

Question Number	Correct Answer	Reject	Mark
4 (a)	Funnel with neck & tap (1) *IGNORE* stopper Organic layer above aqueous layer (1) Stand alone See diagrams	Conical /filter / Buchner funnel with tap Funnel too full to be stoppered	**2**



YES



NO

Question Number	Correct Answer	Reject	Mark
4 (b)(i)	(Organic & aqueous) layers are immiscible **OR** consequence of not shaking e.g. layers form **Accept** 'to ensure layers mix *IGNORE* references to rate	Just 'to mix reagents' Explanations in terms of density differences	**1**

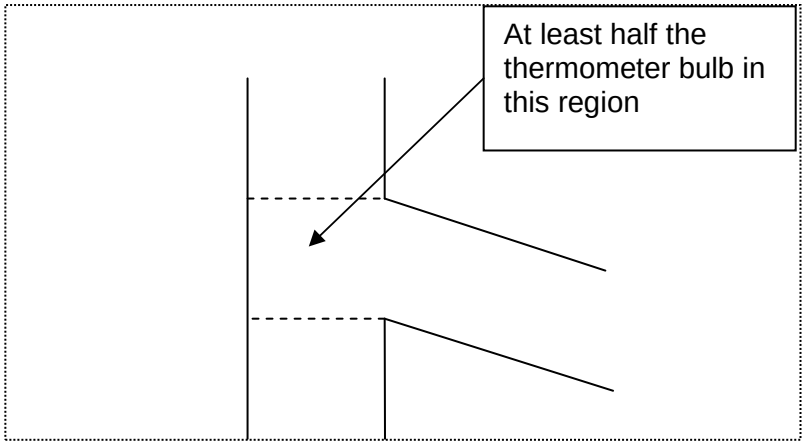
Question Number	Correct Answer	Reject	Mark
4 (b)(ii)	Neutralize (excess) acid / H^+ **Accept** remove acid / H^+ React with acid *IGNORE* Use of HCl for hydrochloric acid release of CO_2	Just 'neutralize / neutralization	**1**

Question Number	Correct Answer	Reject	Mark
4 (b)(iii)	Carbon dioxide / CO_2 /gas is formed (1) Release pressure / pressure builds up (1)		**2**

Question Number	Correct Answer	Reject	Mark
4 (b)(iv)	Drying agent or to remove water	Dehydrating agent	**1**

Question Number	Correct Answer	Reject	Mark
4 (b)(v)	To pour off the liquid leaving the solid behind	Pour / pour carefully / transfer	**1**

Question Number	Correct Answer	Reject	Mark
4 (c)(i)	Bulk of the thermometer bulb adjacent to the outlet leading to the condenser (see diagram)		**1**



Question Number	Correct Answer	Reject	Mark
4 (c)(ii)	Water in through the lower tube and out through the upper If words are used (water in & water out) ignore the direction of any arrows		**1**

Question Number	Correct Answer	Reject	Mark
4 (d)	Mass of alcohol = 5 x 0.805 = 4.025 (g) (1) Moles of alcohol = 4.025 ÷ 88 = 0.0457 = moles of 2-chloro-2-methylbutane Mass 2-chloro-2-methylbutane (100% yield) = 0.0457 x 106.5 = 4.87 70% yield = 4.87 x $\frac{70}{100}$ = 3.41 g (1) ignore sf except for 1 sf If the molar masses are transposed penalise once (answer = 2.32 g) Correct answer and some working (2)		**2**

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Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Monday 11 January 2010 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/5/3/

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Answer ALL the questions. Write your answers in the spaces provided.

1 Compound **A** is a white solid that contains one cation and one anion.

(a) A flame test is carried out on compound **A** by mixing the solid with concentrated hydrochloric acid and using a piece of wire to place some of the solution formed in a Bunsen flame. The flame is coloured yellow.

(i) Name a material from which the wire is made.

Suggest ONE reason why this material is used.

(2)

Name .....

Reason .....

.....

(ii) Identify, by name or formula, the cation present in compound **A**.

(1)

.....

(b) When aqueous silver nitrate solution is added to a solution of compound **A**, a cream precipitate forms. The cream precipitate dissolves in concentrated aqueous ammonia solution.

(i) **Name** the cream precipitate formed when aqueous silver nitrate is added to the solution of compound **A**.

(1)

.....

(ii) Give the **formula** of the anion in compound **A**.

(1)

.....

(iii) Describe what you would see if the cream precipitate in (b)(i) was left in sunlight.

(1)

.....

.....

(c) Concentrated sulfuric acid is added to compound **A** in a test tube. Steamy fumes are seen at the mouth of the test tube.

After a few minutes, the contents of the test tube turn brown. A gas is given off which is tested with a piece of filter paper soaked in a solution of aqueous acidified potassium dichromate(VI). The paper turns green.

(i) Identify, by name or formula, the steamy fumes formed initially.

(1)

.....

(ii) Describe a further test you could carry out to confirm the identity of the steamy fumes. Give the result of your test.

(2)

Test .....

Result .....

.....

(iii) Identify, by name or formula, the substance responsible for the brown colour in the test tube.

(1)

.....

(iv) Name the gas which turned the filter paper green. Suggest the type of reaction by which this gas was formed from sulfuric acid.

(2)

Gas .....

Type of reaction .....

.....

(Total for Question 1 = 12 marks)

2 This question is about two isomeric alcohols, **X** and **Y**, each with molar mass 60 g mol^{-1}.

A solution of potassium dichromate(VI) in dilute sulfuric acid is added to each alcohol. Both alcohols cause the same colour change of the mixture on heating.

(a) A colourless liquid, **B**, is distilled from the mixture containing alcohol **X**.

The liquid **B** forms a red precipitate when it is boiled with Benedict's or Fehling's solution.

Give the displayed formula of liquid **B**, and the name of alcohol **X**.

(2)

Liquid **B**

Name of alcohol **X** .....

(b) A colourless liquid, **C**, is distilled from the mixture containing alcohol **Y**.

C does **not** react when it is boiled with Benedict's or Fehling's solution.

Give the **names** of liquid **C** and alcohol **Y**.

(2)

Liquid **C** .....

Alcohol **Y** .....

(Total for Question 2 = 4 marks)

3 This question is about calcium hydroxide, $Ca(OH)_2$.

The solubility of calcium hydroxide in water can be found by titrating a saturated solution of calcium hydroxide with hydrochloric acid of known concentration.

(a) Describe how you would make a saturated solution of calcium hydroxide suitable for use in this titration. Do not describe the subsequent titration procedure.

(2)

.....

.....

.....

.....

(b) 10.0 cm^3 portions of the saturated solution are placed in a conical flask and titrated with 0.0500 mol dm^{-3} hydrochloric acid added from a burette.

(i) Name the apparatus used to measure the 10.0 cm^3 portions.

(1)

.....

(ii) Suggest a suitable indicator for this titration and state the colour change you would expect to see at the end-point.

(2)

Indicator.....

Colour change from ..... to .....

(c) The following results were obtained:

Titration numbers	1	2	3
Final burette reading / cm^3	19.20	28.05	37.10
Initial burette reading / cm^3	10.00	19.20	28.15
Titre / cm^3	9.20	8.85	

(i) Fill in the third titre value in the table.

(1)

(ii) Suggest why the first titre should be disregarded.

(1)

.....

.....

(iii) Calculate the mean titre.

(1)

..... cm^3

(iv) Calculate the number of moles of hydrochloric acid in the mean titre.

(1)

(v) The equation for the reaction is

$$Ca(OH)_2(aq) + 2HCl(aq) \rightarrow CaCl_2(aq) + 2H_2O(l)$$

Calculate the number of moles of calcium hydroxide in a 10.0 cm^3 portion of the saturated solution.

(1)

(vi) Calculate the concentration of calcium hydroxide in mol dm^{-3}.

(1)

(vii) Calculate the solubility of calcium hydroxide in g dm^{-3}.

(1)

(d) The standard enthalpy change for the reaction of calcium hydroxide with hydrochloric acid was found by reacting 0.0100 mol of solid calcium hydroxide with 50.0 cm^3 of a 1.00 mol dm^{-3} solution of hydrochloric acid (an excess), in a polystyrene cup. The temperature rose from 21.2 °C to 26.7 °C.

(i) Calculate the energy, in joules, transferred in the reaction. Use the expression

Energy transferred = mass × specific heat capacity × temperature change

[Assume density of solution = 1.0 g cm^{-3},
specific heat capacity of solution = 4.18 J g^{-1} °C^{-1}]

(1)

(ii) Calculate the standard enthalpy change, $\Delta H^{\ominus}$, for the reaction. Include a sign and units in your answer.

(2)

(iii) Calculate the percentage error in the temperature change caused by an uncertainty of 0.1°C in each thermometer reading.

(2)

(iv) The experiment was repeated using 50.0 cm^3 of a 1.00 mol dm^{-3} solution of nitric acid instead of the hydrochloric acid. Explain why the temperature change was the same in both experiments.

(1)

.....

.....

(v) The experiment was repeated again using 25 cm^3 of 2.00 mol dm^{-3} hydrochloric acid. Predict the temperature change in this experiment.

(1)

.....

.....

(vi) Which of the experiments in (iv) and (v) gave the least error in the temperature change? Justify your answer.

(1)

.....

.....

(Total for Question 3 = 20 marks)

4 An experiment to prepare a sample of 2-chloro-2-methylpropane uses the reaction of 2-methylpropan-2-ol with concentrated hydrochloric acid.

$$(CH_3)_3COH + HCl \rightarrow (CH_3)_3CCl + H_2O$$

The steps of the experimental procedure are as follows

1. Place 0.20 mol of 2-methylpropan-2-ol and 70 cm^3 of concentrated hydrochloric acid in a large conical flask.
2. Stopper and shake the flask at intervals, releasing any pressure after each shaking.
3. Separate the 2-chloro-2-methylpropane from the aqueous solution using a separating funnel.
4. To the 2-chloro-2-methylpropane in the separating funnel, add 20 cm^3 of sodium hydrogencarbonate solution. Shake the separating funnel, carefully releasing carbon dioxide frequently.
5. Separate the 2-chloro-2-methylpropane and repeat the washing with sodium hydrogencarbonate solution until this washing step is no longer necessary.
6. Transfer the 2-chloro-2-methylpropane to a small conical flask and add a suitable drying agent.
7. Filter off the drying agent, collecting the 2-chloro-2-methylpropane into a distillation flask. Heat the flask, collecting the fraction that distils off between 50 °C and 52 °C.

Data

Property	2-methylpropan-2-ol	2-chloro-2-methylpropane
Density / g cm^{-3}	0.789	0.842
Molar mass / g mol^{-1}	74.1	92.6
Boiling temperature / °C	82.4	50.8

(a) Calculate the volume of 2-methylpropan-2-ol used in the preparation.

(1)

(b) Draw a diagram of a separating funnel that could be used in step 3.
Label the 2-chloro-2-methylpropane layer.

(2)

(c) (i) Suggest why the product is washed with sodium hydrogencarbonate solution (step 4).

(1)

.....

.....

(ii) How would you know that no further washing with sodium hydrogencarbonate was necessary?

(1)

.....

.....

(d) Suggest a suitable drying agent to dry the 2-chloro-2-methylpropane (step 6).

(1)

.....

(e) Draw a labelled diagram of the apparatus you would use to carry out the final distillation (step 7).

(4)

(f) A reaction produced 18.7 cm^3 of 2-chloro-2-methylpropane starting from 0.20 mol 2-methylpropan-2-ol. Calculate the percentage yield of the product of this reaction.

(2)

(g) A suitable chemical test for the chlorine in a chloroalkane, such as 2-chloro-2-methylpropane, is to add the chloroalkane to a mixture of aqueous silver nitrate solution and ethanol.

(i) Suggest why ethanol is added to the mixture.

(1)

.....

.....

(ii) Give the expected result of this test.

(1)

.....

(Total for Question 4 = 14 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

* Lanthanide series

* Actinide series

N 3 4 1 0 4 A 0 1 6 1 6

PMT

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Mark Scheme (Results)
January 2010

GCE

GCE Chemistry (6CH07/01)

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January 2010

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Using the Mark Scheme

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1 (a)(i)	Nichrome (1) ALLOW Platinum/Pt/ceramic rod ACCEPT recognisable spelling Second mark depends on first. Unreactive/inert/chemically stable (at high temperatures in air/with acid)/does not colour flame/high melting point (1)	 High resistance Does not decompose Not easily burned/does not catch fire/does not react with flame Can withstand high T/thermodynamically stable	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (a)(ii)	Sodium/sodium ion/Na^+	Na/sodium atom/Na^-	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(i)	Silver bromide ALLOW AgBr/Ag^+Br^-((s))		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(ii)	Br^- $Br^{-1/1-}$ ALLOW I^- or Cl^- if iodide or chloride given in (b)(i)	Br/Br_2 AgBr	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(iii)	The precipitate darkens ALLOW Precipitate turns purple/grey/black/ blue/silver	Green, orange, red, brown, yellow	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(i)	Hydrogen bromide/HBr/BrH ALLOW hydrobromic acid	HCl/HI Hydrogen chloride/hydrogen iodide	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(ii)	**Test:** Ammonia (solution on glass rod) (1) **Result:** gives white smoke (1) ALLOW white fumes/solid Result mark dependant on ammonia. ALLOW Other indicators with correct colour change from and to. Eg litmus from blue to red for 1max ALLOW addition to silver nitrate solution to form cream precipitate for 1max Reward unexpected correct chemistry! Eg Mix gas with chlorine gas to form a brown liquid/gas for both marks	Steamy fumes	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(iii)	Bromine/Br_2 ALLOW bromine liquid/gas/water/solution	Br^-/Br Bromide/bromine water Chlorine/Cl_2 Iodine/I_2	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(iv)	**Gas:`** Sulfur dioxide (1) ALLOW SO_2 **Type:** Reduction (of sulfuric acid) Redox ALLOW oxidation of (hydrogen) bromide (1) Second mark depends on first unless hydrogen sulfide given.	Displacement	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a)	**Liquid B** H H | | H-C – C – C = O | | | H H H (1) Allow CH_3CH_2CHO/C_2H_5CHO **Name of X** Propan-1-ol/1-propanol (1) Check for 'o' rather than 'a' in propan-1-ol ALLOW correct formula and consistent name for butan-1-ol and pentan-1-ol for 1max	Propanal/prop-1-ol Propanol	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)	**C** propanone ALLOW $(CH_3)_2CO$/fully displayed formula/propan-2-one/propan-2-one (1) **Y** propan-2-ol/2-propanol (1) Ignore punctuation ALLOW consistent answers based on butan-2-ol and pentan-2-ol for **1 max**	If both formula and name given both must be correct Prop-2-ol	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)	Add an **excess** of calcium hydroxide/calcium oxide to water /until no more will dissolve(1) OWTTE leave for 24 hours/heat and leave to cool/ decant/filter/keep temperature constant (1) Accept unexpected correct Chemistry!	Add excess Ca to water	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	(10 cm^3) pipette ALLOW recognisable spelling (eg pipet /pippette)	Burette/measuring cylinder/cylinder	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(ii)	**Indicator** Methyl orange (1) From yellow to orange (1) ALLOW to red/pink ALLOW any named acid-base indicator (recognisable spelling) with correct colour change eg Phenolphthalein (1) From pink/purple/red to colourless (1)	Litmus / universal indicator/ pH paper	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(i)	8.95 (1)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(ii)	First titration is likely to be inaccurate/rough/only a range finder/ not concordant / not within ± 0.2/0.1 cm^3	Too high unless explained as overshoot Difference to high	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(iii)	8.90 (1) ALLOW 8.9 ACCEPT TE from (i)	Use of 9.20 (ans 9.00)	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(iv)	$\frac{8.90 \times 0.05}{1000}$ = 4.45×10^{-4} / $4.45.10^{-4}$ / 0.000445 (mol) ALLOW Answer to (iii) x 0.00005 ALLOW $4.5x10^{-4}$/$4.5.10^{-4}$/ 0.00045		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(v)	2.225×10^{-4} / 0.0002225 (mol) ALLOW Answer to (iv) divided by 2 ALLOW 2.23×10^{-4} / 0.000223 2.2×10^{-4} / 0.00022	2.3×10^{-4} / 0.00023	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(vi)	$2.225 \times 10^{-4} \times 100 = 2.225 \times 10^{-2}$ (mol dm^{-3}) ALLOW answer to (v) x 100		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(vii)	$2.225 \times 10^{-2} \times 74.1$ = 1.648725 = 1.65 (g dm^{-3}) if Mr 74 the answer is 1.6465 = 1.65 (g dm^{-3}) ALLOW Answer to (vi) x 74.1 or x 74 Ignore s.f. Note that 2.23×10^{-4} gives 1.650 with 74 or 1.652 with 74.1 2.3 gives 1.702 and 1.704 respectively 2.2 gives 1.628 and 1.630 respectively		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (d)(i)	50 x 4.18 x 5.5 = 1150/1149.5 (J) ALLOW 1.1/1.150/1.1495 **kJ**	50.74 as mass	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (d)(ii)	$\frac{1149.5 \times 10^{-3}}{0.01}$ =-114.95/-115 kJ mol^{-1} kJ/mol ALLOW -114950/-115000 J mol^{-1} Value (1) Sign and unit (1) ALLOW TE from (d)(i) ALLOW division by incorrect number of moles eg $\frac{1149.5 \times 10^{-3}}{0.05}$ (0) = -22.99/-23.0 kJ mol^{-1} (1) internal TE for sign/unit but only for dividing by an incorrect number of moles.		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (d)(iii)	$\frac{0.2 \times 100}{5.5}$ = 3.6/3.64 % (2) 3.63 % (1max) **First mark** total error = 0.2 **Second mark** percentage ALLOW $\frac{0.1 \times 100}{5.5}$ = 1.8/1.82 % (1max)	1.81 %	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (d)(iv)	as the same neutralisation reaction/ same ionic equation ALLOW as nitric acid is a strong acid /both acids the same strength /same volume of same concentration of acid /same numbers of moles of protons/H^+ **and** same volume.	Same numbers of moles of acid	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (d)(v)	11 °C /doubles	increases	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (d)(vi)	Experiment (v)/ more concentrated hydrochloric acid A bigger temperature change (1) IF temperature rise is the same in (v) ALLOW TE eg (iv) as larger volume gives(lower percentage error in volume measurement) Also: A smaller temperature change in (v) means (iv) is more accurate		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (a)	$\frac{0.2 \times 74.1}{0.789}$ = 18.8 /18.78 (cm^3) but check unit is not wrong ie dm^3 ignore s.f. except one ALLOW 18.76/19 (from M = 74)	18.79	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (b)	Funnel with tap (1) ALLOW any shaped tube with opening at the top(which may be stoppered) with tap at the bottom **Upper** layer labelled as 2-chloro-2-methylpropane (1) Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (c)(i)	To remove/react with acid/neutralize (hydrochloric acid)		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (c)(ii)	No more bubbles/gas/pressure build up/carbon dioxide	Use of indicators	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (d)	(Anhydrous) sodium sulfate/calcium chloride/magnesium sulfate	anhydrous copper sulfate /anhydrous cobalt chloride/concentrated sulfuric acid /calcium oxide	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (e)	Round-bottom/pear shaped flask with 'heat'/arrow underneath/heating mantle/hot water bath(ignore drying agent in the flask)(1) Still head with thermometer at exit (1) Condenser with water (flowing up) (1) collection of product (1) Be generous on drawing – ignore accidental closures by poor drawing	Closed apparatus -1 Significant gaps allowing escape of product (eg between condenser and flask/around thermometer at top of still head (ie no bung)) -1	**4**

Question Number	Acceptable Answers	Reject	Mark
4 (f)	$\frac{18.7 \times 0.842}{92.6}$ = 0.17 (1) $\frac{0.17 \times 100}{0.2}$ =85% /85.0% /85.018% (1) It is possible and acceptable to arrive at the answer by working out masses or volumes: Masses give $\frac{15.754 \times 100}{18.52}$ Volumes give $\frac{18.7 \times 100}{21.995}$ ALLOW Internal TE for incorrect number of moles, providing there is a clear attempt to find the number of moles OR ALLOW second mark for $\frac{\text{Actual amount} \times 100}{\text{Expected amount}}$ if clearly stated in words Correct answer with no working (2)		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (g)(i)	To dissolve the halogenoalkane/ to mix the reagents/as a solvent/reactants are immiscible	To allow reaction	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (g)(ii)	White precipitate	AgCl formed	**1**

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Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Thursday 13 May 2010 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/7/2/

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Answer ALL the questions. Write your answers in the spaces provided.

1 Compound **A** is a white solid that contains one Group 1 cation and one anion.

(a) (i) Describe how you would carry out a flame test on compound **A**.

(3)

(ii) In a flame test, compound **A** gives a red flame. Deduce the formula of the cation present.

(1)

(b) On prolonged strong heating, compound **A** forms a white solid, **B**, and a gas. The gas turns limewater milky.

(i) Identify, by name or formula, the compound that is dissolved in water to make limewater.

(1)

(ii) Suggest the formula for the anion in compound **A**. Justify your answer.

(2)

(c) When water is added to the white solid, **B**, it dissolves completely and exothermically to form solution **C**.

(i) Identify, by name or formula, the anion present in **B**.

(1)

.....

(ii) Identify, by name or formula, the anion present in **C**.

(1)

.....

(iii) Suggest a test for the anion present in **C**. Give the result of your test.

(2)

Test .....

Result .....

(d) Suggest the **formula** of compound **A**.

(1)

.....

(Total for Question 1 = 12 marks)

2 This question is about two isomeric halogenoalkanes, **P** and **Q**.

(a) A hot aqueous solution of silver nitrate is added to each halogenoalkane. Both halogenoalkanes react to form a yellow precipitate.

(i) Identify, by name or formula, this yellow precipitate.

(1)

.....

(ii) The isomers have relative molecular mass 169.9. Deduce the molecular formula of the isomers.

(1)

(iii) Halogenoalkane **P** forms the yellow precipitate faster than halogenoalkane **Q**. Draw a displayed formula for halogenoalkane **P**.

(1)

(iv) Give the name or structural formula of the alcohol, **R**, formed by the reaction of halogenoalkane, **P**, with hot aqueous silver nitrate.

(1)

.....

(b) When **R** is boiled with a mixture of potassium dichromate(VI) and dilute sulfuric acid, the organic product **S** forms.

(i) Give the colour change you would expect to see.

(2)

From ..... **to** .....

(ii) Give the **name** of **S**.

(1)

.....

(iii) Give the type of reaction involved in the conversion of **R** to **S**.

(1)

.....

(Total for Question 2 = 8 marks)

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3 The purity of a sample of potassium iodate(V) was determined by titration.

The steps of the experimental procedure are as follows.

1. 0.100 g of the sample was dissolved in water in a beaker and the solution made up to 100 cm^3 in an appropriate flask.

2. A 10.0 cm^3 portion of this solution of potassium iodate(V) was transferred to a conical flask.

3. An excess of both potassium iodide solution and sulfuric acid were then added to the conical flask. This produced a solution, **T**, containing iodine.

4. Solution **T** was titrated with 0.0200 mol dm^{-3} sodium thiosulfate solution using a suitable indicator.

5. Steps 2, 3 and 4 were repeated twice.

(a) (i) Name the piece of apparatus used to remove the 10.0 cm^3 portions of potassium iodate(V) solution (step 2).

(1)

.....

(ii) Name the indicator you would use for the titration and give the colour change you would expect to see (step 4).

(2)

Indicator .....

Colour change from ..... **to** .....

(b) The following results were obtained for the titrations.

Titration number	1	2	3
Final burette reading / cm^3	19.50	33.20	46.95
Initial burette reading / cm^3	5.00	19.50	33.20
Titre / cm^3			

(i) Complete the table by calculating the titres.

(1)

(ii) Explain why the correct value for the mean titre is 13.73 cm^3.

(1)

.....

.....

.....

(iii) Calculate the number of moles of sodium thiosulfate in the mean titre.

(1)

(c) The ionic equation for the reaction between iodine and sodium thiosulfate in the titration is shown below.

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

Calculate the number of moles of iodine in solution **T** using this equation and your answer to (b)(iii).

(1)

(d) The ionic equation for the reaction of iodate(V) ions with iodide ions is shown below.

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

Using this equation and your answer to (c), calculate the number of moles of iodate(V) ions which reacted to produce solution **T**.

(1)

(e) (i) Name the appropriate flask used in step 1.

(1)

.....

(ii) Describe how you would make up exactly 100 cm^3 of potassium iodate(V) solution in this flask, ready for step 2.

(3)

.....

.....

.....

.....

.....

.....

(iii) Calculate the number of moles of potassium iodate(V) in 100 cm^3 of the solution, using your answer to (d).

(1)

(iv) Calculate the mass of potassium iodate(V) in the sample.

[Assume the molar mass of potassium iodate(V) is 214 g mol^{-1}]

(1)

(v) Calculate the percentage purity of the sample.

(1)

(f) Suggest the most significant hazard in step 3.

(1)

.....

(Total for Question 3 = 16 marks)

4 An experiment to prepare 0.100 mol of 1-bromobutane uses the reaction of butan-1-ol with hydrogen bromide.

Hydrogen bromide is formed in the reaction mixture from potassium bromide and moderately concentrated sulfuric acid.

The process has an 80 % yield after purification of the 1-bromobutane.

$$KBr + H_2SO_4 \rightarrow KHSO_4 + HBr$$

$$CH_3CH_2CH_2CH_2OH + HBr \rightarrow CH_3CH_2CH_2CH_2Br + H_2O$$

The steps of the experimental procedure are as follows.

1. Add measured amounts of potassium bromide and butan-1-ol to 10 cm^3 of water into a 50 cm^3 two-necked flask.

2. Fit the two-necked flask with a reflux condenser and a tap funnel.

3. Immerse the flask in a beaker of cold water and add 10 cm^3 of concentrated sulfuric acid from the tap funnel, a few drops at a time.

4. Remove the flask from the cold water and close the tap on the tap funnel. Heat the mixture under reflux for 30 minutes.

5. Allow the mixture to cool. Then set up the apparatus for distillation. Boil the mixture and collect the distillate in a measuring cylinder.

6. Transfer the distillate to a separating funnel. The distillate consists of two layers, an aqueous layer and impure 1-bromobutane. Separate the two layers.

7. Wash the impure 1-bromobutane with concentrated hydrochloric acid and separate the two layers.

8. Wash the 1-bromobutane layer with sodium hydrogencarbonate solution, releasing any gas formed.

9. Collect the 1-bromobutane layer in a conical flask and add anhydrous sodium sulfate.

10. Decant the 1-bromobutane into a 50 cm^3 flask.

Data

Property	Butan-1-ol	1-bromobutane	Water
Density / g cm^{-3}	0.81	1.3	1.0
Molar mass / g mol^{-1}	74	137	18
Boiling temperature / °C	117.3	101.7	100.0

(a) (i) Show, by calculation, that 0.125 mol of butan-1-ol is needed to make 0.100 mol of 1-bromobutane.

(2)

(ii) Calculate the volume of 0.125 mol of butan-1-ol, in cm^3.

(2)

(iii) Calculate the minimum mass of potassium bromide required in step 1.

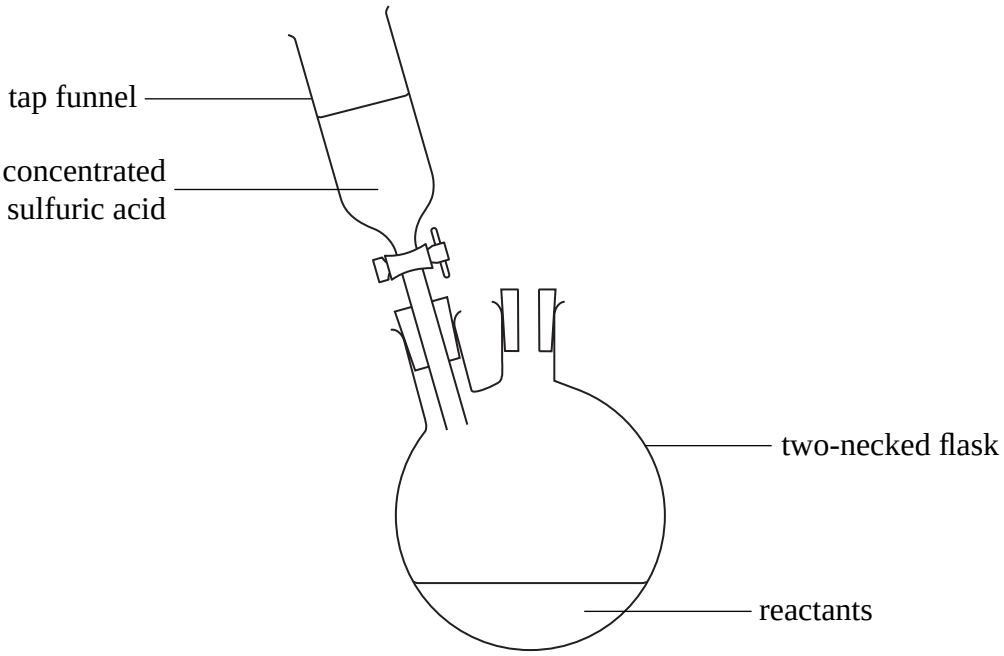
[The molar mass of potassium bromide is 119 g mol^{-1}]

(1)

(b) Complete and label the diagram below of the apparatus assembled in steps 1, 2 and 3.

[You may assume that the apparatus is suitably clamped.]

(4)



(c) (i) State, with a reason, whether the upper or lower layer contains 1-bromobutane in step 6.

(1)

.....

.....

(ii) The product is washed with concentrated hydrochloric acid in step 7 to remove unreacted butan-1-ol. In step 8, why is the product then washed with sodium hydrogencarbonate solution and what causes a build up of gas?

(2)

.....

.....

.....

.....

(d) (i) What further step is necessary to purify the 1-bromobutane obtained in step 10?

(1)

.....

(ii) How does the step in (d)(i) give information about the purity of the product?

(1)

.....

.....

(Total for Question 4 = 14 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

N 3 5 6 9 3 A 0 1 6 1 6

PMT

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Mark Scheme (Results)
June 2010

GCE

GCE Chemistry (6CH07/01)

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Summer 2010

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Question Number	Acceptable Answers	Reject	Mark
1 (a)(i)	Nichrome wire / platinum wire / ceramic / silica rod **(1)** Accept recognisable spelling eg platinium, nickrome (Concentrated /dilute) hydrochloric acid/HCl/HCl(aq)/ solution **(1)** Salt (mixed with wire and acid, and) placed in a hot/blue/roaring/non-luminous/Bunsen/Bunsen burner **flame (1)**	Titanium, aluminium, nickel, chromium, copper, silicon Salt placed in Bunsen burner OR flame alone OR burn it	**3**

Question Number	Acceptable Answers	Reject	Mark
1 (a)(ii)	Li^+ Accept li^+/ Li^+ ions/ A is Li^+ Ignore (aq), (s), (l), (g)	Li, Li^{2+},Ca, Sr, Rb Ca^{2+}, Sr^{2+}, Rb^+ Lithium/ lithium ions	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(i)	Calcium hydroxide/$Ca(OH)_2$ / slaked lime Accept calcium oxide/CaO / quicklime Ignore (aq) / solution / (s) / solid	Calcium/Ca CO_2/$CaCO_3$	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(ii)	CO_3^{2-} / HCO_3^- **(1)** Ignore separated additional cation **Carbon dioxide** gas given off (when this carbonate /hydrogencarbonate is heated/decomposed) **(1)** Second mark depends on a recognisable carbonate/hydrogencarbonate ie CO_3, CO_3^-, carbonate, hydrogencarbonate Li_2CO_3, $LiHCO_3$, $CaCO_3$ etc	CO_3, CO_3^-, carbonate, hydrogencarbonate Li_2CO_3, $LiHCO_3$, $CaCO_3$ etc	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(i)	Oxide / O^{2-}	Oxygen, O_2, O, O^- calcium oxide / CaO	**1**

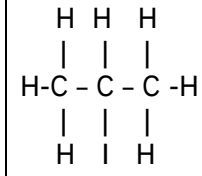
Question Number	Acceptable Answers	Reject	Mark
1 (c)(ii)	Hydroxide / OH^-/$(OH^-)_2$	$(OH)_2^-$	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(iii)	Mark with reference to (ii) For correct answer to (ii) Universal indicator (paper) **(1)** Turns blue/purple/pH12-14 **(1)** Accept other appropriate indicators eg (red) litmus (paper) turns blue OR Add a suitable metal ion solution **(1)** to give a correct colour of precipitate **(1)** [see User Guide 2 page 17 for some details] OR **Warm / heat** with ammonium ions **(1)** Alkaline gas given off/damp red litmus turns blue/ammonia gas given off **(1)** OR Other reasonable tests with results eg Titrate with hydrochloric acid and suitable indicator with correct final colour If incorrect answer to (ii) but answer as above (1) max If incorrect answer to (ii) with correct test and correct result for that ion (1) max		**2**

Question Number	Acceptable Answers	Reject	Mark
1 (d)	Li_2CO_3 Accept $Li_2(CO_3)$ OR $LiHCO_3$ Accept correct formula of any red flame coloured s block metal carbonate/hydrogencarbonate eg Rb_2CO_3, $CaCO_3$, $SrCO_3$	$LiCO_3$	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(i)	Silver((I))iodide (solid / precipitate) / AgI / Ag^+I^- /AgI(s) OR Silver((I))iodide (solid / precipitate) and AgI / Ag^+I^- /AgI(s)	Iodide (alone) Iodine Silver ((I)) iodine AgBr and AgI $Cl^-/Br^-/I^-$ If both name and formula are given and either is wrong eg Silver((I)) Iodine and AgI	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(ii)	**C_3H_7I** (in any order) Accept additional information like additional formulae	Any answer which does not have **C_3H_7I** somewhere	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iii)	 Accept structural formula CH_3CHICH_3	Displayed or structural formula for 1-iodopropane	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iv)	At first ignore answer to (iii) Propan-2-ol / 2-propanol / $CH_3CH(OH)CH_3$ Accept displayed formula (allow slightly displaced bonds C) H | HO Accept skeletal formula Allow TE from (a)(iii) eg 1-iodopropane forms propan-1-ol	Propanol prop-1-ol C_3H_7OH	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(i)	Mark colours independently From orange **(1)** To green/blue **(1)** Accept shades of green eg dark green, muddy green, green-brown	yellow	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(ii)	Propanone Accept propan-2-one Allow propanal/propanoic acid if TE from **(a)(iv)**	prop((-2-))one	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(iii)	Oxidation / redox / oxidation and reduction / oxidation of … (eg alcohol)	Reduction Condensation/ substitution/ Addition	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	(Glass/graduated/volumetric/bulb)pipette (and pipette filler) Accept any recognisable spelling of pipette eg pipet, pipette etc	Burette/ pipette and burette/ measuring cylinder/ teat pipette/ dropping pipette Pipate/pipotte	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	Starch (solution) **(1)** Accept startch Blue-black/blue/black to colourless **(1)** Accept purple/blue-black to colourless **Second mark depends on first**	Other indicators eg Methyl orange /phenolph-thalein Colourless to blue-black/blue/ black	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	14.5(0), 13.7(0), 13.75 All three needed for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(ii)	The first result is discarded/ ignored/ not included/a range finder OR Only use last two values OR The second and third are concordant / first value not within 0.2 cm^3 Accept: This is the average of the second and third runs OR Actual correct average calculation to give 13.73/13.725		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(iii)	$\frac{13.73 \times 0.0200}{1000} = 2.746 \times 10^{-4}$ /0.0002746(mol) Accept $2.7/2.75 \times 10^{-4}$ Note that 13.725 gives 2.745×10^{-4} Allow TE from different calculated average titre	1 sf	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)	1.373×10^{-4} /0.0001373(mol) Also $1.35/1.37/1.375/1.4 \times 10^{-4}$ Accept answer to $\frac{\text{(b)(iii)}}{2}$	1 sf (unless already penalised anywhere in this question)	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (d)	4.58×10^{-5} /0.0000458(mol) 4.57667/4.577 x 10^{-5} etc Also 4.583/4.57/4.6(0) x 10^{-5} Accept answer to $\frac{(c)}{3}$	1 sf (unless already penalised anywhere in this question)	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (e)(i)	Volumetric/graduated (flask)	($100\ cm^3$) round bottomed flask/ conical flask/ measuring cylinder	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (e)(ii)	These marks are independent of flask used in (i) Transfer solution and rinsings/washings **(1)** Make up to the mark **(1)** Mixing / inverting / shaking (this must be at the end) **(1)**	Make sure it is all transferred	**3**

Question Number	Acceptable Answers	Reject	Mark
3 (e)(iii)	4.58×10^{-4} /0.000458 (mol) Also 4.57/4.6 x 10^{-4} Accept Answer to (d) x 10	1 sf (unless already penalised anywhere in this question)	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (e)(iv)	$4.58 \times 10^{-4} \times 214$ = 0.098 /0.98012 g Also 0.097941/0.0979 etc Accept answer to (e)(iii) x 214 Ignore SF	1 sf (unless already penalised anywhere in this question)	**1**

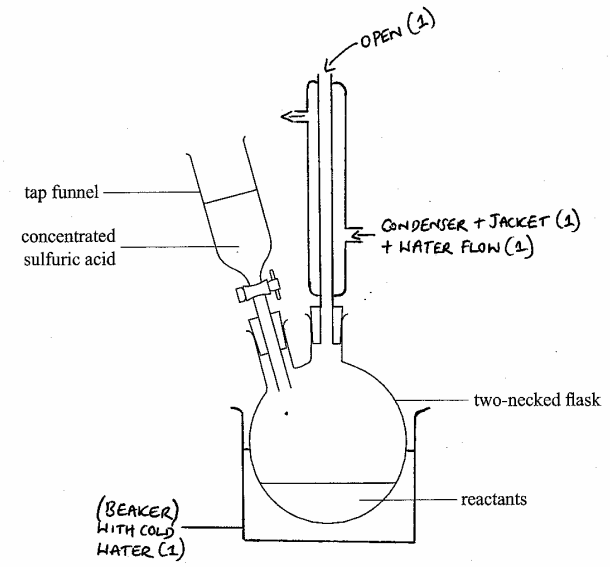
Question Number	Acceptable Answers	Reject	Mark
3 (e)(v)	$\frac{0.098}{0.10} \times 100$ = 98 /98.0/98.01/98.012 % Also 97.941/97.94/97.9 % Accept answer to $\frac{\text{(e)(iii)}}{0.10} \times 100$ correct answer with no working scores **(1)** Ignore SF	1 sf (unless already penalised anywhere in this question)	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (f)	Sulfuric acid is corrosive/irritant/irritable/burns (skin)	Sulfuric acid is harmful/ hazardous/ toxic	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (a)(i)	From the equation 1 mol butan-1-ol gives 1 mol of 1-bromobutane / ratio 1:1 OWTTE **(1)** As 80% yield, 0.125 mol of butan-1-ol gives 0.125 x 0.8 mol = 0.1 mol of 1-brombutane **(1)** Accept any clear indication that they appreciate the proportion calculation and the mole ratio Examples: Number of moles of butan-1-ol = $0.1 \times \frac{100}{80} / \frac{0.1}{0.8}$ (= 0.125) OR Number of moles of 1-bromobutane $= \frac{80}{100} \times 0.125$ (= 0.1) In both these examples 'butan-1-ol' / '1-bromobutane' as appropriate, must be present to gain **(2)** The numerical expression alone would gain **(1)** OR As above examples but additionally using molar masses to calculate masses		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (a)(ii)	74 x 0.125 **(1)** = 9.25 (g) $\frac{9.25}{0.81}$ = 11.4 /11.42/11.420/11.419753 cm^3 **(1)** ie ignore sf unless only one Accept 11.4 /11.42/11.420/11.419753 cm^3 **(2)** (with no working)	1sf	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (a)(iii)	0.125 x 119 = 14.875 /14.87/14.88/14.9/15 (g)	1 sf	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (b)	Flask **in** beaker of labelled cold water **(1)** Water need not be drawn in but… Condenser with jacket **(1)** Need not be labelled, can be at any angle so long as it goes upwards Condenser inlet and outlet with correct water direction **(1)** This mark can be given if no jacket is present open at top **and** no leaks**(1)** This mark is conditional on a condenser **Do not penalise** accidental closures in drawing or attempts to draw out perimeter of apparatus making the condenser appear closed If distillation set up is drawn the beaker of cold water mark can be awarded  	heated beaker (of cold water) stopper in the top/tap funnel in the top of the condenser unless clearly open	**4**

Question Number	Acceptable Answers	Reject	Mark
4 (c)(i)	Lower layer as more dense Lower layer is 1-bromobutane because it is dense**r** Lower layer as denser than water / butan-1-ol		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (c)(ii)	To remove / neutralize / react with remaining hydrochloric acid/HCl/acid/sulfuric acid/H_2SO_4 **(1)** by reacting to form **carbon dioxide** (gas) **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (d)(i)	Distillation /fractional distillation /redistil /distil /distillate Accept any recognisable spelling Ignore further description Allow a description which includes the words heating / boiling followed by condensing	Dry/filter/or anything else	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (d)(ii)	Measure boiling temperature of liquid {and compare with Data Book value (101.7 ^oC) (Pure if it agrees)} OR Boils at boiling temperature of liquid/ 101.7 ^oC / boils over a very small temperature range/ boils at one particular temperature OR Collect the product at 101.7 ^oC/ between 100 and 103 ^oC		**1**

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6CH07_01
1006

Write your name here

Surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Monday 10 January 2011 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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3/3/e2



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Answer ALL the questions. Write your answers in the spaces provided.

1 (a) Compound **X** is a white crystalline solid that dissolves easily in water to form a clear, colourless solution. **X** contains one cation and one anion. Complete the table below.

(5)

	Test	Observation	Inference
(i)	Warm solid **X** with dilute	A gas was evolved which turned damp red litmus paper blue.	Ammonia is formed so the ammonium ion is present.
(ii)	Add aqueous barium chloride to a solution of **X**.	....	**X** contains either sulfite (sulfate(IV)) or ..... or .....
(iii)	Add dilute hydrochloric acid to the result of test (ii).	A gas was evolved which	Sulfite (sulfate(IV)) confirmed.

(iv) Describe a further **chemical** test, not involving indicators, that you could use to confirm that ammonia is formed in part (i).

(2)

Test .....

Result .....

.....

(b) Compound **Y** is a white solid that contains one cation and one anion. Complete the table below.

(4)

	Test	Observation	Inference
(i)	Flame test	Brick red (yellow-red) flame.	The cation in **Y** is .....
(ii)	Gently heat a sample of **Y** in a test tube, testing any vapours evolved with cobalt chloride paper.	Vapour turned cobalt chloride paper from blue to	Water is produced. **Y** contains water of crystallization.
(iii)	Heat the sample of **Y** in the test tube.	Brown gas evolved.	Gas is ....
(iv)	Continue to heat the sample of **Y**.	Gas reignited a glowing splint.	Gas is .....

(v) Identify, by name or formula, the anion in **Y**.

(1)

.....

(vi) Give the formula of **Y** (one mole of **Y** contains one mole of water of crystallization).

(2)

.....

(Total for Question 1 = 14 marks)

2 (a) The organic compounds propan-1-ol and propan-2-ol are isomers. Propan-1-ol has the structure $CH_3CH_2CH_2OH$ and propan-2-ol has the structure $(CH_3)_2CHOH$.

Describe a test and its expected result to confirm the presence of the –OH group in propan-1-ol or propan-2-ol.

(2)

Test .....

Result .....

(b) When propan-1-ol or propan-2-ol is heated to 170 °C with concentrated sulfuric acid, propene is formed.

Name the type of reaction that has occurred in the reaction with sulfuric acid.
Describe a test and its positive result to show the presence of the C═C bond in propene.

(3)

Type of reaction .....

Test .....

Result .....

(Total for Question 2 = 5 marks)

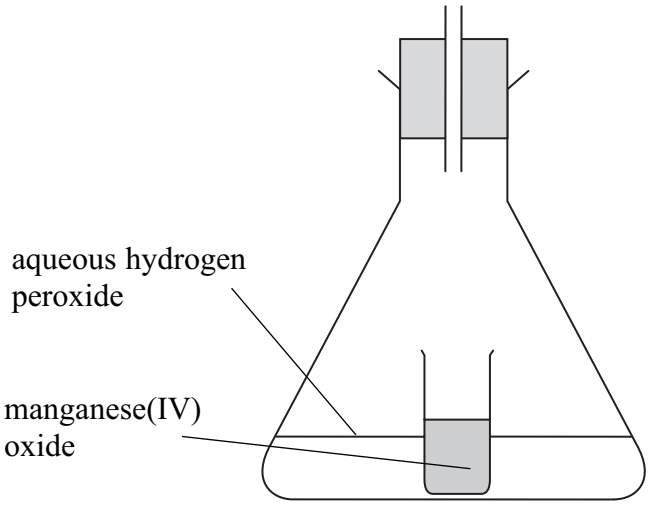
3 Aqueous hydrogen peroxide decomposes according to the following equation.

$$2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$

The decomposition is very slow under normal conditions but it is catalysed by a number of substances. The rate of the reaction using manganese(IV) oxide as the catalyst was investigated by measuring the volume of oxygen produced at various times as the reaction proceeded. Part of the apparatus used for the experiment is shown below. The manganese(IV) oxide was placed in the small glass container which was tipped over to start the reaction and a stop clock was started at the same time.

(a) Complete the diagram to show how the gas was collected **and** its volume measured.

(2)

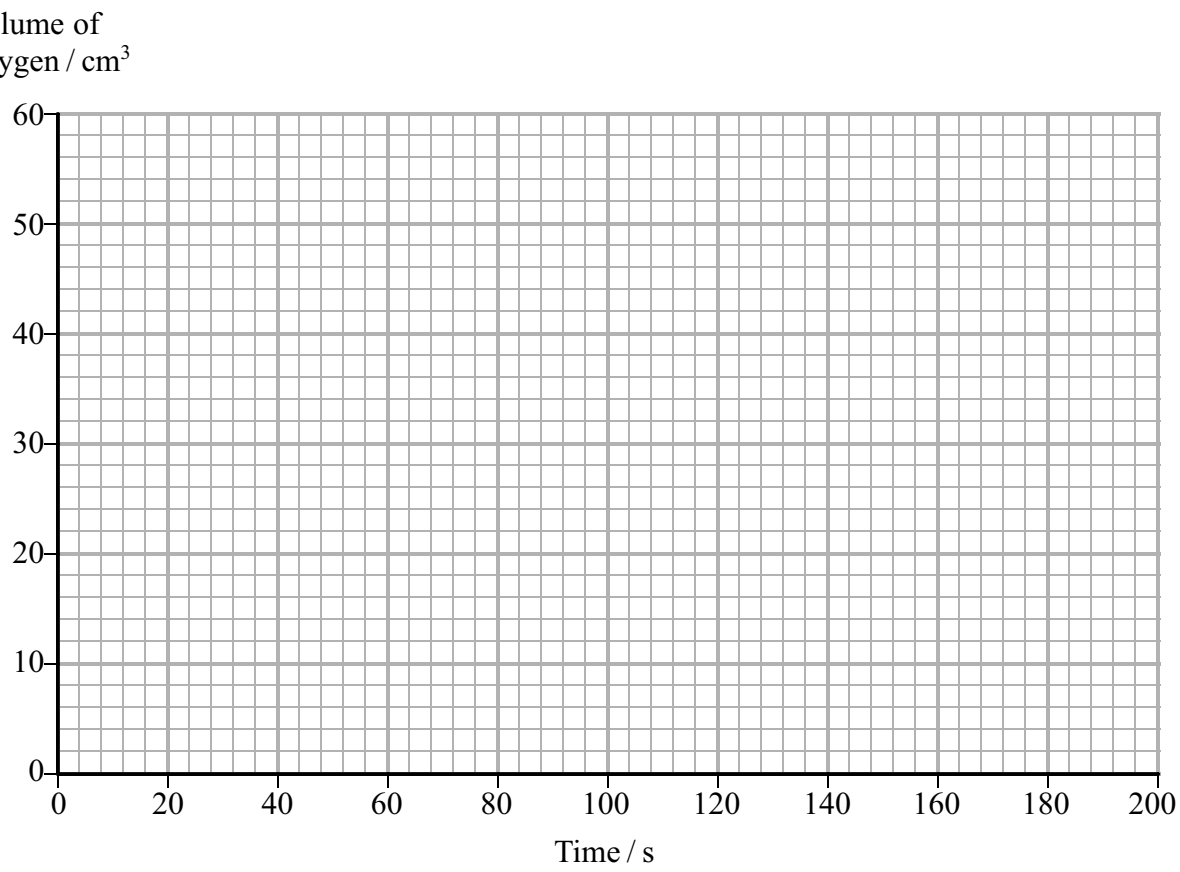


(b) In an experiment using 0.25 g of manganese(IV) oxide granules (small pieces) and 50 cm^3 of aqueous hydrogen peroxide of concentration 0.080 mol dm^{-3}, the following results were obtained.

Time / s	0.0	20.0	30.0	40.0	60.0	80.0	100	120	150
Volume of O_2 / cm^3	0	29	36	40	45	46	47	48	48

(i) Plot these results on the grid below and draw a best fit line through the points.

(3)



(ii) The rate of reaction may be assumed to be approximately constant up to the first volume measurement (20.0 seconds in this experiment) and is called the initial rate. Use this approximation to calculate the initial rate of this reaction, giving your answer to **two** significant figures and stating the units.

(2)

(iii) In a second experiment, the manganese(IV) oxide granules were replaced by the same mass of the compound as a fine powder. The volume and concentration of the aqueous hydrogen peroxide were kept the same.
On the grid in (b)(i), draw the line that you would expect to obtain in this experiment.

(2)

(iv) Explain any similarities in the lines you have drawn on the grid.
Use the collision theory of reaction rates to explain any differences between the shapes of the lines.

(3)

(c) Catalysts are not used up during a reaction. Outline an experiment to demonstrate that the manganese(IV) oxide is not used up in the decomposition of hydrogen peroxide (practical details of the experiment are **not** required).

(4)

(Total for Question 3 = 16 marks)

4 Bromoethane may be prepared by reacting ethanol with bromine and red phosphorus.

$$10C_2H_5OH(l) + 2P(s) + 5Br_2(l) \rightarrow 10C_2H_5Br(l) + 2H_3PO_4(aq) + 2H_2O(l)$$

The steps of the experimental procedure are as follows.

1. Measure 10.0 cm^3 of ethanol into a round-bottom flask.
2. Add 1.5 g of red phosphorus to the ethanol.
3. Pre-cool 5 cm^3 of liquid bromine in an ice bath, then slowly add it to the mixture of ethanol and red phosphorus, while cooling the flask under running water.
4. Gently reflux the mixture for about 10 minutes.
5. Rearrange the apparatus for distillation, immersing the receiver in ice-cold water and distil until no more bromoethane is formed.
6. Decant as much water as possible and then wash the product with dilute sodium carbonate solution and distilled water, decanting off the aqueous layer each time.
7. Transfer the washed product to a separating funnel and, from this, run off the organic layer into a small distillation flask.
8. Add anhydrous calcium chloride, stopper the flask and allow it to stand until the liquid turns clear.
9. Distil the bromoethane over a suitable temperature range, immersing the receiver in ice-cold water.

Data

Property	Ethanol	Bromoethane
Density / g cm^{-3}	0.789	1.47
Molar mass / g mol^{-1}	46.0	109
Boiling temperature / °C	78.4	38.4

(a) Suggest the apparatus most suitable for measuring the volume of ethanol to an accuracy of $\pm$ 0.1 cm^3 (step 1).

(1)

.....

(b) Explain why it is necessary to pre-cool the bromine (step 3).

(1)

.....

.....

(c) Suggest why it is also necessary to cool the mixture while adding the bromine (step 3).

(1)

.....

(d) Draw a labelled diagram of the apparatus that you would use to heat the mixture under reflux (step 4).

(3)

(e) Suggest why, in both the distillations, the receiver is immersed in ice-cold water (steps 5 and 9).

(1)

.....

(f) State the purpose of the following in this procedure:

(i) Washing the product with dilute sodium carbonate solution (step 6).

(1)

.....

(ii) Adding anhydrous calcium chloride to the organic layer (step 8).

(1)

.....

(g) Suggest a suitable temperature range for the collection of the product in the final distillation (step 9), giving the temperatures in whole numbers.

(1)

From .....

To .....

(h) (i) Calculate the number of moles of ethanol used in the preparation.

(1)

(ii) Given that one mole of ethanol forms one mole of bromoethane, calculate the maximum mass, in grams, of bromoethane that may be prepared using 10 cm^3 of ethanol.

(1)

(iii) Using the procedure described, a student prepared 13.3 g of bromoethane. Calculate the percentage yield of bromoethane in this preparation.

(1)

(iv) Suggest why the yield is calculated in relation to the ethanol rather than the bromine.

(1)

.....

.....

.....

(v) Suggest **one** reason, other than volatility of the reactants or products, why the preparation does **not** produce a 100 % yield.

(1)

.....

.....

.....

(Total for Question 4 = 15 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

N 3 7 6 9 0 A 0 1 2 1 2

PMT

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Mark Scheme (Results)
January 2011

GCE

GCE Chemistry (6CH07/01)

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January 2011

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Question Number	Acceptable Answers	Reject	Mark
1 (a) (i)	Sodium hydroxide (solution) / NaOH(aq) / NaOH Potassium hydroxide (solution) / KOH(aq) /KOH Allow calcium hydroxide (solution) / $Ca(OH)_2$(aq) / $Ca(OH)_2$	Alkali Aqueous ammonia Ammonium hydroxide	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (a) (ii)	**Observation**: White precipitate (or ppt or ppte) Allow white solid / suspension **(1)** **Inference**: any two valid ions gain both marks Sulfate or sulfate(VI) or sulphate or sulphate(VI) or SO_4^{2-} **(1)** Carbonate or CO_3^{2-} **(1)** Allow hydrogensulfate / hydrogensulfate(VI) / hydrogensulphate / hydrogensulphate(VI)) / HSO_4^- Allow hydrogencarbonate / HCO_3^- If a formula is used charge must be correct Ignore 'barium'	(solution) goes cloudy Incorrect oxidation number if used hydrogensulfite (or hydrogensulfate(IV))	**3**

Question Number	Acceptable Answers	Reject	Mark
1 (a) (iii)	(Gas evolved) was pungent / acrid or turned (orange) potassium dichromate / dichromate(VI) / $K_2Cr_2O_7$ green / blue Allow dichromate (etc) ions / $Cr_2O_7^{2-}$ or decolorized potassium manganate(VII) / permanganate (allow potassium manganate) /$KMnO_4$ Allow manganate(VII) (etc) ions /MnO_4^- Allow turns blue litmus red	Steamy fumes Was acidic /sulfur dioxide / SO_2 Incorrect oxidation number if used	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (a) (iv)	With HCl(g) (allow HCl) / conc HCl on a glass rod or stopper or open bottle **(1)** White fumes /smoke **(1)** Observation mark **not** stand alone but award for a near miss (e.g. 'add (conc.) HCl(aq)') No TE on a forbidden test (indicators / smell)	Add conc HCl Steamy / misty	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b) (i)	Calcium (ion) or Ca^{2+} (ion)	Ca / Ca^{+}	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b) (ii)	Pink Allow red or purple		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b) (iii)	Nitrogen dioxide or or nitrogen(IV) oxide or NO_2 Allow dinitrogen tetroxide or N_2O_4	Incorrect oxidation number if used	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b) (iv)	Oxygen or O_2	O	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b) (v)	Nitrate or nitrate(V) or NO_3^-	Incorrect oxidation number if used Incorrect / no charge	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b) (vi)	$Ca(NO_3)_2$ **(1)** H_2O **(1)** or $Ca(NO_3)_2.H_2O$ **(2)** If this formula is correct, ignore incorrect formula / charge in 1(b)(v) TE on a name or **correct** formula from 1(b)(v)	Name H_2O with no attempt at a compound formula	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a)	**Test** Add PCl_5 or phosphorus pentachloride or phosphorus(V) chloride **(1)** Ignore heat **Result** Steamy or misty fumes or fumes which turn litmus or UI red **(1)** Allow white fumes **OR** **Test** Add sodium **(1)** **Result** Effervescence / gas which pops with a lighted splint **(1)** **OR** **Test** Add named carboxylic acid and sulfuric / hydrochloric acid **(1)** **Result** Sweet / pear drops / glue smell **(1)** Observation marks **not** stand alone Allow oxidizing agents (max 1) **Test** Add acidified (potassium) dichromate / dichromate(VI) **Result** orange to / turns green/blue OR **Test** Add acidified (potassium) manganate(VII) or permanganate Allow acidified potassium manganate **Result** Purple to / turns colourless or decolorized	PCl_3 PCl_5 solution White smoke HCl observed	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)	Elimination **(1)** Allow dehydration **Test** Bromine (water /organic solvent) **(1)** **Result** (Orange or red-brown or brown or yellow to) /turns colourless or decolorized **(1)** Ignore clear **Test** Acidified potassium manganate (VII) or permanganate **(1)** Allow acidified potassium manganate **Result** (Purple to) /turns colourless or decolorized **(1)** **Test** Alkaline potassium manganate (VII) or permanganate **(1)** Allow acidified potassium manganate **Result** (Purple to) brown (ppt) or turns green **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (i)	Gas syringe **(2)** (cylinder & plunger reasonably distinct) or Collection over water **(1) graduated** collection vessel **(1)** Max (1) if gaps in apparatus or if delivery tube goes straight through the walls of trough and collection vessel		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (i)	5 points correctly plotted **(1)** 8 or 9 points correctly plotted **(2)** Smooth best fit line **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (ii)	29.0/20 (= 1.45) = 1.5 **(1)** $cm^3 s^{-1}$ or cm^3/s **(1)** (2 SF only)		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (iii)	Initial rate faster / higher / line steeper **(1)** Final gas volume the same **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (iv)	Amount of H_2O_2 & therefore volume /amount of O_2 remains the same **(1)** (both points needed) Greater surface area (of MnO_2) **(1)** Results in more (frequent) collisions (between H_2O_2 molecules & MnO_2) **(1)**	No consequential marking 'smaller pieces' or fine powder(for greater surface area)	**3**

Question Number	Acceptable Answers	Reject	Mark
3 (c)	Weigh **(1)** filter **(1)** dry **(1)** and re-weigh **(1)** the catalyst Allow evaporation of H_2O_2/ H_2O for filter mark Repeat experiment using fresh H_2O_2 (1) Rate is the same / similar (1)	Just 'mass constant'	**4**

Question Number	Acceptable Answers	Reject	Mark
4 (a)	Burette or pipette Allow volumetric flask	Measuring cylinder	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (b)	Bromine volatile or low boiling point or evaporates easily Or To ensure that the bromine does not evaporate		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (c)	Reaction is exothermic or gives off heat (allow reaction is vigorous)	Reaction is fast	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (d)	Round or pear-shaped flask with some attempt at a vertical condenser **(1)** Correct **vertical** condenser **(1)** Working reflux apparatus (heat, correct water flow, no stopper, no gaps, apparatus not one piece) **(1)** Ignore use of a Bunsen burner Fully correct distillation **(1)** max		**3**

Question Number	Acceptable Answers	Reject	Mark
4 (e)	Product / bromoethane is volatile or has a low boiling point or evaporates easily Allow To prevent evaporation of the bromoethane Or Bromoethane boils at 38.4 (ºC) Or To ensure bromoethane is liquid		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (f) (i)	Neutralize the (phosphoric) **acid** / **bromine** Allow react with or remove the **acid** / **bromine**		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (f) (ii)	Drying agent or to remove water	Dehydration	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (g)	From: 35, 36, 37 or 38 (ºC) To: 39, 40, 41 or 42 (ºC)	Fractions of degrees	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (h) (i)	10 x 0.789/46 (=0.17152) = 0.172 (ignore sf except 1 sf)	incorrect rounding	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (h) (ii)	0.17152 x 109 = 18.6959 = 18.7 (g) 0.172 x 109 = 18.748 = 18.7 (g) 0.17 x 109 = 18.53 = 18.5 (g) ECF on 4 (h)(i) Allow use of 108.9 (from periodic table) If M_r values transposed in 4hi) and 4hii) (mass = 3.33 g) penalise once (ignore sf except 1 sf)		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (h) (iii)	100 x 13.3/18.7 = 71.123 = 71.1 (%) 100 x 13.3/18.5 = 71.8919 = 71.9 (%) Or using moles: Moles of C_2H_5Br formed = 13.3/109 = 0.12202 Yield = 100 x 0.12202 / 0.17152 = 71.123 = 71.1 (%) Final answer = 71.1% if all values in calculator ECF on 4 (h)(ii) (ignore sf except 1 sf)	Yield > 100 %	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (h) (iv)	Bromine is in excess or All the ethanol is used up	Ethanol limiting reagent	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (h)(v)	Transfer losses or handling losses or specific examples of these (e.g. some product remains in the aqueous layer during separation or in the flask during distillation. Reaction incomplete or Side / competing reactions	Just 'lost' Handling errors Evaporation Equilibrium Named other products of this reaction formed (i.e. phosphoric acid or water) Waste products	**1**

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Centre Number | Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Monday 23 May 2011 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P37682A

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7/7/5/3/

P 3 7 6 8 2 A 0 1 1 6

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Answer ALL the questions. Write your answers in the spaces provided.

1 A student carried out a series of tests on two solids, **X** and **Y**. In parts (a) and (b), complete the inference column in the tables using names or formulae.

(a)

(3)

	Test	Observation	Inference
(i)	Carry out a flame test on solid **X**.	Lilac flame.	Cation in **X** .....
(ii)	Dissolve solid **X** in water. Add dilute nitric acid followed by aqueous silver nitrate. Test any precipitate formed with **concentrated** ammonia solution.	Pale cream precipitate formed which dissolved in **concentrated** ammonia solution.	Anion in **X** .....
(iii)	Add a few drops of concentrated sulfuric acid to a small portion of solid **X**.	A red-brown gas **Z** was released which condensed to a red-brown liquid.	Identity of gas **Z** .....

(iv) Give the **formula** of solid **X**.

(1)

.....

(b)

(3)

	Test	Observation	Inference
(i)	Warm a small quantity of solid **Y** with aqueous sodium hydroxide and test any gas evolved with damp red litmus paper.	Colourless gas evolved that turned damp red litmus paper blue.	Gas evolved ..... Cation in **Y** .....
(ii)	Acidify a solution of **Y** with dilute hydrochloric acid and then add aqueous barium chloride.	White precipitate formed.	Anion in **Y** .....

(iii) Give the **formula** of solid **Y**.

(1)

.....

(Total for Question 1 = 8 marks)

2 An organic liquid, **W**, has the structure

$$HOCH_2CH{=}CHCH_2OH$$

Complete the table by writing the observations you would expect to make when the following tests are carried out.

Test	Observation
Add **W**, drop by drop, to a small volume of bromine water and shake the mixture until there is no further change.	Colour change from ..... to .....
Add phosphorus(V) chloride to **W**. Test any gas evolved with damp blue litmus paper.	....
Add aqueous potassium dichromate(VI), acidified with dilute sulfuric acid, to **W** and heat the mixture.	Colour change from ..... to .....

(Total for Question 2 = 6 marks)

3 A titration was carried out in order to investigate the neutralization reaction shown below.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

Procedure

1. Using a pipette, transfer 50.0 cm^3 of sodium hydroxide solution, concentration 1.00 mol dm^{-3}, to a polystyrene cup. Allow to stand for a few minutes.

2. Record the temperature of the solution.

3. From a burette, add 5.00 cm^3 of dilute hydrochloric acid to the solution in the cup.

4. Stir the mixture with the thermometer and record the temperature.

5. Add successive 5.00 cm^3 portions of hydrochloric acid, stirring the mixture and recording the temperature after each addition.

6. Continue adding hydrochloric acid until a total of 50.00 cm^3 of the acid has been added.

Results

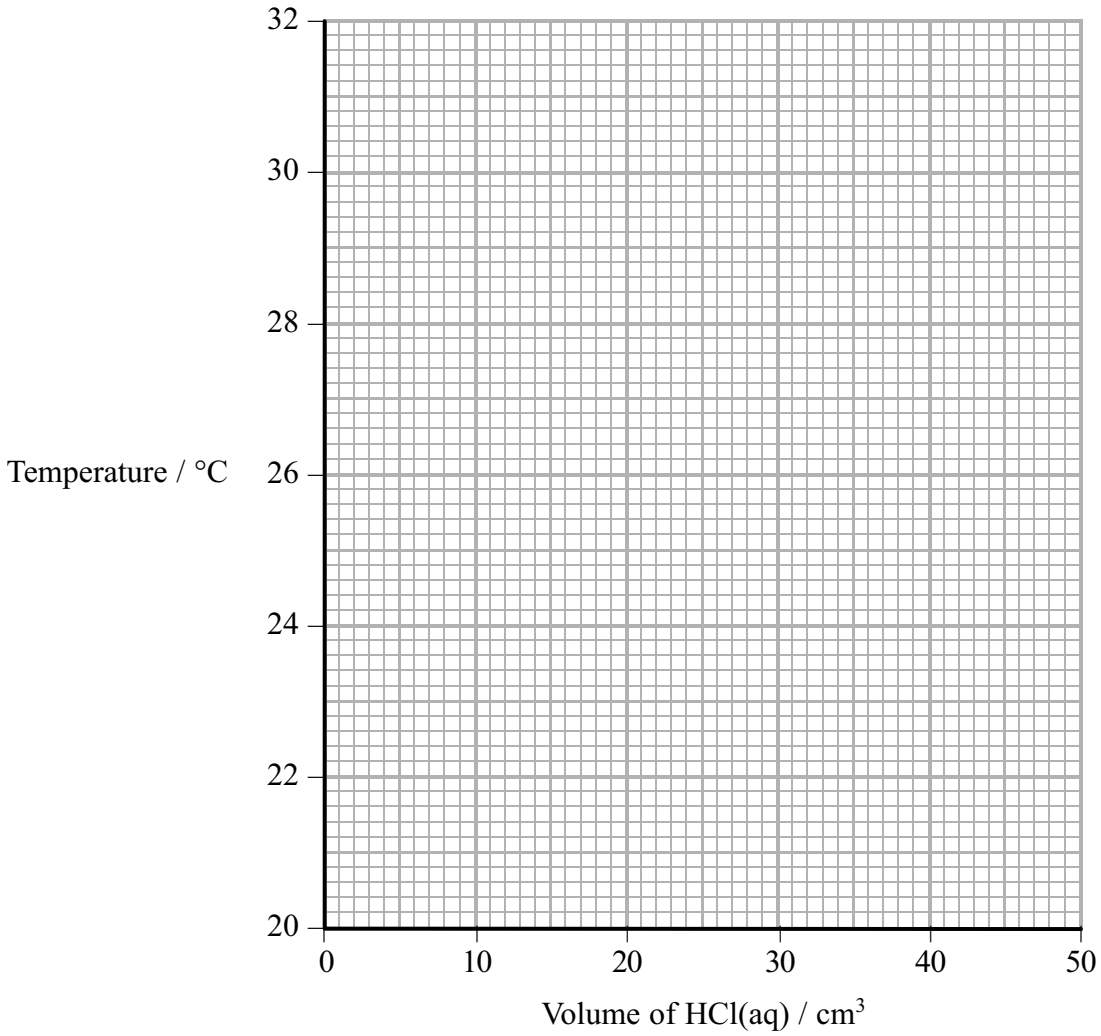
Volume of HCl(aq) added / cm^3	0.00	5.00	10.00	15.00	20.00	25.00	30.00	35.00	40.00	45.00	50.00
Temperature / °C	22.2	23.7	25.1	26.6	28.0	29.5	29.2	28.4	27.6	26.8	26.0

A graph of the temperature (*y*-axis) against the volume of hydrochloric acid added (*x*-axis) enables the maximum temperature rise and the volume of acid required for neutralization to be determined. From this information it is possible to calculate

- the concentration of the hydrochloric acid
- the enthalpy change for the reaction.

(a) (i) Plot a graph of temperature against volume of acid added on the axes below. Draw two straight lines on your graph and extrapolate the lines until they intersect.

(2)



(ii) Use the extrapolated lines on your graph to read off the maximum temperature reached in the neutralization reaction.

(2)

Maximum temperature ..... °C

(iii) The point at which the two extrapolated lines meet corresponds to the volume of hydrochloric acid required for neutralization. Read off this volume from your graph.

(1)

Volume of hydrochloric acid ..... cm^3

(iv) Calculate the number of moles of sodium hydroxide in 50.0 cm^3 of a 1.00 mol dm^{-3} solution.

(1)

(v) $HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$

Use this equation and your answers to (iii) and (iv) to calculate the concentration of the hydrochloric acid in mol dm^{-3}.

(2)

(b) (i) Use your graph and answer to (a)(ii) to calculate the maximum temperature **change**, ΔT, for the reaction.

(1)

$\Delta T =$ ..... °C

(ii) Use your value for the temperature rise, ΔT, to calculate the heat energy produced when 50.0 cm^3 of sodium hydroxide is exactly neutralized by the volume of hydrochloric acid you obtained in (a)(iii).

Use the expression

$$\text{energy produced (J)} = \text{total mass of solution} \times \text{specific heat capacity of solution} \times \text{temperature rise}$$

[Assume the specific heat capacity of the solution to be 4.2 J g^{-1} $°C^{-1}$ and the density of the solution to be 1.0 g cm^{-3}]

(2)

(iii) Use your answers to (a)(iv) and (b)(ii) to calculate the enthalpy change, in kJ mol^{-1}, for this reaction.

Give your answer to **two** significant figures and include a sign.

(3)

ΔH = ... kJ mol^{-1}

(Total for Question 3 = 14 marks)

4 An experiment was carried out to determine the concentration of a solution of potassium iodate(V), KIO_3.

Procedure

1. From a large volume of a solution of potassium iodate(V), use a pipette to withdraw a 25.00 cm^3 sample and place the sample in a conical flask.

2. Add excess amounts of both potassium iodide solution and dilute sulfuric acid to the 25.00 cm^3 of potassium iodate(V) solution in the conical flask. The iodate(V) ions oxidize iodide ions to iodine, in acidic solution, as shown in Equation 1:

$$IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O \qquad \textbf{(Equation 1)}$$

3. Titrate the iodine formed with a solution of sodium thiosulfate, $Na_2S_2O_3$, using starch as indicator.

$$I_2 + 2Na_2S_2O_3 \rightarrow 2NaI + Na_2S_4O_6 \qquad \textbf{(Equation 2)}$$

Results

Number of titration	1	2	3
Burette reading (final) / cm^3	25.10	26.35	24.10
Burette reading (initial) / cm^3	0.00	2.05	0.00
Volume of $Na_2S_2O_3$ used / cm^3	25.10	24.30	24.10

(a) (i) Which **two** titrations should be used to calculate the mean (average) titre? Explain your answer.

(2)

.....

.....

.....

.....

(ii) Calculate the mean titre in cm^3.

(1)

(iii) The sodium thiosulfate solution used in the titration has a concentration of 0.100 mol dm^{-3}. Calculate the number of moles of sodium thiosulfate in the mean titre.

(1)

(iv) Use **Equation 2** to calculate the number of moles of iodine, I_2, that reacted with the number of moles of sodium thiosulfate you have calculated in part (a)(iii).

(1)

(v) Use your answer to part (a)(iv) and **Equation 1** to calculate the number of moles of iodate(V) ions in 25.00 cm^3 of solution.

(1)

(vi) Use your answer to (a)(v) to calculate the concentration of the potassium iodate(V) solution, KIO_3, **in g dm^{-3}**.

[The molar mass of KIO_3 is 214 g mol^{-1}]

(2)

(b) (i) The error associated with reading the 25.00 cm^3 volume of the potassium iodate(V) solution in a pipette is ± 0.06 cm^3.

Calculate the percentage error associated with using a 25.00 cm^3 pipette.

(1)

(ii) Describe **two** things you could do to ensure that the burette readings are as accurate as possible. Assume that the burette has been appropriately rinsed and filled with the sodium thiosulfate solution.

(2)

1 .....

.....

.....

2 .....

.....

.....

(Total for Question 4 = 11 marks)

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5 An experiment was carried out to prepare iodoethane, CH_3CH_2I.

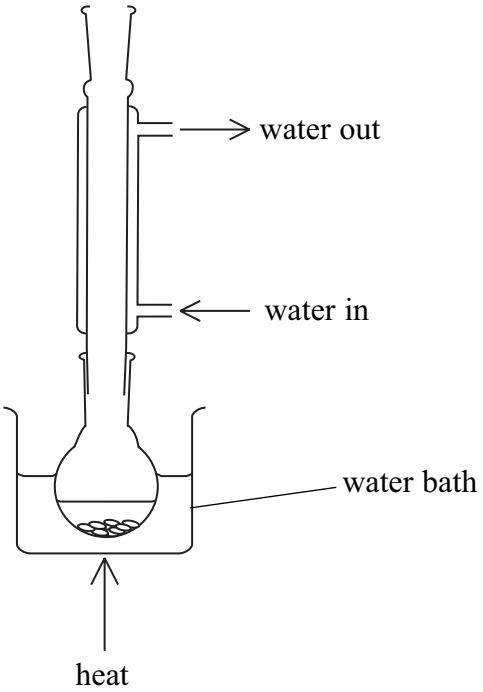
Procedure

1. Put some solid, moist red phosphorus into a flask.

2. Add ethanol to the flask.

3. Set up the apparatus as shown in diagram 1.

Diagram 1



4. Add 25.4 g of powdered iodine, in small portions, to the flask.

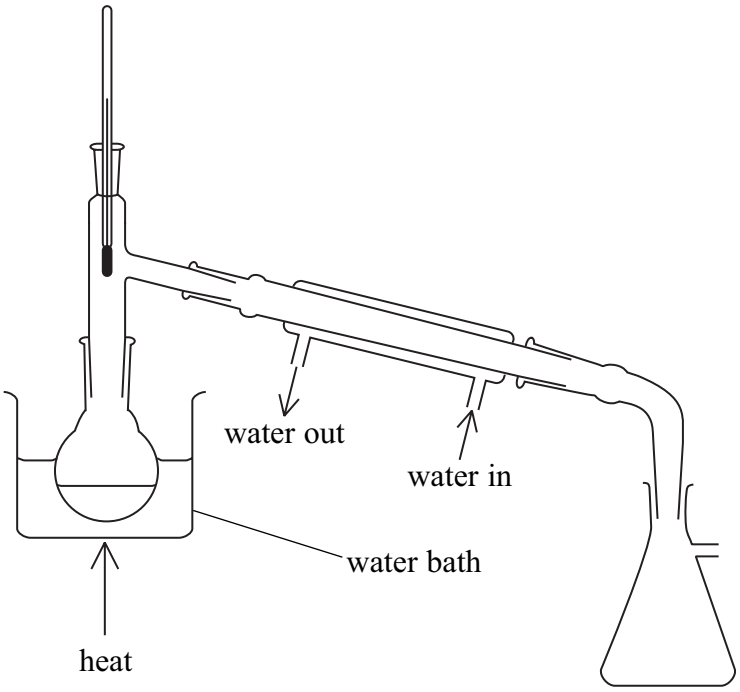
5. Before each addition, remove the condenser. Add the iodine and then immediately replace the condenser.

6. When all the iodine has been added, allow the flask to stand for 10 minutes and then heat the flask for one hour as shown in diagram 1.

7. Separate the iodoethane from the reaction mixture and dry it.

8. Finally, purify the iodoethane using the apparatus shown in diagram 2. Collect the iodoethane over a suitably narrow temperature range.

Diagram 2



Data

Name	Appearance	Flammability	Boiling temperature / °C
ethanol	colourless liquid	flammable	78
iodoethane	colourless liquid	flammable	72

Equations

$$2P + 3I_2 \rightarrow 2PI_3$$

$$3CH_3CH_2OH + PI_3 \rightarrow 3CH_3CH_2I + H_3PO_3$$

(a) (i) Identify the technique shown in each diagram.

(2)

Diagram 1 .....

Diagram 2 .....

(ii) Explain why a stopper should **not** be placed in the top of the condenser shown in diagram 1.

(1)

.....

.....

(b) (i) Give **one** reason why the iodine was added over a period of time and in small amounts.

(1)

.....

.....

(ii) Explain why water baths were used in both step 6 and step 8 rather than heating the flasks directly with a Bunsen flame.

(1)

.....

.....

.....

(iii) Suggest the temperature range suitable for the collection of iodoethane shown in diagram 2.

(1)

From ..... to ..... °C

(c) (i) Calculate the number of moles of iodine, I_2, in 25.4 g of iodine.

Use the relative atomic mass of I = 127

(1)

(ii) In this reaction, 1 mol I_2 forms 2 mol CH_3CH_2I.

Calculate the maximum mass of iodoethane, in g, that could be formed from 25.4 g of iodine.

Use the following relative atomic masses: C = 12, H = 1, I = 127

(3)

(iii) In a preparation, the mass of iodoethane collected was 23.4 g.

Calculate the percentage yield in this preparation.

(1)

(Total for Question 5 = 11 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 3 7 6 8 2 A 0 1 6 1 6

PMT

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Mark Scheme (Results)

June 2011

GCE Chemistry (6CH07) Paper 01
Chemistry Laboratory Skills (WA)

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June 2011
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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

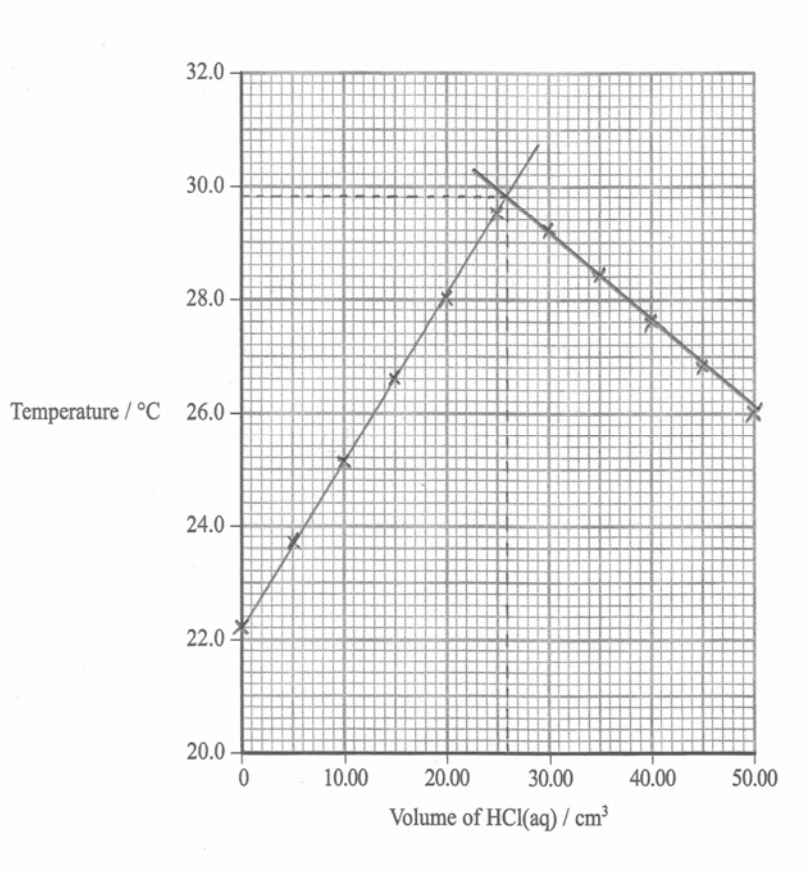
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1 (a)	**(i) Cation in X** is potassium / K^+ **(1)** **(ii) Anion in X** is bromide / Br^- **(1)** **(iii) Gas Z** is bromine / Br_2 **(1)** **(iv) X is** KBr **(1)** Mark cq on (i) and (ii)	"K" Br_2 or "bromine" "bromide" or Br^- or Br Just "potassium bromide" CQ formula from incorrectly charged ions	**4**

Question Number	Acceptable Answers	Reject	Mark
1 (b)	**(i) Gas evolved:** ammon**ia** / NH_3 **(1)** **Cation in Y:** ammon**ium**/ NH_4^+ **(1)** *If formula given, it must be correct* **(ii) Anion in Y:** sulfate / SO_4^{2-} **(1)** **(iii) Y is** $(NH_4)_2SO_4$ **(1)** Mark cq on (i) and (ii)	"ammonium" "ammonia" Just "ammonium sulfate" CQ formula from incorrectly charged ions	**4**

Question Number	Acceptable Answers	Reject	Mark
2	**Bromine water** **From:** red / brown / orange / yellow (or combinations of these colours) **(1)** **To:** colourless/decolourised **(1)** *NOTE:* If colours are both correct but are given the wrong way round, award **(1)** **Phosphorus(V) chloride** Steamy fumes/misty fumes/white fumes/steamy vapour/steamy gas/white dense fumes **(1)** Ignore fizzing/gets hot/ etc. (damp blue litmus paper) red **(1)** **Acidified potassium dichromate(VI)** **From:** orange **(1)** **To:** green or blue **(1)** (or combinations of blue and green) *NOTE:* If colours are both correct but are given the wrong way round, award **(1)**	Just “clear” (White) **smoke**/**solid** **Just** ‘fumes’ yellow yellow	**6**

Question Number	Acceptable Answers	
3 (a) (i)	Points correctly plotted **(1)** [allow one slip] Two best fit straight lines **(1)**  	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (ii)	Extrapolation **(1)** **Maximum temperature** Read off candidate's graph Expect value between 29.6 – 30.0(^{o}C) **(1)** *ALLOW* a stated value within ±0.1 (^{o}C) of graph's max temp	If the two straight lines do not meet **above** 29.5 ^{o}C	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (iii)	**Volume of HCl(aq):** Read off candidate's graph Expect value between 25.5 – 26.5 (cm^3) *ALLOW:* a stated volume within ±0.5 cm^3 of graph's volume of HCl(aq) *ALLOW:* whole numbers (e.g. "27" if intersection is at 27.0)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (iv)	0.05(00)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (v)	**Mark consequentially on (a)(iii) and (iv):** Working e.g. 0.05(00) ÷ candidate's volume of HCl(aq) in dm^3 **(1)** Answer **(1)** e.g. for a volume of HCl(aq) = 26.0 cm^3 [NOTE: *ALLOW* "26" for 26.0] 0.05(00) ÷ candidate's volume of HCl(aq) in dm^3 = $\frac{0.05(00)}{0.026}$ **=** 1.92 (mol dm^{-3}) Correct answer only using suitable volume of HCl(aq) scores both marks *IGNORE* s.f. including 1 s.f. (e.g. "2 (mol dm^{-3})")		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (i)	**Read off candidate's graph:** Expect ΔT = (29.8 — 22.2) = 7.6 (^{o}C) *IGNORE* s.f. *IGNORE* any signs *NOTE:* Initial temp is that from the graph		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (ii)	**Mark consequentially on (a)(iii):** Working **(1)** Answer **(1)** (e.g. [**volume of HCl(aq) + 50(.00)** x 4.2 x ΔT] = 76 x 4.2 x 7.6 = 2426 (J)) Assume 2.426 (or similar) is the answer in **kJ** *NOTE:* 2nd mark can be awarded cq on a wrong mass and/or a wrong ΔT (e.g. use of 50(.00) x 4.2 x 7.6 = 1596 (J) scores **(1)**) *IGNORE* sig figs (except one sig fig) *IGNORE* any signs *ALLOW* use of 4.18 instead of 4.2	Incorrect rounding of figures	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (iii)	**Working** Dividing as follows:- (—) answer to (b)(ii) in kJ or J / answer to (a)(iv) **(1)** **Negative sign** **(1)** **Answer to 2 s.f.** **(1)** ***NOTE:* The 2 s.f. mark is CQ on dividing kJ or J by mol** e.g. — 2.426 / 0.05(00) = — 49 (kJ mol^{-1}) ***NOTE:* must be to 2 s.f.** Correct answer to correct s.f. gets 3 marks even with no working Correct answer to 2 s.f. with negative sign in **J mol^{-1}** (e.g. — 49000) scores max **(2)**		**3**

Question Number	Acceptable Answers	Reject	Mark
4 (a) (i)	Titres 2 and 3 **(1)** Concordant / agree within (±)0.2 (cm^3) / in close agreement/ titration 1 is a trial or rangefinder or a rough titration, etc. **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (a) (ii)	24.20 / 24.2 (cm^3) **Mark cq** on **any** titres chosen		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (a) (iii)	**Mark CQ on (a)(ii)** $\frac{0.100 \times 24.20}{1000}$ = 0.00242 / 0.0024 / 2.42×10^{-3} / 2.4×10^{-3} (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (a) (iv)	Answer to (a)(iii) **÷ 2** = 0.00121 / 0.0012 / 1.21×10^{-3} / 1.2×10^{-3} (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (a) (v)	Answer to (a)(iv) **÷ 3** = 0.000403 / 0.0004(0) / 4.03×10^{-4} / $4(.0) \times 10^{-4}$		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (a) (vi)	EITHER Answer to (a)(v) ÷ 0.025(0) = 0.0161 / 0.016(0) / 1.61 x 10^{-2} / 1.6(0) x 10^{-2} (mol dm^{-3}) **(1)** so concentration of KIO_3 in g dm^{-3} is 214 (g mol^{-1}) x 0.0161 (mol dm^{-3}) = 3.45 (g dm^{-3}) OR 214 (g mol^{-1}) x 0.016(0) (mol dm^{-3}) = 3.42 (g dm^{-3}) **(1)** OR Calculate mass KIO_3 using 0.000403 x 214 = 0.086242 (g) **(1)** *IGNORE* units even if incorrect (then) $\frac{0.086242 \text{ (g)}}{0.025 \text{ (dm}^3\text{)}}$ = 3.45 (g dm^{-3}) **(1)** *ALLOW* 2 s.f. but reject 1 s.f. *NOTE:* Check all calculations as final answer is dependent on accuracy in interim steps		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (b) (i)	$\frac{0.06}{25.00}$ x 100% = (±) 0.24 / 0.2% *NOTE:* **±** not required for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (b) (ii)	Any **TWO** from:- • use white tile or paper as background to burette readings • have eyes level with meniscus (to avoid parallax error) • measure level at bottom of the meniscus • ensure that the burette is upright *ALLOW* • ensure that there are no air bubbles • ensure that the jet is full • remove the funnel from the top of the burette • use a white tile beneath flask • swirl the (conical) flask • run solution from burette **slowly** (into conical flask) • ensure no solution from the burette is left on the sides/walls of the (conical) flask • add solution from burette drop-wise close to the end-point **(2)**	Do more repeats / take more means Temperature of lab must be kept constant, etc	**2**

Question Number	Acceptable Answers	Reject	Mark
5 (a) (i)	**Diagram 1:** (heating under) reflux **(1)** **Diagram 2:** distillation **(1)** ***IGNORE*** "simple" before "distillation"	**fractional** distillation /condensation	**2**

Question Number	Acceptable Answers	Reject	Mark
5 (a) (ii)	(Expansion of vapour will) build up pressure / prevent explosion	**Just** "dangerous" OR "to prevent vapour escaping" OR "so that heat is not able to escape"	**1**

Question Number	Acceptable Answers	Reject	Mark
5 (b) (i)	The reaction is vigorous OR the reaction is exothermic OR the reaction is (very) fast or violent *ALLOW* To stop a reactant or product escaping *ALLOW* To prevent too much heat being produced *IGNORE* any reference to accidents	So that all the iodine reacts/so that iodine is not in excess OR "It is very reactive" OR "Increase the time for which the solids are in contact" OR "To compensate for heat loss" OR Iodine/I_2 is toxic	**1**

Question Number	Acceptable Answers	Reject	Mark
5 (b) (ii)	(One or both of) the **liquids** flammable / the mixture is flammable/ the organic compounds are flammable OR ethanol and iodoethane are flammable OR ethanol is flammable OR iodoethane is flammable OR to keep the temperature below 100°C OR to control the temperature throughout the heating OR for uniform heating OR to prevent uneven heating	Any mention that iodine/I_2 is flammable OR **Just** "gentle heating" OR To prevent the reaction going (any) faster	**1**

Question Number	Acceptable Answers	Reject	Mark
5 (b) (iii)	Any lower temperature: 69 to 71 (^{o}C) Any upper temperature: 73 to 75 (^{o}C) *NOTE:* Award the mark if the correct numbers are written the other way round (e.g. **from** 74 (^{o}C) **to** 70 (^{o}C))		**1**

Question Number	Acceptable Answers	Reject	Mark
5 (c) (i)	0.1(00) (mol)	0.2(00) (mol)	**1**

Question Number	Acceptable Answers	Reject	Mark
5 (c) (ii)	***1st mark*** M_r (CH_3CH_2I) = 156 **(1)** 0.2(00) mol of iodoethane **(1)** ***2nd mark*** *CQ* on (c)(i) 0.2(00) x 156 = 31.2 g **(1)** ***3rd mark*** is cq on moles of iodoethane ***NOTE*** If 0.2(00) mol of iodine given in Q5 (c)(i), by CQ marking can score all 3 marks here with: M_r (CH_3CH_2I) = 156 **(1)** 0.4(00) mol of iodoethane **(1)** 0.4(00) x 156 = 62.4 g **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
5 (c) (iii)	23.4 / ans to (c)(ii) x 100 % = 75% *IGNORE* s.f. except 1 s.f. ***NOTE*** If 0.2(00) mol of iodine given in 5 (c)(i), by CQ marking can score the mark here with: 23.4 / 62.4 x 100 % = 37.5%	23.4 / 25.4 x 100 % = 92.1%	**1**

TOTAL FOR PAPER = 50 MARKS

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Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Monday 9 January 2012 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39305A

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7/7/5/3/

P 3 9 3 0 5 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A series of tests was carried out on **A**, a white powder, which is known to contain one cation and one anion. Complete the table below. You may use names or formulae in your answers.

	Test	Observations	Inferences	
(a)	Carry out a flame test on **A**.	.....	Cation is potassium	**(1)**
(b)	Add a mixture of dilute nitric acid and aqueous silver nitrate to an aqueous solution of **A**. Then add an excess of **dilute** aqueous ammonia to the mixture.	A yellow precipitate forms. When excess dilute aqueous ammonia is added	Anion is	**(2)**
(c)	Add an aqueous solution of bromine to an aqueous solution of **A**.	The colour of the solution of bromine is ..... When bromine is added to an aqueous solution of **A** the colour of the mixture is	The change in colour is due to the formation of	**(3)**

(d)

Test	Observations	Inferences
Add concentrated sulfuric acid to a **solid** sample of **A**.	A vigorous reaction occurs producing a black solid, a yellow solid, a gas with an unpleasant smell and some coloured fumes.	The black solid is ..... and the yellow solid is .....

(2)

(Total for Question 1 = 8 marks)

2 A series of tests was carried out on a compound, **B**, which is known to contain **either** carbonate **or** sulfate (sulfate(VI)) ions as well as one cation.

Complete the inferences column. You may use names or formulae in your answers.

	Test	Observations	Inferences	
(a)	Carry out a flame test on **B**.	Yellow flame.	The cation in **B** is	**(1)**
(b)	Add aqueous barium chloride solution to an aqueous solution of **B**.	A white precipitate forms.	The precipitate could be either ..... or	**(2)**
(c)	Add dilute hydrochloric acid to the mixture formed in (b) until there is no further change.	Some fizzing occurs and the precipitate dissolves.	The anion in **B** is ..... and the fizzing is due to formation of	**(2)**

(d) The **formula** of **B** is

(1)

.....

(Total for Question 2 = 6 marks)

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3 Magnesium carbonate reacts with dilute nitric acid as shown in the equation below.

$$MgCO_3(s) + 2HNO_3(aq) \rightarrow Mg(NO_3)_2(aq) + CO_2(g) + H_2O(l)$$

The enthalpy change for this reaction can be determined as follows:

Procedure

1. Weigh 3.50 g of finely powdered magnesium carbonate.
2. Transfer 50.0 cm^3 of 2.00 mol dm^{-3} nitric acid into a polystyrene cup and record the temperature of the acid.
3. Add the magnesium carbonate to the nitric acid.
4. Stir the mixture and record the maximum temperature reached.

Results

Temperature of nitric acid before addition of magnesium carbonate	21.0 °C
Final temperature of solution	29.7 °C

(a) Explain why the magnesium carbonate used in this experiment should be finely powdered rather than in lumps.

(1)

.....

.....

(b) (i) Calculate the number of moles of magnesium carbonate in 3.50 g.

[Assume the molar mass of magnesium carbonate is 84 g mol^{-1}.]

(1)

(ii) The volume of dilute nitric acid used contained 0.100 mol of HNO_3. Suggest why this amount is suitable.

(1)

.....

.....

.....

(c) (i) Calculate the heat energy transferred, in joules, in this reaction between magnesium carbonate and nitric acid.

Use the expression

$$\text{energy transferred (J)} = \text{mass of solution} \times \text{specific heat capacity of solution} \times \text{temperature rise}$$

[Assume the mass of solution is 50 g and its specific heat capacity is 4.18 J g^{-1} $°C^{-1}$.]

(1)

(ii) Calculate the enthalpy change, ΔH, for the reaction of one mole of magnesium carbonate with nitric acid. Your answer should be in units of kJ mol^{-1}, expressed to **three** significant figures, and include a sign.

(2)

(d) (i) The nitric acid for this experiment could be measured using either a pipette or a measuring cylinder. Give **one** practical advantage of using each piece of apparatus.

(2)

Pipette .....

.....

Measuring cylinder .....

.....

(ii) The **total error** in measuring the mass of the magnesium carbonate was ±0.01 g. Calculate the percentage error in the weighing.

(1)

(e) State and explain the effect, if any, on the calculated enthalpy change, ΔH, if

(i) a copper calorimeter were used instead of the polystyrene cup.

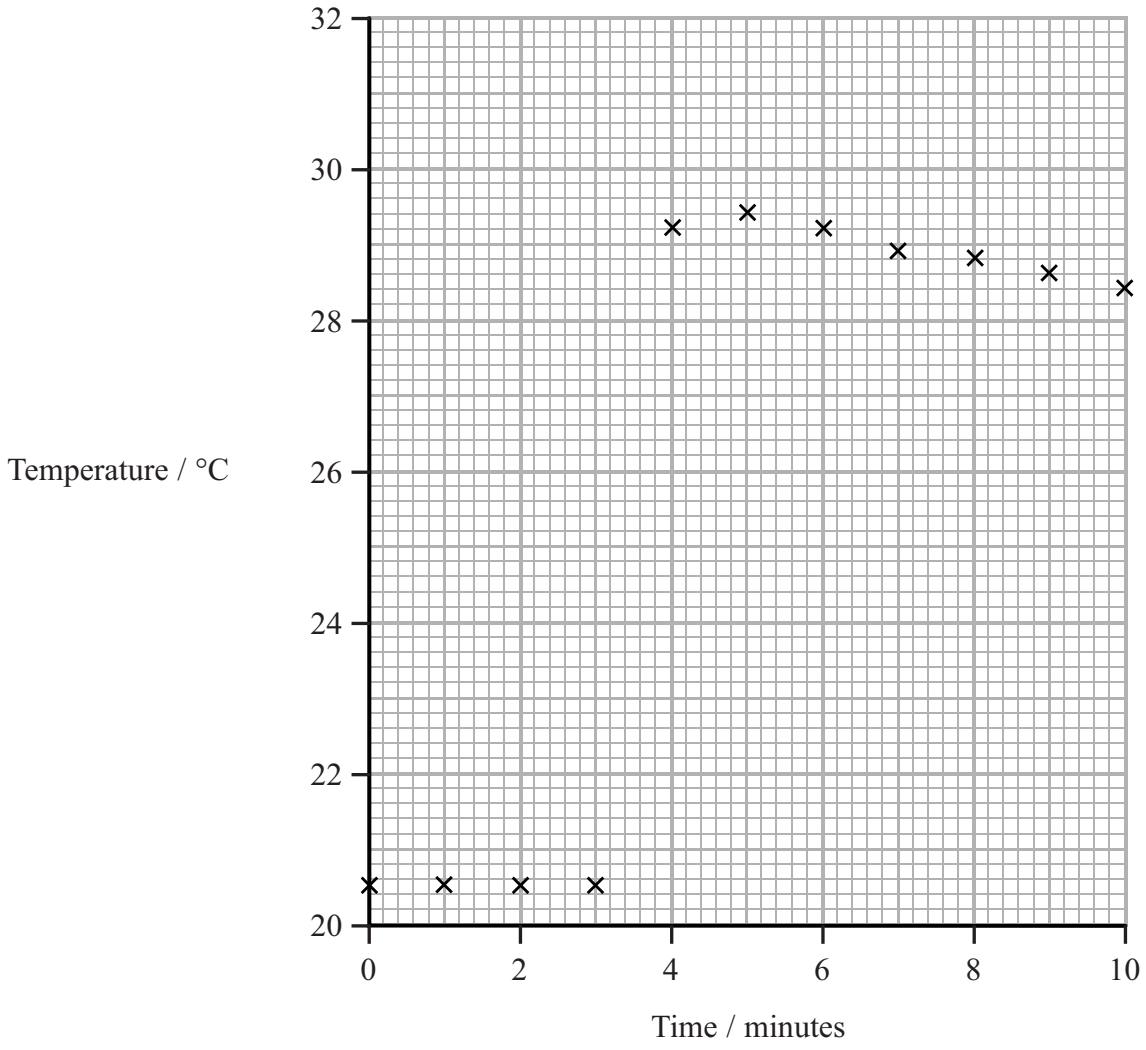
(2)

(ii) 3.50 g of **damp** magnesium carbonate were used.

(2)

(f) The experiment was repeated with a change in the procedure. The temperature of the dilute nitric acid was measured every minute for three minutes. After exactly three and a half minutes, the magnesium carbonate was added and the mixture was stirred. The temperature of the mixture was then taken every minute for another six minutes.

A graph of the temperature readings against time using this procedure is shown opposite.



(i) Use this graph to calculate the maximum temperature change. Show your working on the graph.

(2)

Maximum temperature change = ... °C

(ii) Why does this method give a more accurate result than the original procedure?

(1)

.....

.....

.....

(Total for Question 3 = 16 marks)

4 This question is about the alcohol, propan-1-ol.

(a) Give **two** observations when propan-1-ol reacts with a small piece of sodium.

(2)

Observation 1 .....

.....

Observation 2 .....

.....

(b) A student investigated the rate of reaction of propan-1-ol with sodium.

Suggest **one** suitable measurement which could be made to determine the rate of this reaction.

(1)

.....

.....

.....

(c) A small amount of phosphorus(V) chloride (phosphorus pentachloride), PCl_5, is added to propan-1-ol in a test tube.

(i) Describe the appearance of the fumes at the mouth of the test tube.

(1)

.....

(ii) An open bottle of concentrated ammonia is held near the mouth of the tube. Describe what would be seen at the mouth of the test tube.

(1)

.....

.....

(Total for Question 4 = 5 marks)

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5 Propanoic acid may be prepared by oxidizing propan-1-ol in acidic conditions.

$$CH_3CH_2CH_2OH \xrightarrow{\mathbf{X} + H_2SO_4} CH_3CH_2COOH$$

Procedure

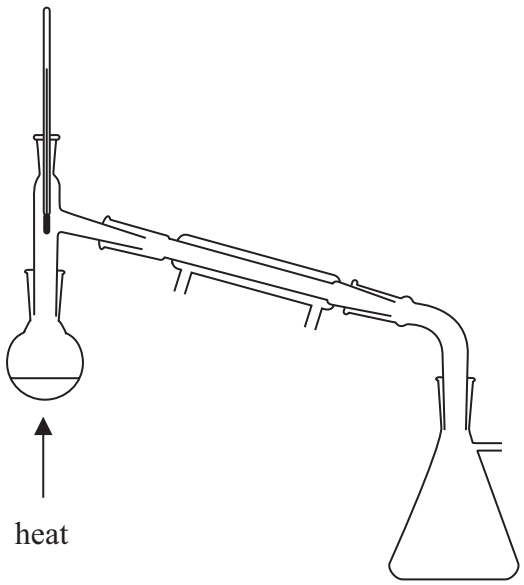
1. Pour 10 cm^3 of distilled water into a boiling tube and add 12 g of oxidizing agent **X**. Shake the mixture and leave **X** to dissolve.

2. Pour 3 cm^3 of propan-1-ol into a round-bottom flask and add 10 cm^3 of distilled water and a few anti-bumping granules. Set up the apparatus for heating under reflux.

3. Add 4 cm^3 of concentrated sulfuric acid, drop by drop, to the propan-1-ol. While the mixture is still warm, add the solution of oxidizing agent **X**, drop by drop. The energy released from the reaction should cause the mixture to boil without external heating.

4. When all of the solution of **X** has been added, use a low Bunsen burner flame to keep the mixture boiling for 10 minutes, not allowing any vapour to escape.

5. Distil the mixture in the flask using the apparatus shown below. Collect 5–6 cm^3 of distillate, which is an aqueous solution of propanoic acid.



(a) Suggest, by name or formula, a suitable oxidizing agent, **X**, for this reaction.

(1)

.....

(b) What colour change does **X** undergo when it oxidizes propan-1-ol?

(1)

From ..... to .....

(c) Draw a **labelled** diagram showing the apparatus for heating under reflux.

(2)

(d) Give **two** reasons why the escape of vapour in step 4 should be prevented.

(2)

Reason 1 .....

.....

Reason 2 .....

.....

(e) How does the reflux apparatus prevent escape of vapour?

(1)

.....

.....

(f) Some water can be removed from the distillate in step 5 by adding a solid drying agent. The solution of propanoic acid can then be decanted leaving the drying agent behind.

(i) Suggest a suitable solid drying agent.

(1)

.....

(ii) Suggest why removing excess solid drying agent by decanting, rather than filtering through filter paper, improves the yield.

(1)

.....

.....

(g) In a larger scale preparation of propanoic acid, 10.0 g of propan-1-ol was used.

(i) Calculate the maximum mass of propanoic acid which could be formed from 10.0 g of propan-1-ol.

	Propan-1-ol	Propanoic acid
Molar mass / g mol^{-1}	60.1	74.1

(2)

(ii) After purification, 6.0 cm^3 of dry propanoic acid was obtained.

Calculate the percentage yield in the preparation.

The density of propanoic acid is 0.99 g cm^{-3}.

(2)

(h) In another experiment, the same reaction mixture (propan-1-ol, **X** and concentrated sulfuric acid) was heated in the apparatus shown in step 5. Identify the main organic product which would be collected and explain why propanoic acid is not produced.

(2)

Product .....

Explanation .....

.....

(Total for Question 5 = 15 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 3 9 3 0 5 A 0 1 6 1 6

PMT

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Mark Scheme (Results)
January 2012

GCE Chemistry (6CH07) Paper 01
Chemistry Laboratory Skills I (WA)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Correct Answer	Reject	Mark
1 (a)	Lilac/purple/pale lilac (coloured flame) ALLOW mauve	Violet red	**1**

Question Number	Correct Answer	Reject	Mark
1 (b)	Iodide/I^- **(1)** Precipitate does not dissolve/does not disappear/is insoluble (in NH_3) /remains yellow/no change/no reaction **(1)**	Iodine Iodine ion, unless formula also given I, I_2	**2**

Question Number	Correct Answer	Reject	Mark
1(c)	(Aqueous bromine is) brown/red brown/yellow/orange/combination of these colours **(1)** (mixture is) darker (brown)/grey or black (solid) **(1)** Mark independently but the colour after adding bromine must be **darker** than the colour given for bromine. Eg bromine yellow brown, mixture brown scores **(2)** Bromine brown, mixture light brown scores **(1)** Bromine reddish brown, mixture brown scores **(2)** Iodine/I_2/I_3^- **(1)**	Just 'red' Purple/purple-black/colours with organic solvent Iodide/I/I^- Br^- and iodine	**3**

Question Number	Correct Answer	Reject	Mark
1(d)	Black solid is iodine/$\mathbf{I_2}$ **(1)** Yellow solid is sulfur/S/S_8 **(1)**	Iodide / I / I^-	**2**

Question Number	Correct Answer	Reject	Mark
2(a)	Sodium/Na^+	Na Sodium, Na	**1**

Question Number	Correct Answer	Reject	Mark
2(b)	Barium carbonate/$BaCO_3$ **(1)** Barium sulfate((VI))/$BaSO_4$ **(1)** Either order	SO_4^{2-} , CO_3^{2-} Barium sulfite Barium sulfate(IV) $BaSO_3$	**2**

Question Number	Correct Answer	Reject	Mark
2(c)	Carbonate/CO_3^{2-} **(1)** Carbon dioxide/CO_2 **(1)** For second mark allow a correct equation if state symbols show that carbon dioxide is the only gas	HCO_3^-	**2**

Question Number	Correct Answer	Reject	Mark
2(d)	Na_2CO_3 ALLOW TE from incorrect cation in (a) and/or incorrect anion in (c) Answer should follow from (a) and (c)	Sodium carbonate Any formula based on incorrect charges	**1**

Question Number	Correct Answer	Reject	Mark
3(a)	So that there is less (time for) cooling ALLOW so that reaction is fast/to increase the rate of reaction OR using lumps will be slow	To ensure all magnesium carbonate reacts Just "To make surface area larger"	**1**

Question Number	Correct Answer	Reject	Mark
3(b)(i)	(3.50/84) = 0.041667 = 0.0417/ 0.042/4.2 x 10^{-2} (mol) ACCEPT 3.50/84.3 = 0.041518 = 0.0415/0.042 (mol) Mark FINAL answer IGNORE sf except 1 sf IGNORE units	0.04, 0.041, 0.0416	**1**

Question Number	Correct Answer	Reject	Mark
3(b)(ii)	To ensure all magnesium carbonate reacts/ it is in excess/moles of acid is more than twice the number of moles of magnesium carbonate ALLOW To ensure all magnesium carbonate dissolves Statement that acid is in excess even if calculation not totally correct	To ensure all the acid reacts Calculation of number of moles without indication that acid is in excess To ensure there is enough/adequate acid There are more moles of acid than carbonate	**1**

Question Number	Correct Answer	Reject	Mark
3(c)(i)	(50 x 4.18 x 8.7) = 1818.3 = 1820/ 1818/1800 (J**)** accept 1.8183 = 1.82 **kJ** IGNORE sf except 1 sf IGNORE signs	2000 (J) 53.5 x 4.18 x 8.7 = 1945.58	**(1)**

<table>
<tr><th>Question Number</th><th>Correct Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>3(c)(ii)</td><td>
First mark:
Answer in (c)(i)/number of moles (1)

Second mark:
Correct value with negative sign and 3sf (1)
Correct answer with no working scores (2)

= -43.6 (kJ mol^{-1})

ACCEPT answers from -43.3 up to -45.5 which may arise from using different roundings, but check they come from values in (c)(i) and a suitable number of moles.

<table>
<tr><td>1818.3</td><td>0.042</td><td>43.3</td></tr>
<tr><td>1818.3</td><td>0.04</td><td>45.5</td></tr>
<tr><td>1818.3</td><td>0.041667</td><td>43.6</td></tr>
<tr><td>1818</td><td>0.041667</td><td>43.6</td></tr>
<tr><td>1820</td><td>0.041667</td><td>43.7</td></tr>
<tr><td>1818.3</td><td>0.0417</td><td>43.6</td></tr>
<tr><td>1818</td><td>0.0417</td><td>43.6</td></tr>
<tr><td>1820</td><td>0.0417</td><td>43.6</td></tr>
<tr><td>1818.3</td><td>0.041518</td><td>43.8</td></tr>
<tr><td>1818</td><td>0.041518</td><td>43.8</td></tr>
<tr><td>1820</td><td>0.041518</td><td>43.8</td></tr>
<tr><td>1818.3</td><td>0.0415</td><td>43.8</td></tr>
<tr><td>1818</td><td>0.0415</td><td>43.8</td></tr>
<tr><td>1820</td><td>0.04</td><td>45.5</td></tr>
<tr><td>1820</td><td>0.0417</td><td>43.6</td></tr>
<tr><td>1820</td><td>0.0415</td><td>43.9</td></tr>
</table>

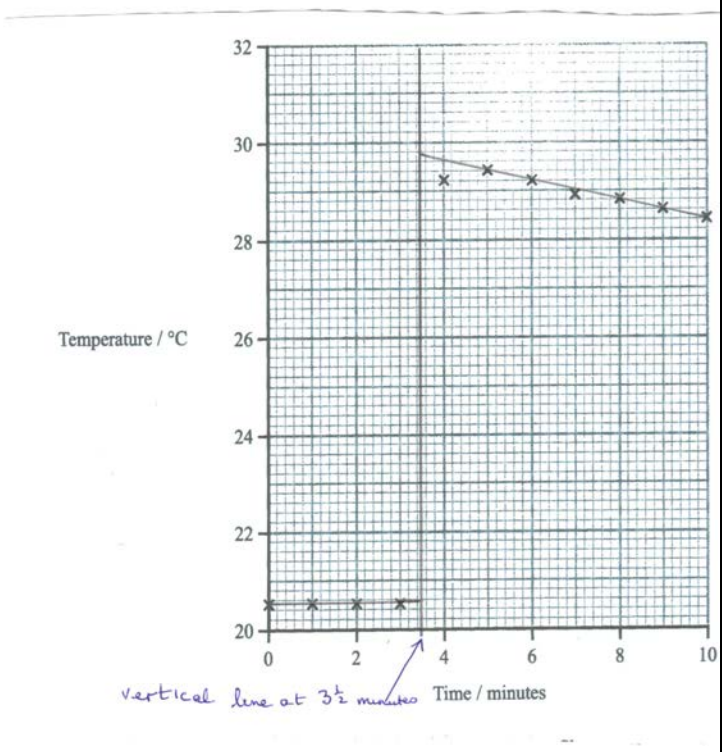
Answer to c(i) divided by one (for one mole of magnesium carbonate) scores second mark only, if sign and sf correct and in kJ mol^{-1}
</td><td></td><td>2</td></tr>
</table>

Question Number	Correct Answer	Reject	Mark
3(d)(i)	Pipette : more accurate/more precise/lower % error **(1)** Measuring cylinder : faster/easier/more convenient **(1)**	Cost Safer Measures a range of volumes/ larger volumes Easier to clean More suitable	**2**

Question Number	Correct Answer	Reject	Mark
3(d)(ii)	$\frac{(0.01 \times 100)}{3.50}$ = (±)0.28571 = (±) 0.286/ (±)0.29/ (±)0.3 % IGNORE sf	0.285, 0.28	**1**

	Correct Answer	Reject	Mark
3(e)(i)	(calculated) enthalpy change less negative/less exothermic **(1)** allow (value) less or smaller or decreases (Temp rise will be lower) due to heat loss/more heat absorbed by calorimeter **(1)** Mark independently		**2**

Question Number	Correct Answer	Reject	Mark
3(e)(ii)	(calculated) enthalpy change less negative/less exothermic **(1)** allow (value) less or smaller or decreases Less $MgCO_3$ to react (so temp rise will be lower) **(1)** Mark independently	Water will not affect the reaction	**2**

Question Number	Correct Answer	Reject	Mark
3(f)(i)	 Extrapolated horizontal line, extrapolated (best fit) cooling line and vertical line at 3.5 minutes **(1)** 9.3°C ±0.2 **(1)** Mark independently	Diagonal line from 3 or 3.5	**2**

Question Number	Correct Answer	Reject	Mark
3(f)(ii)	Corrects for (loss of heat during) cooling/checks original solution is at equilibrium with surroundings IGNORE reference to anomalous readings	There is no heat loss The original method included heat loss to the surroundings	1

Question Number	Correct Answer	Reject	Mark
4(a)	Sodium dissolves/disappears/gets smaller **(1)** Bubbles/effervescence/fizzes **(1)** White solid (Allow white precipitate) remains / forms on surface of sodium **(1)** Mixture gets hot **(1)** Any TWO	Sodium melts Sodium sinks Gas/hydrogen given off Makes hissing sound Lighted splint held above mixture gives a pop	**2**

Question Number	Correct Answer	Reject	Mark
4(b)	Measure volume of gas in **fixed time**/measure time to collect a volume of gas/measure time for sodium to dissolve	Just time Just volume Just temperature	**1**

Question Number	Correct Answer	Reject	Mark
4(c)(i)	Steamy/misty (fumes) ALLOW white (fumes)	White smoke White solid	**1**

Question Number	Correct Answer	Reject	Mark
4(c)(ii)	White smoke White solid ALLOW **White** smoky fumes	Steamy/misty fumes White fumes	**1**

Question Number	Correct Answer	Reject	Mark
5(a)	Potassium dichromate ((VI))/ $K_2Cr_2O_7$ Sodium dichromate ((VI))/ $Na_2Cr_2O_7$ IGNORE acidified/solution/aqueous	Dichromate ((VI)) ions/$Cr_2O_7^{2-}$ Potassium manganate(VII)/ $KMnO_4$	**1**

Question Number	Correct Answer	Reject	Mark
5(b)	Orange to green/blue/blue-green/ brown	yellow	**1**

Question Number	Correct Answer	Reject	Mark
5(c)	Flask fitted with condenser in vertical position **(1)** Direction of water flow in condenser **(1)** Heat not required IGNORE contents	Stoppered equipment and/ or gaps between flask and condenser loses first mark	**2**

Question Number	Correct Answer	Reject	Mark
5(d)	Any two of Yield would be reduced/reactants and or products would be lost **(1)** complete **oxidation** could not occur **(1)** Vapour is flammable/toxic/ hazardous/harmful/ acidic/irritant **(1)**	To increase (%) yield To prevent boiling dry To allow reaction to go to completion Reactant / product is very volatile	**2**

Question Number	Correct Answer	Reject	Mark
5(e)	Any one from Mixture being heated returns to the flask The vapour is (cooled and) condensed The water in the condenser is cold (and flowing)		**1**

Question Number	Correct Answer	Reject	Mark
5(f)(i)	(Anhydrous) calcium chloride/ (Anhydrous) magnesium sulfate/ (Anhydrous) sodium sulfate ALLOW Silica gel ACCEPT formula	Calcium oxide Conc sulfuric acid Aluminium chloride Potassium sulfate Copper sulfate Cobalt chloride Calcium carbonate	**1**

Question Number	Correct Answer	Reject	Mark
5(f)(ii)	Filter paper absorbs some of the product ALLOW Some product is absorbed BY/ INTO filter paper Answer should be appropriate for collection of a liquid product, not a solid	Transfer losses Spillage Product sticks to filter paper Some product is left ON filter paper Decanting is faster	**1**

Question Number	Correct Answer	Reject	Mark
5(g)(i)	Mol propanol = (10/60.1) = 0.166/ 0.17 = (mol propanoic acid) (1) Mass propanoic acid = (0.166 x 74.1) = 12.32945 = 12.33/12.3 (g) If 0.17 mol then 12.597/12.6 (g) **(1)** If molar masses are reversed, 8.1066 (g) scores **(1)** IGNORE sf except 1 sf Correct answer no working **(2)** marks		**2**

Question Number	Correct Answer	Reject	Mark
5(g)(ii)	Mass propanoic acid = 6 x 0.99 = 5.94 (g) **(1)** % yield = (5.94/ 12.33)x100 = 48.17% = 48/ 48.2/48.18 % **(1)** Allow 48.29 (if 12.3 used) 47.14 (if 12.6 used) **(1)** Allow calculation based on volumes: 12.33g propanoic acid = 12.33/0.99 = 12.455 cm^3 **(1)** % yield = (6.0/ 12.455)x100 = 48.17 % IGNORE sf except 1 sf Correct answer no working **(2)** marks TE from (i) If molar masses are reversed, 73.24%		**2**

Question Number	Correct Answer	Reject	Mark
5(h)	(Product) Propanal/CH_3CH_2CHO/ C_2H_5CHO **(1)** ALLOW propan-1-al Product removed as formed/ Incomplete oxidation/only partial oxidation occurs **(1)**	Molecular formulae Formulae written with OH Reaction does not go to completion	**2**

TOTAL FOR PAPER = 50 MARKS

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Welsh Assembly Government

Rewarding Learning

6CH07_01
1201

Write your name here

Surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Wednesday 9 May 2012 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39310A

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7/5/5/5/

P 3 9 3 1 0 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A student is given aqueous solutions of:

- sodium chloride, NaCl(aq)
- potassium iodide, KI(aq)
- dilute hydrochloric acid, HCl(aq)
- dilute nitric acid, HNO_3(aq)

The solutions are labelled **A**, **B**, **C** and **D**, but not necessarily in the order listed above.

The student carried out two tests on each solution.

Test 1

1. The student put a 1 cm depth of each of the solutions **A**, **B**, **C** and **D** into separate test tubes.
2. The student added one spatula measure of solid sodium carbonate, Na_2CO_3, to each test tube.
3. The student's observations were recorded as shown in Table 1 below, in the column labelled Test 1.

Test 2

1. The student put a 1 cm depth of each of the solutions **A**, **B**, **C** and **D** into separate test tubes.
2. The student added an equal volume of aqueous silver nitrate solution, $AgNO_3$, to each test tube.
3. The student's observations were recorded as shown in Table 1 below, in the column labelled Test 2.

Table 1

	Observations	
Solution	**Test 1**	**Test 2**
A	Effervescence	No reaction
B	No reaction	Yellow precipitate
C	No reaction	White precipitate
D	Effervescence	White precipitate

(a) Use the results of the tests to identify each of the four solutions using the letters **A**, **B**, **C** and **D** in Table 2.

(3)

Table 2

Name of solution	Letter
Sodium chloride solution	
Potassium iodide solution	
Dilute hydrochloric acid	
Dilute nitric acid	

(b) Explain how the observations allowed the student to distinguish between dilute hydrochloric acid and sodium chloride solution.

(1)

.....

.....

.....

(c) Give the ionic equation, including state symbols, for the reaction of solution **B** in **Test 2**.

(2)

(d) What would you expect to **see** when dilute ammonia solution is added to the white precipitate formed by solution **C** in **Test 2**?

(1)

.....

.....

(Total for Question 1 = 7 marks)

2 A series of tests was carried out on a white powder, **E**, which is known to be a Group 2 nitrate.

(a) Complete the inference column for each test in the table below by giving a name or formula.

(4)

Test	Observation	Inference
Carry out a flame test on **E**.	Pale green flame	The metal ion is .....
Add dilute sulfuric acid to an aqueous solution of **E**.	White precipitate	The precipitate is .....
Heat a sample of **E** very strongly. Test any gases given off with a glowing splint.	A brown gas is evolved The glowing splint relights	The brown gas is ..... The gas which relights the glowing splint is .....

(b) The **formula** of **E** is .....

(1)

(c) Write an equation to show the reaction which occurs when a sample of **E** is heated very strongly. State symbols are **not** required.

(2)

(Total for Question 2 = 7 marks)

3 (a) Two colourless liquids, **X** and **Y**, both with the formula $C_4H_{10}O$, are oxidized on heating with acidified potassium dichromate(VI) solution to form different carboxylic acids.

(i) Give the colour change you would expect to observe when each reaction takes place.

(2)

From ..... to .....

(ii) Give the two possible structural formulae for the compounds **X** and **Y** which both have the formula $C_4H_{10}O$.

(2)

First possible structural formula

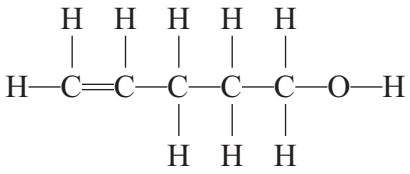
Second possible structural formula

(b) A colourless liquid, **Z**, also with the formula $C_4H_{10}O$, resists oxidation on heating with acidified potassium dichromate(VI) solution.

Give the structural formula for liquid **Z**.

(1)

(c) An organic compound, **W**, has the displayed formula



(i) A few drops of bromine water were added to a sample of **W** in a test tube and the mixture shaken.

Give the colour change you would expect to observe.

(2)

From ..... to .....

(ii) Give the displayed formula of the product formed in (c)(i).

(1)

(iii) What would you expect to **see** when a small quantity of phosphorus(V) chloride was added to a sample of **W** in a test tube?

(1)

.....

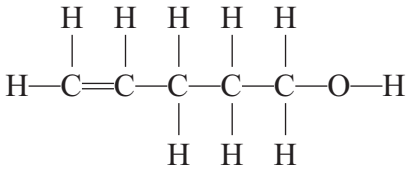
.....

(iv) Give the displayed formula of the **organic** product formed in (c)(iii).

(1)

(v) Identify, by **name**, the two functional groups present in compound **W**.

(2)



First functional group

.....

Second functional group

.....

(Total for Question 3 = 12 marks)

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4 In two similar, separate experiments, the enthalpy changes for the reactions of potassium hydrogencarbonate, $KHCO_3$, and potassium carbonate, K_2CO_3, with excess dilute hydrochloric acid were determined.

(a) The first experiment was to find the enthalpy change, ΔH_1, for the reaction

$$KHCO_3(s) + HCl(aq) \rightarrow KCl(aq) + H_2O(l) + CO_2(g)$$

Measurement	Reading
Mass of solid potassium hydrogencarbonate added to hydrochloric acid	3.48 g
Volume of hydrochloric acid	25.0 cm^3
Temperature of hydrochloric acid before addition of solid potassium hydrogencarbonate	22.0 °C
Final temperature of solution	12.0 °C

(i) Calculate the heat energy absorbed, in joules, by the reaction of $KHCO_3(s)$ with the solution of dilute hydrochloric acid.

Use the expression

energy absorbed (J) = 25.0 × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of $KHCO_3(s)$ used.
Molar mass of $KHCO_3(s)$ is 100 g mol^{-1}.

(1)

(iii) Use your answers to (a)(i) and (ii) to calculate, in kJ mol^{-1}, the enthalpy change, ΔH_1, when one mole of $KHCO_3(s)$ reacts completely with the acid. Include the sign for ΔH_1.

(2)

(b) In the second experiment, the enthalpy change for the reaction between potassium carbonate and dilute hydrochloric acid was calculated from the results.

$$K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + H_2O(l) + CO_2(g)$$

The molar enthalpy change, ΔH_2, for this reaction was calculated to be –34.0 kJ mol^{-1}.

(i) State **one** way in which the temperature change is different when equal numbers of moles of potassium hydrogencarbonate and potassium carbonate react separately with the same volume of excess dilute hydrochloric acid.

(1)

.....

.....

.....

(ii) Give **one** assumption made when calculating the values of ΔH_1 and ΔH_2 from experimental results.

(1)

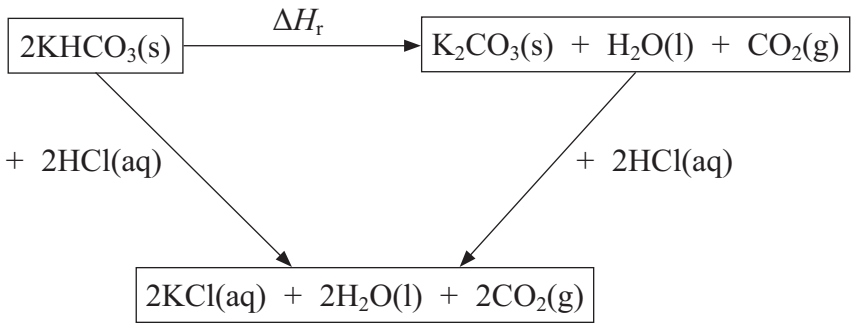
.....

.....

(c) The values of ΔH_1 and ΔH_2 may be used to determine the enthalpy change for the following reaction (ΔH_r).

$$2KHCO_3(s) \rightarrow K_2CO_3(s) + H_2O(l) + CO_2(g)$$

A Hess cycle based on these reactions is shown below.



(i) Use Hess's Law to complete an expression for ΔH_r in terms of ΔH_1 and ΔH_2.

(1)

ΔH_r =

(ii) Calculate the value of ΔH_r in kJ mol^{-1}. Include a sign in your answer.

(2)

(Total for Question 4 = 9 marks)

BLANK PAGE

5 A student carried out an experiment to determine the value of **x** in the formula of hydrated sodium bromide, $NaBr \cdot \mathbf{x}H_2O$.

Hydrated sodium bromide is heated until all the water of crystallization is removed. Anhydrous sodium bromide, NaBr, is formed.

The student was given the following instructions.

- Weigh a sample of the hydrated sodium bromide crystals in a pre-weighed crucible.
- Heat the crucible containing the sample to remove the water of crystallization.
- Allow the crucible to cool and then reweigh the crucible.

The student's results are shown in the table below.

(a) Complete the table.

(2)

Mass of crucible empty / g	18.02
Mass of crucible + contents before heating / g	21.49
Mass of crucible + contents after heating / g	20.51
Mass of contents before heating / g	3.47
Mass of contents after heating / g	
Mass of water removed / g	

(b) (i) Calculate the number of moles of water removed on heating the hydrated sodium bromide crystals.

(1)

(ii) Calculate the number of moles of anhydrous sodium bromide, NaBr, formed after heating.

(2)

(iii) Use your answers from (b)(i) and (ii) to calculate the value of **x**. Give your answer to **two** significant figures.

(2)

(c) Each mass reading in the table has a maximum error of ±0.005 g.

Calculate the percentage error in the mass of the contents of the crucible before heating the 3.47 g of crystals.

(2)

(d) The correct value for **x** is 2.

Two possible errors that might occur during the experiment are described below.

For each error, predict the effect the error would have on

- the apparent mass of water removed
- the calculated value of **x**

(i) Carbon from the Bunsen burner flame was deposited on the crucible during heating.

(2)

Apparent mass of water removed:

.....

Value of **x**:

.....

(ii) A few crystals of hydrated sodium bromide jumped out of the crucible during heating.

(2)

Apparent mass of water removed:

.....

Value of **x**:

.....

(e) Suggest **two** improvements to the experiment, other than changing the balance, that would help to achieve a more accurate result.

(2)

First improvement

.....

.....

Second improvement

.....

.....

(Total for Question 5 = 15 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
																	4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number				1.0 H hydrogen 1					10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 3 9 3 1 0 A 0 1 6 1 6

PMT

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Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH07) Paper 01
Chemistry Laboratory Skills (WA)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

<table>
<tr><th>Question Number</th><th>Correct Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>1(a)</td><td>
<table>
<tr><th>Name of solution</th><th>Letter</th></tr>
<tr><td>Sodium chloride solution</td><td>C</td></tr>
<tr><td>Potassium iodide solution</td><td>B</td></tr>
<tr><td>Dilute hydrochloric acid</td><td>D</td></tr>
<tr><td>Dilute nitric acid</td><td>A</td></tr>
</table>
All four letters correct = 3
Two / three letters correct = 2
One letter correct = 1
</td><td></td><td>3</td></tr>
</table>

Question Number	Correct Answer	Reject	Mark
1(b)	Hydrochloric acid gives effervescence/fizzing/gas /CO_2 OR sodium chloride gives no effervescence/fizzing/gas /CO_2/no reaction	Incorrect gas Incorrect gas	**1**

Question Number	Correct Answer	Reject	Mark
1(c)	$Ag^+(aq) + I^-(aq) \rightarrow AgI(s)$ species **(1)** ALLOW Ag^+I^- state symbols **(1)** This mark is only available if the equation is correct OR is correctly balanced with only the ion charge(s) incorrect. ALLOW Non-ionic equation with correct state symbols **(1)** Equations including spectator ions with correct state symbols **(1)** $Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$ **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
1(d)	(The white precipitate) dissolves/ disappears OR a colourless solution is formed	**Just** "clear" instead of "colourless"	**1**

Question Number	Correct Answer	Reject	Mark
2(a)	(**The metal ion is**) barium/Ba^{2+} **(1)** **(The precipitate is)** barium sulfate/ $BaSO_4$ **(1)** ALLOW barium sulphate **(The gas is)** nitrogen dioxide/NO_2 **(1)** ALLOW dinitrogen tetroxide/N_2O_4 **(The gas which relights the glowing splint is)** Oxygen/O_2 **(1)** **Note:** If both name and formulae are given both must be correct Mark the four parts independently	**Just** "Ba" Ba^+	**4**

Question Number	Correct Answer	Reject	Mark
2(b)	$Ba(NO_3)_2$ ALLOW $Ba(NO_3)_2.xH_2O$ where x is a number between 1 and 10 e.g. $Ba(NO_3)_2.2H_2O$		**1**

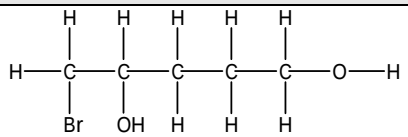
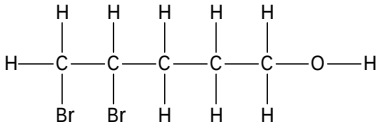
Question Number	Correct Answer	Reject	Mark
2(c)	$2Ba(NO_3)_2 \rightarrow 2BaO + 4NO_2 + O_2$ Fully correct equation **(2)** Formulae of all three products correct **(1)** ALLOW multiples ALLOW $4BaNO_3 \rightarrow 2Ba_2O + 4NO_2 + O_2$ **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
3(a)(i)	**(From)** orange **(1)** **(To)** green/blue/brown **(1)**	Two colours e.g. "blue/green" "blue-green"	**2**

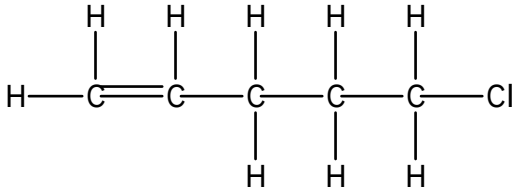
Question Number	Correct Answer	Reject	Mark
3(a)(ii)	$CH_3CH_2CH_2CH_2OH$ **(1)** $CH_3CH(CH_3)CH_2OH$/ $(CH_3)_2CHCH_2OH$ **(1)** In either order Formulae may also be displayed or skeletal	C_4H_9OH Displayed formula with C-H-O OR C-HO	**2**

Question Number	Correct Answer	Reject	Mark
3(b)	$(CH_3)_3COH$ ALLOW $CH_3COH(CH_3)CH_3$ Formula may also be displayed or skeletal ALLOW $CH_3CH_2CH_2OCH_3$ $CH_3CH(CH_3)OCH_3$ $CH_3CH_2OCH_2CH_3$	Displayed formula with C-H-O OR C-HO	**1**

Question Number	Correct Answer	Reject	Mark
3(c)(i)	**(From)** red-brown/ orange/yellow/brown **(1)** ALLOW Any combination of these colours **(To)** colourless **(1)**	**Just** "clear"	**2**

Question Number	Correct Answer	Reject	Mark
3(c)(ii)	 ALLOW Addition of –Br and –OH across the double bond, in either order OR  ALLOW Correct structural or skeletal formula		**1**

Question Number	Correct Answer	Reject	Mark
3(c)(iii)	steamy fumes/misty fumes/white fumes/cloudy fumes IGNORE dense	Any mention of "smoke", "solid" or "precipitate"	**1**

Question Number	Correct Answer	Reject	Mark
3(c)(iv)	 IGNORE addition of HCl across the C=C double bond ALLOW Correct structural or skeletal formula		**1**

Question Number	Correct Answer	Reject	Mark
3(c)(v)	Alkene **(1)** ALLOW carbon-carbon double bond Alcohol/primary alcohol/hydroxy/hydroxyl/alkanol **(1)** In either order	Ethene, alkyl hydroxide	**2**

Question Number	Correct Answer	Reject	Mark
4(a)(i)	(25.0 x 4.18 x 10.0 =) 1045/1050/1000 (J) ALLOW 1.045/1.05/1.0 **kJ** IGNORE signs IGNORE sf except 1		**1**

Question Number	Correct Answer	Reject	Mark
4(a)(ii)	$\left(\frac{3.48}{100}\right)$ = 0.0348/0.035 (mol) IGNORE sf except 1		**1**

Question Number	Correct Answer	Reject	Mark
4(a)(iii)	$\left(\frac{\text{Answer to (a)(i) in kJ}}{\text{Answer to (a)(ii)}}\right) = \frac{1.045}{0.0348}$ = **+**30.03/30.0/30 (kJ mol^{-1}) ALLOW any answer which rounds to 30 to 2 sf. Mark CQ on (a)(i) and (ii) which should be checked. Value must round to the correct answer to 2 sf. Sign **(1)** value **(1)** Mark independently	1.0/0.035=29	**2**

Question Number	Correct Answer	Reject	Mark
4(b)(i)	Decrease (in temperature) for $KHCO_3$ **and** an increase (in temperature) for K_2CO_3 **(1)** OR Endothermic for $KHCO_3$ **and** exothermic for K_2CO_3 **(1)**	**Just** Temperature change different	**1**

Question Number	Correct Answer	Reject	Mark
4(b)(ii)	No heat lost/no heat gained/ reaction is complete/ specific heat capacity of the solution is the same as water/molar mass of $KHCO_3$ is 100 (not 100.1)/density of solution is 1.00 gcm^{-3}	Thermometer is accurate	**1**

Question Number	Correct Answer	Reject	Mark
4(c)(i)	(ΔH_r =) 2 x ΔH_1 — ΔH_2		**1**

Question Number	Correct Answer	Reject	Mark
4(c)(ii)	(ΔH_r = (2 x +30) — (—34) =) + 94 (kJ mol^{-1}) value **(1)** sign **(1)** The sign mark is only available if the value is correct or almost correct. ALLOW (ΔH_r = (+30) — (—34) =) = +64 (kJ mol^{-1}) **(1)** IGNORE sf except 1		**2**

Question Number	Correct Answer	Reject	Mark
5(a)(i)	(Mass of contents after heating / g) **2.49**		**1**

Question Number	Correct Answer	Reject	Mark
5(a)(ii)	(Mass of water removed / g) **0.98**		**1**

Question Number	Correct Answer	Reject	Mark
5(b)(i)	$\left(\frac{0.98}{18.0}\right)$ = 0.0544 / 0.054/ 5.44×10^{-2}/ 5.4×10^{-2} (mol) IGNORE sig figs except ONE sf CQ on mass of water removed		**1**

Question Number	Correct Answer	Reject	Mark
5(b)(ii)	$\left(\frac{2.49}{102.9}\right)$ = 0.0242 / 0.024/ 2.42×10^{-2}/2.4×10^{-2} (mol) NaBr molar mass = 102.9/ 23.0+79.9 (g mol^{-1}) ALLOW 103 instead of 102.9 **(1)** answer **(1)** CQ on molar mass IGNORE sig figs except ONE sf CQ on mass of contents after heating		**2**

Question Number	Correct Answer	Reject	Mark
5(b)(iii)	(x = 0.0544/0.0242 = 2.2499) **x** = 2.2 to 2 sf ALLOW 2.3 answer **(1)** two sig figs **(1)** ALLOW 2.1,2.4,2.5 **(1)** ALLOW Either numerator 0.054 or denominator 0.024 and answer correct to 2 sf **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
5(c)	$\left(\frac{2 \times \pm 0.005}{3.47} \times 100\%\right) =$ 0.3% / 0.29% / 0.288% Ignore sf doubling the maximum error **(1)** answer **(1)** NOTE $\left(\frac{\pm 0.005}{3.47} \times 100\%\right) =$ 0.1% / 0.14% / 0.144% scores one only		**2**

Question Number	Correct Answer	Reject	Mark
5(d)(i)	**(Apparent mass of water removed)** decreases/less **(1)** **(Value of x)** decreases/less (than 2) **(1)** Mark independently		**2**

Question Number	Correct Answer	Reject	Mark
5(d)(ii)	**(Apparent mass of water removed)** increases/more **(1)** **(Value of x)** increases/ more (than 2) **(1)** Mark independently		**2**

Question Number	Correct Answer	Reject	Mark
5(e)	**Any two improvements from** • use a lid on the crucible • heat to constant mass • heat with a gentle/blue flame • use a larger mass of crystals • cool in a dry atmosphere • repeat experiment • electrical heating IGNORE "use a more accurate balance"	Heat loss	**2**

TOTAL FOR PAPER: 50 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Monday 7 January 2013 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/6/5/5/5/5/5/

P 4 1 2 1 6 A 0 1 1 6

PEARSON

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Answer ALL the questions. Write your answers in the spaces provided.

1 (a) A student carried out a series of tests on solid potassium iodide, KI.
Complete the table below.

(5)

	Test	Observation	Inference
(i)	Carry out a flame test on potassium iodide.	Colour of flame is	Cation is K^+
(ii)	Dissolve potassium iodide in water. Add dilute nitric acid followed by aqueous silver nitrate.	Colour of precipitate formed is	Anion is I^-
(iii)	Test the precipitate formed in (ii) with **concentrated** ammonia solution.	.....	Confirms iodide ions
(iv)	Dissolve potassium iodide in water. Add 10 drops of aqueous chlorine solution.	Colour of solution formed is	Formula of the coloured species is .....

(v) A hydrocarbon solvent, which is less dense than water, was added to the solution formed in test (iv). What would you expect to see in the test tube after the solvent has been added, the contents of the test tube vigorously shaken and left to stand for a few minutes?

(2)

.....

.....

.....

.....

(b) In an experiment, iodide ions from potassium iodide react with iodate(V) ions and hydrogen ions from hydrochloric acid according to the ionic equation

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

The amount of iodine formed can be determined by titration with sodium thiosulfate solution of known concentration. The equation for this reaction is

$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

30.0 cm^3 of a solution of hydrochloric acid was added to an excess of potassium iodate(V) and potassium iodide solutions in a conical flask.

The iodine formed in the conical flask was titrated with sodium thiosulfate solution of concentration 0.100 mol dm^{-3}. The mean titre was 45.00 cm^3.

(i) Name the indicator that is used in thiosulfate/iodine titrations.

(1)

.....

(ii) Give the colour change at the end-point of the titration.

(1)

From ..... to .....

(iii) Calculate the number of moles of sodium thiosulfate in the mean titre.

(1)

(iv) Hence deduce the number of moles of iodine, I_2, which reacted with the number of moles of sodium thiosulfate calculated in (b)(iii).

(1)

(v) How many moles of hydrogen ions, H^+, are required to produce the number of moles of iodine stated in (b)(iv)?

$$IO_3^-(aq) + 5I^-(aq) + 6H^+(aq) \rightarrow 3I_2(aq) + 3H_2O(l)$$

(1)

(vi) Use your answer to (b)(v) to calculate the concentration of the hydrochloric acid in mol dm^{-3}.

(1)

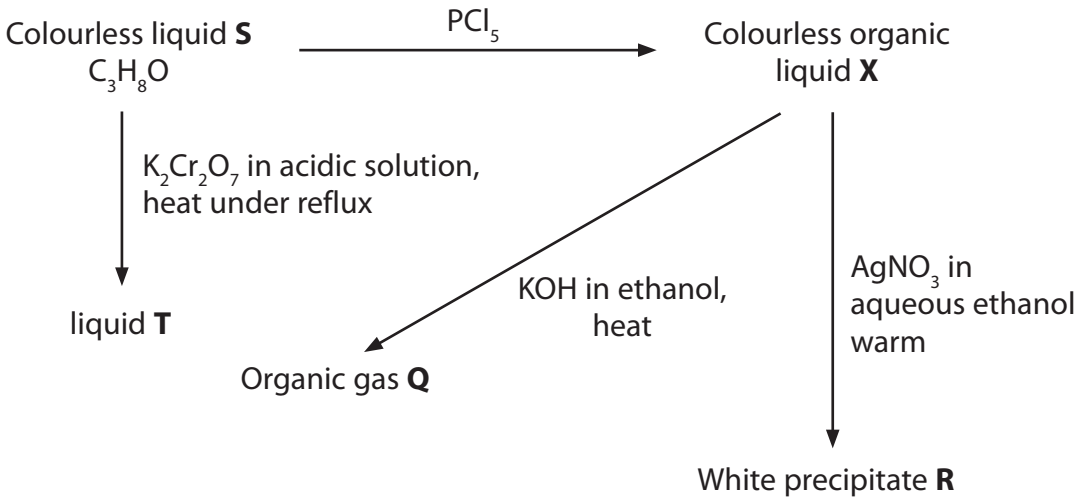
(c) Complete the half-equation showing the reduction of iodate(V) ions in acidic solution.

(1)

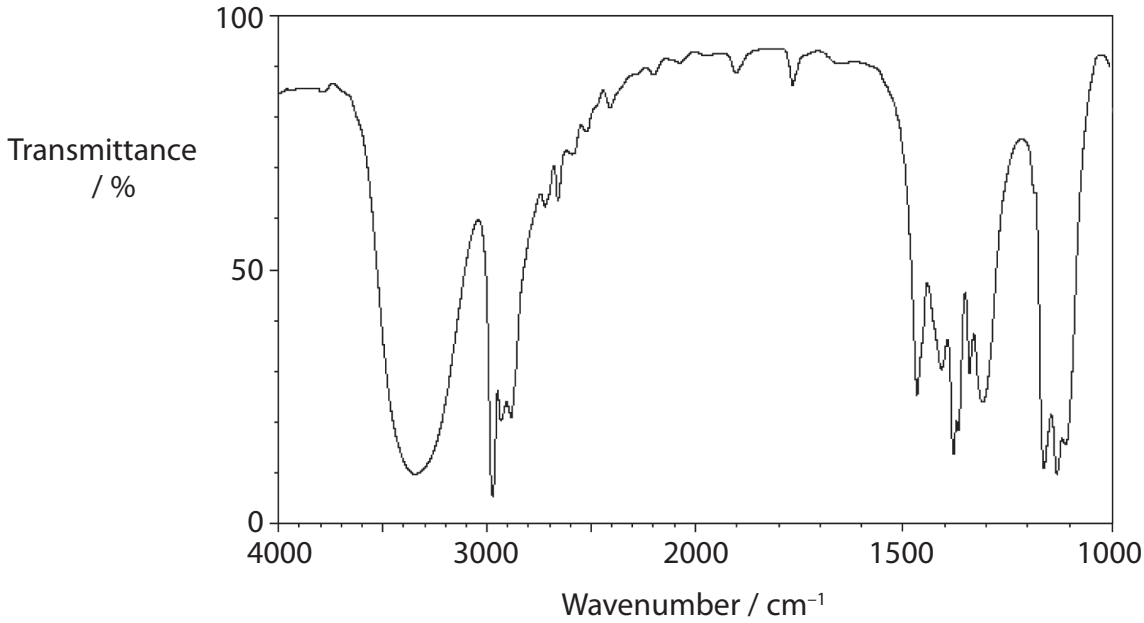
$$IO_3^-(aq) + 6H^+(aq) + \text{.....}e^- \rightarrow \tfrac{1}{2}\, I_2(aq) + 3H_2O(l)$$

(Total for Question 1 = 14 marks)

2 Consider the following reaction scheme.



The infrared spectrum of compound **S** is shown below.



Bond	Group	Wavenumber range / cm^{-1}
C—H	alkane	2962 – 2853
	alkene	3095 – 3010
O—H	alcohol	3750 – 3200
C═C	alkene	1669 – 1645
C═O	aldehyde	1740 –1720
	ketone	1720 – 1680

(a) (i) Give the wavenumber range of the absorption in the infrared spectrum that shows that compound **S** is an alcohol.

(1)

.....

(ii) Identify the type of organic compound formed in the reaction of **S** with phosphorus(V) chloride, PCl_5.

(1)

.....

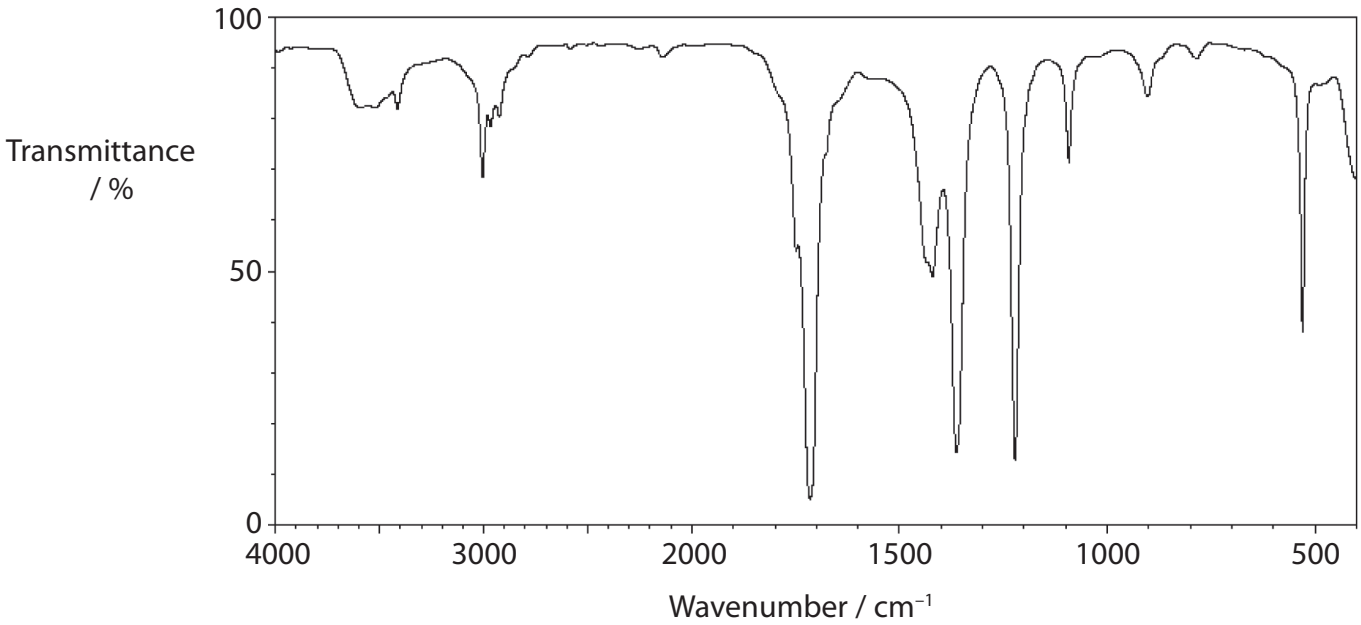
(b) Compound **T** does not produce carbon dioxide when added to a solution of sodium carbonate.

From this information **alone**, what can you deduce about compound **T**?

(1)

.....

(c) The infrared spectrum of liquid **T** is shown below.



(i) Give the wavenumber range of the absorption in the infrared spectrum that shows that compound **T** is formed from a **secondary** alcohol.

(1)

.....

(ii) Identify the type of organic compound **T**.

(1)

.....

(iii) Draw the **skeletal** formula for **S**.

(1)

(d) Liquid **X** gives a white precipitate, **R**, on warming with an aqueous ethanolic solution of silver nitrate.

(i) Identify **R** by name or formula.

(1)

(ii) Describe what you would see if precipitate **R** was left in sunlight.

(1)

(iii) Suggest why an aqueous ethanolic solution of silver nitrate gives a better result in this test than would be obtained by aqueous silver nitrate.

(1)

(e) If **X** is heated with a concentrated ethanolic solution of potassium hydroxide, a gas **Q** is produced.

(i) Describe a test and its expected result to show that this gas is an alkene.

(2)

Test .....

.....

Result .....

.....

(ii) Give the displayed formula of the alkene **Q**.

(1)

(Total for Question 2 = 12 marks)

3 Weak acids such as ethanoic acid cannot be titrated with weak bases such as ammonia using an indicator since there is never any distinct colour change.

An alternative technique is to use thermometric titration as follows.

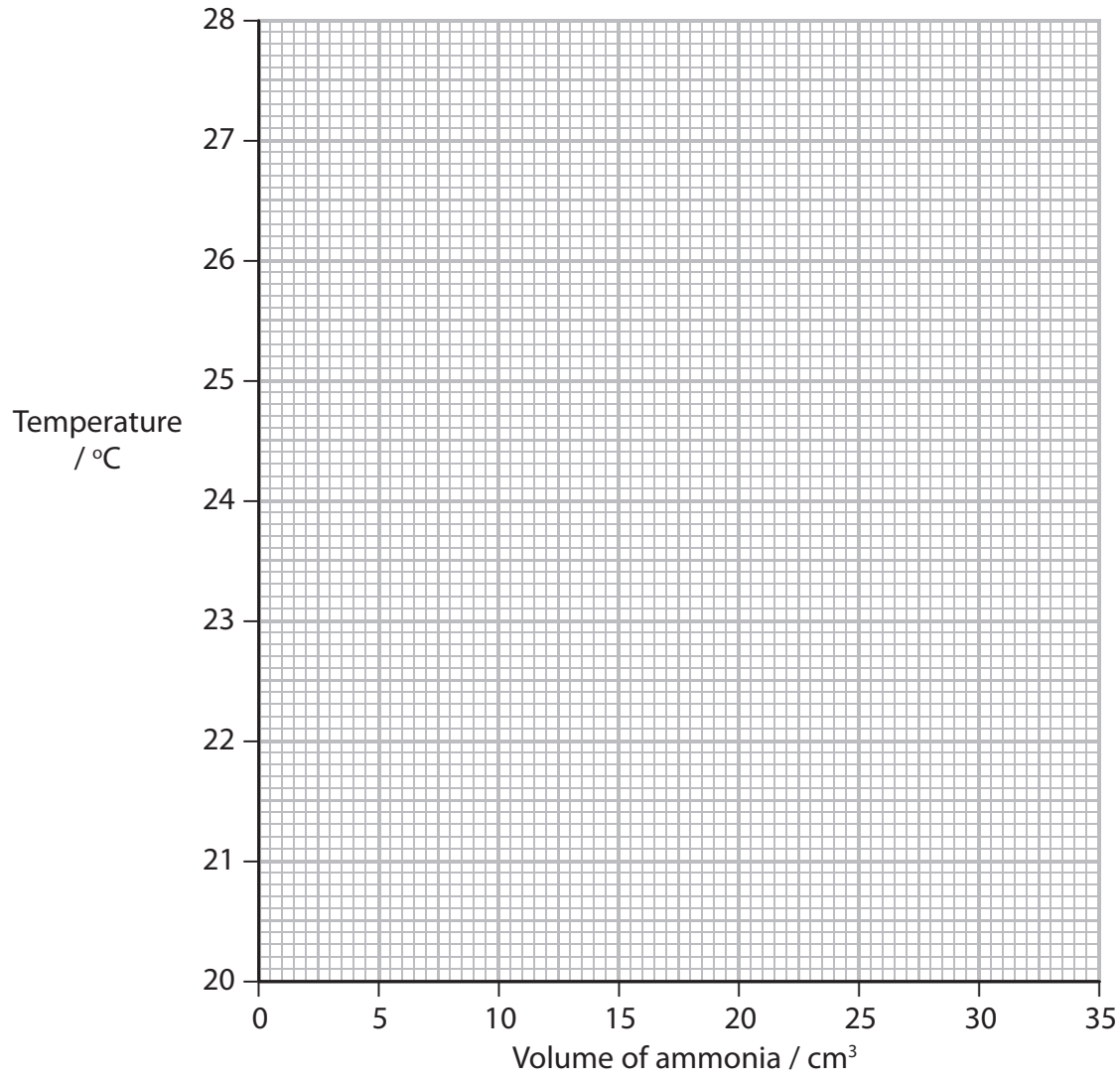
1. 30.0 cm^3 of dilute ethanoic acid is placed in a polystyrene cup and its temperature measured.
2. 5.00 cm^3 of ammonia solution of concentration 1.05 mol dm^{-3} is then added to the acid, the mixture stirred and the temperature measured again.
3. Further 5.00 cm^3 portions of ammonia are added, followed by measurement of the temperature, until a total of 35.0 cm^3 has been added.

The results of this experiment are tabulated below.

Volume of $NH_3(aq)$ added /cm^3	0.00	5.00	10.0	15.0	20.0	25.0	30.0	35.0
Temperature /°C	20.7	22.4	24.0	25.7	26.4	25.3	24.0	22.7

(a) (i) Plot these data on the axes below. Draw **two straight** lines through the points on your graph. Extrapolate the lines until they intersect, to enable you to determine the end-point volume.

(2)



(ii) State the volume of the ammonia solution at the end-point.

(2)

.....

(iii) Explain why the temperature rises until the end-point is reached.

(1)

.....

.....

(iv) Explain why the temperature falls when more ammonia solution is added after the end-point.

(2)

.....

.....

.....

.....

(b) In a similar experiment, 25.0 cm^3 of ethanoic acid of concentration 2.00 mol dm^{-3} was reacted with 25.0 cm^3 of 2.00 mol dm^{-3} aqueous ammonia. The initial temperature was 20.6 °C and the temperature at the end-point was 29.8 °C.

(i) Use the expression below to calculate the heat energy evolved in this reaction. (Assume that the density of the reaction mixture is 1.00 g cm^{-3} and that the specific heat capacity of the mixture is 4.18 J g^{-1} $°C^{-1}$.)

energy transferred = mass × specific heat capacity × temperature change
in joules

(2)

(ii) Calculate the number of moles of ethanoic acid used in this reaction.

(1)

(iii) The reaction that occurs is

$$CH_3COOH(aq) + NH_3(aq) \rightarrow CH_3COONH_4(aq)$$

Use your values from (b)(i) and (ii) to calculate the enthalpy change per mole for this reaction. Include a sign and units in your answer. Give your answer to **three** significant figures.

(3)

(Total for Question 3 = 13 marks)

4 The procedure below can be used to make 1-bromobutane.

1. Place a mixture of water, sodium bromide and butan-1-ol in a round-bottomed flask.
2. Slowly add a suitable volume of concentrated sulfuric acid to this mixture whilst it is also shaken and cooled.
3. When this addition is complete, heat the mixture under reflux for about 45 minutes.
4. Rearrange the apparatus for distillation and distil off the crude 1-bromobutane, collecting the distillate between 95 ° and 105 °C.
5. Shake the 1-bromobutane first with water, then with dilute sodium carbonate solution.
6. Separate the 1-bromobutane from the aqueous layer, add some anhydrous calcium chloride and leave the mixture to stand.
7. Decant the 1-bromobutane from the calcium chloride.

(a) (i) Explain why sodium bromide and sulfuric acid are required in **step 2**.

(1)

.....

.....

(ii) What would be the effect on this preparation if concentrated sulfuric acid was added in **step 2 without** water having been added in **step 1**? Justify your answer.

(2)

.....

.....

.....

.....

(b) Explain why the acid must be added slowly and with cooling in **step 2**.

(1)

.....

.....

(c) Draw a labelled diagram of the apparatus that could be used to carry out the distillation in **step 4**.

(4)

(d) Explain why the 1-bromobutane is shaken with sodium carbonate solution in **step 5**.

(1)

(e) What is the purpose of the calcium chloride in **step 6**?

(1)

(f) Suggest how you would obtain pure 1-bromobutane after **step 7**.

(1)

(Total for Question 4 = 11 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 4 1 2 1 6 A 0 1 6 1 6

PMT

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Mark Scheme (Results)

January 2013

GCE Chemistry (6CH07) Paper 01
Chemistry Laboratory Skills (WA)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear

  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter

  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.

( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable answers	Reject	Mark
1a(i)	Lilac Allow mauve/purple/violet Allow a near-miss with spelling e.g. lillac/liliac. Allow pink when viewed through blue glass. Ignore any qualification of colour e.g pale lilac.		**1**

Question Number	Acceptable answers	Reject	Mark
1a(ii)	Yellow (solid/precipitate)	Cream/pale yellow	**1**

Question Number	Acceptable answers	Reject	Mark
1a(iii)	Insoluble/does not dissolve/ precipitate remains. Allow no change Allow precipitate becomes paler Ignore the colour of the precipitate if given.	Precipitate forms Any other observation e.g. effervescence	**1**

Question Number	Acceptable answers	Reject	Mark
1a(iv)	Brown/red-brown/yellow **(1)** Allow orange/orange-brown Ignore any qualification of colour e.g dark brown I_2 / I_3^- **(1)** Mark independently	Purple Any other colour given with acceptable answers Just red. I^-	**2**

Question Number	Acceptable answers	Reject	Mark
1a(v)	(two) layers (1) (hydrocarbon/top layer) purple/pink/violet (1) Ignore reference to effervescence and the colour of the lower layer. Mark independently, but if the layers mark is awarded, then for the second mark the **top** layer must be purple/pink/violet.	Three layers.	**2**

Question Number	Acceptable answers	Reject	Mark
1b(i)	Starch (solution/indicator)		**1**

Question Number	Acceptable answers	Reject	Mark
1b(ii)	blue-black OR blue OR black to **colourless** Ignore any qualification of colour e.g dark blue.	clear for colourless purple	**1**

Question Number	Acceptable Answers	Reject	Mark
1b(iii)	(amount sodium thiosulfate = 0.045 x 0.100) $=4.5 \times 10^{-3}$ / 0.0045 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
1b(iv)	(Amount of iodine = $4.5 \times 10^{-3} \div 2$) **=** 2.25×10^{-3} / 0.00225 (mol) TE answer to (b)(iii) ÷ 2	$0.0025/2.5 \times 10^{-3}$	**1**

Question Number	Acceptable Answers	Reject	Mark
1b(v)	Amount of H^+ ions = $2.25 \times 10^{-3} \times 2$ = 4.5×10^{-3} / 0.0045 (mol) TE answer to (b)(iv) x 2		**1**

Question Number	Acceptable Answers	Reject	Mark
1b(vi)	Concentration of HCl = $4.5 \times 10^{-3} \times 1000/30$ = 0.15 (mol dm^{-3}) TE answer to (b)(v) x 1000/30		**1**

Question Number	Acceptable answers	Reject	Mark
1c	$IO_3^- + 6H^+ + 5e^- \rightarrow ½ I_2 + 3H_2O$ Ignore any other numbers written around the equation.		**1**

Total = 14 marks

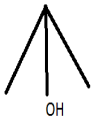
Question Number	Acceptable Answers	Reject	Mark
2a(i)	Quoted range **within** the appropriate range (3750-3200 cm^{-1} for –OH group) Allow range the other way round e.g 3200-3750. Allow a single value **within** the appropriate range e.g 3350. Ignore units		**1**

Question Number	Acceptable answers	Reject	Mark
2a(ii)	Halogenoalkane/haloalkane/chloroalkane/alkyl halide/alkyl chloride	Chloropropane alone	**1**

Question Number	Acceptable Answers	Reject	Mark
2b	Not a (carboxylic) acid/ not acidic/does not contain H^+ ions. Ignore reference to ketone	A carboxylic acid is not formed.	**1**

Question Number	Acceptable Answers	Reject	Mark
2c(i)	Quoted range **within** the appropriate range (1720-1680 cm^{-1} for C=O ketone group) Allow range the other way round e.g 1680-1720. Allow a single value **within** the appropriate range e.g 1700. Ignore units		**1**

Question Number	Acceptable Answers	Reject	Mark
2c(ii)	Ketone	Propanone alone.	**1**

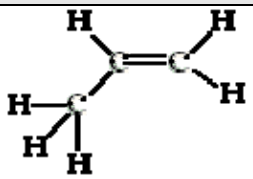
Question Number	Acceptable Answers	Reject	Mark
2c(iii)	 or  Allow skeletal diagram rotated at any angle Ignore structural or displayed formulae.	Structural formula Displayed formula given alone	**1**

Question Number	Acceptable answers	Reject	Mark
2d(i)	silver chloride/AgCl If name and formula are given, then both must be correct.		**1**

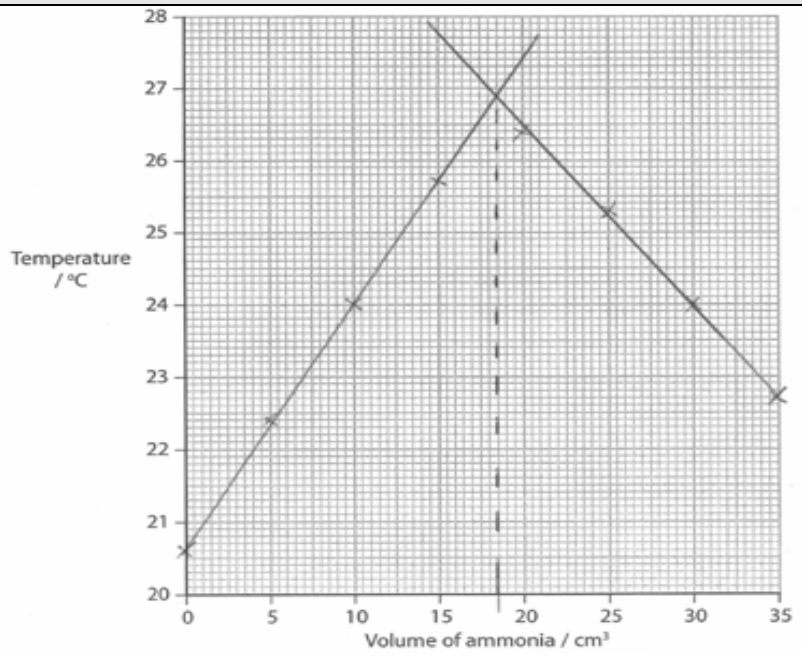
Question Number	Acceptable answers	Reject	Mark
2d(ii)	(precipitate) darkens OR goes grey /purple/blue/black (precipitate)	 Brown	**1**

Question Number	Acceptable Answers	Reject	Mark
2d(iii)	Halogenoalkane **X** is more soluble in (aqueous) ethanol (than in water alone)/ethanol is a better solvent (for **X**) OR Ethanol dissolves ionic/polar and non-polar compounds	Just 'ethanol acts as a solvent'. Just 'ethanol will allow them to mix better'.	**1**

Question Number	Acceptable Answers	Reject	Mark
2e(i)	bromine (water) **(1)** turns (from orange/yellow/brown to) **colourless**/decolorised **(1)** OR (acidic) potassium manganate(VII) **(1)** turns (from purple to) colourless/brown precipitate **(1)** OR alkaline potassium manganate(VII) **(1)** turns (from purple to) green / brown precipitate **(1)** Allow correct formulae for reagents Oxidation number not essential but if given then must be correct	clear for colourless	2

Question Number	Acceptable answers	Reject	Mark
2e(ii)	 Allow $-CH_3$ for the side-chain Ignore structural or skeletal formula.		**1**

Total = 12 Marks

Question Number	Acceptable answers	Reject	Mark
3a(i)	 All points correctly plotted, ±1 small square (allow one slip) **(1)** two best-fit straight lines which include all points**(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3a(ii)	18.5 ± 0.5 (cm^3)**(2)** ± 1.5 (cm^3)**(1)** further out scores zero		**2**

Question Number	Acceptable answers	Reject	Mark
3a(iii)	Reaction is exothermic **OR** heat is given out (until reaction is complete)		**1**

Question Number	Acceptable Answers	Reject	Mark
3a(iv)	No further reaction occurring / no further heat produced/all the ethanoic acid is used up. **(1)** the ammonia solution is cool/the volume increases. **(1)** Mark Independently.	Just 'there is no ethanoic acid'. Just 'heat is lost to the surroundings'.	**2**

Question Number	Acceptable Answers	Reject	Mark
3b(i)	q = 50 x 4.18 x (29.8 – 20.6) (J) **(1)** = 1922.8 (J) / 1923 (J) **(1)** Ignore SF except 1 SF OR 1.923 kJ Answer alone scores 2. TE for second mark if incorrect mass or temperature change e.g Use of 25 gives 961.4 (J) and scores 1 Ignore any sign and units if given		**2**

Question Number	Acceptable Answers	Reject	Mark
3b(ii)	(amount = (2.00 x 25/1000) =) 0.050/0.0500.		**1**

Question Number	Acceptable Answers	Reject	Mark
3b(iii)	ΔH = - 1922.8 ÷ 0.05 J mol^{-1} = - 38456 (J mol^{-1}) **(1)** = - 38.5 **(1)** kJ mol^{-1} **(1)** OR ΔH = - 1923 ÷ 0.05 J mol^{-1} = - 38460 (J mol^{-1}) **(1)** = - 38.5 **(1)** kJ mol^{-1} **(1)** If 1920 J quoted above the answer is – 38.4 kJ mol^{-1} second mark is for number to 3 SF third mark is for sign and units		**3**

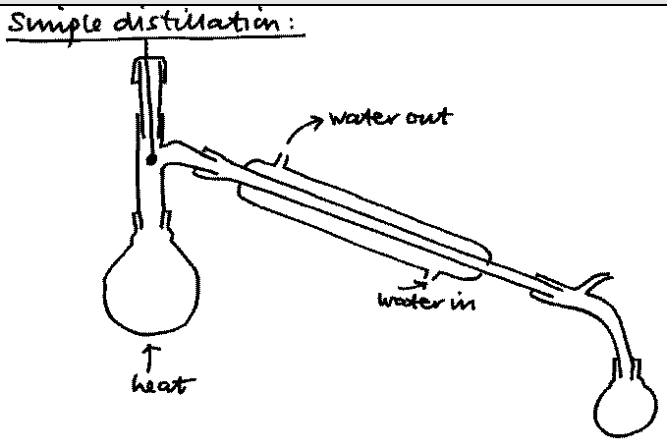
Total = 13 Marks

Question Number	Acceptable Answers	Reject	Mark
4a(i)	(The mixture) generates HBr (which attacks the alcohol) OR the alcohol must be protonated for the bromide ion to attack it successfully		**1**

Question Number	Acceptable Answers	Reject	Mark
4a(ii)	The yield would be lower **(1)** Allow no 1-bromobutane made. Because bromine/Br_2 would be formed/less HBr would be formed **(1)** Formation of alkene (by dehydration reaction) **(1)** Any two from the above three answers.	Bromide is reduced to bromine.	**2**

Question Number	Acceptable answers	Reject	Mark
4b	***EITHER*** Dilution of sulfuric acid is exothermic/ reaction (of sulfuric acid with water) is (very) exothermic. ***OR*** would cause loss of volatile organics. Ignore the reaction is vigorous.	Reaction is explosive. Just 'acid is corrosive/ dangerous/causes frothing'.	**1**

`

Question Number	Acceptable answers	Reject	Mark
4c	 Round-bottomed/pear-shaped flask (and contents) and heat/mantle/water bath **(1)** Still-head with stoppered thermometer opposite opening to condenser **(1)** Condenser with water flowing up**(1)** Collection of product from an unsealed apparatus either as shown or from a delivery tube into a flask/beaker or straight from the condenser into flask/beaker. **(1)** Allow continuous apparatus without joints.		**4**

Question Number	Acceptable Answers	Reject	Mark
4d	Removes/neutralizes acid/HBr Allow neutralizes sulfuric acid.	Just 'react with acid' Removes HCl	**1**

Question Number	Acceptable Answers	Reject	Mark
4e	Drying agent/To dry 1-bromobutane / Absorbs any water present/To remove water.	Dehydrating agent Removes **excess** water.	**1**

Question Number	Acceptable answers	Reject	Mark
4f	(Re-)distillation (over a narrow range either side of its boiling temperature/at its boiling temperature). Allow fractional distillation.	Stated temperature range of 95 - 105◦C or all other values outside of this range.	**1**

Total = 11 Marks
QUESTION PAPER TOTAL = 50 MARKS

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Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 3B: Chemistry Laboratory Skills I Alternative

Wednesday 8 May 2013 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH07/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41652A

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10/5/6/7/

P 4 1 6 5 2 A 0 1 1 2

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Answer ALL the questions. Write your answers in the spaces provided.

1 Tests were carried out on compounds **X**, **Y** and **Z**. Complete the tables below.

(a) Compound **X** is a white, water-soluble solid.

	Test	Observation	Inference (Name or formula)	
(i)	Flame test	Lilac flame	.....	**(1)**
(ii)	To a solution of **X**, add barium chloride solution and acidify with hydrochloric acid	.....	Sulfate ions absent	**(1)**
(iii)	To a solution of **X**, add dilute nitric acid followed by	.....	Iodide ions present	**(2)**
(iv)	Add concentrated aqueous ammonia solution to the mixture remaining from test (iii)	.....	Confirms presence of iodide ions	**(1)**

(v) The **formula** of **X** is: .....

(1)

(b) Compound **Y** is a white solid that is insoluble in water.

	Test	Observation	Inference (Name or formula)	
(i)	Flame test	Yellow-red (brick red) flame	.....	**(1)**
(ii)	Add dilute hydrochloric acid to **Y** Bubble the gas through	The mixture fizzed and the solid ..... It turned milky	 CO_2 evolved	**(2)**

(iii) The **formula** of **Y** is: .....

(1)

(c) **Z** is a colourless organic liquid with only one functional group. **Z** is completely miscible with water to form a neutral solution.

	Test	Observation	Inference
(i)	Add bromine water to **Z**	No colour change	..... (1)
(ii)	Add solid phosphorus(V) chloride, PCl_5, to **Z**	Misty fumes (of hydrogen chloride)	..... (1)
(iii)	Warm **Z** with potassium dichromate(VI) solution and dilute sulfuric acid	Colour changes from orange to green	**Z** could be ..... or ..... (2)

(d) The composition by mass of **Z** is C 60.0%, H 13.3%, O 26.7%.

(i) Calculate the empirical formula of **Z**.

(2)

(ii) The molecular formula of **Z** is the same as its empirical formula. Give the **displayed** formulae of the two possible isomers of **Z**.

(2)

(Total for Question 1 = 18 marks)

2 An experiment to determine the enthalpy change of reaction between aqueous copper(II) sulfate and zinc was carried out as follows.

1. 50.0 cm^3 of copper(II) sulfate solution, of concentration 1.00 mol dm^{-3}, was placed in a polystyrene cup.
2. The temperature of the solution was measured with a 0 – 110 °C thermometer and was found to be 23.0 °C.
3. Zinc powder with a mass of 5 g (an excess) was added to the solution with vigorous stirring and the highest temperature recorded was 69.5 °C.

(a) (i) Write the **ionic** equation for the reaction between zinc and aqueous copper(II) ions, including state symbols.

(2)

(ii) Calculate the quantity of heat energy produced in the experiment above, giving your answer in J. (Assume that the heat capacity of the mixture is 4.18 J g^{-1} °C^{-1} and its density is 1.00 g cm^{-3}.) Use the expression

energy transferred in joules = mass × specific heat capacity × temperature change

(2)

(iii) Calculate the number of moles of copper(II) sulfate used in the experiment.

(1)

(iv) Use your answers from (a)(ii) and (a)(iii) to calculate the enthalpy change for the reaction in kJ mol^{-1}. Give your answer to **three** significant figures and include the appropriate sign.

(2)

(b) The thermometer used in this experiment gave an uncertainty in each temperature reading of ±0.5 °C.

(i) State the maximum temperature difference in this experiment that could have been obtained using this thermometer.

(1)

(ii) What is the percentage error in the temperature change using this thermometer?

(1)

(c) **Using the same equipment**, together with a stop clock, suggest a procedure that would improve the accuracy of this experiment by obtaining a more accurate temperature change. You must use the same mass of zinc powder and the same volume of 1.00 mol dm^{-3} copper(II) sulfate solution.

(4)

(Total for Question 2 = 13 marks)

3 Chloroalkanes and bromoalkanes can be made from alcohols by reaction of the alcohol with sodium chloride or bromide, in the presence of 50% aqueous sulfuric acid.

Iodoalkanes cannot be made from sodium iodide and sulfuric acid; red phosphorus and iodine can be used instead as the halogenating agent.

(a) (i) What would you **see** if concentrated sulfuric acid was added to solid sodium iodide? Give **two** observations.

(2)

1. .....

.....

2. .....

.....

(ii) Explain why sodium iodide and sulfuric acid cannot be used to make iodoalkanes from alcohols.

(2)

.....

.....

.....

.....

(b) Give the equation for the reaction between phosphorus and iodine to form phosphorus(III) iodide. State symbols are not required.

(1)

(c) A preparation of 1-iodobutane is given in outline below.

Procedure

1. Suitable quantities of red phosphorus and butan-1-ol are placed in a round-bottomed flask fitted with a reflux condenser.
2. The mixture is heated until it boils gently and then the heat source is removed.
3. A suitable quantity of powdered iodine is added in small portions down the condenser at a rate which just maintains gentle boiling. The reaction should be allowed to subside after each addition.
4. After the addition of iodine is complete, the mixture is heated under reflux for 30 – 60 minutes, until little or no iodine is visible.
5. The apparatus is allowed to cool and the condenser rearranged for distillation.
6. The crude 1-iodobutane is distilled off until the residue in the distilling flask is about one-fifth of its original volume. Double its volume of water is added and the distillation continued until no more oily drops condense into the receiver.
7. The crude 1-iodobutane is separated and washed with dilute sodium thiosulfate solution and then with dilute sodium carbonate solution.
8. The organic layer is separated and allowed to stand over anhydrous calcium chloride.

(i) What does the manner in which the iodine is added in **step 3** suggest about the nature of the reaction?

(1)

.....

(ii) Completion of **step 4** requires that 'little or no iodine is visible'. State what you would look for in this step to ensure that this is true.

(1)

.....

.....

(iii) Draw the apparatus that is used in **step 6** for distillation.

(3)

(iv) Suggest why the first washing of the product in **step 7** is with dilute sodium thiosulfate solution rather than with water alone.

(1)

(v) State why calcium chloride used in **step 8** must be anhydrous.

(1)

(vi) To complete the preparation, after decanting the mixture from the calcium chloride, there should be a **step 9**. What is this step?

(1)

(d) Chloroalkanes can be made from an alcohol and phosphorus(V) chloride, PCl_5. The equation for the reaction of butan-1-ol with PCl_5 is

$$CH_3CH_2CH_2CH_2OH + PCl_5 \rightarrow CH_3CH_2CH_2CH_2Cl + HCl + POCl_3$$

This reaction is not suitable for the manufacture of 1-chlorobutane on a large scale.

(i) In a laboratory preparation of 1-chlorobutane, 95.0 g of butan-1-ol was used. Calculate the maximum mass of 1-chlorobutane that could be obtained.

(Assume the molar masses are, in g mol^{-1}, butan-1-ol = 74.0, 1-chlorobutane = 92.5)

(2)

(ii) In practice, 95.3 g of 1-chlorobutane was obtained. Calculate the percentage yield.

(1)

(iii) Give **one** reason why the actual yield is lower than the maximum possible yield.

(1)

.....

.....

(iv) Give **two** reasons why this reaction would not be used industrially to make 1-chlorobutane.

(2)

.....

.....

.....

.....

(Total for Question 3 = 19 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 1 6 5 2 A 0 1 2 1 2

PMT

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Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH07/01
Chemistry Laboratory Skills I
Alternative

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	Potassium (ions) / K^+	K /incorrect formula Name with incorrect formula e.g. "Potassium, K"	**1**

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	No precipitate forms / no change / no reaction / colourless **solution** ALLOW clear for colourless	White precipitate dissolves just "dissolves"	**1**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	Silver nitrate (solution) / $AgNO_3$ Allow acidified silver nitrate **(1)** Yellow precipitate / solid ALLOW yellow suspension **(1)** Second mark depends on first mark (use of silver nitrate)	 Pale yellow precipitate	**2**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iv)	(precipitate) does not dissolve / **(**precipitate) is insoluble/ (precipitate) becomes paler in colour ALLOW "no change / no reaction" ALLOW mark for insoluble even if wrong reagent is used in (a)(iii) to form a **precipitate** regardless of colour Mark can only be given if there is a **precipitate** in (a)(iii)	Grey solid	**1**

Question Number	Acceptable Answers	Reject	Mark
1(a)(v)	KI Consequential on cation other than K^+ in (a)(i) ALLOW K^+I^-	Just potassium iodide Formula based on cation with incorrect charge or anion other than iodide	**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	calcium (ions) / Ca^{2+} ALLOW +2 for 2+	Ca / incorrect formula Name with incorrect formula e.g. "Calcium, Ca"	**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	Dissolved / disappeared **(1)** Limewater /calcium hydroxide (solution) /$Ca(OH)_2$ ((aq)) **(1)**	Melted	**2**

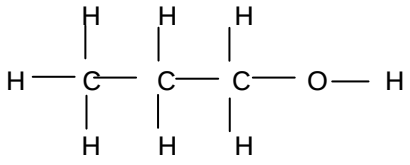
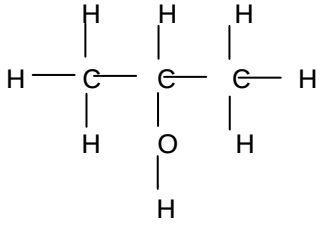
Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	$CaCO_3$ ALLOW $Ca(HCO_3)_2$ TE on incorrect metal ion in b(i) if correct formula given e.g $SrCO_3$, Na_2CO_3	Name Formula based on cation with incorrect charge e.g Ca_2CO_3 or anion other than carbonate or hydrogencarbonate	**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(i)	No double bonds between C atoms /C=C absent/not an alkene / **Z** is saturated / only single bonds between C atoms ALLOW not an alkene or alkyne	Just "no double bonds" Just "single bond(s)" alkane or any other functional group stated even if alcohol	**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	Alcohol / (−)OH / ROH / hydrox**yl** group present ALLOW (−)COH	OH^- / hydroxide for hydroxyl CHO carboxylic acid Phenol	**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)(iii)	Primary / 1 ° alcohol **(1)** Secondary / 2 ° alcohol **(1)** ALLOW **Not** a tertiary alcohol for one mark ALLOW propan-1-ol **(1)** propan-2-ol **(1)**	Just "alcohol" Tertiary alcohols Other specific examples Alcohol and carboxylic acid	**2**

Question Number	Acceptable Answers	Reject	Mark
1(d)(i)	<table><tr><td>C 60.0 ÷ 12</td><td>= 5.0</td><td>3</td></tr><tr><td>H 13.3 ÷ 1</td><td>= 13.3</td><td>8</td></tr><tr><td>O 26.7 ÷ 16</td><td>= 1.67</td><td>1</td></tr></table> Ratio 5.0 : 13.3 : 1.67 **(1)** C_3H_8O **(1)** Correct answer without working scores 2 Correct answer with incorrect working (eg mole calculations inverted) scores 1 No TE on incorrect ratios	 C_3H_7OH	**2**

Question Number	Acceptable Answers	Reject	Mark
1(d)(ii)	 **(1)**  **(1)** ALLOW –OH for the hydroxyl group, but bond should go from C to O in propan-1-ol. IGNORE poorly placed OH in propan-2-ol. ALLOW skeletal formulae / structural formulae both correct – 1 mark ALLOW TE from 1(d)(i), e.g. if a different number of carbon atoms is given in 1di then allow 2 different isomers drawn displayed correctly	C-H-O C_3H_7OH	**2**

Total for Question 1 = 18 Marks

Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$ First mark for correct species in a balanced equation ALLOW hexaqua ions providing the equation is balanced IGNORE reversible arrows **(1)** Second mark for states Consequential on a reasonable attempt at the equation, including for a full equation or unbalanced equation E.g. ALLOW as reasonable Zn with one+ instead of 2+ Sulfate ions shown correctly but not cancelled out **(1)**	Sulfate ions not cancelled out Reversed equation Zn and Cu metal both shown as ions	**2**

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	q = 50.0 x 4.18 x 46.5 **(1)** = 9718.5 (J) /9.7185 **kJ** **(1)** Correct answer with no working scores (2) IGNORE s.f. except 1 (ie allow 9719 / 9720 / 9700 or 9.719 / 9.72 / 9.7 **kJ**) IGNORE sign of q if given If mass used 55.0g and q = 55.0 x 4.18 x 46.5 = 10690.35 (J) scores (1) If mass used is 5g and q = 5 x 4.18 x 46.5 = 971.85(J) scores (1)	9718	**2**

Question Number	Acceptable Answers	Reject	Mark
2(a)(iii)	$\frac{50.0 \times 1}{1000}$ = 0.05 (mol) Mark is for final answer		**1**

Question Number	Acceptable Answers	Reject	Mark
2(a)(iv)	ΔH = − 9718.5 ÷ (0.050 x 1000) = -194.370 (kJ mol^{-1}) = **− 194** (kJ mol^{-1}) ALLOW = − 194000 **J mol^{-1}** First mark Value, ignore sign and sf Only penalise units if value is in J (mol $^{-1}$) without stating this **(1)** TE (a)(ii) ÷ ((a)(iii) x 1000) Using 10690.5 gives -2138810J = **-214** kJ mol^{-1} Second mark Sign and 3 s.f. **(1)** **This mark depends on a correct calculation method**		**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	47.5 (^{o}C)		**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	(1.0 x 100) ÷ 46.5 = 2.1505376 = (±) **2.15 / 2.2 / 2** (%) IGNORE sf ALLOW answer with 47.5 in the denominator which gives 2.1052631 = (±) **2.11 / 2.1 / 2** (%) ALLOW TE on value (b)(i)	2.0 and 2.1 2.0 and 2.2	**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)	**First mark** Measure the temperature (of copper(II) sulfate) every minute / at realistic time interval (15 s to 1 minute) for e.g. 2 – 4 minutes before adding zinc OR measure temperature (of copper(II) sulfate) before adding zinc **(1)** **Second mark** Measure temperature each minute / at realistic time intervals (after adding zinc) for several minutes **(1)** **Note** These readings may be started after the maximum temperature is reached / after reaction has stopped and taken until the mixture has cooled to room temperature. Intervals should be chosen to allow at least 4 readings on cooling section of curve. **Third mark** Plot a temperature - time graph / plot a graph using measurements (of temp and time) obtained **(1)** This mark can be awarded if first two marks are insufficient for credit **Fourth mark** **Extrapolate** to find ΔT / maximum temperature (at the time of mixing) **OR** Use properly described intersecting lines to find maximum temperature **(1)** Allow third and fourth marking points to be shown on annotated diagrams / graph **If zinc is added in small portions or over a period of time only first and third marks can be awarded** (Since measurements of cooling will be incorrect and there is no definite time when reaction starts)	Readings more often than every 15s	**4**

Total for Question 2 = 13 Marks

Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	Any two from Misty /steamy fumes **(1)** Purple / violet fumes **(1)** ALLOW purple gas / vapour Brown or black solution/ liquid /solid OR grey / grey-black solid **(1)** Yellow solid / deposit ALLOW yellow precipitate **(1)** IGNORE effervescence, bubbles, colour change, coloured fumes, solid disappears, description of smells, identification of products even if incorrect, follow-on tests e.g. effect on potassium dichromate paper	White fumes Steamy white Smoke Yellow fumes Yellow liquid	**2**

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	There is little / no HI formed (which is the reagent needed) **(1)** Because HI is **oxidized** (to iodine)/ because iodide ions are **oxidized** (to iodine)/sulfuric acid is oxidizing / HI **reduces** sulfuric acid / iodide ions **reduce** sulfuric acid **(1)** Must mention oxidation or reduction correctly for second mark IGNORE "an elimination reaction would occur" ALLOW "HI is oxidized to iodine" for both marks	Iodide **ions** react with sulfuric acid sulfuric acid oxidizes **iodine** HI is **reduced** to iodine	**2**

Question Number	Acceptable Answers	Reject	Mark
3(b)	$2P + 3I_2 \rightarrow 2PI_3$ OR $P + 3 / 2\ I_2 \rightarrow PI_3$ OR $P_4 + 6I_2 \rightarrow 4PI_3$ ALLOW reversible sign IGNORE state symbols even if incorrect	Equations with ions I for I_2	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	Exothermic ALLOW fast / vigorous / violent	Dangerous Reactive (In)flammable Volatile	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	(very) pale purple / yellow / straw coloured OR colourless mixture / is decolourised OR no purple colour	clear for colourless no (grey) solid remains add starch	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	Diagram to show: Distillation flask and still-head and heat **(1)** (no need for a thermometer) ALLOW appropriate tubing as alternative to still head ALLOW heating with electrical, water bath, Bunsen or just arrow IGNORE thermometer and position, tap funnel in still head, absence of reagents in flask Condenser sloping downwards **(1)** With water entering at the bottom and suitable receiver (e.g. flask or beaker) **(1)**	Conical flask	**3**

Question Number	Acceptable Answers	Reject	Mark
3(c)(iv)	This removes / reacts with (any residual) iodine OR Removes excess iodine / I_3^-	Removes acid Removes impurities Removes iodide Removes ions (other than I_3^-) Just reduces iodine to iodide	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(v)	Anhydrous calcium chloride / it is drying agent OR anhydrous salt needed to remove water/hydrated salt will not remove water Allow moisture for water and absorb for remove	Just "calcium chloride is a drying agent"	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(vi)	Distillation / re-distillation (over a narrow range of temperature) (either side of the boiling temperature of 1-iodobutane) ALLOW fractional distillation IGNORE filtering before distillation and any temperatures given	Recrystallization Just "purification"	**1**

Question Number	Acceptable Answers	Reject	Mark
3(d)(i)	(95.0 ÷ 74.0) x 92.5 g **(1)** = 118.75 / 118.8/ 119 g **(1)** ALLOW 118.77 (from use of 1.284) 3, 4 or 5 sf in final answer Correct final answer scores 2 marks OR Rounding errors by dividing 95.0 ÷ 74.0 as a first step e.g. (95.0 ÷ 74.0)=1.28, followed by 1.28 x 92.5 = 118.4 /118 **(1)** e.g. (95.0 ÷ 74.0)=1.3 followed by 1.3 x 92.5 =120.25 /120.3/120 **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3d(ii)	95.3 ÷ 3(d)(i) (95.3 ÷ 118.75) x 100 = 80.2563 = **80.25/80.3** % Many candidates give the answer to 3 d(i) to 3sf e.g. 119 but keep the full answer in their calculator resulting in a answer of 80.25 which is correct and should be allowed TE from 3(d)(i)	80.2	**1**

Question Number	Acceptable Answers	Reject	Mark
3d(iii)	**One** of: Handling / transfer losses competing reactions / (unwanted) side reaction / byproducts form incomplete reaction	Just "losses"/spillage Impure reagents Loss by evaporation Other products form Not enough PCl_5 to react	**1**

Question Number	Acceptable Answers	Reject	Mark
3d(iv)	**Two** of: • low atom economy Ignore "low percentage / 80% yield" • phosphorus(V) chloride expensive • disposal of unwanted materials expensive or difficult • no (large scale) use for $POCl_3$ • difficult/expensive to separate required product No credit for Slow / time consuming Exothermic Not efficient High energy use Competing reactions Non renewable reactants HCl toxic / acidic Unwanted product**s**	Just "Atom economy not 100%" Just "It" would be expensive Anything to do with environmental friendliness or the ozone layer or the end of life on Earth!	**2**

Total for Question 3 = 19 Marks

Total for paper = 50 Marks

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Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Tuesday 7 January 2014 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/6/2/2/3/

P 4 2 9 7 4 R A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A series of tests was carried out on **X**, a white solid, which is known to contain one cation and one anion.

(a) **X** gave a pale green colour in a flame test. Give the name or formula of the cation in **X**.

(1)

.....

(b) When dilute nitric acid was added to a sample of solid **X**, no reaction occurred. Suggest the name or formula of an anion that could **not** be present in **X**.

(1)

.....

(c) Dilute nitric acid was added to an aqueous solution of **X**, and then aqueous silver nitrate was added to the mixture. A white precipitate formed, which dissolved in dilute aqueous ammonia.

Give the name or formula of the anion in **X**.

(1)

.....

(d) A sample of the white precipitate in (c) was left to stand in sunlight.

(i) What colour change would be seen?

(1)

.....

(ii) Name the substance responsible for the new colour that appeared in (d)(i).

(1)

.....

(e) **Dilute** sulfuric acid was added to an aqueous solution of **X**.

(i) What change would be observed?

(1)

.....

(ii) Write an equation for the reaction in (e)(i). Include state symbols.

(2)

(f) (i) A few drops of **concentrated** sulfuric acid were added to a small portion of **solid X** in a test tube. Misty fumes, but no other vapours, were seen.

Identify these fumes by name or formula.

(1)

.....

(ii) Describe a further **chemical** test to confirm the identity of the gas responsible for the misty fumes.

Give the expected result of the test.

(2)

Test .....

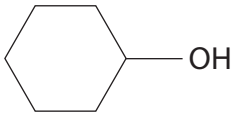
.....

Result .....

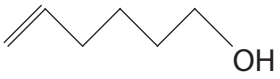
.....

(Total for Question 1 = 11 marks)

2 The skeletal formulae of two compounds with molecular formula $C_6H_{12}O$ are shown below.



cyclohexanol



hex-5-en-1-ol

(a) Each of the compounds reacts when warmed with a mixture of potassium dichromate(VI) and sulfuric acid.

(i) What colour change is seen during this reaction?

(1)

From ..... to .....

(ii) One of the compounds forms a carboxylic acid when it is heated under reflux with a mixture of potassium dichromate(VI) and sulfuric acid.

Give the **structural** formula of this carboxylic acid.

(1)

(b) Under suitable conditions, each of the compounds reacts slowly with a small piece of sodium to form a sodium salt and one other product. Give **two** observations you would make when this reaction occurs.

(2)

Observation 1 .....

.....

Observation 2 .....

.....

(c) Hex-5-en-1-ol can be distinguished from cyclohexanol by its reaction with aqueous bromine.

(i) What colour change would be seen in this reaction when hex-5-en-1-ol is used?

(1)

From ..... to .....

(ii) Complete the skeletal formula below to show the product of this reaction.

(1)



(d) Hex-5-en-1-ol reacts with acidified potassium manganate(VII) at room temperature.

(i) What colour change would be seen in this reaction?

(1)

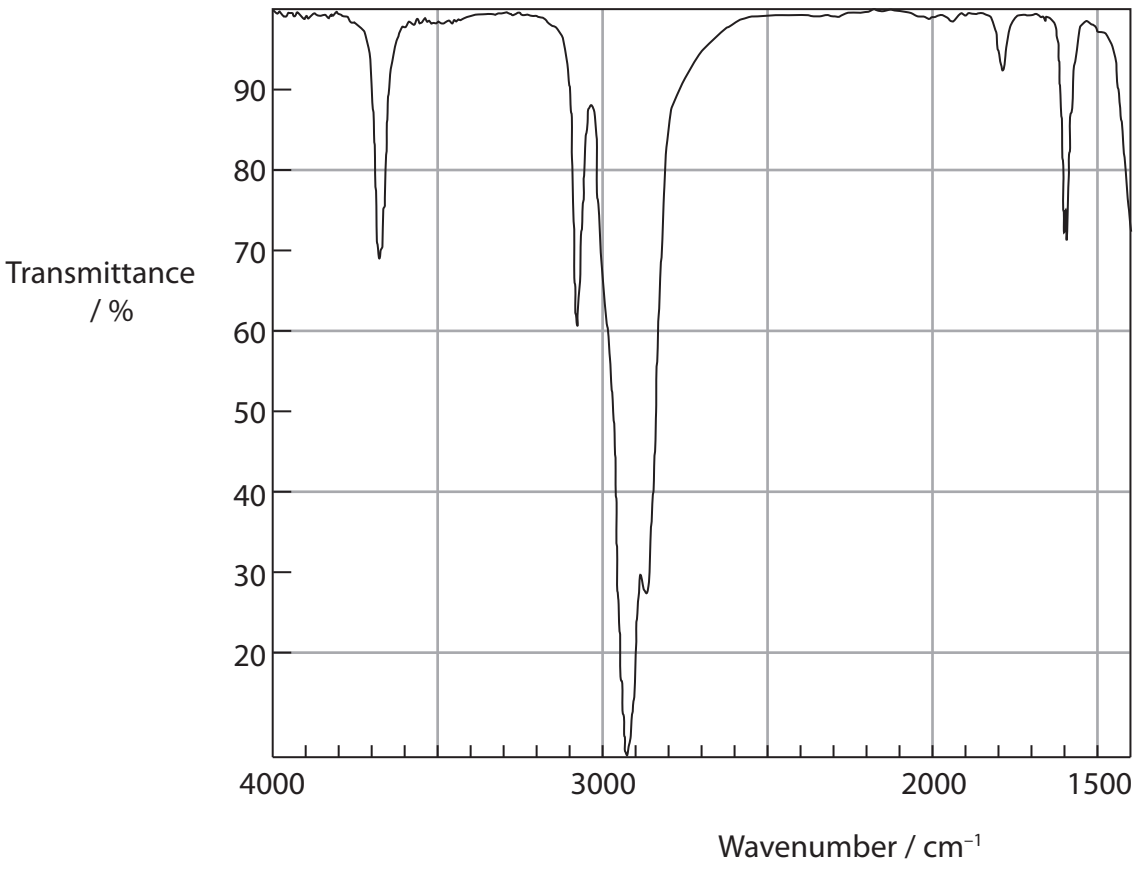
From ..... to .....

(ii) Complete the skeletal formula below to show the product of this reaction.

(1)



(e) The infrared spectrum below is for either cyclohexanol or hex-5-en-1-ol.



For which of the two compounds is this the infrared spectrum? Use **two** pieces of data from the table below to justify your answer.

Bond	Wavenumber / cm^{-1}
C—H stretch, alkane	2962–2853
C—H stretch, alkene	3100–3010
C═C stretch, alkene	1669–1600
O—H stretch, alcohols	3750–3200

(2)

Spectrum is for .....

Justification: .....

.....

.....

(Total for Question 2 = 10 marks)

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3 The mass of magnesium hydroxide, $Mg(OH)_2$, in an indigestion tablet was determined as follows:

Step 1 The tablet was crushed and dissolved in exactly 40.00 cm^3 of dilute hydrochloric acid (an excess).

Step 2 The amount of hydrochloric acid remaining was measured by titration with 0.250 mol dm^{-3} sodium hydroxide solution.

22.80 cm^3 of this sodium hydroxide solution was required.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

(a) (i) A student suggested using Universal Indicator for the titration. Why would this indicator be unsuitable?

(1)

.....

.....

(ii) Suggest a suitable indicator and give its colours in acidic and alkaline solutions.

(2)

Indicator .....

Colour in acid .....

Colour in alkali .....

(b) (i) Calculate the number of moles of sodium hydroxide used in the titration.

(1)

(ii) Hence state the number of moles of hydrochloric acid that react with the sodium hydroxide in (b)(i).

(1)

(iii) The amount of acid added to the tablet in **Step1** was 2.00×10^{-2} mol. Use this information and your answer to (b)(ii) to calculate the number of moles of hydrochloric acid that reacted with the tablet.

(1)

(iv) The equation for the reaction of the magnesium hydroxide in the tablet with hydrochloric acid is shown below.

$$Mg(OH)_2(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + 2H_2O(l)$$

Calculate the mass of magnesium hydroxide in the tablet. Give your answer to **three** significant figures.

The molar mass of magnesium hydroxide is 58.3 g mol^{-1}.

(2)

(c) The volume of hydrochloric acid added to the tablet was 40.00 cm^3.

(i) Suggest a change in the procedure which would make the result of the experiment **more reliable** for each tablet which is analysed.

(1)

.....

.....

.....

.....

(ii) The hydrochloric acid was measured using a burette. Each time the burette was read, the error was ± 0.05 cm^3. Calculate the total percentage error in measuring 40.00 cm^3 of hydrochloric acid.

(2)

(d) When an indigestion tablet reacts with hydrochloric acid in the stomach, it is important that the reaction is not too exothermic.

The enthalpy change of this reaction can be determined by reacting magnesium hydroxide with an excess of hydrochloric acid in an insulated container and measuring the maximum temperature change.

State **two** ways, other than improvements in insulation or use of more accurate measuring instruments, which would ensure that the measured temperature change was the **maximum** possible for the amounts of reactants used.

(2)

1 .....

.....

.....

2 .....

.....

.....

(Total for Question 3 = 13 marks)

4 Cyclohexene, C_6H_{10}, can be prepared from cyclohexanol, $C_6H_{11}OH$, using the procedure below.

Step 1 Place 0.100 mol of cyclohexanol in a flask and add about 4 cm^3 of concentrated phosphoric(V) acid, drop by drop, while shaking the flask.

Step 2 Assemble the flask for distillation, and collect the liquid which distils over between 70 °C and 90 °C.

Step 3 Add the distillate to an equal volume of a saturated solution of sodium chloride. Shake the mixture, allow the layers to separate, and discard the aqueous (sodium chloride) layer.

Step 4 Transfer the layer containing cyclohexene into a small flask. Add a few pieces of a solid drying agent to the crude cyclohexene, stopper the flask and shake it for a few minutes.

Step 5 Decant the crude liquid alkene and carry out a final purification in order to obtain pure cyclohexene.

(a) (i) Use the formulae of the reactant and product to deduce the role of phosphoric(V) acid in this reaction.

(1)

.....

(ii) Suggest the main hazard when using concentrated phosphoric(V) acid in this preparation.

Give **one** precaution which should be taken when using it, other than the use of safety goggles and a laboratory coat.

(2)

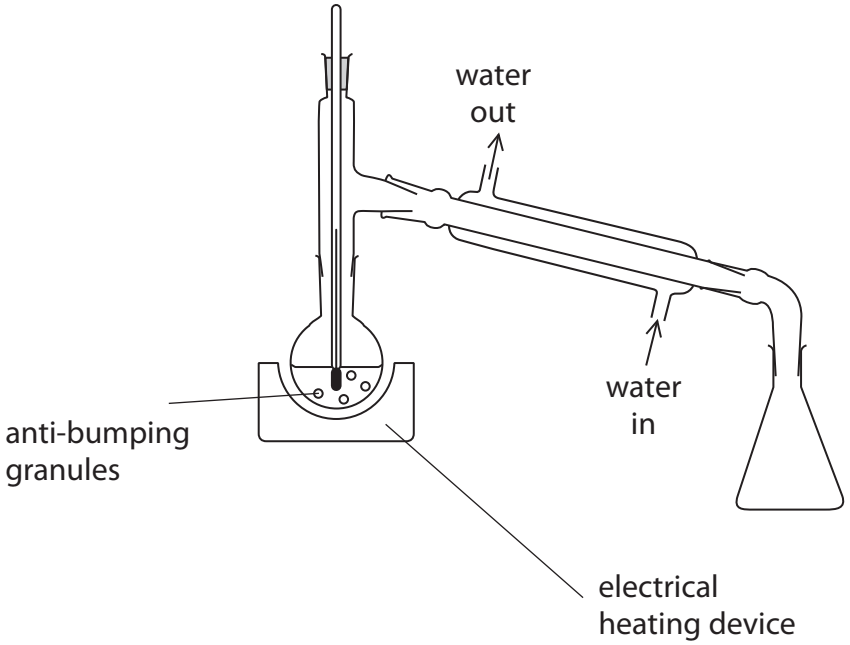
Hazard .....

Precaution .....

(b) A student suggested using the apparatus shown in the diagram below to carry out **Step 2**.

Describe **two** ways in which this apparatus must be modified for safe and efficient use in **Step 2**. Assume the apparatus is suitably clamped.

(2)



1 .....

.....

2 .....

.....

(c) (i) Cyclohexene can be separated from other products in **Step 3** because it is insoluble in aqueous solutions.

Explain this lack of solubility.

(2)

.....

.....

.....

.....

.....

.....

(ii) Draw a diagram of the apparatus which should be used in **Step 3**.

Label the cyclohexene layer.

Data

Substance	Density / g cm^{-3}
Cyclohexene	0.81
Saturated sodium chloride solution	1.20

(2)

(d) (i) Suggest a suitable solid drying agent to use in **Step 4**.

(1)

.....

(ii) What change would you see in the appearance of the organic liquid when it is dried in **Step 4**?

(1)

.....

.....

(e) Suggest a method for the final purification of the crude cyclohexene in **Step 5**.

(1)

.....

(f) (i) Calculate the volume of 0.100 mol of cyclohexanol, $C_6H_{11}OH$.

The density of cyclohexanol is 0.962 g cm^{-3}.

(2)

(ii) After final purification, the yield of cyclohexene was 5.50 g.

Calculate the percentage yield in this reaction. Each mole of cyclohexanol can give a maximum yield of one mole of cyclohexene.

(2)

(Total for Question 4 = 16 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 7 4 R A 0 1 6 1 6

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Mark Scheme (Results)

January 2014

IAL Chemistry (WCH03/01)

Unit 3: Chemistry Laboratory Skills I

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable answers	Reject	Mark
1(a)	Ba^{2+} / barium (ion) If charge is given must be correct ALLOW Ba^{+2}	Ba Ba^{+} Cu^{2+} Correct name with incorrect formula or vice versa	**1**

Question Number	Acceptable answers	Reject	Mark
1(b)	Carbonate / CO_3^{2-} ALLOW Hydrogencarbonate / HCO_3^-/ sulfite / sulfate (IV) /SO_3^{2-} /hydroxide / OH^- / oxide/ O^{2-}	Barium carbonate sulfate	**1**

Question Number	Acceptable answers	Reject	Mark
1(c)	Cl^- / chloride (ion) ALLOW Cl^{-1}, Cl^{1-}	Cl, Cl_2, Chlorine (ion) Correct name with incorrect formula or vice versa	**1**

Question Number	Acceptable answers	Reject	Mark
1(d)(i)	(The white precipitate goes) darker / purple / grey / lilac	(Goes) black, silver, silvery, cream, pale yellow, green	**1**

Question Number	Acceptable answers	Reject	Mark
1(d)(ii)	Silver ALLOW Ag	 Ag^+	**1**

Question Number	Acceptable answers	Reject	Mark
1(e)(i)	White precipitate ALLOW White solid Both words needed	Just “goes white”	**1**

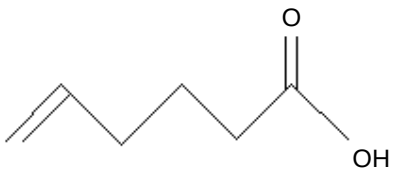
Question Number	Acceptable answers	Reject	Mark
1(e)(ii)	$BaCl_2(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2HCl(aq)$ OR $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$ OR $Ba^{2+}(aq) + 2Cl^-(aq) + 2H^+(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s) + 2Cl^-(aq) + 2H^+(aq)$ **First mark** All formulae correct (**1**) TE from the cation in 1(a) and the anion in 1(c) if the charge on the ion chosen is correct eg Cu^{2+} **Second mark** Balancing and state symbols (**1**) ALLOW second mark for ss and balancing in equation with mixture of ions and molecules $Ba^{2+}(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H^+(aq)$ scores 1 TE for second mark based on incorrect formulae only if a balanced equation forming a precipitate is given eg $2BaCl(aq) + H_2SO_4(aq) \rightarrow Ba_2SO_4(s) + 2HCl(aq)$ scores 1 No TE for equations with incorrect products e.g. H_2 and Cl_2	Any incorrect formulae For first mark, equation with mixture of ions and molecules eg $Ba^{2+}(aq) + H_2SO_4(aq) \rightarrow BaSO_4(s) + 2H^+(aq)$ $HCl(g)$ Equations in which hydrogen or sulfur dioxide is formed	**2**

Question Number	Acceptable answers	Reject	Mark
1(f)(i)	HCl / hydrogen chloride ALLOW (Droplets of) hydrochloric acid	Hydrogen chloride ions Hydrochloric acid gas	**1**

Question Number	Acceptable answers	Reject	Mark
1(f)(ii)	(mix gas being tested with) ammonia / hold open ammonia bottle near fumes (**1**) ALLOW (test with) ammonia (gas) Use of ammonia solution if clearly on a glass rod / stopper White smoke / white solid forms (**1**) Allow **dense white** fumes, **white** precipitate No TE if gas in (f)(i) is not HCl No TE in second mark if test given for first mark is incorrect	Dissolve in water and test with silver nitrate Indicators Misty / smoky fumes Just "White fumes"	**2**

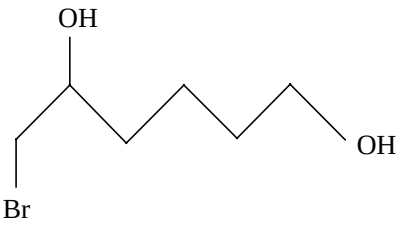
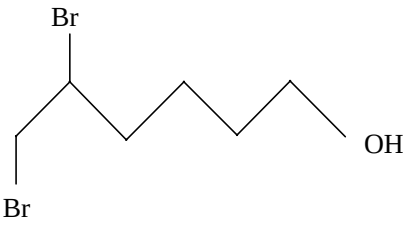
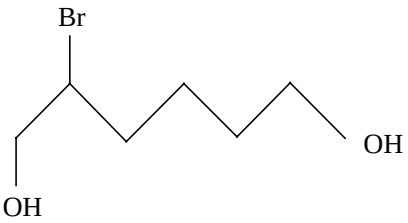
Total for Question 1 = 11 marks

Question Number	Acceptable answers	Reject	Mark
2(a)(i)	Orange to green / blue / brown ALLOW Dark green / green-brown	Combinations of blue and green Green to orange	**1**

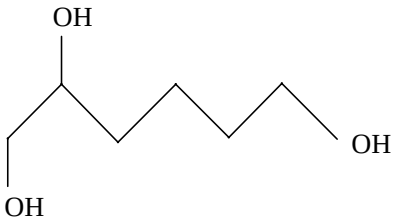
Question Number	Acceptable answers	Reject	Mark
2(a)(ii)	$CH_2=CH(CH_2)_3COOH$ Double bond need not be shown ALLOW CO_2H for COOH ALLOW  ALLOW displayed formula	$C_6H_{10}O_2$ Formulae not showing H atoms	**1**

Question Number	Acceptable answers	Reject	Mark
2(b)	Any TWO of Bubbles / effervescence / fizzing Sodium dissolves / disappears **White** residue / solid / ALLOW **White** precipitate ALLOW Rise in temperature / gets hotter / heat is given out IGNORE Moves / Floats / Sinks / Catches fire / Hydrogen given off	 Just "Gas forms" Bubbles form if incorrect gas identified. White solid dissolves Crystals form Just "exothermic"	**2**

Question Number	Acceptable answers	Reject	Mark
2(c)(i)	Brown / red-brown / orange / yellow / combinations of these colours to colourless	Red to colourless Clear for colourless Paler for colourless White for colourless	**1**

Question Number	Acceptable answers	Reject	Mark
2(c)(ii)	 ALLOW  ALLOW  IGNORE orientation of Br and OH, eg both Br pointing down IGNORE lengths of bonds Check that there are **6C** in formula	Br at left hand end without a bond to it	**1**

Question Number	Acceptable answers	Reject	Mark
2(d)(i)	Purple / pink to colourless ALLOW For purple pink: pinkish-purple, dark purple For colourless: brown	Clear for colourless White for colourless Green / orange for colourless Lilac for purple	**1**

Question Number	Acceptable answers	Reject	Mark
2(d)(ii)	 IGNORE orientation of OH, eg both OH pointing down IGNORE lengths of bonds Check that there are **6C** in formula	OH at left hand end without a bond to it Bond to H of OH group	**1**

Question Number	Acceptable answers	Reject	Mark
2(e)	hex-5-en-1-ol Alkene/ C=C at 1669 – 1600 (cm^{-1}) (alkene) C-H at 3100-3010 (cm^{-1}) Correct identification **and** one correct piece of evidence (**1**) Correct identification with two pieces of evidence (**2**) Correct identification and correct bonds quoted without any data can score 1.		**2**

Total for Question 2 = 10 marks

Question Number	Acceptable answers	Reject	Mark
3(a)(i)	No sharp colour change / colour change gradual / difficult to see end-point/ end-point not clear / end-point not obvious / no specific colour change at end-point / colour change hard to distinguish many different colours during the vertical section of a pH curve	Colour changes slowly Does not give accurate results No significant colour change end-point not visible Colour does not change in vertical section of pH curve Forms various colours with acid and alkali Comments about suitability for weak/ strong acids	**1**

Question Number	Acceptable answers	Reject	Mark
3(a)(ii)	Suitable acid-base indicator (**1**) correct colours (**1**) Likely answers: methyl orange (**1**) red in acid, yellow in alkali (**1**) Phenolphthalein (**1**) colourless in acid, pink / purple / red in alkali (**1**) ALLOW Bromothymol blue (**1**) Yellow in acid, blue in alkali (**1**) No TE on colours for litmus Second mark depends on first	Litmus Orange for red Spelling is not a reasonable match for pronunciation	**2**

Question Number	Acceptable answers	Reject	Mark
3(b)(i)	$\frac{(22.80 \times 0.250)}{1000}$ = 5.70×10^{-3}/ 5.7×10^{-3} / 0.0057	6×10^{-3}	**1**

Question Number	Acceptable answers	Reject	Mark
3(b)(ii)	5.70×10^{-3} / 5.7×10^{-3} / 0.0057 TE: Same as 3b(i)		**1**

Question Number	Acceptable answers	Reject	Mark
3(b)(iii)	$(2.00 \times 10^{-2} - 5.70 \times 10^{-3})$ $=1.43 \times 10^{-2}$ / 14.30×10^{-3} / 0.0143 TE 2.00×10^{-2} – answer from 3b(ii) IGNORE SF except 1	Numbers obtained without having done a subtraction	**1**

Question Number	Acceptable answers	Reject	Mark
3(b)(iv)	Mol $Mg(OH)_2$ = answer to 3b(iii) /2 (**1**) $=7.15 \times 10^{-3}$ /0.00715 mass = 58.3 x number of mol =0.416845 =0.417 (g) (**1**) TE for second mark based on number of moles calculated for first mark. ALLOW use of 58 instead of 58.3 (giving 0.415(g)) Correct answer with no working scores 2	Answers with more or less than 3 significant figures	**2**

Question Number	Acceptable answers	Reject	Mark
3(c)(i)	Split sample into two / several portions (so that titration can be repeated) OR make solution to a standard volume (e.g. 100cm^3) and take measured aliquots	Just "repeat the titration" Just " use more concentrated acid " or "Use more acid". Use more accurate burettes / pipettes / balance	**1**

Question Number	Acceptable answers	Reject	Mark
3(c)(ii)	$\frac{100 \times (2 \times 0.05)}{40.00}$ = (±) 0.250/ 0.25% Doubling error in each reading (**1**) Final answer (**1**) 0.125%/ 0.13% scores 1 mark	0.3/ 0.30% 0.12, 0.1	**2**

Question Number	Acceptable answers	Reject	Mark
3(d)	Any two from Use (finely) powdered magnesium hydroxide Use moderately concentrated acid / acid which is not very dilute/ acid of higher concentration / keep excess acid to minimum possible volume. Ensure good mixing / stir mixture ALLOW Measure temperature before adding magnesium hydroxide and for some time after; plot temperatures against time and extrapolate (cooling) line (to where reagents are mixed, to allow for cooling) IGNORE Put a lid on the container/ other comments on insulation	 Break magnesium hydroxide into smaller pieces Use a more accurate thermometer Just "plot temperatures against time and extrapolating"	**2**

Total for Question 3 = 13 marks

Question Number	Acceptable answers	Reject	Mark
4(a)(i)	Dehydrating agent / dehydration/ removes (elements of) water / removes H_2O / eliminates water / eliminates H and OH IGNORE reference to catalyst	Drying agent Just elimination	**1**

Question Number	Acceptable answers	Reject	Mark
4(a)(ii)	Corrosive / burns skin (**1**) Wear gloves (**1**) Second mark depends on first being corrosive **or** harms skin **or** irritant	Just "harms skin" Toxic Use tongs Avoid spillage Use fume cupboard	**2**

Question Number	Acceptable answers	Reject	Mark
4(b)	**First mark** Apparatus should not be completely sealed / put vent in apparatus / leave gap between condenser and receiving flask / insert gas outlet / use receiving flask with opening (**1**) ALLOW "Open end of apparatus for pressure release" **Second mark** Move (bulb of) thermometer to opposite opening to condenser (**1**) These points may be shown on diagram.	Just "Move thermometer up"/ "position in neck of flask" / "position in mouth of flask"	**2**

Question Number	Acceptable answers	Reject	Mark
4(c)(i)	EITHER Cyclohexene only forms London forces / cyclohexene only forms van der Waals forces / cyclohexene can only form weak forces / cyclohexene is non-polar AND water is polar (**1**) Hydrogen bonds would be broken if cyclohexene mixed with water / cyclohexene cannot form hydrogen bonds with water / cyclohexene cannot replace hydrogen bonds with a strong bond / cyclohexene cannot form bonds with water of comparable strength (to original ones) (**1**) OR (alternative approach) Hydrogen bonds would be broken if cyclohexene mixes with water (**1**) Only weaker London forces would replace them (**1**) IGNORE comments on ionic bonding in sodium chloride	Just "cyclohexene is non-polar" Cyclohexene forms permanent dipole-dipole forces Just "there are hydrogen bonds in water"	**2**

Question Number	Acceptable answers	Reject	Mark
4(c)(ii)	Separating funnel with tap (and stopper) ALLOW Any shaped tube with opening at top which can be stoppered and tap at bottom (**1**) Cyclohexene in upper layer (**1**) Don't penalise if labelled cyclohex**ane**, not –ene. Mark independently	Filter funnel Buchner funnel Very large opening at the top of the funnel. 3 layers	**2**

Question Number	Acceptable answers	Reject	Mark
4(d)(i)	(anhydrous) calcium chloride / $CaCl_2$ / magnesium sulfate / $MgSO_4$ / sodium sulphate / Na_2SO_4 ALLOW silica gel	Other compounds, even if anhydrous Incorrect formulae (concentrated) sulfuric acid	**1**

Question Number	Acceptable answers	Reject	Mark
4(d)(ii)	(cloudy) liquid would go clear/ liquid becomes less cloudy	Volume decreases Water layer disappears Viscosity changes	**1**

Question Number	Acceptable answers	Reject	Mark
4(e)	(re)distillation (collecting liquid close to its boiling point) ALLOW Simple distillation Fractional distillation Correct description of process	collecting liquid more than 5° from its boiling point) Filtering	**1**

Question Number	Acceptable answers	Reject	Mark
4(f)(i)	Mass cyclohexanol = (0.100 x 100) = 10.0/ 10 g (**1**) Volume = $\frac{10.0}{0.962}$ = 10.395 / 10.40/ 10.4 (cm^3) (**1**) Second mark TE from mass of cyclohexanol calculated	10/ 10.39(cm^3)	**2**

Question Number	Acceptable answers	Reject	Mark
4(f)(ii)	EITHER Max yield = (0.100 x 82) = 8.20/ 8.2g (**1**) % yield = $\frac{(5.50 \times 100)}{8.20}$ = 67.073/ 67.1/ 67% (**1**) Second mark TE from mass of cyclohexene, but NOT if max yield = 10.4 or 10 (ie from volume of cyclohexanol or molar mass of cyclohexanol). OR Mol cyclohexene = $\frac{5.5}{82}$ = 0.067073 (**1**) Ignore sf except 1 sf % yield = $\frac{(0.067073 \times 100)}{0.1}$ = 67.073/ 67.1/ 67% (**1**) Correct answer with no working scores 2 Use of 84 as molar mass cyclohexene scores max 1 Ignore SF except 1	0 overall if yield greater than 100%	**2**

Total for Question 4 = 16 marks

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Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Wednesday 7 May 2014 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/6/

P 4 2 9 8 0 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A series of tests was carried out on **A**, a white powder. **A** is known to contain one cation and one anion. Complete the table below. You may use names or formulae in your answers.

	Test	Observation	Inference
(a)	Carry out a flame test on **A**.	.....	Cation is calcium. (1)
(b)	Add a few drops of dilute nitric acid to an aqueous solution of **A**, followed by aqueous silver nitrate.	.....	Anion is probably iodide.
	Then add concentrated aqueous ammonia solution.	.....	This confirms the anion is iodide. (2)
(c)	Add an aqueous solution of chlorine to an aqueous solution of **A**.	The colour of the resulting solution is	The colour is due to the formation of ..... (2)
(d)	Add an aqueous solution of starch to the mixture formed in (c).	The colour of the resulting mixture is	This confirms the inference made in (c). (1)
(e)	Add a solution of sodium carbonate to an aqueous solution of **A**.	A white precipitate forms.	The precipitate is .....
	If there is no further change, add dilute hydrochloric acid to the mixture.	The precipitate dissolves in the acid and bubbles of gas are seen.	The gas is ..... (2)

Exemplar

(f) When **concentrated** sulfuric acid is added to a **solid** sample of **A**, there is a vigorous redox reaction.

(i) Identify, by name or formula, the product formed by the oxidation of the iodide ion in this reaction. Describe the appearance of this product.

(2)

Product .....

Appearance .....

(ii) Identify, by name or formula, one product formed when the concentrated sulfuric acid is reduced. Describe an observation you could make that shows this product has formed.

(2)

Product .....

Observation .....

.....

(Total for Question 1 = 12 marks)

Exemplar

2 This question concerns the analysis of an organic compound.

(a) (i) How can the relative molecular mass of a compound be found from its mass spectrum?

(1)

.....

.....

(ii) The general formula of an alcohol can be written ROH, where R is an alkyl group.

The relative molecular mass of an alcohol **Q** is 88. The formula of the alkyl group may be represented as C_xH_y.

State the values of x and y.

(1)

x ..... y .....

(b) When **Q** was warmed with a mixture of sulfuric acid and aqueous potassium dichromate(VI), there was no colour change.

Deduce the displayed formula of alcohol **Q**.

(1)

Exemplar

(c) When a sample of **Q** was reacted with phosphorus(V) chloride, PCl_5, steamy fumes were seen.

(i) Identify these steamy fumes by name or formula.

(1)

.....

(ii) The steamy fumes were tested by reacting them with ammonia gas. A white smoke was seen.

Write an equation, including state symbols, for the reaction in which the white smoke was formed.

(2)

(d) One of the isomers of the alcohol **Q** is an ether. Ethers contain two alkyl groups linked by an oxygen atom and can be represented as R-O-R.

Explain how the information in an **infrared** spectrum would be used to decide whether the spectrum is produced by an alcohol or an ether. Wavenumber data are not required.

(1)

.....

.....

.....

.....

(Total for Question 2 = 7 marks)

Exemplar

3 (a) The concentrations of acids and alkalis can be found by titration using a suitable indicator.

Give the colours which are seen if the indicator phenolphthalein is used.

(2)

Colour in acid .....

Colour in alkali .....

(b) Another type of titration is a **thermometric** titration.

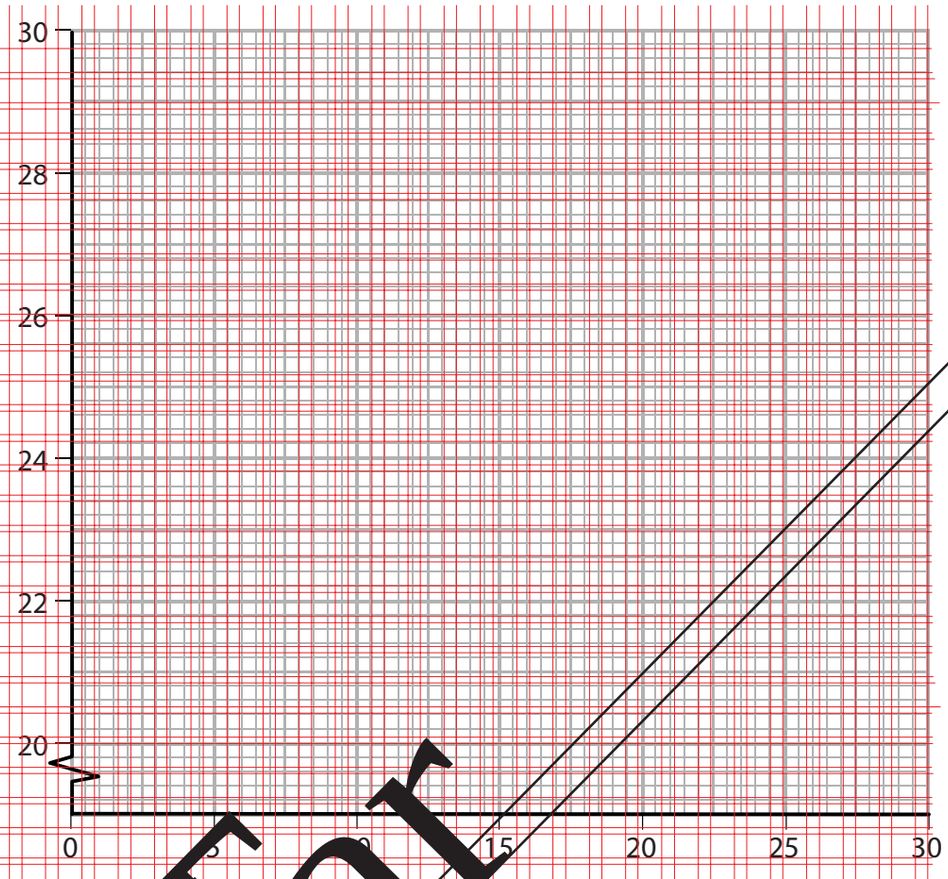
In a thermometric titration, 20.0 cm^3 of 1.50 mol dm^{-3} hydrochloric acid was placed in a well-insulated cup, and its temperature was measured. Portions of sodium hydroxide solution were added from a burette. The mixture was stirred continuously and the temperature measured after each addition.

Total volume of sodium hydroxide added /cm^3	0.00	5.00	10.00	15.00	20.00	25.00	30.00
Temperature / °C	20.4	22.8	25.[illegible]	28.0	27.2	24.1	20.8

On the axes opposite, plot a graph of temperature against the total volume of sodium hydroxide added. Draw two straight lines on your graph and extrapolate the lines until they intersect. Hence find the maximum temperature of the reaction mixture and the total volume of sodium hydroxide which just neutralized the hydrochloric acid.

(4)

Draft



Maximum temperature .....

Total volume of sodium hydroxide that just neutralized the hydrochloric acid.

.....

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P 4 2 9 8 0 A 0 7 1 6

(c) In an experiment using a **different** sample of sodium hydroxide solution, 20.0 cm^3 of 1.50 mol dm^{-3} hydrochloric acid was neutralized by 15.50 cm^3 of sodium hydroxide solution. The starting temperature was 20.4°C and the temperature at neutralization was 30.6°C.

(i) Calculate the energy, in joules, transferred when the acid is just neutralized.

$$\text{Energy transferred (J)} = \text{total mass of solution (g)} \times 4.18\ (\text{J g}^{-1}\,^{\circ}\text{C}^{-1}) \times \text{temperature rise (°C)}$$

Assume that the density of the solution is 1 g cm^{-3}.

(1)

(ii) The number of moles of hydrochloric acid used was 3.00×10^{-2}.

Calculate the enthalpy change of the reaction, in kJ mol^{-1}, for the neutralization of one mole of hydrochloric acid.
Give your answer to **three** significant figures and include a sign.

(2)

ΔH = ... kJ mol^{-1}

Exemplar

(iii) Why is it important that the temperature readings are taken as quickly as possible?

(1)

(iv) Thermometric titrations can also be carried out using an electronic probe connected to a computer, instead of a thermometer.

The sodium hydroxide is run into the acid from the burette at a steady rate. The acid is in an insulated beaker with a magnetic stirrer. The computer then produces a plot of the results.

Explain why this modified method can give improved results, other than because of any increase in accuracy of the temperature readings by the electronic probe.

(2)

(d) (i) Calculate the concentration, in mol dm^{-3}, of the sodium hydroxide used when 20.0 cm^3 of 1.5 mol dm^{-3} hydrochloric acid is neutralized by 15.50 cm^3 of sodium hydroxide.

(2)

Exemplar

(ii) Each time a burette is read, the error is ±0.05 cm^3.

Calculate the percentage error in using a burette to measure a volume of 5.00 cm^3 of sodium hydroxide.

(1)

(e) (i) When a titration is carried out using an indicator, the concentrations of acid and alkali are usually between 0.05 and 0.20 mol dm^{-3}.

Explain why more concentrated solutions are used in thermometric titrations.

(1)

(ii) Sodium hydroxide is described as an irritant at concentrations less than 0.10 mol dm^3.

In what way is more concentrated sodium hydroxide hazardous?

(1)

(Total for Question 3 = 17 marks)

Exemplar

Example

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4 Butanone, $CH_3COCH_2CH_3$, can be prepared from butan-2-ol, $CH_3CH(OH)CH_2CH_3$, using the procedure below.

An organic solvent suitable for this procedure has a low boiling temperature and is extremely flammable, so adequate safety precautions must be taken.

Procedure

1. Place about 10 g of sodium dichromate(VI) and 20 cm^3 of distilled water in a conical flask. Shake the flask to dissolve the solid. Then slowly add about 8 cm^3 of concentrated sulfuric acid.

2. Dissolve 5.00 g of butan-2-ol in the organic solvent in a round-bottom flask. Stand the flask in a large beaker containing ice and water. Slowly add the acidified sodium dichromate(VI) solution through a funnel to the butan-2-ol solution in the flask.

3. When the addition is finished, leave the mixture to cool and separate the organic layer, which contains the butanone, from the aqueous layer.

4. Wash the organic layer with sodium hydrogencarbonate solution, and then with water. Discard the aqueous layer.

5. Add some sodium sulfate, Na_2SO_4, to the organic layer and wait until this solution is clear.

6. Decant the solution into a flask, and add a few anti-bumping granules. Use distillation to remove the solvent, which has a **lower** boiling temperature than butanone. The solvent boils between 30 °C and 36°C.

(a) What colour change will be seen when the acidified sodium dichromate(VI) reacts with the butan-2-ol?

(1)

From .....

Draft

(b) The reaction is exothermic. Other than the risk of explosion, why is it important to cool the flask in a beaker of ice and water in **step 2**?

(1)

.....

.....

.....

.....

(c) State the purpose of washing the crude butanone in **step 4** with sodium hydrogencarbonate solution. Describe the method used to carry out this process, naming the piece of apparatus used.

(3)

Purpose .....

Method .....

.....

.....

.....

.....

.....

.....

.....

(d) What is the purpose of adding sodium sulfate in **step 5**?

(1)

.....

.....

Exemplar

(e) Draw a labelled diagram of the apparatus used in **step 6** to distil off the solvent from the organic layer. The diagram should show at least one precaution which must be taken when distilling an extremely flammable liquid.

(4)

(f) (i) Calculate the volume, in cm^3, of 5.00 g of butan-2-ol.

The density of butan-2-ol is 0.805 g cm^{-3}.

(1)

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(ii) Each mole of butan-2-ol can produce a maximum yield of one mole of butanone.

Calculate the mass of butan-2-ol that would be required to make 3.00 g of butanone if the yield is 64%.

Relative molecular masses:

butan-2-ol	74.1
butanone	72.1

(3)

Exemplar

(Total for Question 4 = 14 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2										3	4	5	6	7	0 (8)
																(18)
																4.0 He helium 2
(1)	(2)										(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4										10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key

1.0 H hydrogen 1

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

EXEMPLAR

P 4 2 9 8 0 A 0 1 6 1 6

PMT

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Mark Scheme (Results)
Summer 2014

IAL Chemistry (WCH03/01)
Chemistry Laboratory Skills I

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answer	Reject	Mark
1 (a)	(Flame colour is) yellow-red / brick-red / orange-red / red-yellow ALLOW Red	Crimson, orange, yellow	**1**

Question Number	Acceptable Answer	Reject	Mark
1(b)	Yellow solid / crystals / precipitate (both words required) **(1)** (Precipitate) does not dissolve / does not change / is insoluble / remains **(1)** ALLOW Goes lighter / paler yellow "Nothing happens / no reaction" ONLY IF there is reference to precipitate in first part	Cream precipitate	**2**

Question Number	Acceptable Answers	Reject,	Mark
1(c)	(Dark) Brown / yellow / yellow-brown / red-brown / (pale) straw coloured **(1)** ALLOW combinations of colours or reverse of colour orders in pairs Iodine / tri-iodide ion / I_2 / I_3^- **(1)**	Red, orange, purple, violet, (dark) grey, black Iodide, I^-, I^{-3}	**2**

Question Number	Acceptable Answers	Reject	Mark
1(d)	Blue-black ALLOW Just "blue" / just "black" / dark blue	Purple Blue-black to colourless	**1**

Question Number	Acceptable Answer	Reject	Mark
1(e)	(The precipitate is) calcium carbonate / $CaCO_3$ **(1)** (The gas is) carbon dioxide / CO_2 **(1)** Mark independently		**2**

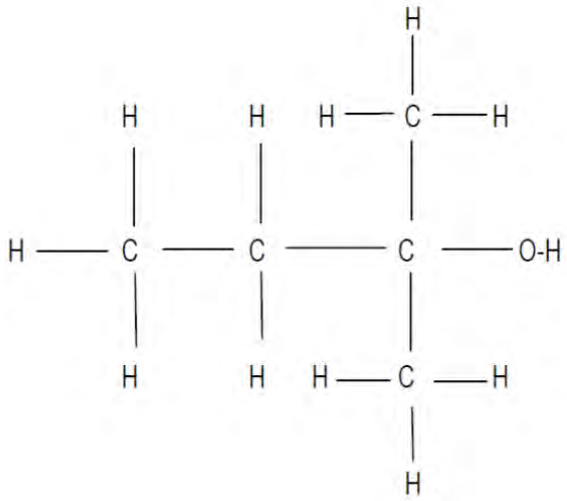
Question Number	Acceptable Answers	Reject	Mark
1(f)(i)	Iodine / I_2 **(1)** (Shiny) black solid / grey solid / purple fumes State AND colour needed ALLOW Vapour or gas for fumes Violet for purple (Dark) brown solution Purple in organic solvent **(1)** No TE for a test on an incorrect product, or if no product is given	 Brown solid Just “purple”	**2**

Question Number	Acceptable Answers	Reject	Mark
1(f)(ii)	Hydrogen sulphide / H_2S **(1)** (Colourless gas with) bad egg smell / turns lead ethanoate (paper) black / turns lead nitrate (paper) black **(1)** OR Sulfur / S **(1)** Yellow solid ALLOW Yellow precipitate **(1)** ALLOW Sulfur dioxide / SO_2 **(1)** (Colourless gas with) choking smell / pungent smell / acrid smell / Turns... (potassium / sodium) dichromate((VI)) (paper) green blue litmus (paper) red Universal Indicator (paper) red potassium manganate((VII)) colourless potassium permanganate colourless ALLOW Correct formulae **(1)** IGNORE Bubbles / effervescence / misty fumes / steamy fumes No TE for a test on an incorrect product, or if no product is given		**2**

Total for Question 1 = 12 marks

Question Number	Acceptable Answer	Reject	Mark
2(a)(i)	From maximum value of *m/e* OR From maximum value of *m/z* OR From maximum mass / charge ratio OR From (position of) peak furthest to right of spectrum (excluding small peaks due to isotopes) ALLOW Value furthest to the right hand side from (position of) last peak "line" for peak IGNORE Molecular ion	Just "highest value" Biggest peak Highest peak	**1**

Question Number	Acceptable Answers	Reject	Mark
2a(ii)	x = 5 y = 11		**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)	 TE on (a)(ii) for a correct tertiary alcohol with the number of C atoms given in (a) (ii) ALLOW Partial display eg –OH, -CH_3, -C_2H_5 ALLOW CH_3 | CH_3-C-OH | C_2H_5	Structure shown as fully structural (no bonds shown) skeletal formula -HO Bonds should not go from C to H of OH	**1**

Question Number	Acceptable Answer	Reject	Mark
2(c)(i)	Hydrogen chloride / hydrochloric acid / HCl / HCl(aq)		**1**

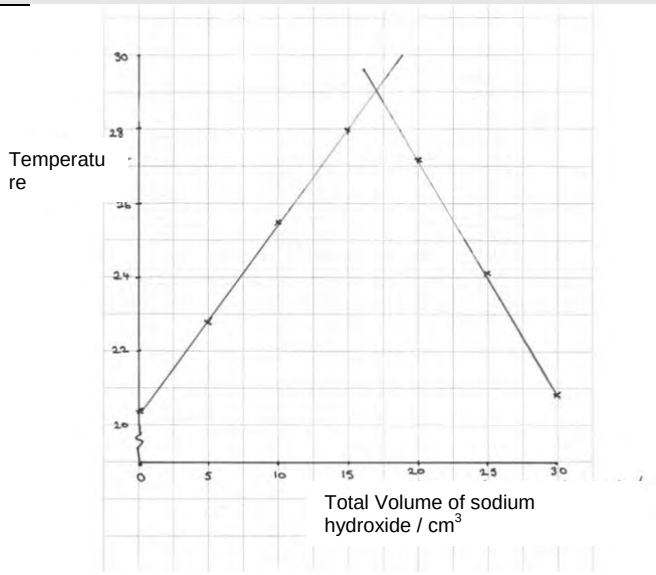
Question	Acceptable Answers	Reject	Mark

Number			
2(c)(ii)	$NH_3(g) + HCl(g) \rightarrow NH_4Cl(s)$ Correct formulae ALLOW $NH_4^+ Cl^-$ / $NH_4^+ + Cl^-$ Multiples **(1)** State symbols **(1)** Second mark depends on equation showing **only** correct species even if unbalanced. ALLOW HCl(aq)		**2**

Question Number	Acceptable Answer	Reject	Mark
2(d)	Alcohol has a peak for O-H bond OR ether has no peak for O-H bond ALLOW Alcohol has a peak for C-OH / C-O-H / -OH OR **Identification from C-O if stated that** C-O in ether absorbs at a different wavenumber from C-O in alcohol / ether has C-O-C OR Look at fingerprint region **and** compare with a compound of known identity ALLOW Use of " absorption / stretch / vibration / wave number / reading / drop / trough" instead of peak R-O for C-O IGNORE "ester" if apparently written by mistake for "ether" Broad and sharp (peaks)	Just 'alcohol has an OH bond / group' Just identification from C-O without detail C-O peak higher in ether range / spectrum instead of peak	**1**

Total for Question 2 = 7 marks

Question Number	Acceptable Answers	Reject	Mark
3(a)	In acid: colourless **(1)** In alkali: (pale) pink ALLOW Purple / red / magenta in alkali or combinations of colours eg purple-red **(1)** Correct colours wrong way round scores **(1)**	Clear or white for colourless Violet	**2**

Question Number	Acceptable Answers	Reject	Mark
3(b)	 Points correctly plotted **(1)** 2 best-fit straight lines through the points intersecting **(1)** Maximum temperature 29.1 ± 0.2 °C TE on linear extrapolation **(1)** Volume of NaOH 17.25 ± 0.5 cm^3 ALLOW 17 cm^3 TE on volume corresponding to maximum temperature after linear extrapolation **(1)** IGNORE sf except for one sf		**4**

Question Number	Acceptable Answer	Reject	Mark
3(c)(i)	35.5 x 4.18 x 10.2 = (1513.578) = 1514 (J) ALLOW 1.514 kJ IGNORE sf except 2 sf or less	1500 J 1513 J 1.5 kJ / 1.513 kJ	**1**

Question Number	Acceptable Answers	Reject	Mark

3(c)(ii)	(1513.578/3.00 x 10^{-2} = 50452.6 J)
	
	ΔH = -50.5 (kJ mol^{-1})
	Value
	
	ALLOW
	If (c)(i) is 1510, ΔH = -50.3 (kJ mol^{-1})
	
	TE from (c)(i)
	e.g.
	If (c)(i) is 1500, ΔH = -50.0 (kJ mol^{-1})
	If (c)(i) is 1513, ΔH = -50.4 (kJ mol^{-1})
	
	If (c)(i) = 20 x 4.18 x 10.2 = 852.72J
	Then ΔH = -28.4 (kJ mol^{-1}) **(1)**
	
	Sign **and** 3 sf if a value has been calculated **(1)**
			2

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	Temperature is taken before heat loss occurs / before mixture cools ALLOW Because heat will be lost To reduce errors due to heat loss Temperature falls / drops quickly	To prevent heat loss Temperature rises / changes quickly	**1**

Question Number	Acceptable Answer	Reject	Mark
3(c)(iv)	**One** mark each for any TWO of the following Temperatures are monitored continuously Equivalent to having more / many readings More points give a more accurate line / plot Magnetic stirrer more efficient than manual stirring / stirring is more uniform / makes temperature more uniform / makes concentration more uniform Heat loss is reduced because reaction is completed more quickly / because there is no time delay in readings IGNORE Comments on insulation of beaker, rate of reaction as opposed to time for experiment to be completed, parallax error Prevents human error	Monitored frequently Prevents errors when drawing graphs Just “Heat loss is reduced”	**2**

Question Number	Acceptable Answers	Reject	Mark
3(d)(i)	Correct answer without working scores **(2)** (Moles of HCl) = 20.0 x 1.50/1000 = 3.00×10^{-2} = (Moles of NaOH) ALLOW Moles of HCl / NaOH = 3.00×10^{-2} **(1)** Concentration = $\frac{3.00 \times 10^{-2}}{15.50} \times 10^{3}$ =) 1.93548 / 1.94 /1.9 (mol dm^{-3}) **(1)** IGNORE sf except 1 sf TE from first to second mark	Just '3.00×10^{-2} / 0.03' 1.93 and other incorrect roundings	**2**

Question Number	Acceptable Answers	Reject	Mark
3(d)(ii)	$\frac{2 \times 0.05}{5.00} \times 100\%$ = (±)2%	Two answers eg 0.02 and 2	**1**

Question Number	Acceptable Answers	Reject	Mark
3(e)(i)	To make temperature (change) bigger / (more) obvious / (more) significant OR To make more exothermic / to produce more heat energy / so more heat is given out OR To reduce percentage error in **temperature** (change) IGNORE Additional comments on rate increasing if rest of answer is correct Reference to volumes Easier to measure temperature change	To allow reaction to go to completion To increase enthalpy change Just 'to increase the heat'	**1**

Question Number	Acceptable Answer	Reject	Mark
3(e)(ii)	It is corrosive / burns skin / damages eyes / caustic ALLOW Damages skin IGNORE More irritant or harmful or dangerous NaOH is an alkali	Toxic Just “damaging” Flammable	**1**

Total for Question 3 = 17 marks

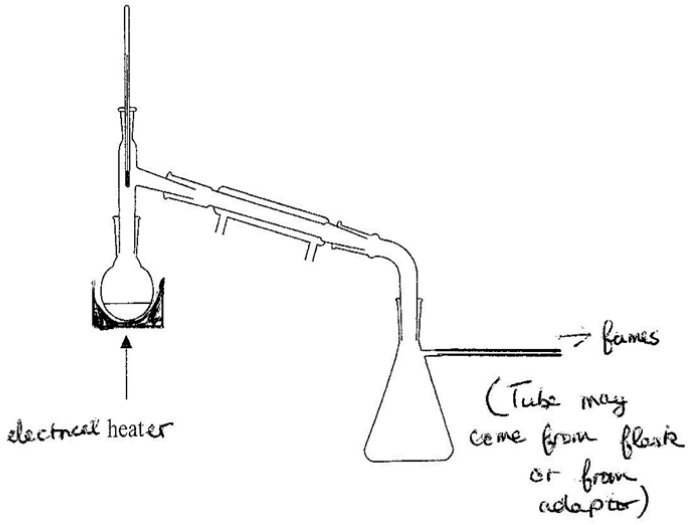
Question Number	Acceptable Answers	Reject	Mark
4(a)	Orange to green / blue / brown ALLOW Orange to blue-green Orange to dark green		**1**

Question Number	Acceptable Answers	Reject	Mark
4(b)	To prevent solvent boiling / vaporising / escaping (from mouth of flask) ALLOW **Solvent** may ignite / is flammable Reactant / product / butan-2-ol / butanone are prevented from boiling / vaporising / escaping (from mouth of flask) IGNORE Comments on sulfuric acid spray being corrosive Butan-2-ol / solvent / butanone is volatile or has a low boiling temperature		**1**

Question Number	Acceptable Answers	Reject	Mark
4(c)	(Purpose:) removes / neutralizes (excess) acid **(1)** (Method:) Put in a (stoppered) **separating funnel / tap funnel** with sodium hydrogencarbonate (and shake the mixture) **(1)** Open the tap at intervals / remove stopper at intervals / release pressure at intervals ALLOW Pressure builds up because carbon dioxide forms **(1)** Final mark can be awarded if washing is carried out in a **stoppered** flask IGNORE comments on separating organic product after washing	Removes impurities	**3**

Question Number	Acceptable Answers	Reject	Mark
4(d)	Drying agent / removes water / removes moisture ALLOW Absorbs water	Dehydrating agent Reacts with water Removes impurities	**1**

Question Number	Acceptable Answer	Reject	Mark
4(e)	**First mark**: Suitable flask (round bottom or pear shaped) fitted with stillhead, **and** with thermometer in correct position with bulb opposite opening to condenser ALLOW Flask with long neck and delivery tube in place of flask & stillhead IGNORE Fractionating column **(1)** **Second mark:** Condenser angled downwards with correctly drawn inner tube and (water cooled) outer tube IGNORE (Direction of) water flow in condenser **(1)** **Third mark**: Collecting flask with vent in flask or in connection to it ALLOW Open necked flask / beaker **(1)** **Fourth mark**: Electrical heater ALLOW Water bath heated by electrical heater / Bunsen / heat arrow If heat source is shown as “Heat” or with an arrow then ALLOW either of these precautions: Tube between condenser and collecting flask to lead fumes away to drain or fume cupboard OR Cool collecting flask in ice **(1)** Labels only needed for items which cannot be identified in diagram eg electric heater	Conical flask Still head open Air condenser (ie no water jacket) Sealed system Use of Bunsen but no water bath	**4**



Question Number	Acceptable Answers	Reject	Mark
4(f)(i)	(5.0 / 0.805) = 6.2112 / 6.211 / 6.21 / 6.2 (cm^3) ALLOW comma for decimal point	6 (cm^3)	**1**

Question Number	Acceptable Answers	Reject	Mark
4(f)(ii)	There are many possible correct methods for this calculation. Two of these methods are shown below: **Look at final answer:** **4.8(2) (g) scores 3 marks,** **1.97 (g) OR 3.08 (g) scores 2 marks** For other answers, look at working; do not penalise intermediate rounding. 0.042 moles butanone gives final answer of 4.9 (g) **First mark:** 3.0 g butanone = 0.041609 mol **(1)** **THEN Route 1:** **Second mark** Need to make $\frac{0.0416 \times 100}{64}$ = 0.065 mol **(1)** **Third mark** Mass butanol = (0.065 x 74.1) = 4.8175 / 4.8(2) (g) **(1)** **OR Route 2:** **Second mark** Mass of 0.041609 mol butanol = 0.041609 x 74.1 = 3.082 (g) (Use of 0.042 mol gives 3.11 (g)) **(1)** **Third mark** **M**ass butanol needed = (3.082 x 100/ 64) = 4.8175 / 4.8(2) (g) **(1)** IGNORE sf except 1 sf at all stages Rounding may be done at different stages of calculation and intermediate values may not be shown		**3**

Total for Question 4 = 14 marks

Total for Paper = 50 marks

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Surname	Other names

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Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Wednesday 14 January 2015 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P45043A

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P 4 5 0 4 3 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 Tests were carried out on compounds **P** and **Q**. Complete the tables below.

(a) Compound **P** is a white inorganic solid which contains one cation and one anion.

	Test	Observation	Inference (Name or formula)	
(i)	Warm **P** with dilute aqueous sodium hydroxide	A gas is given off which turns damp red litmus paper blue	The gas is	**(1)**
(ii)	Add dilute nitric acid followed by aqueous silver nitrate to an aqueous solution of **P**	A cream coloured precipitate forms	**P** contains the ..... ion	**(1)**
(iii)	Add dilute aqueous ammonia to the cream coloured precipitate	....	This confirms the inference in (a)(ii)	**(1)**

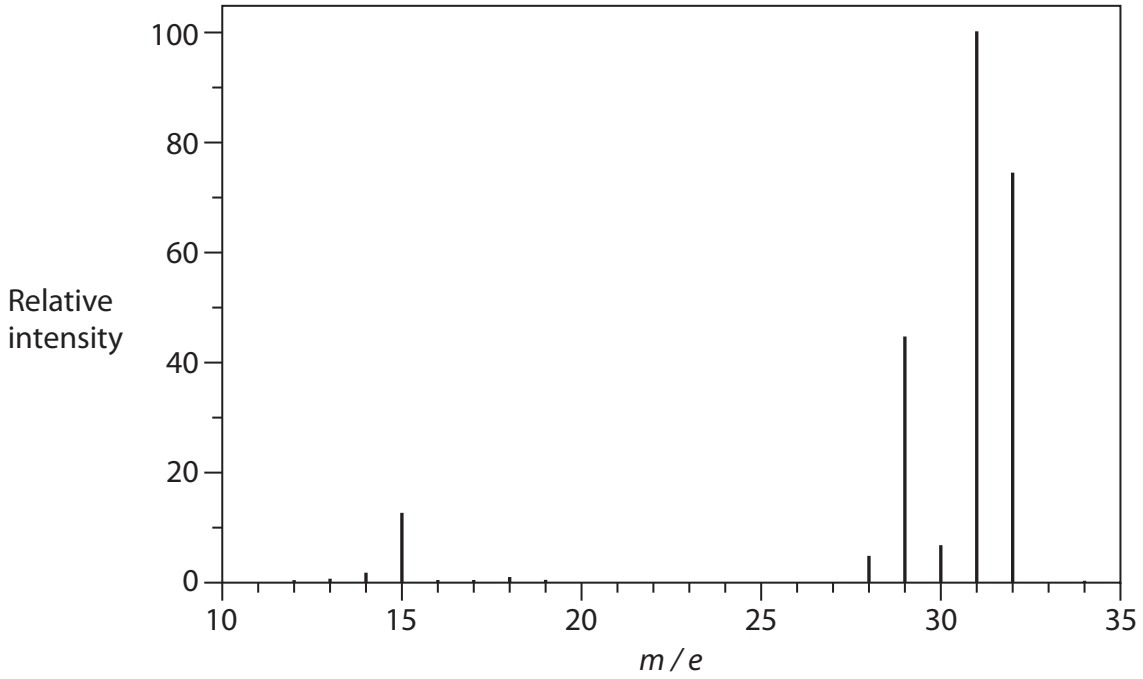
(iv) The **formula** of **P** is .....

(1)

(b) **Q** is an organic liquid which has only one functional group. **Q** dissolves in water forming a **neutral** solution.

	Test	Observation	Inference	
(i)	Add bromine water to **Q**	The bromine is not decolorised	....	**(1)**
(ii)	Add phosphorus(V) chloride to **Q**	Misty fumes which react with ammonia to form a white smoke	The misty fumes are .... The **formula** of the functional group in **Q** is	**(2)**
(iii)	Add a small piece of sodium to **Q**	....	This confirms the inference made in (b)(ii)	**(1)**

(iv) The mass spectrum of **Q** is shown below.



Identify **Q** by name or formula. Use information from the spectrum to justify your answer.

(2)

Identity of **Q** .....

Justification .....

.....

.....

(Total for Question 1 = 10 marks)

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2 A white powder is the carbonate of an element in Group 2. Its formula can be written XCO_3.

0.150 g of the pure carbonate was mixed with excess dilute hydrochloric acid.

The following reaction occurred.

$$XCO_3(s) + 2HCl(aq) \rightarrow XCl_2(aq) + CO_2(g) + H_2O(l)$$

(a) Describe the test for carbon dioxide.

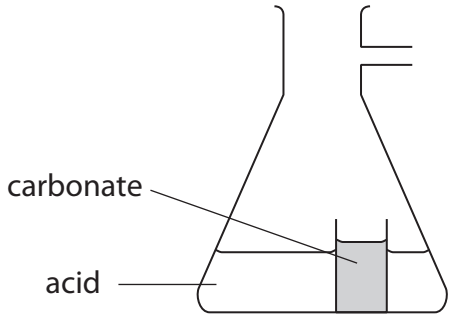
(1)

Test .....

Observation .....

(b) The carbonate and dilute hydrochloric acid were mixed in a conical flask with a side arm. Complete the diagram below to show how to collect the carbon dioxide and measure its volume.

(2)



(c) The volume of carbon dioxide, measured at room temperature and pressure, was 41 cm^3. Calculate the number of moles of gas formed.

[The molar volume of a gas under these conditions is 24 $dm^3\,mol^{-1}$.]

(1)

(d) Use your answer to (c), and the mass of the carbonate used, to calculate the molar mass of XCO_3.

(2)

(e) Deduce the value which this experiment gives for the relative atomic mass of **X**. Suggest which Group 2 metal is most likely to be **X**.

(1)

(f) Suggest why less gas is collected than expected. You should assume that the reaction is complete and no gas escapes.

(1)

(g) What would be observed when a flame test is carried out on XCO_3?

(1)

(h) A student attempted to determine the molar mass of other carbonates of Group 2 by the method used in this question.

The student measured the volume of gas produced by each carbonate, but replaced hydrochloric acid with sulfuric acid.

Explain why the results of the student's experiments would give very inaccurate values for the molar mass of some carbonates of Group 2.

(2)

(Total for Question 2 = 11 marks)

3 A titration was carried out to find the relative molecular mass of a solid acid.
The formula of the acid can be written H_2A.

(a) 1.05 g of the acid was dissolved in water and the solution made up to 250 cm^3.

Name the piece of apparatus used for making a solution with volume exactly 250 cm^3.

(1)

.....

(b) 25.0 cm^3 of the acid solution was pipetted into a conical flask and titrated with 0.100 mol dm^{-3} sodium hydroxide solution. This titration was repeated three times.

The equation for the reaction is shown below.

$$H_2A(aq) + 2NaOH(aq) \rightarrow Na_2A(aq) + 2H_2O(l)$$

(i) The indicator used in the titration was phenolphthalein. What colour change took place at the end point of the titration?

H_2A and its ions are colourless.

(2)

From ..... to .....

(ii) The following results were recorded.

Titration number	1	2	3	4
Burette reading (final) /cm^3	23.60	46.90	24.35	47.65
Burette reading (initial) /cm^3	0.00	23.60	1.00	24.40
Volume of NaOH used /cm^3	23.60	23.30	23.35	23.25

Titration number 1 was a rangefinder, or rough titration.
Describe how you would use the rough titration value when carrying out the accurate titrations.

(1)

.....

.....

.....

.....

(iii) The uncertainty in each burette reading was ± 0.05 cm^3.

Calculate the percentage uncertainty in titration number 2.

(1)

(iv) Calculate the mean titre for titration numbers 2, 3 and 4.

(1)

Mean titre = ... cm^3

(v) Calculate the number of moles of sodium hydroxide in the mean titre and hence calculate the number of moles of H_2A in the 25.0 cm^3 pipette samples.

(2)

(vi) Calculate the relative molecular mass of H_2A. You **must** show your working.

(2)

(c) The acid, H_2A, can be prepared by the oxidation of ethane-1,2-diol, $HOCH_2CH_2OH$.

(i) State the reagents and conditions needed for this oxidation reaction.

(2)

Reagents ..... and .....

Conditions .....

(ii) What colour change would occur when the oxidation took place?

(1)

From ..... to .....

(iii) Use the formula of ethane-1,2-diol to deduce the **displayed** formula of H_2A.

(1)

(Total for Question 3 = 14 marks)

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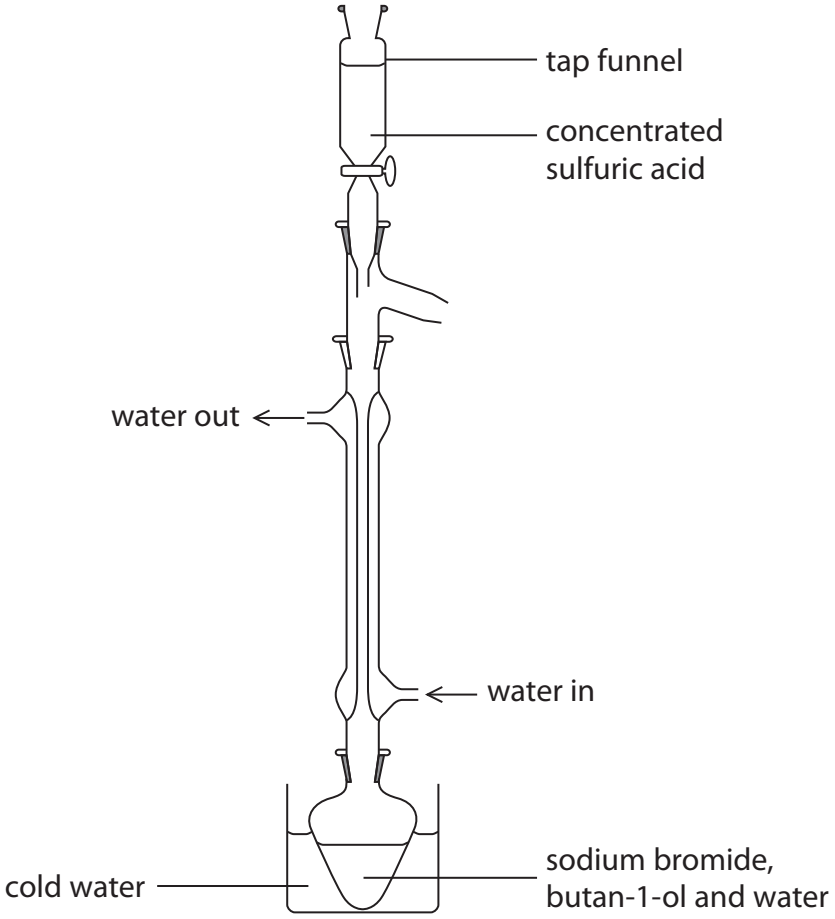
4 One method of preparing 1-bromobutane from butan-1-ol is given below.

Procedure

Step 1 10 g of sodium bromide, 10 cm^3 of water and 7.5 cm^3 of butan-1-ol are placed in a flask. The flask is partially immersed in a large beaker of cold water. A condenser is fitted vertically in the neck of the flask as shown in the diagram.



Step 2 10 cm^3 of concentrated sulfuric acid is dripped slowly from the tap funnel into the reaction mixture. The flask is shaken gently.

Step 3 The tap funnel is removed from the top of the condenser and the flask is taken out of the cold water bath. The flask is then heated gently for about 45 minutes.

Step 4 The apparatus is then rearranged for distillation. The 1-bromobutane and water are distilled into a small beaker where they form two layers.

Step 5 The 1-bromobutane layer is separated from the water.

Step 6 The 1-bromobutane layer is washed with concentrated hydrochloric acid to remove unreacted butan-1-ol.

Step 7 The 1-bromobutane is then washed with dilute sodium carbonate solution.

You will need the following data to answer the questions.

Butan-1-ol, $CH_3CH_2CH_2CH_2OH$ $M_r = 74$

1-bromobutane, $CH_3CH_2CH_2CH_2Br$ $M_r = 137$

Liquid	Density / g cm^{-3}
butan-1-ol	0.81
water	1.0
concentrated hydrochloric acid	1.2
1-bromobutane	1.3

(a) The use of the beaker of cold water in **Step 1**, and the slow addition of concentrated sulfuric acid in **Step 2**, both prevent a reaction which gives unwanted **inorganic** products.

Identify **one** of these unwanted products. State the type of reaction occurring when these products form.

(2)

Product .....

Type of reaction .....

.....

(b) (i) Explain why the condenser is set up so that the water flows from bottom to top, as shown in the diagram.

(1)

.....

.....

.....

(ii) Without the reflux condenser, the procedure in **Step 2** would become more hazardous. Explain why.

(1)

.....

.....

(c) To achieve the best possible yield of 1-bromobutane, the purification stages should involve the minimum number of transfers of the organic product from one piece of apparatus to another.

(i) How could the water layer be removed from the small beaker in **Step 5** without transferring the organic product?

(1)

.....

(ii) Name the apparatus you would use to carry out the washing of the crude 1-bromobutane in **Step 6**.

Describe how you would obtain the organic layer from this mixture.

(2)

.....

.....

.....

.....

(d) What is the purpose of **Step 7**?

(1)

.....

.....

(e) After **Step 7**, the crude 1-bromobutane is washed with pure water and separated again. Two further steps are needed to obtain a pure sample of 1-bromobutane.

State what these steps are. Detailed experimental procedures are not required, but you should name any reagents which are needed.

(3)

Step 8 .....

.....

.....

.....

Step 9 .....

.....

(f) (i) Calculate the mass of butan-1-ol used in **Step 1**.

(1)

(ii) In this experiment, a student obtained 7.5 g of 1-bromobutane.

Calculate the percentage yield of 1-bromobutane. Assume that each mole of butan-1-ol can produce a maximum of one mole of 1-bromobutane.

Give your answer to **two** significant figures.

(3)

(Total for Question 4 = 15 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 5 0 4 3 A 0 1 6 1 6

PMT

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Mark Scheme (Results)

January 2015

Pearson Edexcel International Advanced Subsidiary in Chemistry (WCH03) Paper 01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	Ammonia / NH_3	Ammonium / NH_4^+	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	Bromide / Br^- If name and formula are given **both** must be correct	Bromine, Br_2, Br Iodide, I^-, Chloride, Cl^-	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	Precipitate does **not** dissolve / no change / remains ALLOW Precipitate insoluble/ Precipitate is partially soluble /sparingly soluble TE from (a)(ii) for chloride dissolves / iodide does **not** dissolve	"Resolved" for "dissolved" Precipitate becomes paler/ colour does not change	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(iv)	NH_4Br / $NH_4^+Br^-$ ALLOW correct formula even if charge missing on ion in (ii) TE on incorrect halide anion or halide ion with incorrect negative charge if formula otherwise correct No TE on a formula with a metal cation Ignore name even if incorrect	NH_3Br	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	C=C bonds absent / alkene absent IGNORE "it is an alkane"/ contains C-C/ It is saturated/ is a saturated hydrocarbon	Just "double bonds absent"	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	(Fumes are)HCl/ hydrogen chloride ALLOW Hydrochloric acid **(1)** (Formula) (-) OH /O-H ALLOW C-OH **(1)**	 OH^- /alcohol/ (-) CH_2OH COOH $C_nH_{2n+1}OH$	2

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	Fizzing/ bubbles/ effervescence (of colourless gas)/ (sodium/ it) dissolves/ (sodium/ it) disappears/ **white** solid forms ALLOW **White** precipitate forms **Gas** evolved which pops with a lighted splint/ which ignites IGNORE Gets warmer/ Heat is evolved/ temperature rises/ vigorous reaction Vapour forms Sodium sinks/floats	References to coloured gas or coloured fumes **white** solid disappears / dissolves Just “solution is colourless”	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(iv)	(Identity) Methanol / CH_3OH OR Displayed/skeletal formula **(1)** (Justification) (only) alcohol with M_r = 32 / methanol has M_r = 32 / CH_3OH = 32/ right hand peak has mass 32/ right hand peak has M_r of methanol NOTE Allow mark for any mention of 32 in conjunction with methanol. OR Other use of mass spec data: Peak at *m*/*e* 15 is for $CH_3(^+)$ **and** 32-15=$OH^{(+)}$ OR 32 – (mass of) OH = $CH_3(^+)$ OR Peak at 31 is for $CH_3O(^+)$/ $CH_2OH(^+)$ IGNORE Negative or missing charges on peaks **(1)** Second mark depends on identification of methanol.	Correct name with wrong formula or vice versa. Highest peak has M_r of methanol Just "Peak at *m*/*e* 15 is for $CH_3(^+)$ " Peak at 29 is for COH / CHO	2

Total for Question 1 = 10 marks

Question Number	Acceptable Answers	Reject	Mark
2(a)	(Bubble into) lime water / calcium hydroxide (solution) / $Ca(OH)_2$((aq)) **and** Goes cloudy / white precipitate forms / turns milky / turns chalky IGNORE extinguishes a lighted splint	 Goes muddy Turns misty	1

Question Number	Acceptable Answers	Reject	Mark
2(b)	Flask stoppered with connection to apparatus in which gas can be collected. ALLOW Either bung in neck or side arm sealed IGNORE Small gaps between bung and mouth of flask Heater under flask **(1)** Syringe OR inverted burette/ inverted measuring cylinder in trough of water ALLOW Tubes without graduation marks shown if labelled as burette, syringe or measuring cylinder **(1)**	Large gaps in connection to flask / unstoppered flask Delivery tube through wall of trough Burette or measuring cylinder without water (Test) tube without graduation marks	2

Question Number	Acceptable Answers	Reject	Mark
2(c)	(Mol gas = 41/24000 =) 1.7083×10^{-3} / 0.0017083 (mol) Ignore sf except 1sf Ignore lack of units	 Incorrect units	1

Question Number	Acceptable Answers	Reject	Mark
2(d)	Correct answer of **87.8** without working scores 2 Mol XCO_3 = 1.7083 x 10^{-3} **(1)** Mass of 1 mol = (0.15/1.7083 x 10^{-3}) = 87.8 (Use of 1.7 gives mass 88.2 use of 1.71 gives 87.7) Ignore sf except 1 sf **(1)** TE from 2c Ignore lack of units	Incorrect units but do not penalise if already penalised in (c).	2

Question Number	Acceptable Answers	Reject	Mark
2(e)	Relative atomic mass X = (87.8-(12+48)) = 27.8 X = Mg ALLOW Mg^{2+} No mark for identification of Mg **without** relative atomic mass or some working. ALLOW Calculation of atomic mass shown in (d) TE from 2d	Element with no justification. Identification as Sr because 2(d) gives 88	1

Question Number	Acceptable Answers	Reject	Mark
2(f)	(Some) carbon dioxide dissolved in the dilute hydrochloric acid / water ALLOW CO_2 reacts with water Ignore references to standard conditions and faulty apparatus	CO_2 reacts with hydrochloric acid. Impure carbonate Impure acid Incomplete reaction Side reactions	1

Question Number	Acceptable Answers	Reject	Mark
2(g)	No colour/ no change (to flame) ALLOW Colourless flame TE from incorrect Group 2 metal in 2(e): Ca (brick) red/ yellow-red Sr crimson/ (dark) red Ba green	White/ bright light Answers about Mg metal No flame More than one colour given	1

Question Number	Acceptable Answers	Reject	Mark
2(h)	Some sulfates are insoluble/ $BaSO_4$ is insoluble/ Sulfates become less soluble going down group ALLOW A precipitate of the **sulfate** would form IGNORE All group II sulfates are insoluble **(1)** Reaction with acid will be incomplete **(1)** Mark independently.	Carbonates become less soluble going down group Element is insoluble in sulfuric acid. Gases other than carbon dioxide form e.g SO_2. Just "**it** would form a precipitate"	2

Total for Question 2 = 11 marks

Question Number	Acceptable Answers	Reject	Mark
3(a)	(250 cm^3) Volumetric flask / graduated flask	Flat bottom flask Titration flask Measuring flask Measuring cylinder Conical flask Pipette Burette Beaker	1

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	(From) colourless **(1)** (to) pink **(1)** ALLOW (to) red (to) Combination of pink and red/ permanent pink From pink to colourless scores **(1)**	 to purple Blue to red **loses both marks**	2

Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	As an indication of when to add drop by drop OR Add slowly when approaching rough value OR Add a significant volume /a stated volume in region 18-23.0 cm^3 of alkali/a volume approaching range finder volume (quickly) **and** then slow down ALLOW It is an indication of when to slow down IGNORE To prevent overshooting Don't use in calculating mean titre The answer should show how the rough titration value is used when carrying out the accurate titration	Just "to get an estimate" It gives an idea of where the end-point is Use as a control Add slowly when reaches rough value	1

Question Number	Acceptable Answers	Reject	Mark
3(b)(iii)	$\frac{(2 \times 0.050 \times 100)}{23.30}$ = (±)0.42918/ 0.4292/0.429 / 0.43/ 0.4 (%)		1

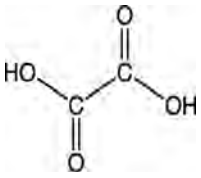
Question Number	Acceptable Answers	Reject	Mark
3(b)(iv)	23.3(0) (cm^3)		1

Question Number	Acceptable Answers	Reject	Mark
3(b)(v)	Mol NaOH = $(23.3 \times 0.1 \times 10^{-3})$ $= 2.33 \times 10^{-3}$ **(1)** Mol H_2A = $\frac{(23.3 \times 0.1 \times 10^{-3})}{2}$ $=1.165 \times 10^{-3} / 1.17 \times 10^{-3}$ **(1)** Ignore sf except 1 sf TE on 3b(iv) Correct answer with no working scores 2		2

Question Number	Acceptable Answers	Reject	Mark
3(b)(vi)	mol acid in 250 cm^3 = 1.165×10^{-2} /0.01165 **(1)** $M_r = 1.05/1.165 \times 10^{-2}$ = 90.129/ 90.1 / 90 Ignore sf **(1)** Give both marks for final answer if some working is shown, even if first marking point is not shown separately. TE from 3b(v) Final answer of **901** because mol acid in 25 cm^3 is used **scores (1)** Using 1.17×10^{-3} gives M_r = 89.7 Using 1.2×10^{-2} gives M_r = 87.5 Using 1.15×10^{-2} gives M_r = 91.3	90 with no working (just deduced from (c)(i))	2

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	Potassium/ sodium dichromate((VI))/ $K_2Cr_2O_7$ / $Na_2Cr_2O_7$ **and** sulfuric acid/ H_2SO_4 **(1)** IGNORE concentration of acid alcoholic potassium/ sodium dichromate((VI)) (Heat under) reflux **(1)** Mark independently.	Potassium manganate(VII)/ potassium permanganate hydrochloric acid nitric acid Just "heat"	2

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	Orange to (dark)green / blue / brown TE if one of the reagents in c(i) is potassium dichromate and the other is not coloured. TE on use of potassium manganate(VII) and sulfuric acid: Purple to colourless No TE on other incorrect reagents		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	 Allow undisplayed O-H as above or O-H bonds shown. Ignore orientation/ bond angles		1

Total for Question 3 = 14 marks

Question Number	Acceptable Answers	Reject	Mark
4(a)	Bromine / Br_2 **(1)** Redox/ oxidation **(1)** OR sulfur dioxide / SO_2 **(1)** Redox/ reduction **(1)** ALLOW Redox but no product given scores 1 mark Butanal/ butanoic acid and redox / oxidation scores 1 mark	HBr and redox scores 0. Oxidation/ reduction if no product given	2

Question Number	Acceptable Answers	Reject	Mark
4(b)(i)	To ensure condenser is full of water / to prevent an airlock forming/ to stop air bubbles forming / to stop hot spots forming ALLOW To ensure that all of the condenser surface is covered with cold water/ So that (hot) vapour is next to the coolest water first / So the lower region (of the condenser) is colder / Makes cooling more efficient	To prevent back flow of water Just "So that nothing escapes" Just explanation that condensation occurs Makes cooling faster	1

Question Number	Acceptable Answers	Reject	Mark
4(b)(ii)	There would be **escape** of flammable liquid / corrosive spray / corrosive acid (spray) /poisonous gas/ toxic gas/ harmful gas IGNORE Prevents boiling over Very exothermic Any **named** toxic gas is only allowed if it would condense.	Named substance e.g. Br_2 / sulfuric acid without reference to hazard Eg bromine could escape Escape of HBr /SO_2 which are toxic (because they do not condense) Risk of explosion Just "escape of product"	1

Question Number	Acceptable Answers	Reject	Mark
4(c)(i)	(teat) pipette/ syringe (to remove upper aqueous layer) ALLOW decant / description of decanting	To remove lower aqueous layer Add drying agent Add dehydrating agent Just "Use separating funnel" Use a siphon	1

Question Number	Acceptable Answers	Reject	Mark
4(c)(ii)	Separating funnel / tap funnel **(1)** Run off lower layer **(1)** ALLOW pipette off upper layer	Run off lower **aqueous** layer BUT do not penalise if mark in (c)(i) lost for wrong layers. Answers showing candidate is unaware that lower layer is the product	2

Question Number	Acceptable Answers	Reject	Mark
4(d)	To remove / neutralize (excess) acid OR to neutralize unreacted acid OR to remove / neutralize HCl ALLOW To neutralise the solution To remove all the HCl To wash out unreacted acid IGNORE To remove impurities	To **eliminate** HCl Just "to react with acid" To remove/ neutralise H_2SO_4 (and HCl) To remove HBr	1

Question Number	Acceptable Answers	Reject	Mark
4(e)	**Step 8** Dry/ remove water from the bromobutane **(1)** With (anhydrous) calcium chloride / (anhydrous) magnesium sulfate / sodium sulfate/ silica gel ALLOW $CaCl_2$ / $MgSO_4$ / Na_2SO_4 If name and formula are given both must be correct **(1)** **Step 9** (Filter / decant and then) redistil / distil **(1)** If only one step is given accept the answer in **Step 8** or **Step 9** ALLOW Description of drying carried out **after** redistillation max (2)	Dry in an oven/ evaporate to half volume scores 0 for this step. Copper sulfate Concentrated sulphuric acid Calcium hydroxide Metal carbonates Calcium sulfate recondense	3

Question Number	Acceptable Answers	Reject	Mark
4(f)(i)	(7.5 x 0.81) = 6.075 / 6.08 (g) Ignore sf except 1sf	6.07 Wrong units	1

Question Number	Acceptable Answers	Reject	Mark
4(f)(ii)	**Look at final answer.** **67% scores 3 marks; answers with 3sf rounding to 67 score 2 marks.** If this is incorrect follow this scheme: **METHOD 1** Mol butan-1-ol = (6.075/74) = 0.0820945 **(1)** maximum mass 1-bromobutane = (0.0820945 x 137) = 11.246959 g **(1)** % yield = ((7.5/11.24659)x100 = 66.85) =67% to 2 sf **(1)** **OR METHOD 2** 7.5/137 = 0.0547445 mol (bromobutane) **(1)** 6.075/74 = 0.0820945 mol butan-1-ol **(1)** % yield = ((0.05474455)x100/0.0820945) = 66.85) =67% to 2 sf **(1)** Also TE from one step of the calculation to the next and TE on 4f(i) unless yield > 100%. Use of 6.08 gives 0.082161 mol, 11.256216 g bromobutane, final answer 67% 11.3g bromobutane gives 66%.	Percentages calculated from volumes with no conversion to mol or mass. 6.075/7.5 x 100 =81% scores 0 67.0 (This is 3sf)	3

Total for Question 4 = 15 marks

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Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Thursday 7 May 2015 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/5/

P 4 4 8 8 3 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 (a) A series of tests is carried out on a white solid, **X**, which contains one cation and one anion.

Complete the table below.

	Test	Observation	Inference (Name or formula)	
(i)	Carry out a flame test on **X**	A persistent yellow colour	The cation in **X** is	**(1)**
(ii)	Add dilute hydrochloric acid to the solid **X** Bubble the gas given off into limewater	Effervescence The limewater turns cloudy	The anion in **X** is	**(1)**

(iii) Write a balanced equation, including state symbols, for the reaction between the gas formed in the reaction in (a)(ii) and limewater (calcium hydroxide solution).

(2)

(b) Another white solid, **Y**, also contains one cation and one anion.

Complete the table below.

	Test	Observation	Inference	
(i)	Carry out a flame test on **Y**	.....	Strontium ions are present	**(1)**
(ii)	Add dilute nitric acid and dilute aqueous silver nitrate to a solution of **Y**	....	The anion in **Y** is probably a chloride	**(1)**

(iii) A further test is carried out on the mixture formed in (b)(ii). This confirms that **Y** contains chloride ions, and **not** bromide or iodide ions.

Describe this test and give the result.

(2)

Test.....

.....

Result.....

.....

(iv) What would you observe when the mixture formed in (b)(ii) is left to stand in sunlight?

Name the **product** responsible for this observation.

(2)

Observation.....

Product.....

(c) When aqueous solutions of **X** and **Y** are mixed, a white precipitate forms.

Write an **ionic** equation for the reaction which produces the white precipitate. State symbols are not required.

(1)

(Total for Question 1 = 11 marks)

2 An organic compound, **Z**, has only one –OH group.

(a) State the test which confirms the presence of an –OH group and give the result of a positive test.

(2)

Test .....

Result .....

.....

(b) Name **two** series of organic compounds, with different general formulae, each of which has one –OH group.

(1)

..... and .....

(c) Neither red nor blue litmus paper changed colour when used to test an aqueous solution of **Z**. A different sample of **Z** was warmed with a mixture of aqueous potassium dichromate(VI) and sulfuric acid. No change was observed.

What can be deduced about the identity of the functional group in **Z** from each of these observations? Justify your answer.

(2)

Test with litmus paper

.....

.....

Warming with aqueous potassium dichromate(VI) and sulfuric acid

.....

.....

(d) **Z** was investigated by measuring the volume of carbon dioxide formed on complete combustion.

A sample of 0.10 mol of **Z** produced 9.6 dm^3 of carbon dioxide.

Under the conditions of the experiment, the molar volume of a gas is 24 $dm^3\,mol^{-1}$.

Use this information to calculate the number of carbon atoms in one molecule of **Z**. Use the result of your calculation and your deduction in (c) to draw the displayed formula of **Z**. Show your working.

(3)

(e) **Z** has several isomers, only some of which contain an –OH group.

(i) Give **one** piece of evidence from their mass spectra which would show that two compounds could be isomers.

(1)

.....

.....

(ii) How could infrared spectroscopy be used to show that two isomers of **Z** both have an –OH group? You are not required to give wavenumber values.

(1)

.....

.....

.....

.....

(Total for Question 2 = 10 marks)

3 This question is about enthalpy changes which occur on dissolving different substances.

(a) The enthalpy change which occurs when solid ammonium chloride, NH_4Cl, dissolves in water was found using the method below.

25.0 cm^3 of water was measured using a burette and put into a small beaker. The temperature of the water was measured.

5.00 g of powdered ammonium chloride was added to the water, the mixture was stirred continuously and the lowest temperature of the resulting solution was recorded.

Results:

Initial temperature of water = 22.0 °C

Lowest recorded temperature = 11.5 °C

(i) Calculate the energy transferred when 5.00 g of ammonium chloride dissolves in 25.0 cm^3 of water.

Hence calculate the enthalpy change, $\Delta H_{solution}$, which occurs when 1 mol of ammonium chloride dissolves in water.

Give your final answer to **three** significant figures and include a sign and units.

Use the equation:

Energy transferred (J) = mass of water $\times$ 4.18 $\times$ temperature change.

The density of water is 1.00 g cm^{-3}

(3)

(ii) The thermometer used in this experiment gave a total uncertainty in the temperature measurement of just under ±5%.

The mass of ammonium chloride was measured using a balance which had an uncertainty of ±0.005 g in each reading.

Show by calculation that the uncertainty of the result of the experiment would not be improved significantly if a more precise balance was used.

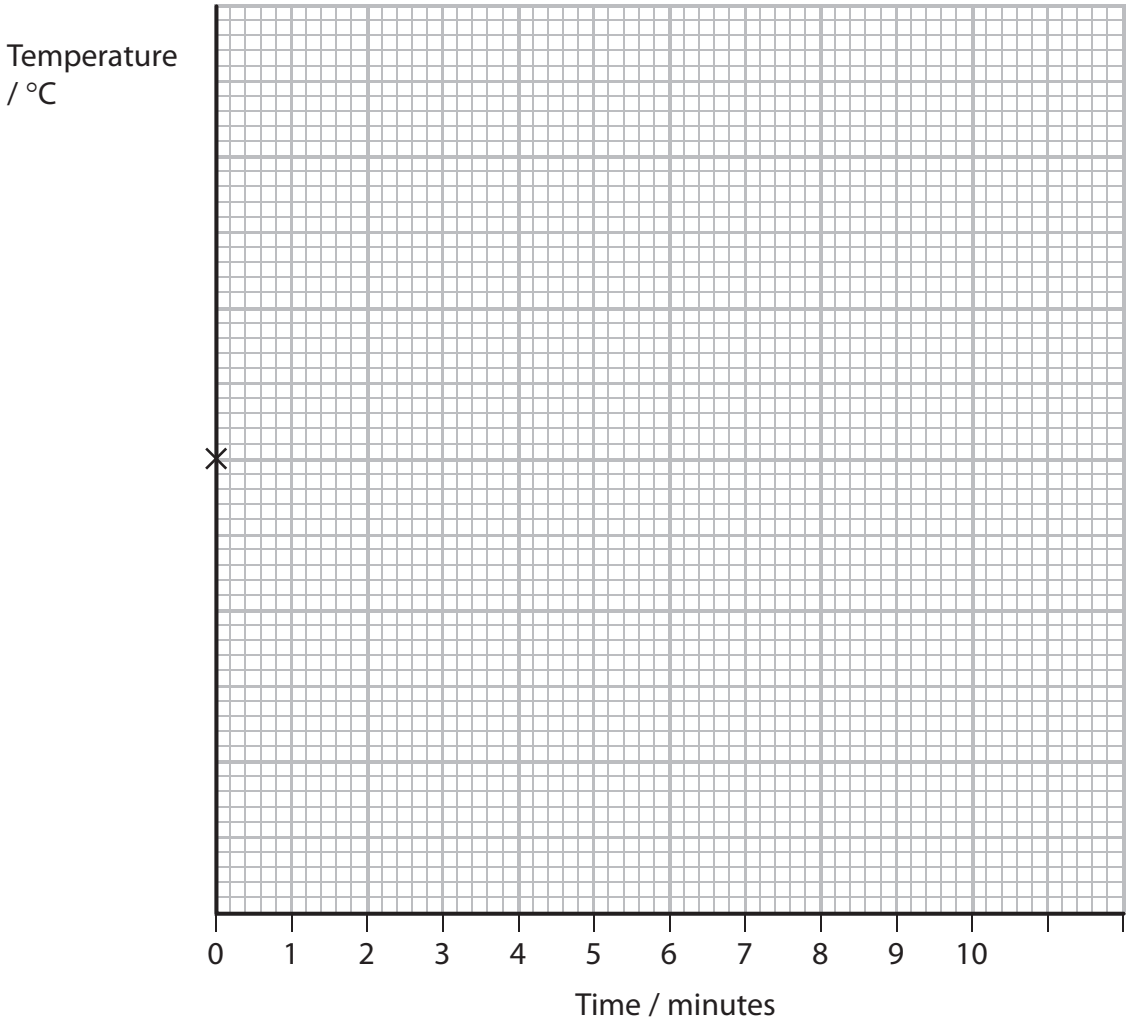
(2)

(b) In order to determine a more accurate value for the temperature change, the experiment in (a) was repeated with some modifications to the procedure.

The temperature of the water was measured as a stop clock was started, and again after one minute and two minutes. Three minutes after starting the clock, the ammonium chloride was added to the water. The temperature was then read each minute from the fourth to the tenth minute, while stirring the mixture continuously.

(i) On the grid below, mark where you would expect to find the points when the temperature measurements are plotted against time. The initial temperature has been plotted for you. You are **not** expected to plot the position of the points accurately; simply indicate their approximate position relative to the starting point.

(2)



(ii) On the grid, draw the lines needed to determine the maximum temperature change. Add a label to show the maximum temperature change on the graph.

(2)

(iii) A student carried out the experiment using water from a tap. What is the purpose of measuring the temperature of the water at 0, 1 and 2 minutes from the time of starting the clock?

(1)

.....

.....

(c) The equation for the thermal decomposition of ammonium chloride is shown below.

$$NH_4Cl(s) \rightarrow NH_3(g) + HCl(g)$$

(i) Suggest why the enthalpy change for this reaction, $\Delta H_{reaction}$, is difficult to determine directly by experiment.

(1)

.....

.....

(ii) Some enthalpy changes which can be determined experimentally are listed below.

$NH_4Cl(s) + water \rightarrow NH_4Cl(aq)$ ΔH_1

$NH_3(g) + water \rightarrow NH_3(aq)$ ΔH_2

$HCl(g) + water \rightarrow HCl(aq)$ ΔH_3

$NH_3(aq) + HCl(aq) \rightarrow NH_4Cl(aq)$ ΔH_4

By adding arrows to the diagram below, construct a Hess cycle which can be used to calculate the enthalpy change, $\Delta H_{reaction}$, for the thermal decomposition of ammonium chloride.

Label each arrow with the appropriate symbol chosen from the list above for the enthalpy change. Assume that water is added where necessary to make a solution.

(1)





(iii) Give the expression for the enthalpy change, $\Delta H_{reaction}$, for the thermal decomposition of ammonium chloride, in terms of the other enthalpy changes in the cycle.

(1)

$\Delta H_{reaction} =$

(Total for Question 3 = 13 marks)

4 Cyclohexene, C_6H_{10}, can be prepared by dehydrating cyclohexanol, $C_6H_{11}OH$, with phosphoric acid.

$$C_6H_{11}OH \xrightarrow{H_3PO_4} C_6H_{10} + H_2O$$

Procedure

Step 1 12.0 cm^3 of cyclohexanol was put into a small flask. 5 cm^3 of concentrated phosphoric acid, an excess, was added slowly to the cyclohexanol using a dropping pipette. Some anti-bumping granules were added to the mixture and the flask was set up for distillation.

Step 2 The portion of the distillate collected between 80 °C and 90 °C contained only cyclohexene and water.

Step 3 The distillate of cyclohexene and water was transferred to a separating funnel and a saturated solution of sodium chloride was added. Most of the water which was in the distillate went into the saturated sodium chloride layer.

Step 4 The crude cyclohexene was run out of the separating funnel and dried with anhydrous calcium chloride.

Step 5 The calcium chloride was removed by filtration through glass wool, and the liquid was redistilled to collect pure cyclohexene.

Cyclohexene has an unpleasant smell and irritates the eyes, so the entire experiment was carried out in a fume cupboard. In **Step 1**, tubing was connected to carry any uncondensed cyclohexene to a drain.

(a) The chemicals involved in this reaction are all hazardous if they make contact with the eyes, or if swallowed or inhaled.

Other than their effect on the eyes or their toxicity, state **two** different hazards of the chemicals involved in this reaction. Name the chemical associated with each hazard.

(2)

Chemical	Hazard

(b) Calculate the number of moles of cyclohexanol used in this experiment. The density of cyclohexanol is 0.962 g cm^{-3}.

(2)

(c) Draw a labelled diagram showing how to distil the reaction mixture in **Step 1** and collect the distillate boiling between 80 °C and 90 °C.

(4)

(d) Explain the difference between a 'dehydrating agent', such as the phosphoric acid used in **Step 1**, and a 'drying agent', such as the anhydrous calcium chloride used in **Step 4**.

(2)

.....

.....

.....

.....

(e) Suggest **one** advantage of using glass wool, rather than filter paper, when removing the calcium chloride in **Step 5**.

(1)

.....

.....

(f) Calculate the mass of cyclohexanol needed to obtain 10.0 g cyclohexene if the yield is 75%.

(3)

(g) The cyclohexene was tested by mixing it with bromine dissolved in an organic solvent.

(i) What colour change would be observed?

(1)

.....

(ii) Give the **displayed** formula for the organic product of this reaction.

(1)

(Total for Question 4 = 16 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 4 8 8 3 A 0 1 6 1 6

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Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH03/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	Sodium (ion)/ Na^+ If name AND formula are given BOTH must be correct	Na	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	Carbonate (ion)/ CO_3^{2-} OR CO_3^{-2}/ CO_3^{--} OR Hydrogencarbonate (ion)/ HCO_3^- ALLOW Hydrogen carbonate (ion) If name AND and formula are given BOTH must be correct		1

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$ Reactants with state symbols (1) Products and state symbols (1) Allow All formulae correct but one or more errors in state symbols (1) All formulae and state symbols correct but incorrect balancing numbers included (1) $Ca^{2+}(aq) + 2OH^-(aq)$ for $Ca(OH)_2(aq)$ Ignore multiples if equation is balanced	$H_2O(aq)$ $Ca(OH)_2(l)$ $Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$	2

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	Crimson/red/ dark red/bright red / persistent red/scarlet (coloured flame)	Orange Brick red Carmine	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	White precipitate ALLOW White solid/crystals ppt/ppte for precipitate Ignore comments about getting darker/turning purple on standing	Cream ppt Yellow ppt Off-white ppt Additional incorrect observations eg white ppt and effervescence or steamy fumes Change on standing to cream or yellow	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	TEST Add **dilute** (aqueous) ammonia (solution) / NH_3 / NH_3 (aq) ALLOW Dilute NH_4OH /ammonium hydroxide IGNORE Additional test with concentrated NH_3 (1) RESULT Precipitate dissolves / (colourless) solution forms ALLOW mixture dissolves / precipitate disappears/ solid dissolves / precipitate is soluble (1) Second mark depends on use of ammonia in first, even concentrated. ALLOW TEST add **concentrated** sulfuric acid **to ppt** (1) RESULT Steamy fumes (only)/ no brown **AND** no purple fumes ALLOW White fumes (1) Second mark depends on use of sulfuric acid.	Just "ammonia / NH_3" Use of ammonia on glass rod Incorrectly identified precipitate dissolves e.g. strontium chloride dissolves White smoke	2

Question Number	Acceptable Answers	Reject	Mark
1(b)(iv)	(goes) dark / purple / grey ALLOW Black / lilac (1) Silver / Ag (forms) (1)	Goes blue-black Silver colour/ mirror Ag^+ / silver ions	2

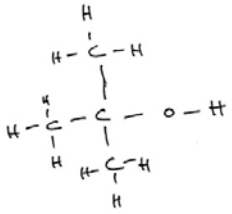
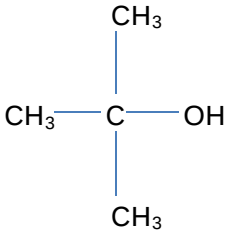
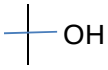
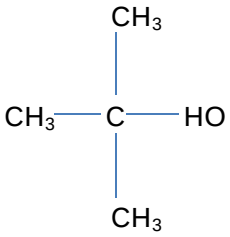
Question Number	Acceptable Answers	Reject	Mark
1(c)	$Sr^{2+} + CO_3^{2-} \rightarrow SrCO_3$ Ignore state symbols, even if incorrect Ignore full equation, written as "rough" work and mark ionic equation only.		1

Total for Question 1 = 11 marks

Question Number	Acceptable Answers	Reject	Mark
2(a)	**TEST** Add PCl_5 / phosphorus(V) chloride / phosphorus pentachloride /$SOCl_2$ / thionyl chloride / sulphur dichloride oxide (1) **RESULT** Mark depends on correct reagent, but allow PCl_5 (aq) Steamy / misty / white fumes ALLOW Gas for fumes (1) Ignore incorrect identification of fumes **OR** **TEST** Add sodium / Na (1) **RESULT** Mark depends on correct reagent Effervescence / bubbling / fizzing Ignore incorrect identification of fumes and tests for products white solid (forms) / sodium dissolves mixture gets hot (1)	Acidified PCl_5 / PCl_5 (aq) Acidified dichromate(VI) PCl_3 Test to form an ester Any smoke Just “HCl fumes” Just “gas turns litmus red” Just “hydrogen”	2

Question Number	Acceptable Answers	Reject	Mark
2(b)	(primary / secondary / tertiary) Alcohol **and** carboxylic acid ALLOW ROH **and** RCOOH R_2CHOH/ R_3COH for ROH $C_nH_{2n+1}OH$ for ROH RCO_2H for RCOOH Phenol(s) (as one alternative) Fatty acid / alkanoic acid for carboxylic acid	diol carboxyl cyclic alcohol specific alcohol eg ethanol	1

Question Number	Acceptable Answers	Reject	Mark
2(c)	Z identified as tertiary alcohol (1) **Justification:** Any one from Test with litmus Not (carboxylic) acid because there is no change (in (blue) litmus paper) It's an alcohol because there is no change (in (red / blue) litmus paper) It is neutral /not an acid or an alkali because there is no change (in (red / blue) litmus paper) Test with dichromate It is a tertiary alcohol because it can't be oxidized (by acidified dichromate(VI))/ doesn't react with acidified dichromate(VI) It is not a primary or secondary alcohol because it can't be oxidized (by acidified dichromate(VI))/ doesn't react with acidified dichromate(VI) IGNORE Not an amine (1) If more than one justification is given, both must be correct		2

Question Number	Acceptable Answers	Reject	Mark
2(d)	MP1 (0.1 mol **Z** produces) 0.4 mol CO_2 OR 1 mol Z produces 4 mol CO_2 (1) MP2 (dependent on MP1 awarded) So **Z** has 4C atoms ALLOW Formula shown with 4C (1) MP3 (stand alone)  OR  ALLOW undisplayed CH_3 and OH as above Skeletal formula  (1)	Just 9.6/24 = 0.4 with no reference to what numbers refer to or if not applied  Only if bond clearly shown to the H of OH	3

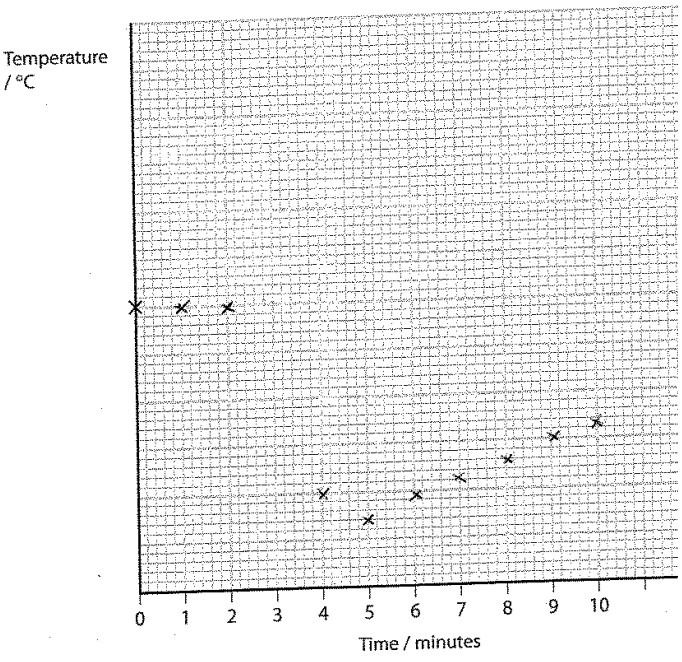
Question Number	Acceptable Answers	Reject	Mark
2(e)(i)	Molecular ions have same *m/e* ALLOW same molecular ion isomers have same molar mass / molecular mass molecular ion with same mass same maximum *m/e* value same peak furthest to right same last peak Parent ion / M^+ for molecular ion IGNORE Reference to peak heights	Same fragments Same *m/e* value for highest peak Similar for "same"	1

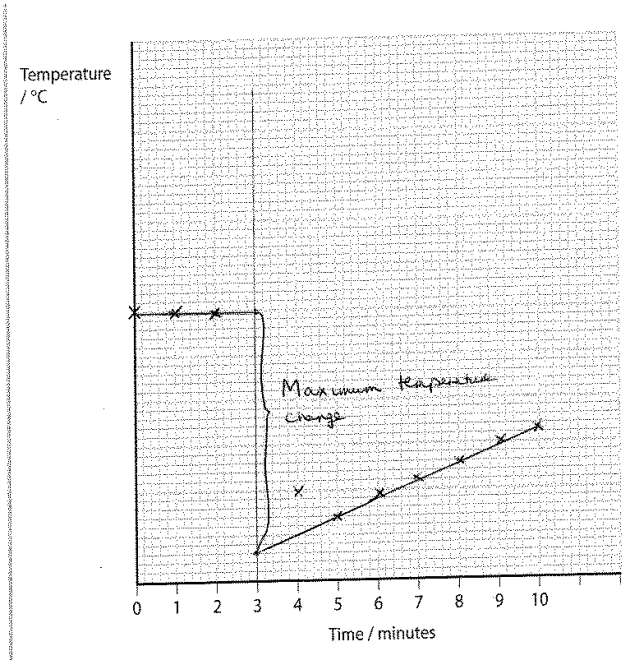
Question Number	Acceptable Answers	Reject	Mark
2(e)(ii)	They both have an (absorption) peak for (wavenumber of) alcohol / hydroxyl group / O-H ALLOW both have peak for –OH / OH frequency / wavelength for wavenumber IGNORE wavenumber values have peak with specific shape for OH	Absorption for C-OH	1

Total for Question 2 = 10 marks

Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	**Correct final answer with + sign, 3 sf and units scores 3** (25 x 4.18 x 10.5) = 1097.25 (J) / 1.097 kJ Ignore sign if given (1) Mol NH_4Cl = (5.00/53.5) = 0.09346/ 0.0935 (1) $\Delta H_{solution}$ = (+1.097/0.09346) (= +11.7376 / +11.7406) = **+11.7 kJ mol^{-1}** OR **+11700 J mol^{-1}** Sign, unit and sf must be correct for third mark Use of 2sf earlier may lead to an inaccurate answer (1) ALLOW Final answer = +11.8 kJ mol^{-1} from rounding of MP1 and/or MP2 (3) TE from each step to the next If mass used is 30 g Energy transferred = 1316.7 J $\Delta H_{solution}$ = +14.1 kJ mol^{-1} max (2) If mass used is 5 g Energy transferred = 219.45 J $\Delta H_{solution}$ = +2.35 kJ mol^{-1} max (2)	Answers not to 3 sf No sign or negative sign	3

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	First mark is for calculation of error. Second mark is for comparison of temperature error to mass error. Uncertainty in mass = (0.005 x 100 x 2/5.00) = (±)0.2% (1) Uncertainty / error in mass measurement (much) smaller than uncertainty in temperature reading (1) Second mark depends on first being correct, but allow second mark if mass error is 0.1% (as 0.005 not doubled)	Just "0.2% is negligible / very small"	2

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	Points (close to the) horizontal from starting temperature at 0, 1 and 2 (and 3) minutes (1) Points (on a line) rising from a minimum up to 10 minutes (at least 2 points needed at the warming up stage for extrapolation.) The minimum can be at 4, 5, 6, 7 or 8 minutes. (1)  	Large change of temperature at 3 minutes Cooling curve instead of warming curve	2

Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	Line through temperature points where warming occurs extrapolated back to 3 minutes. ALLOW Line at minimum temperature shown as staying horizontal and extrapolated back (1) Max temperature change indicated as vertical difference between starting temperature and extrapolated line at 3 minute (1) TE if cooling curve drawn in 3(b)(i) for both marks.  		2

Question Number	Acceptable Answers	Reject	Mark
3(b)(iii)	To check water temperature is steady / constant OR To deduce temperature at 3 mins / at start by extrapolation of line ALLOW to allow water temperature to equilibrate with surroundings/ to reach temperature of surroundings/ to acclimatise IGNORE to get initial temperature accurate	Water temperature may change Minerals in water may affect result	1

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	Heat must be supplied (and cannot be measured) ALLOW impossible to tell when/if reaction is complete reaction goes to equilibrium/ is reversible IGNORE reference to gases escaping / products are gases / hazards	Just " because it is endothermic" Needs high temperature	1

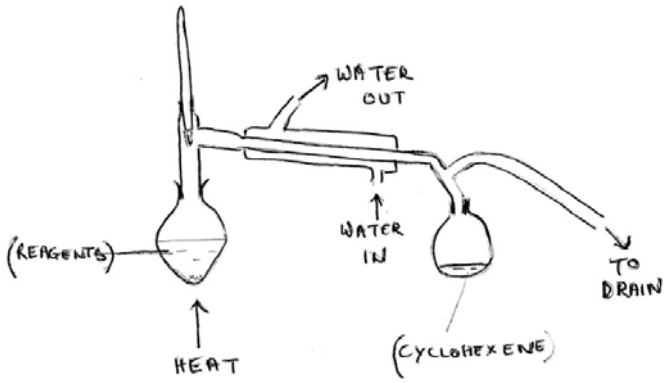
Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	$NH_4Cl(s)$ → $\Delta H_{reaction}$ $NH_3(g) + HCl(g)$ ΔH_1 ↓ $\Delta H_2 + \Delta H_3$ ↓ $NH_4Cl(aq)$ ΔH_4 ← $NH_3(aq) + HCl(aq)$ OR 2 separate parallel arrows for $\Delta H_2 + \Delta H_3$ OR ΔH_2 ΔH_3 next to one arrow without being separated by + ALLOW Arrows reversed if signs of enthalpy changes are reversed. IGNORE Any water molecules added/ aq signs / other reactant species Arrow size		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	$\Delta H_{reaction} = \Delta H_1 - \Delta H_2 - \Delta H_3 - \Delta H_4$ ALLOW any order of terms with correct signs Any correct use of brackets No TE on incorrect cycle		1

Total for Question 3 = 13 marks

Question Number	Acceptable Answers	Reject	Mark
4(a)	Two different hazards must be given to score 2 marks. Phosphoric acid corrosive ALLOW burns skin/ damages skin (1) Cyclohexanol / cyclohexene (in)flammable ALLOW Irritant (1) IGNORE Comments on glass wool, calcium chloride Cyclohexene / cyclohexanol is volatile	Additional hazards e.g. irritant harms skin carcinogenic Additional hazards e.g. explosive carcinogenic	2

Question Number	Acceptable Answers	Reject	Mark
4(b)	**Correct final answer scores (2)** Mass of 12 cm^3 $C_6H_{11}OH$ = 12 x 0.962 (1) = 11.544 / 11.54 / 11.5 (g) Number of moles = (11.544 / 100 = 0.11544) = 0.115 / 0.12 (mol) ALLOW TE from incorrect mass (1) Ignore sf except 1 sf	0.11	2

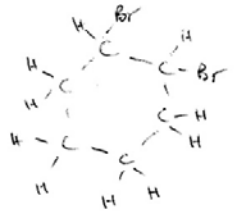
Question Number	Acceptable Answers	Reject	Mark
4(c)	Flask with heat source AND stillhead AND a closed system to the left hand side of the outlet to the condenser. Heat source can be electrical heater, water bath ALLOW bunsen or just arrow ALLOW appropriate tubing or flask with long neck as alternative to stillhead (1) Bulb of thermometer opposite opening to condenser (1) Water condenser sloping downwards AND direction of water (1) Connected to receiver with a vent OR delivery tube to an open **narrow** necked flask (1) Ignore fractionating column if included. Drawing showing reflux distillation scores max 1 for water direction in condenser.  	Conical flask Sealed receiver, beaker	4

Question Number	Acceptable Answers	Reject	Mark
4(d)	**Dehydrating agent** removes water in a (chemical) reaction OR causes two H and one O atoms to be lost (in a reaction) OR removes the elements of water (from reactant molecules) OR removes water from molecules of a compound ALLOW answers indicating a reaction occurs eg H^+ protonates OH in alcohol forming water removes water causing bonds to break reference to elimination reactions (1) **Drying agent** removes water mixed with other materials OR removes water from a mixture OR removes water in a physical change ALLOW Absorbs water (1) "A dehydrating agent removes water in a reaction but there is no reaction when a drying agent removes water" scores 1	Reference to removal of solvents other than water	2

Question Number	Acceptable Answers	Reject	Mark
4(e)	Glass wool less absorbent OR No cyclohexene left on wool OR filtration is faster through glass wool OR filter paper absorbs liquids/ product/ mixture IGNORE yield is higher with glass wool/ lower with filter paper more efficient filtration		1

Question Number	Acceptable Answers	Reject	Mark
4(f)	**Look at final answer. If correct award 3 marks.** There are several correct methods. All involve calculating a number of moles of cyclohexene, a mass of cyclohexanol and the use of the 75% but these stages can be done in different orders. EITHER Need theoretical yield of (10.0 x 100/75) = 13.3333 / 13.33 / 13.3 g (1) 13.3333g= (13.3333/82) = 0.1626 / 0.163 mol cyclohexene (1) 0.1626 mol cyclohexanol = **16.26 / 16.3 / 16 g** (1) OR Mol of cyclohexene = (10/82) = 0.12195 (1) Mol of cyclohexanol = (0.12195 x 100/75) = 0.1626 (1) Mass of cyclohexanol = (0.1626 x 100) = **16.26 / 16.3 / 16 g** (1) OR Mol of cyclohexene = (10/82) = 0.12195 (1) Theoretical mass of cyclohexanol = (0.12195 x 100) = 12.195/12.2g (1) Mass of cyclohexanol = (12.2 x 100/75) = **16.26 / 16.3 / 16 g** (1) ALLOW **16.2** (g) in all methods from rounding **9.146** (g) from incorrect use of 75% scores **(2)** Ignore SF in final answer except 1 SF	Theoretical yield = (10.0 x 75/100) = 7.5g (0.12195 x 75/100) = 0.09146	3

Question Number	Acceptable Answers	Reject	Mark
4(g)(i)	Brown / red-brown / orange / yellow/ yellow-brown to colourless ALLOW Brown / red-brown / orange / yellow is decolorised. IGNORE Clear for colourless	Red to colourless	1

Question Number	Acceptable Answers	Reject	Mark
4(g)(ii)	 ALLOW Rings with CH_2 and/or CHBr IGNORE Angles in ring Placing of H and Br inside or outside ring	Benzene ring Just skeletal formula/ molecular formula Bromoalcohols Non-adjacent Br atoms	1

Total for Question 4 = 16 marks

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Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Thursday 21 January 2016 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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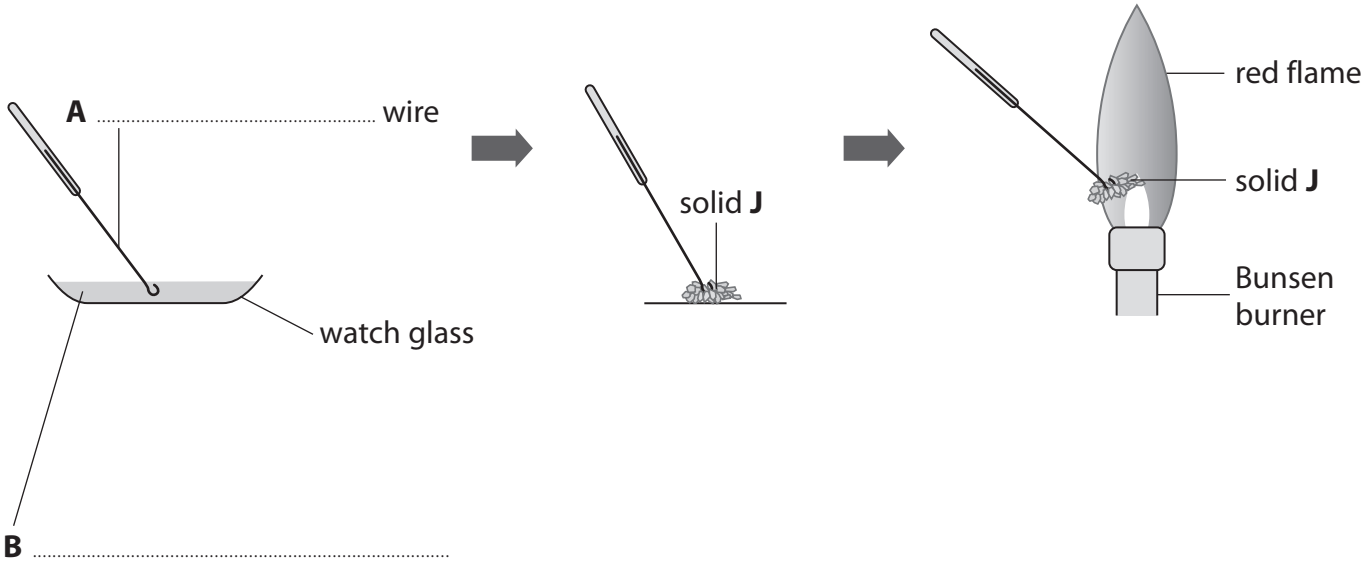
PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A series of tests is carried out on a white solid, **J**, which is a mixture of two compounds. One compound contains a Group 1 cation, and the other a Group 2 cation. The two compounds contain the same anion.

(a) Complete the labels **A** and **B** in the diagram below, which shows the procedure and result for a flame test on solid **J**.

(2)



(b) It is known that the Group 2 cation in **J** gives no colour in a flame test, so the red colour seen must be due to the Group 1 cation.

Give the name or formula of the Group 1 cation, which is responsible for the red colour observed in the flame test, and give the name or formula of the Group 2 cation.

(2)

Group 1 cation .....

Group 2 cation .....

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(c) Dilute hydrochloric acid is added to a sample of **J**.
J dissolves in the acid but there is no other change.

(i) If **J** contained a carbonate anion, what would be the observation on the addition of dilute hydrochloric acid?

(1)

.....

(ii) Give the name or formula of another anion which would produce the same observation with dilute hydrochloric acid as the carbonate anion.

(1)

.....

(iii) Aqueous barium chloride is then added to the solution of **J** in hydrochloric acid.
A white precipitate forms.

Give the **formulae** for the two salts present in **J**.

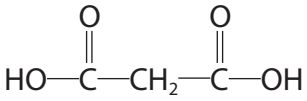
(2)

.....

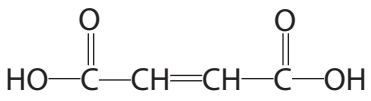
.....

(Total for Question 1 = 8 marks)

2 This question is about the following two dicarboxylic acids.
Both acids are solid at room temperature.



Propanedioic acid



Butenedioic acid

(a) (i) Phosphorus(V) chloride is often used to confirm the presence of an —OH group in a compound.

Suggest a practical problem if solid phosphorus(V) chloride is used with these two dicarboxylic acids.

(1)

.....

.....

.....

(ii) Suggest a reagent that could be used to confirm the presence of an **acid** group in either of the two compounds above, and the positive observation that would be made.

(2)

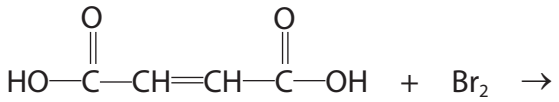
Reagent .....

Observation .....

(b) Bromine dissolved in an organic solvent reacts rapidly with butenedioic acid.

Complete the equation for the reaction of butenedioic acid with bromine.

(1)



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(c) Propanedioic acid can be produced by the oxidation of propane-1,3-diol.

(i) Draw the **skeletal** formula of propane-1,3-diol.

(1)

(ii) Identify **one** way in which the infrared spectrum of propanedioic acid would be different from that of the infrared spectrum of propane-1,3-diol.

Wavenumber data are not required.

(1)

.....

.....

.....

(Total for Question 2 = 6 marks)

3 Washing soda is hydrated sodium carbonate, $Na_2CO_3.xH_2O$, where the number of moles of water of crystallization, x, can vary.

A sample of washing soda is analysed. Two methods are used to determine the value of x in the sample.

Method 1: Heating

2.50 g of the washing soda is placed in a crucible. The crucible is gently heated for three minutes and then heated strongly for five minutes. The mass of the solid after heating is 1.06 g.

$$Na_2CO_3.xH_2O(s) \rightarrow Na_2CO_3(s) + xH_2O(g) \quad \textbf{Equation 1}$$

(a) Suggest why the crucible is heated gently for the first three minutes.

(1)

.....

.....

(b) What additional step after heating strongly for five minutes is needed to make sure that all of the water of crystallization has been removed?

(1)

.....

.....

(c) What is the correct chemical term for sodium carbonate without water of crystallization?

(1)

.....

(d) (i) Calculate the number of moles of sodium carbonate that remain after heating the sample, assuming that all of the water of crystallization has been removed.

(2)

(ii) Calculate the number of moles of water lost from the sample of washing soda on heating.

(1)

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(iii) Hence deduce the value of x in the sample of washing soda, $Na_2CO_3.xH_2O$, obtained using Method 1.

(1)

x = ...

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Method 2: Titration

Sodium carbonate reacts with hydrochloric acid as follows:

$$Na_2CO_3 + 2HCl \rightarrow 2NaCl + CO_2 + H_2O \quad \textbf{Equation 2}$$

A 2.50 g sample of the washing soda is placed in a beaker and dissolved in deionized water. This solution is poured into a 250 cm^3 volumetric flask, made up to the mark and mixed thoroughly.

A pipette is then used to transfer 25.00 cm^3 of the washing soda solution to each of three conical flasks. A burette is filled with hydrochloric acid, of concentration 0.100 mol dm^{-3}, and titrations are carried out. The results are shown in the table.

Titration numbers	1	2	3
Burette reading (final) / cm^3	17.00	33.55	16.45
Burette reading (initial) / cm^3	0.00	17.00	0.00
Titre / cm^3	17.00	16.55	16.45

(e) What should be done to make sure that all of the washing soda is transferred to the volumetric flask?

(1)

.....

.....

(f) Explain why only titrations 2 and 3 are used to calculate the mean titre.

(1)

.....

.....

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(g) (i) Calculate the mean titre, and then calculate the number of moles of hydrochloric acid in the mean titre.

(1)

(ii) Using your answer to part (g)(i) and **Equation 2**, calculate the number of moles of sodium carbonate present in 25 cm^3 of the washing soda solution.

(1)

(iii) Hence calculate the total number of moles of sodium carbonate present in 250 cm^3 of the washing soda solution.

(1)

(iv) Calculate the molar mass of the hydrated washing soda, $Na_2CO_3.xH_2O$. Hence deduce the value of x in the sample of washing soda from the data in Method 2.

(2)

x = ...

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(h) A student carrying out Method 2 overshot the end-point of each titration.

Explain how this would affect the calculated value of x.

(2)

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(Total for Question 3 = 16 marks)

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4 The thermal decomposition of copper(II) carbonate is

$$CuCO_3(s) \rightarrow CuO(s) + CO_2(g) \qquad \textbf{Equation 3}$$

The enthalpy change for this reaction, ΔH_3, cannot be determined directly. However, it can be calculated using Hess's law, from the enthalpy changes for the reaction of sulfuric acid with copper(II) carbonate and with copper(II) oxide.

(a) A student carried out an experiment to determine the enthalpy change, ΔH_4, for the reaction

$$CuCO_3(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l) + CO_2(g) \qquad \textbf{Equation 4}$$

In the experiment, a known mass of copper(II) carbonate was mixed with a known volume of sulfuric acid in a polystyrene cup, and the temperature change measured. The results of the experiment are shown in the table.

Measurement	Reading
Mass of copper(II) carbonate added to sulfuric acid	2.54 g
Volume of sulfuric acid, 1 mol dm^{-3}	50.0 cm^3
Initial temperature of sulfuric acid before addition of copper(II) carbonate	24.3°C
Maximum temperature of sulfuric acid after the addition of copper(II) carbonate	29.0°C

(i) Calculate the energy transferred, in joules, for this reaction using the expression

Energy transferred (J) = 50.0 × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of copper(II) carbonate used.

Molar mass of copper(II) carbonate = 123.5 g mol^{-1}

(1)

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(iii) Use your answers to (a)(i) and (a)(ii) to calculate, in kJ mol^{-1}, the enthalpy change, ΔH_4, for the reaction shown in **Equation 4**. Include a sign for ΔH_4 and give your answer to **three** significant figures.

(2)

(iv) Why does the sulfuric acid need to be in excess?

(1)

.....

.....

(v) The enthalpy change obtained from this experiment is much less negative than the Data Booklet value.

Suggest one likely reason for this difference, other than a measurement error.

(1)

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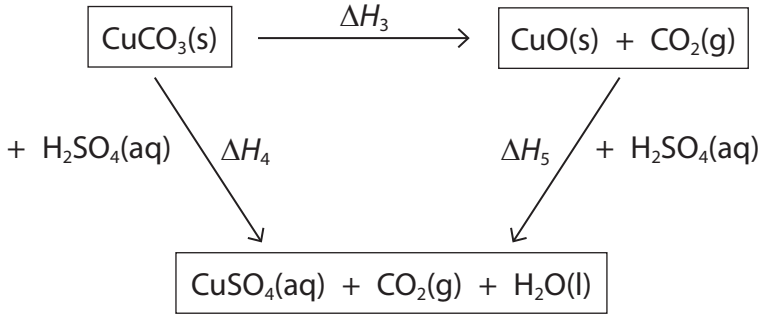
(b) The student then carried out a similar experiment to determine the enthalpy change, ΔH_5, for the reaction between copper(II) oxide and sulfuric acid.

$$CuO(s) + H_2SO_4(aq) \rightarrow CuSO_4(aq) + H_2O(l)$$ **Equation 5**

From the results of this experiment, ΔH_5 was calculated to be –56.1 kJ mol^{-1}.

The values of ΔH_4 and ΔH_5 can be used to determine the enthalpy change for the thermal decomposition of copper(II) carbonate using the Hess cycle shown below.



Use Hess's law to calculate the value of ΔH_3, in kJ mol^{-1}. Include a sign in your answer.

(2)

(c) Suggest why it is not possible to determine directly the enthalpy change for the thermal decomposition of copper(II) carbonate.

(1)

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(Total for Question 4 = 9 marks)

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5 A method for the preparation of iodoethane is given in outline below.

Procedure

Step 1 Suitable quantities of red phosphorus and iodine are placed in a round-bottom flask. The flask is fitted with a reflux condenser and immersed in cold water.

Step 2 Using a dropping pipette, a suitable volume of ethanol is added, in 1 cm^3 portions, down the condenser.

Step 3 After the addition of the ethanol is complete, and a further 15 minutes have passed, the cold water bath is removed and the mixture in the flask is heated under reflux for 45 minutes.

Step 4 The apparatus is allowed to cool and the condenser is rearranged for distillation.

Step 5 The crude iodoethane is distilled off.

Step 6 The distillate is washed with dilute sodium carbonate solution.

Step 7 The washed iodoethane is separated from the aqueous solution.

Step 8 Anhydrous calcium chloride is added to the washed iodoethane.

The equations for the reactions are

$$2P + 3I_2 \rightarrow 2PI_3$$

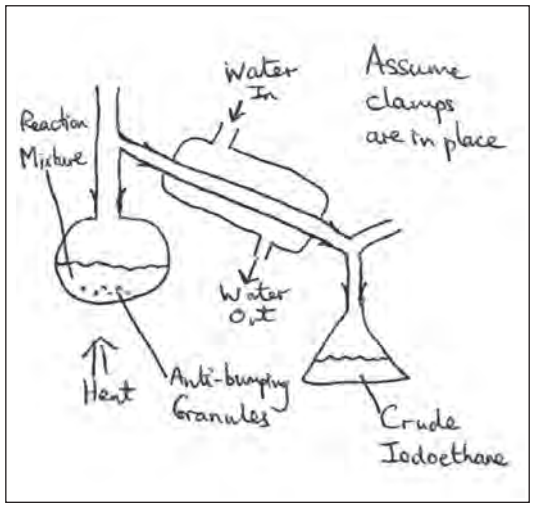
$$3CH_3CH_2OH + PI_3 \rightarrow 3CH_3CH_2I + H_3PO_3$$

(a) What does the way in which ethanol is added in **step 2** suggest about the nature of the reaction?

(1)

.....

(b) A student drew a diagram of the apparatus used in **step 5**. There are a number of errors in the diagram.



(i) One of the errors is that the flow of water in the condenser is the wrong way round. Explain the effect of this error.

(1)

.....

.....

(ii) Identify the most significant error in the diagram and explain the effect of this.

(1)

Error .....

Effect .....

.....

.....

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(c) Suggest why, in **step 6**, the crude iodoethane is washed with dilute sodium carbonate solution.

(1)

.....

.....

(d) Draw a diagram of the apparatus that would be used in **step 7** to separate the iodoethane. Name the apparatus and label its contents.

The density of iodoethane is 1.5 g cm^{-3} and the density of the aqueous solution is about 1.0 g cm^{-3}.

(3)

Name of apparatus.....

Diagram

(e) How will the appearance of the iodoethane be changed by the addition of anhydrous calcium chloride in **step 8**?

(1)

.....

.....

(f) How would the iodoethane be separated from the calcium chloride after **step 8**?

(1)

.....

.....

(g) To obtain pure iodoethane, one further step in the preparation is needed. What is this step?

(1)

.....

(h) It is not possible to effectively produce iodoethane by reacting ethanol with a mixture of sodium iodide and 50% sulfuric acid. This is because the sulfur in the sulfuric acid can be reduced to form substances such as hydrogen sulfide and sulfur.

State what happens to the iodide ions in the sodium iodide when this occurs.

(1)

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.....

(Total for Question 5 = 11 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

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Mark Scheme (Results)

January 2016

Pearson Edexcel International Advanced Level in Chemistry (WCH03) Paper 01 – Chemistry Laboratory Skills I

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1(a)	**A** Nichrome / Nickel-Chromium /Platinum / Pt (wire) **(1)** **B** (Concentrated) HCl(aq)/ (Concentrated) hydrochloric acid **(1)** ALLOW Just 'HCl' Dilute HCl/Dilute hydrochloric acid	Just" Nickel" Just "Chromium" HCl **(g)** Hydrogen chloride Any other named acids	**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)	(Group 1 cation) Lithium/Li^+ ALLOW Rubidium/Rb^+ **(1)** (Group 2 cation) Magnesium/Mg^{2+} **(1)** If the name and formula are given then both must be correct If two ions are given for one cation both must be correct Penalise omission of / incorrect charges on symbols once only Standalone marks	Li Rb Mg	**2**

Question Number	Acceptable Answers	Reject	Mark
1(c)(i)	Effervescence/Fizzing/Bubbles IGNORE Gas / carbon dioxide / CO_2 given off	Reference to any colour Fumes	1

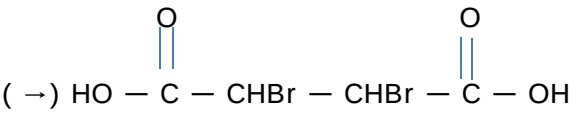
Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	Hydrogencarbonate/HCO_3^- **(1)** If the name and formula are given then both must be correct ALLOW Sulfite/sulfate(IV)/SO_3^{2-}/ Thiosulfate/$S_2O_3^{2-}$/ Sulfide/S^{2-}	 Sulfate / Sulfate(VI)/ SO_4^{2-}	1

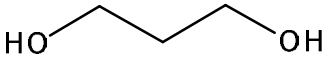
Question Number	Acceptable Answers	Reject	Mark
1(c)(iii)	$MgSO_4$ ALLOW any Group 2 sulfate **(1)** Li_2SO_4 /Rb_2SO_4 ALLOW any Group 1 sulfate **(1)** Salts can be in either order IGNORE Names Sulfites/ SO_3^{2-} /Sulfate/SO_4^{2-} with incorrect cations or formulae scores (1)		2

(TOTAL FOR QUESTION 1 = 8 MARKS)

Question Number	Acceptable Answers	Reject	Mark
2(a)(i)	Rate of reaction between **solids** is slow OR Difficult for two **solids** to react easily ALLOW Both (acid(s) and reagent) are **solid** IGNORE reference to any need for heating	"Dissolves" for "reacts"	1

Question Number	Acceptable Answers	Reject	Mark
2(a)(ii)	**Marking point 1** Sodium/potassium carbonate **and** solution/aqueous/water OR Sodium/potassium hydrogencarbonate **and** solution/aqueous/water **(1)** **Marking point 2** Effervescence/Fizzing/Bubbles **(1)** **MP2** conditional on **MP1** ALLOW **MP2** for effervescence etc. for any carbonate/hydrogencarbonate given as reagent OR **Marking point 1** Named alcohol + named strong acid **(1)** **Marking point 2** Fruity smell **(1)** **MP2** conditional on **MP1**	Sodium/Na Indicators	2

Question Number	Acceptable Answers	Reject	Mark
2(b)	 (→) HO — C — CHBr — CHBr — C — OH OR Displayed formula IGNORE Position of the bond to the hydrogen of the OH group	Additional products	1

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	 Ignore bond lengths, bond angles, and bond between O and H	Bond clearly to the hydrogen of the OH group e.g. –HO	1

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	Peak/Absorption/Absorbance/Trough for C=O (only) present in propanedioic acid infrared spectrum ALLOW Peak/Absorption/Absorbance/Trough for C=O absent from propane-1,3-diol infrared spectrum OR O-H peak/absorption/trough for carboxylic acid has a different wavenumber to that for the alcohol OR Different fingerprint region	Line	1

(TOTAL FOR QUESTION 2 = 6 MARKS)

Question Number	Acceptable Answers	Reject	Mark
3(a)	To avoid (loss of solid due to) 'spitting' ALLOW To prevent loss of solid/reactant IGNORE reference to water vapour	Spillage Removal of impurities	1

Question Number	Acceptable Answers	Reject	Mark
3(b)	Heat to constant mass/weight IGNORE Keep heating until .... no more steam/misty fumes are given off OR there is no further reaction OR the crystals turn to powder		1

Question Number	Acceptable Answers	Reject	Mark
3(c)	Anhydrous (sodium carbonate)	Dry/Dehydrated	1

Question Number	Acceptable Answers	Reject	Mark
3(d)(i)	**Additional Comments** **Throughout 3d,** **correct answers score full marks** **and** **ignore SF (including 1SF)** **and** **penalise incorrect units once only** (M_r Na_2CO_3=) 2x23 + 12 + 3x16 / 106 (g mol^{-1}) **(1)** (1.06 ÷ 106 =) 0.01/ 1.0 x 10^{-2} (mol) **(1)** TE for incorrect M_r		2

Question Number	Acceptable Answers	Reject	Mark
3(d)(ii)	(m= 2.50 – 1.06 = 1.44(g) n = 1.44 ÷18=) 0.08 (mol)		1

Question Number	Acceptable Answers	Reject	Mark
3(d)(iii)	(0.08 ÷ 0.01 =) 8 TE from (d)(i) and (d)(ii)		1

Question Number	Acceptable Answers	Reject	Mark
3(e)	Washings/Rinsing (from the beaker) should have been transferred to the volumetric flask		1

Question Number	Acceptable Answers	Reject	Mark
3(f)	Titration 1 is not concordant/a range finder/ an overshot/ an outlier/a trial /only a 'rough'/ more than 0.2 cm^3 from the other 2 titres IGNORE Inaccurate OR (Titrations 2 and 3) are within 0.1/0.2 cm^3/concordant IGNORE More accurate		1

Question Number	Acceptable Answers	Reject	Mark
3(g)(i)	**Throughout 3g ignore SF except 1SF** (Mean titre = 16.5 cm^3/ 0.0165 dm^3) n=(0.10 x 0.0165=) 1.65 x 10^{-3}/0.00165 (mol) Correct answer with no working scores (1) No TE on incorrect mean		1

Question Number	Acceptable Answers	Reject	Mark
3(g)(ii)	n=(1.65 x 10^{-3} ÷ 2=) 8.25 x 10^{-4}/0.000825 (mol) TE Ans to (g) ÷ 2		1

Question Number	Acceptable Answers	Reject	Mark
3(g)(iii)	n(8.25 x 10^{-4} x 10=) 8.25 x 10^{-3}/0.00825 (mol) TE Ans to (g)(ii) x 10		1

Question Number	Acceptable Answers	Reject	Mark
3(g)(iv)	M_r=(2.50 ÷ 8.25 x 10^{-3} =) 303.03 **(1)** (303.03 -106 = 197.03 then 197.03 ÷ 18=) (x =) 10.946/10.95/10.9/11 **(1)** Alternative Methods M_r = 106 + 18x Mass = (8.25 x 10^{-3}) x M_r = 0.8745 + 0.1485x **(1)** 2.50 = 0.8745 + 0.1485x X=(2.50-0.8745) ÷ 0.1485 = 10.946 **(1)** OR Mass Na_2CO_3 = 8.25x10^{-3} x106 = 0.8745(g) Mass H_2O = 2.5 – 0.8745 = 1.6255 **(1)** Mol H_2O = 1,6255÷18 = 0.0903 X = 0.0903÷ 8.25x10^{-3} = 10.946 **(1)** TE from previous answers Correct final answer with/without working scores (2)		2

Question Number	Acceptable Answers	Reject	Mark
3(h)	**Marking point 1** The number of moles of sodium carbonate would be too large **OR** the molar mass of hydrated salt would be too small **(1)** **Marking point 2** Hence the value of x would be too small/low **(1)** MP2 is **not** standalone and may be awarded only if one or other of the statements for the first mark is given No TE on incorrect MP1		2

(TOTAL FOR QUESTION 3 = 16 MARKS)

Question Number	Acceptable Answers	Reject	Mark
4(a)(i)	**Additional Comment** **For parts (i), (ii),** **correct answers score full marks** **and** **ignore SF (except 1SF)** **and** **penalise incorrect units once only** **and** **penalise incorrect rounding once only** (energy = 50.0 x 4.18 x 4.7 =) 982.3 (J) /982 ALLOW 0.9823 **kJ** IGNORE any sign		1

Question Number	Acceptable Answers	Reject	Mark
4(a)(ii)	(n = 2.54 ÷ 123.5 =) 0.0206/0.0205668 (mol)		1

Question Number	Acceptable Answers	Reject	Mark
4(a)(iii)	ΔH = (0.9823 ÷ 0.0205668 =) 47.76144 (kJ mol^{-1}) **(1)** −47.8 (kJ mol^{-1}) **(1)** Sign and 3 SF required for second mark TE on ans (a)(i) ÷ ans (a)(ii)		2

Question Number	Acceptable Answers	Reject	Mark
4(a)(iv)	To ensure that enthalpy change is per mol of copper(II) carbonate OR So that the limiting factor is the mass of copper(II) carbonate ALLOW To ensure all copper(II) carbonate reacts IGNORE To ensure the reaction goes to completion OR So sulfuric acid is not a limiting factor		1

Question Number	Acceptable Answers	Reject	Mark
4(a)(v)	Heat loss OR Heat capacity of apparatus is not negligible ALLOW Copper(II) carbonate contains copper(II) hydroxide OR Specific heat capacity of solution is not 4.18 IGNORE Non-standard conditions/ Just impurities	Incomplete reaction By-products Side reactions	1

Question Number	Acceptable Answers	Reject	Mark
4(b)	$\Delta H_3 = \Delta H_4 - \Delta H_5$ **(1)** ΔH_3 = –47.8 – –56.1 = + 8.3 (kJ mol^{-1}) OR ΔH_3 = –47.7 – –56.1 = + 8.4 (kJ mol^{-1}) **(1)** Answer alone scores (2) IGNORE SF TE on 4(a)(iii) No TE on incorrect Hess' Law		2

Question Number	Acceptable Answers	Reject	Mark
4(c)	Difficult to measure heat absorbed when heating any substance OR Difficult to measure the temperature (change) of a solid OR Difficult to measure the temperature change when heating	Just 'it's endothermic'	1

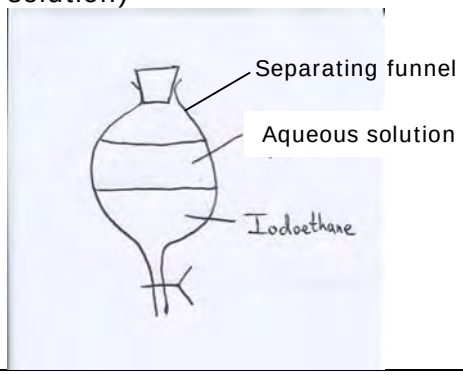
(TOTAL FOR QUESTION 4 = 9 MARKS)

Question Number	Acceptable Answers	Reject	Mark
5(a)	Reaction is (extremely) exothermic IGNORE Vigorous Violent Reactive Dangerous Explosive		1

Question Number	Acceptable Answers	Reject	Mark
5(b)(i)	Condenser doesn't fill properly/airlock forms ALLOW inefficient condensation/inefficient cooling/air bubbles form IGNORE Reference to the time taken for condensation	No condensation	1

Question Number	Acceptable Answers	Reject	Mark
5(b)(ii)	(Error) (left hand side of apparatus) open at the top / no stopper at the top **and** (Effect) (vapours of) iodoethane / product / reaction mixture will escape ALLOW "evaporate" for "escape" IGNORE Gas(es) / fumes will escape Reactants /ethanol escaping References to missing thermometer		1

Question Number	Acceptable Answers	Reject	Mark
5(c)	Remove/Neutralize/React with phosphoric acid/ H_3PO_3 ALLOW Remove/Neutralize/React with HI/acid IGNORE References to "excess" (acid)	Any other specific acid	1

Question Number	Acceptable Answers	Reject	Mark
5(d)	**All marks standalone** **Marking point 1** Separating funnel/ tap funnel/ dropping funnel **(1)** **Marking point 2** Diagram of a funnel with tap **and** stopper OR Diagram of a funnel with tap **and** a definite neck capable of taking a stopper **(1)** **Marking point 3** Two layers with lower layer labelled as iodoethane **and** top layer as aqueous solution) **(1)** 	Filter funnel with or without stopper	3

Question Number	Acceptable Answers	Reject	Mark
5(e)	Go clear/cloudiness will disappear ALLOW Less cloudy IGNORE colourless	Any specified colour	1

Question Number	Acceptable Answers	Reject	Mark
5(f)	Decanted/poured off/(teat) pipette/ filtered through glass wool IGNORE Just “filtered”		1

Question Number	Acceptable Answers	Reject	Mark
5(g)	(re)distillation ALLOW Fractional distillation IGNORE references to a specified temperature range		1

Question Number	Acceptable Answers	Reject	Mark
5(h)	(Iodide ions) are oxidized and (form iodine) ALLOW (Iodide ions) turn into iodine IGNORE references to the colour or state of the iodine product		1

(TOTAL FOR QUESTION 5 = 11 MARKS)

(TOTAL FOR PAPER = 50 MARKS)

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Write your name here

Surname	Other names

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Advanced Level

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Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Tuesday 10 May 2016 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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5/5/5/5/1/

P 4 6 6 6 3 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 Some tests are carried out on an inorganic compound **A**. Compound **A** is anhydrous and has one cation and one anion.

(a) Compound **A** gives a lilac colour in a flame test.

(i) Describe how to carry out a flame test.

(3)

(ii) Identify, by name or formula, the cation present in **A**.

(1)

(b) When a sample of solid **A** is placed in a test tube and heated, a gas and a vapour are evolved. The gas turns lime water cloudy and the vapour is identified as water.

(i) Identify the gas evolved.

(1)

(ii) Give a test for the **presence** of water. State the positive result of the test.

(2)

Test .....

Result .....

(c) (i) Identify, by name or formula, the anion present in **A**.

(1)

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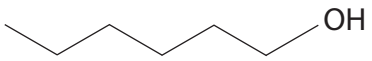
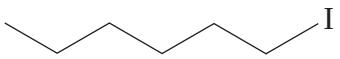
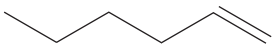
(ii) Write the equation for the action of heat on **A**.
Include state symbols in your equation.

(2)

(Total for Question 1 = 10 marks)

2 The skeletal formulae of three organic compounds, **E**, **F** and **G**, are shown in the table.

E	
F	
G	

(a) Name compound **E**.

(1)

.....

(b) Give a chemical test and its result that could be used to show the presence of the OH group in **E**.

(2)

Test .....

Result .....

.....

(c) Give a chemical test and its result that could be used to show the presence of the iodine atom in **F**.

(2)

Test .....

.....

Result .....

.....

(d) A few drops of **G** are shaken with 2 cm^3 of a dilute aqueous solution of potassium manganate(VII) acidified with dilute sulfuric acid.

(i) State the colour change that occurs in this reaction.

(1)

From ..... to .....

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(ii) Draw the **skeletal** formula of the organic product of this reaction.

(1)

(e) State the reagent and give the essential conditions for the conversion of **F** to **G**.

(2)

Reagent .....

Conditions .....

.....

(f) A student attempted to convert **G** to **F** using a standard method involving the addition of hydrogen iodide, HI, prepared *in situ*. However, very little of **F** was formed.

(i) Draw the structure of the **major** product obtained by the student.

(1)

(ii) Explain, by referring to the intermediate in the mechanism of the reaction, why **F** is only a minor product.

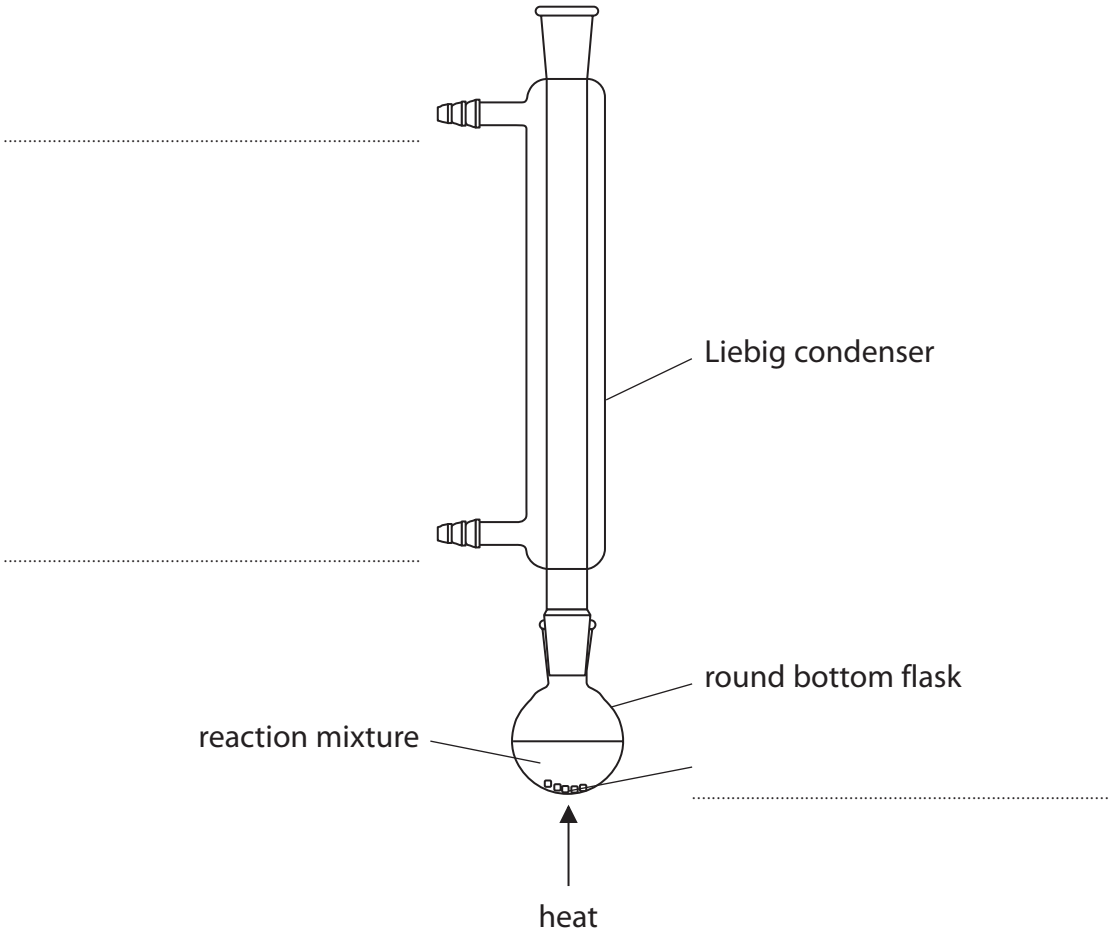
(1)

.....

.....

.....

(g) Compound **E** may be oxidized with potassium dichromate(VI) acidified with sulfuric acid, using the apparatus shown below. For clarity, clamps, stands and rubber tubing have been omitted from the diagram.



(i) Complete the labelling of this diagram.

(2)

(ii) Name the technique that is carried out using this apparatus.

(1)

(iii) Explain how the Liebig condenser works and its purpose in the apparatus shown.

(2)

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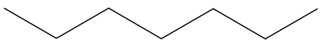
(h) Oxidation of **E** can result in the formation of an aldehyde or a carboxylic acid.

E	

(i) Give the skeletal or displayed formulae of these products.

(2)

Aldehyde

Carboxylic acid

(ii) By considering the bonds in these two products, explain how infrared spectroscopy can be used to distinguish between them. You are **not** expected to give specific wavenumbers.

(1)

.....

.....

.....

(i) The carboxylic acid produced by the oxidation of **E** is an oily liquid which boils at 206 °C. The carboxylic acid may be obtained from the reaction mixture by distillation.

(i) Name the **three** additional pieces of apparatus, apart from clamps and stands, which are essential to convert the apparatus shown at the start of part (g) for distillation.

(3)

1. .....

2. .....

3. .....

(ii) Suggest a suitable temperature range over which to collect the carboxylic acid distillate.

(1)

.....

(iii) The distillate contains a trace of water. Suggest a drying agent that could be used to remove this.

(1)

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(Total for Question 2 = 24 marks)

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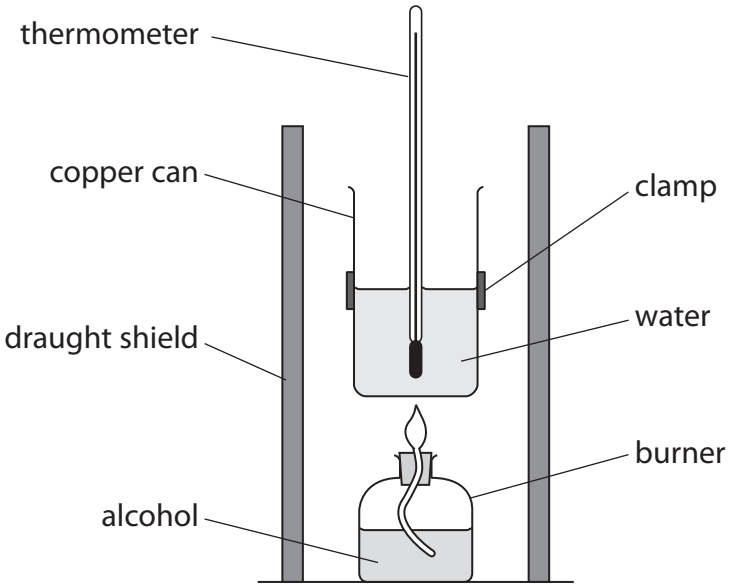
3 The apparatus below was used in a series of experiments by a group of students to determine the enthalpy change of combustion of some alcohols.



(a) In the experiment to determine the enthalpy change of combustion of CH_3OH, one student obtained the following results.

Measurement	Value
Mass of copper can / g	300.00
Mass of copper can + water / g	700.00
Mass of burner + CH_3OH (start) / g	151.65
Mass of burner + CH_3OH (finish) / g	150.00
Temperature of water (start) / °C	21.5
Temperature of water (finish) / °C	33.5

Data

Specific heat capacity of copper = 0.39 J g^{-1} $°C^{-1}$
Specific heat capacity of water = 4.2 J g^{-1} $°C^{-1}$

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(i) Calculate the heat energy transferred. Use the expression

heat energy transferred / J = [(0.39 × mass of copper can) + (4.2 × mass of water)] × temperature rise

(2)

(ii) Use your answer from (a)(i) to calculate the enthalpy change of combustion of CH_3OH.

Give your answer in kJ mol^{-1} and include the appropriate sign.

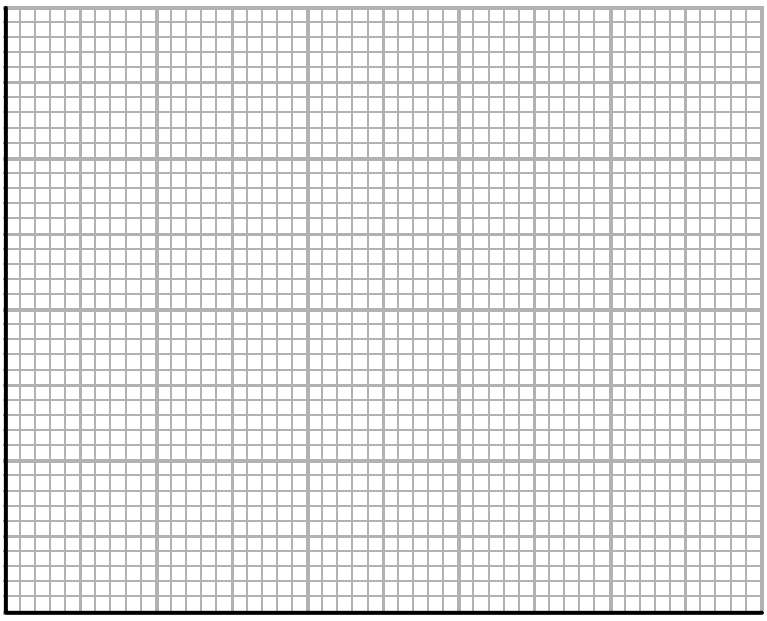
(3)

(b) The mean values obtained by the students were collected in a table.

Alcohol	(–) Enthalpy change of combustion / kJ mol^{-1}
CH_3OH	450
C_2H_5OH	800
C_3H_7OH	No value obtained
C_4H_9OH	1600
$C_5H_{11}OH$	2000

(i) Label the axes below and plot a graph of (the magnitude of) the enthalpy change of combustion (on the vertical axis) against the number of carbon atoms in the alcohol (on the horizontal axis).

(2)



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(ii) Use your graph to estimate the enthalpy change of combustion of C_3H_7OH.

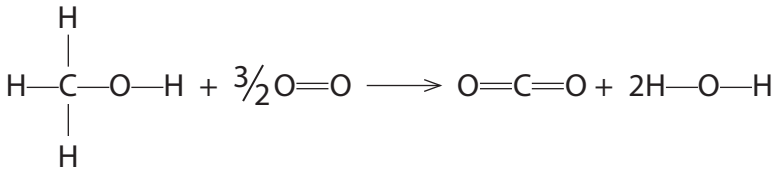
(1)

.....

(iii) By considering the combustion equations for the alcohols, explain the trend shown by the graph in terms of the bond changes.

The equation for the combustion of CH_3OH is given below; you are **not** expected to write any other equations.

(2)



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(c) The students then compared their results to the values in the Data Booklet. They found that the magnitudes were consistently much smaller; for example, the Data Booklet value for C_2H_5OH is –1367.3 kJ mol^{-1}.

The students suggested a number of possible explanations for the discrepancy:

I uncertainties in the measurement of mass and temperature

II the values used for the specific heat capacities of copper (0.39 J g^{-1} K^{-1}) and water (4.2 J g^{-1} K^{-1}) are rounded (from 0.385 and 4.18 J g^{-1} K^{-1})

III heat losses to the surroundings

IV incomplete combustion of the alcohols

(i) Calculate the percentage error in the students' mean value for the enthalpy change for combustion of C_2H_5OH compared with the Data Booklet value. Give your answer to **two** significant figures.

(2)

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(ii) By considering your answer to (c)(i), evaluate the validity of each of the four reasons that the students put forward to explain the discrepancies between their values and those in the Data Booklet.

(4)

Suggestion I .....

Suggestion II .....

Suggestion III .....

Suggestion IV .....

(Total for Question 3 = 16 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
																	4.0 **He** helium 2
(1)	(2)		Key				1.0 **H** hydrogen 1					(13)	(14)	(15)	(16)	(17)	
6.9 **Li** lithium 3	9.0 **Be** beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									10.8 **B** boron 5	12.0 **C** carbon 6	14.0 **N** nitrogen 7	16.0 **O** oxygen 8	19.0 **F** fluorine 9	20.2 **Ne** neon 10
23.0 **Na** sodium 11	24.3 **Mg** magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 **Al** aluminium 13	28.1 **Si** silicon 14	31.0 **P** phosphorus 15	32.1 **S** sulfur 16	35.5 **Cl** chlorine 17	39.9 **Ar** argon 18
39.1 **K** potassium 19	40.1 **Ca** calcium 20	45.0 **Sc** scandium 21	47.9 **Ti** titanium 22	50.9 **V** vanadium 23	52.0 **Cr** chromium 24	54.9 **Mn** manganese 25	55.8 **Fe** iron 26	58.9 **Co** cobalt 27	58.7 **Ni** nickel 28	63.5 **Cu** copper 29	65.4 **Zn** zinc 30	69.7 **Ga** gallium 31	72.6 **Ge** germanium 32	74.9 **As** arsenic 33	79.0 **Se** selenium 34	79.9 **Br** bromine 35	83.8 **Kr** krypton 36
85.5 **Rb** rubidium 37	87.6 **Sr** strontium 38	88.9 **Y** yttrium 39	91.2 **Zr** zirconium 40	92.9 **Nb** niobium 41	95.9 **Mo** molybdenum 42	[98] **Tc** technetium 43	101.1 **Ru** ruthenium 44	102.9 **Rh** rhodium 45	106.4 **Pd** palladium 46	107.9 **Ag** silver 47	112.4 **Cd** cadmium 48	114.8 **In** indium 49	118.7 **Sn** tin 50	121.8 **Sb** antimony 51	127.6 **Te** tellurium 52	126.9 **I** iodine 53	131.3 **Xe** xenon 54
132.9 **Cs** caesium 55	137.3 **Ba** barium 56	138.9 **La*** lanthanum 57	178.5 **Hf** hafnium 72	180.9 **Ta** tantalum 73	183.8 **W** tungsten 74	186.2 **Re** rhenium 75	190.2 **Os** osmium 76	192.2 **Ir** iridium 77	195.1 **Pt** platinum 78	197.0 **Au** gold 79	200.6 **Hg** mercury 80	204.4 **Tl** thallium 81	207.2 **Pb** lead 82	209.0 **Bi** bismuth 83	[209] **Po** polonium 84	[210] **At** astatine 85	[222] **Rn** radon 86
[223] **Fr** francium 87	[226] **Ra** radium 88	[227] **Ac*** actinium 89	[261] **Rf** rutherfordium 104	[262] **Db** dubnium 105	[266] **Sg** seaborgium 106	[264] **Bh** bohrium 107	[277] **Hs** hassium 108	[268] **Mt** meitnerium 109	[271] **Ds** darmstadtium 110	[272] **Rg** roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 **Ce** cerium 58	141 **Pr** praseodymium 59	144 **Nd** neodymium 60	[147] **Pm** promethium 61	150 **Sm** samarium 62	152 **Eu** europium 63	157 **Gd** gadolinium 64	159 **Tb** terbium 65	163 **Dy** dysprosium 66	165 **Ho** holmium 67	167 **Er** erbium 68	169 **Tm** thulium 69	173 **Yb** ytterbium 70	175 **Lu** lutetium 71
232 **Th** thorium 90	[231] **Pa** protactinium 91	238 **U** uranium 92	[237] **Np** neptunium 93	[242] **Pu** plutonium 94	[243] **Am** americium 95	[247] **Cm** curium 96	[245] **Bk** berkelium 97	[251] **Cf** californium 98	[254] **Es** einsteinium 99	[253] **Fm** fermium 100	[256] **Md** mendelevium 101	[254] **No** nobelium 102	[257] **Lr** lawrencium 103

* Lanthanide series

* Actinide series

P 4 6 6 6 3 A 0 1 6 1 6

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Mark Scheme (Results)

Summer 2016

Pearson Edexcel
International Advanced Level
in Chemistry (WCH03) Paper 01
Chemistry Laboratory Skills I

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answer	Reject	Mark
1(a)(i)	**MP1 and MP2** Dip (clean) nichrome / platinum wire ALLOW NiCr for nichrome loop / rod for wire OR Silica rod (1) in (concentrated) hydrochloric acid / HCl(aq) ALLOW any mention of HCl(aq) e.g. cleaning or mixing solid and acid or making a paste HCl for HCl(aq) (1) IGNORE Dilute ALLOW (for MP1 and MP2) (Wooden) splint (in place of a wire) and Soaked in distilled / deionised water (2) **MP3** then dipped in solid **and** placed in (hot / roaring / blue-cone) (Bunsen) **flame** ALLOW salt / compound / substance / paste / solution for 'solid' On / over / under / near / show / above for 'in' (1) IGNORE inoculating / flame-test (wire)	Nickel / chrome / chromium spatula Other acids Just 'water' Just 'Bunsen'	**(3)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(ii)	K^+ OR Potassium (ion)	K	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(i)	Carbon dioxide / CO_2		**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(ii)	MP2 dependent on MP1 Cobalt chloride / $CoCl_2$ (paper) (1) Turns (from blue to) pink ALLOW Turns red (1) OR Anhydrous copper(II) sulfate / $CuSO_4$ (1) Turns (from white to) blue (1) ALLOW copper(II) sulfate / $CuSO_4$ (1) Turns from white **and** to blue (1)	Boiling temperature	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(c)(i)	Hydrogencarbonate / HCO_3^- ALLOW Hydrogen carbonate Bicarbonate potassium hydrogencarbonate / $KHCO_3$	Carbonate / CO_3^{2-}	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(c)(ii)	$2KHCO_3(s) \rightarrow K_2CO_3(s) + H_2O(l) + CO_2(g)$ Correct species (1) Balanced & states (1) ALLOW $H_2O(g)$ $2KHCO_3(s) \rightarrow K_2O(s) + H_2O(l) + 2CO_2(g)$ scores (1) TE on cation in (a)(ii) If a hydrated Group 2 carbonate or lithium carbonate is used, correct balanced equation scores (1) No TE on a incorrect anion in (c)(i)	Anhydrous carbonate (scores (0))	**(2)**

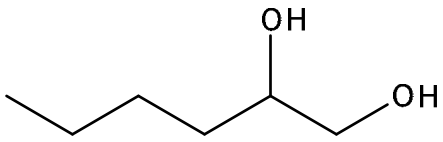
Total for Question 1 = 10 marks

Question Number	Acceptable Answer	Reject	Mark
2(a)	Hexan-1-ol ALLOW Hexane-1-ol / 1-Hexanol If two or more names are given, all must be correct	Hexanol Hexen-1-ol Hexa-1-ol Hex-1-ol	**(1)**

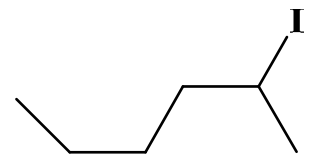
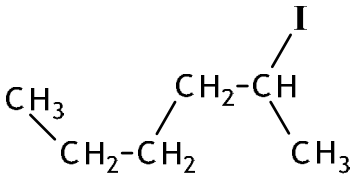
Question Number	Acceptable Answer	Reject	Mark
2(b)	Any test (1) corresponding result (1) MP2 dependent on MP1 **Test** / **Result** Add phosphorus(V) chloride / phosphorus pentachloride / PCl_5 → Steamy / misty / white fumes OR White smoke **and** with ammonia Add thionyl chloride / $SOCl_2$ → Steamy / misty / white fumes Add sodium / Na → Effervescence / bubbling / fizzing IGNORE white solid formed sodium dissolved Add ethanoic acid and a mineral acid and warm → Sweet / fruity / pear drops smell ALLOW PCl_5 solution, unless unsuitable solvent (e.g. water) when max 1 (for result) ALLOW for 1 mark **Acidified** sodium or potassium dichromate((VI)) / $Na_2Cr_2O_7$ / $K_2Cr_2O_7$ turns from orange to green / blue If product is tested, test and result must be fully correct	Phosphorus(III) chloride / phosphorus trichloride / PCl_3 Just smoke Smoke Just $Na_2Cr_2O_7$ / $K_2Cr_2O_7$ (no acid)	**(2)**

Question Number	Acceptable Answer	Reject	Mark
2(c)	MP2 dependent on mention of silver nitrate **First mark** Add (aqueous ethanol solution of) silver nitrate / $AgNO_3$ (and nitric acid) OR Add NaOH, (then) HNO_3 and (followed by) silver nitrate / $AgNO_3$ (1) **Second mark** Yellow precipitate ALLOW Yellow solid / crystals (1) IGNORE Heat Addition of ammonia to precipitate If product is tested, test and result must be fully correct	Other acids Other acids Just 'turns yellow' Tests for iodine (scores (0))	**(2)**

Question Number	Acceptable Answer	Reject	Mark
2(d)(i)	From pink / purple to colourless IGNORE clear dark	Red	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(d)(ii)	 Penalise bond to OH only when it is clearly to the H atom	Displayed or structural formulae H atoms on carbons of skeletal formula	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(e)	These are stand alone marks (Reagent=) potassium hydroxide / KOH ALLOW Sodium hydroxide / NaOH (1) (Conditions =) Alcoholic / ethanolic solution **and** heat / boil / reflux / warm (1) If reagent is given as alcoholic KOH / NaOH and conditions as heat, award **both** marks	additional incorrect reagents Distil	**(2)**

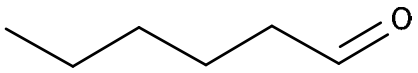
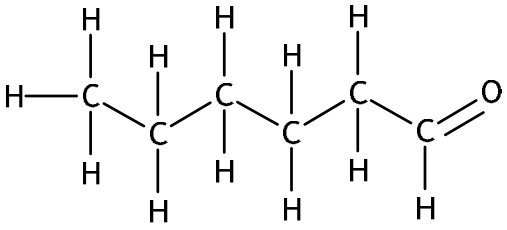
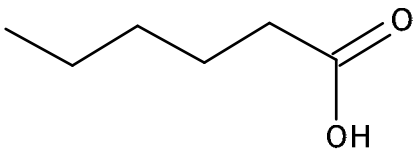
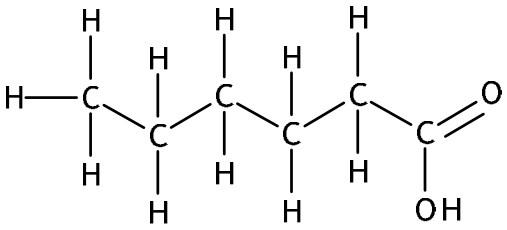
Question Number	Acceptable Answer	Reject	Mark
2(f)(i)	 OR  OR Fully displayed OR $CH_3CH_2CH_2CH_2CHICH_3$		**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(f)(ii)	Secondary **carbocation** (formed in the first step) is more stable (than the primary) (so little F forms) OR Reverse argument Intermediate ions can be shown by structural (or other) formulae IGNORE Reference to Markovnikov's Rule Secondary product is more stable	Just 'intermediate' Just 'structure' cation Just 'carbocation' more stable	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(g)(i)	Water in bottom & water out top (1) anti-bumping granules ALLOW pieces of porcelain nucleation granules glass beads anti-bumping crystals (1)	Just arrows Anti-knock	**(2)**

Question Number	Acceptable Answer	Reject	Mark
2(g)(ii)	(Heat / boil under) Reflux OR Refluxing ALLOW Reflux condenser	Any distillation Just condensing	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(g)(iii)	(Cold) **water** (passing through the condenser) (cools and) condenses the vapours /gases (rising from the reaction mixture) ALLOW Description of condensing (1) Prevents escape of reactants and products ALLOW Prevents escape of reactants / products / vapours / gases ALLOW so that the reaction / oxidation can continue to completion (1)		**(2)**

Question Number	Acceptable Answer	Reject	Mark
2(h)(i)	 ALLOW Aldehyde hydrogen shown OR  (1)  OR  (1) Both functional groups displayed and correct, but with errors on carbon chains or structural formulae used for chain scores (1)	-CHO -COH -COOH	**(2)**

Question Number	Acceptable Answer	Reject	Mark
2(h)(ii)	EITHER Aldehyde / CHO **and** carboxylic acid / COOH **groups** will have characteristic peaks / absorptions (at different wavenumbers / frequencies) OR carboxylic acid has an O–H group which absorbs at a particular frequency / O–H peak ALLOW Wavelength for wavenumber / frequency carboxylic acid has an C–O bond which absorbs at a particular frequency Different fingerprint regions IGNORE Reference to carbonyl / C=O group	**Just** reference to the bonds / groups / stretching / bending	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(i)(i)	Thermometer (1) Stillhead / (3-way) adaptor (1) Conical / Erlenmeyer / collecting flask ALLOW Delivery tube beaker test / boiling tube measuring cylinder round-bottom /pear-shaped flask (1) IGNORE Stopper Side arm tube Vented tube Condenser ALLOW Diagram with appropriate labels	Just 'flask' volumetric flask	**(3)**

Question Number	Acceptable Answer	Reject	Mark
2(i)(ii)	Lower value: any value from 200 to 205(°C) Upper value: any value from 207 to 212(°C)	Single temperature	**(1)**

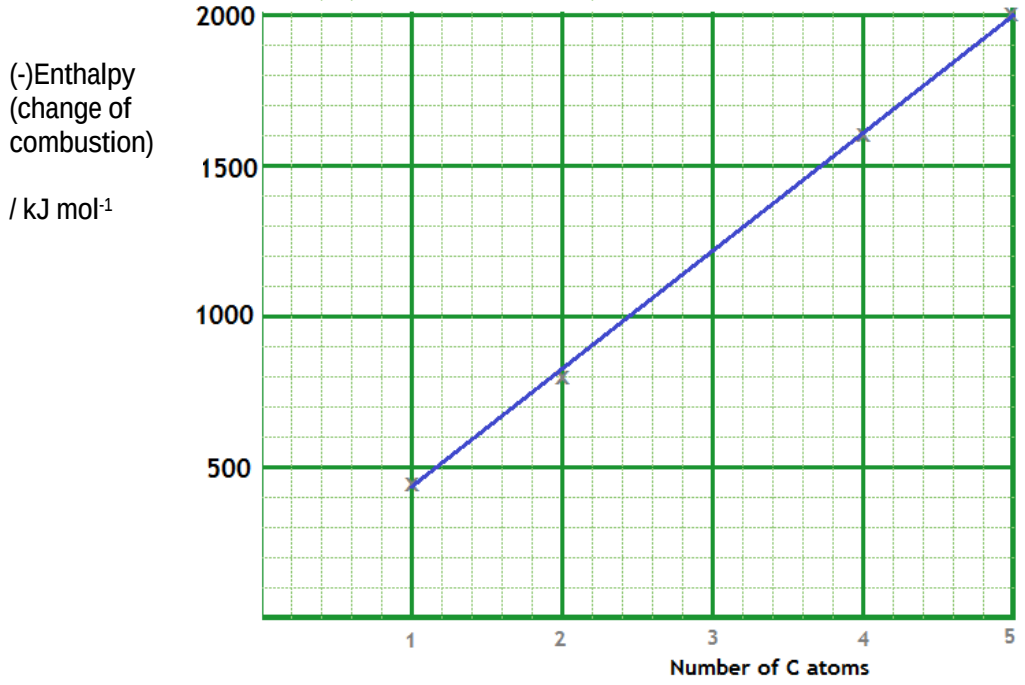
Question Number	Acceptable Answer	Reject	Mark
2(i)(iii)	(anhydrous) Calcium chloride / $CaCl_2$ OR Magnesium sulfate / $MgSO_4$ OR Sodium sulfate / Na_2SO_4 ALLOW Calcium sulfate / $CaSO_4$ If name & formula **both** must be correct	Sulfuric acid / H_2SO_4 $CuSO_4$ $CuCl_2$ Silica gel	**(1)**

Total for Question 2 = 24 marks

Question Number	Acceptable Answer	Reject	Mark
3(a)(i)	E = [(0.39 x 300) + (4.2 x 400)] x 12 (1) = 21564 (J) / 21.564 **kJ** (ans*) TE on incorrect **values** in expression ALLOW for MP2 20277(J) / 20.277 **kJ** (1) IGNORE SF except 1 SF IGNORE sign Correct answer with no working scores (2)		**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(ii)	M_r (CH_3OH) = 32 Amount methanol = 1.65/32 (ans**) (1) (= 0.05156) ΔH_c = −ans* / ans** = −21564 x 32 / 1.65 = −418211 **J mol^{-1}** = **−**418 (kJ mol^{-1}) If 20277 used ΔH_c = **−**393251 **J mol^{-1}** = **−**393 (kJ mol^{-1}) Value (1) Correct sign and units (if given) (1) TE on any value obtained in (a)(i) TE on **correctly** rounded values from (a)(i) IGNORE SF except 1 SF Correct answer with no working scores (3) If units are given for the final answer they must be fully correct	use of values rounded to 1 SF	**(3)**

Question Number	Acceptable Answer	Reject	Mark
3(b)(i)	See graph below Axes labelled including units and scale as shown or similar (1) All four points correct **and** best fit line drawn TE on axes reversed (1) ALLOW ΔH_c label with units on y-axis Graph plotted with negative enthalpy changes Formulae of alcohols on the intervals of the x-axis with or without axis label IGNORE Omission of negative sign before enthalpy of combustion Extrapolation	scale that does not use top ¼ and / or right-hand $^3/_{10}$ of the grid non-linear scales scores zero	**(2)**



Question Number	Acceptable Answer	Reject	Mark
3(b)(ii)	This mark is stand alone (−)1200 ± 50 (kJ mol^{-1}) IGNORE omission of negative sign If units are given they must be fully correct No TE on incorrect graph		**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(b)(iii)	**Marking Point 1** For each successive alcohol 1 extra C−C bond and 2 extra C−H bonds and $^3/_2$ extra O=O bonds have to be broken and 2 extra C=O bonds and 2 extra O−H bonds are formed OR The same **extra** bonds are broken and formed on each increment ALLOW As the chain length increases more bonds need to be broken but more bonds are formed. OR Each successive alcohol has an extra CH_2 group OR Each successive alcohol has two extra C-H bonds and one extra C-C bond (1) **Marking Point 2** Breaking (C−C and C−H) bonds is endothermic / requires energy **and** forming (C=O and O−H) bonds is exothermic /releases energy (1) If intermolecular forces used at any point as an explanation, max (1)		**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(i)	Correct answer with no working scores (2) % Error = 100 x (1367.3 – 800) / 1367.3 (1) = 41.4905 = 41% (1) TE for SF only on use of 800 as denominator (error = 71% (to 2SF)) IGNORE Use of negative signs on enthalpy changes (–1367.3 & –800) ± in front of answer Answer greater than 100% score zero	= 41.5 = 42%	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(c)(ii)	I. The % uncertainties in the thermometer and balance readings are very small (compared with the difference between the student mean and the Data Book value) OR The thermometer and balance reading uncertainties are random and would give values both high and low rather than consistently low II. The rounding of the specific heat capacities is small (compared with the observed differences) OR Both specific heat capacities have been rounded up so would produce larger magnitude / more negative values for the enthalpies III. Heat losses will be large…. despite the draught shield OR from flame or calorimeter or water OR because the copper can is not / should be insulated OR because the copper can does not / should have (loose fitting) lid IV. Incomplete combustion will cause significant error as there will be insufficient oxygen ALLOW 1 mark in place of **either** III **or** IV for Heat loss / incomplete combustion will result in lower magnitude / less negative enthalpy change of combustion values ALLOW Reverse arguments	Just ‘valid’ OR Just ‘invalid’ Just ‘larger’ Use of polystyrene cup Just ‘lower’	**(4)**

Total for Question 3 = 16 marks

Total for Paper = 50 marks

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Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary

Unit 3: Chemistry Laboratory Skills I

Monday 7 November 2016 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH03/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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5/6/6/6/5/

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PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A white solid, **A**, has one metal cation and an anion consisting of two or more elements.

(a) A flame test is carried out on compound **A** by mixing the solid with concentrated hydrochloric acid and using a wire to place some of the mixture formed in the hottest part of a Bunsen flame.

(i) The wire is made from a metal or an alloy. Name a suitable material for the wire and give **one** reason why this material is used.

(2)

Material .....

Reason .....

.....

(ii) Suggest **one** reason for using hydrochloric acid in this test, rather than another strong acid.

(1)

.....

.....

.....

(iii) In a flame test for solid **A**, a red colour is observed. Identify, by name or formula, one Group 1 metal ion and one Group 2 metal ion that could be present.

(2)

Group 1 metal ion .....

Group 2 metal ion .....

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(b) When solid **A** is added to water, some dissolves to form a colourless solution.

When phenolphthalein is added to this mixture, it turns pink.

When dilute hydrochloric acid is added to the mixture, the temperature increases and a colourless solution forms, but no gas is given off.

(i) Identify, by name or formula, the anion present in **A**.

(1)

.....

(ii) Write the **ionic** equation for the reaction that causes the temperature to increase. State symbols are not required.

(1)

(c) When dilute sulfuric acid is added to the solution of **A**, a white precipitate forms.

(i) Name the white precipitate.

(1)

.....

(ii) Write the **ionic** equation, including state symbols, for the formation of this precipitate.

(1)

(d) Give the formula of the white solid, **A**.

(1)

(Total for Question 1 = 10 marks)

2 **P**, **Q** and **R** are different halogenoalkanes with the general formula C_3H_7X.

(a) 2 cm^3 of ethanol is added to three test tubes in a water bath at 50 °C.

Three drops of **P** are added to the first test tube, three drops of **Q** to the second and three drops of **R** to the third.

2 cm^3 portions of aqueous silver nitrate solution are added to each test tube.

Explain why ethanol is added to each test tube.

(1)

.....

.....

.....

(b) Cream coloured precipitates form in the test tubes containing **P** and **Q**. These precipitates are **soluble** in concentrated ammonia solution.

A yellow coloured precipitate forms in the test tube which contains **R**. This precipitate is **insoluble** in concentrated ammonia solution.

Deduce the identity of the halogen present in each halogenoalkane.

(2)

P and **Q** .....

R .....

(c) The mass spectrum of **P** includes a peak at $m/e = 29$ but neither **Q** nor **R** has a peak at this value.

(i) Suggest the identity of the positive ion responsible for this peak at $m/e = 29$.

(1)

.....

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(ii) Deduce the structural formulae of the three halogenoalkanes.

(3)

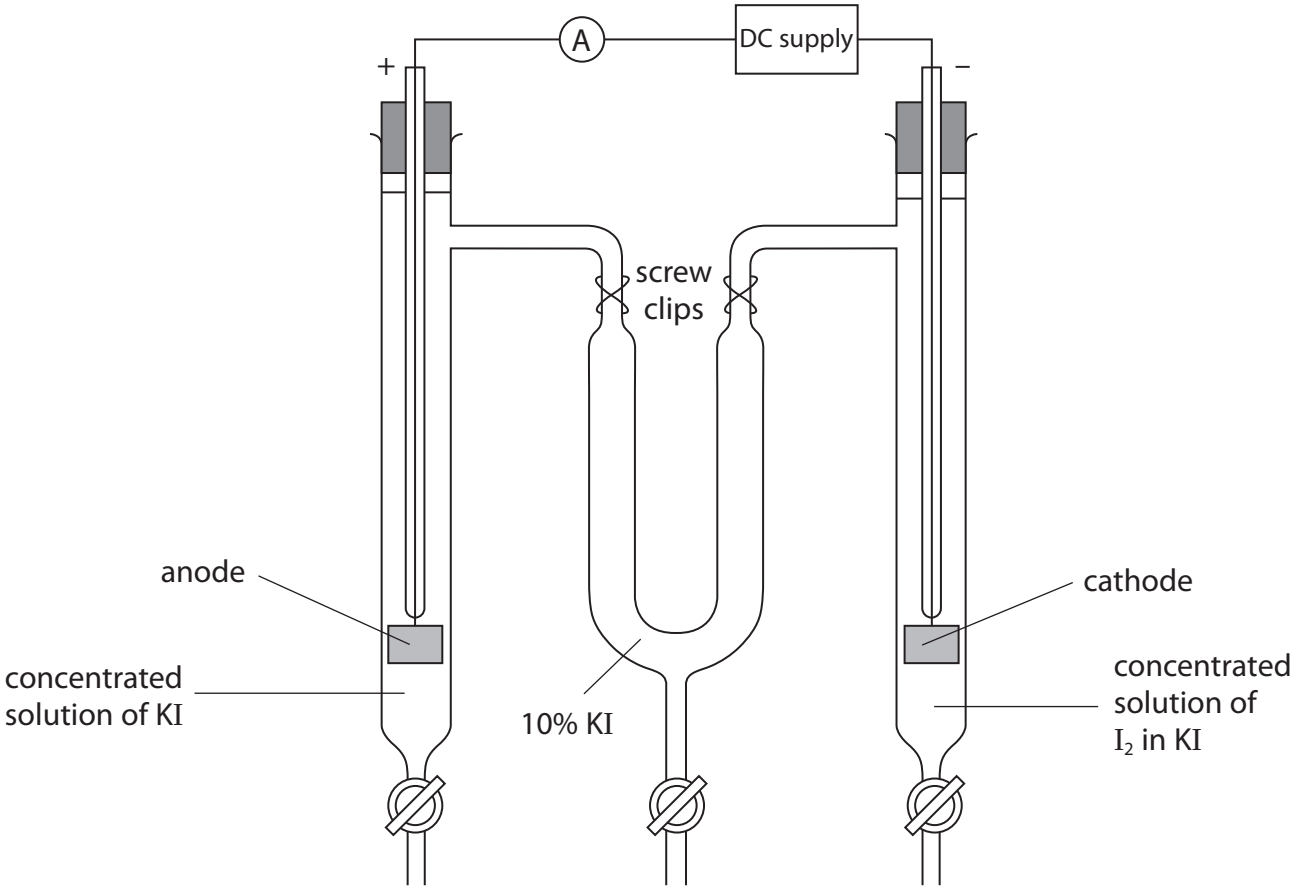
P

Q

R

(Total for Question 2 = 7 marks)

3 An iodine coulometer can be used to find the equation for the reaction between iodine and sodium thiosulfate.



An iodine coulometer

The DC supply is switched on for 15.0 minutes.

The constant current, measured by the ammeter, is 0.200 A.

The screw clips are closed, the left-hand bung is removed and the contents of the anode (positive electrode) tube are run into a 100 cm^3 volumetric flask. The tube and electrode are rinsed with a little distilled water and the washings added to the volumetric flask. The solution in the volumetric flask is made up to the mark with distilled water and mixed thoroughly.

10.0 cm^3 portions of the contents of the volumetric flask are now titrated with 0.0100 mol dm^{-3} sodium thiosulfate solution.

(a) (i) Name the indicator used for the titration, and give the colour change seen at the end-point.

(2)

Indicator .....

Colour change from ..... to .....

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(ii) State the appearance of the titration mixture just before the indicator is added.

(1)

.....

.....

(b) Calculate the number of moles of electrons transferred from the iodide ions to form iodine in the experiment. Use the expression

$$\text{number of moles of electrons} = \frac{\text{current (A)} \times \text{time (s)}}{96\,500}$$

(1)

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(c) The total volume of solution in the volumetric flask is 100 cm^3.

10.0 cm^3 portions of the mixture are titrated with 0.0100 mol dm^{-3} sodium thiosulfate solution.

The results are given in the table below.

Titration number	1	2	3	4
Second reading / cm^3	19.45	38.05	19.05	38.25
First reading / cm^3	0.00	19.45	0.00	19.55
Titre / cm^3				

(i) Complete the table.

(1)

(ii) Which result(s) should be discarded? Give a reason for your answer.

(2)

.....

.....

.....

.....

(iii) Calculate the mean titre for the remaining values.

(1)

(iv) Calculate the number of moles of thiosulfate ions in this mean titre.

(1)

(v) Calculate the number of moles of thiosulfate ions needed to react with the total amount of iodine in the 100 cm^3 of solution in the flask.

(1)

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(d) (i) Complete the ionic half-equations for the oxidation of thiosulfate ions and the oxidation of iodide ions.

(2)

$2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq)$

$2I^-(aq) \rightarrow I_2(aq)$

(ii) In part (b), you calculated the number of moles of electrons lost when the iodide ions are oxidised to form the amount of iodine in the flask.

In part (c)(v), you calculated the number of moles of thiosulfate ions required to reduce this iodine back to iodide ions.

Show that the results calculated from the two experiments are consistent with your ionic half-equations.

(1)

.....

.....

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.....

.....

(e) (i) The uncertainty in each burette reading is ±0.05 cm^3 and the uncertainty in the volume reading for the pipette is ±0.04 cm^3. Calculate the percentage uncertainties for the first burette titre and for the pipette volume of 10.0 cm^3.

(2)

Burette uncertainty = ... %

Pipette uncertainty = ... %

(ii) Explain whether these uncertainties are significant in this experiment.

(1)

.....

.....

(Total for Question 3 = 16 marks)

4 A student investigates the oxidation of the alcohol, propan-1-ol.

(a) To oxidise propan-1-ol to form propanal, the following procedure is used.

- Place about 20 cm^3 of dilute sulfuric acid in a boiling tube.
- Add about 3 g of sodium dichromate(VI) and 2–3 anti-bumping granules.
- Shake the contents of the boiling tube until the solid is fully dissolved.
- Place about 1 cm^3 of propan-1-ol in a pear-shaped flask.
- Keep the pear-shaped flask cool and slowly add the contents of the boiling tube.
- Add the apparatus needed for immediate distillation of the product.
- Gently distil the product directly from the reaction mixture.

(i) Sodium dichromate(VI) is a carcinogen.

It is often supplied as a fine powder.

Suggest the particular hazard associated with the compound being a fine powder.

Give a suitable safety precaution.

(2)

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(ii) Explain why anti-bumping granules are added and how they work.

(2)

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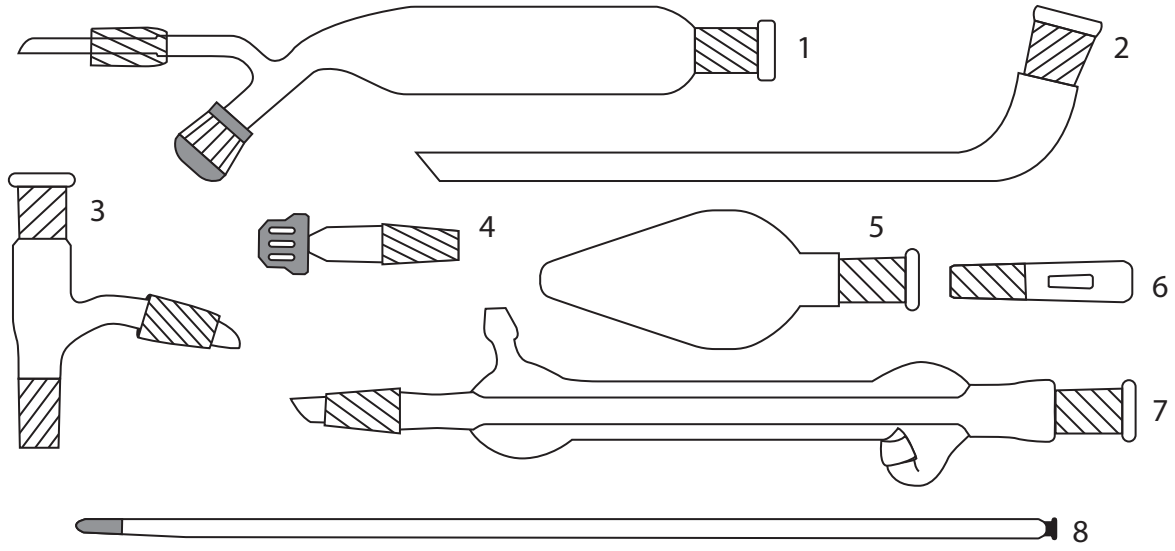
(iii) Select from the apparatus below, the apparatus you would use for distillation.



You should identify each piece of apparatus by number or name and state how you would connect them together for the preparation of propanal.

You should also name a suitable collecting vessel not shown above.

You should **not** draw a diagram.

(3)

(b) The oxidation of propan-1-ol to form propanoic acid is a reaction which involves two steps. These are heating under reflux and distillation.

Differences in the quantities and concentrations of the reactants are also involved, compared to the preparation of propanal.

(i) Give these differences in the quantities and concentrations of reactants. Precise amounts and concentrations are not required.

Justify your answer.

(2)

(ii) When carrying out the heating under reflux step, a Liebig condenser is used in the top of a pear-shaped flask.

State the direction of water flow in the reflux condenser and what will happen if the water flows in the wrong direction.

(1)

(iii) Explain why the condenser is needed in the reflux process and how it works.

(2)

(c) (i) Describe the appearance of propanal and of propanoic acid.

(1)

Propanal .....

Propanoic acid .....

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(ii) Suggest a chemical test that would positively identify the functional group of each product after purification. Give the result of each test.

(4)

Test for propanal

.....

.....

.....

Test for propanoic acid

.....

.....

.....

(Total for Question 4 = 17 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

October 2016

Pearson Edexcel International GCE in Chemistry (WCH03) Paper 1

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	**First mark** Nichrome (wire) ALLOW Recognisable spelling – nichrome/nicrome OR Platinum (wire) ALLOW Recognisable spelling – platinium Pt If both name and formula given both must be correct **(1)** **Second mark** **Depends** on **first** mark **Except** for near miss – eg nichromate/nickel/chromium (The alloy/metal is) unreactive/inert/not reactive/(very) stable/has a high melting temperature ALLOW Less reactive/low(er) reactivity No flame colour OR Does not react with HCl/air **(1)** IGNORE It can withstand the heat No impurities	 'Nichromate' Nickel/Ni OR Chromium/Cr High boiling point	2

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	Chlorides are (more) volatile Comment – ALLOW Sulfates/nitrates less volatile ALLOW (nearly all) chlorides are soluble IGNORE Other acids too reactive/oxidizing	Dissolves impurities HCl (more) volatile HCl dissolves chlorides HCl does not affect flame colour	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	Group 1: Lithium/Li^+ **(1)** IGNORE Rubidium/Rb^+ Group 2: Strontium/Sr^{2+} IGNORE Calcium/Ca^{2+} **(1)** Penalise the omission of or incorrect charge once only	Any other metal ions	2

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	Hydroxide / OH^-/^-OH ALLOW hydroxyl **ion**	OH– / –OH $O^{2-/-2}$ Carbonate/hydrogen carbonate Just 'hydroxyl'	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	$H^+ + OH^- \rightarrow H_2O$ OR $H_3O^+ + OH^- \rightarrow 2H_2O$ Ignore state symbols even if incorrect ALLOW multiples ALLOW TE from carbonate/hydrogen carbonate/oxide in 1(c)(i)		1

Question Number	Acceptable Answers	Reject	Mark
1(c)(i)	Strontium sulfate/sulphate((VI)) ALLOW $SrSO_4$ TE from calcium in (a)(iii) **No TE** from Group 1 ion in (a)(iii) here	Any other spelling of sulfate eg sulfurate $BaSO_4$	1

Question Number	Acceptable Answers	Reject	Mark
1(c)(ii)	$Sr^{2+}(aq) + SO_4^{2-}(aq) \rightarrow SrSO_4(s)$ TE from (c)(i) ALLOW TE on Li or Rb in (a)(iii) here TE for formation of $BaSO_4$ if given in 1(c)(i)	Inclusion of H^+, OH^-, and H_2O	1

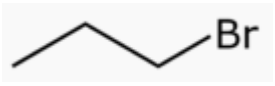
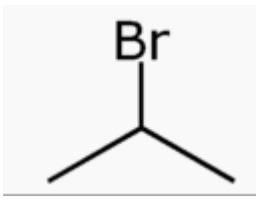
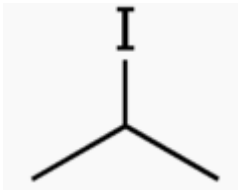
Question Number	Acceptable Answers	Reject	Mark
1(d)	$Sr(OH)_2$ TE for calcium/barium from (c)(i) TE from Li and Rb from (c)(i) ALLOW TE on oxide/carbonate/hydrogen carbonate in (b)(i)	 TE from any other anions in (b)(i)	1

(**Total for Question 1 = 10 marks)**

Question Number	Acceptable Answers	Reject	Mark
2(a)	Ethanol dissolves (both) halogenoalkanes (and silver nitrate) To allow the halogenoalkane and water/silver nitrate to mix To allow reactants to mix OR Ethanol is a **co-solvent** ALLOW Ethanol has polar and non-polar parts/is a polar and non-polar solvent/ dissolves ionic and covalent substances IGNORE Halogenoalkanes are insoluble in water	Just 'to provide the same reaction conditions' Just 'ethanol is a solvent'	1

Question Number	Acceptable Answers	Reject	Mark
2(b)	**P** and **Q** bromine/Br/C_3H_7Br/bromoalkane ALLOW AgBr **(1)** **R** iodine/I/C_3H_7I/bromoalkane ALLOW AgI **(1)** Penalise halide ion(s) only once Penalise X_2 only once	Bromine **and** chlorine	2

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	$CH_3CH_2^+$ / $C_2H_5^+$ ALLOW Structural, displayed, skeletal formulae. Allow charge anywhere on fragment, including outside brackets.	Absence of charge / $C_2H_5^-$ / C_2H_5**–** eth**ane** ion	1

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	**P** $CH_3CH_2CH_2Br$ **(1)** **Q** $CH_3CHBrCH_3$ **(1)** **R** CH_3CHICH_3 **(1)** ALLOW Displayed or skeletal formulae for any or all parts **P**  **Q**  **R**  TE for incorrect halogen(s) in 2(b) Penalise the same error in structural/displayed/skeletal formulae once only. **Special cases** **P** $CH_3CHBrCH_3$, **Q** $CH_3CH_2CH_2Br$, and **R** $CH_3CH_2CH_2I$ **(1)** **P** $CH_3CH_2CH_2Br$, **Q** $CH_3CH_2CH_2Br$, and **R** $CH_3CH_2CH_2I$ **(1)**		3

(Total for Question 2 = 7 marks)

Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	(Freshly prepared) starch (solution/indicator) ALLOW Startch **(1)** Blue-black / blue / dark blue/ black to colourless IGNORE …to clear **(1)** Mark independently	 Purple to…	2

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	Pale yellow/straw coloured	Brown/yellow/brown-yellow/tawny	1

In 3(b) to (d)(ii)

Penalise rounding errors **only once**

Penalise 1 SF **only once**

(Both may be penalised)

Question Number	Acceptable Answers	Reject	Mark
3(b)	**Fully scroll down answer** Number of moles of electrons $= \frac{0.2 \times 15 \times 60}{96\,500}$ $= 1.865 \times 10^{-3}$ / 0.001865 (mol) Correct answer with no working scores 1 IGNORE SF except 1SF IGNORE electrons for units		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	19.45 18.6(0) 19.05 18.7(0) (cm^3)		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	**Method 1** Titres/results/runs 1 **and** 3 should be discarded **(1)** as they are not concordant/within (±) 0.2 cm^3 IGNORE The(ir) first reading is zero OR Reading(s) too far from the others **(1)** **Method 2** Run 1 as rangefinder/rough **(1)** Run 2 as not concordant / within (±) 0.2 cm^3 **(1)** **Use method giving higher mark**		2

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	18.65/18.7 (cm^3) ALLOW TE from (i) and (ii) Runs 2, 3, 4 give 18.783/18.78/18.8 Runs 1, 3, 4 give 19.067/19.07/19.1 Runs 3, 4 give 18.875/ 18.88/ 18.9	18.6 19.06 18.87	1

Question Number	Acceptable Answers	Reject	Mark
3(c)(iv)	$\frac{18.65 \times 0.0100}{1000}$ = 1.865×10^{-4} / 0.0001865 (mol) TE from (iii)		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(v)	$1.865 \times 10^{-4} \times 100/10$ $= 1.865 \times 10^{-3}$ / 0.001865(mol) TE from (iv)		1

Question Number	Acceptable Answers	Reject	Mark
3(d)(i)	$2S_2O_3^{2-}(aq) \rightarrow S_4O_6^{2-}(aq) + 2e(-)$ **(1)** $2I^-(aq) \rightarrow I_2(aq) + 2e(-)$ **(1)** **OR** $2S_2O_3^{2-}(aq) - 2e(-) \rightarrow S_4O_6^{2-}(aq)$ **(1)** $2I^-(aq) - 2e(-) \rightarrow I_2(aq)$ **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
3(d)(ii)	1.865×10^{-3} / 0.001865 (mol) of electrons… lost/gained/equals/reacts with/taken from/ given to/equivalent to 1.865×10^{-3}/0.001865 (mol) $S_2O_3^{2-}$ **NOTE** Numbers do not have to be the same eg 0.001865 electrons with 0.001906 $S_2O_3^{2-}$ **OR** 1 mol of electrons equivalent to 1 mol $S_2O_3^{2-}$ **ALLOW** Any indication of 1:1 ratio for electrons:$S_2O_3^{2-}$ IGNORE Answers referring to equations only.		1

Question Number	Acceptable Answers	Reject	Mark
3(e)(i)	Uncertainty in titre value: (±)0.51/0.514% **OR** **$\frac{2 \times 0.05}{19.45} \times 100 =$** = 0.5 **(1)** Uncertainty in the pipette measurement: $\frac{(0.04 \times 100)}{(10.0)}$ = (±)0.4% **(1)**		

Question Number	Acceptable Answers	Reject	Mark
3(e)(ii)	The uncertainty is not significant because the data are rounded to 1 SF / produce a ratio to the nearest whole number ALLOW Uncertainties are very small / < 5% / < 1% Other reasonable points: eg insignificant as only equation is required	…is significant Uncertainties do not matter as titres have been averaged	1

(Total for Question 3 = 16 marks)

Question Number	Acceptable Answers	Reject	Mark
4(a)(i)	Risk of inhalation / breathing in / risk of going into nose/mouth **(1)** Weigh in a fume cupboard OR Wear a face mask **(1)** IGNORE risk of spillage/gloves/safety glasses Mark independently		2

Question Number	Acceptable Answers	Reject	Mark
4(a)(ii)	**First mark** (why are they needed) (Anti–bump granules) prevent the liquid mixture shooting out / splattering/spurting/spitting/explosive boiling/violent boiling/sudden boiling/ promote smooth/calm/even boiling OR they prevent the mixture superheating /localised boiling OR prevent large bubbles forming **Second mark** (How they work) (Provide)(rough) **surface**/**small holes**/**nucleation sites** OR promote (small) bubble formation OR facilitate/promote heat/energy transfer ALLOW facilitate/promote smooth/ uniform/even heating	**Just**: 'prevent explosion' OR Just 'boiling too fast/strongly' OR Just to stop bumping OR Just to prevent boiling OR Just so **reaction** proceeds smoothly anything to do with rate of reaction	2

Question Number	Acceptable Answers	Reject	Mark
4(a)(iii)	**Read the whole answer first** **First mark** In the top of the still head/3 EITHER thermometer holder/4/cork (containing a thermometer/8) (IGNORE position of thermometer unless incorrect) OR 6/stopper **(1)** **Second mark** The still head/3 is in the top of the flask/5 OR The condenser/7 OR delivery tube/2 is connected to the side arm **(1)** **Third mark** The condenser/7 OR delivery tube/2 delivers to a beaker/test tube/ measuring cylinder/flask **(1)** **Rescue mark** Selection of items 3, 5, 2 **or** 7, **and** 4/6/8 **(1)** All marks may be shown on diagram	delivers to gas syringe /graduated flask Item 1	3

Question Number	Acceptable Answers	Reject	Mark
4(b)(i)	A greater mass /more sodium dichromate((VI)) is used / a greater portion/concentration of sodium dichromate((VI)) OR more/excess oxidizing agent/oxidant **(1)** (More) concentrated/50% sulfuric acid (is added) **(1)** Just 'more concentrated reactants' **(1)** IGNORE needs to be completely oxidized	Just 'more reactants'	2

Question Number	Acceptable Answers	Reject	Mark
4(b)(ii)	The water must flow up the condenser/ from bottom to top/down to up AND If it does not, it will trickle down one side/will not fill OR air bubbles may form/air blockage OR less effective/efficient cooling/condensing ALLOW no cooling/condensing OR causes loss of reactants/products/reaction mixture		1

Question Number	Acceptable Answers	Reject	Mark
4(b)(iii)	**First mark** (A condenser is needed because the organic) mixture/chemicals/materials/reactants/ products/ alcohol/propanal is/are volatile / would boil away/escape (while heating) IGNORE Prevent gas escaping **(1)** **Second mark** Clear description of condensing process, for example: Volatile products/ vapours/gases condense/form liquids (on the cooled glass surface) (which drip/go back into the reaction flask) ALLOW Ensure complete oxidation **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
4(c)(i)	Both are (clear) colourless **liquids** ALLOW No colour **liquid** IGNORE Smell OR Oil like OR Transparent OR Formulae	Colourless **solutions** Any other colours	1

Question Number	Acceptable Answers	Reject	Mark
4(c)(ii)	**Test for propanal** (Boil with) Benedict('s)/Fehling('s) (solution) Allow 'Fheling(s)' ALLOW (almost) correct description of Benedicts/Fehlings eg alkaline copper sulfate **(1)** **red precipitate/solid** (forms) **(1)** **OR** Tollens' reagent ALLOW (almost) correct description of Tollens reagent eg ammoniacal silver nitrate **(1)** silver mirror (forms) **(1)** **Rescue marks** 'Silver mirror test' (forms silver mirror) 1max Acidified potassium/sodium dichromate goes green/blue 1max 2,4-DNH/Brady's (reagent) forms **yellow/orange precipitate/solid** 1max **Test for propanoic acid** Add to sodium carbonate /hydrogencarbonate solution OR Any (metal) carbonate/hydrogen carbonate ALLOW Magnesium / Mg **(1)** Fizzing / bubbles /effervescence/gas turns limewater milky **(1)** **OR** Alcohol (any) with concentrated sulfuric acid **(1)** gives fruity/gluey smell **(1)** **Rescue marks** Add sodium fizzing occurs / bubbles form / effervescence 1max OR Add PCl_5/phosphorus(V) chloride/phosphorus pentachloride. Steamy (ALLLOW White) fumes (form) 1max	Just 'gas'	4

(Total for Question 4 = 17 marks)

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Edexcel Chemistry – AS Grade Boundaries

6CH01 – The Core Principles of Chemistry

Season	Full UMS	A	B	C	D	E
IAL - June 2015	80	67	60	53	47	41
June 2015	76	62	55	49	43	37
IAL - Jan 2015	73	61	55	50	45	40
June 2014	78	66	60	54	48	42
IAL - June 2014	80	66	59	52	46	40
R - June 2014	80	66	58	50	42	35
IAL - Jan 2014	70	58	52	46	41	36
June 2013	73	59	52	45	39	33
R - June 2013	80	69	62	56	50	44
Jan 2013	63	53	48	43	39	35
June 2012	78	66	60	54	48	42
Jan 2012	66	54	48	42	36	30
June 2011	75	61	54	48	42	36
Jan 2011	67	55	49	43	37	32
June 2010	74	62	56	50	44	39
Jan 2010	62	48	41	35	29	23
June 2009	≈68	57	51	45	39	34
Jan 2009	≈63	53	46	40	34	28

6CH02 – Application of Core Principles of Chemistry

Season	Full UMS	A	B	C	D	E
IAL - June 2015	69	57	51	45	39	34
June 2015	72	60	54	48	42	37
IAL - Jan 2015	71	59	53	47	42	37
June 2014	76	64	58	52	47	42
IAL - June 2014	74	62	56	50	45	40
R - June 2014	74	60	53	47	41	35
IAL - Jan 2014	68	58	53	48	43	38
June 2013	75	61	54	47	40	34
R - June 2013	76	64	58	52	46	41
Jan 2013	77	65	59	54	49	44
June 2012	75	63	57	51	45	39
Jan 2012	73	61	55	49	44	39
June 2011	70	58	52	46	40	34
Jan 2011	72	60	54	48	42	36
June 2010	72	60	54	48	42	36
Jan 2010	63	51	45	39	33	27
June 2009	≈61	49	43	37	32	27
Jan 2009	≈68	56	50	44	39	34

Edexcel Chemistry – A2 Grade Boundaries

6CH04 – General Principles of Chemistry I: Rates, Equilibria and Further Organic Chemistry

Season	Full UMS	A*	A	B	C	D	E
IAL - June 2015	78	73	68	63	58	53	48
June 2015	84	78	72	66	60	55	50
IAL - Jan 2015	85	78	71	64	57	50	43
June 2014	81	69	69	63	57	51	46
IAL - June 2014	86	80	74	68	62	56	50
R - June 2014	83	77	71	65	59	54	49
IAL - Jan 2014	86	79	72	65	58	51	44
June 2013	79	74	69	63	57	51	46
R - June 2013	81	75	69	62	56	50	44
Jan 2013	85	79	73	67	61	55	49
June 2012	82	75	68	61	54	48	42
Jan 2012	81	75	69	63	57	52	47
June 2011	88	80	72	64	56	49	42
Jan 2011	76	70	64	58	52	46	40
June 2010	85	77	69	61	53	45	38
Jan 2010	68	62	56	50	44	38	33

6CH05 – General Principles of Chemistry II: Transition Metals and Organic Nitrogen Chemistry

Season	Full UMS	A*	A	B	C	D	E
IAL - June 2015	72	66	60	54	48	42	36
June 2015	80	74	68	62	57	52	47
IAL - Jan 2015	70	64	58	52	46	40	34
June 2014	75	68	61	54	48	42	36
IAL - June 2014	70	64	58	52	47	42	37
R - June 2014	77	70	63	56	49	42	35
IAL - Jan 2014	81	73	65	57	50	43	36
June 2013	86	80	74	67	60	53	47
R - June 2013	76	69	62	55	48	41	35
Jan 2013	85	77	69	61	53	46	39
June 2012	79	73	67	61	55	49	43
Jan 2012	88	80	72	64	56	49	42
June 2011	79	73	67	61	55	49	43
Jan 2011	79	72	65	58	51	44	38
June 2010	80	73	66	59	53	47	41

Merged Unit 5s
Jan 09 - June 16

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Sample Assessment Material
Time: 1 hour 40 minutes

Paper Reference
WCH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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S 4 5 3 6 4 A 0 1 3 2

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The following data are provided.

	$E^{\ominus}$ / V
$ClO^-(aq) + H_2O(l) + e^- \rightleftharpoons \frac{1}{2}Cl_2(aq) + 2OH^-(aq)$	+0.40
$Cl_2(aq) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36

What is the value of $E^{\ominus}_{cell}$ in which the following disproportionation reaction occurs?

$$Cl_2(aq) + 2OH^-(aq) \rightarrow ClO^-(aq) + Cl^-(aq) + H_2O(l)$$

☒ **A** $+\frac{1.36}{2} - 0.40$ V

☒ **B** $+\frac{1.36}{2} + 0.40$ V

☒ **C** $+ 1.36 - 0.40$ V

☒ **D** $+ 1.36 + 0.40$ V

(Total for Question 1 = 1 mark)

2 Which of the following is always proportional to $E^{\ominus}_{cell}$ for a chemical reaction?

☒ **A** $\Delta H_{reaction}$

☒ **B** ΔS_{system}

☒ **C** $\Delta S_{surroundings}$

☒ **D** ΔS_{total}

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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3 The electrode system based on the half-equation below has the standard electrode potential +1.51 V.

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$ $\quad E^{\ominus} = +1.51\ V$

Which of the following statements about this electrode system is correct?

☒ **A** Changing the concentration of $Mn^{2+}(aq)$ would cause a change in the electrode potential.

☒ **B** $Mn^{2+}(aq)$ is acting as an oxidizing agent.

☒ **C** The electrode used is made of manganese.

☒ **D** When connected to a standard hydrogen electrode, the resulting cell voltage would be +0.51 V.

(Total for Question 3 = 1 mark)

4 Consider the following reaction.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

Which of the following ions could catalyse this reaction?

☒ **A** Zn^{2+}

☒ **B** Al^{3+}

☒ **C** Fe^{2+}

☒ **D** Na^+

(Total for Question 4 = 1 mark)

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5 EDTA ions form a complex with aqueous nickel(II) ions as shown by the equation

$$[Ni(H_2O)_6]^{2+}(aq) + (EDTA)^{4-}(aq) \rightleftharpoons Ni(EDTA)^{2-}(aq) + 6H_2O(l)$$

Aqueous nickel(II) ions also form a complex ion with ammonia as shown by the equation

$$[Ni(H_2O)_6]^{2+}(aq) + 6NH_3(aq) \rightleftharpoons [Ni(NH_3)_6]^{2+}(aq) + 6H_2O(l)$$

Aqueous nickel(II) ions form a more stable complex with EDTA ions than with ammonia because

☒ **A** six ammonia ligands cause steric hindrance around the central nickel(II) ion.

☒ **B** EDTA ions carry a negative charge whereas ammonia molecules do not.

☒ **C** there is a large increase in entropy when aqueous nickel(II) ions react with EDTA ions, but not when aqueous nickel(II) ions react with ammonia.

☒ **D** ammonia molecules tend to evaporate from the solution of the complex whereas EDTA ions do not.

(Total for Question 5 = 1 mark)

6 The hydrolysis of a transition metal cation can be represented by the following equation

$$[M(H_2O)_6]^{n+}(aq) + H_2O(l) \rightleftharpoons [M(H_2O)_5OH]^{(n-1)+}(aq) + H_3O^+(aq)$$

In this reaction

☒ **A** the solvent H_2O is acting as an acid by donating a proton to the metal cation.

☒ **B** the pH of the solution will be lower if the value of n is 2 instead of 3.

☒ **C** the equilibrium position lies further to the right if the value of n is 3 instead of 2.

☒ **D** the oxidation state of the metal in the cation has decreased from n to (n – 1).

(Total for Question 6 = 1 mark)

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7 In aqueous solution, manganate(VI) ions disproportionate into manganate(VII) ions and manganese(IV) oxide when carbon dioxide is bubbled through the solution. The ionic equation for the reaction is

$$3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$$

The role of the carbon dioxide is to

☒ **A** lower the pH of the solution.

☒ **B** raise the pH of the solution.

☒ **C** oxidize the manganate(VI) ions.

☒ **D** reduce the manganate(VI) ions.

(Total for Question 7 = 1 mark)

8 Which of the following shows the correct oxidation states of **chromium** in the ions given?

	$[Cr(OH)_6]^{3-}$	CrO_4^{2-}	$[Cr(H_2O)_6]^{2+}$
☒ **A**	−3	−2	+2
☒ **B**	−3	+10	+2
☒ **C**	+3	+8	+6
☒ **D**	+3	+6	+2

(Total for Question 8 = 1 mark)

9 Transition metals are often used as heterogeneous catalysts. Which of the following processes does **not** occur during such a catalysed reaction?

☒ **A** Adsorption of reactant molecules on the surface of the metal.

☒ **B** Bond breaking in the reactant molecules.

☒ **C** Desorption of product molecules from the surface of the metal.

☒ **D** An overall change in the oxidation number of the metal.

(Total for Question 9 = 1 mark)

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10 Consider the equation below.

$$[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(NH_3)_4]^{2+}(aq) + 6H_2O(l)$$

This reaction is best described as

- ☒ **A** acid-base.
- ☒ **B** redox.
- ☒ **C** addition.
- ☒ **D** ligand exchange.

(Total for Question 10 = 1 mark)

11 Which of the following will **not** reduce an acidified solution of potassium dichromate(VI)?

- ☒ **A** $(CH_3)_2C(OH)CH_3$
- ☒ **B** $FeSO_4$
- ☒ **C** $CH_3CH_2CH(OH)CH_3$
- ☒ **D** Zn

(Total for Question 11 = 1 mark)

12 The total number of isomers of dibromobenzene, $C_6H_4Br_2$, containing a benzene ring is

- ☒ **A** 2
- ☒ **B** 3
- ☒ **C** 4
- ☒ **D** 5

(Total for Question 12 = 1 mark)

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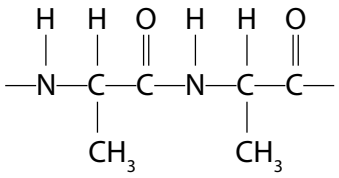
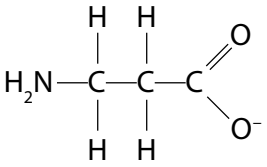
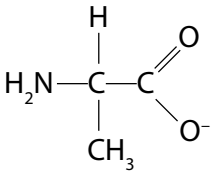
13 A section of the polypeptide made from a single amino acid is shown below.

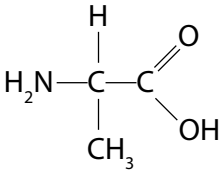


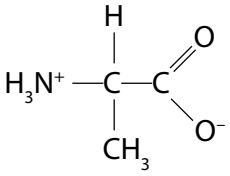
The polypeptide was heated with excess dilute sodium hydroxide solution until no further change took place.

Which of the following products is formed?

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 13 = 1 mark)

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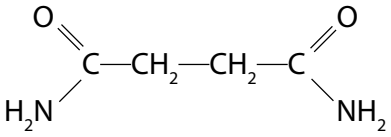
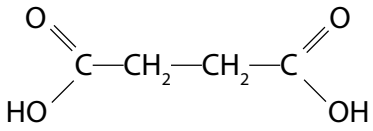
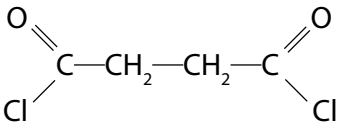
14 Which of the following pairs of compounds could form a polyamide?

☒ **A** $Cl—CH_2—CH_2—Cl$ and $H_2N—CH_2—CH_2—NH_2$

☒ **B** $HO—CH_2—CH_2—OH$ and 

☒ **C**  and $CH_3—CH_2—NH_2$

☒ **D**  and $H_2N—CH_2—CH_2—NH_2$

(Total for Question 14 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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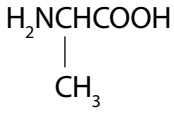
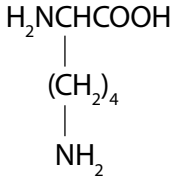
15 Which of the following amino acids is optically active and produces an approximately neutral solution when dissolved in water?

☒ **A** H_2NCH_2COOH

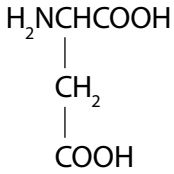
☒ **B**



☒ **C**



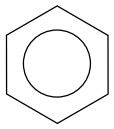
☒ **D**



(Total for Question 15 = 1 mark)

16 Which of the following is **not** planar?

☒ **A**



☒ **B** CCl_4

☒ **C** BF_3

☒ **D** $[Pt(NH_3)_2Cl_2]$

(Total for Question 16 = 1 mark)

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17 A 50 cm^3 sample of a gaseous hydrocarbon required exactly 250 cm^3 of oxygen for complete combustion. A volume of 150 cm^3 of carbon dioxide was produced.

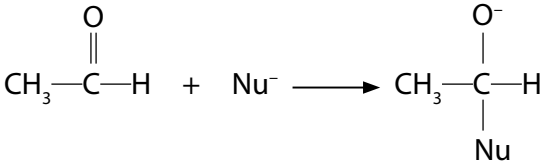
[All volume measurements were made at the same temperature and pressure.]

Which of the following is the correct formula of the hydrocarbon?

- ☒ **A** C_3H_4
- ☒ **B** C_3H_8
- ☒ **C** C_5H_{10}
- ☒ **D** C_5H_{12}

(Total for Question 17 = 1 mark)

18 The first step of a nucleophilic addition reaction to a carbonyl group by a nucleophile, Nu^-, is shown below.



The above step is possible because the

- ☒ **A** nucleophile bonds to the δ+ carbon atom and the carbonyl oxygen accepts an electron pair from the double bond.
- ☒ **B** nucleophile bonds to the δ+ carbon atom and the carbonyl oxygen accepts one electron from the double bond.
- ☒ **C** methyl group donates electrons to the carbonyl carbon atom.
- ☒ **D** C═O bond is weak.

(Total for Question 18 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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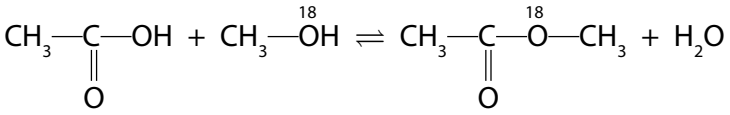
19 In a reaction carried out between ethanoic acid and methanol, the methanol was labelled with the ^{18}O isotope. The ^{18}O was found to be in the organic product of the reaction



From the above information it can be deduced that the mechanism involves

- ☒ **A** free radical substitution.
- ☒ **B** breaking the C—O bond in the ethanoic acid.
- ☒ **C** nucleophilic attack by ethanoic acid on methanol.
- ☒ **D** breaking the C—^{18}O bond in methanol.

(Total for Question 19 = 1 mark)

20 The hydride ion, H^-, is a strong reducing agent, a good nucleophile and a strong base.

Which of the following changes could **not** be brought about by the hydride ion?

- ☒ **A** CH_3CHO to CH_3CH_2OH
- ☒ **B** C_2H_5Br to C_2H_6
- ☒ **C** $CH_2{=}CH_2$ to C_2H_6
- ☒ **D** CH_3COOH to CH_3COO^-

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Hydrogen-oxygen fuel cells can operate in acidic or alkaline conditions.
One such commercial cell uses porous platinum electrodes in contact with concentrated aqueous potassium hydroxide solution, KOH(aq).

(a) Use relevant standard electrode potential values, on pages 15 and 17 of the Data Booklet, to complete the table below in which two $E^{\ominus}$ values are missing.

(2)

Half-equation	$E^{\ominus}$ / V
$2H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq) + H_2(g)$	−0.83
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	

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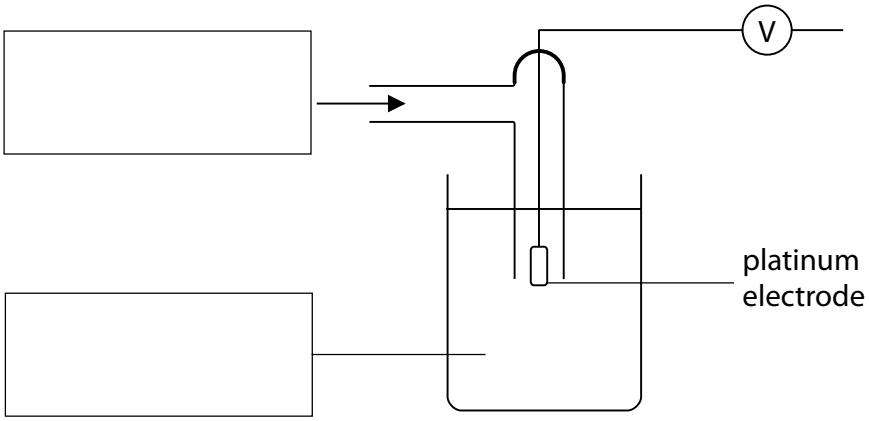
(b) (i) Fill in the boxes to identify, by name or formula, the substances used in the **standard** hydrogen electrode.

(2)



(ii) State **three** conditions that are necessary for a standard hydrogen electrode.

(2)

1. .....

2. .....

3. .....

(c) Write appropriate half-equations and use them to derive an overall equation for the reaction which occurs when an **alkaline** hydrogen-oxygen fuel cell operates.

(2)

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(d) Use the $E^{\ominus}$ values from the table in part (a) to calculate the $E^{\ominus}_{cell}$ for a hydrogen-oxygen fuel cell operating in alkaline conditions.

(1)

(e) Suggest why the $E^{\ominus}_{cell}$ for a hydrogen-oxygen fuel cell, operating in **acidic** conditions, is identical to that of an alkaline fuel cell.

(1)

(f) Give **one** reason (other than cost implications) why the platinum electrodes are made by coating porous material with platinum rather than by using platinum rods.

(1)

(g) Suggest **one** disadvantage of using a hydrogen-oxygen fuel cell compared with a rechargeable battery when providing electrical energy for a motor vehicle.

(1)

(Total for Question 21 = 12 marks)

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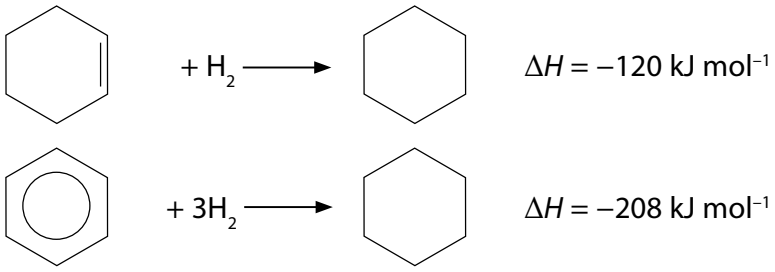
22 (a) Equations for the catalytic hydrogenation of cyclohexene and of benzene are shown below.



(i) What is the type of reaction in both of these hydrogenations?

(1)

.....

*(ii) The enthalpy of hydrogenation of benzene might be expected to be −360 kJ mol^{-1}. Explain why this is **not** the actual value.

(2)

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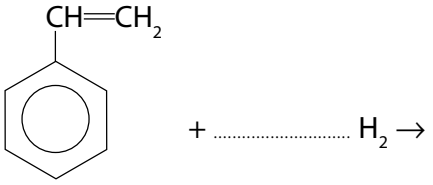
.....

(iii) Complete the following equation for the total hydrogenation of phenylethene. Suggest a value for the enthalpy change of this reaction.

(3)



ΔH = ... kJ mol^{-1}

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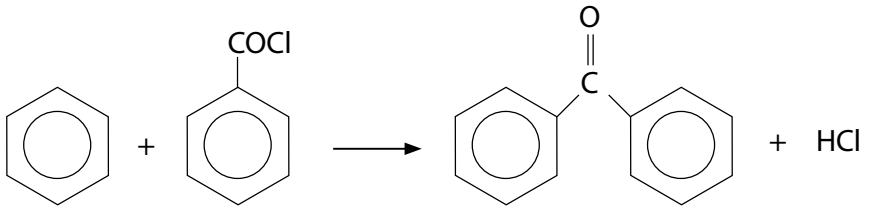
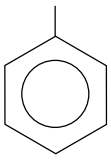
(b) The compound benzophenone is used as a sunscreen. It can be prepared from benzene, in the presence of aluminium chloride by the following reaction.



benzene + compound **A** benzophenone

(i) Complete the diagram below by showing the **displayed** formula of the –COCl group in compound **A**.

(1)



(ii) Classify the type and mechanism of the reaction between benzene and compound **A**.

(1)

.....

(iii) Give the names of the two chemists associated with the type of reaction described in (b)(ii).

(1)

..... and .....

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(iv) Give the mechanism for the reaction between benzene and compound **A** in the presence of an aluminium chloride catalyst.

Start by showing the equation for the generation of the species which then attacks the benzene ring.

(4)

Equation to show generation of species attacking the benzene ring:

Rest of the mechanism:

(v) Suggest the essential property of a substance that will be used as a sunscreen.

(1)

.....

.....

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(c) (i) The identity of a sample of benzophenone can be confirmed by recording its infrared and proton nmr spectra.

Identify **two** different bonds that would produce an absorption in the infrared spectrum of benzophenone. Use the Data Booklet to suggest the wavenumber of each of these absorptions.

(4)

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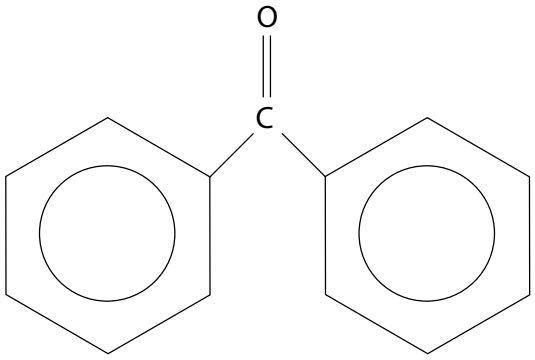
.....

(ii) In benzophenone there are three different hydrogen environments, X, Y and Z, that produce signals in the ratio 2:2:1 respectively in the proton nmr spectrum.

Identify, **on the structure drawn below**, the positions of all the hydrogen atoms in each environment, labelling the different environments **X**, **Y** and **Z**.

(2)



benzophenone

(Total for Question 22 = 20 marks)

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23 A scientist investigated the typical behaviour of primary amines.

(a) Amines such as butylamine, $CH_3CH_2CH_2CH_2NH_2$, and phenylamine, $C_6H_5NH_2$, both behave as bases.

(i) Which feature of an amine molecule allows it to act as a base?

(1)

.....

.....

(ii) The scientist reacted butylamine with two different acids.

Give the **formulae** of the salts that are formed when butylamine reacts with

(2)

sulfuric acid, H_2SO_4 .....

ethanoic acid, CH_3COOH .....

(b) Phenylamine, $C_6H_5NH_2$, is formed by the reduction of nitrobenzene, $C_6H_5NO_2$.

Give the reagents that are used for this reduction.

(2)

.....

.....

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(c) Phenylamine was reacted with a mixture of sodium nitrite, $NaNO_2$, and hydrochloric acid at a temperature between 0 °C and 5 °C. A diazonium ion was formed. In a second step, the scientist reacted the diazonium ion with phenol, under suitable conditions. A precipitate of 4-hydroxyazobenzene (4-hydroxyphenylazobenzene) was formed.

(i) Draw the structure of the diazonium ion, clearly displaying the functional group present in the ion.

(1)

(ii) Draw the structural formula of 4-hydroxyazobenzene.

(1)

(iii) State a condition, other than a suitable temperature, required for the reaction of the diazonium ion with phenol and give a use for 4-hydroxyazobenzene.

(2)

Condition required:

.....

Use for 4-hydroxyazobenzene:

.....

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(d) The scientist repeated the first step in experiment (c), but the temperature was allowed to rise above 10 °C. Under these conditions, the diazonium ion reacted with water to produce phenol. An unreactive gas, of molar mass 28.0 g mol^{-1}, was also formed along with one other product.

Use this information to write the equation for the reaction of the diazonium ion with water.

(2)

(e) The impure sample of 4-hydroxyazobenzene formed in part (c) may be purified by recrystallization. During this process

- the solid is dissolved in the minimum volume of hot solvent
- the mixture is then filtered whilst still hot
- the filtrate is cooled in an ice bath to produce crystals of 4-hydroxyazobenzene
- the crystals are removed by filtration and dried.

(i) Why is the "minimum volume of hot solvent" used?

(1)

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.....

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(ii) The impure 4-hydroxyazobenzene may contain both insoluble and soluble impurities. Describe how

(2)

I. insoluble impurities are removed during recrystallization

.....

.....

.....

II. soluble impurities are removed during recrystallization

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(iii) How would you check the purity of 4-hydroxyazobenzene after recrystallization, other than by using spectroscopy?

(1)

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(Total for Question 23 = 15 marks)

TOTAL FOR SECTION B = 47 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

24

Titanium is the seventh most abundant metal in the Earth's crust and occurs principally as rutile (impure titanium(IV) oxide, TiO_2).

Early attempts to extract the metal from its oxide by reduction with heated carbon failed because the compound titanium carbide is formed. In 1910, however, pure titanium was made by heating titanium(IV) chloride with sodium.

Titanium has a high melting temperature and a density of 4.50 g cm^{-3}. Titanium is as strong as steel, but is about 40% less dense and is therefore suitable for use in the aircraft industry. Titanium metal resists corrosion as it has an impervious coating of titanium(IV) oxide. The metal adheres well to bone, is not rejected by the body and is in demand for the manufacture of replacement joints.

Titanium has two common oxidation states, +3 and +4. Solutions containing the $[Ti(H_2O)_6]^{3+}(aq)$ ion, such as titanium(III) chloride, are purple in colour and are readily oxidized by the oxygen in air to colourless titanium(IV) ions. An aqueous solution of titanium(III) chloride is a strong reducing agent. Titanium(IV) chloride, $TiCl_4$, is a colourless liquid with a boiling temperature of 136 °C. This compound is used, in conjunction with organic compounds of aluminium, as a catalyst for the polymerization of propene to poly(propene). Titanium(IV) chloride is hydrolysed by water to give titanium(IV) oxide, TiO_2 and hydrogen chloride gas.

Titanium(IV) oxide is a white, non-toxic solid at room temperature. It is used as a white pigment in paint, largely replacing toxic lead compounds which were used previously. Titanium(IV) oxide reacts with concentrated sulfuric acid to form a salt and water. Titanium(IV) oxide also reacts with aqueous potassium hydroxide solution, under suitable conditions, to form a compound with formula $K_2Ti(OH)_6$.

(a) (i) Write the equation for the reaction which occurs during the manufacture of titanium from titanium(IV) chloride as described in the article above. State symbols are not required.

(1)

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(ii) Explain, by stating the changes of oxidation numbers, why the reaction in (i) is classified as a redox reaction.

(2)

.....

.....

.....

.....

(b) Complete the electronic configurations of

(2)

Ti [Ar] .....

Ti^{3+} [Ar] .....

Ti^{4+} [Ar] .....

(c) Use your answer to (b) to explain why titanium is

(i) a *d*-block element

(1)

.....

.....

.....

(ii) a transition element

(1)

.....

.....

.....

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*(d) (i) Explain why the hexaaquatitanium(III) ion, $[Ti(H_2O)_6]^{3+}$, is coloured.

(3)

(ii) Explain briefly why titanium(IV) compounds are colourless.

(1)

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*(e)(i) Titanium(IV) oxide has a melting temperature of 1830 °C. Use this data, plus information in the article at the start of the question, to compare the structure and bonding in titanium(IV) oxide with that in titanium(IV) chloride. Hence explain why these two compounds change state at very different temperatures.

(4)

(ii) Give the term used to describe an oxide, such as titanium(IV) oxide, which can react with both acids and bases.

(1)

(iii) Using information in the article, write the equation for the reaction between titanium(IV) oxide and aqueous potassium hydroxide solution. State symbols are not required.

(1)

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(iv) Titanium(IV) chloride is one of the catalysts used in the polymerization of propene to form poly(propene).

Give the displayed formula of the repeat unit of poly(propene).

(1)

(f) The concentration of a solution of titanium(III) chloride can be determined by titration with a solution of hydrogen peroxide, H_2O_2, in acidic conditions. The end-point of the reaction is when the solution of titanium(III) chloride in the flask goes colourless.

(i) Complete the ionic half-equation to show the reduction of hydrogen peroxide.

(1)

$H_2O_2 + 2H^+ +$ ..... $\rightarrow$ .....

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*(ii) One mole of hydrogen peroxide reacts with two moles of titanium(III) chloride.

In an experiment, 5.00 cm^3 of a sample of titanium(III) chloride solution was transferred to a volumetric flask and made up to 250 cm^3 of an aqueous solution. A 25.0 cm^3 portion of this diluted solution was acidified and titrated with a 0.0200 mol dm^{-3} solution of hydrogen peroxide, H_2O_2. The mean titre was 22.50 cm^3.

Calculate the concentration of the **original** titanium(III) chloride solution, in mol dm^{-3}.

(3)

(iii) Use information in the article to suggest why this titration gives a value that is lower than the true value for the concentration of titanium(III) chloride solutions.

(1)

.....

.....

(Total for Question 24 = 23 marks)

TOTAL FOR SECTION C = 23 MARKS
TOTAL FOR PAPER = 90 MARKS

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S 4 5 3 6 4 A 0 3 1 3 2

S 4 5 3 6 4 A 0 3 2 3 2

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

PMT

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

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Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected, it may still be creditworthy.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/	Means that the responses are alternatives and either answer should receive full credit.
()	Means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Bold	Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq	(error carried forward)(transfer error)(consequential) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions that involve the writing of continuous prose require candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where Quality of Written Communication is likely to be particularly important are indicated (Quality of Written Communication) in the mark scheme, but this does not preclude others.

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Section A

Question Number	Answer	Mark
1	C	(1)

Question Number	Answer	Mark
2	D	(1)

Question Number	Answer	Mark
3	A	(1)

Question Number	Answer	Mark
4	C	(1)

Question Number	Answer	Mark
5	C	(1)

Question Number	Answer	Mark
6	C	(1)

Question Number	Answer	Mark
7	A	(1)

Question Number	Answer	Mark
8	D	(1)

Question Number	Answer	Mark
9	D	(1)

Question Number	Answer	Mark
10	D	(1)

Question Number	Answer	Mark
11	A	(1)

Question Number	Answer	Mark
12	B	(1)

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Question Number	Answer	Mark
13	B	**(1)**

Question Number	Answer	Mark
14	D	**(1)**

Question Number	Answer	Mark
15	B	**(1)**

Question Number	Answer	Mark
16	B	**(1)**

Question Number	Answer	Mark
17	B	**(1)**

Question Number	Answer	Mark
18	A	**(1)**

Question Number	Answer	Mark
19	B	**(1)**

Question Number	Answer	Mark
20	C	**(1)**

Total for Section A = 20 Marks

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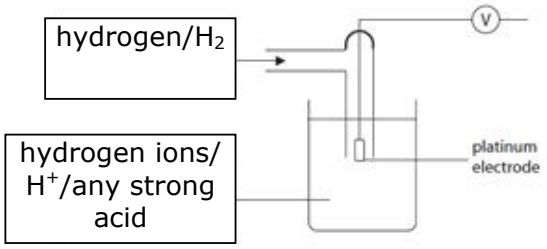
Section B

Question Number	Acceptable Answer	Reject	Mark
21(a)	<table><tr><td>Half-equation</td><td>$E^{\ominus}$/V</td></tr><tr><td></td><td></td></tr><tr><td></td><td></td></tr><tr><td></td><td>+0.4(0)</td></tr><tr><td></td><td>+1.23</td></tr></table> **One mark** for each correct value. Penalise omission of + once only.	+2.46	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(b)(i)	 **First mark:** Hydrogen/H_2(g)/H_2 IGNORE Any pressure value quoted **Second mark:** Name or formula of any strong acid (e.g. HCl/H_2SO_4) ALLOW hydrogen ions/H^+(aq)/H^+. IGNORE Any acid concentration value quoted. IGNORE State symbols for ANY formula of hydrogen and/or acid, even if incorrect. IGNORE any references to platinum.	H(g)/H for hydrogen gas 'HCL'/HSO_4 Just 'acidic'	**(2)**

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Question Number	Acceptable Answer	Reject	Mark
21(b)(ii)	1 atm/100 kPa/101 kPa/1 bar 1 mol dm^{-3} ($[H^+]$/[HCl]) ALLOW '1 molar'/'1M' 298 K/25°C ALLOW '°K' All **THREE** conditions correct = **2 marks.** Any **TWO** conditions correct = **1 mark.** IGNORE References to 'standard conditions'. References to Pt/catalyst. ALLOW 0.5 mol dm^{-3} H_2SO_4. INSTEAD of the 1 mol dm^{-3} ($[H^+]$/[HCl]).	Wrong pressure units Incorrect concentration units (e.g. '1 mol'/1 mol^{-1} dm^3 for $[H^+]$) 273 K/0°C/'room temperature'	**(2)**

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Question Number	Acceptable Answer	Reject	Mark
21(c)	**First mark:** Mentions/some evidence for the use of BOTH equations 1 AND 3 from the table in any way, even if reversed or left unbalanced for example: $O_2(g) + 2H_2O(l) + 4e^- \rightarrow 4OH^-(aq)$ AND $4OH^-(aq) + 2H_2(g) \rightarrow 4H_2O(l) + 4e^-$ **(1)** ALLOW $\rightleftharpoons$ for $\rightarrow$ **Second mark:** (Adds the above half-equations cancelling $4e^-$ to get.) $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$ OR $H_2(g) + \frac{1}{2}O_2(g) \rightarrow H_2O(l)$ **(1)** ALLOW $\rightleftharpoons$ for $\rightarrow$ but must have H_2 and O_2 on left. Mark the second scoring point independently. Award this mark if the correct equation is seen, no matter how it is derived. ALLOW MULTIPLES OF EQUATIONS IN ALL CASES. IGNORE any state symbols, even if incorrect. ALLOW equilibrium sign $\rightleftharpoons$ used in **ANY** of the above equations instead of the full arrows.	Equations involving H^+ **If** $e^-/OH^-/H^+$/two surplus H_2O molecules remain in this final equation **(0)** for 2nd mark	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(d)	$E^{\ominus}_{cell}$ = +0.40 - (-0.83) (V) = (+)1.23 (V) + sign NOT required in final answer Correct answer with or without working scores. **(1)** No ECF from any incorrect $E^{\ominus}$ values used.	-1.23 (V)	**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(e)	Reaction/equation is the same OR Reaction/equation for both is $2H_2(g) + O_2(g) \rightarrow 2H_2O(l)$. ALLOW $\rightleftharpoons$ for $\rightarrow$ IGNORE state symbols even if incorrect. ALLOW statements such as 'they both produce water from hydrogen and oxygen'/'reactants and products are the same'. ALLOW multiples of the **equation.**	'Electrode potentials don't change' **Just** same product/water is produced **Just** same reactants are oxidized and reduced Same reaction but in **reverse** scores **(0)**	**(1)**

Question Number	Acceptable Answer	Mark
21(f)	To **increase** the **surface area**/to increase the number of active sites.	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
21(g)	Any one of: Storage (problems) Hydrogen/oxygen/the gases have to be stored under pressure Leakage (of hydrogen/of oxygen/of gas) Transport(ation) problems Hard to carry/lack of portability Hydrogen flammable inflammable Hydrogen explosive (Fuel cell) costly/expensive Needs (regular) re-filling Needs continual replenishment of H_2 and O_2 Lack of availability (of hydrogen/fuel) Hydrogen is made from fossil fuels/hydrogen is made by electrolysis/hydrogen is made from natural gas/hydrogen is made from non-renewable resources. ALLOW water is a greenhouse gas/ fuel cell(s) have short(er) lifespan/ fuel cells have to be (regularly) replaced. IGNORE references to 'danger' or 'safety' or 'hazardous'. Any arguments in terms of **voltage** output. References to hydrogen-oxygen fuel cell cannot be recharged.	'Fuel cell can only be used once' scores **(0)**	**(1)**

Total for Question 21 = 12 Marks

Question Number	Acceptable Answer	Reject	Mark
22(a)(i)	Addition/reduction/free-radical addition. IGNORE references to 'hydrogenation'.	Redox Electrophilic addition Nucleophilic addition	**(1)**

Question Number	Acceptable Answer	Mark
***22(a)(ii) Quality of Written Communication**	**First mark:** **Delocalisation** (of π/p electrons in benzene ring). **(1)** IGNORE reference to 'resonance' **Second mark:** Results in more **energy** needed to **break** the **bonds** in benzene (compared with three separate π bonds). **(1)** ALLOW confers **stability** on the molecule/makes benzene **more stable** (than expected) IGNORE Reference to carbon-carbon bond lengths Values of any enthalpy changes. Mark the two points independently.	**(2)**

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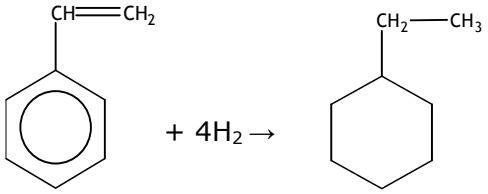
Question Number	Acceptable Answer	Mark
22(a) (iii)	 + $4H_2 \rightarrow$ (ΔH=) **-328 (**kJ mol^{-1}) **First mark**: For '4' **Second mark**: product as above/correct skeletal formula of product ALLOW Side chain written as $-C_2H_5$. **Third mark**: **-**328 (kJ mol^{-1}) **N.B.** **One** H_2 added showing a consequential correct product with only side chain reduced and consequential ΔH = **-**120 (kJ mol^{-1}) scores. **(2)** **Three** H_2 added showing a consequential correct product with only the benzene ring reduced and ΔH = **-**208 (kJ mol^{-1}) scores. **(2)** **Five** H_2 added with fully correct product drawn and ΔH = **-**448 (kJ mol^{-1}) scores. **(2)** **Three and a half** H_2 added showing a fully correct product and ΔH = **-**268/**-**293(.3)(kJ mol^{-1}) scores. **(2)** **N.B.** mark scoring points independently	**(3)**

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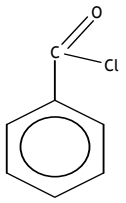
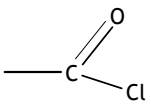
Question Number	Acceptable Answer	Mark
22(b)(i)	 Mark awarded for displaying 	(1)

Question Number	Acceptable Answer	Mark
22(b)(ii)	Electrophilic substitution **BOTH** words needed. **IGNORE references to acylation and/or Friedel-Crafts.**	(1)

Question Number	Acceptable Answer	Mark
22(b)(iii)	Friedel **and** Crafts **BOTH** names are needed for this mark **.**	(1)

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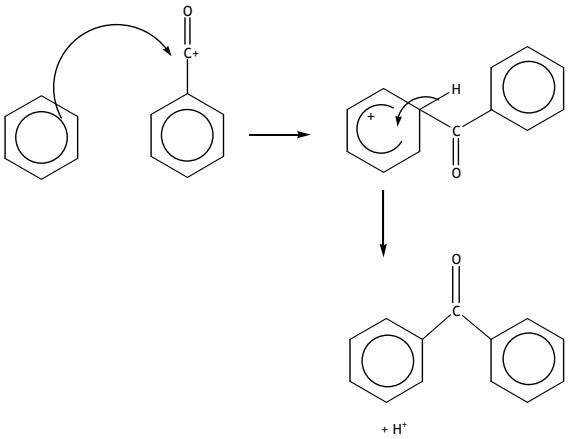
Question Number	Acceptable Answer	Mark
22(b) (iv)	**First mark:** **C_6H_5COCl** + $AlCl_3$ → **$C_6H_5CO^+$** + $AlCl_4^-$ **+** can be anywhere on the C_6H_5CO in the equation for the first mark.  ($AlCl_4^-$ + H^+ → HCl + $AlCl_3$) **N.B.** If ethanoyl chloride or any other acid chloride or the generic RCOCl is used **instead** of benzoyl chloride, no first mark can be awarded but the 2nd, 3rd and 4th marks can be awarded consequentially. **Second mark**: First curly arrow, as shown, to start from inside the hexagon to the correct C+ carbon (i.e. not to the benzene ring)**.** **N.B.** the + must be on the C of the C=O/CO for this mark **Third mark:** Intermediate correctly drawn. **N.B. +** can be shown anywhere in the ring or at the C atom where electrophile is bonded. The 'horseshoe' in the intermediate to cover at least three carbon atoms. **Fourth mark:** Second curly arrow as shown from C—H bond to reform the ring, not from the H atom in this bond **N.B.** products do not have to be shown nor the equation for regeneration of the catalyst given.	**(4)**

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Question Number	Acceptable Answer	Reject	Mark
22(b)(v)	Absorbs/reflects/blocks/protects from/shields against/**uv** (light/radiation) IGNORE 'non-toxic'/references to IR	**Adsorbs** UV light	**(1)**

Question Number	Acceptable Answer	Mark
22(c)(i)	Any **TWO** of the following: One mark for identifying the bond by formula as shown and one mark for wavenumber in each matching pair. **UNITS** are not required. Bond / Wavenumber range/wavenumber (cm^{-1}) C=C / 1600/1580/1500/1450 **All four values needed** C=O / 1700–1680 C-H / 3030 C-H / 750/700 **Both values needed** ALLOW correct wavenumber range, or any number within the correct range, **for C=O.** Mark identification of the bond and the wavenumber independently. (e.g. a correct bond with a wrong wavenumber, or vice versa, scores one of the two marks in each case) IGNORE nmr values/chemical shifts.	**(4)**

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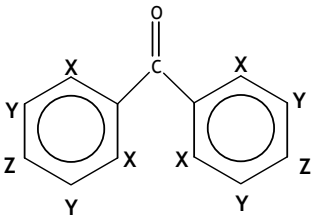
Question Number	Acceptable Answer	Mark
22(c)(ii)	 **First mark:** EITHER Identifies correctly the **three** different proton environments ALLOW If the three different proton environments are shown on only one of the benzene rings. **N.B.** on right-hand ring, clockwise from C=O, positions 2, 3 and 4 And/or 2, 4 and 5 are shown as different environments and/or on left-hand ring, anti-clockwise from C=O, positions 2, 3 and 4 And/or 2, 4 and 5 are shown as different environments. OR Identifies proton Z correctly on both benzene rings. **Second mark:** Fully correct labelling on both rings using the letters **X**, **Y** and **Z.** **N.B. X** and **Y** labels are interchangeable, **Z** is not.	**(2)**

Total for Question 22 = 20 Marks

Question Number	Acceptable Answer	Reject	Mark
23(a)(i)	**Lone pair** (of electrons on the nitrogen atom) ALLOW non-bonded pair (of electrons on the nitrogen atom).	**Lone pairs** **Spare pair**	**(1)**

Question Number	Acceptable Answer	Mark
23(a)(ii)	**(with H_2SO_4)** $(C_4H_9NH_3^+)_2SO_4^{2-}$ **(1)** ALLOW $C_4H_9NH_3^+HSO_4^-$ **(with CH_3COOH)** $C_4H_9NH_3^+CH_3COO^-$ **(1)** **CHARGES** not essential. Cation and anion can be in either order. Maximum one mark if formula of the amine is incorrect in either case. ALLOW one mark if only the correct cation is given in each case (i.e. the anion has been omitted in both cases). **N.B.** the correct ions can be shown separately, e.g. $(C_4H_9NH_3^+)_2$ **+** SO_4^{2-} .	**(2)**

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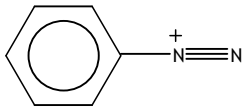
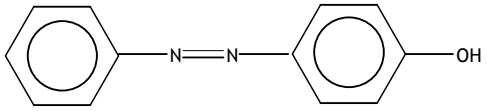
Question Number	Acceptable Answer	Reject	Mark
23(b)	Tin/Sn ALLOW Iron/Fe **(1)** (concentrated) **hydrochloric acid** **N.B.** if candidates write 'HCl', there must be some indication of concentrated, e.g. 'conc HCl'/'concentrated HCl'. ALLOW HCl(aq). (Followed by addition of alkali to liberate the free amine) **(1)** Mark the two points independently. **N.B.** do not allow second mark if there is a suggestion that the acid and alkali are added together simultaneously.	$LiAlH_4$ Just 'HCl' 'Dilute' hydrochloric acid/sulfuric acid	**(2)**

Question Number	Acceptable Answer	Reject	Mark
23(c)(i)	 **N.B.** if the above structure is drawn, the + charge must be on the N connected directly to the benzene ring. ALLOW —N=N^+ on ring. IGNORE Cl^-.	N_2^+ on ring	**(1)**

Question Number	Acceptable Answer	Mark
23(c)(ii)		**(1)**

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Question Number	Acceptable Answer	Mark
23(c)(iii)	**(Conditions)** (Presence of) NaOH/KOH/alkali/OH^- **(1)** ALLOW 'Alkaline (conditions)' or 'base' or 'high pH'. IGNORE Any references to temperature. **(Use)** Dye/pigment/colouring/indicator/in foodstuff/in paint/methyl orange **(1)** IGNORE Any reference to medicines.	**(2)**

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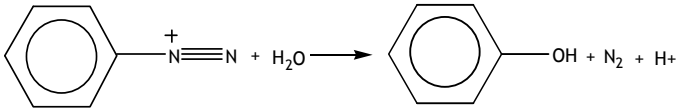
Question Number	Acceptable Answer	Mark
23(d)	 ALLOW The + sign to be on either N atom in the benezenediazonium ion. OR $C_6H_5N_2^+ + H_2O \rightarrow C_6H_5OH + N_2 + H^+$ OR $C_6H_5N_2Cl + H_2O \rightarrow C_6H_5OH + N_2 + HCl$ OR $C_6H_5N_2^+ + 2H_2O \rightarrow C_6H_5OH + N_2 + H_3O^+$ OR $C_6H_5N_2^+Cl^- + H_2O \rightarrow C_6H_5OH + N_2 + HCl$ **N.B.** $-C_6H_5$ can be written or drawn **First mark:** for **N_2** **(1)** **Second mark:** for rest of the equation correct **(1)** IGNORE State symbols, even if incorrect.	**(2)**

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Question Number	Acceptable Answer	Mark
23(e)(i)	(Otherwise) too much (product) remains in solution OR If excess (solvent) is used, crystals might not form ALLOW To avoid losing (too much) product (in the filtrate when crystallization occurs). To maximise the yield. Will crystallize better from a concentrated solution/will recrystallize (better) when cold. IGNORE References to a 'saturated solution' or references to 'dilution' or references to the time taken for crystals to form.	**(1)**

Question Number	Acceptable Answer	Mark
23(e)(ii)	**(Insoluble impurities removed)** By **hot** filtration/During the **first** filtration/During the **second** step in the process. **(1)** **(Soluble impurities removed)** By remaining in solution/Left in filtrate/Removed when washed (with cold solvent). **(1)**	**(2)**

Question Number	Acceptable Answer	Reject	Mark
23(e)(iii)	Measure the melting temperature/melting point **and** compare with data/known value (from a data book/literature/internet/database) (BOTH points needed for the mark). OR The melting point is sharp (just this statement is needed for the mark). ALLOW Any form of chromatography. IGNORE References to any types of spectroscopy.	**(0)** If reference to determination of the boiling point is made	**(1)**

Total for Question 23 = 15 Marks

Total for Section B = 47 Marks

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Question Number	Acceptable Answer	Mark
24(a)(i)	$TiCl_4 + 4Na \rightarrow 4NaCl + Ti$ IGNORE State symbols, even if incorrect. ALLOW Multiples. Reversible arrows.	**(1)**

Question Number	Acceptable Answer	Mark
24(a)(ii)	Ti **reduced** as oxidation number decreases from **+4 to 0**/changes from **+4 to 0.** **(1)** Na **oxidized** as oxidation number increases from **0 to +1**/changes from **0 to +1.** **(1)** ALLOW Correct oxidation numbers only for one mark. **N.B.** max (1) if no + sign included. ALLOW **'4+'** and/or **'1+'** given instead of **+4** and **+1.** **N.B.** if any of the oxidation numbers are wrong, award max (1) for the idea that during oxidation the oxidation number increases **AND** during reduction the oxidation number decreases. IGNORE References to loss and /or gain of electrons.	**(2)**

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Question Number	Acceptable Answer	Mark
24(b)	(Ti [Ar]) $3d^2$ $4s^2$/$4s^2$ $3d^2$ **(1)** (Ti^{3+} [Ar]) $3d^1$ /$3d^1$ $4s^0$ (Ti^{4+} [Ar]) 'nil'/$3d^0$ $4s^0$ /$3d^0$ space left blank by candidate BOTH Ti^{3+} and Ti^{4+} correct for second mark. **(1)** Mark CQ on Ti electron configuration for the second mark. ALLOW Upper case (e.g. 'D' for 'd' in electronic configurations). Subscripts for numbers of electrons. Full correct electronic configurations $1s^2$ $2s^2$.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
24(c)(i)	**(d-block element)** EITHER Ti has (two) electrons in the 3d subshell/ Ti has a partially filled d-subshell/ Ti has a partially filled d-orbital/ Ti has electrons in d-orbital(s)/ Ti has electrons in d-subshell (During the build up of its atoms) last added/valence electron is in a d-subshell/d-orbital. OR (During the build up of its atoms) last added/valence electron is in a d-subshell/d-orbital.	**Outer/highest energy** electrons are in a d-orbital/**Outer/highest energy** electrons are in a d-subshell Electrons in the 'd-block'/ 'electrons in the d-shell'	**(1)**

Question Number	Acceptable Answer	Mark
24(c)(ii)	(Transition element) Forms one (or more stable) **ions**/forms **Ti^{3+}** (ions) which have. Incomplete d-orbital(s)/an incomplete d-subshell/a partially filled d-subshell/an unpaired d electron IGNORE references to variable oxidation states.	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
*24(d)(i) Quality of Written Communication	**First mark:** d-subshell splits/d-orbital**s** split (in energy by ligands)/d energy level(s) split(s) **(1)** **Second mark:** Absorbs light (in visible region) **(1)** **Third mark:** Electron transitions from lower to higher energy/electron(s) jump from lower to higher energy. OR Electron(s) promoted (within d). **(1)** Mark independently **N.B.** maximum of (1) mark (i.e. the first mark only) if refers to electrons falling back down again.	d-**orbital/**d-**shell** splits Absorbs **purple** light	**(3)**

Question Number	Acceptable Answer	Mark
24(d)(ii)	No d-electrons/empty d-subshell	**(1)**

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Question Number	Acceptable Answer	Reject	Mark
***24(e)(i) Quality of Written Communication**	**TiO_2 'Structure' mark** EITHER Giant (structure) OR Lattice (structure) **(1)** IGNORE Whether stated as ionic or covalent for this mark. **TiO_2 'Bonding' mark** EITHER **Strong** (electrostatic) attraction between ions. ALLOW **Strong** ionic bonds/ionic bonds require a lot of energy to break. OR **Strong** covalent bonds/covalent bonds require a lot of energy to break. **(1)** **$TiCl_4$ 'Structure' mark** (Simple) molecules/(small) molecules /molecular. **(1)** **$TiCl_4$ 'Bonding' mark** **Weak** London/dispersion/van der Waals' forces (between molecules)/ London/dispersion/van der Waals' forces (between molecules) require little energy to break. **(1)**	TiO_2 (small) molecules/simple molecular For TiO_2 mention of any type of intermolecular forces between molecules of TiO_2 $TiCl_4$ giant structure Covalent bonds broken (on melting) in $TiCl_4$ Ionic bonding in $TiCl_4$ Hydrogen bonding **(0)** for this mark	**(4)**

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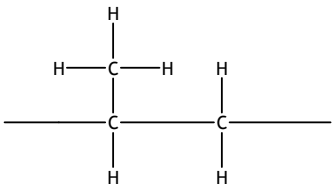
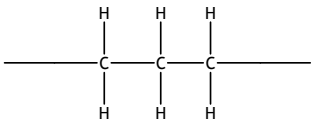
Question Number	Acceptable Answer	Mark
24(e)(i) continued	**N.B.** if candidate assumes TiO_2 and $TiCl_4$ are both simple molecular, can score last mark for saying that the named intermolecular forces in TiO_2 are stronger. IGNORE (Permanent) dipole-dipole forces. Mark the four scoring points independently.	

Question Number	Acceptable Answer	Mark
24(e)(ii)	Amphoteric ALLOW Recognisable spellings.	**(1)**

Question Number	Acceptable Answer	Mark
24(e) (iii)	$TiO_2 + 2H_2O + 2KOH \rightarrow K_2Ti(OH)_6$ OR $TiO_2 + 2H_2O + 2OH^- \rightarrow Ti(OH)_6^{2-}$ IGNORE state symbols even if incorrect.	**(1)**

Question Number	Acceptable Answer	Reject	Mark
24(e) (iv)	 **MUST** have continuation bonds at each end. ALLOW CH_3 IGNORE n and any brackets.	 **Two** (or more) repeat units shown.	**(1)**

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Question Number	Acceptable Answer	Mark
24(f)(i)	(H_2O_2 + $2H^+$ +) **$2e^{(-)}$ → $2H_2O$** **BOTH** $2e^{(-)}$ **and 2**H_2O needed for the mark.	**(1)**

Question Number	Acceptable Answer	Mark
***24(f)(ii) Quality of Written Communication**	(Moles H_2O_2 = 0.0200 x 22.50/1000) = 4.5 x 10^{-4} mol H_2O_2 **(1)** (Moles Ti^{3+} reacting in 25.0 cm^3) = 9.0 x 10^{-4} mol Ti^{3+} **(1)** (Moles Ti^{3+} in 250 cm^3) = 9.0 x 10^{-3} mol Ti^{3+} **(1)** (Original concentration of Ti^{3+}= 9.0 x 10^{-3}/0.00500) = 1.8 (mol dm^{-3}) **(1)** 1.8 (mol dm^{-3}) with or without working scores **(3)** **N.B.** if mole ratio H_2O_2 : Ti^{3+} is 1:1 final answer for concentration of Ti^{3+} is 0.9 (mol dm^{-3}) scores. Overall **(2)** If mole ratio H_2O_2 : Ti^{3+} is 2:1 final answer for concentration of Ti^{3+} is 0.45 (mol dm^{-3}) scores. Overall **(2)** If candidate forgets to multiply number. of moles of Ti^{3+} by 10 then answer is 0.18 (moldm^{-3}) this scores. **(2)** If volume of H_2O_2 used is 25.0 no first mark, but can score two marks if final answer CQ is 2(.0) (mol dm^{-3}).	**(3)**

Question Number	Acceptable Answer	Reject	Mark
24(f)(iii)	(It/titanium(III)/Ti^{3+}) **oxidized** (by oxygen in the air) ALLOW 'It is a **strong** reducing agent'	Hydrolysis	**(1)**

Total for Question 24 = 23 marks

Total for Section C = 23 marks

Total for Paper = 90 marks

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Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Monday 28 June 2010 – Morning
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions
- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information
- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice
- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 In the reaction of manganate(VII) ions with reducing agents in strongly acidic solution, the half-reaction for the reduction is

☒ **A** $MnO_4^- + 4H^+ + 3e^- \rightarrow MnO_2 + 2H_2O$

☒ **B** $MnO_4^- + 4H^+ + 5e^- \rightarrow Mn^{2+} + 2H_2O$

☒ **C** $MnO_4^- + 8H^+ + 3e^- \rightarrow Mn^{2+} + 4H_2O$

☒ **D** $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

(Total for Question 1 = 1 mark)

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2 In the titration of iodine with standard sodium thiosulfate solution, starch is often used as an indicator. The starch should **not** be added until nearly all the iodine has reacted because

☒ **A** it is decomposed by high concentrations of iodine.

☒ **B** the blue complex formed is bleached by high concentrations of iodine.

☒ **C** the blue complex formed with high concentrations of iodine is insoluble and does not re-dissolve as more thiosulfate is added.

☒ **D** the starch reacts with the thiosulfate ions being added.

(Total for Question 2 = 1 mark)

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3 The conditions needed for the $E^{\ominus}$ value of the standard hydrogen electrode to be exactly 0 V are

☒ **A** 1 mol dm^{-3} solution of hydrogen ions, 1 atm pressure of hydrogen, 25 °C.

☒ **B** 1 mol dm^{-3} solution of hydrogen ions, 1 atm pressure of hydrogen, room temperature.

☒ **C** 1 mol dm^{-3} solution of hydrogen ions, laboratory pressure of hydrogen, 25 °C.

☒ **D** 0.1 mol dm^{-3} solution of hydrogen ions, 1 atm pressure of hydrogen, 25 °C.

(Total for Question 3 = 1 mark)

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4 The electrode potential for a cell can be used to calculate the equilibrium constant for the cell reaction. This is because

☒ **A** $E^{\ominus}_{\text{cell}}$ is proportional to $\ln K$.

☒ **B** $E^{\ominus}_{\text{cell}}$ is proportional to K.

☒ **C** $\ln E^{\ominus}_{\text{cell}}$ is proportional to $\ln K$.

☒ **D** $\ln E^{\ominus}_{\text{cell}}$ is proportional to K.

(Total for Question 4 = 1 mark)

5 Which of the following successive ionization energies (values in kJ mol^{-1}) could have come from a transition element?

☒ **A** 496 4563 6913 9544 13352 16611 20115 25941

☒ **B** 590 1145 4912 6474 8144 10496 12320 14207

☒ **C** 717 1509 3249 4940 6985 9200 11508 18956

☒ **D** 2081 3952 6122 9370 12177 15239 19999 23069

(Total for Question 5 = 1 mark)

6 Although platinum is very unreactive, it is used as a catalyst in catalytic converters in motor cars. Which of the following is true?

☒ **A** It converts nitrogen oxides and carbon monoxide to nitrogen and carbon dioxide by adsorbing the reactants on its surface so weakening their bonds.

☒ **B** It converts nitrogen oxides and carbon monoxide to nitrogen and carbon dioxide by being able to change its oxidation state.

☒ **C** It oxidizes unburnt fuel to carbon monoxide.

☒ **D** It oxidizes unburnt fuel to carbon dioxide.

(Total for Question 6 = 1 mark)

7 Which of the following gives the electronic configuration for chromium and for the Cr^{3+} ion?

		Cr	Cr^{3+}
☒	**A**	$[Ar]3d^4 4s^2$	$[Ar]3d^3 4s^0$
☒	**B**	$[Ar]3d^5 4s^1$	$[Ar]3d^2 4s^1$
☒	**C**	$[Ar]3d^5 4s^1$	$[Ar]3d^3 4s^0$
☒	**D**	$[Ar]3d^4 4s^2$	$[Ar]3d^1 4s^2$

(Total for Question 7 = 1 mark)

8 Which of the following gives the colours of solutions containing $Cr_2O_7^{2-}$, CrO_4^{2-}, hydrated Cr^{3+} and hydrated Cr^{2+}, in this order?

☒ **A** Yellow, orange, green, blue

☒ **B** Orange, yellow, green, blue

☒ **C** Orange, yellow, blue, green

☒ **D** Orange, green, yellow, blue

(Total for Question 8 = 1 mark)

9 When dichromate(VI) ions, $Cr_2O_7^{2-}$, react with iron(II) ions in acidic solution, the products are chromium(III) ions and iron(III) ions. In what ratio do the dichromate(VI) ions and the iron(II) ions react?

☒ **A** 1:6

☒ **B** 1:5

☒ **C** 2:5

☒ **D** 1:3

(Total for Question 9 = 1 mark)

10 The compound $[Pt(NH_3)_2Cl_2]$ is

☒ **A** tetrahedral with no isomers.

☒ **B** square planar with no isomers.

☒ **C** tetrahedral with two isomers.

☒ **D** square planar with two isomers.

(Total for Question 10 = 1 mark)

11 The hexaaquacopper(II) ion, $[Cu(H_2O)_6]^{2+}$, is blue because the water ligands

☒ **A** split the *p*-orbital energies and *p*-*p* electron transitions emit blue light.

☒ **B** split the *d*-orbital energies and *d*-*d* electron transitions absorb all but blue light.

☒ **C** split the *p*-orbital energies and *p*-*p* electron transitions absorb all but blue light.

☒ **D** split the *d*-orbital energies and *d*-*d* electron transitions emit blue light.

(Total for Question 11 = 1 mark)

12 If phenol and benzene are tested separately with bromine water, you would expect to see that

- ☒ **A** benzene and phenol would both decolorize bromine water.
- ☒ **B** benzene would decolorize bromine water, but phenol would not do so.
- ☒ **C** neither benzene nor phenol would decolorize bromine water.
- ☒ **D** benzene would not decolorize bromine water, but phenol would do so.

(Total for Question 12 = 1 mark)

13 An organic compound **X** is much more soluble in dilute hydrochloric acid than in water. Compound **X** forms a coloured complex with aqueous copper(II) ions.

Compound **X** could be

- ☒ **A** C_6H_5COOH
- ☒ **B** $C_6H_5NO_2$
- ☒ **C** $C_6H_5NH_2$
- ☒ **D** C_6H_5OH

(Total for Question 13 = 1 mark)

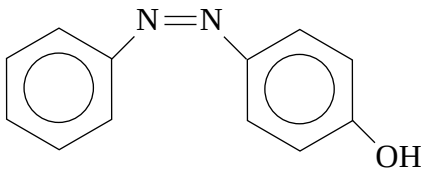
14 Which of the following shows the generation of the electrophile in the reaction of benzene with ethanoyl chloride in the presence of anhydrous aluminium chloride?

- ☒ **A** $CH_3COCl + AlCl_3 \rightarrow [CH_3CO]^+ + AlCl_4^-$
- ☒ **B** $CH_3COCl + AlCl_3 \rightarrow [CH_3CO]^- + AlCl_4^+$
- ☒ **C** $CH_3CH_2Cl + AlCl_3 \rightarrow [CH_3CH_2]^+ + AlCl_4^-$
- ☒ **D** $CH_3COOCl + AlCl_3 \rightarrow [CH_3COO]^- + AlCl_4^+$

(Total for Question 14 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

15 Which of the following reagents and conditions would enable phenylamine to be converted to the yellow dye 4-hydroxyazobenzene in a good yield?



☒ **A** Sodium nitrite, $NaNO_2$, in concentrated HCl, between 0 °C and 10 °C; followed by an alkaline solution of phenol.

☒ **B** Sodium nitrite, $NaNO_2$, in concentrated HCl, between 0 °C and 10 °C; followed by an acidic solution of phenol.

☒ **C** Sodium nitrate, $NaNO_3$, in concentrated HCl, between 0 °C and 10 °C; followed by an alkaline solution of phenol.

☒ **D** Sodium nitrite, $NaNO_2$, in concentrated HCl, room temperature; followed by an alkaline solution of phenol.

(Total for Question 15 = 1 mark)

16 1-butylamine, $CH_3CH_2CH_2CH_2NH_2$, reacts with ethanoyl chloride to form

☒ **A** $CH_3CH_2CH_2CH_2NH_3^+Cl^-$

☒ **B** $CH_3CH_2CH_2CH_2NHCOCH_3$

☒ **C** $CH_3CH_2CH_2CH_2NHCH_2CH_3$

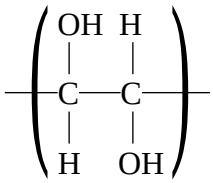
☒ **D** $CH_3CH_2CH_2CH(COCH_3)NH_2$

(Total for Question 16 = 1 mark)

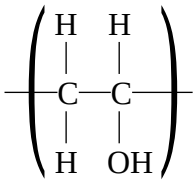
Use this space for any rough working. Anything you write in this space will gain no credit.

17 The addition polymer poly(ethenol) is water-soluble. The repeating unit of poly(ethenol) is

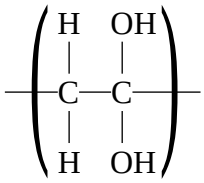
☒ **A**



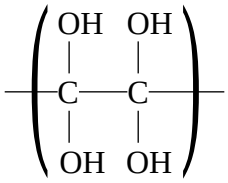
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

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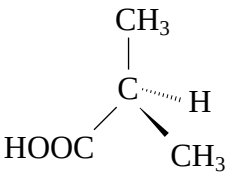
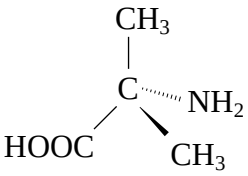
18 A white organic compound, **X**, is optically active and reacts with ninhydrin to give a coloured product. The structural formula of **X** could be

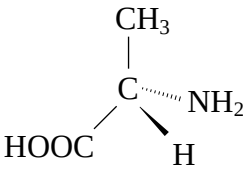
☒ **A**



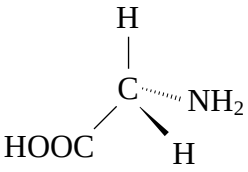
☒ **B**



☒ **C**



☒ **D**



(Total for Question 18 = 1 mark)

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19 Glycine, H_2NCH_2COOH, is a solid that has a melting temperature of about 250 °C, and it is very soluble in water. This is because of the

- ☒ **A** formation of intermolecular hydrogen bonds in the solid and hydrogen bonds with water.
- ☒ **B** formation of $H_3N^+CH_2COO^-$ ions which interact strongly with each other in the solid and with water.
- ☒ **C** dissociation of the molecule to form $H_2NCH_2COO^-$ and H^+ ions in the solid and the solution.
- ☒ **D** protonation of the molecule to form $H_3N^+CH_2COOH$ ions in both the solid and the solution.

(Total for Question 19 = 1 mark)

20 Organic solids are often purified by recrystallization. This technique works on the basis that

- ☒ **A** the impurities must be insoluble in the solvent used.
- ☒ **B** the impurities must react with the solvent used.
- ☒ **C** the impurities crystallize first when the hot solution is cooled.
- ☒ **D** the cooled solution is saturated with the desired material but not with the impurities.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Brass is an alloy of copper, zinc and, in some cases, other metals too. There are over 30 varieties of brass for different applications.

The amount of copper in a brass can be found as follows:

- A weighed sample of brass is reacted with the minimum amount of concentrated nitric acid.
- The solution is neutralized, a portion of it pipetted into a conical flask, and excess potassium iodide solution is added.
- The iodine produced is titrated with a solution of sodium thiosulfate of known concentration.

(a) The ionic equation for the reaction between copper metal and concentrated nitric acid is shown below.

$$Cu(s) + 2NO_3^-(aq) + 4H^+(aq) \rightarrow Cu^{2+}(aq) + 2NO_2(g) + 2H_2O(l)$$

(i) Give the oxidation numbers of the copper and nitrogen in both the reactants and products.

(2)

Copper: from ..... **to** .....

Nitrogen: from ..... **to** .....

(ii) Write the two half-equations that can be combined to give the ionic equation shown above.

(2)

(iii) Explain why the standard electrode potentials for the two ionic half-equations that you have written give an incorrect value for E_{cell} for this reaction as described above.

(2)

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(b) The solution produced contains a mixture of zinc ions and copper ions.

(i) State TWO observations that you would **see** if concentrated ammonia solution were to be added, drop by drop, to the solution until in excess.

(2)

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(ii) Copper ions can be separated from the zinc ions in the solution by adding sodium hydroxide solution in excess, followed by filtration of the mixture.

Write equations, including state symbols, for the THREE reactions that occur.

(3)

Equation 1

Equation 2

Equation 3

*(iii) Give examples of amphoteric behaviour and ligand exchange, by reference to the reactions of zinc compounds.

(3)

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(c) A sample of Admiralty Brass of mass 3.00 g was treated with nitric acid and made up to a neutral solution of volume 250 cm^3. Excess potassium iodide was added to 25.0 cm^3 portions of this solution, and the liberated iodine was titrated with sodium thiosulfate solution, concentration 0.100 mol dm^{-3}. The mean titre was 33.10 cm^3.

(i) Write the ionic equation for the reaction between thiosulfate ions and iodine.

(1)

*(ii) The equation for the reaction between copper(II) ions and iodide ions is shown below.

$$2Cu^{2+} + 4I^- \rightarrow 2CuI + I_2$$

Hence calculate the percentage by mass of copper in Admiralty Brass. Give your answer to **three** significant figures.

(6)

(iii) When setting up the burette, a student failed to fill the jet of the burette. Explain the effect that this would have on the value of the first titre.

If this first titre was included in the calculation of the mean titre, what effect would this have on the value for the percentage of copper in the brass?

(2)

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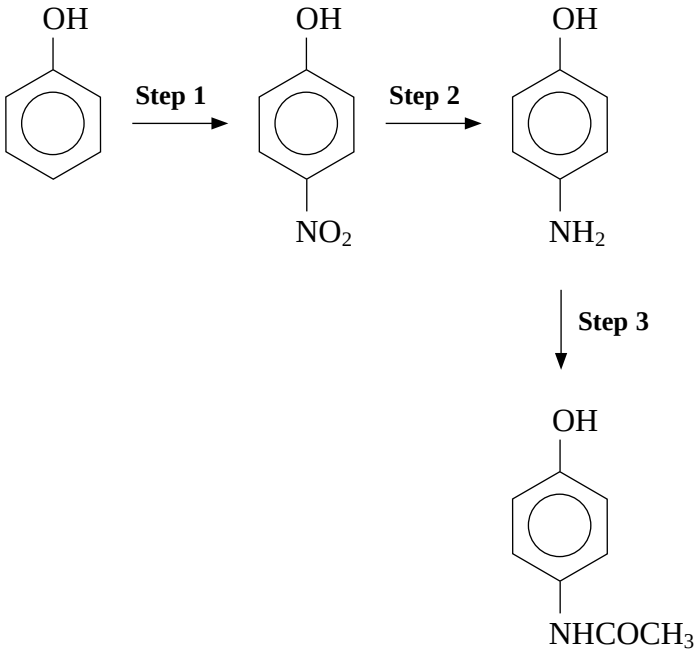
(Total for Question 21 = 23 marks)

22 Paracetamol is possibly the most widely used analgesic (painkiller) in the world. It can be made from phenol as shown below.



Paracetamol

(a) The nitration of phenol in **step 1** uses dilute nitric acid at room temperature, whereas the nitration of benzene requires a mixture of concentrated nitric and sulfuric acids at about 55 °C.

(i) Give the mechanism for the nitration of **benzene**, including the equation for the reaction that produces the electrophile.

(4)

*(ii) Explain why phenol can be nitrated under much milder conditions than those required to nitrate benzene.

(2)

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(iii) Suggest reagents that could be used for **step 2**.

(2)

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(iv) Suggest the name or formula of a reagent that could be used in **step 3**.

(1)

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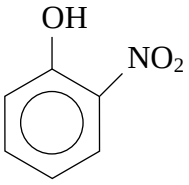
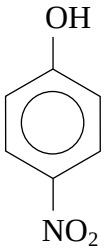
*(b) In the nitration of phenol, **step 1**, two compounds are produced.



2-nitrophenol



4-nitrophenol

These compounds can be separated by steam distillation, since 2-nitrophenol is volatile in steam but 4-nitrophenol is not.

Describe briefly the technique of steam distillation and give ONE advantage of steam distillation over normal distillation.

(3)

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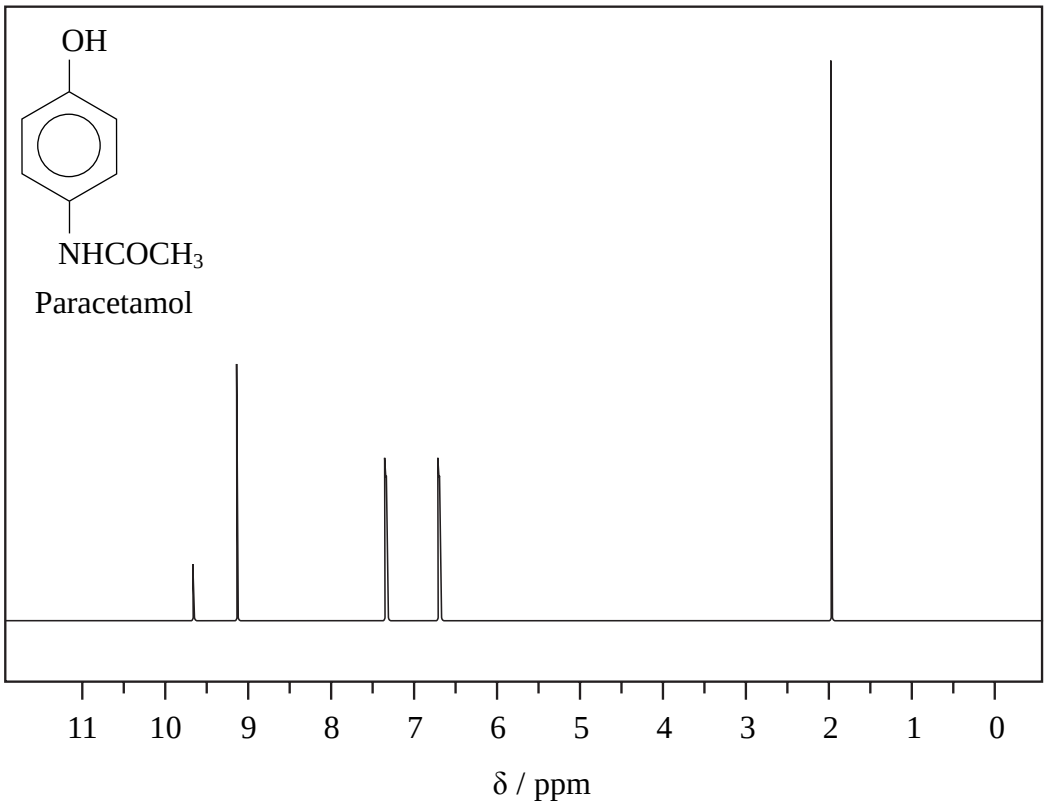
(c) The nmr spectrum of paracetamol is given below. The peaks at 6.7 and 7.4 ppm are due to the protons on the benzene ring and are both doublets.

Explain why these two peaks are doublets but all the other peaks are singlets.

[There is no need to refer to your data booklet]

(2)



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(Total for Question 22 = 14 marks)

23 More than half of the elements in the Periodic Table are transition elements. Vanadium, element 23, is a typical transition element.

(a) (i) Give TWO properties shown by vanadium **compounds** that are characteristic of transition metal chemistry, other than variable oxidation state.

(2)

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(ii) Vanadium(III) ions in aqueous solution exist as $[V(H_2O)_6]^{3+}$.

Draw this ion so as to clearly show its shape. Name the type of bond between the ligand and the vanadium ion and state the feature of the ligand that enables this bond to be formed.

(3)

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(b) Vanadium ions exist in oxidation states from (V) to (II).

(i) Use your data booklet (page 15) to find the standard electrode (reduction) potential for the reduction of vanadium(IV), VO^{2+}, to vanadium(III), V^{3+}.

(1)

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*(ii) Explain the term **disproportionation.**

(2)

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(iii) Use your answer to (b)(i), and the data below, to calculate $E^{\ominus}_{cell}$ for the formation of vanadium(V) and vanadium(III) from vanadium(IV) in acidic solution. State if the reaction is feasible under standard conditions and justify your answer.

$VO_2^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l) \quad E^{\ominus} = +1.00\ V$

(2)

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(Total for Question 23 = 10 marks)

TOTAL FOR SECTION B = 47 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

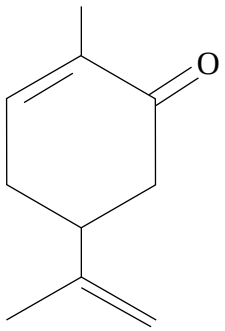
24

A major function of the chemical industry is the manufacture of perfumes and flavourings. Perfumes were originally made from natural products, such as spermaceti from whales or civetone from the civet cat. The use of synthetic equivalents is generally cheaper and the supply is more reliable, and does not require the animals to be killed which obtaining spermaceti did. Synthetic perfumes and flavourings are usually nature-identical, although naturally-occurring molecules that have stereoisomers are sometimes produced synthetically as mixtures since the stereospecific synthesis required might be difficult to achieve economically.

Some chiral molecules have a different taste depending on which enantiomer is present. The enantiomer (–)-carvone tastes and smells of spearmint, and its mirror-image, (+)-carvone, of caraway or dill. In some cases only one enantiomer has any taste; this is true for glucose. The mirror image molecule of naturally occurring glucose has no taste and cannot even be absorbed or metabolized. Many drug molecules are chiral, though paracetamol is not. The wrong isomer present in a drug may be positively damaging, which was the case with thalidomide. In order to synthesize optically-pure drug molecules, it is important to understand the mechanism of any reaction used. Using an S_N1 reaction which involves the chiral centre would result in the product mixture being racemic. It is advantageous to use stereospecific catalysts wherever possible, and industry on the whole prefers to use heterogeneous rather than homogeneous catalysts.

(a) The skeletal formula of carvone is shown below. Draw a circle around the chiral carbon atom.

(1)



(b) Explain why the synthesis of paracetamol is more efficient than the synthesis of a single enantiomer such as (–)-carvone.

(3)

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(c) Carvone contains two types of functional group. For each of these, give a suitable chemical test to show its presence, and state what you would see in each case.

(4)

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(d) Carvone can be reduced in a variety of ways.

(i) On reduction with hydrogen, in the presence of a platinum catalyst, 4.5 g of carvone reacted with 1.44 dm^3 of hydrogen. Use these data to deduce the skeletal formula of the reduction product.

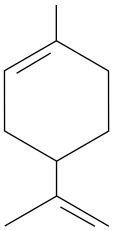
[Molar mass of carvone is 150 g mol^{-1}; molar volume of hydrogen at the temperature and pressure of the experiment is 24 dm^3 mol^{-1}.]

(3)

Working

Hence skeletal formula of reduction product.

(ii) Reduction of carvone, using hydrazine in potassium hydroxide solution, gives limonene.



How would you show from a comparison of the infra-red spectra of carvone and of limonene that this reduction had occurred? You should quote appropriate data, from the data booklet, to support your answer.

(2)

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(e) (i) Draw the skeletal formula of the molecule that would be obtained if carvone were to be reacted with an excess of hydrogen bromide in an inert solvent.

(2)

(ii) If the product from (e)(i) were to be heated with ethanolic potassium hydroxide solution, elimination would occur and HBr would be lost. Would the resulting molecule necessarily be carvone? Explain your answer.

(2)

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(f) *(i) Give the mechanism of one nucleophilic reaction of your choice, which **either** gives rise to a racemic mixture **or** results in the inversion of the chirality of the starting material. Explain what your mechanism predicts about the stereochemistry of the product.

(5)

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(ii) Suggest why industrial chemists prefer to use heterogeneous rather than homogeneous catalysts.

(1)

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(Total for Question 24 = 23 marks)

TOTAL FOR SECTION C = 23 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

N 3 6 5 0 7 A 0 2 8 2 8

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June 2010

GCE

GCE Chemistry (6CH05/01)

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Section A

Question Number	Correct Answer	Mark
1	D	**1**

Question Number	Correct Answer	Mark
2	C	**1**

Question Number	Correct Answer	Mark
3	A	**1**

Question Number	Correct Answer	Mark
4	A	**1**

Question Number	Correct Answer	Mark
5	C	**1**

Question Number	Correct Answer	Mark
6	A	**1**

Question Number	Correct Answer	Mark
7	C	**1**

Question Number	Correct Answer	Mark
8	B	**1**

Question Number	Correct Answer	Mark
9	A	**1**

Question Number	Correct Answer	Mark
10	D	**1**

Question Number	Correct Answer	Mark
11	B	**1**

Question Number	Correct Answer	Mark
12	D	**1**

Question Number	Correct Answer	Mark
13	C	**1**

Question Number	Correct Answer	Mark
14	A	**1**

Question Number	Correct Answer	Mark
15	A	**1**

Question Number	Correct Answer	Mark
16	B	**1**

Question Number	Correct Answer	Mark
17	B	**1**

Question Number	Correct Answer	Mark
18	C	**1**

Question Number	Correct Answer	Mark
19	B	**1**

Question Number	Correct Answer	Mark
20	D	**1**

Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	**Copper:** 0 to +2/2+/2^+/II/2 **(1)** **Nitrogen:** +5/5+/5^+/V/5 to +4/4+/4^+/IV/4 **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	$Cu \rightarrow Cu^{2+} + 2e^{(-)}$ OR $Cu - 2e^{(-)} \rightarrow Cu^{2+}$ **(1)** $Cu[(H_2O)_6]^{2+}$ OK if 6 waters shown on l.h.s. $NO_3^- + 2H^+ + e^{(-)} \rightarrow NO_2 + H_2O$ OR $2NO_3^- + 4H^+ + 2e^{(-)} \rightarrow 2NO_2 + 2H_2O$ **(1)** OR $2NO_3^- + 4H^+ + 2e^{(-)} \rightarrow N_2O_4 + 2H_2O$ **(1)** Ignore the full equation if it is given as well Allow equations written as reverse of above Ignore state symbols even if wrong Allow $\rightleftharpoons$ for $\rightarrow$		**2**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	(electrode potential) values are for standard conditions **(1)** **nitric acid** is concentrated / not 1 mol dm^{-3} / not 1 M **(1)** Allow temperature not stated for second mark	NO_3^- are not 1 mol dm^{-3} Any reference to loss of NO_2	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	initially a (pale/light) **blue precipitate (1)** Allow blue solid Ignore white precipitate (re-dissolves in excess to form) a (deep) blue **solution (1)** Stand alone mark Accept any shade of blue except greenish-blue	Any colour (other than blue) precipitate in blue solution	**2**

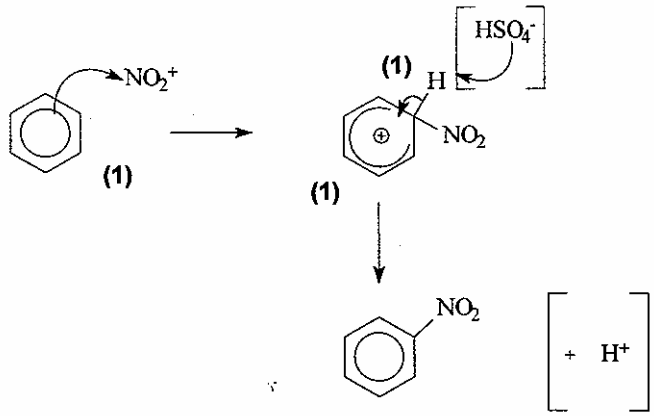
Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ **(1)** $Zn^{2+}(aq) + 2OH^-(aq) \rightarrow Zn(OH)_2(s)$ **(1)** $Zn(OH)_2(s) + 2OH^-(aq) \rightarrow Zn(OH)_4^{2-}(aq)$ **(1)** If two previous equations combined correctly then **(1)** only : $Zn^{2+} + 4OH^- \rightarrow Zn(OH)_4^{2-}$ **Allow** $Zn(OH)_2(s) + 2OH^-(aq) \rightarrow ZnO_2^{2-}(aq) + 2H_2O(l)$ OR $Zn(OH)_2(s) + 4OH^-(aq) \rightarrow Zn(OH)_6^{4-}(aq)$ OR equivalent non-ionic equations, including those with Zn^{2+} + 2NaOH etc OR Correct balanced equations starting with hexaqua or tetraqua cations ALLOW the hydroxides to be shown as e.g. $Zn(OH)_2(H_2O)_4$ (s) provided that the whole equation balances. Penalise missing /incorrect state symbols on product once only. Ignore other state symbols		**3**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii) QWC	**First 2 marks:** zinc **hydroxide/oxide** amphoteric because it reacts with alkali (to give a solution of a zincate) **(1)** and reacts with acid (to give a salt) **(1)** zinc hydroxide **is / acts as** both an acid and an alkali – scores **(1)** only **Third mark:** hexaquazinc or hydrated zinc ions exchanged water for ammonia or other named ligand **(1)** OR $Zn(H_2O)_6^{2+} + 4NH_3 \rightarrow$ etc **(1)** Allow any number of ammonias from 1 to 6 Allow balanced equations, ionic or full. Ligand exchange reaction must start with a complex ion **Note:** If zinc mentioned initially but equation refers to a correct compound then credit should be given If equations wrong but words are correct then ignore equations	Reference to zinc ions or zinc metal Do not allow deprotonation	**3**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ Ignore state symbols even if wrong.	Non-ionic equation.	**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii) QWC	Amount thiosulphate = 0.0331 dm^3 x 0.1 mol dm^{-3} = 0.00331 mol **(1)** = amount of copper(II) ions in 25 cm^3 portion **(1)** ∴ amount Cu = 10 x 0.00331= 0.0331 mol in total **(1)** ∴ mass Cu = 0.0331 mol x 63.5 g mol^{-1} **(1)** = 2.102 g ∴ % copper = (2.102 x 100)÷ 3.00 **(1)** = 70.1% **(1)** to **3 s.f. only** Mark consequentially but if % > 100 then (-1) If equation in (i) is incorrect but used correctly in part (ii) then all marks can be scored unless answer > 100% Correct answer can score 6 marks irrespective of the stoichiometry of the equation in (c)(i) If candidates uses 64 for molar mass of Cu final answer will be 70.6; scores max of 5	70.06 or 70.0	**6**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iii)	some reagent used to fill the jet (which does not react with the iodine solution) **and so** the titre is too high **(1)** and hence the percentage value would be too high **(1)** Allow only if the titre is said to be high If the titre is thought to be too low then allow percentage value too low for 2nd mark **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	$H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_2O + HSO_4^-$ OR $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$ $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$ Both needed OR $2H_2SO_4 + HNO_3 \longrightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ **(1)** Ignore state symbols even if wrong  arrow showing attack on the nitronium ion with arrow going to N atom, or into the C – N gap **(1)** Arrow must start at or inside ring Ignore position of + charge structure of the intermediate showing reasonable delocalisation (over at least 3 carbon atoms) **(1)** arrow **from the bond** showing the loss of H^+ from the intermediate. Removal by hydrogen sulphate ion preferable but not essential **(1)** Kekulé structures score full marks If the electrophile is incorrect then the intermediate structure mark is lost	Delocalisation mustn't go over C where NO_2^+ is attached	**4**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii) QWC	**First mark:** (lone pair of) electrons on the oxygen atom or on the OH group is delocalised / incorporated into the ring **(1)** OR the OH group is electron donating **(1)** **Second mark:** so the ring in phenol is more negative / has increased electron density / **ring** is more nucleophilic / hence more susceptible to electrophilic attack **(1)** OR the OH group activates the ring **(1)** Second mark stand alone	Reject hydroxide for first mark only Nucleophilic attack on the ring 'Makes it more reactive' on its own	**2**

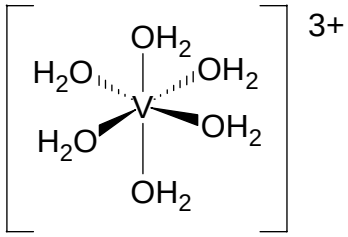
Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	tin **(1)** and **concentrated** hydrochloric acid **(1)** Formulae acceptable. If NaOH is added after HCl then ignore; if implication that HCl and NaOH are added together then second mark is lost OR iron **(1)** and **concentrated** hydrochloric acid **(1)** **2nd mark conditional on a metal** OR hydrogen **(1)** and platinum / palladium catalyst **(1)**	lithium aluminium hydride sodium borohydride Nickel Raney Nickel	**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iv)	ethanoyl chloride OR acetyl chloride OR CH_3COCl OR equivalent displayed formula OR ethanoic anhydride OR acetic anhydride OR $(CH_3CO)_2O$ OR equivalent displayed formula Right name but wrong formula does not score Ignore minor spelling errors if the formula is correct		**1**

Question Number	Acceptable Answers	Reject	Mark
22(b) **QWC**	**First mark:** steam is passed into the mixture OR water is added and mixture boiled or distilled or heated **(1)** **Second mark:** and the 2-nitrophenol / product vapour distilled off **with the water** (and condensed) **(1)** **Advantage:** The 2-nitrophenol / product distils at a lower temperature / prevents decomposition**(1)** Stand alone	Passed over; anything that implies external heating with a steam bath or water bath any implication of fractional distillation any suggestion that separation based on differing boiling temperature water-soluble	**3**

Question Number	Acceptable Answers	Reject	Mark
22(c)	Read the whole answer to get the sense The (ring) hydrogen atoms are on carbon atoms which have **one / a** hydrogen on an **adjacent** carbon atom, so are doublets **(1)** All the other hydrogen atoms have no adjacent hydrogen (bearing carbon) atoms, so are singlets **(1)**	 nearby	**2**

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	Any TWO of: complex ions / complexes **(1)** coloured ions / compounds / solutions **(1)** catalytic properties **(1)** paramagnetic **(1)** Allow coloured complexes **(2)** coloured complex compound **(1)** If a list appears with 1 or 2 correct properties followed by properties related to the element, then (1) mark only Ignore 'partially filled *d*-orbitals'	complex compounds	**2**

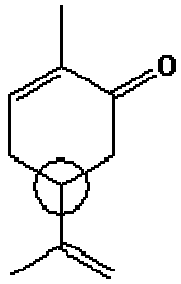
Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	 ignore absence of charge **clearly** octahedral (ignore bonds to the H in H_2O) **(1)** but allow some latitude in the symbols used to show the 3D structure. Wedges do not have to be exact – if used they are enough to show 3D if the axial bonds are lines The word 'octahedral' does not salvage a poor drawing dative (covalent) / coordinate (bond) **(1)** not just shown by an arrow lone pair (of electrons on the oxygen) **(1)** can be shown on the diagram		**3**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	(+) 0.34 (V) OR (+) 0,34 V sign not needed		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii) QWC	(simultaneous) oxidation and reduction **(1)** Allow redox of a species / substance / reactant / compound / chemical / element **(1)**		**2**

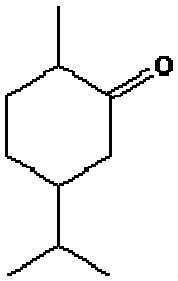
Question Number	Acceptable Answers	Reject	Mark
23(b)(iii)	− 0.66(V) **(1)** Allow TE from (b)(i) reaction not feasible **since the potential is negative** (2nd mark is for an answer consistent with sign of E°) **(1)**		**2**

Section C

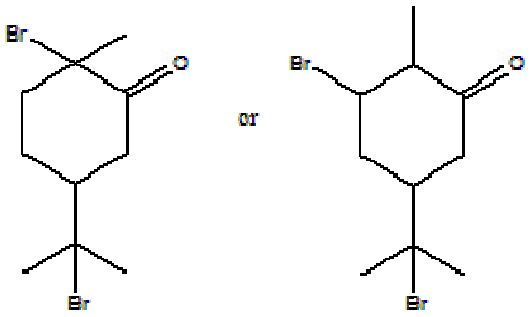
Question Number	Acceptable Answers	Reject	Mark
24(a)		Circles that encompass two atoms	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)	**First mark:** Recognition that paracetamol is not chiral / has no enantiomers / does not have optical isomers **(1)** **Second and third marks:** Any two of: there is no racemisation so the product will not be a mixture **(1)** no need to separate (the enantiomers) **(1)** do not have to discard an unwanted enantiomer / atom economy is higher **(1)** **OR** converse arguments starting from (-)-carvone.	Is not optically active	**3**

Question Number	Acceptable Answers	Reject	Mark
24(c)	(C=C): add bromine (water) **(1)** decolourises **(1)** OR $KMnO_4$ **(1)** purple → brown / colourless **(1)** (C=O): add 2,4-dnp / 2,4-dinitrophenylhydrazine/ Brady's reagent **(1)** orange or yellow or orange-red or red ppt **(1)** Ignore a negative Fehling's / Tollens' test If a positive Fehling's / Tollens' is given in addition to 2,4 DNP then third and fourth marks are lost Observation dependent on test	1,4-dnp	**4**

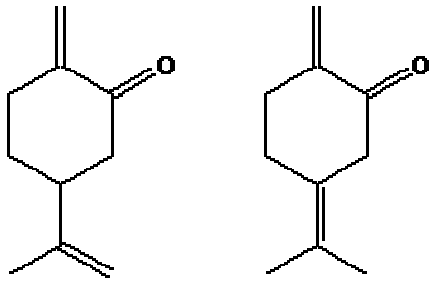
Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	amount of carvone = (4.5 ÷ 150) mol = 0.03 mol **(1)** amount of hydrogen = (1.44 ÷ 24) mol = 0.06 mol (allow 1st mark for either of the mole calculations) so two double bonds are reduced **(1)** OR 2 moles H_2 : (1 mol carvone) OR 4 mole H : (1 mol carvone) If hydrogen is used it must be clear whether they are atoms or molecules This mark can be salvaged if the structure is correct and both double bonds are reduced  **(1)** stand alone Accept displayed formula if completely correct	Any structure that shows reduction of the C=O bond	**3**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	(a ketone/C=O) absorption / peak / trough / within the range 1680 – 1700 (cm^{-1}) **(1)** Ignore units will be seen in carvone but not in limonene / the reduction product **(1)** omission of the value for the absorption loses first mark only	1720 - 1740 cm^{-1}	**2**

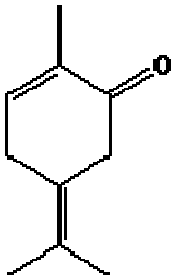
Question Number	Acceptable Answers	Reject	Mark
24(e)(i)	 for both double bonds having HBr added **(1)** ignore added hydrogens for correct orientation in **exocyclic** double bond **(1)** stand alone	Any structure retaining C=C bonds	**2**

Question Number	Acceptable Answers	Reject	Mark
24(e)(ii)	HBr can be eliminated using a hydrogen from the carbon on either side of the bromine **(1)** which would then give a double bond in a different position from that in carvone **(1)** this second mark can be answered using a skeletal / structural formula (below)	Reference to substitution	**2**

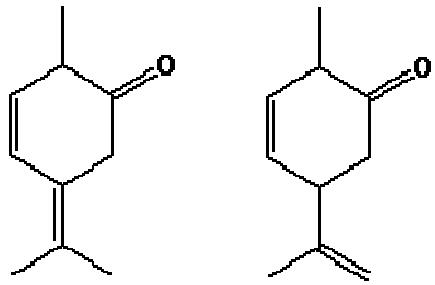
From the left-hand structure above:



From either of the structures above:



From the right-hand structure above:



Question Number	Acceptable Answers	Reject	Mark
24(f)(i) QWC	**Using an $S_N1$mechanism:** selection of a chiral starting material **(1)** curly arrow from C-X bond to X **(1)** and intermediate carbocation **(1)** curly arrow from nucleophile (can come from negative charge) **(1)** **planar intermediate** attacked from either side to give a racemic mixture **OR** **intermediate equally** attacked from either side to give a racemic mixture **(1)** **Using an S_N2 mechanism:** selection of a chiral starting material **(1)** curly arrow from nucleophile (can come from negative charge) **(1)** curly arrow from C-X bond to X **(1)** to give correct transition state **(1)** attack from opposite side to C-X bond gives inverted product can be shown on a diagram **(1)** **Using nucleophilic addition to C= O:** Selection of any aldehyde (other than methanal) or any asymmetric ketone **(1)** Curly arrow from nucleophile (can come from negative charge) to C of C=O and curly arrow from = to O **(1)** Intermediate **(1)** Arrow from O^- of intermediate to H^+ **(1)** **planar molecule** attacked from either side to give a racemic mixture **OR** **molecule equally** attacked from either side to give a racemic mixture **(1)**	If H-X used then -1	**5**

Question Number	Acceptable Answers	Reject	Mark
24(f)(ii)	heterogeneous catalysts can be filtered off OR do not appear in any liquid or gaseous products OR are easy to separate OR are stereospecific OR suited to continuous processes rather than batch processes	greater surface area	**1**

Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Monday 31 January 2011 – Morning
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/5/5/2/

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 What type of bonding occurs between the metal ion and ligand in the complex ion $[Cu(H_2O)_6]^{2+}$?

☒ **A** Metallic

☒ **B** Ionic

☒ **C** Hydrogen

☒ **D** Dative covalent

(Total for Question 1 = 1 mark)

---

2 Which of these four amino acids could **not** rotate the plane of plane-polarised light?

☒ **A** $H_2NCH(CH_3)COOH$

☒ **B** $H_2NCH(CH_2COOH)COOH$

☒ **C** H_2NCH_2COOH

☒ **D** $H_2NCH(CH_2SH)COOH$

(Total for Question 2 = 1 mark)

---

3 In the solid state, the amino acid serine exists in the form

☒ **A** $H_3N^+CH(CH_2OH)COOH$

☒ **B** $H_3N^+CH(CH_2OH)CO_2^-$

☒ **C** $H_2NCH(CH_2OH)COOH$

☒ **D** $H_2NCH(CH_2OH)CO_2^-$

(Total for Question 3 = 1 mark)

---

4 The best method for separating a mixture of amino acids in solution is

☒ **A** distillation.

☒ **B** solvent extraction.

☒ **C** chromatography.

☒ **D** recrystallization.

(Total for Question 4 = 1 mark)

---

5 How many different peaks due to hydrogen atoms would you expect to see in a **low resolution** proton nmr spectrum of propanoic acid, CH_3CH_2COOH?

☒ **A** Two

☒ **B** Three

☒ **C** Five

☒ **D** Six

(Total for Question 5 = 1 mark)

6 In a **high resolution** proton nmr spectrum of ethanoic acid, CH_3COOH, the peak due to the hydrogen atoms in the methyl group would be a

☒ **A** singlet.

☒ **B** doublet.

☒ **C** triplet.

☒ **D** quartet.

(Total for Question 6 = 1 mark)

7 Which of these compounds will **not** form an amide in a reaction with ethanoyl chloride?

☒ **A** NH_3

☒ **B** $CH_3CH_2NH_2$

☒ **C** $CH_3CH_2NH(CH_3)$

☒ **D** $CH_3CH_2N(CH_3)_2$

(Total for Question 7 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

8 This question concerns the following organic compounds.

A CH_3COCl

B CH_3COOH

C $CH_3COOCH_2CH_3$

D C_6H_5OH

Which compound is most likely to

(a) form the solution with the lowest pH when mixed with water?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) burn with a smoky flame?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) have a fruity smell?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) have an absorption in its IR spectrum at about 1795 cm^{-1}?

(1)

☒ **A**

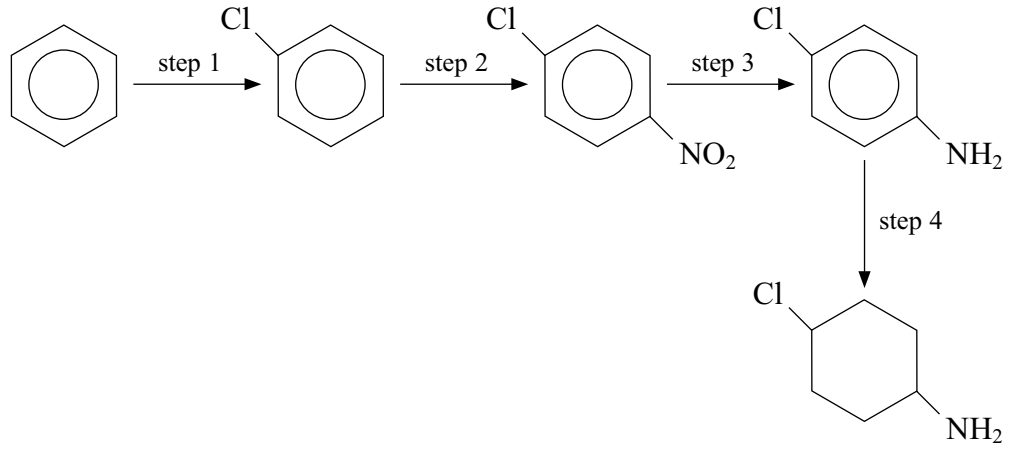
☒ **B**

☒ **C**

☒ **D**

(Total for Question 8 = 4 marks)

9 This question is about the reaction scheme below.



Which step is most likely to need

(a) tin and concentrated hydrochloric acid?

(1)

- ☒ **A** Step 1
- ☒ **B** Step 2
- ☒ **C** Step 3
- ☒ **D** Step 4

(b) a catalyst of iron(III) chloride?

(1)

- ☒ **A** Step 1
- ☒ **B** Step 2
- ☒ **C** Step 3
- ☒ **D** Step 4

(c) a nickel catalyst?

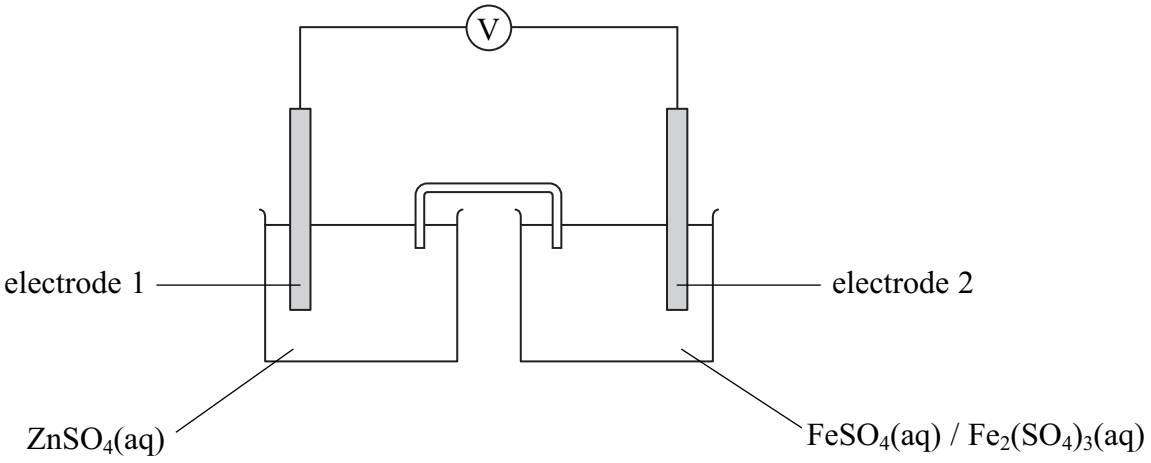
(1)

- ☒ **A** Step 1
- ☒ **B** Step 2
- ☒ **C** Step 3
- ☒ **D** Step 4

(Total for Question 9 = 3 marks)

10 The apparatus below can be used to measure the value of E_{cell} for the reaction

$$2Fe^{3+}(aq) + Zn(s) \rightarrow 2Fe^{2+}(aq) + Zn^{2+}(aq)$$



The electrodes are:

		electrode 1	electrode 2
☒	**A**	zinc	iron
☒	**B**	iron	zinc
☒	**C**	zinc	platinum
☒	**D**	platinum	platinum

(Total for Question 10 = 1 mark)

11 Copper reacts with silver ions according to the reaction below.

$$Cu(s) + 2Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$$

$E^{\ominus}_{cell}$ for this reaction is

☒ **A** +0.46 V

☒ **B** +1.14 V

☒ **C** +1.26 V

☒ **D** +1.94 V

(Total for Question 11 = 1 mark)

12 $E^{\ominus}_{cell}$ for four reactions are shown in the table below.

	$E^{\ominus}_{cell}$ / V
Reaction 1	+1.10
Reaction 2	+0.65
Reaction 3	+0.10
Reaction 4	–1.30

Which reaction

(a) is thermodynamically not feasible?

(1)

☒ **A** Reaction 1

☒ **B** Reaction 2

☒ **C** Reaction 3

☒ **D** Reaction 4

(b) has the largest value for ln *K*?

(1)

☒ **A** Reaction 1

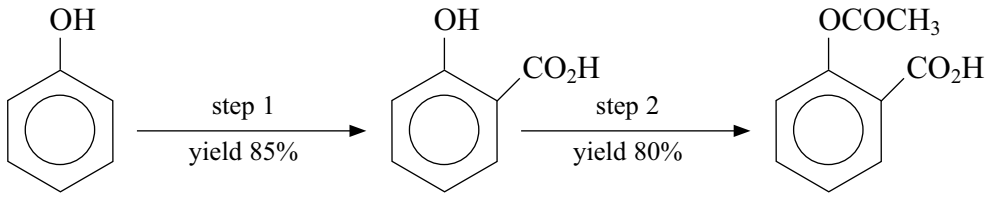
☒ **B** Reaction 2

☒ **C** Reaction 3

☒ **D** Reaction 4

(Total for Question 12 = 2 marks)

13 Consider the reaction scheme below and calculate the mass of aspirin you would expect to form if you started with 47 g of phenol.



phenol, $M_r = 94$ aspirin, $M_r = 180$

☒ **A** 31.96 g

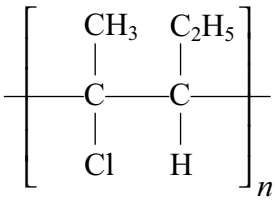
☒ **B** 61.20 g

☒ **C** 74.25 g

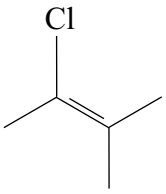
☒ **D** 90.00 g

(Total for Question 13 = 1 mark)

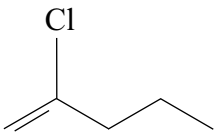
14 Which of the monomers **A to D** would form the polymer below?



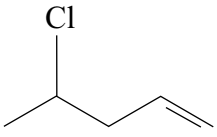
☒ **A**



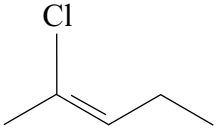
☒ **B**



☒ **C**



☒ **D**



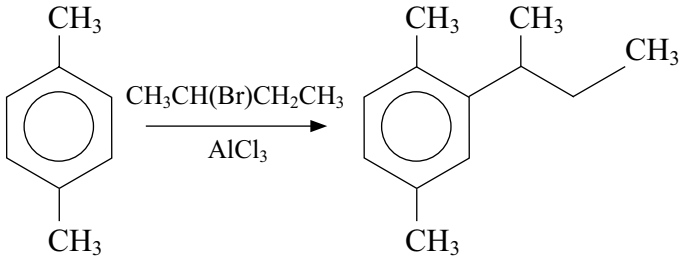
(Total for Question 14 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

15 In the reaction shown below, the aromatic compound 1,4-dimethylbenzene reacts with 2-bromobutane. The reaction is catalysed by aluminium chloride, $AlCl_3$, which dissolves in the reaction mixture.



1,4-dimethylbenzene

(a) (i) Name the type of reaction and the mechanism.

(1)

.....

(ii) Write the equation to show how the attacking species forms and give the mechanism for the reaction.

(4)

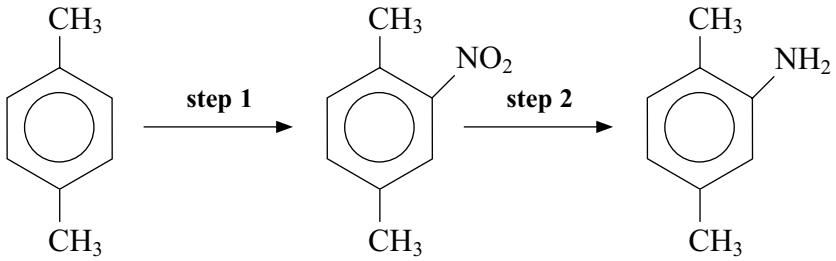
Equation

Mechanism

(b) The same reaction can also be carried out using a heterogeneous graphite catalyst under similar conditions. Assuming both reactions have a similar rate and yield, suggest one advantage of using the solid graphite catalyst instead of aluminium chloride. Justify your answer.

(2)

(c) A student proposed to synthesise the compound 2,5-dimethylphenylamine, used in the manufacture of dyes, following the scheme below.



1,4-dimethylbenzene 2,5-dimethylphenylamine

(i) What two reagents are needed for **step 1**?

(2)

(ii) Suggest why 1,4-dimethylbenzene is more reactive than benzene in reactions such as **step 1**.

(2)

(iii) What type of reaction occurs in **step 2**?

(1)

.....

*(iv) 2,5-dimethylphenylamine can be used to make azo-dyes. State the reagents and conditions needed to make an azo-dye from 2,5-dimethylphenylamine and phenol. Include equations for the organic reactions.

(5)

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(Total for Question 15 = 17 marks)

16 The leaves of the rhubarb plant contain ethanedioic acid, $(COOH)_2$, a toxic white soluble solid. The acid is readily oxidized by potassium manganate(VII) under acidic conditions. A sample of 250 g of rhubarb leaves was finely chopped then soaked in warm water to release any ethanedioic acid present. The mixture was then filtered and made up to a volume of 500 cm^3 using distilled water. 10.0 cm^3 of the solution was then titrated with 0.0100 mol dm^{-3} acidified potassium manganate(VII) solution from a burette, requiring 11.30 cm^3 to completely oxidize the sample.

(a) (i) Write the half equation for the oxidation of ethanedioic acid to form carbon dioxide, and the half equation for the reduction of manganate(VII) ions, MnO_4^-, in acidic solution to form manganese(II) ions. State symbols are **not** required.

(2)

(ii) Use your answers to (a)(i) to write the overall equation for the reaction, showing that the ratio of ethanedioic acid to manganate(VII) ions in the full equation is 5 : 2. State symbols are **not** required.

(1)

*(iii) Calculate the % by mass of the ethanedioic acid present in the leaves, giving your final answer to **two** decimal places.

(5)

(iv) What is the level of accuracy of a burette in each reading? Use your answer to calculate the percentage error in the titre volume of 11.30 cm^3.

(2)

(v) Suggest **two** reasons, other than the accuracy of the equipment used for measurements, why the results obtained in this experiment may be considered unreliable.

(2)

(vi) A student risk assessment for this experiment suggested wearing gloves, but a supervisor said that this was unnecessary. Why do you think this precaution was suggested by the student and why was it rejected by the supervisor?

(2)

(vii) An aqueous solution of MnO_4^- ions contained a small amount of chloride ions, Cl^-, as an impurity. Use this fact, and items 70 and 85 from page 16 of the data booklet, to suggest why this solution went cloudy after a time.

(2)

(b) An aqueous solution containing Mn^{2+} ions is pale pink in colour due to the presence of the complex ion $[Mn(H_2O)_6]^{2+}(aq)$.

(i) Complete the electronic configuration of the Mn^{2+} ion.

(1)

$1s^2$ .....

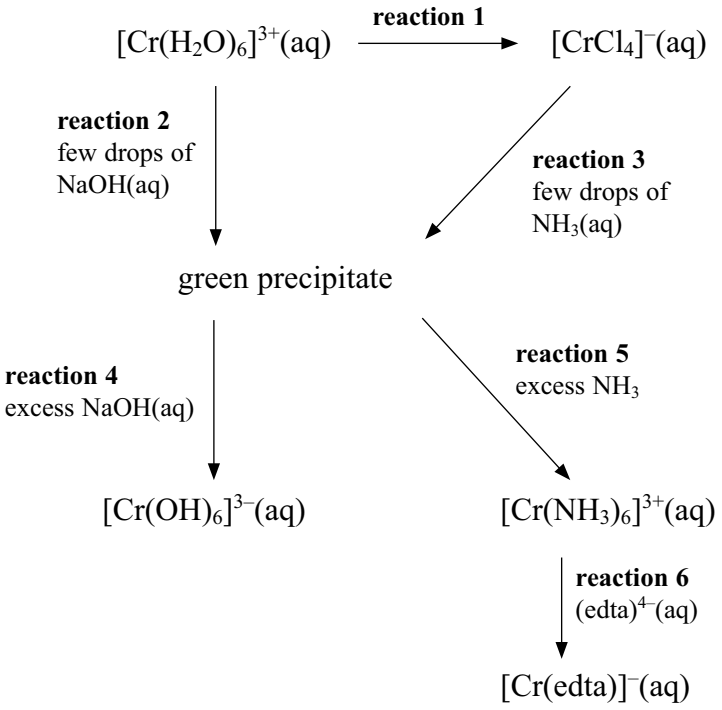
(ii) What shape would you expect this complex ion to be?

(1)

.....

(Total for Question 16 = 18 marks)

17 The reaction scheme below summarises some of the reactions of chromium ions in aqueous solution. Look carefully at the scheme and answer the questions that follow.



(a) (i) Explain why the $[Cr(H_2O)_6]^{3+}$ ion is coloured.

(3)

(ii) Suggest what reagent is needed for **reaction 1** and identify the type of reaction.

(2)

(b) (i) $[Cr(H_2O)_6]^{3+}$ ions react with water to form an acidic solution. Complete the equation for this reaction.

(2)

$[Cr(H_2O)_6]^{3+}(aq) + H_2O(l) \rightleftharpoons$ ..... + ...

(ii) The pH of an aqueous solution of $[Cu(H_2O)_6]^{2+}$ is higher than that of an aqueous solution of $[Cr(H_2O)_6]^{3+}$ of the same concentration. Suggest why this is so.

(2)

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.....

.....

(c) Give the formula of the green precipitate formed in **reactions 2 and 3**.

(1)

.....

(d) By considering the nature of the reactants in **reaction 4**, explain why the green precipitate reacts as shown in the scheme. Suggest how you could reverse **reaction 4**.

(3)

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.....

(e) Write the equation for **reaction 6** and use this to explain, in terms of the entropy change, why the complex $[Cr(edta)]^-$ is relatively more stable than $[Cr(NH_3)_6]^{3+}$.

(2)

Equation

.....

.....

.....

.....

(Total for Question 17 = 15 marks)

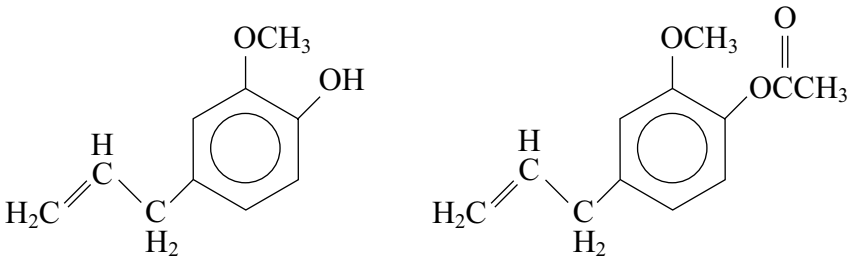
TOTAL FOR SECTION B = 50 MARKS

BLANK PAGE

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

18 Eugenol, a pale yellow oil, and eugenol ethanoate are phenol-derived compounds found in the evergreen clove tree *Eugenia aromaticum*.



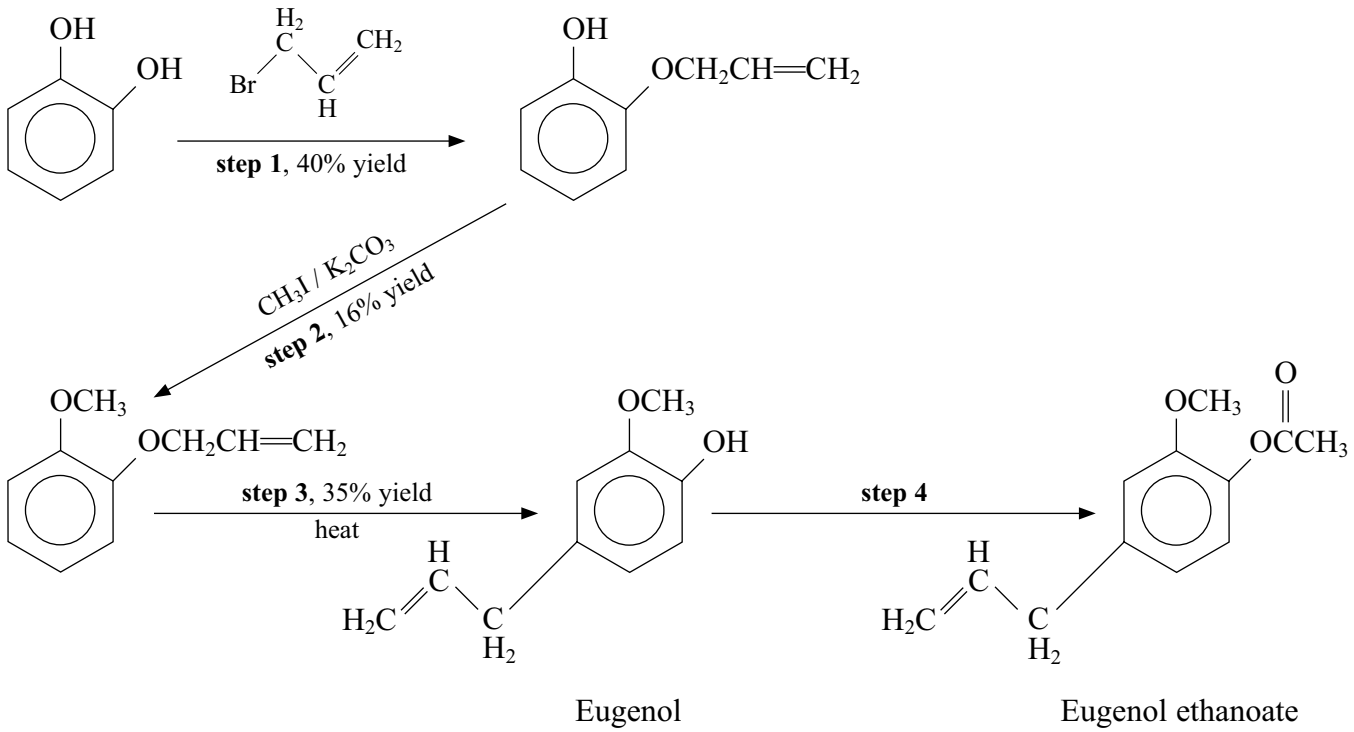
Eugenol Eugenol ethanoate

Eugenol is used in perfumes, the manufacture of food flavourings and as a local anaesthetic. Eugenol ethanoate is mainly used in perfumes and aftershaves. Although used for many years, both compounds are classified as harmful and have been tested to determine their toxicity by ingestion. However, humans would need to consume very large amounts to reach toxic levels.

The compounds are the main constituents of clove oil which can be extracted from the dried buds of *Eugenia aromaticum's* flowers. Traditionally the oil is extracted by steam distillation, though a greater yield of oil can be obtained using a Soxhlet extractor to pass a chlorinated solvent through the dried buds several times to dissolve the clove oil. An alternative technique uses carbon dioxide as a solvent. Above a temperature of 304 K and a high pressure of 73.8 atm, carbon dioxide behaves as a supercritical fluid and when passed through the clove buds, it dissolves the clove oil. Releasing the pressure causes the carbon dioxide to turn back into a gas, leaving the clove oil behind. A summary of the characteristics of the clove oil obtained by the three extraction techniques is shown in the table below.

Extraction method	Mass of oil per 100 g of dried buds / g	% eugenol and eugenol ethanoate in the oil produced	Extraction time / h	Colour and texture	Use of organic solvent
Supercritical carbon dioxide	19.6	78.4	2	pale yellow oil	no
Steam distillation	11.5	53.5	4–6	brown-yellow oil	yes
Soxhlet extraction	41.8	40.1	6	brown paste	yes

Both molecules can also be manufactured synthetically in the laboratory. A reaction scheme for synthesising both molecules is summarised below.



Eugenol Eugenol ethanoate

(a) (i) 0.328 g of eugenol produced synthetically was burnt completely in excess oxygen, producing 0.880 g of carbon dioxide and 0.216 g of water. Use these data to show they are consistent with the molecular formula of eugenol.

(4)

(ii) Describe a chemical test you could carry out to confirm the presence of a carbon-carbon double bond in the product of **step 1**. What would you expect to see?

(2)

.....

.....

.....

.....

(iii) What technique would you use to heat the reactants in **step 3** to minimise the loss of any volatile material?

(1)

.....

(iv) Suggest what reagent(s) could be used in **step 4**.

(1)

.....

.....

(b) (i) Draw and label the apparatus suitable for extracting clove oil from clove buds by steam distillation in the laboratory.

(3)

(ii) The distillate formed is a mixture of water and clove oil with a significant amount of oil dissolved in the water. Outline the steps that have to be taken to obtain the dry oil.

(3)

(c) Toxicity data for substances such as eugenol are generally obtained by tests on animals such as rats and guinea pigs. In the case of eugenol, do you think such tests are reasonable? Briefly justify your answer.

(1)

.....

.....

.....

*(d) Evaluate the three extraction methods for obtaining clove oil using information from the table. Give **one** reason why the synthetic route of obtaining eugenol, shown on page 20, is less preferable than extraction from clove buds.

(5)

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(Total for Question 18 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

N 3 7 9 5 4 A 0 2 4 2 4

PMT

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Mark Scheme (Results)
January 2011

GCE

GCE Chemistry (6CH05/01)

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January 2011

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1	D	**1**

Question Number	Correct Answer	Mark
2	C	**1**

Question Number	Correct Answer	Mark
3	B	**1**

Question Number	Correct Answer	Mark
4	C	**1**

Question Number	Correct Answer	Mark
5	B	**1**

Question Number	Correct Answer	Mark
6	A	**1**

Question Number	Correct Answer	Mark
7	D	**1**

Question Number	Correct Answer	Mark
8 (a)	A	**1**

Question Number	Correct Answer	Mark
8 (b)	D	**1**

Question Number	Correct Answer	Mark
8 (c)	C	**1**

Question Number	Correct Answer	Mark
8 (d)	A	**1**

Question Number	Correct Answer	Mark
9 (a)	C	**1**

Question Number	Correct Answer	Mark
9 (b)	A	**1**

Question Number	Correct Answer	Mark
9 (c)	D	**1**

Question Number	Correct Answer	Mark
10	C	**1**

Question Number	Correct Answer	Mark
11	A	**1**

Question Number	Correct Answer	Mark
12 (a)	D	**1**

Question Number	Correct Answer	Mark
12 (b)	A	**1**

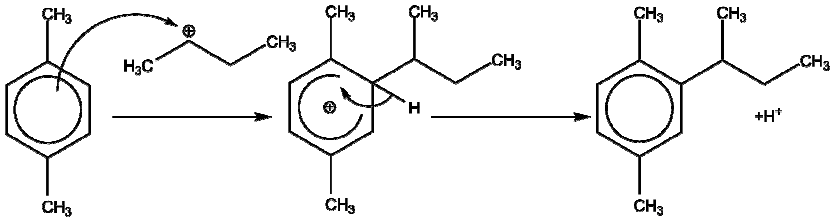
Question Number	Correct Answer	Mark
13	B	**1**

Question Number	Correct Answer	Mark
14	D	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
15 (a) (i)	Electrophilic substitution (any order)		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (a) (ii)	$AlCl_3 + CH_3CH(Br)CH_2CH_3 \rightarrow AlCl_3Br^- + CH_3C^+HCH_2CH_3$ ALLOW $CH_3CH(Br)CH_2CH_3 \rightarrow Br^- + CH_3C^+HCH_2CH_3$ Ignore position of the + for this mark Ignore curly arrows in this equation **(1)**  Electron pair (curly arrow) from ring to positively charged **second** carbon of carbocation **(1)** Structure of intermediate must include positive sign **(1)** Electron pair from C-H bond reforms delocalized ring **(1)**	$AlCl_4^-$	**4**

Question Number	Acceptable Answers	Reject	Mark
15 (b)	**Advantage** Graphite catalyst easier to remove / separate / can be filtered off (from reaction mixture) / graphite can be re-used **(1)** **Justification** $AlCl_3$ is soluble or graphite is insoluble /different state / different phase **OR** Graphite can be re-used **(1)** **Mark independently**	Just graphite is a heterogeneous catalyst	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (c) (i)	(Conc) nitric acid **(1)** (Conc) sulfuric acid **(1)** penalise dilute once only		**2**

Question Number	Acceptable Answers	Reject	Mark
15 (c) (ii)	Greater electron density **in ring** / ring is activated / more susceptible to electrophilic attack **(1)** Due to electron releasing / donating methyl groups **(1)**	Just more susceptible to attack	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (c) (iii)	Reduction ALLOW redox	Hydrogenation	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (c) (iv)	$NaNO_2$ / sodium nitrite / sodium nitrate(III) & HCl (any strong acid) **(1)** Temp 0-10˚C / less than 10˚C / any quoted temperature between 0 -10˚C / in ice bath **(1)** $C_6H_3(CH_3)_2NH_2 + HNO_2 + HCl \rightarrow C_6H_3(CH_3)_2N_2^+Cl^- + 2H_2O$ **(1)** Add phenol dissolved in alkali **(1)** $(C_6H_3(CH_3)_2N_2^+Cl^- + C_6H_5OH) \rightarrow C_6H_3(CH_3)_2N_2C_6H_4OH + (HCl)$ **(1)** Mark given for correct organic product Allow correct organic product shown as $-O^-$ instead of -OH **Mark independently**	HNO_3	**5**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (i)	$(COOH)_2 \rightarrow 2CO_2 + 2H^+ + 2e^-$ **(1)** $MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$ **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (ii)	$5(COOH)_2 + 2MnO_4^- + 6H^+ \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O$ ALLOW multiples ALLOW $5(COOH)_2 + 2MnO_4^- + 16H^+ \rightarrow 10CO_2 + 2Mn^{2+} + 8H_2O + 10H^+$ Ignore state symbols even if incorrect	Equation with electrons left in	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (iii)	Moles of MnO_4^- = 11.30/1000 x 0.010 = 1.13×10^{-4} (mol) **(1)** Moles of $(COOH)_2$ in 10 cm^3 = 1.13×10^{-4} x 5/2 = 2.825×10^{-4} (mol) **(1)** Moles of $(COOH)_2$ in whole sample = 2.825×10^{-4} x 50 = 0.01412(5) (mol) **(1)** Mass of acid = 0.01412(5)x 90 = 1.27 g **(1)** % in leaves = 1.27/250 x 100 = 0.51 (%) **(1)** If ratio 5 : 2 is not used, maximum **(4)** e.g. if ratio 2:5 is used then percentage in leaves = 0.08%	TE for 5th mark if % is greater than 100% Rounding errors once in first 4 marks Final answers not quoted to 2 dp	**5**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (iv)	± 0.05 cm^3 **(1)** [(0.05 x 2) / 11.3] x 100 = 0.88% **(1)** ALLOW ±0.025 cm^3 **(1)** [(0.025 x 2) / 11.3] x 100 = 0.44% **(1)** ALLOW TE for second mark		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (v)	Any two from: Only one titration carried out **(1)** Leaves may contain other substances that MnO_4^- could oxidize/ react with **(1)** Not all ethanedioic acid extracted from leaves **(1)** ALLOW temperature too low / below 60˚C **(1)** Different amounts of acid from different leaves **(1)**	Errors in technique e.g. transfer errors	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (vi)	(Wearing gloves suggested as) ethanedioic acid is toxic / harmful OR rhubarb **leaves** are toxic /harmful **(1)** (Unnecessary because) it is (very) dilute / present in small amounts **(1)** ALLOW because is not absorbed through the skin **Second mark is independent of the first**	References to weak acid Rhubarb is toxic	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (vii)	(Cloudiness due to) **MnO_2** (solid /precipitate) **(1)** Ignore colour of precipitate EITHER Suitable use of E^θ (+0.34V) **OR** MnO_4^- ions are a strong enough oxidizing agent to oxidize Cl^- ions **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (i)	$(1s^2)2s^22p^63s^23p^63d^5$ $(4s^0)$	$4s^2$ $3d^3$	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (ii)	Octahedral		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a) (i)	(Ligands cause) d orbitals / sub-shell / sub level to split **(1)** **Some** frequencies of light (energy) are absorbed **(1)** To promote electrons (within d level / d → d transitions) **(1)** ALLOW as alternative for second mark Remaining light is transmitted / reflected (resulting in the colour seen) **Mark independently**	Description of flame test	**3**

Question Number	Acceptable Answers	Reject	Mark
17 (a) (ii)	Concentrated HCl / HCl / HCl (aq) **(1)** **Ligand** exchange / replacement / substitution **(1)** **Mark independently**	Dilute HCl	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (i)	$[Cr(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Cr(H_2O)_5(OH)]^{2+} + H_3O^+$ **(1) (1)** ALLOW $[Cr(H_2O)_6]^{3+} + H_2O \rightleftharpoons [Cr(H_2O)_5(OH)]^{2+} + H_2O + H^+$ **(1) (1)** ALLOW second mark for number of H_3O^+ ions related to incorrect complex e.g. $[Cr(H_2O)_4(OH)_2]^{2+} + 2H_3O^+$ scores second mark Ignore state symbols even if wrong		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (ii)	The concentration of oxonium / hydrogen ions is less in the $[Cu(H_2O)_6]^{2+}$ / fewer hydrogen ions produced or reverse argument based on Cr ion **(1)** ALLOW $[Cr(H_2O)_6]^{3+}$ / chromium ion deprotonates more easily if H_3O^+ shown in equation in (b) (i) Because copper ion is 2+ whilst the chromium ion is 3+ / charge on copper ion is less than charge on Cr ion / less charge density on 2+ ions / Cr (3+) draws more electron density from the O-H bond **(1)**	Just chromium complex more acidic The concentration of oxonium / hydrogen ions is greater in the $[Cu(H_2O)_6]^{2+}$ / more hydrogen ions produced Ligand exchange	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (c)	$Cr(OH)_3$ / $Cr(H_2O)_3(OH)_3$		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d)	NaOH is a (strong) base / alkali **(1)** $Cr(H_2O)_3(OH)_3$ loses (three) protons / undergoes further deprotonation **OR** $Cr(OH)_3$ is amphoteric (so reacts with strong bases) **(1)** To reverse reaction 4 add (sulfuric) acid / H^+ / HCl **(1)**	Chromium is amphoteric	**3**

Question Number	Acceptable Answers	Reject	Mark
17 (e)	$[Cr(NH_3)_6]^{3+} + (edta)^{4-} \rightarrow [Cr(edta)]^- + 6NH_3$ **(1)** Ignore missing brackets Ignore state symbols even if wrong During the reaction number of particles increases (2 to 7) / more moles of product than reactants AND entropy (of system) increases **(1)**	Entropy increases because a gas is produced only Just more products than reactants	**2**

TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
18 (a) (i)	Mass of C in CO_2 = 12/44 x 0.88 = 0.24 g Mass of H in H_2O = 2/18 x 0.216 = 0.024g **(1)** So mass of oxygen = 0.328 – (0.24 + 0.024) = 0.064 g **(1)** Moles of C = 0.24/12 = 0.02 Moles of H = 0.024/1 = 0.024 Moles of O = 0.064/16 = 0.004 **(1)** Ratio = simplest ratio = 5:6:1 so $C_{10}H_{12}O_2$ **(1)** **OR** Moles of CO_2 0.88/44 = 0.02 Moles of H_2O 0.216/18 = 0.012 **(1)** Moles of H = 0.024 therefore ratio of C:H is 5:6 **(1)** Can gain remaining two marks if they continue calculation as above **OR** $C_{10}H_{12}O_2$ = 164 **(1)** Percentage carbon is 120/164 = 73.2% Percentage hydrogen is 7.3% Percentage oxygen is 19.5% **(1)** Mass of carbon = 73.2 x 0.328/100 = 0.24 Mass of hydrogen = 7.3 x 0.328/100 = 0.024 Mass of oxygen = 19.5 x 0.328/100 = 0.064 **(1)** Mass of carbon in CO_2 is 12/44 x 0.88 = 0.24 Mass of hydrogen in H_2O is 1/9 x 0.216 = 0.024 **(1)** **OR** Mass of C in CO_2 = 12/44 x 0.88 = 0.24 g Mass of H in H_2O = 2/18 x 0.216 = 0.024g **(1)** So mass of oxygen = 0.328 – (0.24 + 0.024) = 0.064 g **(1)** Percentage of C = 0.24/0.328 = 73.2% Percentage of H = 0.024/0.328 = 7.3% Percentage of O = 0.064/0.328 =19.5% **(1)** $C_{10}H_{12}O_2$ = 164 Percentage carbon is 120/164 = 73.2% Percentage hydrogen is 12/164 = 7.3% Percentage oxygen is 32/164 = 19.5% **(1)**		**4**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (ii)	Add (small amount of) Br_2 / bromine **(1)** (Br_2 turns from orange / yellow / red-brown to) colourless / decolourised **(1)** **OR** Add (small amount of) **acidified** $KMnO_4(aq)$ **(1)** $KMnO_4(aq)$ turns from purple/pink to colourless / brown **(1)** **OR** Add (small amount of) **alkaline** $KMnO_4(aq)$ **(1)** $KMnO_4(aq)$ turns from purple/pink to green **(1)**	clear	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (iii)	(Heat under) reflux **OR** microwave (in sealed container)		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (iv)	CH_3COCl / $CH_3COO(COCH_3)$ / ethanoyl chloride / ethanoic anhydride ALLOW CH_3COOH / ethanoic acid **and** H_2SO_4 / sulfuric acid / HCl / hydrochloric acid	Correct answer plus $AlCl_3$ Acyl chloride	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (i)	steam source and r.b /pear-shaped flask (and clove buds) **OR** r.b /pear-shaped flask being heated and containing **water** (and clove buds) **(1)** Condenser with water jacket, in correct position and direction of water flow **(1)** Collection vessel **(1)** -1 if apparatus does not work e.g. sealed -1 for no joints or leaky joint	Conical flask if being heated with the clove buds in	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	Mix organic solvent and oil-water mixture in a separating funnel then separate **(1)** Distil / rotary evaporate (to separate clove oil from organic solvent) **(1)** Add (anhydrous)$CaCl_2$ /(anhydrous) $MgSO_4$ /(anhydrous) Na_2SO_4 /silica gel / calcium oxide to clove oil, (then filter / decant) **(1)** ALLOW name or formula of drying agent (Second and third marks in either order) **OR** Add (saturated solution) of NaCl / sodium salt **(1)** Separate in a separating funnel **(1)** Add named drying agent to clove oil, (then filter / decant) **(1)**	(Anhydrous) $CuSO_4$ NaOH, sodium carbonate, sodium hydrogencarbonate , calcium carbonate	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c)	Choice with justification **(1)** e.g. 'yes it's reasonable as clove oil may be in use at harmful /toxic levels so we need to identify what that **level** is' 'no as clove oil has been in use for many years in many ways so tests on animals not necessary to confirm it's safe to use at current levels' / no, as humans would have to consume large amounts	Yes because it's toxic No, because of objections to animal testing in general	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (d)*	**4 clear justified comparisons – 1 mark each** **$ScCO_2$** oil obtained seems **purer** (as colour closely matches that of eugenol) requires no further purification, (others use solvent extraction) greater yield per hour yield 15.3g per 100g of buds no organic solvent (because it is chlorinated) **and** so environmental problems / harmful / damage ozone layer requires high pressure so likely to be expensive / requires specialist equipment **Steam distillation** steam distillation can be done using standard lab equipment /does not require high pressures yield only 6.1g / 6.2g per 100g of buds Steam gives the least yield per hour **Soxhlet** produces greater yield of oil but has a smaller percentage of eugenol /eugenol ethanoate yield 16.8g per 100g of buds (takes longer) but does not require high pressures uses organic solvent (because it is chlorinated) **and** so environmental problems / harmful / damage ozone layer Oil obtained seems least pure **(4)** **Synthetic route** has several steps, each with a low yield clove buds are renewable but materials in synthesis are not / materials in synthesis likely to be obtained from oil **(1)**	produces pale yellow oil Just no organic solvent Only two hours / shorter time than other methods Just higher percentage yield Just no organic solvent Higher yield than soxhlet Cost of chemicals Yield is 35 %	**5**

TOTAL FOR SECTION C = 20 MARKS

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Edexcel GCE

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Friday 24 June 2011 – Morning

Time: 1 hour 40 minutes

Paper Reference

6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P38480A

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7/7/5/3/

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Four complex ions have the following formulae:

A $Cu(edta)^{2-}$

B $Zn(H_2O)_6^{2+}$

C $Ni(NH_3)_6^{2+}$

D $CrCl_4^{2-}$

(a) Which complex ion is most likely to be tetrahedral in shape?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which complex ion is most likely **not** to be coloured?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Each of these complex ions may be formed by ligand exchange from an aqua complex. For which complex ion is the entropy change of this reaction most positive?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 3 marks)

2 When a **few drops** of aqueous ammonia are added to a solution containing $[Cr(H_2O)_6]^{3+}$ ions the product formed will be

☒ **A** $[Cr(NH_3)_6]^{3+}$

☒ **B** $Cr(H_2O)_3(OH)_3$

☒ **C** $[Cr(NH_3)_4]^{3+}$

☒ **D** $[Cr(H_2O)_2(OH)_4]^-$

(Total for Question 2 = 1 mark)

3 Which of these statements about a standard hydrogen electrode, for which $E^{\ominus} = 0$ V, is **not** correct?

☒ **A** The hydrogen gas is at a pressure of 1 atm.

☒ **B** A solution containing 1 mol dm^{-3} of $H^+(aq)$ ions is used.

☒ **C** A platinum electrode is used.

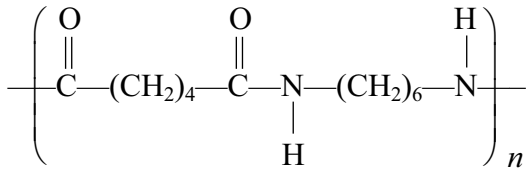
☒ **D** The temperature is kept at 20 °C.

(Total for Question 3 = 1 mark)

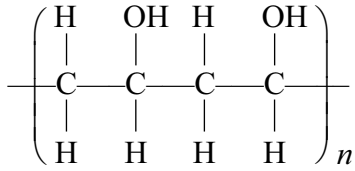
Use this space for any rough working. Anything you write in this space will gain no credit.

4 Four polymers labelled **A to D** have the following formulae:

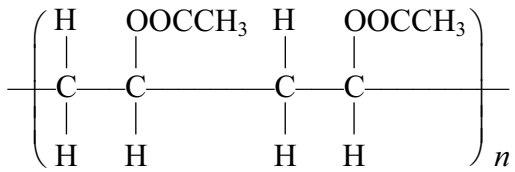
A



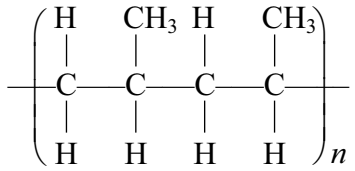
B



C



D



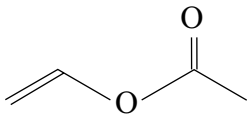
(a) Which polymer is most soluble in hot water?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(b) Which polymer is formed from the monomer shown below?

(1)



- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(c) Which polymer is a condensation polymer?

(1)

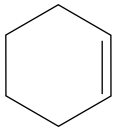
- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

(Total for Question 4 = 3 marks)

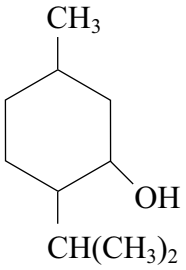
Use this space for any rough working. Anything you write in this space will gain no credit.

5 The formulae of some organic compounds labelled **A to D** are shown below.

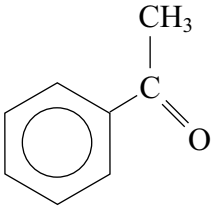
A



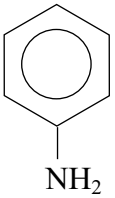
B



C



D



(a) Which compound reacts with sodium to form hydrogen?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which compound forms a green complex ion with $CuSO_4(aq)$?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which compound forms an orange precipitate with 2,4-dinitrophenylhydrazine?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 5 = 3 marks)

6 How many peaks would you expect to see in a **low resolution** proton nmr spectrum of the ester $HCOOCH_2CH_2CH_3$?

☒ **A** 8

☒ **B** 7

☒ **C** 4

☒ **D** 3

(Total for Question 6 = 1 mark)

7 In a **high resolution** proton nmr spectrum of ethyl ethanoate, $C\mathbf{H_3}COOCH_2CH_3$, the peak due to the hydrogen atoms shown **in bold** would be a

☒ **A** singlet.

☒ **B** doublet.

☒ **C** triplet.

☒ **D** quartet.

(Total for Question 7 = 1 mark)

8 Which of these compounds, whose formulae are shown below, **cannot** exist as a racemic mixture?

☒ **A** $CH_2ClCHClCOOH$

☒ **B** $HOOCCHClCOOH$

☒ **C** $CH_3CHClCOOH$

☒ **D** $CH_3CH(OH)COOH$

(Total for Question 8 = 1 mark)

9 Phenol reacts with bromine water whereas benzene reacts with bromine in the presence of iron.

(a) The mechanism for both these reactions is

(1)

☒ **A** electrophilic substitution.

☒ **B** electrophilic addition.

☒ **C** nucleophilic substitution.

☒ **D** nucleophilic addition.

(b) In the reaction of benzene with bromine, iron

(1)

☒ **A** acts as a heterogeneous catalyst.

☒ **B** acts as a homogeneous catalyst.

☒ **C** reacts with the bromine to make iron(III) bromide, $FeBr_3$.

☒ **D** allows bromine to attack the hydrogen atoms on benzene more readily.

(c) Bromine reacts more readily with phenol than with benzene because the OH group on phenol

(1)

☒ **A** is a good leaving group.

☒ **B** attracts the bromine particles more readily.

☒ **C** is a good nucleophile.

☒ **D** increases the electron density of the ring.

(Total for Question 9 = 3 marks)

---

10 Ammonia (NH_3), butylamine ($CH_3CH_2CH_2CH_2NH_2$) and phenylamine ($C_6H_5NH_2$) all form alkaline solutions in water. The order of **increasing** pH of equimolar solutions is

☒ **A** $C_6H_5NH_2 < CH_3CH_2CH_2CH_2NH_2 < NH_3$

☒ **B** $NH_3 < CH_3CH_2CH_2CH_2NH_2 < C_6H_5NH_2$

☒ **C** $C_6H_5NH_2 < NH_3 < CH_3CH_2CH_2CH_2NH_2$

☒ **D** $CH_3CH_2CH_2CH_2NH_2 < NH_3 < C_6H_5NH_2$

(Total for Question 10 = 1 mark)

---

11 The distance on a chromatogram moved by an individual amino acid, in a mixture of different amino acids, mainly depends on

☒ **A** the molar mass of the amino acid.

☒ **B** the molar mass of the solvent used.

☒ **C** the intermolecular forces between the solvent and the stationary phase.

☒ **D** the intermolecular forces between the amino acid and both the solvent and the stationary phase.

(Total for Question 11 = 1 mark)

12 Amino acids are crystalline solids with a high melting temperature because

☒ **A** each molecule has a large number of electrons.

☒ **B** each molecule forms hydrogen bonds at both ends.

☒ **C** a proton is transferred from one end of the molecule to the other.

☒ **D** their shape allows the molecules to pack close together.

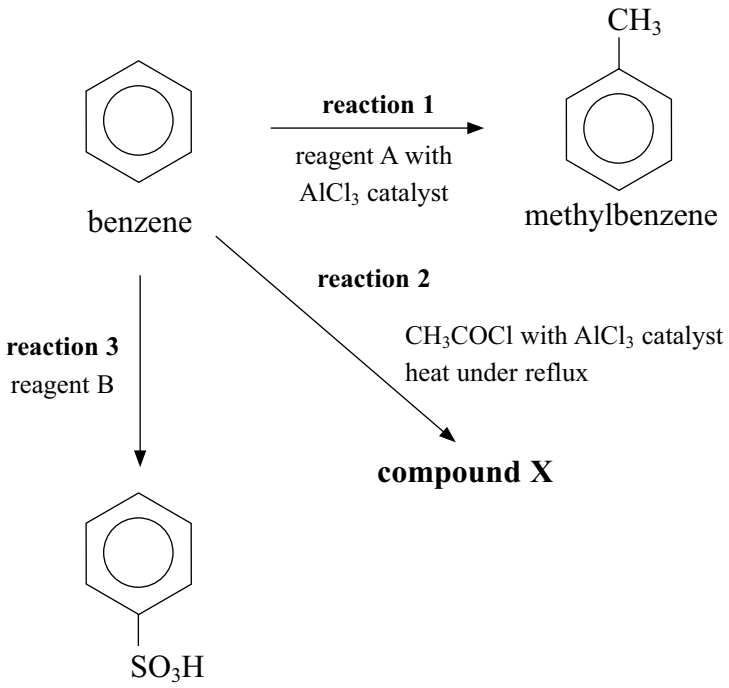
(Total for Question 12 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

13 Some reactions of benzene are shown below.



(a) (i) Suggest the formula of reagent A in **reaction 1**.

(1)

.....

(ii) Write the equation to show how the catalyst, $AlCl_3$, reacts with reagent A to form the species which attacks the benzene ring.

(1)

(iii) Draw the structure of the intermediate ion formed when the species in (ii) attacks the benzene ring.

(1)

(b) The methylbenzene formed in **reaction 1** generally reacts in a similar way to benzene but faster, as the ring is said to be activated.

(i) Explain how the presence of a methyl group activates the benzene ring.

(1)

.....

.....

(ii) Use your answer to (i) to explain why methylbenzene reacts faster.

(1)

.....

.....

(c) (i) Draw the structural formula of **compound X**, formed in **reaction 2**.

(1)

(ii) The organic product of **reaction 2** is also formed when the same reactants, but with an aluminium catalyst, are heated using microwave radiation. Suggest two reasons why this technique may be considered 'greener'.

(2)

.....

.....

.....

.....

(d) Name reagent B needed for **reaction 3**.

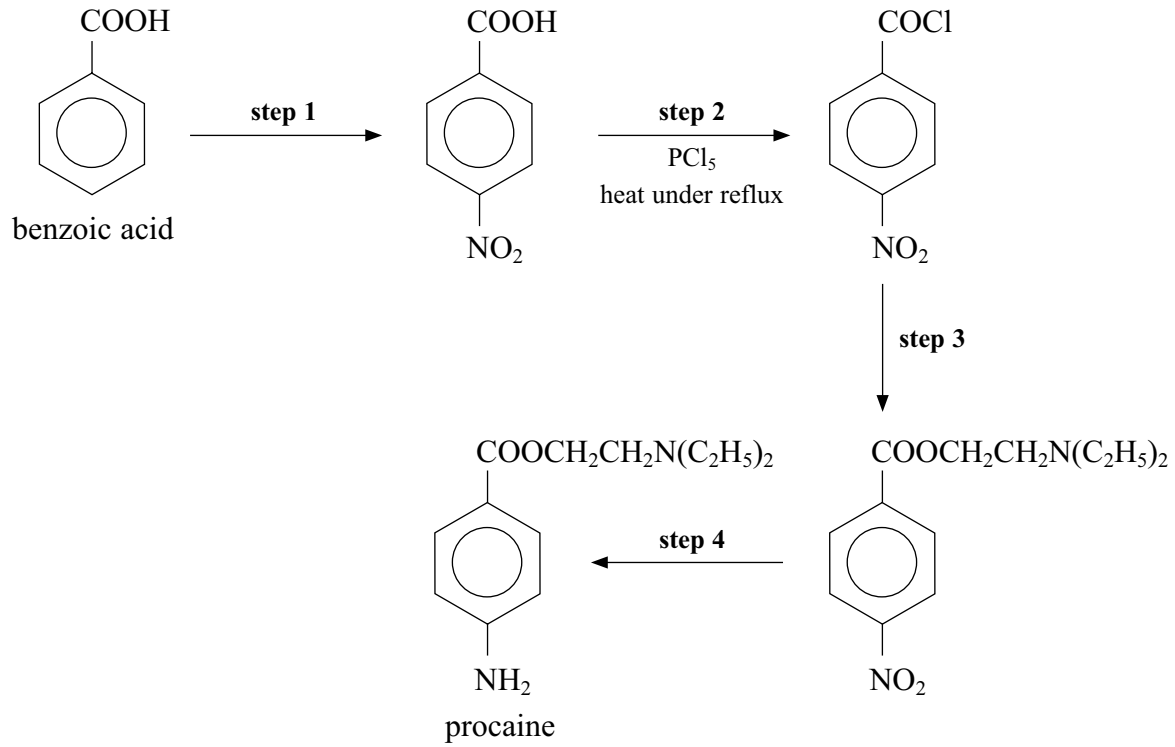
(1)

.....

(Total for Question 13 = 9 marks)

14 This question is about synthetically produced painkillers and anaesthetics.

(a) The local anaesthetic procaine can be synthesised from benzoic acid. The simplified route is shown below.



(i) Suggest the two reagents needed for **step 1**.

(2)

.....

.....

(ii) Draw the apparatus needed to heat under reflux in **step 2**.

(3)

(iii) Suggest why the reagents for the reaction in **step 2** are

(2)

heated .....

.....

under reflux .....

.....

(iv) Give the structural formula for the organic reagent needed in **step 3**.

(1)

(v) What type of reaction is taking place in **step 4**? Suggest the reagents used.

(2)

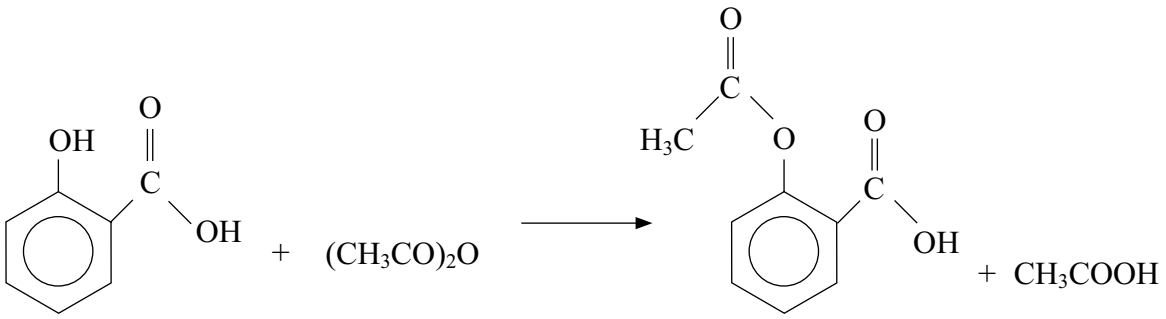
.....

.....

.....

.....

(b) A student produced a sample of aspirin by the esterification of 9.40 g of 2-hydroxybenzoic acid with excess ethanoic anhydride.



2-hydroxybenzoic acid ethanoic anhydride aspirin

After purification by recrystallization, 7.77 g of aspirin was obtained.

[M_r of 2-hydroxybenzoic acid = 138, M_r of aspirin = 180]

(i) Calculate the percentage yield obtained.

(3)

*(ii) Outline how to purify a solid, such as aspirin, by recrystallization, using water as the solvent.

(4)

(iii) Explain what effect recrystallization has on the final yield.

(1)

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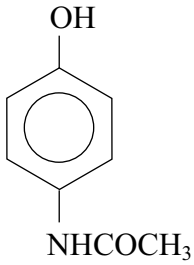
(c) Paracetamol is found in many non-prescription painkillers, often in conjunction with other compounds such as codeine.



paracetamol

(i) Suggest, by name or formula, a reagent that could be used to form paracetamol from 4-aminophenol.

(1)

(ii) Suggest why sales of non-prescription painkillers, often containing paracetamol and codeine, are limited to 32 tablets.

(1)

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(iii) Explain why paracetamol is only slightly soluble in water although it can form hydrogen bonds with water.

(1)

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(Total for Question 14 = 21 marks)

15 Hydrogen gas can be used as a fuel in car engines by being burnt in a combustion reaction or reacted with oxygen in a fuel cell to produce electricity.

(a) Write half-equations for the reaction of hydrogen gas at the anode and oxygen gas at the cathode in the fuel cell.

(2)

Anode

Cathode

(b) Describe one advantage of using hydrogen in fuel cells rather than burning the hydrogen directly.

(1)

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(c) Other fuels, such as ethanol, can also be used in fuel cells. By considering the possible sources of ethanol and hydrogen, explain why some scientists believe the use of such cells could provide a more sustainable source of energy for cars, compared with fossil fuels.

(3)

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(Total for Question 15 = 6 marks)

16 This question is about the transition metal iron and some of its compounds.

(a) Give the electronic configuration of the Fe^{3+} ion and use this to define what is meant by a transition element.

(2)

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*(b) Iron will act as a surface catalyst in some gaseous reactions. Outline the processes that take place during such catalysis and suggest two reasons to explain why the catalyst speeds up the reaction.

(4)

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(c) One of the components of rust, found on objects made from iron, is iron(III) hydroxide, $Fe(OH)_3$. Use items 17, 19 and 44 from the Standard Electrode Potential table in your data booklet to show how it is able to form in two steps, writing an equation for each step.

(4)

(d) Haemoglobin is a complex containing iron(II) ions.

Describe how nitrogen atoms in the haemoglobin bond to the iron(II) ions.

(2)

.....

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(Total for Question 16 = 12 marks)

TOTAL FOR SECTION B = 48 MARKS

SECTION C

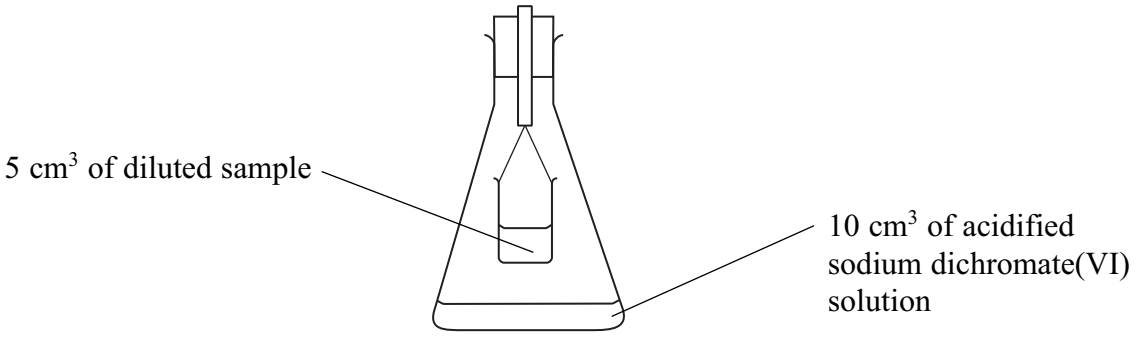
Answer ALL the questions. Write your answers in the spaces provided.

17

Alcoholic drinks contain ethanol, CH_3CH_2OH, in aqueous solution. The percentage of alcohol in a drink can be determined by a redox titration, whilst the amount of alcohol present on the breath of someone who has consumed such a drink can be estimated using a breathalyser.

The earliest breathalysers used the colour change that occurs when dichromate(VI) ions react with ethanol to measure the amount of alcohol. Later models measure the current from a fuel cell. Cheaper versions of these meters are available for drivers to buy for self-testing. Some police forces also use fuel cell breathalysers in conjunction with infrared breath analysers, which can determine the amounts of alcohol from an infrared spectrum.

In an experiment to find out the concentration of ethanol in a drink, a small beaker containing 5.00 cm^3 of a diluted sample of the drink is suspended above 10.0 cm^3 of excess acidified sodium dichromate(VI) solution, of concentration 0.0800 mol dm^{-3}, and left for 24 hours in a warm place.



The ethanol vaporizes and reacts with some of the acidified sodium dichromate(VI) ions. Excess potassium iodide is then added to the unreacted acidified sodium dichromate(VI), forming iodine, $I_2(aq)$.

The $I_2(aq)$ is then titrated with a solution of sodium thiosulfate, $Na_2S_2O_3$, of concentration 0.0250 mol dm^{-3}.

(a) Ethanol and dichromate(VI) ions in acidic solution react in the mole ratio 3:2.

(i) Complete the two half-equations below. State symbols are **not** required.

(2)

$$Cr_2O_7^{2-} \rightarrow Cr^{3+}$$

$$CH_3CH_2OH \rightarrow CH_3COOH$$

(ii) Use either the half-equations in (i) or that the mole ratio of CH_3CH_2OH:$Cr_2O_7^{2-}$ is 3:2 to construct the ionic equation for the reaction between ethanol and acidified dichromate(VI) ions. State symbols are **not** required.

(1)

*(iii) The iodine formed in the experiment reacted completely with 34.40 cm^3 of the 0.0250 mol dm^{-3} sodium thiosulfate solution. Use this information, the fact that the mole ratio of CH_3CH_2OH:$Cr_2O_7^{2-}$ is 3:2 and the equations below, to calculate the concentration of the ethanol in the 5.00 cm^3 of the diluted sample of the drink.

(6)

$$Cr_2O_7^{2-} + 14H^+ + 6I^- \rightarrow 2Cr^{3+} + 3I_2 + 7H_2O$$

$$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

(iv) The solution used in the experiment was made by adding 10.0 cm^3 of the drink to a 100 cm^3 volumetric flask, making up the remainder of the volume using distilled water. Use the information and your final answer to (a)(iii) to calculate the concentration, in mol dm^{-3}, of ethanol in the undiluted drink.

(1)

(v) Suggest why the sample was suspended above the acidified sodium dichromate(VI) solution, rather than simply being mixed with it.

(1)

(vi) Suggest two reasons why the apparatus was left in a **warm** place for **24 hours**. What would be the effect on the final result if this procedure were not followed?

(3)

(vii) Do you think that this experiment gives a reliable result? Explain your answer.

(1)

*(b) (i) Explain how each type of breathalyser, mentioned in the passage, shows the amount of ethanol present.

(3)

Earliest type.....

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Fuel cell.....

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Infrared.....

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(ii) Suggest why infrared breathalysers do not use the OH absorption to detect the amount of alcohol on the breath.

(1)

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(iii) Suggest why some police forces use infrared breathalysers together with fuel cell breathalysers.

(1)

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(iv) Suggest **one** advantage and **one** disadvantage of buying a personal breathalyser.

(2)

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(Total for Question 17 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 3 8 4 8 0 A 0 2 4 2 4

PMT

edexcel

Mark Scheme (Results)

June 2011

GCE Chemistry (6CH05) Paper 01
General Principles of Chemistry II

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1 (a)	D	**1**

Question Number	Correct Answer	Mark
1 (b)	B	**1**

Question Number	Correct Answer	Mark
1 (c)	A	**1**

Question Number	Correct Answer	Mark
2	B	**1**

Question Number	Correct Answer	Mark
3	D	**1**

Question Number	Correct Answer	Mark
4 (a)	B	**1**

Question Number	Correct Answer	Mark
4 (b)	C	**1**

Question Number	Correct Answer	Mark
4 (c)	A	**1**

Question Number	Correct Answer	Mark
5 (a)	B	**1**

Question Number	Correct Answer	Mark
5 (b)	D	**1**

Question Number	Correct Answer	Mark
5 (c)	C	**1**

Question Number	Correct Answer	Mark
6	C	**1**

Question Number	Correct Answer	Mark
7	A	**1**

Question Number	Correct Answer	Mark
8	B	**1**

Question Number	Correct Answer	Mark
9 (a)	A	**1**

Question Number	Correct Answer	Mark
9 (b)	C	**1**

Question Number	Correct Answer	Mark
9 (c)	D	**1**

Question Number	Correct Answer	Mark
10	C	**1**

Question Number	Correct Answer	Mark
11	D	**1**

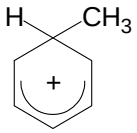
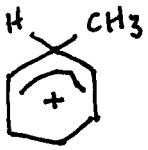
Question Number	Correct Answer	Mark
12	C	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

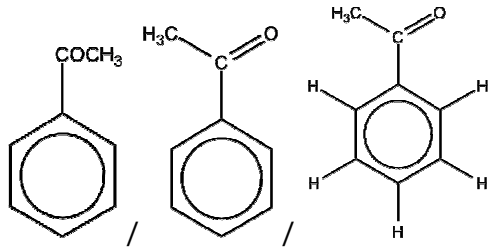
Question Number	Acceptable Answers	Reject	Mark
13 (a)(i)	CH_3Cl / CH_3Br / CH_3I Ignore name and state symbols Allow displayed formula	Name alone	**1**

Question Number	Acceptable Answers	Reject	Mark
13 (a)(ii)	$CH_3Cl + AlCl_3 \rightarrow CH_3^+ + AlCl_4^-$ Allow $CH_3^{\delta+}$ $AlCl_4^{\delta-}$ and other halogens Ignore state symbols and curly arrows	$CH_3^{\delta+}$-$AlCl_3^{\delta-}$ + Cl^-	**1**

Question Number	Acceptable Answers	Reject	Mark
13 (a)(iii)	 Ignore curly arrows and use of wedges/dashes Ignore attempts to complete mechanism if intermediate is correct Must show reasonable delocalisation over at least 3 carbon atoms Allow positive charge anywhere inside benzene ring Allow delocalization shown as dashed line e.g  Allow correct Kekulé structure	Complete circle of delocalization 'Upside down' delocalization e.g. 	**1**

Question Number	Acceptable Answers	Reject	Mark
13 (b)(i)	(Methyl group) donates/increases electron density to the ring/feeds electrons into ring Allow the methyl group is electron releasing	Donates **lone** pair of electrons Ring becomes more electronegative Just 'inductive effect'	**1**

Question Number	Acceptable Answers	Reject	Mark
13 (b)(ii)	(Methylbenzene) is more susceptible to electrophilic attack/attack by **positive** species/makes it a stronger nucleophile Ignore comments about ring stability Allow methyl group stabilizes carbocation		**1**

Question Number	Acceptable Answers	Reject	Mark
13 (c)(i)	 $C_6H_5COCH_3$ / / / / Allow displayed or skeletal formulae or Kekulé		**1**

Question Number	Acceptable Answers	Reject	Mark
13 (c)(ii)	**Any 2 from 4** Lower energy input (to heat reaction)/less heat losses/more efficient heating **(1)** Electrical energy can be obtained from renewable resources whereas gas is non renewable **(1)** Easier separation of catalyst/(easier to) re-use catalyst **(1)** Involves less chlorine/chlorine compounds **(1)** Ignore any comments regarding carbon dioxide level/global warming	Faster reaction because using a catalyst Just 'uses less fuel' Just uses less toxic/harmful chemicals	**2**

Question Number	Acceptable Answers	Reject	Mark
13 (d)	Fuming sulfuric acid / oleum / sulfur trioxide (dissolved) in concentrated sulfuric acid Allow fuming H_2SO_4 /$H_2S_2O_7$ / SO_3 (dissolved) in concentrated H_2SO_4	Just sulfuric acid or sulfur trioxide	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (a)(i)	Conc. Nitric acid **(1)** Conc. Sulfuric acid **(1)** Allow correct formulae Ignore state symbols Sulfuric acid and nitric acid with no mention of concentrated scores (1)		**2**

Question Number	Acceptable Answers	Reject	Mark
14 (a)(ii)	Pear shaped/round bottomed flask & heat source **(1)** Allow vertical arrow with or without the word heat Allow water bath as a heat source Liebig condenser, shown vertically **(1)** (Water) flow shown correctly into a jacket **(1)** Ignore thermometers unless stoppered Penalise (one for each): Stopper/sealed Gaps between flask and condenser Condenser inner tube extends into liquid in flask	Conical flask in diagram or label	**3**

Question Number	Acceptable Answers	Reject	Mark
14 (a)(iii)	Heat Speed up reaction / to overcome the activation energy / provide energy to break bonds / because activation energy for the reaction is high **(1)** Under reflux Prevent escape of reactants / products Or As they may be flammable / harmful / volatile **(1)**	Just to provide energy for the reaction to start Just to increase the yield/make reaction go to completion	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (a)(iv)	$HOCH_2CH_2N(C_2H_5)_2$ Allow $OHCH_2CH_2N(C_2H_5)_2$ Allow displayed or skeletal formulae		**1**

Question Number	Acceptable Answers	Reject	Mark
14 (a)(v)	Reduction **(1)** Allow redox Tin / iron / zinc **and** (conc./dilute) hydrochloric acid **(1)** Accept correct names or formulae for both alternatives Ignore references to tin as a catalyst Ignore conditions Allow $NaBH_4$ in alkali (Pd catalyst)	 Addition of NaOH unless clearly after the reduction Hydrogen gas and nickel (catalyst) $LiAlH_4$	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (b)(i)	Moles of 2-hydroxy benzoic acid = 9.4/138 **(1)** (= 0.0681) So theoretical yield of aspirin = 0.0681 x 180 **(1)** = 12.26 g % yield = 100 x 7.77/12.26 = 63.4% **(1)** Or Moles of 2-hydroxy benzoic acid = 9.4/138 **(1)** (= 0.0681) Moles of aspirin = 7.77/180 **(1)** (=0.0432) % yield = 100 x 0.0432/0.0681 = 63.4/63% **(1)** Correct answer with no working 3 marks Allow 1 max. if *M*r values are transposed 108%	100 x 7.77/9.40 = 82.7%	**3**

Question Number	Acceptable Answers	Reject	Mark
14 *(b)(ii)	Dissolve/add to impure solid in min. volume / amount **(1)** of hot solvent / water **(1)** (Filter whilst hot) Allow to cool **and** filter off product / (re)crystallize **and** filter off product **(1)** Wash with cold / small amount of solvent / water (then dry) **(1)**	Just 'small/little amount of water' Named solvents other than water – penalise once	**4**

Question Number	Acceptable Answers	Reject	Mark
14 (b)(iii)	It reduces yield as some product remains in solution Allow stated and explained errors due to transfer e.g. left on filter paper	Just 'transfer errors'	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(i)	CH_3COCl / $(CH_3CO)_2O$ / ethanoyl chloride / ethanoic anhydride If both name and formula are given then both must be correct Allow acetyl chloride / acetic anhydride Ignore any additional information Allow displayed formulae	Ethanoic acid	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(ii)	(Lessen) risk of overdose / as paracetamol is toxic in larger doses/ as paracetamol is harmful in larger doses / reduce risk of taking medication over a longer time period than necessary / reduce risk of addiction		**1**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(iii)	Net forces between paracetamol and water are less than the forces between water and water and / or paracetamol and paracetamol Allow benzene / ring doesn't interact with water Allow benzene ring is hydrophobic / non polar / only forms London forces / can't form hydrogen bonds	Just paracetamol / benzene ring is large / steric hindrance	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (a)	Either Anode $H_2 - 2e^{(-)} \rightarrow 2H^+$ **(1)** Cathode $O_2 + 4H^+ + 4e^{(-)} \rightarrow 2H_2O$ **(1)** Or Anode $H_2 + 2OH^- - 2e^{(-)} \rightarrow 2H_2O$ **(1)** Cathode $O_2 + 2H_2O + 4e^{(-)} \rightarrow 4OH^-$ **(1)** Electrons can be on either side of the equation Allow multiples Allow equilibria signs Ignore state symbols		**2**

Question Number	Acceptable Answers	Reject	Mark
15 (b)	One advantage e.g. quieter, more efficient (energy transfer), no NO_x formed Ignore references to carbon dioxide and / or water as only product	Just easier to control	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (c)	Ethanol can be obtained from biomass / plants / fermentation / ethanol is a bio fuel **(1)** hydrogen from (electrolysis of) water using a non-fossil source of energy **(1)** these are renewable / fossil fuels are a finite resource **(1)** Allow for third mark so less burning/use of fossil fuels hence lower carbon emissions / less impact on greenhouse effect		**3**

Question Number	Acceptable Answers	Reject	Mark
16 (a)	$1s^2 2s^2 2p^6 3s^2 3p^6 3d^5 (4s^0)$ **(1)** Accept $[Ar]3d^5(4s^0)$ (Ion) has an incompletely filled (3)d-orbital / sub-shell / unpaired d electron **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
***16 (b)**	Gases adsorb onto / bind to catalyst (surface) **(1)** Allow gases are absorbed onto surface Then react **and** desorb / leave **(1)** Reaction could be faster because Any two • These processes lower the activation energy (by providing an alternative route so a greater proportion of molecules react) • Bonds in reactant(s) are weakened • Reactants may be positioned in more favourable orientations • Reactants can migrate towards each other on surface • Increases likelihood of molecules coming into contact / colliding • Adsorption onto surface means more reactant molecules in a given space	Just 'bonds in reactants are broken'	**4**

Question Number	Acceptable Answers	Reject	Mark
16 (c)	E_{cell} for reaction is (+) 0.84 (V) (so will work) / E_{cell} for item 44 is more positive than for item 19 / illustrate using anti-clockwise rule **(1)** $2Fe + O_2 + 2H_2O \rightarrow 2Fe^{2+} + 4OH^-$ or $2Fe + O_2 + 2H_2O \rightarrow 2Fe(OH)_2$ **(1)** E_{cell} for reaction is (+)0.96 (V) (so will work) / E_{cell} for item 44 is more positive than for item 17 / illustrate using anti-clockwise rule **(1)** $4Fe(OH)_2 + O_2 + 2H_2O \rightarrow 4Fe(OH)_3$ **(1)**	Just 'because of the anti-clockwise rule'	**4**

Question Number	Acceptable Answers	Reject	Mark
16 (d)	Lone pair(s) (from nitrogen(s)) **(1)** Forms dative / dative covalent / coordinate bond (with Fe^{2+}) **(1)**		**2**

TOTAL FOR SECTION B = 48 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
17 (a)(i)	$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$ **(1)** $CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$ **(1)** Allow multiples Ignore state symbols		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	$3CH_3CH_2OH + 2\ Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O$ Allow hydrogen ions and water molecules not cancelled e.g. $3CH_3CH_2OH + 2\ Cr_2O_7^{2-} + 28H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O + 12H^+$ $3CH_3CH_2OH + 2\ Cr_2O_7^{2-} + 16H^+ + 3H_2O \rightarrow 3CH_3COOH + 4Cr^{3+} + 14H_2O$ $3CH_3CH_2OH + 2\ Cr_2O_7^{2-} + 28H^+ + 3H_2O \rightarrow 3CH_3COOH + 4Cr^{3+} + 14H_2O + 12H^+$	Equations with electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
***17 (a)(iii)**	Moles of thiosulfate = 34.40/1000 x 0.025 = 8.6 x 10^{-4} (mol) **(1)** So moles I_2 = 4.3 x 10^{-4} (mol) **(1)** So moles of dichromate unreacted = 4.3 x 10^{-4} / 3 = 1.433 x 10^{-4} (mol) **(1)** So moles of dichromate reacted with ethanol = 8 x 10^{-4} – 1.43 x 10^{-4} = 6.567 x 10^{-4} (mol) **(1)** So moles of ethanol = 6.567 x 10^{-4} x 3/2 mol = 9.85 x 10^{-4} (mol) **(1)** Concentration = 9.85 x 10^{-4} /0.005 = 0.197 (mol dm^{-3}) **(1)** Correct answer (0.197) with no working 6 marks Allow 4 max. for missing subtraction in step 4 and gaining answer of 0.043(0)		**6**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iv)	0.197 x 10 = 1.97 (mol dm^{-3}) Allow answer to (a) (iii) x 10		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(v)	To prevent other (non volatile) substances (in the drink) from reacting with the dichromate ions		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(vi)	because it allows the ethanol to evaporate (allowing it to mix with the dichromate) **(1)** make sure all ethanol reacts **(1)** Concentration / results would have been lower than the actual value **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(vii)	No, as only one sample titrated so no evidence that results are repeatable / no, as not all the ethanol has evaporated/no, as the dichromate may have reacted with something else/ no, as not all the ethanol has reacted Allow only 1 titration carried out		**1**

Question Number	Acceptable Answers	Reject	Mark
***17 (b)(i)**	Early breathalysers: (the extent to which) dichromate turns **green (1)** Fuel cells: (more alcohol means larger) current / quantity of electricity **(1)** Infrared breathalysers: (more alcohol means greater) absorbance **(1)** Ignore reference to specific bonds provided they are present in ethanol	Just colour change Just 'potential difference measured' Just 'voltage measured' Just 'gives a peak'	**3**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	Water (in the breath) also has an OH bond Allow other named molecules on the breath provided they have an OH bond		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iii)	Additional evidence is more reliable Or Police often use IR as well as fuel cell breath test to provide sufficient evidence to prosecute (without need for blood test) Or Fuel cell breathalysers are portable and determine whether or not to check with IR at the police station	Answers only related to accuracy	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iv)	Advantage It could check if you are below the legal limit / safe to drive **(1)** Disadvantage It may not be sensitive enough to give an accurate reading / may give a value that does not closely match police value OR It encourages people to drink and drive **(1)**		**2**

TOTAL FOR SECTION C = 22 MARKS

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Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Wednesday 1 February 2012 – Morning
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P35302A

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7/7/5/5/3/

P 3 5 3 0 2 A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 An electrochemical cell consists of a standard hydrogen electrode and a $Cu^{2+}(aq)|Cu(s)$ electrode which uses copper(II) sulfate solution. Which one of the following does **not** affect the e.m.f. of the cell?

☒ **A** The volume of the copper(II) sulfate solution.

☒ **B** The temperature.

☒ **C** The pressure of the hydrogen.

☒ **D** The concentration of the copper(II) sulfate solution.

(Total for Question 1 = 1 mark)

2 Which answer corresponds to the correct value of $E^{\ominus}_{cell}$ for the oxidation of hydrogen peroxide by manganate(VII) ions? The half-reactions are

$$2H^+ + O_2 + 2e^- \rightleftharpoons H_2O_2 \qquad E^{\ominus} = +0.68\ V$$

$$MnO_4^- + 8H^+ + 5e^- \rightleftharpoons Mn^{2+} + 4H_2O \qquad E^{\ominus} = +1.51\ V$$

The overall equation is

$$2MnO_4^- + 6H^+ + 5H_2O_2 \rightleftharpoons 2Mn^{2+} + 8H_2O + 5O_2$$

☒ **A** $E^{\ominus}_{cell} = +2.19\ V$

☒ **B** $E^{\ominus}_{cell} = -0.83\ V$

☒ **C** $E^{\ominus}_{cell} = -0.38\ V$

☒ **D** $E^{\ominus}_{cell} = +0.83\ V$

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 The transition metal complex $Pt(NH_3)_2Cl_2$ exists as two geometric isomers. This is because the complex

☒ **A** is square-planar.

☒ **B** is tetrahedral.

☒ **C** contains a double bond.

☒ **D** is octahedral.

(Total for Question 3 = 1 mark)

4 Hydrogen peroxide, H_2O_2, can be analysed by titration. The hydrogen peroxide solution is treated with acidified potassium iodide solution, and the liberated iodine is titrated with a standard solution of sodium thiosulfate, $Na_2S_2O_3$. The products are iodide ions and tetrathionate ions, $S_4O_6^{2-}$.

Which of the following applies to this reaction?

		Action of H_2O_2	Action of $S_2O_3^{2-}$
☒	**A**	oxidizing agent	oxidizing agent
☒	**B**	oxidizing agent	reducing agent
☒	**C**	reducing agent	oxidizing agent
☒	**D**	reducing agent	reducing agent

(Total for Question 4 = 1 mark)

5 A hydrated transition metal ion is colourless. Which of the following could be the electronic configuration of this ion?

☒ **A** [Ar] $3d^5 4s^2$

☒ **B** [Ar] $3d^8$

☒ **C** [Ar] $3d^{10} 4s^2$

☒ **D** [Ar] $3d^{10}$

(Total for Question 5 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

6 Which of the following reagents would enable you to separate iron(III) hydroxide from a mixture of iron(III) hydroxide and copper(II) hydroxide?

☒ **A** Dilute hydrochloric acid

☒ **B** Aqueous ammonia

☒ **C** Dilute nitric acid

☒ **D** Sodium hydroxide solution

(Total for Question 6 = 1 mark)

7 When a solution containing 0.10 mol of chromium(III) chloride, $CrCl_3.6H_2O$, is treated with excess silver nitrate solution, 0.20 mol of silver chloride, AgCl, is immediately precipitated. The formula of the complex ion in the solution is

☒ **A** $[Cr(OH)_6]^{3-}$

☒ **B** $[Cr(H_2O)_6]^{3+}$

☒ **C** $[CrCl(H_2O)_5]^{2+}$

☒ **D** $[CrCl_2(H_2O)_4]^{+}$

(Total for Question 7 = 1 mark)

8 Which of the following species is **not** able to act as a ligand in the formation of transition metal complexes?

☒ **A** $C_6H_5NH_2$

☒ **B** NH_3

☒ **C** $NH_2CH_2CH_2CH_2NH_2$

☒ **D** NH_4^+

(Total for Question 8 = 1 mark)

9 The element zinc, with electronic configuration $1s^2 2s^2 2p^6 3s^2 3p^6 3d^{10} 4s^2$, is **not** regarded as a transition element because

☒ **A** the oxide of zinc is amphoteric.

☒ **B** none of its ions has an unpaired electron in the *d*-subshell.

☒ **C** it does not readily form complex ions.

☒ **D** it has a boiling temperature low enough for it to be easily distilled.

(Total for Question 9 = 1 mark)

10 The compounds below were heated with aqueous sodium hydroxide solution. Which one of them did **not** give sodium ethanoate, CH_3COONa, as one of the products?

☒ **A** CH_3COOCH_3

☒ **B** CH_3COCH_3

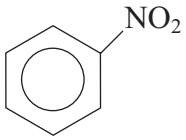
☒ **C** CH_3COOH

☒ **D** CH_3COCl

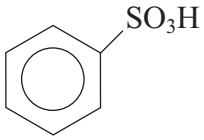
(Total for Question 10 = 1 mark)

11 Which of the following products is formed when phenylamine (aniline) is reacted with **dilute** sulfuric acid?

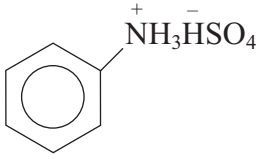
☒ **A**



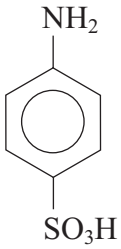
☒ **B**



☒ **C**



☒ **D**



(Total for Question 11 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

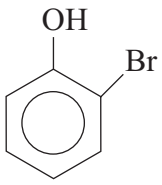
12 For the nitration of phenol, which is the most suitable set of conditions and the reason for its use?

		Conditions	Reactivity of phenol to electrophiles compared with benzene
☒	**A**	dilute nitric acid at room temperature	more reactive
☒	**B**	concentrated nitric and sulfuric acid at room temperature	more reactive
☒	**C**	concentrated nitric and sulfuric acid at 55 °C	the same
☒	**D**	dilute nitric acid and dilute sulfuric acid at room temperature	less reactive

(Total for Question 12 = 1 mark)

13 Phenol reacts with excess bromine water to give as the organic product(s)

☒ **A**



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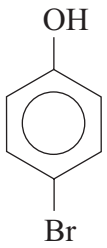
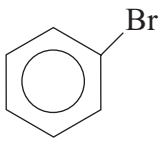
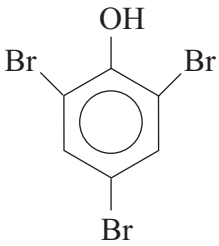


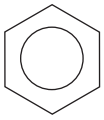
☒ **B**



☒ **C**



☒ **D**



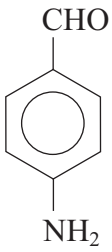
(Total for Question 13 = 1 mark)

14 An organic compound, **X**, shows the following properties:

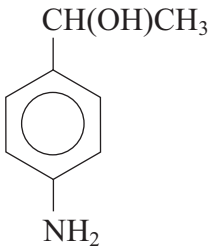
- Oxidation of compound **X** produces a substance that reacts with 2,4-dinitrophenylhydrazine to give a yellow precipitate but does **not** react with Fehling's or Benedict's solution.
- Compound **X** reacts with ice-cold nitrous acid to form a compound that gives a yellow precipitate with an alkaline solution of phenol.

What is the formula of compound **X**?

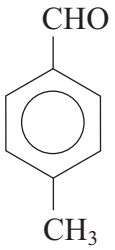
☒ **A**



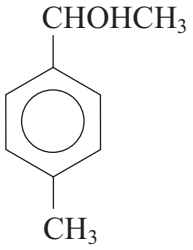
☒ **B**



☒ **C**



☒ **D**



(Total for Question 14 = 1 mark)

15 Which sequence shows the bases in order of decreasing strength?

☒ **A** $C_6H_5NH_2 > CH_3NH_2 > NH_3$

☒ **B** $NH_3 > CH_3NH_2 > C_6H_5NH_2$

☒ **C** $CH_3NH_2 > NH_3 > C_6H_5NH_2$

☒ **D** $NH_3 > C_6H_5NH_2 > CH_3NH_2$

(Total for Question 15 = 1 mark)

16 Bromoethane can be made by heating ethanol under reflux with 50% sulfuric acid and sodium bromide. When the mixture is distilled, the products include sulfur dioxide, bromine, hydrogen bromide and water as well as bromoethane.

The product mixture is shaken with sodium carbonate solution and later with anhydrous sodium sulfate before being re-distilled. Which of the following shows the correct list of impurities removed at each step?

		Aqueous sodium carbonate wash	Addition of sodium sulfate
☒	**A**	HBr	SO_2, Br_2, water
☒	**B**	SO_2, Br_2	HBr, water
☒	**C**	SO_2, HBr	Br_2, water
☒	**D**	SO_2, Br_2, HBr	water

(Total for Question 16 = 1 mark)

17 A compound is known to have either the structure $H_2NCH_2CH_2NH_2$ or H_2NCH_2COOH. Which of the following tests would best distinguish between the two compounds?

☒ **A** Reaction with concentrated aqueous sodium hydroxide.

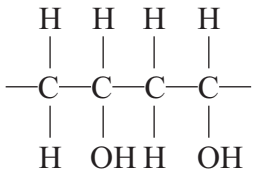
☒ **B** Reaction with nitrous acid.

☒ **C** Reaction with aqueous sodium hydrogencarbonate.

☒ **D** Reaction with ethanoyl chloride.

(Total for Question 17 = 1 mark)

18 Poly(ethenol) is a water-soluble polymer. A section of the chain has the structure shown below.



The polymer is used for making hospital laundry bags so that laundry can be loaded directly into washing machines without it having to be handled.

Poly(ethenol) is water soluble because the polymer

☒ **A** is broken down by the water into monomers.

☒ **B** is broken down by the washing detergent.

☒ **C** breaks into monomers at the temperature of the wash.

☒ **D** forms many strong hydrogen bonds with the water.

(Total for Question 18 = 1 mark)

19 Which of the following substances is capable of damaging the ozone layer?

☒ **A** NaCl

☒ **B** CO_2

☒ **C** C_2HF_5

☒ **D** $C_2F_3Cl_3$

(Total for Question 19 = 1 mark)

20 Analysis suggests that a particular organic synthesis produces a medicine that contains trace impurities that may be hazardous. What is the best way for this discovery to be reported and evaluated?

☒ **A** In a scientific journal which subjects its articles to peer review.

☒ **B** On the Internet in an article on a website.

☒ **C** In a newspaper article in several broadsheet newspapers.

☒ **D** In a widely circulated magazine.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 (a) Chromium is a typical transition metal, although its electronic configuration does **not** fit the general trend found in the first transition series.

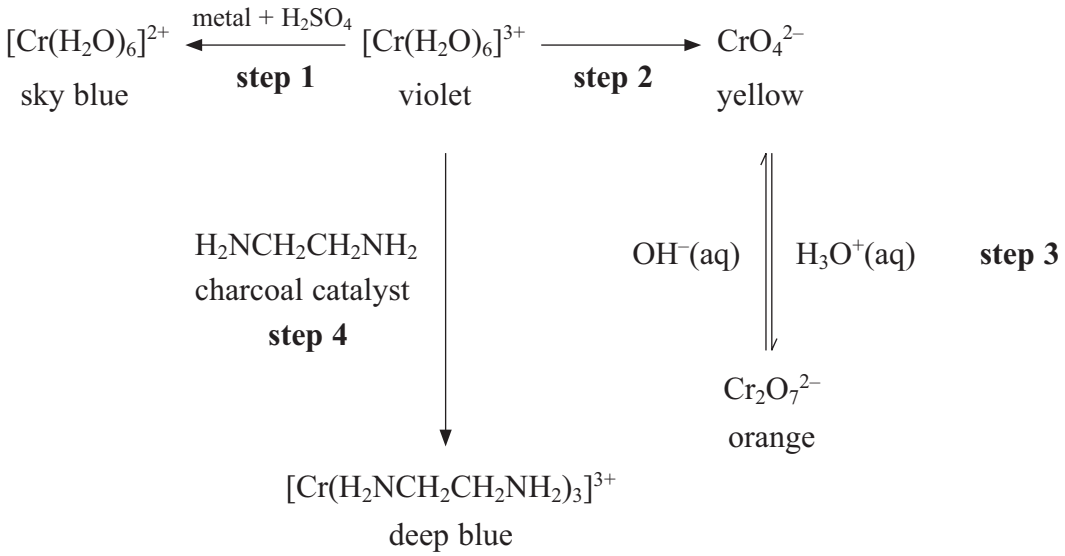
Complete the electronic configurations in *s,p,d* notation for vanadium and chromium.

(1)

Vanadium: [Ar] .....

Chromium: [Ar] .....

(b) Some interconversions found in the chemistry of chromium are shown below. Use this information to answer the questions that follow.



(i) State **two** typical properties of transition metals, other than the formation of coloured ions, which are shown in the diagram above.

(2)

.....

.....

.....

(ii) Use $E^{\ominus}$ values from your data booklet to suggest a metal that could be used for **step 1**. Justify your answer by calculating $E^{\ominus}$ for your cell.

(2)

(iii) Explain, using oxidation numbers, whether or not the conversion in **step 3** is a redox reaction.

(2)

(iv) The organic compound $H_2NCH_2CH_2NH_2$ that is used in **step 4** is 1,2-diaminoethane, often called ethylenediamine.
It is a **bidentate ligand**. Explain the meaning of this term.

(1)

(v) Explain, in terms of its structure, how $H_2NCH_2CH_2NH_2$ can act as a bidentate ligand whereas H_2NNH_2 cannot.

(2)

(c) The half-equations relating the interconversion of the species $Cr^{2+}(aq)$, $Cr^{3+}(aq)$ and $Cr_2O_7^{2-}(aq)$ are given below.

Half-equation I: $Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$

Half-equation II: $Cr_2O_7^{2-}(aq) + 6e^- + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$

(i) Use your data booklet to find $E^{\ominus}$ for each of the above half-equations.

(1)

Half-equation I ..... Volts

Half-equation II ..... Volts

*(ii) Write the overall equation for the disproportionation of Cr^{3+} into Cr^{2+} and $Cr_2O_7^{2-}$.

Use the $E^{\ominus}$ values you have obtained in (c)(i) to show whether or not this disproportionation is feasible under standard conditions.

(4)

.....

.....

.....

.....

.....

(Total for Question 21 = 15 marks)

22 (a) Tiglic acid is a compound that is used as a defensive agent by some beetles.

(i) Tiglic acid contains, by mass, 60% carbon, 8% hydrogen, with the remainder being oxygen. Show that these data are consistent with the formula $C_5H_8O_2$.

(1)

(ii) Tiglic acid contains a carbon-carbon double bond and a carboxylic acid group.

Suggest **one** test for each of these groups in tiglic acid. State what you would do and what you would see as a positive result for the tests.

(4)

Test for C═C .....

.....

.....

.....

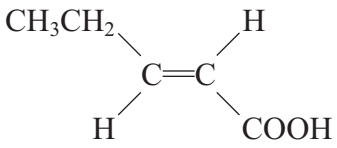
Test for —COOH .....

.....

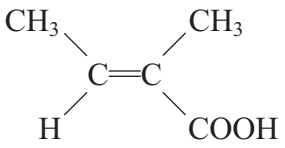
.....

.....

(b) It is suggested that the structure of tiglic acid is either that of **A** or **B**.



A



B

(i) State, with a reason, whether **B** is the *E*- or *Z*- isomer.

(2)

.....

.....

.....

(ii) The mass spectrum of tiglic acid shows two prominent peaks at mass/charge ratios 45 and 55. Write the formulae of the fragments giving rise to each of these peaks.

(2)

45 .....

55 .....

(iii) Does this data from the mass spectrum **alone** enable you to decide which of **A** or **B** is the structure of tiglic acid? Explain your answer.

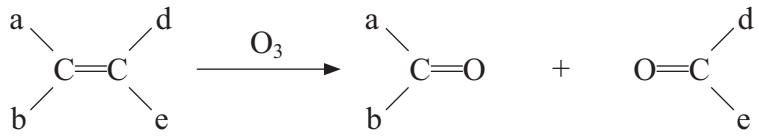
(1)

.....

.....

.....

(c) The position of a C═C double bond in a molecule can be determined by ozonolysis. The compound is reacted with ozone and then dilute acid, two carbonyl compounds being produced as shown below.



Ozonolysis of tiglic acid gives two carbonyl compounds, **C** and **D**.

Compound **C** gives a silver mirror with Tollens' reagent and gives iodoform with iodine in alkali.

Compound **D** does **not** give a silver mirror with Tollens' reagent, but does give iodoform with iodine in alkali.

*(i) From the results of the experiments, deduce the functional groups present in **C** and **D**. By considering the two possible structures for tiglic acid, give the structural formulae of **C** and **D**.

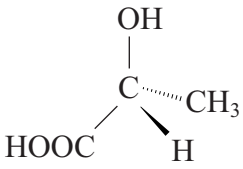
From the structures you have drawn, state which of the structures **A** or **B** could represent tiglic acid.

(6)

(ii) Explain whether or not these tests show definitely that your answer to (c)(i) represents tiglic acid.

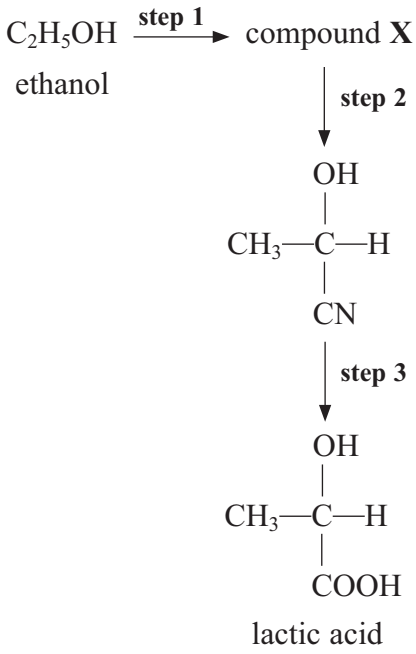
(1)

(d) Lactic acid is a chiral molecule that is found in sweat as the (–) isomer only. Its structural formula is



(–) - lactic acid

(i) Lactic acid can be made from ethanol in three steps.



lactic acid

Give the structural formula of the intermediate **X** and the reagents and conditions required for **steps 1** and **2**.

(4)

Step 1 .....

.....

Step 2 .....

.....

(ii) Classify the type and mechanism of the reaction that occurs in **step 2**.

(1)

.....

*(iii) By considering the stereochemistry of the mechanism in **step 2**, explain why this synthesis would **not** give a single optical isomer of lactic acid.

(2)

.....

.....

.....

.....

(iv) Suggest why synthetic pathways for the manufacture of pharmaceuticals may require reactions that are highly stereospecific.

(1)

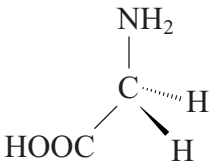
.....

.....

.....

(Total for Question 22 = 25 marks)

23 Proteins are polymers of α-amino acids, the simplest of which is glycine.



(a) (i) Draw the **structural** formula for the zwitterion of glycine in the solid state.

(1)

(ii) Explain, on the basis of your answer to (a)(i), why glycine has a relatively high melting temperature for such a small molecule.

(2)

(iii) Draw the structure of the protein chain that would be formed if glycine alone were to be polymerized. Show part of the chain containing two glycine residues.

(2)

*(b) A solution of hydrolysed protein contains the individual amino acids that make up the protein. Briefly state how you would use chromatography, together with known samples of amino acids, to show which amino acids the protein contained. Do **not** give detailed experimental instructions.

(5)

(Total for Question 23 = 10 marks)

TOTAL FOR SECTION B = 50 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

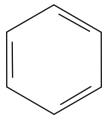
24 Read the passage below carefully and answer the questions which follow.

Molecular structure and colour chemistry

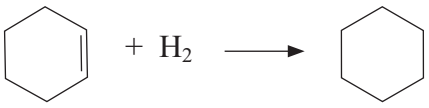
The sight of tubes of paint or of coloured pencils in an artists' supply shop is something that most people enjoy; we love colour.

The ability to synthesise brightly-coloured compounds coincides with the rapid growth of the organic chemicals industry. Synthetic organic dyes started to appear in the mid-19th century when William Perkin synthesised Mauve in 1856 at the age of 18. He was trying to synthesise quinine even though he did not know the structure of the molecule.

In the 19th century many chemists did not believe that molecules existed. The work of Butlerov, Couper, and notably Kekulé showed that molecules not only exist but have specific structures. In 1865 Kekulé suggested a ring structure for the aromatic compound benzene which he represented as



Kekulé knew that benzene does not react with bromine water. Later work showed that the enthalpy change of hydrogenation of the compound is $-205\ kJ\ mol^{-1}$, rather than the value of $-360\ kJ\ mol^{-1}$ that would be expected if the structure was exactly as shown above, given that the enthalpy change of hydrogenation for cyclohexene to cyclohexane



is $-120\ kJ\ mol^{-1}$.

When Greiss in 1856 discovered diazotisation and the azo dyes, he used a reaction characteristic of aromatic amines. Witt, in 1876, found the functional groups in the dye molecule that make it water-soluble and enable it to attach to the cloth fibres. Graebe, Liebermann and Perkin in 1869 patented the synthesis of alizarin, found in madder root grown in Holland and Von Baeyer synthesised indigo in 1880, until then grown in India. Synthetic dyes were made available in large quantities and were cheaper than the sources from plants.

Now the organic chemical industry produces a vast range of pigments and dyestuffs for use in paints and for fabrics, inks and other materials, making our world the most colourful that it has ever been.

(a) (i) Explain why Perkin's attempted synthesis of quinine was almost certain to fail.

(1)

(ii) Suggest the effect that the growth of the organic chemicals industry in the late 19th century had on Holland and India in particular.

(2)

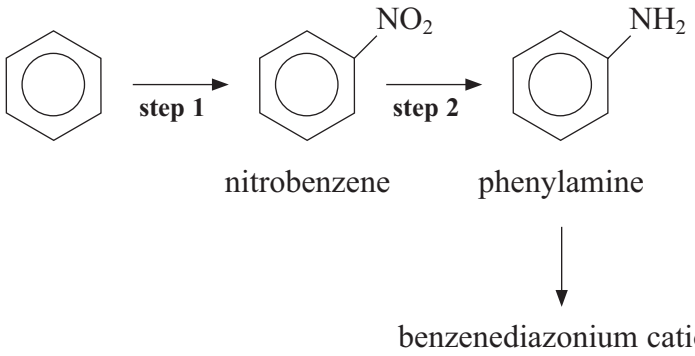
(b) (i) What observation did Kekulé make to show that benzene does **not** react with bromine water? Explain the significance of this with reference to his representation of the molecule.

(2)

(ii) Explain, in terms of the bonding in the benzene ring, why the enthalpy of hydrogenation is less exothermic than would be expected from a molecule with three double bonds.

(3)

(c) The first steps in the preparation of an azo dye from benzene are shown below.



Give the mechanism for the reaction in **step 1**, including the equation for the formation of the electrophile.

(4)

Equation for formation of electrophile

Mechanism

(d) (i) Phenylamine is converted into the benzenediazonium cation using sodium nitrite and hydrochloric acid at a temperature between 0 °C and 10 °C.

Explain why the temperature must **not** be lower or higher than these limits if a good yield is to be obtained.

(2)

.....

.....

.....

.....

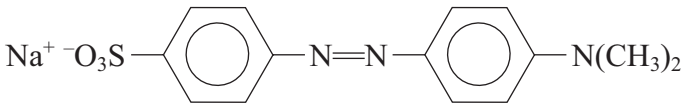
(ii) Draw the structural formula of the benzenediazonium cation showing all the bonds and the charge.

(1)

(iii) Suggest how you could convert a sample of the benzenediazonium cation into an azo dye. Give the name of the other compound you would use and the skeletal formula of the azo dye you would obtain.

(3)

(e) The structural formula of methyl orange is given below.



Suggest the main features of methyl orange which make it water-soluble, giving your reasons.

(2)

.....

.....

.....

.....

(Total for Question 24 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 3 5 3 0 2 A 0 2 8 2 8

PMT

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Mark Scheme (Results)
January 2012

GCE Chemistry (6CH05) Paper 01
General Principles of Chemistry II
Transition Metals and Organic Nitrogen Chemistry
(including synoptic assessment)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	A	**1**

Question Number	Correct Answer	Mark
2	D	**1**

Question Number	Correct Answer	Mark
3	A	**1**

Question Number	Correct Answer	Mark
4	B	**1**

Question Number	Correct Answer	Mark
5	D	**1**

Question Number	Correct Answer	Mark
6	B	**1**

Question Number	Correct Answer	Mark
7	C	**1**

Question Number	Correct Answer	Mark
8	D	**1**

Question Number	Correct Answer	Mark
9	B	**1**

Question Number	Correct Answer	Mark
10	B	**1**

Question Number	Correct Answer	Mark
11	C	**1**

Question Number	Correct Answer	Mark
12	A	**1**

Question Number	Correct Answer	Mark
13	C	**1**

Question Number	Correct Answer	Mark
14	B	**1**

Question Number	Correct Answer	Mark
15	C	**1**

Question Number	Correct Answer	Mark
16	D	**1**

Question Number	Correct Answer	Mark
17	C	**1**

Question Number	Correct Answer	Mark
18	D	**1**

Question Number	Correct Answer	Mark
19	D	**1**

Question Number	Correct Answer	Mark
20	A	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)	$3d^3 4s^2$ OR $4s^2 3d^3$ $3d^5 4s^1$ OR $4s^1 3d^5$ both must be correct. ALLOW Electron numbers could be on the line or as subscripts IGNORE case of letters		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	Variable/varying/different/several/ more than one **oxidation state /number** **(1)** Complex (ion formation) **(1)** Treat Physical properties (if correct) including catalytic activity as neutral	Each metal has a different oxidation number Ligand exchange	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	The following metals scores (2) marks with correct E value: Mg 1.96, Ce 1.92, U 1.39, Al 1.25, Mn 0.78, V 0.77, Zn 0.35 **NOTE:** Positive sign/unit not needed, but penalise negative value The following metals score (1) mark with correct E value: Li 2.62, Rb 2.52, K 2.51, Ca 2.46, Na 2.30, Cr 0.33, Fe 0.03 **NOTE:** Positive sign/unit not needed, but penalise negative value	All other metals 0/2	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	Not a redox process Chromate and dichromate **both** the same/no change in oxidation number **(1)** contain Cr(VI) 6/6+ **(1)** Mark independently OR Not redox and **both** contain Cr(VI) 6/6+ **(2)**		**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Forms two (dative/covalent) bonds/has two lone pairs (to the Transition Metal/ion) OR donates two pairs of electrons (to the Transition Metal/ion) **Check answer to (v) if mark not awarded here**	'…to the molecule'	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(v)	**Any two from** Both have two nitrogen atoms with lone pairs or implied **(1)** or Far enough apart/longer chain in between in en (but not in hydrazine)/too close in hydrazine/hydrazine is too short/not as long **(1)** or Dative bonds/lone pairs too close/repel in hydrazine **(1)** OR for two marks Forms 5-membered ring (with en with no angle strain/stable) **(2)** or Bond angles too acute/too much ring strain in hydrazine **(2)** **Mark for iv can be awarded here.**	N=N, or triple bond in hydrazine max 1 or if implies **only** en has lone pairs max 1	**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	- 0.41 (V) +1.33 (V) **Both** answers needed, with number and sign, for 1 mark IGNORE additional words		**1**

Question Number	Acceptable Answers	Reject	Mark
***21(c)(ii) QWC**	Combines the equations to obtain $8Cr^{3+} + 7H_2O \rightarrow 6Cr^{2+} + Cr_2O_7^{2-} + 14H^+$ ALLOW $6Cr^{3+} + 2Cr^{3+}$ instead of $8Cr^{3+}$ IGNORE state symbols even if wrong species **(1)**, balance **(1)** $E^{\ominus}_{reaction}$ = — 1.74V **(1)** So not feasible on condition of negative value **(1)** OR $6Cr^{2+} + Cr_2O_7^{2-} + 14H^+ \rightarrow 8Cr^{3+} + 7H_2O$ If fully correct **(1)** $E^{\ominus}_{reaction}$ = + 1.74V **(1)** **Disproportionation** not feasible on condition of positive value but reject 'reaction is spontaneous' **(1)** **Other wrong equations** **IF** $Cr_2O_7^{2-}$ or Cr^{2+} on left Then + 1.74 V **(1)** **If** Cr^{3+} alone on the left Then -1.74 V **(1)** and reaction not feasible **(1)**	1 max for the equation if electrons are shown balanced or unbalanced	**4**

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	C 60/12 = 5 H 8/1 = 8 O 32/16 = 2 ALLOW 1 mol = 100 g So 60 %C = C_5, etc		**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	**C=C** **Test** : add bromine water/Br_2(aq) **(1)** **Result**: From yellow/brown/red-brown/orange to colourless/decolorises **(1)** OR **Test** : add (acidified) potassium manganate((VII)) (solution) **(1)** **Result**: goes from pink/purple to colourless/brown **(1)** **Test** : add alkaline potassium manganate((VII)) (solution) **(1)** **Result**: goes green **(1)** **COOH:** **Test** : add $NaHCO_3$ /Na_2CO_3/sodium carbpnate (solution) **(1)** **Result**: Fizzes/bubbles/large volume neutralized **(1)**	 Bromine/Br_2/Br_2(l) clear for colourless clear for colourless PCl_5 /$LiAlH_4$ as test NaOH/NaOH(aq) colourless gas evolved	**4**

	ALLOW gas given off that turns limewater cloudy OR **Test** : with **blue** litmus **(1)** **Result**: turns red **(1)** The test can be with any other indicator, including universal indicator, with the correct initial and final colour ALLOW pH meter **(1)** pH 4-6 **(1)** OR **Test** : add ethanol with conc H_2SO_4 (and warm) **(1)** **Result**: gives pleasant/fruity smell of ester **(1)** OR **Test:** add magnesium **(1)** **Result:** fizzing/bubbles etc (of hydrogen) **(1)** ALLOW gas given off that burns with a squeaky pop	Add sodium colourless gas evolved	

Question Number		Reject	Mark
22(b)(i)	Explanation of precedence/priority in terms of atomic numbers/masses of the attached groups OR Highest-precedent/priority groups on each carbon are on opposite sides of the molecule **(1)** *E*-/entgegen **(1)** Mark independently	Both CH_3/methyl groups on the same side so Z (0/2)	**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	45 $COOH^+$ /CO_2H^+ **(1)** 55 $C_4H_7^+$ OR $C_3OH_3^+$ **(1)** ALLOW Structural/displayed formulae of ions Absence of + charge (1 max)		**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)(iii)	If they say yes **(0)** (No) (Cleavage of the C—COOH bond in) both compounds gives fragment(s) of the same mass OR Both give the same peak(s)/fragment(s) Both give CO_2H^+/ $C_4H_7^+$ fragments The mark can be scored by referring to just one of the fragments/peaks/masses.	'No' on its own	**1**

Question Number	Acceptable Answers	Reject	Mark
***22(c)(i) QWC**	**C** is CH_3CHO (alone) **(2)** **D** is $CH_3COCOOH$ (alone) **(2)** so tiglic acid must be **B** **(1)** tiglic acid mark can only be awarded if correct structures of either **C** or **D** are given. **Any one of the following** **C** must be an aldehyde **(1)** **D** is a ketone **(1)** Mention that CH_3CO present in either/both compounds (because of formation of iodoform) **(1)** If one or both of the structures are incorrect any of the last 3 marks can be awarded max 5 If C and D are fully correct, but the wrong way round max 5	CH_3COH **1 max**	**6**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	Doesn't distinguish *E*- isomer from *Z*-isomer/geometric isomers (so no) OR Doesn't distinguish which sides of C=C functional groups are on	Just isomers/ stereoisomers/ enatiomers	**1**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	CH_3CHO **(1)** ACCEPT displayed or skeletal **Step 1** (heat)using acidified potassium dichromate/or $H^+/Cr_2O_7^{2-}$ **(1)** distil (product as formed) conditional on dichromate **(1)** **Step 2** HCN with KCN OR KCN with H^+/acid OR KCN with (cold) NaOH(aq)/alkali **(1)** ALLOW HCN with NaOH/alkali For step 2 Ignore conditions e.g. any references to heat	CH_3COH Manganate VII/$KMnO_4$ Reflux HCN alone	**4**

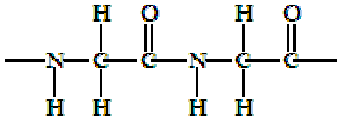
Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	**Nucleo**philic addition Any recognisable spelling of 'philic' and addition, either order **Both** words needed	**Nutro**philic addition Any other or additional words	**1**

Question Number	Acceptable Answers	Reject	Mark
***22(d)(iii) QWC**	Ethanal is planar (at the reaction site) OR Ethanal is a planar molecule **(1)** Attack (from CN^- to give the cyanohydrin) is (equally likely) from either side/above or below/from both sides (of the molecule) (so a racemic mixture is formed) **(1)** Mark independently	Intermediate is planar Square planar Can attack carbocation from either side/any reference to SN1/SN2	**2**

Question Number	Acceptable Answers	Reject	Mark
22(d)(iv)	Receptors for the compound in the body are often stereospecific so only one stereoisomer is pharmacologically active OR Body recognises one (stereo)isomer ALLOW Only one (stereo)isomer is active OR One/the other isomer may be toxic/dangerous/harmful OR One isomer destroys body cells OR (Different) isomers have different biological/pharmacological/biochemical properties		**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	Formula showing $-NH_3^+$ and $—COO^-$ /$—CO_2^-$ Charges can be anywhere on functional group Rest of the molecule must be correct ALLOW displayed/part displayed formula		**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	**Any two from** High energy needed (to overcome) **(1)** strong ionic/electrostatic forces OR strong forces between oppositely charged ions/between positive and negative **(1)** between **different** (zwitter)ions OR between $-NH_3^+$ and $—COO^-$ OR between one molecule and another OR Chains of zwitterions/molecules **(1)**	any reference to intermolecular forces eg (strongly) polar/bond polarity if they state the ionic bond is within the same molecule	**2**

Question Number	Acceptable Answers	Reject	Mark
23(a)(iii)	 Correct peptide link **(1)** Minimum two residues and extension to the rest of the molecule **(1)** ALLOW $-NHCH_2CONHCH_2CO-$ **(2)** Drawn the other way round, i.e. starting with the carbonyl group Brackets around outside with 'n' ie $(.....)_n$ Second mark depends on first		**2**

Question Number	Acceptable Answer	Reject	Mark
***23(b) QWC**	**Key Points** **KP1** Spot (of hydrolysate) on paper/tlc/thin layer chromatogram **(1)** **KP2** Marker spots of known amino-acids/measure R_f **(1)** **KP3** Run in (suitable) solvent/discussion of comparative solubilities in phases **(1)** **KP4** (Spray with) ninhydrin (and heat) [Stand alone mark] **(1)** **KP 5** Marker spots and the unknown spots correspond ALLOW Compare R_f values of marker spots with hydrolysate spots **(1)** OR If 2-d chromatography used (2 different solvents run in two directions at right angles): **KP1** Spot (of hydrolysate) on paper/tlc/thin layer chromatogram **(1)** **KP2** Run in (suitable) solvent in one direction **(1)** **KP3** Develop in suitable/different solvent at right angles OR discussion of comparative solubilities in phases **(1)** **KP4** Spray with ninhydrin (andheat) **(1)** **KP5** Compare hydrolysate spots with same experiment for known amino acids **(1)** OR	Spot one amino acid/protein Water alone as solvent Spot one amino acid	**5**

	if column/GLC/GC used **KP1** Put amino acid mixture **(**Hydrolysate) into column **(1)** **KP2** Separately known amino-acids into column **(1)** **KP3** Detect amino acids in effluent with Ninhydrin/mass spectrometry **(1)** **KP4** Measure retention times/ discussion of comparative solubilities in phases **(1)** **KP 5** Compare retention times **(1)**	Spot one amino acid	

TOTAL FOR SECTION B = 50 MARKS

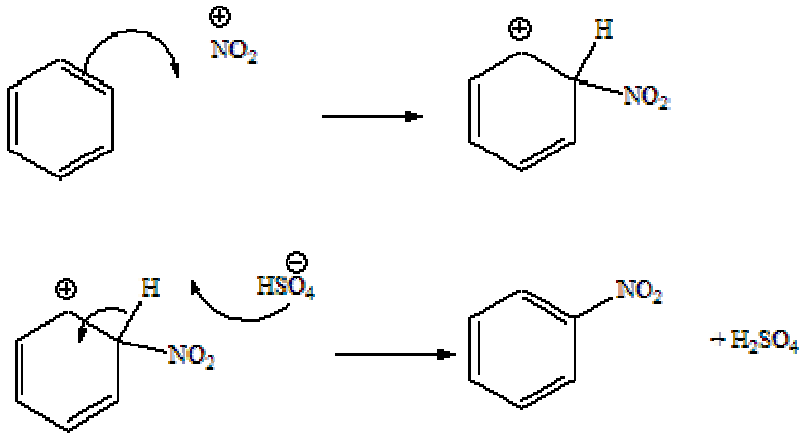
Section C

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	Not knowing the structure of the molecule (means that the reactions/reagents/reactants needed to make it are also unknown) ALLOW Structure not known		**1**

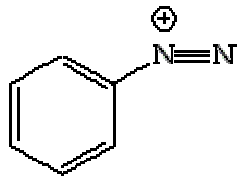
Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	Credit any reasonable arguments for example: **First mark** No longer any demand for madder/indigo OR Cheaper alternatives available **(1)** **Second mark** So the growing industries collapsed OR no market for crops OR farmers had to grow alternative crops OR decreased employment OR economic damage OR decreased GDP OR Loss of export **(1)**		**2**

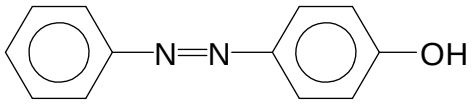
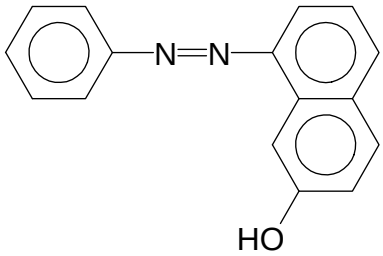
Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	**First mark** Double bonds expected to react with bromine water turning it colourless OR Bromine water remained yellow/orange/red/brown **(1)** **Second mark** So benzene does not contain double bonds OR Double bonds not normal/not simply double bonds/any indication that double bonds are different OR His representation incorrect **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	The p/pi-/π/6 electrons (of carbon) OR π system **(1)** Electrons are delocalised around the ring **(1)** Which gives the molecule greater stability/need more energy to break the bonds in benzene (and hence a less exothermic hydrogenation enthalpy) Allow it is more stable **(1)**	Harder to break/disrupt [alone]	**3**

Question Number	Acceptable Answers	Reject	Mark
24(c)	$2H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ **(1)** OR $H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_2O + HSO_4^-$ OR $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$ **and** $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$ **Charges are needed for first mark**  Attack on nitronium ion arrow must start on or in the benzene **(1)** Wheland intermediate Can be a part, but not complete circle, in correct place inside ring BUT part circle must cover minimum of 3 carbon atoms AND must not include where nitro group is attached and must positive charge somewhere **(1)** **Either but only one of first two marks can be lost if bond is clearly to oxygen** Arrow from H bond into the ring to produce either H^+ or H_2SO_4 and return to aromaticity **(1)**		**4**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	< 0° C/temperature too low: reaction too slow/insufficient energy to overcome activation energy **(1)** > 10° C/temperature too high: diazonium ion decomposes/produces phenol **(1)**	Will not take place	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	 Positive charge can be on either N Cl^- may be given as well ALLOW circle in benzene ring and hydrogens/carbons displayed OR ---N=N^+ Is acceptable providing charge is on the end N	Positive charge on wrong N	**1**

Question Number	Acceptable Answers	Reject	Mark
24 (d)(iii)	Adds phenol in sodium hydroxide/OH^-/alkali ALLOW 2-naphthol in sodium hydroxide/OH^- /alkali **(1)** Correct structure for the -N=N- bond between 2 benzene rings **(1)** Remainder of molecule **(1)** which is either:  ALLOW anionic form of —OH OR if 2-naphthol is used it is:  	Ignore position of –OH group on the ring	**3**

Question Number	Acceptable Answers	Reject	Mark
24 (e)	**First mark** $—SO_3^-$ are solvated / hydrated Can be drawn with polar H of water OR Negative ion bonds with/attracted to water **(1)** **Second mark** **Nitrogen/oxygen** atoms **hydrogen-bonded** (to water) Can be drawn **(1)**	Just sodium ions attracted to water	**2**

TOTAL FOR SECTION C = 20 MARKS

TOTAL FOR PAPER = 90 MARKS

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Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Tuesday 19 June 2012 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39309A

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7/7/5/5/3/

P 3 9 3 0 9 A 0 1 2 0

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The acid used in a standard hydrogen electrode to provide a 1 mol dm^{-3} solution of hydrogen ions is

☒ **A** ethanoic acid.

☒ **B** phosphoric(V) acid.

☒ **C** sulfuric acid.

☒ **D** hydrochloric acid.

(Total for Question 1 = 1 mark)

2 To measure the standard electrode potential for the $Ag^+(aq)|Ag(s)$ electrode, the most suitable chemical for the solution in a salt bridge to connect the two half cells is

☒ **A** potassium chloride.

☒ **B** potassium iodide.

☒ **C** potassium nitrate.

☒ **D** potassium sulfate.

(Total for Question 2 = 1 mark)

3 For any reversible reaction, ln K is proportional to

☒ **A** both ΔS_{total} and E_{cell}.

☒ **B** ΔS_{total} but not E_{cell}.

☒ **C** E_{cell} but not ΔS_{total}.

☒ **D** neither E_{cell} nor ΔS_{total}.

(Total for Question 3 = 1 mark)

4 This question is about a titration to determine the iron content of a tablet. The iron(II) ions in the tablet are oxidized to iron(III) ions by acidified manganate(VII) ions which are reduced to manganese(II) ions.

(a) The mole ratio of iron(II) to manganate(VII) ions in the reaction is

(1)

	Fe^{2+}	MnO_4^-
☒ **A**	1	5
☒ **B**	2	5
☒ **C**	5	2
☒ **D**	5	1

(b) A 0.200 g tablet is dissolved to make exactly 100 cm^3 of solution. 10 cm^3 of this solution is found to contain 5.38×10^{-5} mol of iron(II) ions.

The percentage by mass of iron (A_r = 55.8) in the tablet is

(1)

☒ **A** $\dfrac{5.38\times10^{-5}\times55.8}{0.200}\times\dfrac{100}{10}\times100\%$

☒ **B** $\dfrac{5.38\times10^{-5}}{55.8\times0.200}\times\dfrac{100}{10}\times100\%$

☒ **C** $\dfrac{5.38\times10^{-5}\times55.8}{0.200}\times\dfrac{10}{100}\times100\%$

☒ **D** $\dfrac{5.38\times10^{-5}\times0.200}{55.8}\times\dfrac{10}{100}\times100\%$

(Total for Question 4 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

5 Some fuel cells are used to produce energy from the combination of hydrogen and oxygen. The half-equations for a hydrogen-oxygen fuel cell in alkaline solution are

$$2H_2O(l) + 2e^- \rightleftharpoons H_2(g) + 2OH^-(aq) \qquad E^{\ominus} = -0.83\ V$$

$$\tfrac{1}{2}O_2(g) + H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq) \qquad E^{\ominus} = +0.40\ V$$

(a) The equation for the cell reaction is

(1)

☒ **A** $3H_2O(l) + \tfrac{1}{2}O_2(g) \rightarrow H_2(g) + 4OH^-(aq)$

☒ **B** $H_2(g) + 4OH^-(aq) \rightarrow 3H_2O(l) + \tfrac{1}{2}O_2(g)$

☒ **C** $H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l)$

☒ **D** $H_2O(l) \rightarrow H_2(g) + \tfrac{1}{2}O_2(g)$

(b) From the data above, E_{cell} for the reaction in the hydrogen-oxygen fuel cell is

(1)

☒ **A** –0.43 V

☒ **B** +0.43 V

☒ **C** –1.23 V

☒ **D** +1.23 V

(c) An advantage of operating a hydrogen fuel cell over a conventional jet engine for powering an aeroplane is

(1)

☒ **A** it is 100% efficient.

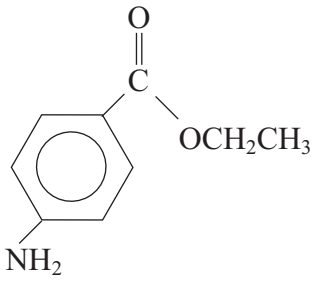
☒ **B** it does not produce greenhouse gas emissions.

☒ **C** it does not produce emissions which damage the ozone layer.

☒ **D** hydrogen is easier to transport.

(Total for Question 5 = 3 marks)

6 Benzocaine is used as a local anaesthetic.



Separate samples of a solution of benzocaine are added to 2,4-dinitrophenylhydrazine, hot aqueous sodium hydroxide, and dilute hydrochloric acid.

Which chemicals react with benzocaine?

☒ **A** All three

☒ **B** Only sodium hydroxide and hydrochloric acid

☒ **C** Only hydrochloric acid

☒ **D** Only sodium hydroxide

(Total for Question 6 = 1 mark)

7 In the first commonly used breathalyser, acidified potassium dichromate(VI) was used which was reduced to chromium(III) by alcohol.

The colour change seen when alcohol was present in a motorist's breath is from

☒ **A** orange to green.

☒ **B** orange to yellow.

☒ **C** yellow to green.

☒ **D** yellow to orange.

(Total for Question 7 = 1 mark)

8 For which of the following are both tests acceptable evidence for a driver to be successfully prosecuted for excess alcohol in the blood in many countries?

☒ **A** A dichromate(VI) breath analyser and a blood test.

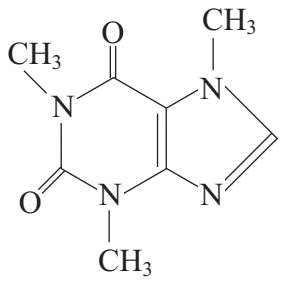
☒ **B** A dichromate(VI) breath analyser and a fuel cell breath analyser.

☒ **C** A dichromate(VI) breath analyser and an infrared breath analyser.

☒ **D** An infrared breath analyser and a blood test.

(Total for Question 8 = 1 mark)

9 The structural formula of caffeine, $C_8H_{10}O_2N_4$, is shown below.



(a) How many main peaks would you expect in the proton nuclear magnetic resonance spectrum of caffeine?

(1)

☒ **A** 1

☒ **B** 2

☒ **C** 3

☒ **D** 4

(b) At which of the following wavenumbers is an absorption peak **not** present in the infrared spectrum of caffeine?

(1)

☒ **A** 3600 cm^{-1}

☒ **B** 2925 cm^{-1}

☒ **C** 1690 cm^{-1}

☒ **D** 1660 cm^{-1}

(c) The parent ion peak of caffeine in the mass spectrum of caffeine would be at m/e ratio

(1)

☒ **A** 101

☒ **B** 102

☒ **C** 193

☒ **D** 194

(d) Intermolecular forces between caffeine molecules would include

(1)

☒ **A** London forces only.

☒ **B** London forces and hydrogen bonds.

☒ **C** London forces and permanent dipole forces.

☒ **D** London forces, permanent dipole forces, and hydrogen bonds.

(Total for Question 9 = 4 marks)

10 (a) The principal advantage of combinatorial chemistry over traditional methods for developing pharmaceuticals is that

(1)

☒ **A** very small amounts of compounds are used.

☒ **B** many more compounds can be made in a given time.

☒ **C** compounds formed are more powerful drugs.

☒ **D** compounds formed have fewer side effects.

(b) A refinement of combinatorial chemistry involves initially attaching compounds firmly to polymer beads. The type of attachment is most likely to be by

(1)

☒ **A** metallic bonds.

☒ **B** covalent bonds.

☒ **C** London forces.

☒ **D** permanent dipole forces.

(Total for Question 10 = 2 marks)

11 Four reactions involving the transition elements copper and chromium are given below.

1 $Cu^{2+}(aq) + 2OH^{-}(aq) \rightarrow Cu(OH)_2(s)$

2 $[Cu(H_2O)_4(OH)_2](s) + 4NH_3(aq) \rightarrow [Cu(H_2O)_2(NH_3)_4]^{2+}(aq) + 2OH^{-}(aq) + 2H_2O(l)$

3 $[Cr(H_2O)_3(OH)_3](s) + 3OH^{-}(aq) \rightarrow [Cr(OH)_6]^{3-}(aq) + 3H_2O(l)$

4 $[Cr(H_2O)_3(OH)_3](s) + 3H^{+}(aq) \rightarrow [Cr(H_2O)_6]^{3+}(aq)$

(a) Which reaction produces a dark blue solution?

(1)

☒ **A** **1**

☒ **B** **2**

☒ **C** **3**

☒ **D** **4**

(b) Which two reactions show the amphoteric behaviour of a metal hydroxide?

(1)

☒ **A** **1** and **2**

☒ **B** **2** and **3**

☒ **C** **2** and **4**

☒ **D** **3** and **4**

(c) Predict, without calculation, which reaction has the most negative value for ΔS_{system}.

(1)

☒ **A** **1**

☒ **B** **2**

☒ **C** **3**

☒ **D** **4**

(Total for Question 11 = 3 marks)

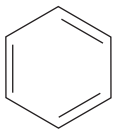
TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

12 This question is about benzene and its compounds.

(a) A Kekulé structure of benzene suggests the molecule consists of alternate double and single carbon to carbon bonds.



The standard enthalpy change of hydrogenation of a carbon to carbon double bond is -120 kJ mol^{-1}.

(i) Calculate the standard enthalpy change of hydrogenation of benzene for the Kekulé structure.

(1)

.....

*(ii) The actual standard enthalpy change of hydrogenation of benzene is -208 kJ mol^{-1}.

Use this information and your answer to (i), to calculate the difference in stability of benzene and the Kekulé structure.

What does this tell us about the bonding in benzene?

Explain how this influences the type of chemical reactions that benzene undergoes.

(4)

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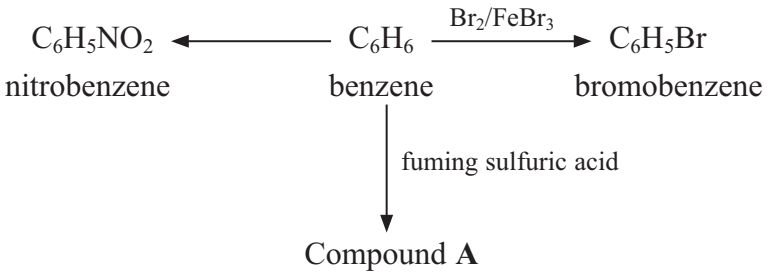
(b) The flow chart shows some typical reactions of benzene.



(i) Identify the two chemicals needed to make nitrobenzene from benzene.

(2)

.....

.....

(ii) Classify the type of reagent required in all three reactions.

(1)

.....

(iii) Show, with appropriate diagrams, the mechanism for the reaction of benzene with bromine, in the presence of iron(III) bromide, to form bromobenzene. Include the formation of the ion attacking the benzene molecule.

(4)

(iv) Give the structural formula and the name for compound **A**.

(2)

Name .....

(c) (i) Explain why phenol, C_6H_5OH, and methoxybenzene, $C_6H_5OCH_3$, are much more reactive than benzene with bromine.

(3)

.....

.....

.....

.....

.....

.....

(ii) Write the equation for the reaction between phenol and bromine water. State symbols are **not** required.

(2)

(d) Diphenylmethane, $(C_6H_5)_2CH_2$, is often added to soap to create the pleasant smell of geraniums. It can be made from benzene and one other reagent, using a suitable catalyst.

Identify the other starting material and the catalyst by name or formula.

(2)

.....

.....

(Total for Question 12 = 21 marks)

13 This question is about 1,2-diaminoethane, $H_2NCH_2CH_2NH_2$.

(a) Write an equation for the reaction between 1,2-diaminoethane and **excess** dilute hydrochloric acid.

(2)

(b) When an aqueous solution of nickel(II) ions is added to 1,2-diaminoethane, a complex ion forms.

$$3H_2NCH_2CH_2NH_2 + Ni(H_2O)_6^{2+} \rightarrow Ni(H_2NCH_2CH_2NH_2)_3^{2+} + 6H_2O$$

(i) Suggest the colour of this complex.

(1)

.....

(ii) Without using the data booklet, suggest why the complex formed is more stable than $Ni(H_2O)_6^{2+}$ by considering the appropriate entropy change.

(2)

.....

.....

.....

.....

(iii) This complex can exist as two structures, which are non-superimposable mirror images.

Suggest the physical property that would enable you to distinguish between these two structures.

(1)

.....

.....

(c) 1,2-diaminoethane reacts with butane-1,2-dioyl dichloride, $ClOCCH_2CH_2COCl$, to form a polymer.

(i) Draw a displayed formula for this polymer showing one repeat unit.

(2)

(ii) Give, and explain, the name for this type of polymerization reaction.

(2)

*(iii) State and explain the intermolecular forces between two of these polymer chains.

(5)

(Total for Question 13 = 15 marks)

14 An organic compound **X** contains carbon, hydrogen, oxygen and nitrogen.

0.132 g of **X** is burned completely in oxygen to produce 0.072 g of water, 0.176 g of carbon dioxide and 24.0 cm^3 of nitrogen.

[Molar volume of nitrogen under the conditions of the experiment = 24 000 $cm^3\ mol^{-1}$]

(a) Calculate the empirical formula of compound **X**.

(5)

(b) The molar mass of **X** is 132 g mol^{-1}. Deduce the molecular formula for **X**. Show how you arrived at your answer.

(1)

(c) When **X** is refluxed with concentrated hydrochloric acid for several hours, cooled and neutralized, there is only one organic product, **Y**, which has the molecular formula $C_2H_5O_2N$.

One mole of **Y** will react with either one mole of hydrochloric acid or one mole of sodium hydroxide solution.

When **Y** is sprayed with a solution of ninhydrin and heated, a purple colour is observed.

(i) Use **all** the information above to deduce the functional groups present in **Y** and to classify the type of compound it is. Justify your answer.

(3)

.....

.....

.....

.....

.....

.....

(ii) Deduce the displayed formula for **Y** and give its name.

(2)

Name of **Y**.....

(iii) Hence give the structural formula for **X**.

(1)

(Total for Question 14 = 12 marks)

TOTAL FOR SECTION B = 48 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

15

Some unusual oxidation states

You will probably have seen manganese in its common oxidation states during your study of chemistry. Manganese(II) sulfate occurs as very pale pink crystals in the hydrated form. Manganese(IV) oxide is a black powder which is often used as a catalyst. Potassium manganate(VII) occurs as very dark purple crystals and forms a purple aqueous solution, which is a powerful oxidizing agent.

You are less likely to have seen compounds containing the other oxidation states of manganese, which are manganese(VI), manganese(V), manganese(III) and manganese(I). However, compounds containing each of these four oxidation states can be prepared.

Manganese(VI)

Manganese(VI), in MnO_4^{2-}, can be prepared in a reverse disproportionation reaction, by reacting manganate(VII) ions with manganese(IV) oxide in alkali.

Equation 1

$$2MnO_4^-(aq) + MnO_2(s) + 4OH^-(aq) \rightarrow 3MnO_4^{2-}(aq) + 2H_2O(l) \quad E^{\ominus}_{cell} = -0.03V$$

The reaction is not thermodynamically favourable under standard conditions. However, the E_{cell} value can be made positive by increasing the concentration of hydroxide ions so that green manganate(VI) ions form.

Manganese(V)

Manganese(V) can be formed by adding a little potassium manganate(VII) to very concentrated (12 mol dm^{-3}) aqueous sodium hydroxide. The solution slowly becomes blue as manganate(V) ions, $MnO_3^-(aq)$, form. The ionic half-equations are:

Equation 2

$$MnO_4^-(aq) + H_2O(l) + 2e^- \rightarrow MnO_3^-(aq) + 2OH^-(aq)$$

Equation 3

$$4OH^-(aq) \rightarrow 2H_2O(l) + O_2(g) + 4e^-$$

Manganese(III)

A deep red solution containing manganese(III) ions is formed by the oxidation of manganese(II) hydroxide by potassium manganate(VII) in acid solution. The ionic equation for the reaction is:

Equation 4

$$MnO_4^-(aq) + 4Mn(OH)_2(s) + 16H^+(aq) \rightarrow 5Mn^{3+}(aq) + 12H_2O(l)$$

Manganese(I)

Manganese(I) ions are not stable in aqueous solution, but do form stable complex ions. They can be made by reducing hexacyanomanganate(II) ions, $Mn(CN)_6^{4-}$, to hexacyanomanganate(I) ions, $Mn(CN)_6^{5-}$.

(a) (i) Give the formula of manganese(IV) oxide.

(1)

(ii) How do catalysts speed up reactions?

(2)

(iii) Explain how transition metal ions can act as homogeneous catalysts.

(2)

(b) (i) Suggest why the preparation of manganate(VI) ions, MnO_4^{2-}, in **equation 1**, may be described as a reverse disproportionation reaction by considering the relevant oxidation states.

(2)

(ii) The two half-equations which are combined to form **equation 1** are

$$MnO_4^-(aq) + e^- \rightleftharpoons MnO_4^{2-}(aq) \qquad E^{\ominus} = +0.56\ V$$

$$MnO_4^{2-}(aq) + 2H_2O(l) + 2e^- \rightleftharpoons MnO_2(s) + 4OH^-(aq) \qquad E^{\ominus} = +0.59\ V$$

Explain, by reference to these half-equations, why increasing the concentration of hydroxide ions alters the electrode potential to make the preparation of manganate(VI) ions more likely.

(3)

(c) Use equations **2** and **3** to answer the following questions.

(i) Identify the gas formed in the preparation of manganate(V) ions.

(1)

(ii) By appropriately combining these two equations, write the ionic equation for the formation of manganate(V) ions from manganate(VII) ions.

(2)

(iii) Identify the main hazard and state how you would minimize the associated risk in this preparation of manganate(V) ions.

(2)

(d) Identify the reagents you would use to make manganese(II) hydroxide for the preparation of manganese(III) ions.

(2)

.....

.....

(e) (i) Draw a dot and cross diagram to show the electron arrangement in the cyanide ion, CN^-.

(2)

(ii) Explain how the cyanide ion acts as a ligand.

(2)

.....

.....

.....

.....

(iii) Suggest the name of the shape of the hexacyanomanganate(I) ion.

(1)

.....

(Total for Question 15 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 3 9 3 0 9 A 0 2 0 2 0

PMT

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Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH05) Paper 01

General Principles of Chemistry II Transition Metals and Organic Chemistry (Including synoptic assessment)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	D		**1**
2	C		**1**
3	A		**1**
4(a)	D		**1**
4(b)	A		**1**
5(a)	C		**1**
5(b)	D		**1**
5(c)	C		**1**
6	B		**1**
7	A		**1**
8	D		**1**
9(a)	D		**1**
9(b)	A		**1**
9(c)	D		**1**
9(d)	C		**1**
10(a)	B		**1**
10(b)	B		**1**
11(a)	B		**1**
11(b)	D		**1**
11(c)	A		**1**
		Total for section A	**20 marks**

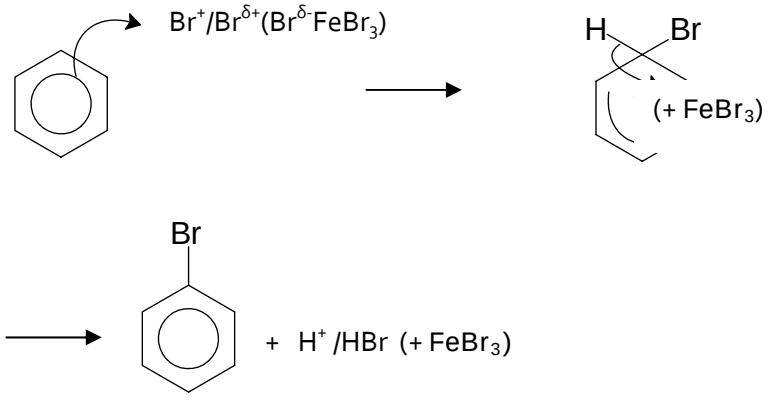
Section B

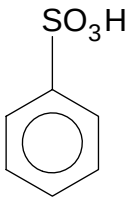
Question Number	Acceptable Answers	Reject	Mark
12(a)(i)	(3 x -120) = -360 (kJ mol^{-1}) IGNORE ΔH, and case of letters in units e.g allow Kj	No sign or + sign in answer, ie 360/+360 Any other wrong units ΔE	**1**

Question Number	Acceptable Answers	Reject	Mark
***12(a)(ii)**	• (Bonding in) benzene/it is more **stable** (than Kekule) by **152** kJ mol^{-1} (consequential on (a)(i)) **(1)** IGNORE sign • **π /p/double bond electrons** are delocalized (around the ring) OR six **p electrons** shared between six (ring) carbon atoms OR delocalized because of overlap of **p orbitals** OR resonance hybrid of C=C's and C-C's **(1)** • **Substitution** reactions (rather than addition) **(1)** NOTE: **Nucleophilic** substitution negates the substitution mark because it is wrong additional information • Maintains/regains delocalized system OR maintains/regains stability OR maintains/regains stabilization energy **(1)**	Attack by electrophiles with no mention of substitution	**4**

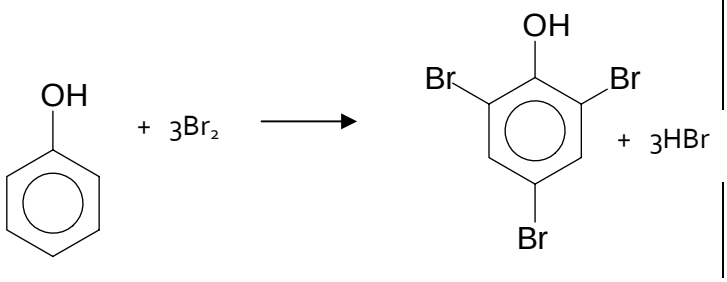
Question Number	Acceptable Answers	Reject	Mark
12(b)(i)	Concentrated nitric acid/HNO_3 **(1)** Concentrated sulfuric acid/H_2SO_4 **(1)** Allow conc or c. in place of 'concentrated' ALLOW Concentrated nitric acid and sulfuric acid OR Concentrated HNO_3 and H_2SO_4 **(2)** Second mark depends on nitric acid Max. (1) if no mention of concentrated Nitric acid and concentrated sulfuric acid scores (1) NOTE: conc. HNO_3 and H_2SO_4(aq) scores (1) but conc. HNO_3 and conc H_2SO_4(aq) scores (2)	Concentrated hydrochloric acid	**2**

Question Number	Acceptable Answers	Reject	Mark
12(b)(ii)	Electrophile/electrophilic ALLOW Electrophyl(e)	Acid Base Oxidizing agent Reducing agent	**1**

Question Number	Acceptable Answers	Reject	Mark
12(b)(iii)	$Br_2 + FeBr_3 \rightarrow FeBr_4^- + Br^+$ OR $Br\text{-}Br + FeBr_3 \rightarrow Br^{\delta+}\ldots\ldots Br^{\delta-}FeBr_3$ **(1)** IGNORE state symbols even if wrong  Arrow from benzene ring electrons (from **inside** the hexagon) to **Br^+ / $Br^{\delta+}$**($\ldots\ldots Br^{\delta-}FeBr_3$) **(1)** Correctly drawn intermediate with delocalization covering at least three carbon atoms, but not the carbon atom bonded to the bromine with the positive charge shown inside the hexagon The bonds to H and Br may be dotted **(1)** Arrow from or close to **bond** to H to centre of ring **and** H^+/HBr as a product **(1)** ALLOW Kekulé structure for benzene and intermediate **Each marking point is independent**	lack of charges	**4**

Question Number	Acceptable Answers	Reject	Mark
12(b)(iv)	 OR $C_6H_5SO_3H$ accept: displayed $-SO_3H$ $-SO_3^-H^+$ $-SO_2OH$ If two formulae are given both must be correct **(1)** Penalise if bond **clearly** goes to O or H rather than S **Benzenesulfonic acid** **(1)** ALLOW **phenyl sulfonic acid**	Benzenesulfuric acid/benzosulfonic acid/benzylsufonic acid	**2**

Question Number	Acceptable Answers	Reject	Mark
12(c)(i)	**Non-bonding/lone pair** electron**s** from **oxygen**... **(1)** ...are delocalized/incorporated/donated into the ring (electron system) (Could be shown in diagram) OR increases electron density on the ring **(1)** makes it (the ring) more susceptible to electrophilic attack/makes it (the ring) a better nucleophile **(1)**	...from methyl/methoxy Makes it more electronegative	**3**

Question Number	Acceptable Answers	Reject	Mark
12(c)(ii)	 **(1)** organic formula **(1)** balancing ALLOW • Condensed structural formulae, for example $C_6H_5OH + 3Br_2 \rightarrow C_6H_2Br_3OH + 3HBr$ **(1)** **(1)** balancing • multiples • substitution to any positions IGNORE: H_2O Position of bond to OH NOTE: Correct balanced equations giving mono and disubstitution phenols score **1 mark**		**2**

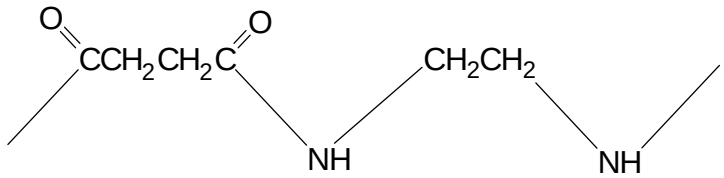
Question Number	Acceptable Answers	Reject	Mark
12(d)	(Chloromethyl)benzene/chloromethylbenzene/ chlorophenylmethane/ benzyl chloride OR dichloromethane **(1)** ALLOW phenylchloromethane Aluminium chloride **(1)** ACCEPT formulae eg C_7H_7Cl, $C_6H_5CH_2Cl$, CH_2Cl_2, $AlCl_3$ ACCEPT other halogen carriers eg $FeCl_3$/iron**(III)** chloride/$ZnCl_2$ ACCEPT bromine in place of chlorine for either/both marks Correct formula and wrong name or correct name and wrong formula or any other wrong additional information loses mark	CH_2Cl	**2**

Question Number	Acceptable Answers	Reject	Mark
13(a)	$H_2NCH_2CH_2NH_2 + 2HCl \rightarrow H_3N^+CH_2CH_2NH_3^+ + 2Cl^-$ **(1)** organic product Positive charges can be on nitrogens Balancing with **HCl** and **Cl^-** **(1)** Chloride ions can be at ends of product ie $ClH_3NCH_2CH_2NH_3Cl$ for right hand side, with or without charges, but if given charges must balance $H_2NCH_2CH_2NH_2 + 2H^+ \rightarrow H_3N^+CH_2CH_2NH_3^+$ **(2)** Reaction with 1 mol HCl for 1 max If molecular formulae used 1 max IGNORE state symbols even if wrong	Covalent bond to Cl, (-Cl)	**2**

Question Number	Acceptable Answers	Reject	Mark
13 (b)(i)	Blue or green or blue-green or lavender ALLOW qualification of blue or green e.g. dark blue, but not with another colour e.g. blue purple	Any other colour e.g. Purple Violet	**1**

Question Number	Acceptable Answers	Reject	Mark
13(b)(ii)	The entropy change of the **system** is positive **(1)** Because there is an increase in the number of particles/entities/moles/molecules OR The number of particles/entities/moles goes from four to seven OR Complex with three molecules goes to a complex with six molecules **(1)** Second mark depends on a positive entropy change	Additional incorrect numbers molecules/ atoms from four to seven	**2**

Question Number	Acceptable Answers	Reject	Mark
13(b)(iii)	They will **rotate** the **plane of plane-** polarised light (equally in opposite directions) Allow They will **rotate** the **plane** of polarised light (equally in opposite directions) OR They will **rotate plane-** polarised light (equally in opposite directions)	Optically active Reflect/ bend/ refract	**1**

Question Number	Acceptable Answers	Reject	Mark
13(c)(i)	 Amide linkage correct **(1)** Further detail correct, including trailing bonds **(1)** IGNORE brackets ALLOW multiple units Second mark dependent on correct amide link ALLOW fully correct structural formulae for 1 ~~(~~$OCCH_2CH_2CONHCH_2CH_2NH$~~)~~ Can start with NH group		**2**

Question Number	Acceptable Answers	Reject	Mark
13(c)(ii)	Condensation **(1)** Hydrogen chloride/HCl/water/H_2O or another **small** molecule/is produced/lost/formed/removed (as well as the polymer) **(1)** Mark independently	Addition/elimination	**2**

Question Number	Acceptable Answers	Reject	Mark
***13(c)(iii)**	**Types of force** Hydrogen bonds **and** (permanent) dipole(-permanent dipole) forces **and** London/van der Waals'/dispersion forces OR Explanation e.g temporary/induced dipoles **(1)** All three needed for 1st mark (which is given even if the forces are later explained incorrectly) **Hydrogen bonds** (Between) the hydrogen atoms on the nitrogen atoms and ... OR (Between) N-H and ... **(1)** ... (the lone pair of electrons on) oxygen/ nitrogen atoms **(1)** These marks can be shown by a diagram **Permanent dipole-permanent dipole forces** Because the C=O / carbon-oxygen bond/the C-N bond is polar/a dipole OR N and/or O are electronegative atoms This mark can be shown by a diagram providing the polarity of the bond is shown **(1)** **London forces** Polymer has large number of/many electrons OR Explanation e.g temporary/induced/fluctuating dipoles **(1)**	Just p.d.- p.d Just v d W Large molecular mass alone	**5**

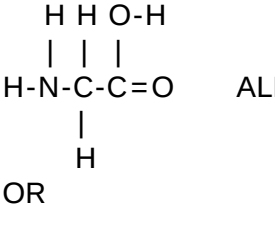
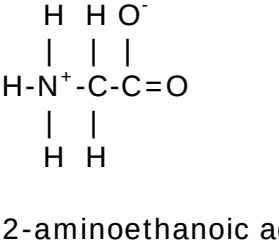
Question Number	Acceptable Answers	Reject	Mark
14(a)	**Route 1 by mol of H, C and N** $\frac{0.072}{18}$ = 0.004 mol water OR 0.008 mol H(atoms) **And** $\frac{0.176}{44}$ = 0.004 mol carbon (dioxide) **(1)** $\frac{24.0}{24000}$ = 0.001 mol nitrogen N_2 OR 0.002 mol N(atoms) **(1)** Mass of H + mass of C + mass of N = 0.008 + 0.004 x 12 + 0.028 **(1)** = 0.084 g mass of oxygen = 0.132 – (0.008 + 0.004 x 12 + 0.028) = 0.048 g amount of oxygen = $\frac{0.048}{16}$ = 0.003 mol **(1)** empirical formula is $C_4H_8O_3N_2$ **(1)** **Route 2 by mass of H, C and O calculated in one step** mass of H = 2/18 x 0.072 = 0.008 g **(1)** mass of C = 12/44 x 0.176 = 0.048 g **(1)** mass of N = 24/24000 x 28 = 0.028 g **(1)** mass of O = 0.132 – (0.008 + 0.048 + 0.028) = 0.048 g moles of O = 0.003 **(1)** moles of H = 0.008		**5**

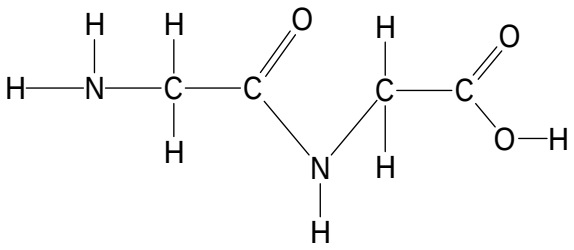
	moles of C = 0.004 moles of N = 0.002 empirical formula is $C_4H_8O_3N_2$ **(1)** **Route 3 Percentage by mass of each element in 0.132 g** First three marks by either method above. Then percentages are: H – 6.06 C – 36.36 N – 21.21 So O is 100 – (6.06 + 36.36 + 21.21) = 100 – 63.63 = 36.37 Mole ratios O – 2.27 – allow = or – 0.02 **(1)** H – 6.06, C – 3.03, N – 1.515 Dividing by smallest gives H – 4, C – 2, N – 1, O – 1.5 empirical formula is $C_4H_8O_3N_2$ **(1)** **The following transferred errors are allowed:** If nitrogen gas taken as N, first two marks can still be awarded for all methods Then mass of nitrogen is 0.014 g This gives mass of oxygen as 0.062 g and amount of oxygen as 0.003875 mol **(1)** now empirical formula is $C_4H_8O_4N$ **(1)** **OR** percentage method: N – 10.61% O – 46.97%		

	Mole ratio N – 0.7575 O – 2.935 **(1)** empirical formula is $C_4H_8O_4N$ **(1)** **Transferred error for hydrogen** Two from first three marks still awarded Then amount of hydrogen is 0.004 mol This gives 0.003125 mol oxygen empirical formula is $C_4H_4O_3N_2$ **(1)** **Both the above nitrogen and hydrogen errors** Award 1 mark for correct mass of carbon or correct moles of carbon Then mass of nitrogen is 0.014 g Then mass of hydrogen is 0.004 g This gives 0.004125 mol oxygen **(1)** Empirical formula is $C_4H_4O_4N$ **(1)**		

Question Number	Acceptable Answers	Reject	Mark
14(b)	**(12 x 4 + 1 x 8 + 16 x 3 + 14 x 2)** n = 132 n = 1 So molecular formula is $C_4H_8O_3N_2$ Some element of working must be shown TE from (a) of nitrogen error can be given **only if**: **(12 x 4 + 1 x 8 + 16 x 4 + 14)** n = 132 n = 0.98 (which is approximately 1) TE from (a) of hydrogen error can be given **only if**: **(12 x 4 + 1 x 4 + 16 x 3 + 14 x 2)** n = 132 n = 1.03 (which is approximately 1) TE from (a) of nitrogen and hydrogen error can be given **only if**: **(12 x 4 + 1 x 4 + 16 x 4 + 14)** n = 132 n = 1.015/1.02 (which is approximately 1)		**1**

Question Number	Acceptable Answers	Reject	Mark
14(c)(i)	**Y** reacts with HCl/acid so it is an amine /contains NH_2 /CO_2^- **(1)** It reacts with alkali/NaOH so it is a carboxylic acid/contains CO_2H/NH_3^+ **(1)** It forms a purple colour/reacts with ninhydrin so it is an amino acid **(1)** OR As it is an amine/contains NH_2 /CO_2^- it will react with HCl/acid **(1)** As it is a carboxylic acid/contains CO_2H/NH_3^+ it will react with alkali/NaOH **(1)** As it is an amino acid so it forms a purple colour/reacts with ninhydrin **(1)** Each marking point is independent and requires both the functional group and the test **NOTE:** It is an amino acid so it reacts with acid and alkali (with neither of first two points) **(1)**	Just ... it is a base Just ... it is an acid ...it is amphoteric (alone)	**3**

Question Number	Acceptable Answers	Reject	Mark
14(c)(ii)	 ALLOW OH OR  **(1)** 2-aminoethanoic acid/ aminoethanoic acid/glycine **(1)** Mark independently	C-H-O if bond is clearly to H **1**- aminoethanoic acid	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(iii)	$H_2NCH_2CONHCH_2CO_2H$ Or $NH_2CH_2CONHCH_2CO_2H$ Or $HOCOCH_2NHOCCH_2NH_2$ ALLOW  Or reversed displayed formula ALLOW ionic formulae with H_3N^+ and CO_2^-		**1**

TOTAL FOR SECTION B = 48 MARKS

Question Number	Acceptable Answers	Reject	Mark
15(a)(i)	MnO_2((s))	Anything else eg MnO_4^-	**1**

Question Number	Acceptable Answers	Reject	Mark
15(a)(ii)	• They provide alternative routes/mechanisms for reactions • With lower activation energies/E_a OR catalysts lower activation energy /E_a • So a greater proportion of /more particles/reactants have sufficient energy/E_a (to react)/greater frequency of/more successful collisions All three points **2** any two points **1** All points stand alone and can be in any order IGNORE references to adsorption/surfaces Provide alternate route with lower activation energy scores one mark NOTE: The term activation energy could be described rather than stated		**2**

Question Number	Acceptable Answers	Reject	Mark
15(a)(iii)	Transition metals form various/variable oxidation states **(1)** They are able to **donate and receive** electrons/they are able to **oxidize and reduce**/they are able to be **oxidized and reduced** /ions contain **partially filled** (sub-)shells of **d electrons** **(1)** ALLOW Energy differences between the oxidation states are small (for second mark) OR Reduce reactant with more positive/higher electrode potential **(1)** Then oxidize reactant with more negative/lower electrode potential **(1)** Or other way round: Oxidize reactant with lower electrode potential etc	They change oxidation state Any mention of providing a surface/adsorption loses second mark Formation of intermediates (alone)	**2**

Question Number	Acceptable Answers	Reject	Mark
15(b)(i)	Two (less stable) oxidation states/one higher and one lower oxidation state of **the same/an element** react to form one(more stable) oxidation state ALLOW The reverse reaction is a disproportionation in which (one oxidation state of) the **same/an element** and it EITHER: reacts to give one higher and one lower oxidation state/two oxidation states OR is both oxidized and reduced **(1)** Correct oxidation states +7 and +4 to +6 Mn(VII) and Mn(IV) to Mn(VI) ALLOW Mn^{7+} and Mn^{4+} to Mn^{6+} **(1)** Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
15(b)(ii)	(When the hydroxide ion concentration is increased) the equilibrium (of the second half equation) moves to the left/back **(1)** *E* becomes less positive/more negative/decreases/reduces **(1)** Therefore E_{cell} becomes positive (so reaction feasible) **(1)** ALLOW confusion between E, $E^{\ominus}$, E_{cell} if meaning is clear		**3**

Question Number	Acceptable Answers	Reject	Mark
15(c)(i)	Oxygen/oxygen gas/O_2/O_2(g)	O (alone) Anything else	**1**

Question Number	Acceptable Answers	Reject	Mark
15(c)(ii)	$2MnO_4^-(aq) \rightarrow 2MnO_3^-(aq) + O_2(g)$ Entities **(1)** balancing **(1)** Correct equation with H_2O and/or OH^- on both sides (even if in brackets) max. 1 IGNORE state symbols ACCEPT multiples ACCEPT $\rightleftharpoons$ for arrow Reverse equation max. 1 No signs on entities max. 1	Equations including electrons	**2**

Question Number	Acceptable Answers	Reject	Mark
15(c)(iii)	**(Hazard –)** the sodium hydroxide/alkali is corrosive/caustic/burns (skin)/attacks the skin OR attacks the cornea/eye/causes blindness **(1)** IGNORE Harmful/Irritant/toxic/hazardous/concentrated **(Minimize Risk by –)** wear gloves OR (full) eye protection/goggles/safety glasses **(1)** Protection **must** relate to **sodium hydroxide** e.g. sodium hydroxide is irritant so wear gloves / eye protection **scores 1 mark** This means 'This experiment is dangerous so wear eye protection' **score zero** IGNORE lab coats and/or fume cupboards (Oxygen) gas given off so container must not be sealed **(2)**	MnO_4^- is toxic Cl_2 is toxic	**2**

Question Number	Acceptable Answers	Reject	Mark
15(d)	Manganese**(II)**/manganous sulfate (solution) **(1)** ALLOW any named soluble manganese**(II)** salt – chloride, bromide, iodide, nitrate Sodium hydroxide (solution) **(1)** ALLOW any named soluble hydroxide ACCEPT formulae Mark independently except contradiction eg NaOH + HCl (0)	Mn^{2+}(aq) alone Ammonia unless dilute **and** added dropwise	**2**

Question Number	Acceptable Answers	Reject	Mark
15(e)(i)	 Accept dots, crosses, mixture of both Triple bond **(1)** Non-bonding electrons **(1)** IGNORE presence/absence of negative charge But if positive charge max 1 Second mark dependent on first IGNORE correct inner shell electrons on either or both atoms	 If not paired Incorrect inner shell electrons 1 max	**2**

Question Number	Acceptable Answers	Reject	Mark
15(e)(ii)	The non-bonding / lone pair of electrons on the carbon **(1)** ALLOW non-bonding/lone pair of electrons on the nitrogen Forms a **dative covalent/coordinate** bond (to central metal ion) **(1)** Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
15(e)(iii)	Octahedral/octahedron ALLOW Oct**o**hedral Oct**e**hedral	Tetrahedral/hexagonal/square planar/(trigonal) bipyramid	**1**

TOTAL FOR SECTION C = 22 MARKS

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Centre Number	Candidate Number

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Tuesday 22 January 2013 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41215A

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7/6/5/4/3/5/

P 4 1 2 1 5 A 0 1 2 4

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The reaction between iron and nickel(II) sulfate may be represented by the ionic equation

$$Ni^{2+}(aq) + Fe(s) \rightarrow Ni(s) + Fe^{2+}(aq)$$

(a) This reaction is classified as a redox reaction because

(1)

☒ **A** the nickel(II) ions are oxidized and iron acts as an oxidizing agent.

☒ **B** the nickel(II) ions are oxidized and iron acts as a reducing agent.

☒ **C** the nickel(II) ions are reduced and iron acts as a reducing agent.

☒ **D** the nickel(II) ions are reduced and iron acts as an oxidizing agent.

(b) This reaction proceeds spontaneously, therefore

(1)

☒ **A** E_{cell} and ΔS_{total} for this reaction must both be positive.

☒ **B** E_{cell} and ΔS_{total} for this reaction must both be negative.

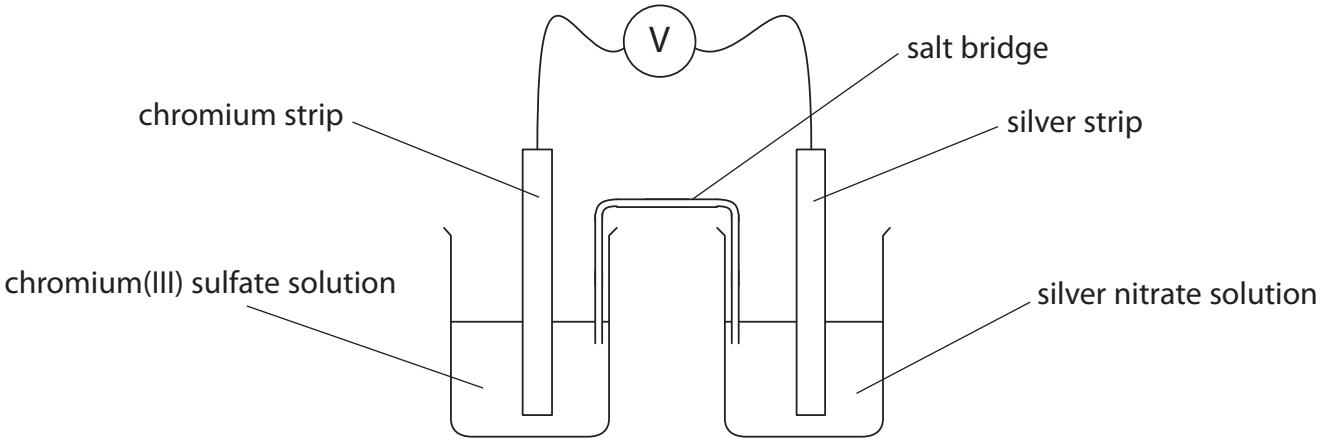
☒ **C** E_{cell} for this reaction must be positive and ΔS_{total} negative.

☒ **D** E_{cell} for this reaction must be negative and ΔS_{total} positive.

(Total for Question 1 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

2 The diagram below shows an electrochemical cell.



(a) The salt bridge in this cell is **best** prepared by soaking filter paper in a

(1)

☒ **A** 1 mol dm^{-3} solution of potassium bromide.

☒ **B** 1 mol dm^{-3} solution of potassium chloride.

☒ **C** saturated solution of potassium nitrate.

☒ **D** saturated solution of potassium iodide.

(b) The relevant standard electrode potentials for this cell are shown below.

$$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s) \quad E^{\ominus} = -0.74\ V$$

$$Ag^{+}(aq) + e^- \rightleftharpoons Ag(s) \quad E^{\ominus} = +0.80\ V$$

The emf of the cell shown in the diagram is

(1)

☒ **A** +1.54 V

☒ **B** −1.54 V

☒ **C** +0.06 V

☒ **D** −0.06 V

(c) The mass of 1 mol of chromium(III) sulfate ($Cr_2(SO_4)_3$) is 392 g. Hence, for the cell in the diagram to measure the **standard** electrode potential, 1 dm^3 of the chromium(III) sulfate solution used must contain

(1)

☒ **A** 104 g of chromium(III) sulfate.

☒ **B** 196 g of chromium(III) sulfate.

☒ **C** 392 g of chromium(III) sulfate.

☒ **D** 784 g of chromium(III) sulfate.

(Total for Question 2 = 3 marks)

3 Vanadium is classified as a transition metal. This is because vanadium

- ☒ **A** is a d-block element.
- ☒ **B** has incompletely filled d orbitals.
- ☒ **C** forms stable ions with incompletely filled d orbitals.
- ☒ **D** forms stable ions in which it has different oxidation states.

(Total for Question 3 = 1 mark)

4 Copper(II) sulfate solution is blue. This is because

- ☒ **A** excited electrons emit light in the blue region of the spectrum as they drop back to the ground state.
- ☒ **B** excited electrons emit light in the red region of the spectrum as they drop back to the ground state.
- ☒ **C** electrons absorb light in the red region of the spectrum and the residual frequencies are observed.
- ☒ **D** electrons absorb light in the blue region of the spectrum and the residual frequencies are observed.

(Total for Question 4 = 1 mark)

5 One method of manufacturing hydrazine (N_2H_4) involves the action of sodium chlorate(I) on excess ammonia at 443 K and 50 atm. The yield is normally around 80% but, if just 1 part per million of copper(II) ions is present, the yield drops to 30%.

The most likely explanation for this is the ability of copper(II) ions to

- ☒ **A** form complex ions with ammonia.
- ☒ **B** catalyse reactions producing other nitrogen compounds.
- ☒ **C** reduce the hydrazine as it is formed.
- ☒ **D** reduce the sodium chlorate(I).

(Total for Question 5 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

6 Platinum forms a complex with the formula $Pt(NH_3)_2Cl_2$ and chromium forms a complex ion with the formula $CrCl_4^-$.

(a) Considering the shapes of these complexes,

(1)

☒ **A** both complexes are square planar.

☒ **B** both complexes are tetrahedral.

☒ **C** $Pt(NH_3)_2Cl_2$ is tetrahedral and $CrCl_4^-$ is square planar.

☒ **D** $Pt(NH_3)_2Cl_2$ is square planar and $CrCl_4^-$ is tetrahedral.

(b) Considering the structures of these complexes,

(1)

☒ **A** both complexes form stereoisomers.

☒ **B** neither complex forms a stereoisomer.

☒ **C** $Pt(NH_3)_2Cl_2$ forms a stereoisomer but $CrCl_4^-$ does not.

☒ **D** $CrCl_4^-$ forms a stereoisomer but $Pt(NH_3)_2Cl_2$ does not.

(c) Considering the bonding between the central atom and the ligands in these complexes,

(1)

☒ **A** the bonding in both complexes is dative covalent.

☒ **B** the bonding in both complexes is ionic.

☒ **C** the bonding in $Pt(NH_3)_2Cl_2$ is dative covalent and in $CrCl_4^-$ is ionic.

☒ **D** the bonding in $Pt(NH_3)_2Cl_2$ is ionic and in $CrCl_4^-$ is dative covalent.

(Total for Question 6 = 3 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 When concentrated ammonia solution is added to a green solution of chromium(III) sulfate, a green precipitate is formed which slowly dissolves in excess of the concentrated ammonia solution.

The chromium-containing species formed in these reactions are

	Green precipitate	Resulting solution
☒ **A**	$Cr(OH)_3$	$[Cr(OH)_6]^{3-}$
☒ **B**	$Cr(OH)_3$	$[Cr(NH_3)_6]^{3+}$
☒ **C**	$(NH_4)_2CrO_4$	$[Cr(OH)_6]^{3-}$
☒ **D**	$(NH_4)_2CrO_4$	$[Cr(NH_3)_6]^{3+}$

(Total for Question 7 = 1 mark)

8 Bromine reacts much faster with phenylamine than with benzene. This is because

☒ **A** N—H bonds are weaker than C—H bonds.

☒ **B** nitrogen is very electronegative.

☒ **C** the benzene ring has greater electron density in phenylamine than in benzene.

☒ **D** phenylamine reacts by addition whereas benzene reacts by substitution.

(Total for Question 8 = 1 mark)

9 X-ray diffraction provides evidence that benzene molecules have

☒ **A** delocalized π electrons.

☒ **B** carbon–carbon bonds that are all the same length.

☒ **C** lower thermodynamic stability than molecules of 1,3,5-cyclohexatriene.

☒ **D** greater thermodynamic stability than molecules of 1,3,5-cyclohexatriene.

(Total for Question 9 = 1 mark)

10 Benzene is nitrated using a mixture of concentrated nitric and sulfuric acids. The sulfuric acid

☒ **A** acts as a solvent for the benzene and the nitric acid.

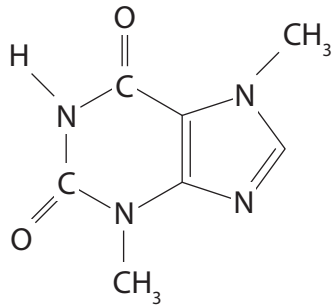
☒ **B** protonates the benzene to speed up the reaction.

☒ **C** protonates the nitric acid which acts as a base.

☒ **D** reacts with the benzene to form a benzenesulfonic acid intermediate.

(Total for Question 10 = 1 mark)

11 The compound shown below is found in cocoa beans and in chocolate. Which of the groups listed is **not** present in its structure?



☒ **A** Alkyl

☒ **B** Amide

☒ **C** Amine

☒ **D** Ketone

(Total for Question 11 = 1 mark)

12 The **distinguishing** characteristic of combinatorial chemistry is that it involves the

☒ **A** simultaneous synthesis of many products.

☒ **B** interaction of starting materials to form a unique product.

☒ **C** use of catalysts.

☒ **D** use of polymer supports.

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

13 Phenylamine (aniline), $C_6H_5NH_2$, may be prepared from nitrobenzene, $C_6H_5NO_2$.

(a) The reagent normally used for this reaction is

(1)

☒ **A** lithium tetrahydridoaluminate(III) (lithium aluminium hydride) in ether.

☒ **B** concentrated ammonia in ethanol.

☒ **C** potassium dichromate(VI) in sulfuric acid.

☒ **D** tin in concentrated hydrochloric acid.

(b) The phenylamine is separated from the reaction mixture by

(1)

☒ **A** paper chromatography.

☒ **B** steam distillation.

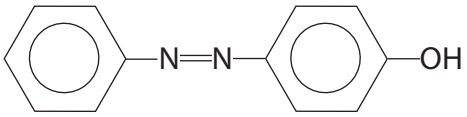
☒ **C** filtration.

☒ **D** recrystallization.

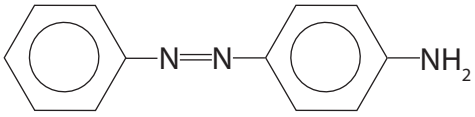
(c) One test for phenylamine is to convert it into a diazonium ion which is then reacted with phenol to form an azo dye. The structure of this dye is

(1)

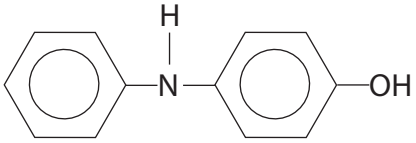
☒ **A**



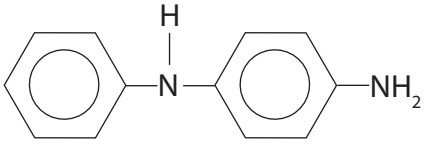
☒ **B**



☒ **C**



☒ **D**



(Total for Question 13 = 3 marks)

TOTAL FOR SECTION A = 20 MARKS

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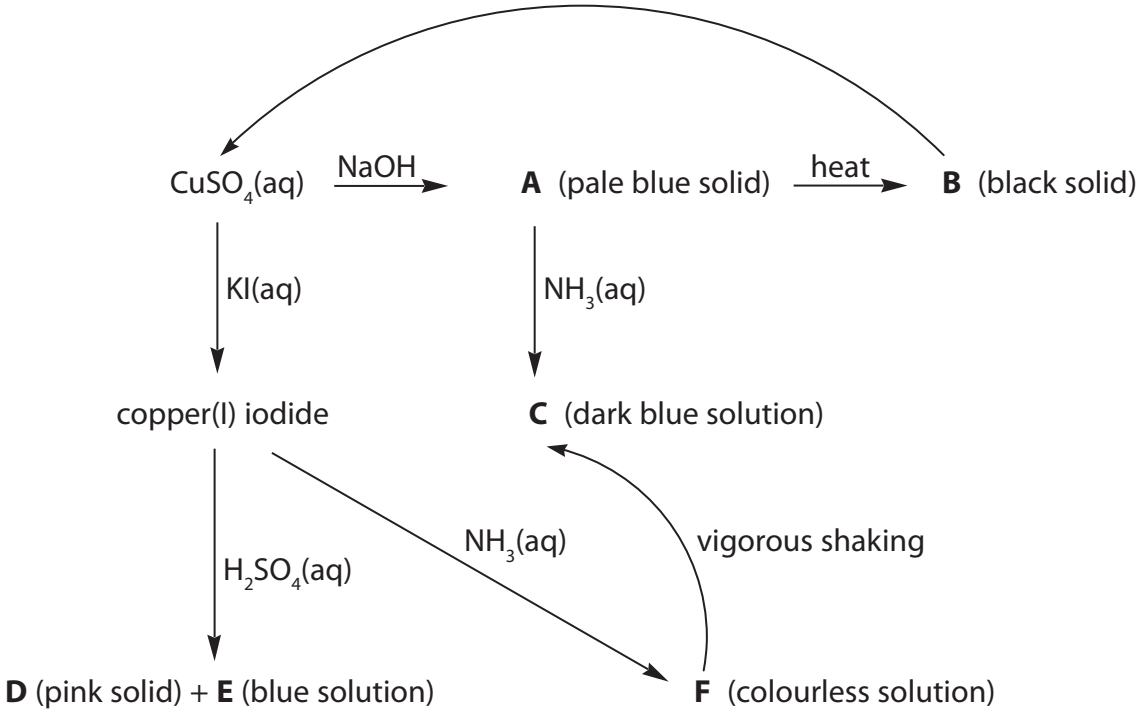
SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

14 This question concerns the chemistry of copper. In the sequence below, **A**, **B**, **C**, **D**, **E** and **F** all contain copper in various oxidation states.



(a) Identify, by name (including the oxidation state where appropriate) or formula, the copper-containing species in the sequence.

(6)

A .....

B .....

C .....

D .....

E .....

F .....

(b) Identify, by name or formula, the reagent that would be used to convert **B** into $CuSO_4(aq)$.

(1)

.....

(c) (i) **C** and **F** are the same type of chemical species. Name this type.

(1)

.....

(ii) Explain why **C** is coloured but **F** is colourless.

(3)

.....

.....

.....

.....

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.....

*(iii) Explain why **F** changes into **C** on shaking.

(2)

.....

.....

.....

.....

.....

(d) The reaction of copper(I) iodide to form **D** and **E** is a disproportionation.

(i) Explain the term disproportionation.

(2)

.....

.....

.....

.....

(ii) Write an ionic equation for this reaction. State symbols are **not** required.

(1)

(iii) Use the relevant standard reduction (electrode) potentials, from the table on page 17 of your data booklet, to calculate the $E^{\ominus}_{cell}$ value for this reaction, giving your answer with the appropriate sign.

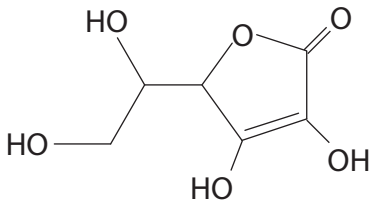
(2)

*(iv) If copper(I) iodide is treated with nitric acid, rather than sulfuric acid, a blue solution is still formed but no pink solid. Use the standard electrode potentials on page 15 of your data booklet to explain this. Quote any data that you use.

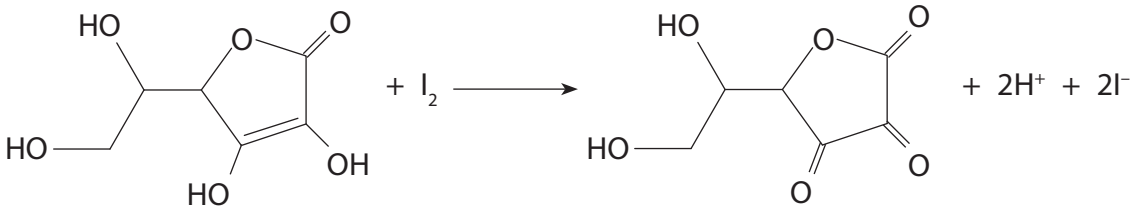
(4)

(Total for Question 14 = 22 marks)

15 Vitamin C (L-ascorbic acid) is present in fresh fruit and vegetables although prolonged cooking destroys it. The structure of ascorbic acid, $C_6H_8O_6$, is shown below.



(a) The amount of ascorbic acid present in a sample is determined by reacting it with a known amount of iodine. The excess iodine is then measured by titration with a solution of sodium thiosulfate, using a starch indicator. The equations for the reactions are given below.



$$2S_2O_3^{2-} + I_2 \longrightarrow S_4O_6^{2-} + 2I^-$$

Four 500 mg vitamin C tablets were dissolved in distilled water and the solution made up to 250 cm^3 in a volumetric flask. A 25.0 cm^3 portion of this solution was added to an iodine solution containing 2.00×10^{-3} moles of iodine. The resulting mixture was titrated with sodium thiosulfate solution of concentration 0.0631 mol dm^{-3}. The titration was repeated and the mean (average) titre was 27.85 cm^3.

(i) State the type of chemical change undergone by ascorbic acid when it reacts with iodine.

(1)

.....

(ii) State the colour of the solution in the flask just before the starch is added to the titration mixture and state the colour change at the end-point of the titration.

(2)

.....

.....

.....

(iii) Calculate the percentage by mass of ascorbic acid in the tablets. The molar mass of ascorbic acid is 176 g mol^{-1}.

(5)

(iv) Explain why using four tablets in 250 cm^3 of solution gives a more accurate result than two tablets in 250 cm^3.

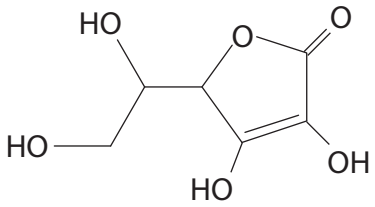
(1)

.....

.....

.....

(b) The structure of ascorbic acid is shown again below. Vitamin C is one of the optical isomers of this structure.



(i) Mark on this diagram the two chiral centres of this molecule.

(2)

(ii) How might you show that vitamin C is a single optical isomer and not a racemic mixture of the optical isomers of ascorbic acid?

(2)

.....

.....

.....

.....

(iii) Despite its name, ascorbic acid is not a carboxylic acid but it does contain an ester group. Suggest what happens to destroy vitamin C on prolonged cooking.

(1)

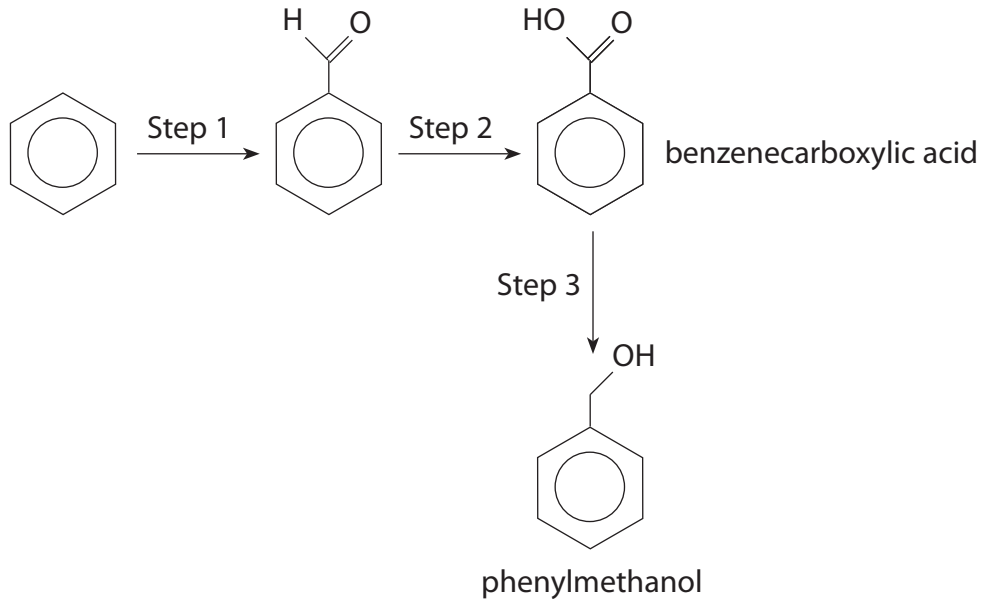
.....

.....

(Total for Question 15 = 14 marks)

16 Benzenecarboxylic acid (benzoic acid) and phenylmethanol (benzyl alcohol) are compounds which occur naturally and have a wide range of uses. For example, benzenecarboxylic acid is used as a food preservative and phenylmethanol is used as a solvent.

A laboratory sequence for the preparation of these two compounds is shown below.



(a) In the first step of the synthesis, benzene reacts with hydrogen chloride and carbon monoxide in the presence of aluminium chloride in an electrophilic substitution called the Gattermann-Koch reaction. The hydrogen chloride and carbon monoxide together behave as if they form the unstable species methanoyl chloride (HCOCl).

(i) Explain why benzene undergoes substitution rather than addition reactions. A detailed description of the bonding in benzene is **not** required.

(2)

(ii) Give the mechanism for step 1, including the formation of the electrophile.

(4)

(iii) Identify the reagents and essential conditions used in the remaining steps of the sequence. You may assume that the correct reaction temperatures are being used.

(4)

Step 2 .....

.....

.....

Step 3 .....

.....

.....

*(b) Phenol reacts faster than phenylmethanol in electrophilic substitution reactions. Suggest why this is so.

(4)

(Total for Question 16 =14 marks)

TOTAL FOR SECTION B = 50 MARKS

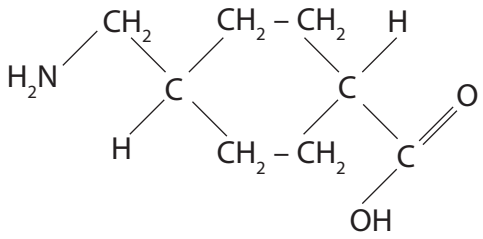
SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

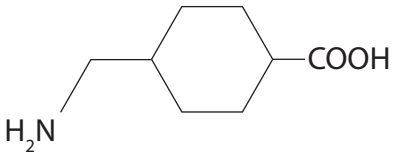
17

Tranexamic acid

Tranexamic acid is an amino acid. It is a white crystalline solid which melts at 300 °C. It is used to reduce bleeding during surgery and dental procedures and is especially useful where patients suffer from deficiencies in blood-clotting factors. The structure of tranexamic acid can be drawn as shown below.



or



As the name suggests, tranexamic acid is the *trans* form of a compound that forms geometric (or *cis-trans* or *E-Z*) isomers.

(a) (i) Explain why some molecules which contain a C═C double bond show geometric isomerism.

(2)

.....

.....

.....

.....

(ii) Suggest how tranexamic acid can form geometric isomers although it does not have a C═C double bond.

(1)

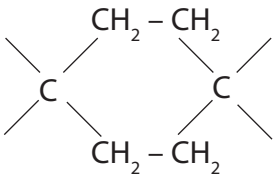
.....

.....

.....

(iii) Complete the diagram to show the structure of the *cis* isomer.

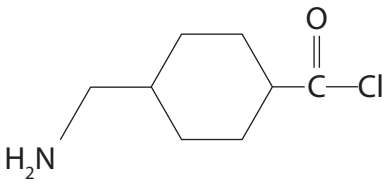
(1)



(iv) Explain why tranexamic acid melts at 300 °C while the alkane, undecane ($C_{11}H_{24}$) which has almost the same number of electrons, melts at −26 °C. A detailed description of the forces involved is **no**t required.

(3)

(b) The diagram below shows a compound, **K**, which is a derivative of tranexamic acid.



(i) Identify by name or formula a compound that might react with tranexamic acid to form **K**.

(1)

(ii) Under suitable conditions, molecules of **K** react together forming a polymer, **L**. Draw the structure of **L**, showing two repeat units.

(2)

(iii) Name the type of polymerization that results in the formation of **L**.

.....

(1)

(iv) State the type of naturally occurring substance which contains the same type of linkage as in the polymer **L**.

(1)

.....

(c) If the sequence of reactions, that produces polymer **L** from tranexamic acid, is carried out starting with the *cis* isomer of tranexamic acid, an organic compound, **M**, is formed.

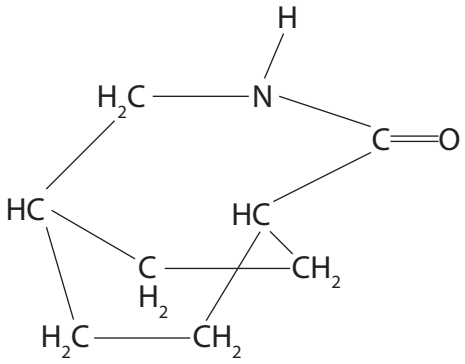
The low resolution nuclear magnetic resonance (nmr) spectrum of **M** has six peaks with relative heights 4:4:2:1:1:1.

The infrared (IR) spectrum of **M** has peaks in the region 1700–1630 cm^{-1} and 3500–3140 cm^{-1}.

(i) The structure of **M** is shown below.

The nmr spectrum shows that the molecule, **M**, has six different hydrogen environments. Use the letters **a** to **f** to label the H atoms of **M** showing the six hydrogen environments. All thirteen hydrogen atoms should be labelled.

(4)



(ii) Explain how the IR data are consistent with the structure of **M**.

(2)

.....

.....

.....

(iii) Suggest why **M** is formed from the *cis* isomer but not from the *trans* isomer.

(2)

.....

.....

.....

(Total for Question 17 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 4 1 2 1 5 A 0 2 4 2 4

PMT

edexcel

Mark Scheme (Results)

January 2013

GCE Chemistry (6CH05) Paper 01

General Principles of Chemistry II
Transition Metals and Organic Chemistry

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1(a)	C		**1**
(b)	A		**1**

Question Number	Correct Answer	Reject	Mark
2(a)	C		**1**
(b)	A		**1**
(c)	B		**1**

Question Number	Acceptable Answers	Reject	Mark
3	C		**1**

Question Number	Acceptable Answers	Reject	Mark
4	C		**1**

Question Number	Acceptable Answers	Reject	Mark
5	B		**1**

Question Number	Correct Answer	Reject	Mark
6(a)	D		**1**
(b)	C		**1**
(c)	A		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Acceptable Answers	Reject	Mark
8	C		**1**

Question Number	Acceptable Answers	Reject	Mark
9	B		**1**

Question Number	Acceptable Answers	Reject	Mark
10	C		**1**

Question Number	Acceptable Answers	Reject	Mark
11	D		**1**

Question Number	Acceptable Answers	Reject	Mark
12	A		**1**

Question Number	Acceptable Answers	Reject	Mark
13(a)	D		**1**
(b)	B		**1**
(c)	A		**1**

TOTAL FOR SECTION = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
14 (a)	**A** = copper(II) hydroxide / $Cu(OH)_2$ / $Cu(OH)_2(H_2O)_4$ **(1)** **B** = copper(II) oxide / CuO **(1)** **C** = tetraamminecopper(II) / $Cu(NH_3)_4^{2+}$ / $Cu(NH_3)_4(H_2O)_2^{2+}$ ALLOW $Cu(NH_3)_6^{2+}$ / hexaamminecopper(II) **(1)** **D** = copper / Cu / copper(0) / Cu(0) **(1)** **E** = copper(II) sulfate / $CuSO_4$ / Cu^{2+} / $Cu(H_2O)_6^{2+}$ **(1)** **F** = diamminecopper(I) / $Cu(NH_3)_2^{+}$ **(1)** ALLOW coordination numbers 1-6 in **F** Oxidation number separate from name IGNORE state symbols even if incorrect names without oxidation numbers except for **D**	Formulae with incomplete or unbalanced charges Incorrect oxidation states even with correct formulae	**6**

Question Number	Acceptable Answers	Reject	Mark
14 (b)	(Dilute) sulfuric acid / H_2SO_4 / $H_2SO_4(aq)$ ALLOW concentrated		**1**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(i)	(transition metal / d-block element) complex(es) /complex ion(s) IGNORE ammines	Complex molecules amines, ions, ligands	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(ii)	Copper ion in **C** has partially filled **d** orbital(s) / subshell / $3d^9$ ALLOW unpaired d electron d shell **(1)** Copper ion in **F** has (completely) filled **d** orbitals / subshell / $3d^{10}$ **(1)** Reference to complete / incomplete d orbitals **max 1** EITHER Electronic **transitions** between partially filled (d) orbitals (of different energy) are possible OR Electronic **transitions** between (completely) filled (d) orbitals (of different energy) are not possible **(1)** ALLOW Equivalent words for transition e.g. promotion / jump / movement Penalise use of just 'shell' once IGNORE references to electrons returning to lower energy levels and emission of light	d orbitals empty no unpaired electrons (in F) orbital (singular) Splitting impossible because d orbitals full	**3**

Question Number	Acceptable Answers	Reject	Mark
14 (c)(iii)	Copper(I) is **oxidized** (to copper(II)) ALLOW **F** / it is **oxidized** **(1)** By oxygen / air **(1)** Second mark depends on first IGNORE 'shaking'		**2**

Question Number	Acceptable Answers	Reject	Mark
14 (d)(i)	(simultaneous) oxidation and reduction **(1)** OR Simultaneous increase or decrease in oxidation number of an element **(1)** ALLOW 'Species' 'atoms of the same type' for 'element' Explanation in terms of copper(I) IGNORE Atom / ion / compound / substance / reactant	molecule	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (d)(ii)	$2Cu^+ \rightarrow Cu + Cu^{2+}$ OR $2CuI + 2H^+ \rightarrow Cu + Cu^{2+} + 2HI$ OR $2CuI \rightarrow Cu + Cu^{2+} + 2I^-$ IGNORE state symbols even if incorrect	Non-ionic equations	**1**

Question Number	Acceptable Answers	Reject	Mark
14 (d)(iii)	ALLOW The use of cell notation (as in the Data Booklet SEP table) in place of equations e.g. $Cu^+(aq) \mid Cu(s)$ $E^\ominus = +0.52$ (V) (from the data book the equations are) $Cu^+(aq) + e^- \rightarrow Cu(s)$ $E^\ominus = +0.52$ (V) $Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$ $E^\ominus = +0.15$ (V) **(1)** So $E^\ominus_{cell} = 0.52 - 0.15 = +0.37$ (V) **(1)** Correct answer including sign with no working scores full marks TE for second mark for use of $Cu^{2+}ICu$ +0.34 (V) which gives +0.19(V)/+0.18(V) No TE on incorrect equation in (d)(ii)	**Answer** without + sign	**2**

Question Number	Acceptable Answers	Reject	Mark
14 (d)(iv)	ALLOW In both schemes the use of cell notation (as in the Data Booklet SEP table) in place of equations e.g. $Cu^{2+}(aq) \mid Cu(s)$ $E^{\ominus} = +0.34$ (V) Penalise omission of electrons from equations and vertical lines from cell diagrams and reversal of equation without reversing sign. once only IGNORE omission of + sign for all $E^{\ominus}$ values **Scheme 1 (oxidation of copper)** Copper (formed (by disproportionation)) is oxidized (by nitric acid) must be stated in words stand alone mark **(1)** Relevant half equations are $Cu^{2+}(aq) + 2e^- \rightarrow Cu(s)$ $E^{\ominus} = +0.34$ (V) **(1)** $2NO_3^-(aq) + 4H^+(aq) + 2e^- \rightarrow N_2O_4(g) + 2H_2O(l)$ $E^{\ominus} = +0.80$ (V) OR $NO_3^-(aq) + 3H^+(aq) + 2e^- \rightarrow HNO_2(aq) + H_2O(l)$ $E^{\ominus} = +0.94$ (V) **(1)** Correct overall equation scores both marks: $Cu + 2\ NO_3^- + 4H^+ \rightarrow Cu^{2+} + N_2O_4 + 2H_2O$ OR $Cu + NO_3^- + 3H^+ \rightarrow Cu^{2+} + HNO_2 + H_2O$ So $E^{\ominus}_{cell}$ is +0.46 (V) (or +0.60 (V) or just 'positive') **(1)** **Scheme 2 (oxidation of copper(I)** Copper(I) iodide / Cu^+ is oxidized (by nitric acid) must be stated in words **(1)** stand alone mark $Cu^{2+}(aq) + e^- \rightarrow Cu^+(aq)$ $E^{\ominus} = +0.15$ (V) **(1)** $2NO_3^-(aq) + 4H^+(aq) + 2e^- \rightarrow N_2O_4(g) + 2H_2O(l)$ $E^{\ominus} = +0.80$ (V) OR $NO_3^-(aq) + 3H^+(aq) + 2e^- \rightarrow HNO_2(aq) + H_2O(l)$ $E^{\ominus} = +0.94$ (V) **(1)** Correct overall equation scores both marks:		**4**

	$2Cu^+ + 2NO_3^- + 4H^+ \rightarrow 2Cu^{2+} + N_2O_4 + 2H_2O$ $2Cu^+ + NO_3^- + 3H^+ \rightarrow 2Cu^{2+} + HNO_2 + H_2O$ So $E^{\ominus}_{cell}$ is +0.65 (V) (or +0.79 (V) or just 'positive') **(1)** IGNORE (omission of) state symbols even if incorrect		

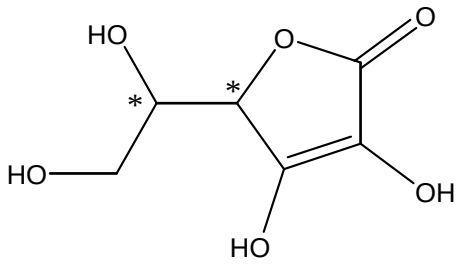
Total for Q14 = 22 Marks

Question Number	Acceptable Answers	Reject	Mark
15 (a)(i)	(vitamin C / ascorbic acid) oxidation / oxidized / oxidised ALLOW oxidisation	Redox / oxidation-reduction / reduction-oxidation	**1**

Question Number	Acceptable Answers	Reject	Mark
15 (a)(ii)	(very) pale yellow / straw coloured **(1)** IGNORE 'just before the end-point' blue-black to colourless (both needed) **(1)** Accept (dark) blue or black ALLOW pale yellow / straw coloured to colourless for 1/2	Just 'yellow' Clear	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (a)(iii)	Moles $S_2O_3^{2-}$ = 27.85 x 10^{-3} x 0.0631 **(1)** (= 1.757335 x 10^{-3}) moles of I_2 remaining = Moles $S_2O_3^{2-}$ ÷ 2 = 27.85 x 10^{-3} x 0.0631 ÷ 2 = 8.786675 x 10^{-4} = 8.79 x 10^{-4} **(1)** Moles ascorbic acid = moles I_2 at start − moles I_2 remaining = 2.00 x 10^{-3} − 8.786675 x 10^{-4} = 1.1213325 x 10^{-3} = 1.12 x 10^{-3} **(1)** M_r (ascorbic acid) = 176 Mass ascorbic acid in 250 cm^3 = 10 x M_r x moles ascorbic acid = 10 x 176 x 1.1213325 x 10^{-3} **(1)** (= 1.97355) Percentage ascorbic acid in tablet 100 x mass ascorbic acid in 250 cm^3 ÷ 2 = 100 x 10 x 176 x 1.1213325 x 10^{-3} ÷ 2 = 98.67726 = 98.7% **(1)** IGNORE SF except 1 SF Premature rounding gives 98.5% (5) Correct answer with no working scores full marks TE at each stage of the calculation.	Answers greater than 100%	**5**

Question Number	Acceptable Answers	Reject	Mark
15(a)(iv)	EITHER Using larger **mass** reduces the percentage error / uncertainty (in weighing) OR Using larger amount reduces the percentage error / uncertainty in **weighing** OR Reverse discussion of two tablets ALLOW using four tablets gives a more representative sample	Just 'reduces the percentage error' Titration value will be larger (with four tablets) so reduces the percentage error (in volume measurement)	**1**

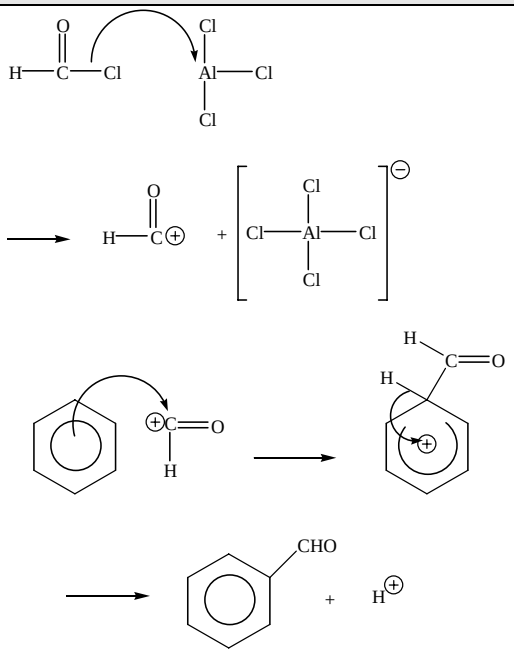
Question Number	Acceptable Answers	Reject	Mark
15 (b)(i)	 **(2)** Mark independently ALLOW any clear indication of chiral centres		**2**

Question Number	Acceptable Answers	Reject	Mark
15 (b)(ii)	**First mark** Use of (plane-)polarized light (mentioned somewhere) **(1)** ALLOW Use a polarimeter **Second mark** Pure optical isomer / enantiomer) **rotates** the **plane** of (plane-) polarized light OR racemic mixture has no effect on the **plane** of (plane-) polarized light **(1)** IGNORE optically active / inactive ALLOW rotates plane-polarized light scores 2		**2**

Question Number	Acceptable Answers	Reject	Mark
15(b)(iii)	(Ester group / vitamin C / it) is hydrolysed ALLOW Vitamin C is oxidized Ester / vitamin C is broken down to form carboxylic acid **and** alcohol (groups) IGNORE Just 'breaks down'	C=O is broken Just 'oxidation'	1

Total for Q15 =14 Marks

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	The delocalization of the (π) electrons of the ring make benzene more stable (than 1,3,5-cyclohexatriene) **(1)** IGNORE bonding in benzene is strong Substitution retains this (stable) arrangement OR Addition removes this (stable) arrangement **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	 Formation of electrophile (curly arrow, structural formulae not required). Positive charge may be anywhere on the electrophile ALLOW HCl + CO for HCOCl ALLOW Non-displayed electrophile **(1)** Curly arrow from benzene ring to electrophile **(1)** Wheland structure with gap opposite tetrahedral carbon **(1)** Curly arrow from C—H bond into ring and formation of **correct** organic product OR Kekulé structures **(1)** IGNORE Use of $AlCl_4^-$ to pick off proton Proton product First curly arrow may come from any part of the delocalisation circle Second curly arrow may come from any part of the C–H bond Positive charge on the Wheland structure may be in any part of the horseshoe	-COH /-HCO Positive charge on the tetrahedral carbon	**4**

Question Number	Acceptable Answers	Reject	Mark
16(a)(iii)	In each step the second mark is dependent on the first **Step 2** Potassium dichromate((VI)) / $K_2Cr_2O_7$ / sodium dichromate((VI)) / $Na_2Cr_2O_7$ ALLOW Potassium manganate ((VII)) / $KMnO_4$ Sodium manganate ((VII)) / $NaMnO_4$ **(1)** Stand alone mark Sulfuric acid / H_2SO_4 (ALLOW nitric acid) **(1)** Ignore 'concentrated' ALLOW Acidified potassium (/ sodium) dichromate((VI)) OR Acid and potassium (/ sodium) dichromate((VI)) **(2)** $Cr_2O_7^{2-}$ and H^+ OR acidified dichromate((VI)) **(1)** **Step 3** Lithium tetrahydridoaluminate((III)) / $LiAlH_4$ OR Lithium aluminium hydride **(1)** Stand alone mark (Dry) ether / ethoxyethane / (di)ethyl ether **(1)** Sodium borohydride / $NaBH_4$ in ethanol, alkali or water scores 1/2 **(1)**	Incorrect oxidation number Hydrochloric acid Hydrogen and catalyst / Tin and HCl	**4**

Question Number	Acceptable Answers	Reject	Mark
16(b)	**Marking Point 1** Electron density of the ring increased **(1)** Stand alone mark **Marking Point 2** Due to donation of oxygen / OH group lone pair to the ring **(1)** **Marking Point 3 and 4** Any two from in phenol oxygen / OH group attached directly to ring Oxygen / OH group in phenylmethanol too far away / not attached directly to ring (In phenol) lone pair overlaps with the π electrons / delocalised electrons (of the ring) ALLOW p orbital for lone pair for this mark **(2)**		**4**

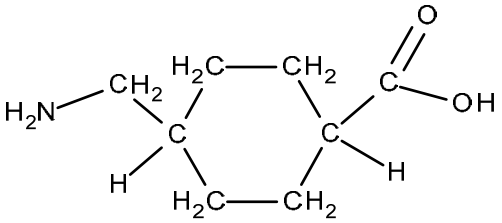
Total for Q16 = 14 Marks

TOTAL FOR SECTION B = 50

Section C

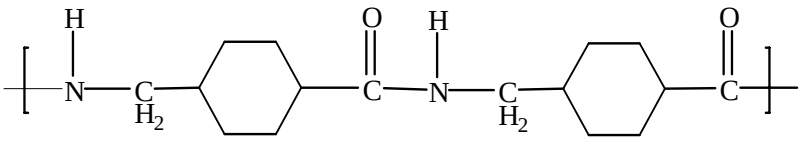
Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	There is a barrier to rotation about a (C=C) bond **(1)** ALLOW restricted / limited / no rotation Each carbon atom (in the C=C double bond) has (two) different atoms / groups attached **(1)** IGNORE reference to priority groups	Just 'molecule cannot rotate'	**2**

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	There is a barrier to / restricted rotation about the ring OR The ring behaves like a double bond	Reference to benzene ring Just 'molecule cannot rotate'	**1**

Question Number	Acceptable Answers	Reject	Mark
17(a)(iii)	 Any diagram of the correct molecule showing the groups (attached to the ring) on same side of the ring OR zwitterion ALLOW Amine group in skeletal form	Omission of amine CH_2	**1**

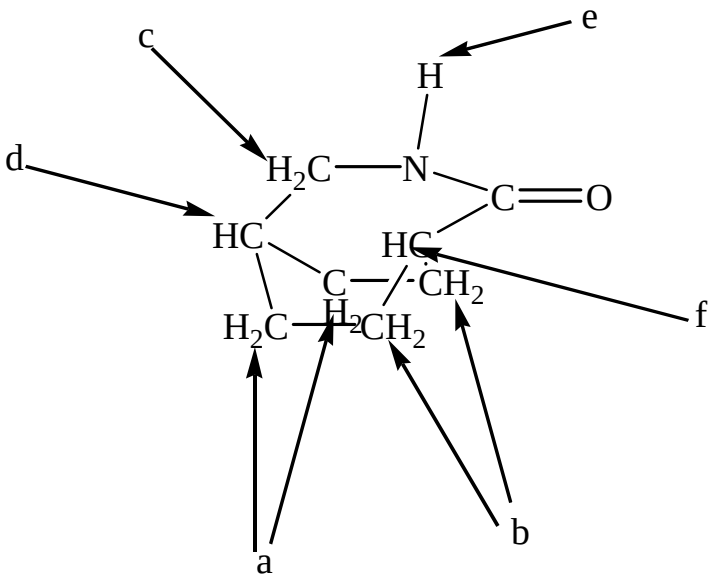
Question Number	Acceptable Answers	Reject	Mark
17(a)(iv)	Tranexamic acid exists as a zwitterion OR Diagram of zwitterion OR Description of zwitterion formation **(1)** So the (strongest) intermolecular forces are ionic (strong) ALLOW electrostatic for ionic **(1)** IGNORE H bonding in tranexamic acid if **either** of the first two marks scored. Otherwise... Hydrogen bonding in tranexamic acid scores 1/2 max Undecane has (only) (much weaker) London / dispersion / van der Waals / temporary induced dipole (-induced dipole) forces / interactions **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	Phosphorus(v) chloride / PCl_5 ALLOW phosphorus pentachloride / phosphorus(III) chloride / PCl_3 / phosphorus trichloride Thionyl chloride (sulfur dichloride oxide) / $SOCl_2$	HCl	**1**

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	 **First mark** amide linkage ALLOW CONH for amide linkage **(1)** **Second mark** Completion of structure (brackets not required) with displayed or skeletal formula **(1)** Second mark dependent on first Dimer scores amide linkage mark only		**2**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	Condensation / addition-elimination (polymerization)	Addition (polymerization) Elimination (polymerization) Polyamide formation	**1**

Question Number	Acceptable Answers	Reject	Mark
17(b)(iv)	Protein / proteins / polypeptide / polypeptides / peptide / peptides ALLOW Enzyme / Enzymes	Nylon Polyamide amino acids	1

Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	Check sequence of letters. Candidates may have labelled the groups of hydrogen atoms with different letters, which is fine. **First mark** Unique N**H** (at e) **(1)** **Second mark** **(1)** Unique C**H**$_2$ (at c) **Third mark** **(1)** C**H** (at d) and C**H** (at f) with different unique labels **Fourth mark** **(1)** 2C**H**$_2$ (at a) and 2C**H**$_2$ (at b) with different new labels  		4

Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	C═O amide (stretching vibrations are in the region) 1700-1630 cm^{-1} **(1)** N—H amide (stretching vibrations are in the region) 3500-3140 cm^{-1} **(1)** Amide only needs to be mentioned once but... These answers without mention of **amide** max 1 Amides have peaks in these regions max 1	Ketone Amine (for amide)	2

Question Number	Acceptable Answers	Reject	Mark
17(c)(iii)	**Any two from** In the trans isomer the (amine and acid chloride) groups are too far apart to react intramolecularly / to form **M** OR Because the groups are on opposite sides of the (plane of the) **ring** OR More likely to polymerize / react with adjacent molecules. **(2)** Marks may also be scored by a reverse argument: In the cis isomer the (amine and acid chloride) groups are on the same side of the (plane of the) **ring** **(1)** So close enough to react intramolecularly / to form **M (1)**	bond	2

Total for Q17 = 20 Marks

TOTAL FOR SECTION C = 20 MARKS

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Edexcel GCE

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Wednesday 19 June 2013 – Morning
Time: 1 hour 40 minutes

Paper Reference
6CH05/01R

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/6/7/

P 4 2 9 8 5 A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 In nitric(V) acid, HNO_3, the oxidation number of the nitrogen is +5.
This means that the **nitrogen** in nitric acid

☒ **A** has five electrons in its outer shell.

☒ **B** is an ion with a charge of +5.

☒ **C** would have a charge of +5 if its bonding electrons were transferred completely.

☒ **D** forms five covalent bonds in total.

(Total for Question 1 = 1 mark)

2 What are the components of the half-cell required to measure the standard reduction potential of the following system?

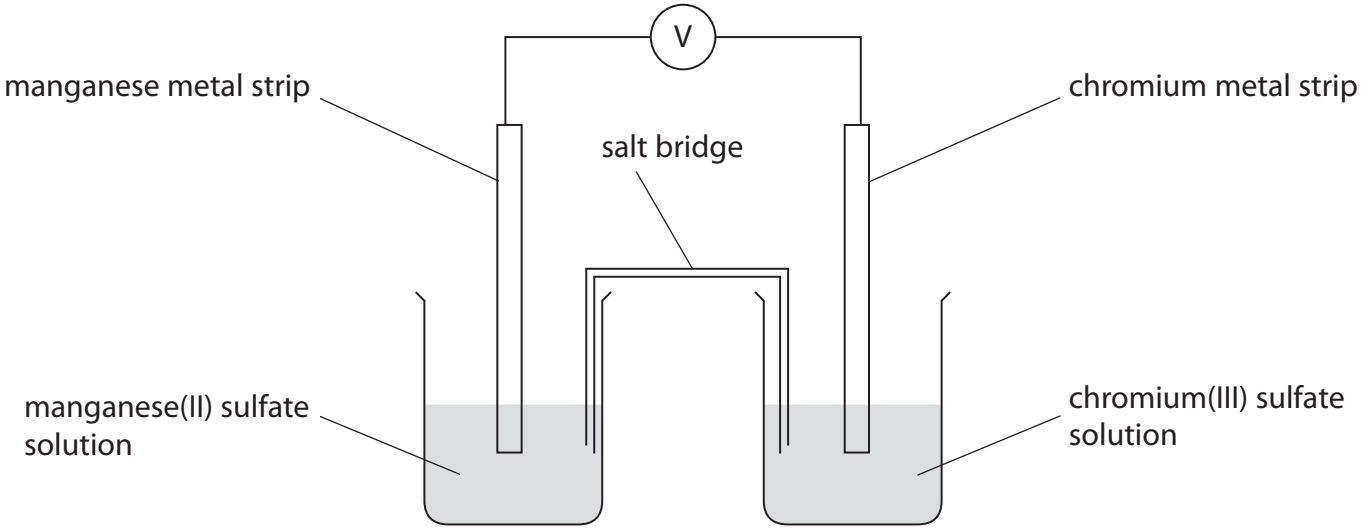
$$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$$

	Ion(s) in the solution	Metal electrode
☒ **A**	Fe^{2+}	iron
☒ **B**	Fe^{3+}	iron
☒ **C**	Fe^{2+} and Fe^{3+}	iron
☒ **D**	Fe^{2+} and Fe^{3+}	platinum

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 The following cell is set up:



The standard electrode potential of the chromium(III)/chromium half cell is −0.74 V and that of the manganese(II)/manganese half cell is −1.19 V. Thus the emf of the cell, as shown in the diagram, under standard conditions is

☒ **A** +1.93 V

☒ **B** +0.45 V

☒ **C** −0.45 V

☒ **D** −1.93 V

(Total for Question 3 = 1 mark)

---

4 The equation for the reaction of iron and nickel(II) ions in aqueous solution is

$$Fe(s) + Ni^{2+}(aq) \rightarrow Fe^{2+}(aq) + Ni(s)$$

Under standard conditions the value of the equilibrium constant, K_c, for this reaction is greater than 1. Hence, for this reaction,

☒ **A** $\Delta S^{\ominus}_{total}$ and $E^{\ominus}_{reaction}$ are both positive.

☒ **B** $\Delta S^{\ominus}_{total}$ is positive and $E^{\ominus}_{reaction}$ is negative.

☒ **C** $\Delta S^{\ominus}_{total}$ is negative and $E^{\ominus}_{reaction}$ is positive.

☒ **D** $\Delta S^{\ominus}_{total}$ and $E^{\ominus}_{reaction}$ are both negative.

(Total for Question 4 = 1 mark)

5 Chlorine is prepared in the laboratory by the reaction of potassium manganate(VII) with concentrated hydrochloric acid. The ionic half-equations and their standard electrode potentials are

$$\tfrac{1}{2}Cl_2(g) + e^- \rightleftharpoons Cl^-(aq) \quad E^{\ominus} = +1.36\ V$$

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l) \quad E^{\ominus} = +1.51\ V$$

(a) Concentrated hydrochloric acid is preferred to 1 mol dm^{-3} hydrochloric acid because

☒ **A** it lowers the activation energy of the reaction.

☒ **B** the reaction is thermodynamically unfavourable under standard conditions.

☒ **C** it increases the rate of reaction.

☒ **D** it increases the equilibrium constant, K_c, for the overall reaction.

(b) From the half-equations it may be deduced that

☒ **A** 1 mol of manganate(VII) ions reacts with 5 mol of chloride ions.

☒ **B** 5 mol of manganate(VII) ions reacts with 1 mol of chloride ions.

☒ **C** 1 mol of manganate(VII) ions reacts with 2.5 mol of chlorine.

☒ **D** 2.5 mol of manganate(VII) ions reacts with 1 mol of chlorine.

(Total for Question 5 = 2 marks)

6 The electronic structure of the chromium(III) ion, Cr^{3+}, is

		3d					4s
☒ **A**	[Ar]	↑					↑↓
☒ **B**	[Ar]	↑	↑				↑
☒ **C**	[Ar]	↑	↑	↑			
☒ **D**	[Ar]	↑↓	↑				

(Total for Question 6 = 1 mark)

7 In the manufacture of sulfuric acid, sulfur dioxide is converted to sulfur trioxide using a catalyst of vanadium(V) oxide:

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

The electronic configuration of vanadium is [Ar] $3d^3\ 4s^2$, so the mechanism for this reaction is most likely to involve a sequence in which vanadium(V) is converted to

☒ **A** vanadium(VI) by oxygen then back to vanadium(V) by sulfur dioxide.

☒ **B** vanadium(VI) by sulfur dioxide then back to vanadium(V) by oxygen.

☒ **C** vanadium(IV) by oxygen then back to vanadium(V) by sulfur dioxide.

☒ **D** vanadium(IV) by sulfur dioxide then back to vanadium(V) by oxygen.

(Total for Question 7 = 1 mark)

8 Titanium has the electronic structure $1s^2 2s^2 2p^6 3s^2 3p^6 3d^2 4s^2$. Which of the following compounds is **unlikely** to exist?

☒ **A** K_3TiF_6

☒ **B** K_2TiF_6

☒ **C** $K_2Ti_2O_5$

☒ **D** K_2TiO_4

(Total for Question 8 = 1 mark)

9 All metal hydroxides dissolve in acid. When aqueous solutions of sodium hydroxide and ammonia are added separately to samples of chromium(III) hydroxide, in both cases the solid dissolves to form a green solution. How should these reactions be classified?

	sodium hydroxide	ammonia
☒ **A**	amphoteric	amphoteric
☒ **B**	amphoteric	ligand exchange
☒ **C**	ligand exchange	amphoteric
☒ **D**	ligand exchange	ligand exchange

(Total for Question 9 = 1 mark)

10 The ligands that form complex ions are either neutral, like NH_3, or negatively charged, like CN^-. Nickel(II) ions, Ni^{2+}, form complexes with both these ligands. The bonding between Ni^{2+} and the ligands in these complexes is

	NH_3	CN^-
☒ **A**	dative covalent	dative covalent
☒ **B**	ionic	dative covalent
☒ **C**	dative covalent	ionic
☒ **D**	ionic	ionic

(Total for Question 10 = 1 mark)

11 When excess aqueous ammonia is added to a solution containing $Zn^{2+}(aq)$ ions, a colourless solution is formed. This solution is colourless because

☒ **A** zinc does not form complex ions.

☒ **B** the d orbitals of Zn^{2+} in the complex formed are not split into different energy levels.

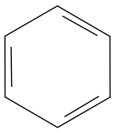
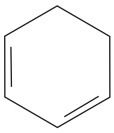
☒ **C** the energy difference between the d orbitals of Zn^{2+} in the complex formed does not correspond to the visible region of the spectrum.

☒ **D** the d orbitals of Zn^{2+} in the complex formed are full.

(Total for Question 11 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

12 Bromine reacts with benzene on heating in the presence of a catalyst and with cyclohexa-1,3-diene in the cold. The types of reaction involved are

	bromine with benzene 	bromine with cyclohexa-1,3-diene 
☒ **A**	addition	addition
☒ **B**	addition	substitution
☒ **C**	substitution	addition
☒ **D**	substitution	substitution

(Total for Question 12 = 1 mark)

13 Phenylamine, $C_6H_5NH_2$, and benzene react with bromine in a similar way, but phenylamine reacts much faster. This increased rate of reaction is most likely due to the effect that the

☒ **A** electronegativity of the nitrogen has on the benzene ring.

☒ **B** electronegativity of the nitrogen has on the bromine molecule.

☒ **C** lone pair of electrons of the nitrogen has on the benzene ring.

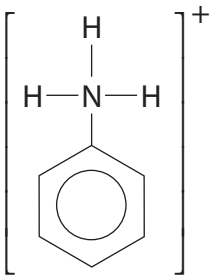
☒ **D** lone pair of electrons of the nitrogen has on the bromine molecule.

(Total for Question 13 = 1 mark)

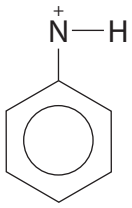
Use this space for any rough working. Anything you write in this space will gain no credit.

14 When dilute nitric(V) acid, HNO_3, reacts with phenylamine, the ion formed is

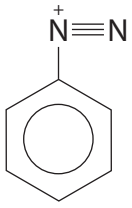
☒ **A**



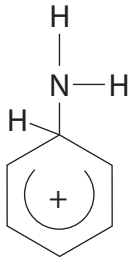
☒ **B**



☒ **C**



☒ **D**



(Total for Question 14 = 1 mark)

15 Methylamine, CH_3NH_2, is **very** soluble in water. This is because it

☒ **A** forms hydrogen bonds with water.

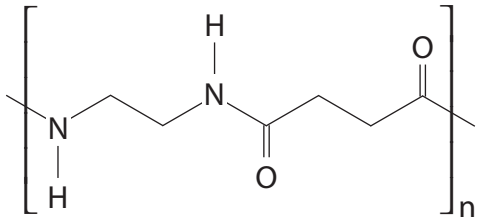
☒ **B** forms London forces with water.

☒ **C** exists mainly as ions in aqueous solution.

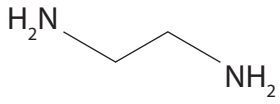
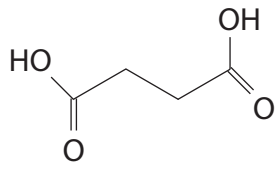
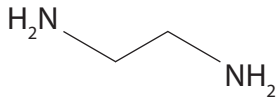
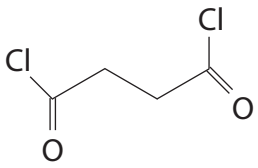
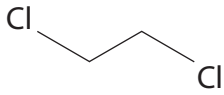
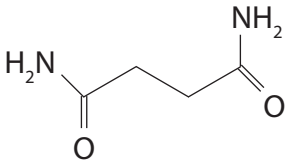
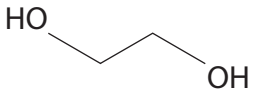
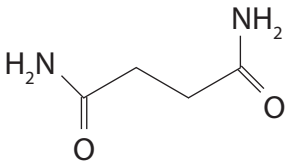
☒ **D** exists as a zwitterion.

(Total for Question 15 = 1 mark)

16 The structure below shows the repeating pattern of a polymer.



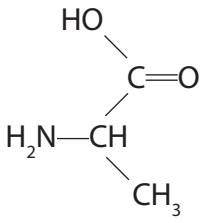
Which of the following pairs of compounds could react **rapidly** to form this polymer?

☒ **A**		
☒ **B**		
☒ **C**		
☒ **D**		

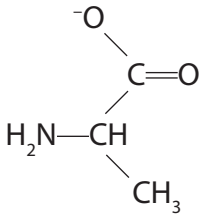
(Total for Question 16 = 1 mark)

17 Which of the following structures best represents the amino acid, alanine, in an aqueous solution with a pH of 12?

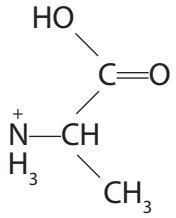
☒ **A**



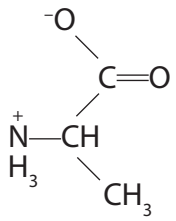
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

18 Which of the following is true for **all** amino acids?

All amino acids

- ☒ **A** exist as optical isomers.
- ☒ **B** are neutral in solution.
- ☒ **C** are essential to life.
- ☒ **D** are crystalline solids at room temperature.

(Total for Question 18 = 1 mark)

19 Which of the following physical methods of chemical analysis is used in modern breathalysers?

- ☒ **A** Infrared spectroscopy
- ☒ **B** Mass spectrometry
- ☒ **C** Nuclear magnetic resonance
- ☒ **D** Ultraviolet spectroscopy

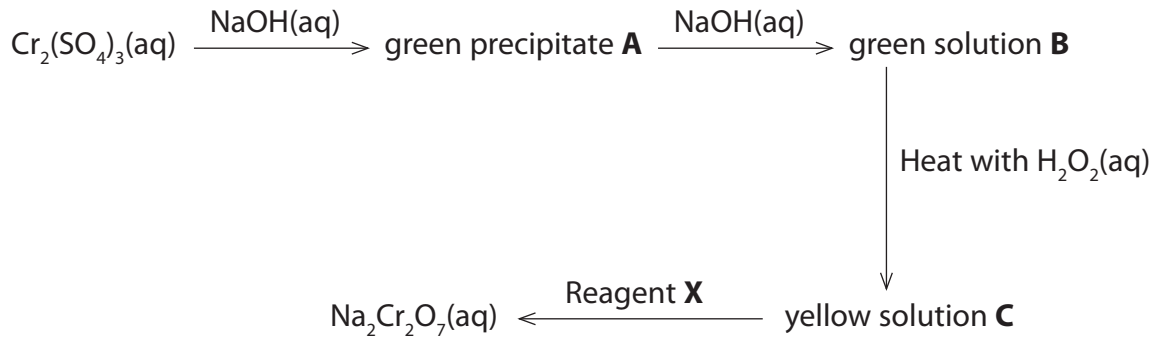
(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20 Sodium dichromate(VI) may be prepared from chromium(III) sulfate using the sequence outlined below.



(a) (i) Complete the table below, giving the **formula** of the chromium containing species.

(4)

Substance	Formula of chromium containing species
$Cr_2(SO_4)_3(aq)$	
Green precipitate **A**	
Green solution **B**	
Yellow solution **C**	

(ii) Complete the half equation for the reduction of hydrogen peroxide, $H_2O_2(aq)$.

(1)

$$H_2O_2 + \text{.....} \rightarrow \text{.....} OH^-$$

(iii) Identify reagent **X**

(1)

.....

(iv) Write an **ionic** equation for the conversion of solution **C** to $Na_2Cr_2O_7$. State symbols are not required.

(1)

(b) Chromium also exists in a +2 oxidation state. Use the Data booklet to determine the feasibility of the disproportionation of chromium(III) in aqueous solution into chromium(II) and dichromate(VI).

In your answer, show both half equations and the overall equation for the proposed disproportionation. Calculate $E^{\ominus}_{cell}$ for this reaction and use this value to predict the feasibility of this reaction.

(4)

(Total for Question 20 = 11 marks)

21 Hydrogen combines rapidly with oxygen in the presence of a platinum catalyst:

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(l)$$

The reaction is highly exothermic.

(a) Use the thermochemical data from the data booklet to obtain the enthalpy change for this reaction under standard conditions.

(1)

..... kJ mol^{-1}

(b) The same reaction occurs, also with a platinum catalyst, in a fuel cell.

(i) Write the two ionic half equations which occur in an **alkaline** fuel cell. Include state symbols.

(3)

Equation 1

Equation 2

(ii) The alkali in an alkaline fuel cell serves the same purpose as the acid in an acid fuel cell. State this purpose.

(1)

.....

.....

*(iii) Platinum catalyses both the direct combination of hydrogen with oxygen and the reactions in the fuel cell. By considering the way in which the catalyst lowers the activation energy, suggest two **similarities** in these processes.

(2)

Similarity 1 .....

.....

.....

Similarity 2 .....

.....

.....

(c) The use of hydrogen as a fuel, both in fuel cells and in direct combustion reactions, is seen as an important potential alternative to fossil fuels.

(i) State what is considered to be the main advantage of hydrogen compared with fossil fuels, bearing in mind that most hydrogen is obtained from fossil fuels.

(1)

.....

.....

*(ii) Explain the main advantage of using a fuel cell over direct combustion of hydrogen.

(2)

.....

.....

.....

.....

(iii) State a disadvantage of using a hydrogen fuel cell compared with direct combustion of hydrogen.

(1)

.....

.....

(iv) Suggest **two** advantages of using an ethanol fuel cell rather than a hydrogen fuel cell.

(2)

.....

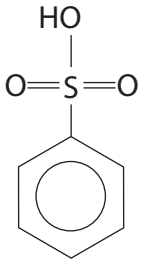
.....

.....

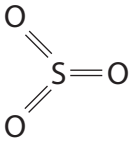
.....

(Total for Question 21 = 13 marks)

22 (a) Benzenesulfonic acid (structure I) may be prepared from benzene. The reaction is a typical electrophilic substitution in which the electrophile is sulfur trioxide (structure II).



Structure I



Structure II

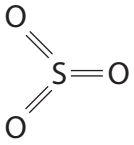
(i) Identify the reagent used as the source of sulfur trioxide in this preparation.

(1)

.....

(ii) On the formula of sulfur trioxide below, show the partial charges on each atom and explain how they arise.

(2)



Structure II

.....

.....

(iii) Suggest why sulfur trioxide is an effective electrophile.

(1)

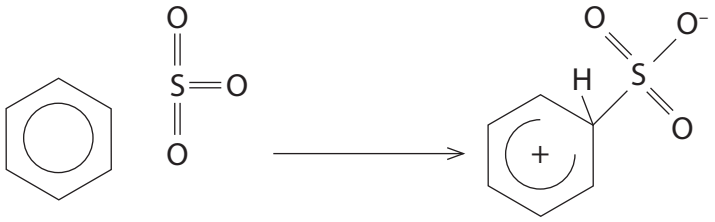
.....

.....

(b) The mechanism for the electrophilic substitution reaction between benzene and sulfur trioxide to form benzenesulfonic acid is similar to that for the nitration of benzene.

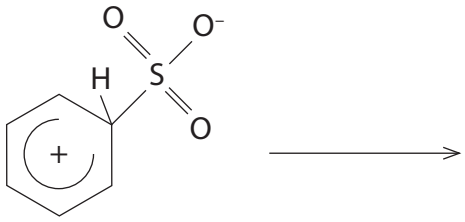
(i) Complete the first step of this mechanism by adding two curly arrows.

(2)



(ii) The mechanism for the formation of benzenesulfonic acid has two further steps. Complete the mechanism, showing curly arrows where appropriate.

(3)

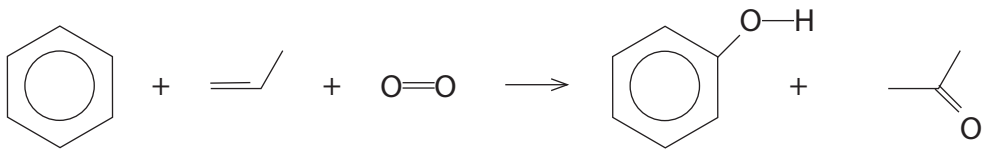


(c) At one time the main industrial use for benzenesulfonic acid was in the manufacture of phenol in a two-stage process. In the first stage, benzenesulfonic acid was reacted with sodium hydroxide forming an intermediate organic compound along with sodium sulfite, Na_2SO_3, and water. In the second stage, the intermediate organic compound was reacted with hydrochloric acid to form phenol.

(i) Write the two equations for the manufacture of phenol by this method. State symbols are not required.

(2)

(ii) Nowadays, phenol is manufactured using the Hock process which is summarised below.



Suggest why the Hock process is preferred.

(2)

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(Total for Question 22 = 13 marks)

23 (a) The following data were obtained from experiments on solutions of aqueous amines of the same concentration.

Amine	Formula	pH of solution
Butylamine	$CH_3CH_2CH_2CH_2NH_2$	11.9
Dibutylamine	$(CH_3CH_2CH_2CH_2)_2NH$	12.1
Phenylamine (aniline)	$C_6H_5NH_2$	8.8

(i) Identify the feature of the amine molecules that causes the solutions to be alkaline.

(1)

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.....

(ii) Write the equation for the reaction that occurs when butylamine is dissolved in water. State symbols are not required.

(1)

*(iii) Suggest why the dibutylamine solution is more alkaline than the butylamine solution.

(2)

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*(iv) Suggest why the phenylamine solution is much less alkaline than the butylamine solution.

(2)

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.....

(b) When butylamine is added to an aqueous solution of copper(II) sulfate, initially a pale blue precipitate is formed. When excess butylamine is added, the precipitate dissolves to form a deep blue solution.

Complete the equations below. State symbols are not required.

(4)

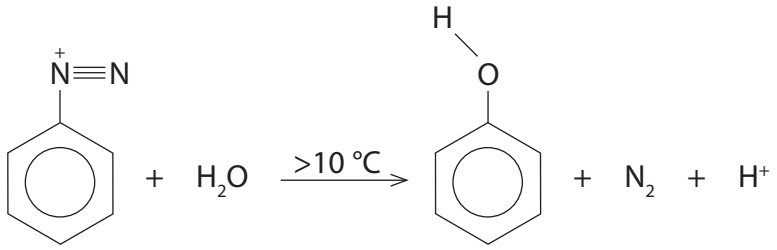
I Formation of the pale blue precipitate

$Cu(H_2O)_6^{2+} + 2C_4H_9NH_2 \rightarrow$

II The overall equation for the formation of the deep blue solution

$Cu(H_2O)_6^{2+} + 4C_4H_9NH_2 \rightarrow$

*(c) When phenylamine is treated with a mixture of sodium nitrite, $NaNO_2$, and hydrochloric acid at about 5 °C, the resulting solution contains the benzenediazonium ion. If the temperature of this solution is allowed to rise above 10 °C, the benzenediazonium ion reacts to form phenol:



By considering the role of the water molecule in this reaction, state the type and mechanism occurring and explain why it is unusual in benzene chemistry.

(2)

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(Total for Question 23 = 12 marks)

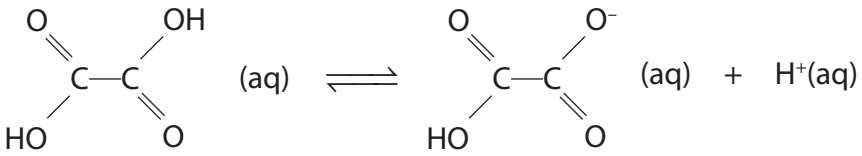
TOTAL FOR SECTION B = 49 MARKS

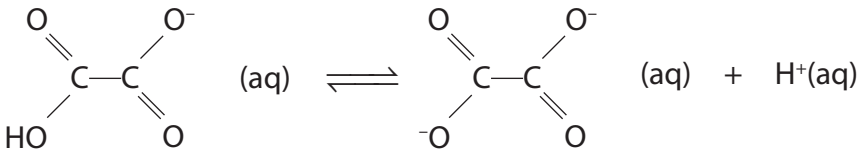
SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

24

Ethanedioic acid (also known as oxalic acid) is a dicarboxylic acid. Like sulfuric acid, it has two replaceable hydrogen atoms so it dissociates in two stages which are shown below. Acids like these are called 'dibasic'.





As is always the case with dibasic acids, the first dissociation occurs to a far greater extent than the second. Ethanedioic acid is a carboxylic acid but, because there are two carboxyl groups, it is a much stronger acid than ethanoic acid.

Ethanedioic acid is toxic, mainly due to the precipitation of calcium ethanedioate in the kidneys. As it occurs in many plants, the toxicity of ethanedioic acid has caused a number of deaths notably during the First World War when people in England used rhubarb leaves, which contain significant concentrations of the compound, as a vegetable substitute. As it is a reducing agent, the concentration of ethanedioic acid is usually determined by titration with a solution of potassium manganate(VII) of known concentration.

The ethanedioate ion, which is formed when ethanedioic acid dissociates fully, is a bidentate ligand. The ethanedioate ion together with 1,2-diaminocyclohexane, another bidentate ligand, forms a complex with platinum(II) called oxaliplatin which has the same geometry as cisplatin. Oxaliplatin is an anti-cancer drug, which has been used to treat cancers that have become resistant to cisplatin.

Ethanedioic acid has numerous uses, from cleaning and rust removal to the purification of metals. Although it can be prepared from ethene in a two stage process, it is usually manufactured by the oxidation of carbohydrates or glucose using nitric acid, or air, in the presence of vanadium(V) oxide.

(a) (i) Suggest why the presence of the second carboxylic acid group increases the extent of the **first** dissociation of ethanedioic acid compared with the dissociation of ethanoic acid.

(2)

(ii) Explain, by referring to the equilibria in the passage, why the second dissociation of a dibasic acid occurs to a lesser extent than the first.

(1)

(b) In an experiment to determine the proportion of ethanedioic acid in rhubarb leaves, 250 g of leaves was crushed and boiled in a solution of sodium carbonate. The resulting mixture was filtered and the filtrate transferred, along with washings from the mixture, to a 250 cm^3 volumetric flask. The solution was acidified with sulfuric acid, made up to the mark and mixed thoroughly. 25.0 cm^3 portions of the solution were pipetted into a conical flask, about 25 cm^3 of sulfuric acid added and the mixture titrated against a solution of potassium manganate(VII) of concentration 0.0200 mol dm^{-3}. The mean titre was 28.55 cm^3. The relevant ionic half equations for the reaction are

$$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightarrow Mn^{2+}(aq) + 4H_2O(l)$$

$$C_2O_4^{2-}(aq) \rightarrow 2CO_2(g) + 2e^-$$

(i) State the colour change that occurs at the end-point of the titration.

(1)

.....

*(ii) Calculate the percentage by mass of ethanedioic acid in rhubarb leaves.

(5)

(c) (i) Explain the term 'bidentate'.

(1)

.....

.....

(ii) Draw a diagram of the oxaliplatin(II) complex, showing clearly the geometry and charge of the complex and how the ligands are attached to the central ion.

(3)

(d) (i) Suggest a two step **laboratory** synthesis of ethanedioic acid from ethene. Indicate the intermediate compound formed and the reagents required.

(3)

(ii) Suggest why it is preferable from an environmental perspective that ethanedioic acid is manufactured from carbohydrates and glucose rather than from ethene.

(1)

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.....

(iii) A sample of ethanedioic acid, manufactured from glucose, was contaminated with a small amount of propanoic acid.

High resolution nmr may be used to distinguish propanoic acid from ethanedioic acid.

Describe the high resolution nmr spectra of both propanoic acid and ethanedioic acid. Do **not** include chemical shift data in your answer.

(4)

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(Total for Question 24 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 8 5 A 0 2 8 2 8

PMT

edexcel

Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH05/01R
General Principles of Chemistry II

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Summer 2013
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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		**1**

Question Number	Correct Answer	Reject	Mark
2	D		**1**

Question Number	Correct Answer	Reject	Mark
3	B		**1**

Question Number	Correct Answer	Reject	Mark
4	A		**1**

Question Number	Correct Answer	Reject	Mark
5(a)	C		**1**
(b)	A		**1**

Question Number	Correct Answer	Reject	Mark
6	C		**1**

Question Number	Correct Answer	Reject	Mark
7	D		**1**

Question Number	Correct Answer	Reject	Mark
8	D		**1**

Question Number	Correct Answer	Reject	Mark
9	B		**1**

Question Number	Correct Answer	Reject	Mark
10	A		**1**

Question Number	Correct Answer	Reject	Mark
11	D		**1**

Question Number	Correct Answer	Reject	Mark
12	C		**1**

Question Number	Correct Answer	Reject	Mark
13	C		**1**

Question Number	Correct Answer	Reject	Mark
14	A		**1**

Question Number	Correct Answer	Reject	Mark
15	A		**1**

Question Number	Correct Answer	Reject	Mark
16	B		**1**

Question Number	Correct Answer	Reject	Mark
17	B		**1**

Question Number	Correct Answer	Reject	Mark
18	D		**1**

Question Number	Correct Answer	Reject	Mark
19	A		**1**

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	$Cr_2(SO_4)_3(aq) = Cr(H_2O)_6^{3+}$ ALLOW $Cr^{3+}(aq)$ / Cr^{3+} **(1)** A = $Cr(H_2O)_3(OH)_3$ / $Cr(OH)_3$ **(1)** B = $Cr(H_2O)_2(OH)_4^-$ / $Cr(OH)_4^-$ / $Cr(OH)_6^{3-}$ **(1)** C = CrO_4^{2-} **(1)** IGNORE SO_4^{2-} and/or Na+		**4**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	$H_2O_2 + 2e^{(-)} \rightarrow 2OH^-$		**1**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	Sulfuric acid / H_2SO_4 ALLOW Name or formula of any strong acid (e.g. HCl) IGNORE H^+ and 'an acid' Dilute or concentrated		**1**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iv)	$2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$ ALLOW Equation showing Na^+ and anion on both sides IGNORE State symbols even if incorrect	Non-ionic equations	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)	**First mark for both half equations** Mentions / some evidence for the use of BOTH half equations in any way even if reversed or left unbalanced $Cr^{3+}(aq) + e^- \rightarrow Cr^{2+}(aq)$ ($E^\ominus = -0.41$ V) $Cr_2O_7^{2-}(aq) + 14H^+(aq) + 6e^-$ $\rightarrow 2Cr^{3+}(aq) + 7H_2O(l)$ ($E^\ominus = +1.33$ V) **(1)** **Second mark for** $8Cr^{3+}(aq) + 7H_2O(l) \rightarrow 6Cr^{2+}(aq) + Cr_2O_7^{2-}(aq) + 14H^+(aq)$ **(1)** **Third mark for** $E^\ominus_{cell} = -0.41 - 1.33 = -1.74$ (V) For **second** and **third marks,** ALLOW reverse equation and $E^\ominus_{cell} = +1.74$ (V) (for **reverse** reaction) **(1)** ALLOW 1.74 (V) only if 'positive' stated in words elsewhere **Fourth mark for** EITHER Disproportionation / (proposed) reaction / "it is" **not feasible** (because its $E^\ominus_{cell}$ is negative) OR Reverse of disproportionation **is feasible** (because its $E^\ominus_{cell}$ is positive) **(1)** IGNORE state symbols even if incorrect ALLOW $\rightleftharpoons$ instead of $\rightarrow$ Third and fourth marks can be awarded CQ on incorrect half equation(s) and stated $E^\ominus$ values		**4**

Total for Question 20 = 11 Marks

Question Number	Acceptable Answers	Reject	Mark
21(a)	−285.8 / −286 (kJ mol^{-1})		**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	$H_2(g) + 2OH^-(aq) \rightarrow 2H_2O(l) + 2e^{(-)}$ **(1)** $O_2(g) + 2H_2O(l) + 4e^{(-)} \rightarrow 4OH^-(aq)$ **(1)** **For state symbols mark:** Two of the four stated equations (see the two equations above and the two equations below) must be quoted even if reversed or unbalanced. All state symbols must be correct in **both** equations for correct species for the state symbol mark (penalise once only) **(1)** Both equations for an **acid** fuel cell score max 2 (1 for correct equations and 1 for states) e.g. $H_2(g) \rightarrow 2H^+(aq) + 2e^{(-)}$ OR $H_2(g) - 2e^{(-)} \rightarrow 2H^+(aq)$ $O_2(g) + 4H^+(aq) + 4e^{(-)} \rightarrow 2H_2O(l)$ ALLOW Equation multiples Equations in reverse direction Any order of equations Reversible arrows		**3**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	Electrolyte / to allow the movement of ions (between electrodes) ALLOW Movement of hydrogen ions/ oxonium ions / hydroxonium ions / hydronium ions / H^+ / H_3O^+ / hydroxide ions / OH^- (between electrodes) IGNORE References to electron transfer	Catalyst Just 'conducts electricity' Movement of other ions / charged species	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	Any two of Both involve breaking / weakening bonds OR Both involve active site(s) (on the catalyst surface) OR **Ad**sorption **(2)** IGNORE Lowers the activation energy Both heterogeneous References to surface area or "surface for the reaction" References to orientation of reactant molecules "Reaction pathway is similar"	**Ab**sorption	**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	Water is the **only** product (at the point of use) / **no** oxide(s) of carbon IGNORE Reference to efficiency and/or high energy density Greener	**Less** oxide(s) of carbon	**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	**Any two from:** Fuel cell is more efficient / 70% efficient ALLOW Any % between 70% and 100% It produces electricity directly OR **Less** heat loss Releasing energy in a more controlled manner **(2)** IGNORE References to safety	Any mention of carbon emissions	**2**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iii)	**Either** High cost / expensive OR Cost of catalyst OR Short life-span IGNORE References to liquefaction and / or storage of hydrogen / size / weight		**1**

Question Number	Acceptable Answers	Reject	Mark
21(c)(iv)	**Any two from** Ethanol renewable / sustainable / carbon neutral / availability of raw materials / low(er) carbon footprint / made from natural processes e.g. fermentation or biomass Less explosive / less flammable / safe(r) Easier to store / pressure not needed for storage / easier to transfer Fuel tank light(er) / small(er) New petrol stations not required ALLOW Reverse arguments for hydrogen IGNORE Reference to cost References to energy density		**2**

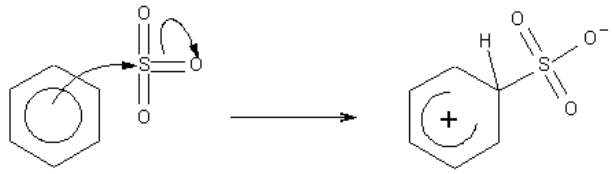
Total for Question 21 = 13 Marks

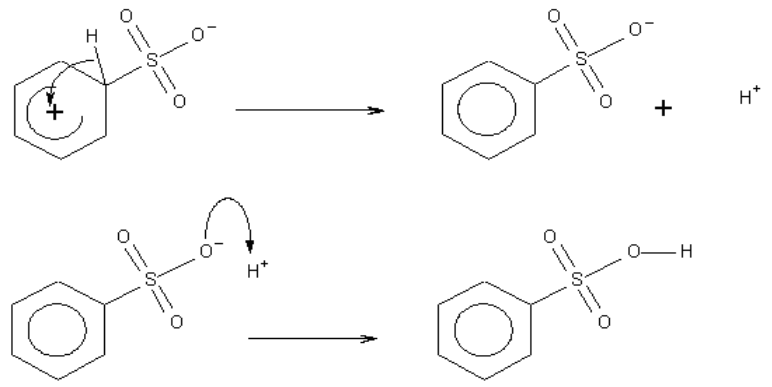
Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	**Fuming** sulfuric acid / **fuming** H_2SO_4 / oleum / $H_2S_2O_7$	Conc. (for fuming) Fuming dilute sulfuric acid **Just** sulfuric acid **Just** H_2SO_4	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Sulfur is δ+ and on at least one oxygen δ- **(1)** Oxygen is (much) more electronegative than sulfur ALLOW Oxygen is very electronegative **(1)**	Full + or – charge(s) 1/3 – on each oxygen	**2**

Question Number	Acceptable Answers	Reject	Mark
22 (a)(iii)	The sulfur trioxide can accept a pair of electrons OR (Three oxygen atoms so) sulfur has a large δ or partial / slight positive charge OR π bonds allow S—O bonds to be polarized more easily ALLOW Electron-deficient sulfur	An electron	**1**

Marks for (b)(i) and (b)(ii) can be awarded from either of the two annotated diagrams on item

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	 First curly arrow as shown to start inside the hexagon to the S atom **(1)** Second curly arrow from bond to O (i.e. not from the S atom itself) **(1)** ALLOW Second curly arrow to any of the three O atoms in SO_3 IGNORE A full + charge on S		**2**

Question Number	Acceptable Answers	Reject	Mark
22 (b)(ii)	 Curly arrow as shown from the C-H bond to reform the ring in first line, not from the H atom in this bond **(1)** Intermediate anion formed in first line (H^+ does not have to be shown) **(1)** Last line with curly arrow and correct structure of benzenesulfonic acid **(1)** ALLOW Use of H_2SO_4 for H^+ with HSO_4^- as other product in final step The marks for (b)(ii) may be awarded from annotations on the right hand structure given in question in (b)(i) If contradictory arrows drawn on structure in question (b)(ii), then penalise any such inconsistency The three marks for the two steps in (b)(ii) can be shown in one step / diagram / structure ALLOW $-SO_3H$ undisplayed	Use of H_2O for H^+ $-HSO_3$	**3**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	$C_6H_5SO_3H + 3NaOH \rightarrow C_6H_5ONa + Na_2SO_3 + 2H_2O$ **(1)** ALLOW Charges on $C_6H_5O^-Na^+$ $C_6H_5ONa + HCl \rightarrow C_6H_5OH + NaCl$ **(1)** ALLOW $C_6H_5O^- + HCl \rightarrow C_6H_5OH + Cl^-$ OR $C_6H_5O^- + H^+ \rightarrow C_6H_5OH$	Charges on $C_6H_5SO_3H$	**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	**Any two from:** (Both) products useful / both are useful / propanone is useful So less waste / high(er) atom economy Fewer steps / one step / does not require many steps (in Hock synthesis) Continuous rather than a batch process **(2)** IGNORE "Only one waste product in Hock" Comments relating to hazardousness of reactants / safety / energy requirements References to yield References to efficiency References to rate	Cheaper	**2**

Total for Question 22 = 13 Marks

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	Lone pair(s) (of electrons on the nitrogen) ALLOW Non-bonded pair(s)	Spare pair	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	$CH_3CH_2CH_2CH_2NH_2 + H_2O \rightleftharpoons CH_3CH_2CH_2CH_2NH_3^+ + OH^-$ ALLOW $\rightarrow$ for $\rightleftharpoons$ IGNORE state symbols even if incorrect Right hand ions must be shown separately ALLOW $C_4H_9NH_2$	Reject near misses	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(iii)	**Any two of:** Butyl / alkyl groups are electron donating / are electron pushing / are electron releasing Two (alkyl) groups in dibutylamine (but only one in butylamine) **Lone pair** (of electrons) on the nitrogen more readily available / higher electron density on the nitrogen or NH_2 or amine group / N more delta negative / N or NH_2 accepts a proton more readily **(2)** Stand alone marks Accept reverse argument for butylamine IGNORE 'electronegativity of nitrogen increasing'		**2**

Question Number	Acceptable Answers	Reject	Mark
23(a)(iv)	**First mark** For the idea of the **lone pair** being withdrawn towards the ring e.g. Lone pair pulled into the ring Lone pair (of electrons) on the nitrogen overlap Lone pair interacts with π electrons / lone pair interacts with delocalized electrons of the (benzene) ring Lone pair (of electrons) on the nitrogen donated to the (benzene) ring **(1)** NOTE The reference to the lone pair may be found in a later part of the answer and credited **Second mark** EITHER For the idea of the **lone pair** being less available OR The **nitrogen** (atom) must be specified as below e.g. Lone pair is less readily available Nitrogen (atom) has lower electron density N (atom) or lone pair is less able to accept protons / H^+ **(1)** ALLOW N is less δ^- for second mark		**2**

Question Number	Acceptable Answers		Mark
23(b)	I $(Cu(H_2O)_6^{2+} + 2C_4H_9NH_2) \rightarrow Cu(H_2O)_4(OH)_2 + 2C_4H_9NH_3^+$ ALLOW I $(Cu(H_2O)_6^{2+} + 2C_4H_9NH_2) \rightarrow Cu(OH)_2 + 2C_4H_9NH_3^+ + 4H_2O$ **(2)** II $(Cu(H_2O)_6^{2+} + 4C_4H_9NH_2) \rightarrow Cu(H_2O)_2(C_4H_9NH_2)_4^{2+} + 4H_2O$ ALLOW II $(Cu(H_2O)_6^{2+} + 4C_4H_9NH_2) \rightarrow Cu(C_4H_9NH_2)_4^{2+} + 6H_2O$ **(2)** Each correct equation scores 2 marks: 1 mark for the formula of the copper complex ion and 1 mark for the rest of the equation being correct Ligands can be in either order IGNORE state symbols even if incorrect IGNORE (lack of) square brackets around complex ions		**4**

Question Number	Acceptable Answers	Reject	Mark
23(c)	Reaction is a nucleophilic substitution **(1)** It is unusual because benzene normally reacts with electrophiles / by electrophilic substitution OR Positive charge withdraws electrons from the ring (making it susceptible to nucleophilic attack) OR Expect nucleophiles to be repelled by the electron density of the ring **(1)**		**2**

Total for Question 23 = 12 Marks

Total for Section B = 49 Marks

Section C

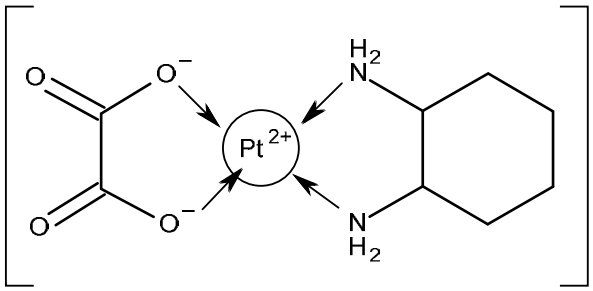
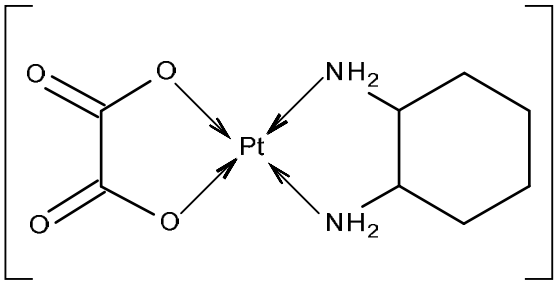
Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	The electron withdrawing effect of the (extra) COOH group / oxygen atoms **(1)** Increases the stability of the (hydrogenethanedioate) ion ALLOW Weakens the OH bond **(1)** IGNORE Reference to OH bond becoming more polar		**2**

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	H^+ ions formed (in first dissociation) shifts (second equilibrium) to the left ALLOW H^+ formed suppresses (second) ionization		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Colourless to (pale) pink ALLOW purple for pink	Clear for colourless	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	Amount of MnO_4^- = 28.55 x 10^{-3} x 0.0200 (= 5.71 x 10^{-4} mol) **(1)** Amount of $C_2O_4^{2-}$ = 5.71 x 10^{-4} x $\frac{5}{2}$ **(1)** = 1.4275 x 10^{-3} (mol) Amount of $C_2O_4^{2-}$ in 250 cm^3 / rhubarb leaves = 1.4275 x 10^{-3} x 10 = 1.4275 x 10^{-2} (mol) **(1)** Mass $H_2C_2O_4$ in 250 cm^3 = 1.4275 x 10^{-2} x 90 **(1)** = 1.28475 g % $H_2C_2O_4$ in rhubarb = $\frac{1.28475}{250}$ x 100 = 0.5139 % **(1)** IGNORE SF except 1 SF Correct answer with no working scores 5 TE on all parts of calculation If M_r = 88 used then final answer is 0.50248%		**5**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	(Ligand that) Has two lone pairs that can bond (separately) (to the central ion / atom) OR Occupies two coordination positions (around a central ion / atom) OR Two points of attachment (to the central ion / atom) OR Forms two **dative** bonds (to the central ion / atom) OR Two atoms of the same ion / molecule that bond with central metal ion / atom	Two ligands **Just** two lone pairs	**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	 Or  Square planar shape around Pt drawn as above and zero net charge NOTE The structure of each ligand must be totally correct **(1)** Both nitrogen atoms attached **and** both C-O oxygen atoms attached from separate COO^- groups **(1)** **Dative** covalent bonds **(1)** **Mark each point separately**	Different oxygen atoms from the same carboxyl group attached to different coordination positions. If O attached from a C=O oxygen	3

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	(Alkaline or neutral or acidified) potassium manganate(VII) / $KMnO_4$ / MnO_4^- **(1)** Forms ethane-1,2-diol (name or structural / skeletal / displayed formula) **(1)** NOTE It does not matter how the ethane-1,2-diol has been formed (Oxidized by) (refluxing with) acidified potassium dichromate(VI) / $Cr_2O_7^{2-}$ and H^+ OR Acidified/alkaline potassium manganate(VII) / MnO_4^- with either H^+ or OH^- OR (Oxidized by) nitric acid (c.f. passage) **(1)** **Mark each point separately** Max 2 for a three step synthesis e.g. bromine followed by NaOH then oxidation ALLOW correct formulae instead of names	Molecular formula $C_2H_6O_2$ Air catalyzed by V_2O_5	**3**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	Carbohydrates and / or glucose are obtained from renewable / sustainable resources (whereas ethene is obtained from crude oil) ALLOW Reverse argument for ethene		**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	**Ethanedioic acid** Will have one (singlet) peak / hydrogen environment (due to the COOH protons) **(1)** **Propanoic acid** Will have three peaks / three hydrogen environments **(1)** Triplet, quartet / quadruplet & singlet in any order OR Split(ting) pattern 3,4,1 in any order **(1)** NOTE If first mark for **propanoic acid** hasn't been awarded "triplet, quartet / quadruplet & singlet" **scores 2** Intensity in ratio 3:2:1 in any order **(1)** ALLOW labelled and annotated diagrams Max. 3 if not clear that hydrogens/protons give rise to the peaks		**4**

Total for Section C = 21 Marks

Total for Paper = 90 Marks

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Edexcel GCE

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Wednesday 19 June 2013 – Morning
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41651A

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10/5/5/7/

P 4 1 6 5 1 A 0 1 3 2

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The following data are provided.

	$E^{\ominus}$ / V
$ClO^-(aq) + H_2O(l) + e^- \rightleftharpoons \frac{1}{2}Cl_2(aq) + 2OH^-(aq)$	+0.40
$Cl_2(aq) + 2e^- \rightleftharpoons 2Cl^-(aq)$	+1.36

What is the value of $E^{\ominus}_{cell}$ in which the following disproportionation reaction occurs?

$$Cl_2(aq) + 2OH^-(aq) \rightarrow ClO^-(aq) + Cl^-(aq) + H_2O(l)$$

☒ **A** $+\frac{1.36}{2} - 0.40$ V

☒ **B** $+\frac{1.36}{2} + 0.40$ V

☒ **C** $+ 1.36 - 0.40$ V

☒ **D** $+ 1.36 + 0.40$ V

(Total for Question 1 = 1 mark)

2 Which of the following is always proportional to $E^{\ominus}_{cell}$ for a chemical reaction?

☒ **A** $\Delta H_{reaction}$

☒ **B** ΔS_{system}

☒ **C** $\Delta S_{surroundings}$

☒ **D** ΔS_{total}

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 The electrode system based on the half-equation below has the standard electrode potential +1.51 V.

$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$ $\quad E^{\ominow} = +1.51\ V$

Which of the following statements about this electrode system is correct?

☒ **A** Changing the concentration of $Mn^{2+}(aq)$ would cause a change in the electrode potential.

☒ **B** $Mn^{2+}(aq)$ is acting as an oxidizing agent.

☒ **C** The electrode used is made of manganese.

☒ **D** When connected to a standard hydrogen electrode, the resulting cell voltage would be +0.51 V.

(Total for Question 3 = 1 mark)

4 Consider the following reaction.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

Which of the following ions could catalyse this reaction?

☒ **A** Zn^{2+}

☒ **B** Al^{3+}

☒ **C** Fe^{2+}

☒ **D** Na^+

(Total for Question 4 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

5 EDTA ions form a complex with aqueous nickel(II) ions as shown by the equation

$$[Ni(H_2O)_6]^{2+}(aq) + (EDTA)^{4-}(aq) \rightleftharpoons Ni(EDTA)^{2-}(aq) + 6H_2O(l)$$

Aqueous nickel(II) ions also form a complex ion with ammonia as shown by the equation

$$[Ni(H_2O)_6]^{2+}(aq) + 6NH_3(aq) \rightleftharpoons [Ni(NH_3)_6]^{2+}(aq) + 6H_2O(l)$$

Aqueous nickel(II) ions form a more stable complex with EDTA ions than with ammonia because

☒ **A** six ammonia ligands cause steric hindrance around the central nickel(II) ion.

☒ **B** EDTA ions carry a negative charge whereas ammonia molecules do not.

☒ **C** there is a large increase in entropy when aqueous nickel(II) ions react with EDTA ions, but not when aqueous nickel(II) ions react with ammonia.

☒ **D** ammonia molecules tend to evaporate from the solution of the complex whereas EDTA ions do not.

(Total for Question 5 = 1 mark)

6 The hydrolysis of a transition metal cation can be represented by the following equation

$$[M(H_2O)_6]^{n+}(aq) + H_2O(l) \rightleftharpoons [M(H_2O)_5OH]^{(n-1)+}(aq) + H_3O^+(aq)$$

In this reaction

☒ **A** the solvent H_2O is acting as an acid by donating a proton to the metal cation.

☒ **B** the pH of the solution will be lower if the value of n is 2 instead of 3.

☒ **C** the equilibrium position lies further to the right if the value of n is 3 instead of 2.

☒ **D** the oxidation state of the metal in the cation has decreased from n to (n – 1).

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 In aqueous solution, manganate(VI) ions disproportionate into manganate(VII) ions and manganese(IV) oxide when carbon dioxide is bubbled through the solution. The ionic equation for the reaction is

$$3MnO_4^{2-}(aq) + 4H^+(aq) \rightarrow 2MnO_4^-(aq) + MnO_2(s) + 2H_2O(l)$$

The role of the carbon dioxide is to

☒ **A** lower the pH of the solution.

☒ **B** raise the pH of the solution.

☒ **C** oxidize the manganate(VI) ions.

☒ **D** reduce the manganate(VI) ions.

(Total for Question 7 = 1 mark)

8 Which of the following shows the correct oxidation states of **chromium** in the ions given?

	$[Cr(OH)_6]^{3-}$	CrO_4^{2-}	$[Cr(H_2O)_6]^{2+}$
☒ **A**	−3	−2	+2
☒ **B**	−3	+10	+2
☒ **C**	+3	+8	+6
☒ **D**	+3	+6	+2

(Total for Question 8 = 1 mark)

9 Transition metals are often used as heterogeneous catalysts. Which of the following processes does **not** occur during such a catalysed reaction?

☒ **A** Adsorption of reactant molecules on the surface of the metal.

☒ **B** Bond breaking in the reactant molecules.

☒ **C** Desorption of product molecules from the surface of the metal.

☒ **D** An overall change in the oxidation number of the metal.

(Total for Question 9 = 1 mark)

10 Consider the equation below.

$$[Cu(H_2O)_6]^{2+}(aq) + 4NH_3(aq) \rightleftharpoons [Cu(NH_3)_4]^{2+}(aq) + 6H_2O(l)$$

This reaction is best described as

☒ **A** acid-base.

☒ **B** redox.

☒ **C** addition.

☒ **D** ligand exchange.

(Total for Question 10 = 1 mark)

11 Which of the following will **not** reduce an acidified solution of potassium dichromate(VI)?

☒ **A** $(CH_3)_2C(OH)CH_3$

☒ **B** $FeSO_4$

☒ **C** $CH_3CH_2CH(OH)CH_3$

☒ **D** Zn

(Total for Question 11 = 1 mark)

12 The total number of isomers of dibromobenzene, $C_6H_4Br_2$, containing a benzene ring is

☒ **A** 2

☒ **B** 3

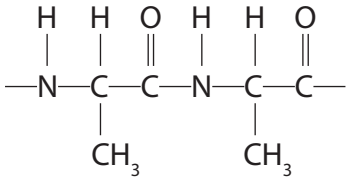
☒ **C** 4

☒ **D** 5

(Total for Question 12 = 1 mark)

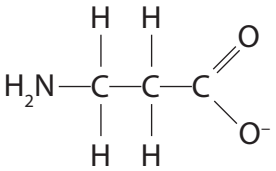
Use this space for any rough working. Anything you write in this space will gain no credit.

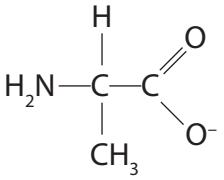
13 A section of the polypeptide made from a single amino acid is shown below.

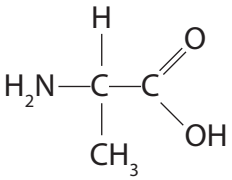


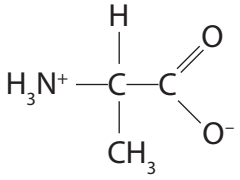
The polypeptide was heated with excess dilute sodium hydroxide solution until no further change took place.

Which of the following products is formed?

☒ **A** 

☒ **B** 

☒ **C** 

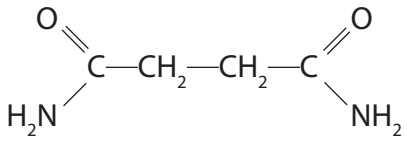
☒ **D** 

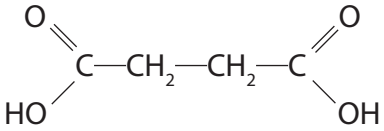
(Total for Question 13 = 1 mark)

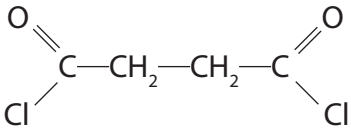
Use this space for any rough working. Anything you write in this space will gain no credit.

14 Which of the following pairs of compounds could form a polyamide?

☒ **A** $Cl—CH_2—CH_2—Cl$ and $H_2N—CH_2—CH_2—NH_2$

☒ **B** $HO—CH_2—CH_2—OH$ and 

☒ **C**  and $CH_3—CH_2—NH_2$

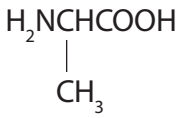
☒ **D**  and $H_2N—CH_2—CH_2—NH_2$

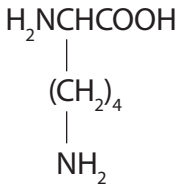
(Total for Question 14 = 1 mark)

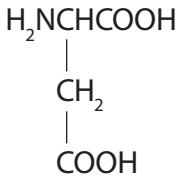
Use this space for any rough working. Anything you write in this space will gain no credit.

15 Which of the following amino acids is optically active and produces an approximately neutral solution when dissolved in water?

☒ **A** H_2NCH_2COOH

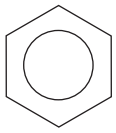
☒ **B**


☒ **C**


☒ **D**


(Total for Question 15 = 1 mark)

16 Which of the following is **not** planar?

☒ **A**


☒ **B** CCl_4

☒ **C** BF_3

☒ **D** $[Pt(NH_3)_2Cl_2]$

(Total for Question 16 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

17 A 50 cm^3 sample of a gaseous hydrocarbon required exactly 250 cm^3 of oxygen for complete combustion. A volume of 150 cm^3 of carbon dioxide was produced.

[All volume measurements were made at the same temperature and pressure.]

Which of the following is the correct formula of the hydrocarbon?

☒ **A** C_3H_4

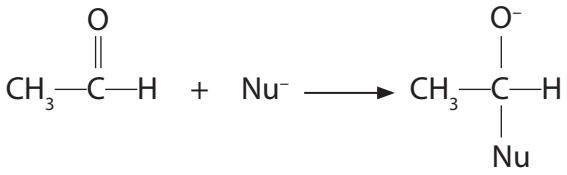
☒ **B** C_3H_8

☒ **C** C_5H_{10}

☒ **D** C_5H_{12}

(Total for Question 17 = 1 mark)

18 The first step of a nucleophilic addition reaction to a carbonyl group by a nucleophile, Nu^-, is shown below.



The above step is possible because the

☒ **A** nucleophile bonds to the δ+ carbon atom and the carbonyl oxygen accepts an electron pair from the double bond.

☒ **B** nucleophile bonds to the δ+ carbon atom and the carbonyl oxygen accepts one electron from the double bond.

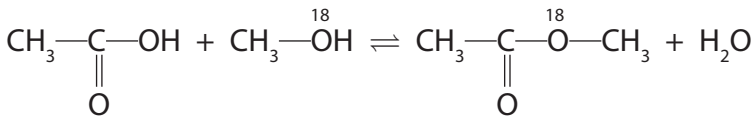
☒ **C** methyl group donates electrons to the carbonyl carbon atom.

☒ **D** C═O bond is weak.

(Total for Question 18 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

19 In a reaction carried out between ethanoic acid and methanol, the methanol was labelled with the ^{18}O isotope. The ^{18}O was found to be in the organic product of the reaction



From the above information it can be deduced that the mechanism involves

☒ **A** free radical substitution.

☒ **B** breaking the C—O bond in the ethanoic acid.

☒ **C** nucleophilic attack by ethanoic acid on methanol.

☒ **D** breaking the C—^{18}O bond in methanol.

(Total for Question 19 = 1 mark)

20 The hydride ion, H^-, is a strong reducing agent, a good nucleophile and a strong base.

Which of the following changes could **not** be brought about by the hydride ion?

☒ **A** CH_3CHO to CH_3CH_2OH

☒ **B** C_2H_5Br to C_2H_6

☒ **C** $CH_2{=}CH_2$ to C_2H_6

☒ **D** CH_3COOH to CH_3COO^-

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Hydrogen-oxygen fuel cells can operate in acidic or alkaline conditions.
One such commercial cell uses porous platinum electrodes in contact with concentrated aqueous potassium hydroxide solution, KOH(aq).

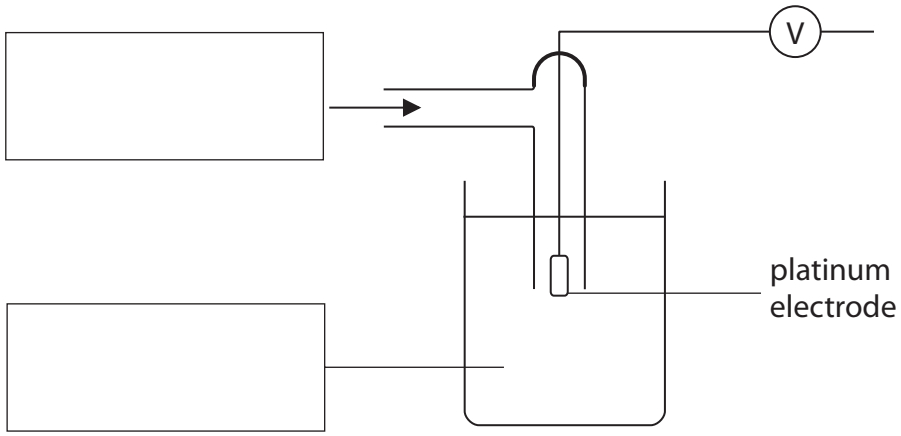
(a) Use relevant standard electrode potential values, on pages 15 and 17 of the Data Booklet, to complete the table below in which two $E^{\ominus}$ values are missing.

(2)

Half-equation	$E^{\ominus}$ / V
$2H_2O(l) + 2e^- \rightleftharpoons 2OH^-(aq) + H_2(g)$	−0.83
$2H^+(aq) + 2e^- \rightleftharpoons H_2(g)$	0.00
$O_2(g) + 2H_2O(l) + 4e^- \rightleftharpoons 4OH^-(aq)$	
$O_2(g) + 4H^+(aq) + 4e^- \rightleftharpoons 2H_2O(l)$	

(b) (i) Fill in the boxes to identify, by name or formula, the substances used in the **standard** hydrogen electrode.

(2)



(ii) State **three** conditions that are necessary for a standard hydrogen electrode.

(2)

1. .....

2. .....

3. .....

(c) Write appropriate half-equations and use them to derive an overall equation for the reaction which occurs when an **alkaline** hydrogen-oxygen fuel cell operates.

(2)

(d) Use the $E^{\ominus}$ values from the table in part (a) to calculate the $E^{\ominus}_{cell}$ for a hydrogen-oxygen fuel cell operating in alkaline conditions.

(1)

(e) Suggest why the $E^{\ominus}_{cell}$ for a hydrogen-oxygen fuel cell, operating in **acidic** conditions, is identical to that of an alkaline fuel cell.

(1)

.....

.....

(f) Give **one** reason (other than cost implications) why the platinum electrodes are made by coating porous material with platinum rather than by using platinum rods.

(1)

.....

.....

(g) Suggest **one** disadvantage of using a hydrogen-oxygen fuel cell compared with a rechargeable battery when providing electrical energy for a motor vehicle.

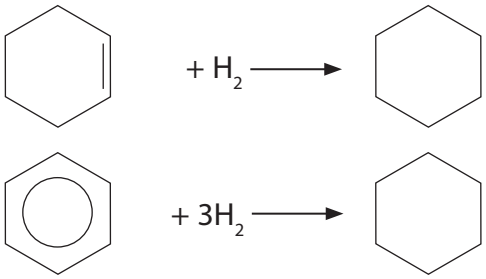
(1)

.....

.....

(Total for Question 21 = 12 marks)

22 (a) Equations for the catalytic hydrogenation of cyclohexene and of benzene are shown below.



(i) What is the type of reaction in both of these hydrogenations?

(1)

.....

*(ii) The enthalpy of hydrogenation of benzene might be expected to be −360 kJ mol^{-1}. Explain why this is **not** the actual value.

(2)

.....

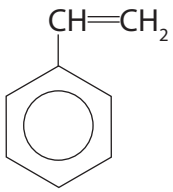
.....

.....

.....

(iii) Complete the following equation for the total hydrogenation of phenylethene. Suggest a value for the enthalpy change of this reaction.

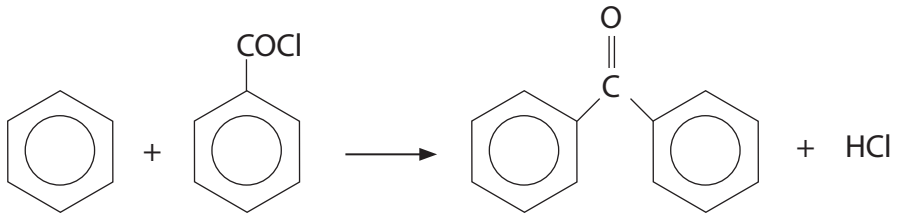
(3)



+ ..... H_2 →

ΔH = ... kJ mol^{-1}

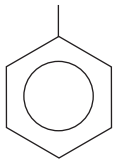
(b) The compound benzophenone is used as a sunscreen. It can be prepared from benzene, in the presence of aluminium chloride by the following reaction.



benzene + compound **A** benzophenone

(i) Complete the diagram below by showing the **displayed** formula of the –COCl group in compound **A**.

(1)



(ii) Classify the type and mechanism of the reaction between benzene and compound **A**.

(1)

.....

(iii) Give the names of the two chemists associated with the type of reaction described in (b)(ii).

(1)

..... and .....

(iv) Give the mechanism for the reaction between benzene and compound **A** in the presence of an aluminium chloride catalyst.

Start by showing the equation for the generation of the species which then attacks the benzene ring.

(4)

Equation to show generation of species attacking the benzene ring:

Rest of the mechanism:

(v) Suggest the essential property of a substance that will be used as a sunscreen.

(1)

.....

.....

(c) (i) The identity of a sample of benzophenone can be confirmed by recording its infrared and proton nmr spectra.

Identify **two** different bonds that would produce an absorption in the infrared spectrum of benzophenone. Use the Data Booklet to suggest the wavenumber of each of these absorptions.

(4)

.....

.....

.....

.....

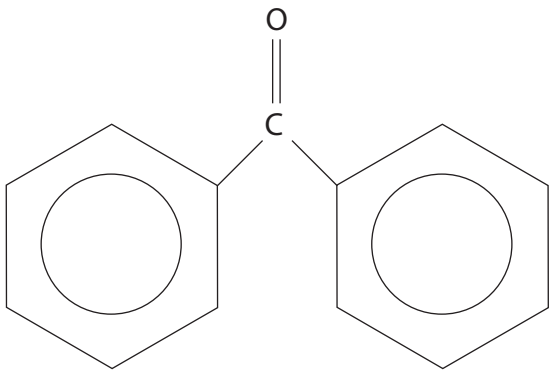
.....

.....

(ii) In benzophenone there are three different hydrogen environments, X, Y and Z, that produce signals in the ratio 2:2:1 respectively in the proton nmr spectrum.

Identify, **on the structure drawn below**, the positions of all the hydrogen atoms in each environment, labelling the different environments **X**, **Y** and **Z**.

(2)



benzophenone

(Total for Question 22 = 20 marks)

23 A scientist investigated the typical behaviour of primary amines.

(a) Amines such as butylamine, $CH_3CH_2CH_2CH_2NH_2$, and phenylamine, $C_6H_5NH_2$, both behave as bases.

(i) Which feature of an amine molecule allows it to act as a base?

(1)

.....

.....

(ii) The scientist reacted butylamine with two different acids.

Give the **formulae** of the salts that are formed when butylamine reacts with

(2)

sulfuric acid, H_2SO_4 .....

ethanoic acid, CH_3COOH .....

(b) Phenylamine, $C_6H_5NH_2$, is formed by the reduction of nitrobenzene, $C_6H_5NO_2$.

Give the reagents that are used for this reduction.

(2)

.....

.....

(c) Phenylamine was reacted with a mixture of sodium nitrite, $NaNO_2$, and hydrochloric acid at a temperature between 0 °C and 5 °C. A diazonium ion was formed. In a second step, the scientist reacted the diazonium ion with phenol, under suitable conditions. A precipitate of 4-hydroxyazobenzene (4-hydroxyphenylazobenzene) was formed.

(i) Draw the structure of the diazonium ion, clearly displaying the functional group present in the ion.

(1)

(ii) Draw the structural formula of 4-hydroxyazobenzene.

(1)

(iii) State a condition, other than a suitable temperature, required for the reaction of the diazonium ion with phenol and give a use for 4-hydroxyazobenzene.

(2)

Condition required:

.....

Use for 4-hydroxyazobenzene:

.....

(d) The scientist repeated the first step in experiment (c), but the temperature was allowed to rise above 10 °C. Under these conditions, the diazonium ion reacted with water to produce phenol. An unreactive gas, of molar mass 28.0 g mol^{-1}, was also formed along with one other product.

Use this information to write the equation for the reaction of the diazonium ion with water.

(2)

(e) The impure sample of 4-hydroxyazobenzene formed in part (c) may be purified by recrystallization. During this process

- the solid is dissolved in the minimum volume of hot solvent
- the mixture is then filtered whilst still hot
- the filtrate is cooled in an ice bath to produce crystals of 4-hydroxyazobenzene
- the crystals are removed by filtration and dried.

(i) Why is the "minimum volume of hot solvent" used?

(1)

.....

.....

.....

(ii) The impure 4-hydroxyazobenzene may contain both insoluble and soluble impurities. Describe how

(2)

I. insoluble impurities are removed during recrystallization

.....

.....

.....

II. soluble impurities are removed during recrystallization

.....

.....

.....

(iii) How would you check the purity of 4-hydroxyazobenzene after recrystallization, other than by using spectroscopy?

(1)

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.....

(Total for Question 23 = 15 marks)

TOTAL FOR SECTION B = 47 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

24

Titanium is the seventh most abundant metal in the Earth's crust and occurs principally as rutile (impure titanium(IV) oxide, TiO_2).

Early attempts to extract the metal from its oxide by reduction with heated carbon failed because the compound titanium carbide is formed. In 1910, however, pure titanium was made by heating titanium(IV) chloride with sodium.

Titanium has a high melting temperature and a density of 4.50 g cm^{-3}. Titanium is as strong as steel, but is about 40% less dense and is therefore suitable for use in the aircraft industry. Titanium metal resists corrosion as it has an impervious coating of titanium(IV) oxide. The metal adheres well to bone, is not rejected by the body and is in demand for the manufacture of replacement joints.

Titanium has two common oxidation states, +3 and +4. Solutions containing the $[Ti(H_2O)_6]^{3+}(aq)$ ion, such as titanium(III) chloride, are purple in colour and are readily oxidized by the oxygen in air to colourless titanium(IV) ions. An aqueous solution of titanium(III) chloride is a strong reducing agent. Titanium(IV) chloride, $TiCl_4$, is a colourless liquid with a boiling temperature of 136 °C. This compound is used, in conjunction with organic compounds of aluminium, as a catalyst for the polymerization of propene to poly(propene). Titanium(IV) chloride is hydrolysed by water to give titanium(IV) oxide, TiO_2 and hydrogen chloride gas.

Titanium(IV) oxide is a white, non-toxic solid at room temperature. It is used as a white pigment in paint, largely replacing toxic lead compounds which were used previously. Titanium(IV) oxide reacts with concentrated sulfuric acid to form a salt and water. Titanium(IV) oxide also reacts with aqueous potassium hydroxide solution, under suitable conditions, to form a compound with formula $K_2Ti(OH)_6$.

(a) (i) Write the equation for the reaction which occurs during the manufacture of titanium from titanium(IV) chloride as described in the article above. State symbols are not required.

(1)

(ii) Explain, by stating the changes of oxidation numbers, why the reaction in (i) is classified as a redox reaction.

(2)

.....

.....

.....

.....

(b) Complete the electronic configurations of

(2)

Ti [Ar] .....

Ti^{3+} [Ar] .....

Ti^{4+} [Ar] .....

(c) Use your answer to (b) to explain why titanium is

(i) a *d*-block element

(1)

.....

.....

.....

(ii) a transition element

(1)

.....

.....

.....

*(d) (i) Explain why the hexaaquatitanium(III) ion, $[Ti(H_2O)_6]^{3+}$, is coloured.

(3)

(ii) Explain briefly why titanium(IV) compounds are colourless.

(1)

*(e)(i) Titanium(IV) oxide has a melting temperature of 1830 °C. Use this data, plus information in the article at the start of the question, to compare the structure and bonding in titanium(IV) oxide with that in titanium(IV) chloride. Hence explain why these two compounds change state at very different temperatures.

(4)

(ii) Give the term used to describe an oxide, such as titanium(IV) oxide, which can react with both acids and bases.

(1)

(iii) Using information in the article, write the equation for the reaction between titanium(IV) oxide and aqueous potassium hydroxide solution. State symbols are not required.

(1)

(iv) Titanium(IV) chloride is one of the catalysts used in the polymerization of propene to form poly(propene).

Give the displayed formula of the repeat unit of poly(propene).

(1)

(f) The concentration of a solution of titanium(III) chloride can be determined by titration with a solution of hydrogen peroxide, H_2O_2, in acidic conditions. The end-point of the reaction is when the solution of titanium(III) chloride in the flask goes colourless.

(i) Complete the ionic half-equation to show the reduction of hydrogen peroxide.

(1)

$H_2O_2 + 2H^+ +$ ..... $\rightarrow$ .....

*(ii) One mole of hydrogen peroxide reacts with two moles of titanium(III) chloride.

In an experiment, 5.00 cm^3 of a sample of titanium(III) chloride solution was transferred to a volumetric flask and made up to 250 cm^3 of an aqueous solution. A 25.0 cm^3 portion of this diluted solution was acidified and titrated with a 0.0200 mol dm^{-3} solution of hydrogen peroxide, H_2O_2. The mean titre was 22.50 cm^3.

Calculate the concentration of the **original** titanium(III) chloride solution, in mol dm^{-3}.

(3)

(iii) Use information in the article to suggest why this titration gives a value that is lower than the true value for the concentration of titanium(III) chloride solutions.

(1)

.....

.....

(Total for Question 24 = 23 marks)

TOTAL FOR SECTION C = 23 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 1 6 5 1 A 0 3 2 3 2

PMT

Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Tuesday 21 January 2014 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
WCH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/6/2/

P 4 2 9 9 3 A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 In which of the following compounds does iron have the highest oxidation number?

☒ **A** Fe_3O_4

☒ **B** K_2FeO_4

☒ **C** $Na_4Fe(CN)_6$

☒ **D** $Na_3Fe(CN)_6$

(Total for Question 1 = 1 mark)

2 Which of the following is **not** a redox reaction?

☒ **A** $3CrCl_2 + Na_2CrO_4 + 8HCl \rightarrow 4CrCl_3 + 4H_2O + 2NaCl$

☒ **B** $2MnO_4^{2-} + C_8H_7O_3^- + 2OH^- \rightarrow 2MnO_4^{3-} + C_8H_5O_3^- + 2H_2O$

☒ **C** $3MnO_4^{2-} + 4H^+ \rightarrow 2MnO_4^- + MnO_2 + 2H_2O$

☒ **D** $MnO_4^- + 3H_2SO_4 \rightarrow MnO_3^+ + H_3O^+ + 3HSO_4^-$

(Total for Question 2 = 1 mark)

3 The standard reduction potentials of two systems are given below.

$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) \qquad E^{\ominus} = +0.34\,V$$

$$Ag^+(aq) + e^- \rightleftharpoons Ag(s) \qquad E^{\ominus} = +0.80\,V$$

What is $E^{\ominus}_{cell}$ for the reaction between copper and silver nitrate?

$$Cu(s) + 2Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$$

☒ **A** −1.26 V

☒ **B** −0.46 V

☒ **C** +0.46 V

☒ **D** +1.26 V

(Total for Question 3 = 1 mark)

4 A cell is set up with two metal-metal ion half cells and the digital voltmeter reads zero. Given that all the components of the cell have been included and are working properly, what is the most likely explanation for the zero reading?

☒ **A** The cell has been set up the wrong way round.

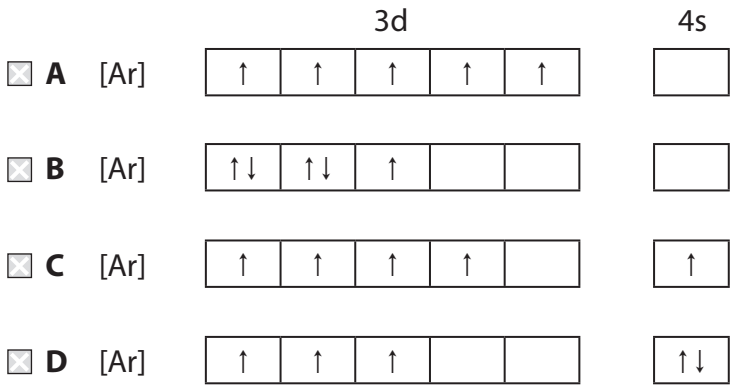
☒ **B** The entropy change, $\Delta S_{system} = 0$.

☒ **C** The activation energy for the reaction is very high.

☒ **D** The reaction system is at equilibrium.

(Total for Question 4 = 1 mark)

5 What is the electronic configuration of the Fe^{3+} ion?



(Total for Question 5 = 1 mark)

6 Ammonia gas is formed in the combustion of biomass fuels and is a significant pollutant when it is released directly into the atmosphere. One method of removing this ammonia involves its oxidation using a titanium(IV) oxide catalyst.

The **best** explanation for the use of titanium(IV) oxide is that the titanium

☒ **A** contains many active sites on which the reaction can occur.

☒ **B** is readily oxidized to a higher oxidation state which can then be reduced back to oxidation state +4.

☒ **C** is readily reduced to a lower oxidation state which can then be oxidized back to oxidation state +4.

☒ **D** has partially filled d orbitals in its +4 oxidation state.

(Total for Question 6 = 1 mark)

7 A transition metal ion, M, forms a complex with a bidentate ligand, B. The formula of the complex is MB_3 so the shape of the complex is most likely to be

- ☒ **A** trigonal planar.
- ☒ **B** pyramidal.
- ☒ **C** trigonal bipyramidal.
- ☒ **D** octahedral.

(Total for Question 7 = 1 mark)

8 Which of the following lists **all** the types of bond that are present in a crystalline sample of the compound tetraamminecopper(II) sulfate?

- ☒ **A** Ionic, covalent and dative covalent
- ☒ **B** Ionic and dative covalent
- ☒ **C** Ionic and covalent
- ☒ **D** Covalent and dative covalent

(Total for Question 8 = 1 mark)

9 A compound, **X**, is dissolved in water. Sodium hydroxide solution and dilute aqueous ammonia were added to different samples of this solution of **X**. In both, a precipitate formed which dissolved in excess reagent. Compound **X** could be

- ☒ **A** copper(II) sulfate.
- ☒ **B** iron(II) sulfate.
- ☒ **C** manganese(II) sulfate.
- ☒ **D** zinc(II) sulfate.

(Total for Question 9 = 1 mark)

10 The carbon-carbon bonds in benzene are all the same length. The best evidence for this comes from

- ☒ **A** high resolution proton nmr spectroscopy.
- ☒ **B** X-ray diffraction.
- ☒ **C** mass spectrometry.
- ☒ **D** bomb calorimetry.

(Total for Question 10 = 1 mark)

11 Benzene reacts very slowly with chlorine but the reaction speeds up when finely divided iron is added. This is because

- ☒ **A** the chlorine molecule donates an electron pair to the iron producing an electrophile.
- ☒ **B** the iron reacts with chlorine to form iron(III) chloride which then acts as an electrophile in its reaction with benzene.
- ☒ **C** the iron reacts with chlorine to form iron(III) chloride which then acts as an electron pair acceptor.
- ☒ **D** iron is a transition metal and acts as a heterogeneous catalyst in the reaction.

(Total for Question 11 = 1 mark)

12 It is calculated that, as a result of delocalization, benzene has a stabilization energy of 150 kJ mol^{-1}. This means that

- ☒ **A** the enthalpy change for the conversion of benzene to cyclohexa-1,3,5-triene would be +150 kJ mol^{-1}.
- ☒ **B** the enthalpy change for the conversion of cyclohexa-1,3,5-triene to benzene would be +150 kJ mol^{-1}.
- ☒ **C** the enthalpy change for the conversion of cyclohexane to benzene is +150 kJ mol^{-1}.
- ☒ **D** the enthalpy change for the conversion of benzene to cyclohexane is +150 kJ mol^{-1}.

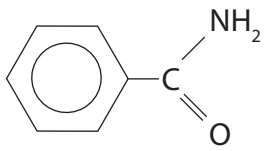
(Total for Question 12 = 1 mark)

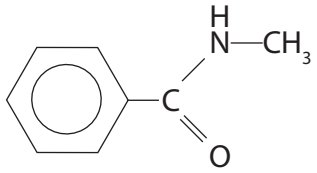
13 When a gas jar containing methylamine is opened near an open bottle of concentrated hydrochloric acid, white smoke is seen. The chemical formula of the white smoke is

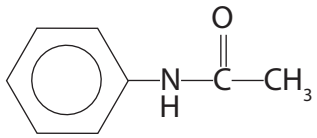
- ☒ **A** CH_3NH_4Cl
- ☒ **B** CH_3NH_3Cl
- ☒ **C** CH_3NH_2Cl
- ☒ **D** NH_4Cl

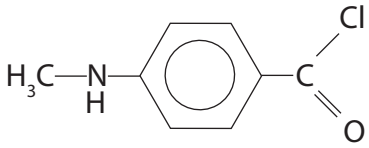
(Total for Question 13 = 1 mark)

14 When benzoyl chloride, C_6H_5COCl, is added to methylamine at room temperature, the main organic product of the reaction is

☒ **A** 

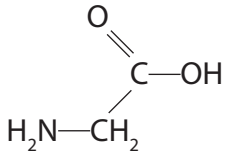
☒ **B** 

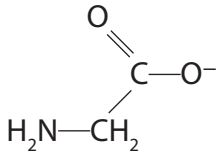
☒ **C** 

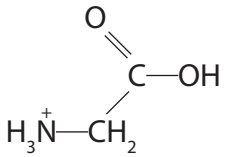
☒ **D** 

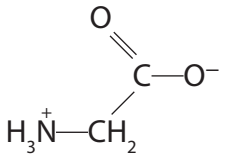
(Total for Question 14 = 1 mark)

15 In an aqueous solution with a pH of 3, the amino acid glycine exists mainly as

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 15 = 1 mark)

16 What is the total number of peaks due to singly charged ions in the **complete** mass spectrum of chlorine, Cl_2?

☒ **A** Two

☒ **B** Three

☒ **C** Four

☒ **D** Five

(Total for Question 16 = 1 mark)

17 The low resolution proton nmr spectrum of a compound contains two peaks. Which of the following compounds could **not** give this spectrum?

☒ **A** Propane

☒ **B** Butane

☒ **C** 2-methylpropane

☒ **D** 2,2-dimethylpropane

(Total for Question 17 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

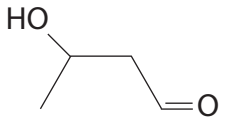
18 A compound, **P**, has the following properties:

P forms a red precipitate when heated with Fehling's or Benedict's solution.

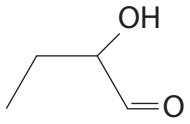
P forms a pale yellow precipitate when warmed with iodine dissolved in aqueous sodium hydroxide.

P could be

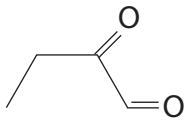
☒ **A**



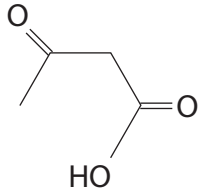
☒ **B**



☒ **C**



☒ **D**



(Total for Question 18 = 1 mark)

19 10 cm^3 of a gaseous hydrocarbon was mixed with excess oxygen and ignited. The gas volumes were measured at room temperature and pressure before and after combustion and it was found that the total gas volume had contracted by 20 cm^3. Given that combustion was complete, the formula of the hydrocarbon was

☒ **A** C_4H_4

☒ **B** C_4H_6

☒ **C** C_4H_8

☒ **D** C_4H_{10}

(Total for Question 19 = 1 mark)

20 Steam distillation may be used in the purification of some compounds. The use of this technique depends on the compound

☒ **A** forming a single layer with water.

☒ **B** forming two layers with water.

☒ **C** having a lower boiling temperature than water.

☒ **D** being flammable.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Potassium manganate(VII) can be used in redox titrations to determine the concentration of iron(II) ions and ethanedioate ions in aqueous solution. Aqueous solutions of potassium manganate(VII) are unstable, so it is often standardized using solutions of iron(II) ammonium sulfate, freshly prepared from Mohr's salt, $Fe(NH_4)_2(SO_4)_2.6H_2O$.

(a) Use the relevant ionic half-equations, and standard reduction potentials on page 17 of the Data Booklet, to answer the following questions. State symbols are not required in the equations.

(i) Write the ionic half-equation for the reduction of manganate(VII) ions in acid solution.

(1)

(ii) Write the ionic half-equation for the oxidation of water to form oxygen and hydrogen ions.

(1)

(iii) Combine your answers to (a)(i) and (a)(ii) to derive an equation to show the production of oxygen in acidified manganate(VII) solution.

(1)

(iv) Calculate $E^{\ominus}_{cell}$ for the reaction in (a)(iii) and hence explain why aqueous solutions of potassium manganate(VII) are unstable.

(2)

.....

.....

(b) 250 cm^3 of a solution containing 10.00 g of Mohr's salt was prepared. Separate 25.0 cm^3 samples of this solution were pipetted into conical flasks, excess sulfuric acid added and then each mixture was titrated against potassium manganate(VII) solution.

The mean titre was 25.85 cm^3.

*(i) Describe in outline how you would prepare the 250 cm^3 of Mohr's salt solution, given 10.00 g of the solid.

(4)

(ii) State what you would see at the end-point of the titration.

(1)

(iii) Write the ionic equation showing that 1 mol of manganate(VII) ions reacts with 5 mol of iron(II) ions in acid conditions. State symbols are not required.

(1)

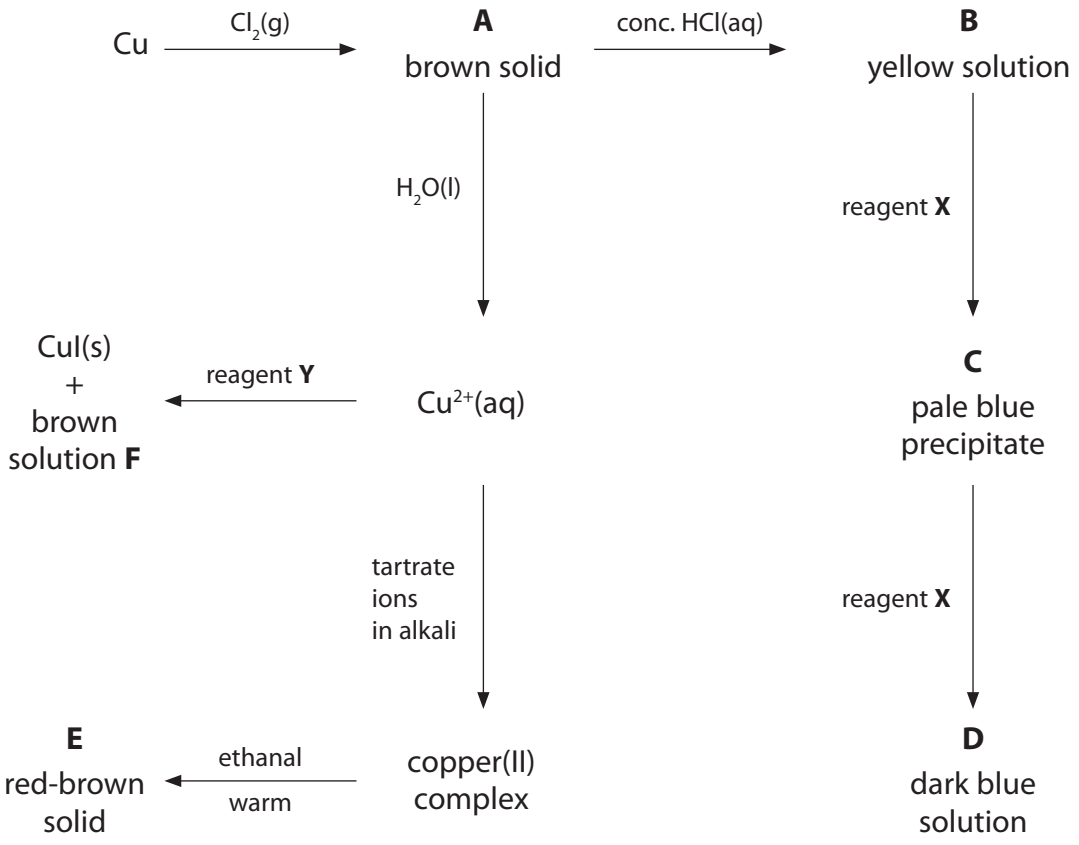
(iv) The concentration of the potassium manganate(VII) solution was stated to be 0.0200 mol dm^{-3}. Calculate the percentage of the potassium manganate(VII) that had reacted between its preparation and the titration.

The molar mass of Mohr's salt is 392 g mol^{-1}.

(4)

(Total for Question 21 = 15 marks)

22 The scheme below summarises some reactions of copper and its compounds.



(a) (i) Identify the copper containing species **A** to **E** either by name, including the oxidation number, or by formula. Also, identify the brown solution, **F**.

(6)

A .....

B .....

C .....

D .....

E .....

F .....

(ii) Identify the reagents **X** and **Y**.

(2)

X .....

Y .....

(iii) Identify the **organic** product of the reaction between the copper(II) complex and ethanal. Hence explain the role of ethanal in the reaction.

(2)

(iv) The reaction between $Cu^{2+}(aq)$ and reagent **Y** forms CuI(s) and a brown solution, **F**. This reaction is the first stage in a method for the determination of the concentration of $Cu^{2+}(aq)$.

Outline briefly how this method is used. Practical details are **not** required.

(1)

*(b) (i) Explain why **B** is coloured.

(4)

(ii) Explain why **B** and **D** have different colours.

(2)

(c) Aqueous copper(I) ions undergo a disproportionation reaction.

(i) Write the ionic equation for this reaction. Include state symbols in your answer.

(1)

(ii) Explain, stating the relevant oxidation numbers, why the reaction in (c)(i) is classified as a disproportionation.

(1)

.....

.....

.....

.....

(iii) Use the standard reduction potentials on page 17 of the Data Booklet to calculate $E^{\ominus}_{cell}$ for this disproportionation. Hence show that this reaction is thermodynamically feasible.

(2)

(Total for Question 22 = 21 marks)

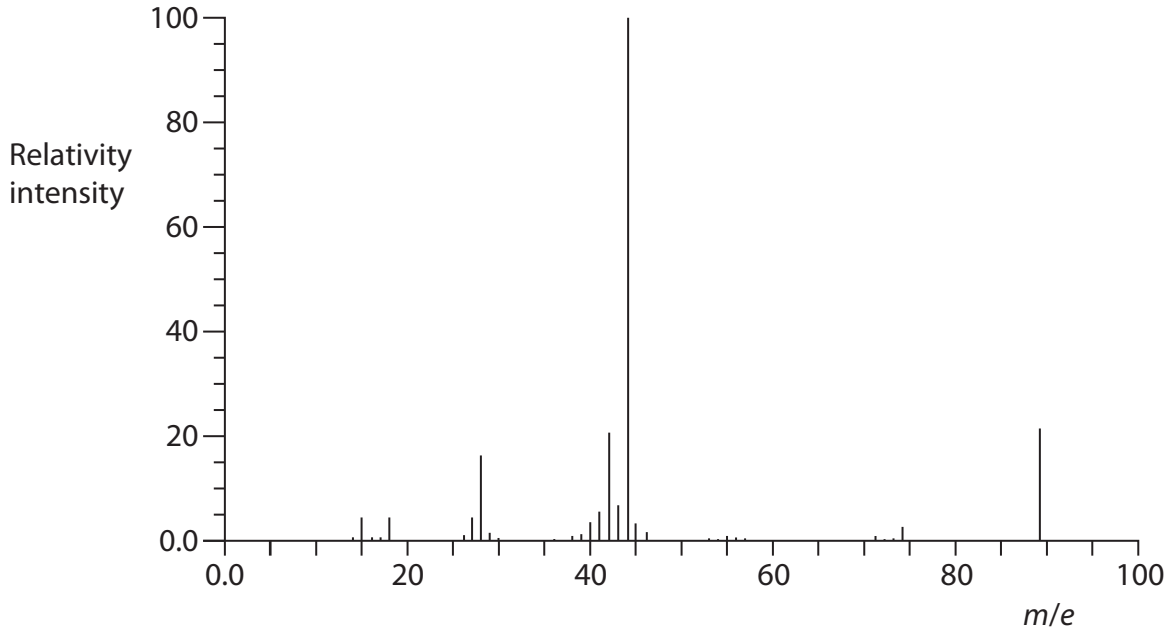
23 Compound **P** is a white crystalline solid with the following percentage composition by mass.

Element	% composition by mass
carbon	40.44
hydrogen	7.87
oxygen	35.96
nitrogen	15.73

(a) Calculate the empirical formula of **P**. You **must** show your working.

(3)

(b) The mass spectrum of **P** is shown below.



(i) Label the molecular ion on the mass spectrum using the symbol M^+.

(1)

(ii) Deduce the molecular formula of **P**.

(1)

(c) **P** was dissolved in sodium carbonate solution and, on heating, a colourless gas, which turned lime water cloudy, was very slowly evolved. When an aqueous solution of **P** was mixed with an aqueous solution of copper(II) sulfate, the blue colour of the copper(II) sulfate solution darkened.

(i) Use the results of these two experiments to deduce the functional groups that are present in **P**. Explain your answers.

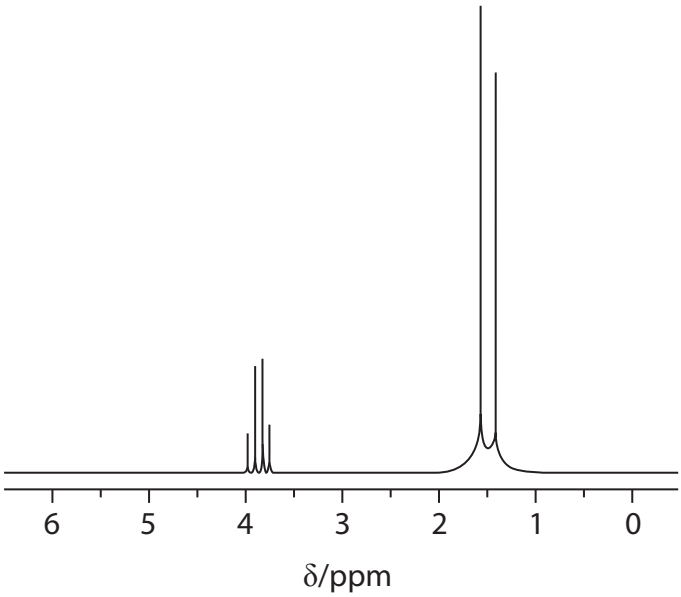
(4)

(ii) There are several compounds which have the formula you have deduced in (b)(ii) and contain the two functional groups you have identified in (c)(i).

Draw the structural or displayed formulae of **two** of these compounds.

(2)

(iii) The nuclear magnetic resonance spectrum of compound **P** is shown below.



This part of the spectrum only shows the peaks due to the hydrogen atoms which are attached directly to carbon atoms.

Use this spectrum to deduce the structure of **P**. Justify your answer.

(2)

.....

.....

.....

(d) Explain why **P** is a solid at room temperature and pressure.

(1)

.....

.....

(Total for Question 23 = 14 marks)

TOTAL FOR SECTION B = 50 MARKS

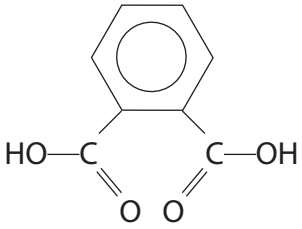
SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

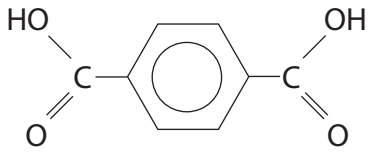
24

Phthalates

The benzene dicarboxylic acids and their esters are important industrial compounds. The structures of two of these acids are shown below.

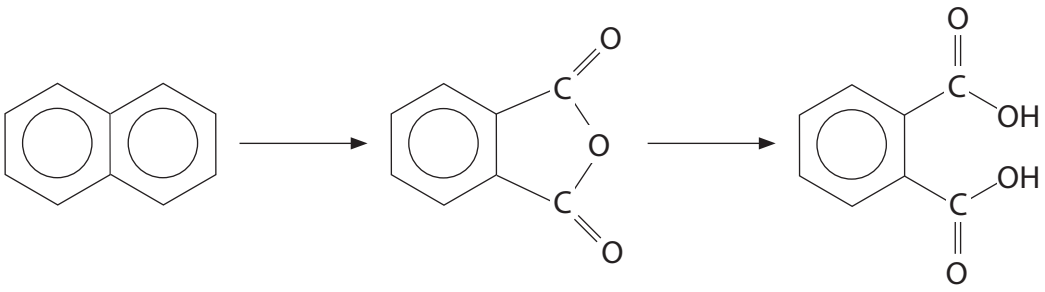


benzene-1,2-dicarboxylic acid



benzene-1,4-dicarboxylic acid

Benzene-1,2-dicarboxylic acid is manufactured by the catalytic oxidation of naphthalene to phthalic anhydride which is then hydrolysed. This reaction sequence is summarised below.



naphthalene

phthalic anhydride

benzene-1,2-dicarboxylic acid

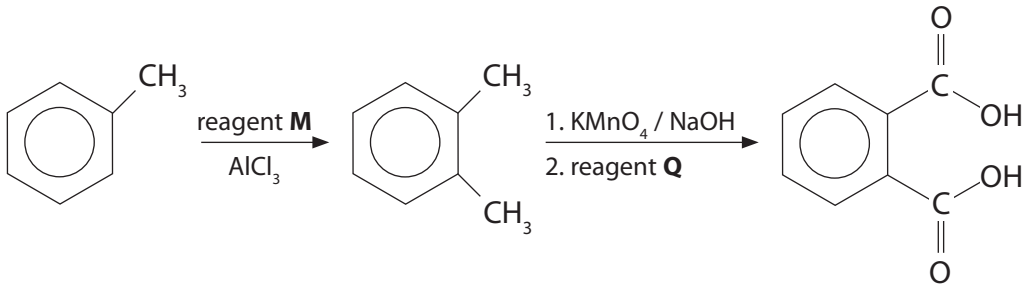
The use of naphthalene as a source of these compounds gave rise to the common names, phthalic acid for benzene-1,2-dicarboxylic acid and terephthalic acid for benzene-1,4-dicarboxylic acid.

The alkyl esters derived from benzene-1,2-dicarboxylic acid are known as phthalates.

Phthalates are used as plasticisers to increase the flexibility of many common plastics. However, some phthalates are known to be endocrine disruptors and recent studies have raised concerns about their role in the fall in human fertility rates. Because phthalates are used in making plastic drinks bottles and leach readily out of the structure, they are easily ingested.

The polyester *Terylene* is derived from benzene-1,4-dicarboxylic acid and ethane-1,2-diol.

(a) One method of preparing benzene dicarboxylic acids in the laboratory is from methylbenzene in the sequence shown below.



(i) Identify reagent **M**, by name or formula.

(1)

.....

(ii) Write the equation for the reaction between **M** and $AlCl_3$ to form an electrophile.

(1)

(iii) Give the mechanism for the reaction of methylbenzene with your electrophile in (a)(ii).

(3)

(iv) Suggest why methylbenzene reacts faster than benzene in this type of reaction.

(2)

(v) In the second step of the synthesis, the potassium manganate(VII) is an oxidizing agent.

Suggest the identity of reagent **Q**, which is added when oxidation is complete.

(1)

(b) In the oxidation of naphthalene to phthalic anhydride, the catalyst is vanadium(V) oxide. With fresh catalyst, the reaction occurs at 360 °C but, over time, the temperature must be slowly increased as the catalyst activity decreases.

(i) State the property which gives transition metal compounds, such as vanadium(V) oxide, catalytic properties.

(1)

.....

.....

(ii) Suggest why the catalyst activity decreases over time.

(1)

.....

.....

.....

(c) The simplest phthalate of benzene-1,2-dicarboxylic acid is its dimethyl ester (1,2-dimethyl benzene-1,2-dicarboxylate).

(i) Draw the structure of this phthalate.

(1)

(ii) Suggest and explain what can be deduced about the interactions between the phthalate and the plastic from the fact that phthalates are readily leached from plastic bottles.

(2)

*(iii) Suggest how a plasticiser works.

(2)

(d) One way of making *Terylene* is by converting benzene-1,4-dicarboxylic acid into the di-acyl chloride and then reacting it with ethane-1,2-diol.

(i) Suggest a reagent that could be used to convert benzene-1,4-dicarboxylic acid into the di-acyl chloride.

(1)

(ii) Suggest an advantage of using the di-acyl chloride rather than the dicarboxylic acid to make the polyester.

(1)

(iii) Draw the structure of the polyester, *Terylene*, showing two repeat units.

(2)

(iv) In practice, the manufacture of *Terylene* involves a process called ester exchange in which ethane-1,2-diol reacts with the dimethyl ester of benzene-1,4-dicarboxylic acid.

What would be the by-product of this reaction?

(1)

.....

.....

(Total for Question 24 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 9 3 A 0 2 8 2 8

PMT

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Mark Scheme (Results)

January 2014

IAL Chemistry (WCH05/01)

Unit 5: General Principles of Chemistry II

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		**1**

Question Number	Correct Answer	Reject	Mark
2	D		**1**

Question Number	Correct Answer	Reject	Mark
3	C		**1**

Question Number	Correct Answer	Reject	Mark
4	D		**1**

Question Number	Correct Answer	Reject	Mark
5	A		**1**

Question Number	Correct Answer	Reject	Mark
6	C		**1**

Question Number	Correct Answer	Reject	Mark
7	D		**1**

Question Number	Correct Answer	Reject	Mark
8	A		**1**

Question Number	Correct Answer	Reject	Mark
9	D		**1**

Question Number	Correct Answer	Reject	Mark
10	B		**1**

Question Number	Correct Answer	Reject	Mark
11	C		**1**

Question Number	Correct Answer	Reject	Mark
12	A		**1**

Question Number	Correct Answer	Reject	Mark
13	B		**1**

Question Number	Correct Answer	Reject	Mark
14	B		**1**

Question Number	Correct Answer	Reject	Mark
15	C		**1**

Question Number	Correct Answer	Reject	Mark
16	D		**1**

Question Number	Correct Answer	Reject	Mark
17	D		**1**

Question Number	Correct Answer	Reject	Mark
18	A		**1**

Question Number	Correct Answer	Reject	Mark
19	A		**1**

Question Number	Correct Answer	Reject	Mark
20	B		**1**

Total for Section A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	In 21(a) IGNORE State symbols even if incorrect Working in half equations (e.g. multipliers & cancelled $e^{(-)}$) $MnO_4^- + 8H^+ + 5e^{(-)} \rightarrow Mn^{2+} + 4H_2O$ ($E^\ominus = 1.51V$) OR Multiples ALLOW reversible and double headed arrows	Electrons omitted	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	$H_2O \rightarrow ½O_2 + 2H^+ + 2e^{(-)}$ ($E^\ominus = 1.23V$) OR Multiples ALLOW reversible and double headed arrows Equation reversed $H_2O - 2e^{(-)} \rightarrow ½O_2 + 2H^+$	Electrons omitted	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	$4MnO_4^- + 12H^+ \rightarrow 4Mn^{2+} + 5O_2 + 6H_2O$ OR $2MnO_4^- + 6H^+ \rightarrow 2Mn^{2+} + 5/2O_2 + 3H_2O$ ALLOW reversible and double headed arrows other multiples uncancelled H^+ and H_2O TE **only** on MnO_4^-|MnO_4^{2-} in (a)(i): $2MnO_4^- + H_2O \rightarrow 2MnO_4^{2-} + ½O_2 + 2H^+$	Uncancelled $e^{(-)}$	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iv)	$E^{\ominus}_{cell}$ = 1.51 – 1.23 = (+)0.28 (V) ALLOW TE on $E^{\ominus}_{cell}$ = −0.67 (V) derived from using MnO_4^-|MnO_4^{2-} if correct equation in (a)(iii) is reversed (1) $E^{\ominus}_{cell}$ is **positive** so reaction is (thermodynamically) feasible / manganate(VII) oxidizes the water / water reduces manganate(VII) ALLOW so **thermodynamically** spontaneous so reaction goes / possible so MnO_4^- unstable (1) No TE on negative $E^{\ominus}_{cell}$ unless correct equation in (a)(iii) is reversed.	Just 'reaction goes'	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	Distilled / deionised water need only be mentioned once. Dissolve solid in (a suitable volume (< 150 cm^3) of) distilled / deionised water / dilute sulfuric acid in a **beaker** (1) Transfer solution to a volumetric / graduated flask (1) add washings (1) Make up to mark / 250 cm^3 **and** mix (1) Preparing the solution in the volumetric flask max 2 (MP2 and MP4) ALLOW Any indication of mixing (e.g. swirl / invert)	Just 'water' conc H_2SO_4 conical flask Just 'flask'	**4**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	colourless /pale yellow to (first permanent pale) pink	purple to pink Purple / mauve	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$ ALLOW multiples reversible and double headed arrows IGNORE state symbols even if incorrect	Uncancelled $e^{(-)}$	**1**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Check the method: If the method is based on [MnO_4^-] being less than 0.02 mol dm^{-3} then correct answer with some working scores full marks. % MnO_4^- remaining = 98.6855 (%) with some correct working scores 3 Correct answer (1.31449 (%)) with no working scores 3 Calculation of the % of the Mohr's salt that has reacted before the titration (assumes [MnO_4^-] = 0.02 mol dm^{-3}) gives (about) the same value and scores max 3 Example of fully correct method Mol Fe^{2+} in 25 cm^3 = (10/392)x(25/250) (1) = 2.55102 x 10^{-3} (*) Mol MnO_4^- in 25.85 cm^3 = Answer */5 (1) = 2.55102 x 10^{-3} / 5 = 5.10204 x 10^{-4} (**) Conc^n of MnO_4^- = 1000 x Answer **/25.85 = 0.019737 mol dm^{-3} (***) (1) % reacted prior to the titration = 100 x (0.02 – Answer ***)/0.02 = 100 x (0.02 – 0.019737) / 0.02 = 1.31449 (%) (1) TE at each stage in the calculation unless conc^n MnO_4^- remaining greater than 0.02 (so % reacted negative) when max 2 **Continued on next page**		**4**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv) continued	A common incorrect calculation is Mol MnO_4^- in 25.85 cm^3 = 25.85 x 0.02/1000 = 5.17 $x10^{-4}$ (0) Mol Fe^{2+} in 25 cm^3 = 5 x 5.17 $x10^{-4}$ = 2.585 x 10^{-3} (1) Mol Fe^{2+} in 250 cm^3 = 10 x 5 x 5.17 $x10^{-4}$ = 2.585 x 10^{-2} Then Actual mol Fe^{2+} in 250 cm^3 = 10/392 = 2.551 $x10^{-2}$ Difference = 2.585$x10^{-2}$ - 2.551 $x10^{-2}$ =0.034 $x10^{-2}$ OR Mass of Mohr's salt = 392 x 2.585 x 10^{-2} = 10.1332 g so difference = 10.1332 – 10 = 0.1332 g (1) Percentage =100 x 0.034 $x10^{-2}$ / 2.585$x10^{-2}$ = 1.3153 (1) Where the calculation breaks down, marks may often be possible for MP1 (mol Fe^{2+} in 25 cm^3) MP2 (**using** 5:1 reacting ratio for Fe^{2+}: MnO_4^-) Ignore SF except 1 SF	1.3333	

Total for Question 21 = 15 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	If name and formula are given, both must be correct **A** = copper(II) chloride / $CuCl_2$ (1) **B** = tetrachlorocuprate(II) (ion) / $CuCl_4^{2-}$ ALLOW **B** = trichlorocuprate(II) / $CuCl_3^-$ (1) **C** = copper(II) hydroxide / $Cu(OH)_2$ / $Cu(OH)_2(H_2O)_4$ (1) **D** = tetraamminecopper(II) (ion) / $Cu(NH_3)_4^{2+}$ / $Cu(H_2O)_2(NH_3)_4^{2+}$ (1) **E** = copper(I) oxide / Cu_2O (1) **F** = iodine / I_2 / triiodide (ion) / I_3^- / KI_3 (1) IGNORE state symbols even if incorrect. **correct** oxidation numbers with formula. order of the ligands.	**B** = $CuCl_2$	**6**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	If name and formula are given, both must be correct **X** = (aqueous) ammonia / $NH_3(aq)$ ALLOW NH_3 / ammonium hydroxide (1) **Y** = potassium iodide / KI ALLOW other soluble iodides (1) IGNORE references to concentration	**X** = NaOH iodide / I^- KI **and** acid HI	**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	(Product is) ethanoic acid / CH_3COOH / ethanoate(ions) / CH_3COO^- (1) IGNORE carboxylic Ethanal is a reducing agent / reduces Cu^{2+} (1) Stand alone marks IGNORE references to oxidation of ethanol products of reduction (e.g. Cu)		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iv)	(Iodine is formed quantitatively and is determined by) titration against sodium thiosulfate solution (of known concentration)	Colorimetry	**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	(3)d orbitals / (3)d subshell split (by the attached ligands) (1) Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy d orbital(s) / levels) ALLOW d—d transitions occur (1) Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light (1) Reflected / transmitted / remaining light is coloured / yellow / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen (1) Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell is split	**4**

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	Colour depends on the frequency /wavelength /energy of the absorbed light (1) Different **ligands** split the d orbitals to a different extent (1)		**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	$2Cu^{+}(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$ ALLOW reversible arrows	Electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	The copper(I) is oxidized to copper(II) and (in the same reaction) reduced to copper((0)) OR Copper changes from +1 to 0 and +2 IGNORE Reference to a Cu atom		**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	Relevant reduction potentials are $Cu^{2+} + e^{-} \rightleftharpoons Cu^{+}$ $E^{\ominus} = +0.15$ (V) $Cu^{+} + e^{-} \rightleftharpoons Cu$ $E^{\ominus} = +0.52$ (V) ALLOW single arrows (1) $E^{\ominus}_{cell} = 0.52 - 0.15 = (+)0.37$ (V) (1) TE on incorrect $E^{\ominus}$ values providing $E^{\ominus}_{cell}$ is positive (E^{o}_{cell} positive so reaction thermodynamically favourable)		**2**

Total for Question 22 = 21 marks

Question Number	Acceptable Answers	Reject	Mark
23(a)			

Element	%		mol	Ratio
C	**40.44**	**÷12**	**= 3.37**	**2.999**
H	**7.87**	**÷ 1**	**= 7.87**	**7.004**
O	**35.96**	**÷ 16**	**= 2.2475**	**2.000**
N	**15.73**	**÷ 14**	**= 1.12357**	**1.000**
			(1)	**(1)**

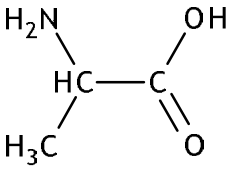
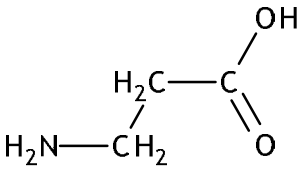
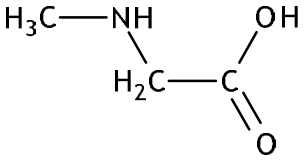
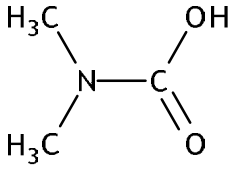
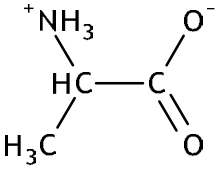
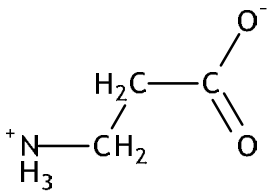
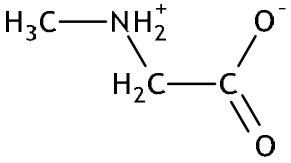
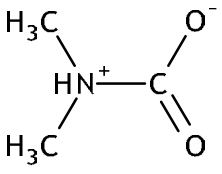
Empirical formula = $C_3H_7O_2N$ (1)
Symbols in any order
Stand alone mark
No TE on incorrect ratio
IGNORE significant figure and rounding errors except 1sf in mole calculation

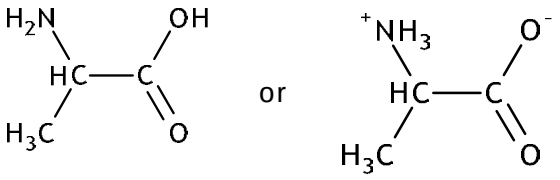
3

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	Peak at *m/e* = 89 labelled M^+ ALLOW Any clear label e.g. $C_3H_7O_2N^+$		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	M_r = 89 = M_r ($C_3H_7O_2N$) so molecular formula is **$C_3H_7O_2N$** Symbols in any order IGNORE structural and displayed formulae	Answer with no explanation M_r = 90 $C_3H_7O_2N^+$	**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	Gas evolved is carbon dioxide / CO_2 (1) (so carboxylic) acid / -COOH group is present (1) Dark blue colour indicates the formation of a (copper(II)) **complex** ALLOW indicates **ligand exchange** has occurred (1) Suggests that an amine / $-NH_2$ group is present ALLOW NH (1) IGNORE ammine amino acid	NH_3 complexes Amide group	**4**

Question Number	Acceptable Answers	Reject	Mark
23(c)(ii)	Any 2 of A, B, C or D (1 mark for each) <u>Molecules</u> A  B  C  D  <u>Zwitterions</u> A  B  C  D  Or fully displayed structures		**2**

Question Number	Acceptable Answers	Reject	Mark
23(c)(iii)	**First mark** **P** has structure A  **Second mark** EITHER Splitting pattern quartet due to CH next to CH_3 and doublet due to CH_3 next to CH ALLOW A comparison e.g A has quartet & doublet but B has two triplets OR As the areas / heights of the two peaks are in a 3:1 ratio (approximately), there must be 3 protons in one environment and 1 in another No TE if A is not one of the isomers given in (c)(ii)	Just quartet & doublet Just two peaks	**2**

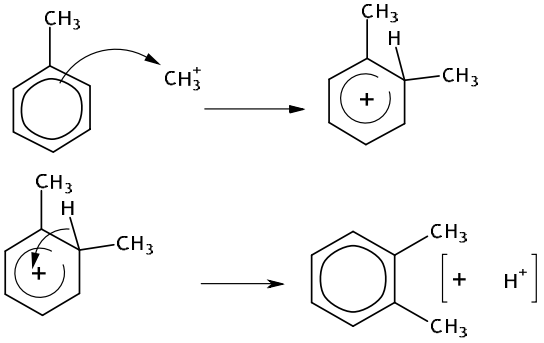
Question Number	Acceptable Answers	Reject	Mark
23(d)	**P** (is an amino acid) exists as a zwitterion ALLOW Zwitterion formula OR molecules are held together by (strong) **ionic** forces IGNORE Just 'electrostatic forces'		**1**

Total for Question 23 = 14 marks
Total for Section B = 50 mark

Section C

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	M = chloro- /bromo- / iodo- methane / CH_3Cl / CH_3Br / CH_3I		**1**

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	$CH_3X + AlCl_3 \rightarrow CH_3^+ + AlXCl_3^-$ Ignore curly arrows even if incorrect Ignore state symbols even if incorrect		**1**

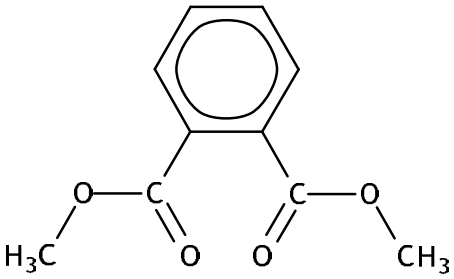
Ques. No.	Acceptable Answers	Reject	Mark
24(a) (iii)	 TE on incorrect electrophile in (a)(ii) If benzene used instead of methylbenzene OR If final product not 1,2-dimethylbenzene (max 2) Curly arrow from on or within the circle to positively charged carbon ALLOW Curly arrow from anywhere within the hexagon Arrow to any part of the CH_3^+ including to the + charge (1) Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** some part of the positive charge must be within the horseshoe (1) Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure (1) Correct Kekulé structures score full marks Ignore any involvement of AlX_4^- in the final step	Curly arrow on or outside the hexagon Dotted bonds to H and CH_3	**3**

Question Number	Acceptable Answers	Reject	Mark
24(a)(iv)	The methyl group donates / pushes electrons into the benzene ring (because of its positive inductive effect / donating inductive effect) (1) (Increased electron density) makes the ring more susceptible to electrophilic attack (1) IGNORE Activating group / ring activation	Mention of lone pair Just 'reacts faster'	**2**

Question Number	Acceptable Answers	Reject	Mark
24(a)(v)	Any identified (name or formula) strong mineral acid: sulfuric acid / $H_2SO_4(aq)$ / hydrochloric acid / $HCl(aq)$ / nitric acid / $HNO_3(aq)$ ALLOW Formulae without (aq) concentrated (acid) IGNORE dilute 'acid' $H^+(aq)$ / H^+ addition of extra alkali before adding acid		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Oxidation state / oxidation number /valency easily changed ALLOW 'Just' variable oxidation state / oxidation number /valency OR easily oxidized **and** reduced IGNORE references to d orbitals / active sites		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	Surface area of catalyst decreases OR Number of active sites is reduced ALLOW Active sites blocked OR Catalyst is poisoned	Active sites saturated / occupied by **reactants** denatured	**1**

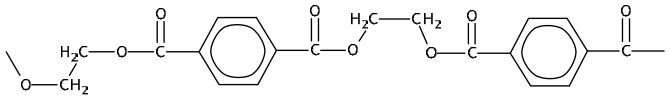
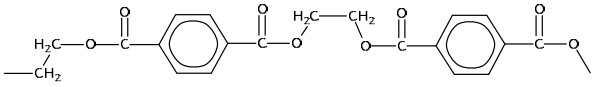
Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	 ALLOW $COOCH_3$ for ester group skeletal / displayed structures omission of benzene ring circle.		**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	The forces between plasticiser / phthalate and polymer molecules are weak (1) So London /dispersion /van der Waals forces (rather than covalent bonds) ALLOW dipole-dipole forces OR Forces between water and plasticiser / phthalate molecules are strong(er) / hydrogen bonds (1)	hydrogen bonds	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	Any **two** of The intermolecular forces between the plasticiser and the polymer molecules are weaker than the those between polymer molecules (1) The polymer molecules move over one another more easily (1) Plasticiser molecules disrupt the polymer structure (1)	break cross-linking between polymer molecules / (covalent) bonds	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	PCl_5 / phosphorus(V) chloride / phosphorus pentachloride OR PCl_3 / phosphorus(III) chloride / phosphorus trichloride OR $SOCl_2$ / thionyl chloride / thionyl dichloride		**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	Reaction goes to completion / (much) faster / not reversible / not an equilibrium / higher yield / catalyst not needed / uses less energy ALLOW Heat / increased temperature not required. Reverse arguments. IGNORE Cost / reacts easily. More reactive.		**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	 OR  ALLOW –$COOCH_2CH_2OOC$– for diester link **three** ester links (i.e. – CO-O-CH_2-) only if polymer is open-chained (non-cyclic) **and** at least a dimer (1) remaining structure (1) this mark is **not** stand alone IGNORE $()_n$	Omission of benzene ring circle	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iv)	Methanol / CH_3OH	alcohol	**1**

Total for Question 24 = 20 marks
Total for Section C = 20 marks

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Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Tuesday 17 June 2014 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/6/3/3/

P 4 2 9 7 3 A 0 1 2 8

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 In which of the following ions does the metal have an oxidation number of +3?

☒ **A** MnO_4^{2-}

☒ **B** VO^{2+}

☒ **C** $[Fe(CN)_6]^{4-}$

☒ **D** $[CrCl_2(H_2O)_4]^{+}$

(Total for Question 1 = 1 mark)

2 Copper metal is oxidized to Cu^{2+} by nitrate(V) ions which are reduced to nitrogen monoxide, NO.
By considering the changes to the oxidation numbers of copper and nitrogen, it can be deduced that in this reaction

☒ **A** 2 mol of copper reacts with 3 mol of nitrate(V) ions.

☒ **B** 2 mol of copper reacts with 5 mol of nitrate(V) ions.

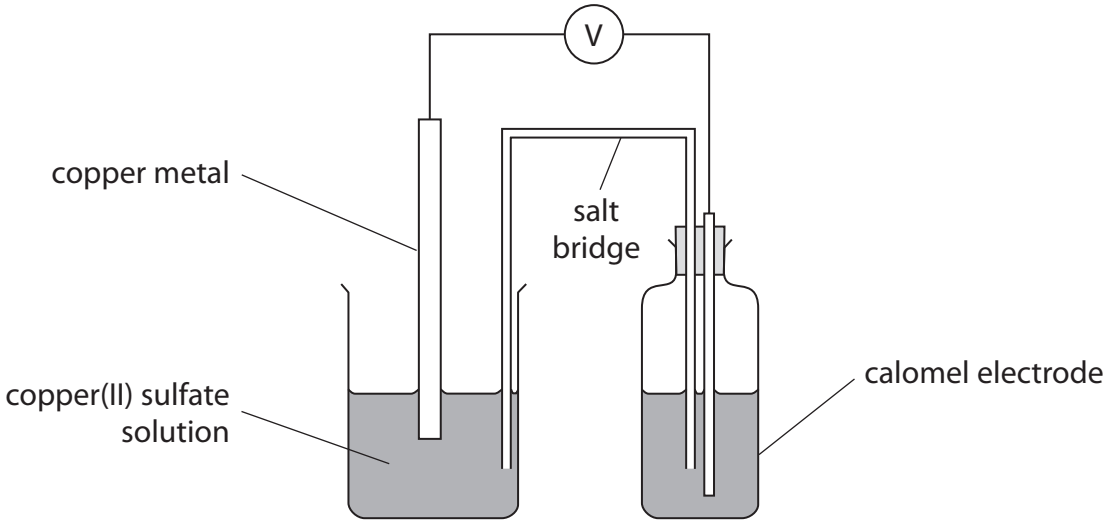
☒ **C** 3 mol of copper reacts with 2 mol of nitrate(V) ions.

☒ **D** 5 mol of copper reacts with 2 mol of nitrate(V) ions.

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 The diagram below shows a cell set up between a copper metal / copper(II) ion electrode and a reference electrode, known as a calomel electrode.



Under standard conditions, the emf of this cell was −0.07 V. The standard electrode potential of the copper metal / copper(II) ion electrode is +0.34 V. Hence the standard electrode potential of the calomel electrode is

☒ **A** −0.41 V

☒ **B** −0.27 V

☒ **C** +0.27 V

☒ **D** +0.41 V

(Total for Question 3 = 1 mark)

---

4 For the reaction

$$2NO_2(g) \rightleftharpoons N_2O_4(g)$$

at 450 K the total entropy change, ΔS_{total}, is negative. Hence the equilibrium constant, K_p, for this reaction at 450 K is

☒ **A** zero.

☒ **B** positive and greater than 1.

☒ **C** positive and less than 1.

☒ **D** negative.

(Total for Question 4 = 1 mark)

---

5 The standard electrode potentials of two half reactions are shown below.

$$\tfrac{1}{2}Cl_2 + e^- \rightleftharpoons Cl^- \qquad E^{\ominus} = +1.36\ V$$

$$Co^{3+} + e^- \rightleftharpoons Co^{2+} \qquad E^{\ominus} = +1.82\ V$$

Which of the following processes is thermodynamically favourable? The reaction of

- ☒ **A** Co^{2+} with Cl_2 to form Cl^-
- ☒ **B** Co^{2+} with Cl^- to form Cl_2
- ☒ **C** Co^{3+} with Cl_2 to form Cl^-
- ☒ **D** Co^{3+} with Cl^- to form Cl_2

(Total for Question 5 = 1 mark)

6 A solution of potassium manganate(VII) was used to determine the concentration of iron(II) ions in solution by titration in the presence of excess dilute sulfuric acid.

(a) With the potassium manganate(VII) in the burette, the end-point of the reaction is when the solution in the conical flask turns

(1)

- ☒ **A** colourless.
- ☒ **B** pink.
- ☒ **C** green.
- ☒ **D** orange.

(b) If insufficient acid is added, the titre value is

(1)

- ☒ **A** low and a brown precipitate forms.
- ☒ **B** low and a green precipitate forms.
- ☒ **C** high and a brown precipitate forms.
- ☒ **D** high and a green precipitate forms.

(Total for Question 6 = 2 marks)

7 What is the electronic configuration of the stable scandium ion?

- ☒ **A** [Ar] $3d^0\ 4s^2$
- ☒ **B** [Ar] $3d^1\ 4s^1$
- ☒ **C** [Ar] $3d^0\ 4s^1$
- ☒ **D** [Ar] $3d^0\ 4s^0$

(Total for Question 7 = 1 mark)

8 The shapes of the complexes $[CrCl_4]^-$ and $[Pt(NH_3)_2Cl_2]$ are

	$[CrCl_4]^-$	$[Pt(NH_3)_2Cl_2]$
☒ **A**	square planar	square planar
☒ **B**	tetrahedral	tetrahedral
☒ **C**	square planar	tetrahedral
☒ **D**	tetrahedral	square planar

(Total for Question 8 = 1 mark)

9 The compound 1,2-diaminoethane, $H_2NCH_2CH_2NH_2$, is a bidentate ligand; in formulae, it is usually abbreviated to 'en'.

When 1,2-diaminoethane is added to $[Co(NH_3)_6]^{2+}$ in aqueous solution, $[Co(en)_3]^{2+}$ is formed. What is the **best** explanation for this?

☒ **A** There are much stronger bonds between the ligands and the cobalt(II) ion in $[Co(en)_3]^{2+}$ than in $[Co(NH_3)_6]^{2+}$.

☒ **B** When $[Co(en)_3]^{2+}$ is formed from $[Co(NH_3)_6]^{2+}$ the reaction is exothermic.

☒ **C** When $[Co(en)_3]^{2+}$ is formed from $[Co(NH_3)_6]^{2+}$ the total entropy change is positive.

☒ **D** When $[Co(en)_3]^{2+}$ is formed from $[Co(NH_3)_6]^{2+}$ the reaction has a low activation energy.

(Total for Question 9 = 1 mark)

10 When aqueous sodium hydroxide is added to an aqueous solution of a transition metal compound, a green precipitate is formed which dissolves in excess sodium hydroxide forming a green solution. The transition metal ion present in the original solution is

☒ **A** Cr^{3+}

☒ **B** Fe^{3+}

☒ **C** Fe^{2+}

☒ **D** Ni^{2+}

(Total for Question 10 = 1 mark)

11 Benzene reacts with a nitrating mixture of concentrated nitric and sulfuric acids. Which species is **least** likely to be present in the nitrating mixture?

- ☒ **A** NO_3^-
- ☒ **B** H_3O^+
- ☒ **C** HSO_4^-
- ☒ **D** NO_2^+

(Total for Question 11 = 1 mark)

12 Benzene (T_b = 80.1 °C) has a higher boiling temperature than ethanol (T_b = 78.5 °C). This is because the

- ☒ **A** benzene ring is stabilised.
- ☒ **B** London forces between benzene molecules are stronger than the hydrogen bonds between ethanol molecules.
- ☒ **C** hydrogen bonds between benzene molecules are stronger than the hydrogen bonds between ethanol molecules.
- ☒ **D** C–H bonds in benzene are stronger than the C–H bonds in ethanol.

(Total for Question 12 = 1 mark)

13 Separate 0.1 mol dm^{-3} aqueous solutions of ammonia, methylamine and phenylamine were prepared. Which of the following sequences shows the solutions in order of **increasing** pH?

- ☒ **A** phenylamine, methylamine, ammonia
- ☒ **B** phenylamine, ammonia, methylamine
- ☒ **C** methylamine, ammonia, phenylamine
- ☒ **D** methylamine, phenylamine, ammonia

(Total for Question 13 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

14 The benzenediazonium ion, $C_6H_5N_2^+$, is an intermediate in the preparation of azo dyes.

(a) In the formation of an azo dye, the benzenediazonium ion is

(1)

☒ **A** an electrophile.

☒ **B** a nucleophile.

☒ **C** a carbocation.

☒ **D** a substituent.

(b) The temperature of the aqueous reaction mixture must be kept below 10 °C to prevent the benzenediazonium ion being converted into

(1)

☒ **A** benzene.

☒ **B** nitrobenzene.

☒ **C** phenylamine.

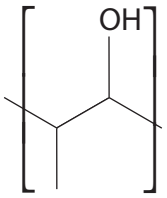
☒ **D** phenol.

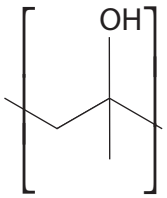
(Total for Question 14 = 2 marks)

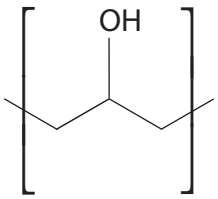
Use this space for any rough working. Anything you write in this space will gain no credit.

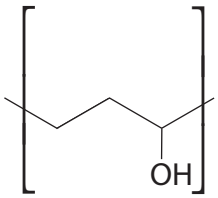
15 The monomer of the addition polymer poly(propenol) may be represented as $CH_3–CH=CHOH$.

The repeat unit of the addition polymer is

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 15 = 1 mark)

16 Chromatography may be used to separate mixtures of amino acids. This is best explained by the fact that different amino acids have different interactions with

☒ **A** the mobile phase only.

☒ **B** the stationary phase only.

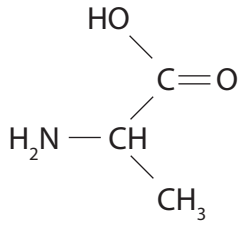
☒ **C** the mobile phase **and** the stationary phase.

☒ **D** ninhydrin.

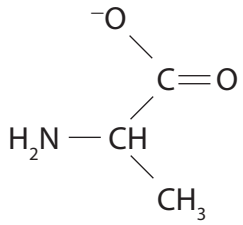
(Total for Question 16 = 1 mark)

17 In an aqueous solution with a pH of 7, the amino acid alanine exists mainly as

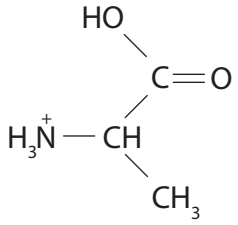
☒ **A**



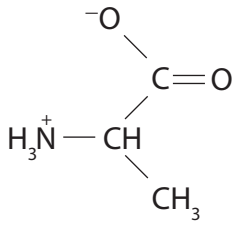
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

18 When a solid is purified by recrystallization, the procedure involves the removal of impurities by filtration of the hot mixture followed by filtration of the cold mixture. Which impurities are removed by these two filtrations?

	Hot filtration	Cold filtration
☒ **A**	insoluble impurities	insoluble impurities
☒ **B**	insoluble impurities	soluble impurities
☒ **C**	soluble impurities	insoluble impurities
☒ **D**	soluble impurities	soluble impurities

(Total for Question 18 = 1 mark)

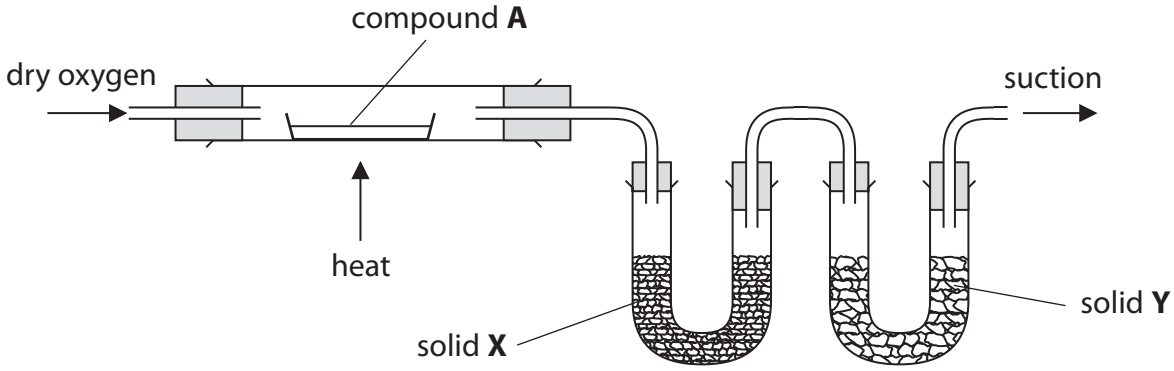
TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

19 A compound **A**, known to contain only the elements carbon, hydrogen and oxygen, was subjected to detailed analysis.

(a) A sample of **A** was burned completely in the apparatus shown below. Solid **X** absorbed the water formed in the combustion and solid **Y** absorbed the carbon dioxide.



(i) Explain why the oxygen must be dry.

(1)

(ii) Suggest a suitable substance to use as solid **X**.

(1)

(iii) Suggest a suitable substance to use as solid **Y**.

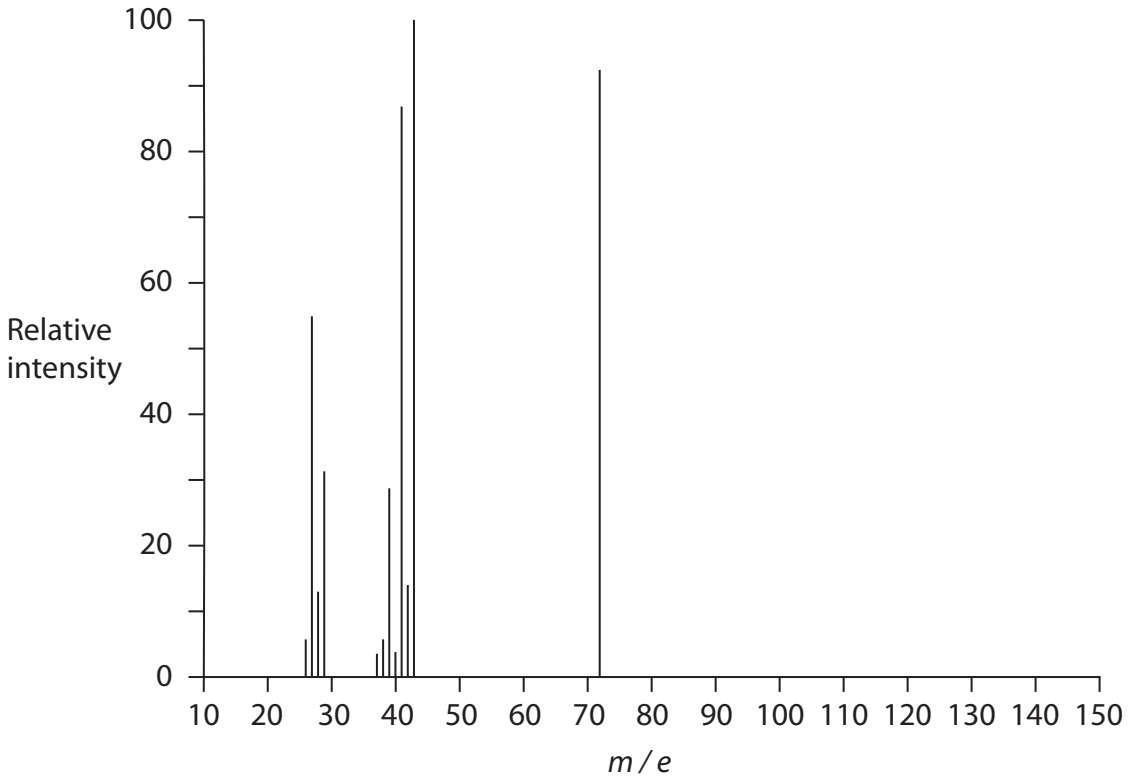
(1)

(iv) 3.60 g of compound **A** was burned completely. The mass of solid **X** increased by 3.60 g and the mass of solid **Y** increased by 8.80 g.

Use these data to calculate the empirical formula of compound **A**.
You **must** show your working.

(5)

(b) The mass spectrum of **A** is shown below.



(i) Identify the molecular ion peak and hence deduce the molecular formula of **A**.

(2)

(ii) Given that **A** does **not** have a ring structure, suggest the **structural** formulae of three of the species that might cause the peak at *m/e* = 43 in the mass spectrum of **A**.

(3)

*(c) The low resolution nmr spectrum of **A** has three peaks in the ratio 6:1:1. Draw the structure of **A** and show how your structure is consistent with the nmr data.

(3)

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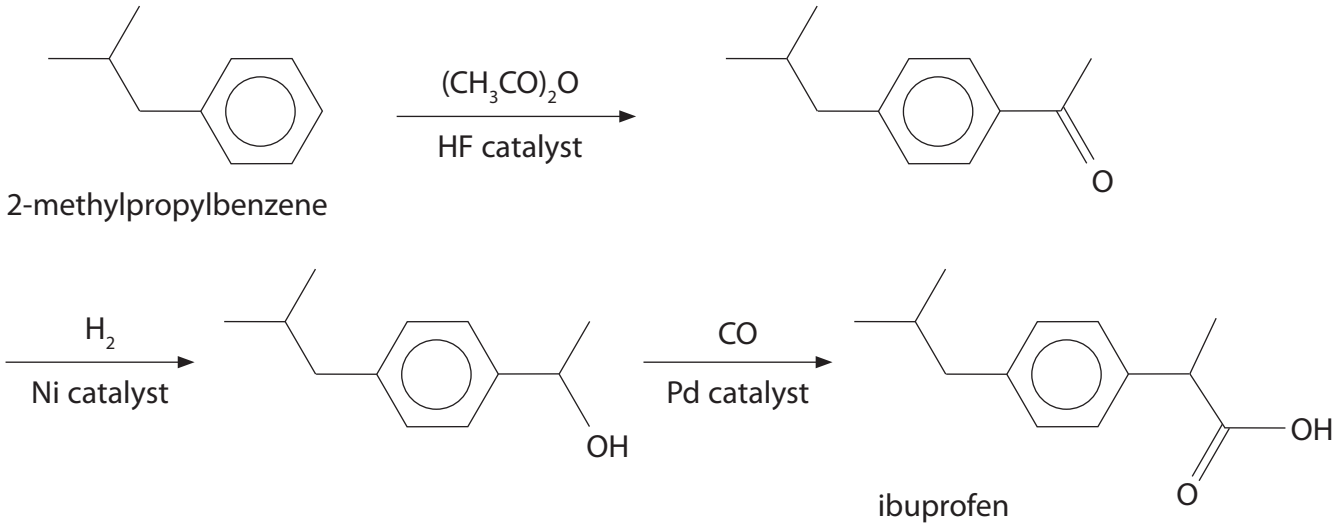
.....

(Total for Question 19 = 16 marks)

20 Ibuprofen is a nonsteroidal anti-inflammatory drug (NSAID) widely used as an analgesic (pain reliever). It was discovered in the 1960s by the Boots Group which developed a six step synthesis from 2-methylpropylbenzene. The synthesis shown below was introduced in the 1990s by the BHC Company and received a Presidential Green Chemistry Challenge award in 1997. The citation noted that the synthesis has just three steps, all of which are catalytic, and an effective atom economy of 99%. Both syntheses are carried out in solution.



(a) (i) Suggest why a three step synthesis is likely to be 'greener' than a six step process.

(1)

.....

.....

(ii) Why does the use of catalysts make processes 'greener' (as well as faster)?

(1)

.....

.....

(b) The first step of the synthesis is an electrophilic substitution which is usually carried out in a school laboratory using ethanoyl chloride and an aluminium chloride catalyst.

(i) Write an equation showing the formation of the electrophile in the **school** experiment.

(1)

(ii) Give the mechanism for the electrophilic substitution of 2-methylpropylbenzene by ethanoyl chloride, using the electrophile you have given in (b)(i).

(3)

(iii) Suggest **one** environmental benefit of using $(CH_3CO)_2O$, rather than ethanoyl chloride, in the manufacture of ibuprofen.

(1)

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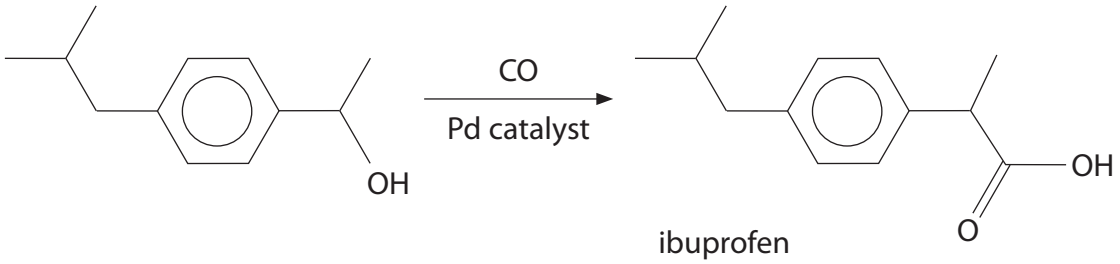
(c) The final stage of the modern synthesis for ibuprofen is shown below.



ibuprofen

(i) Suggest a benefit of using a **solid** catalyst in this reaction.

(1)

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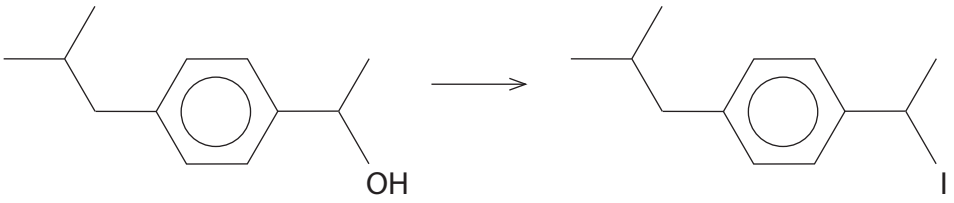
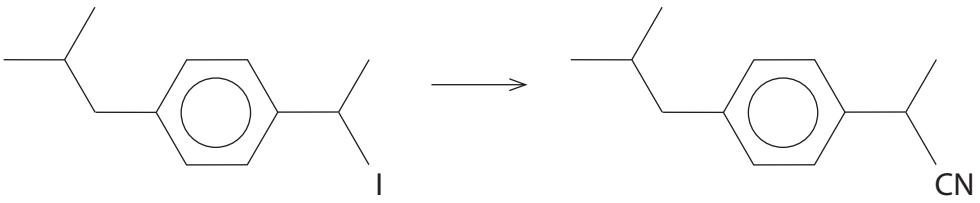
(ii) The preparation in part (c) can be carried out in a laboratory in three reactions.

(3)

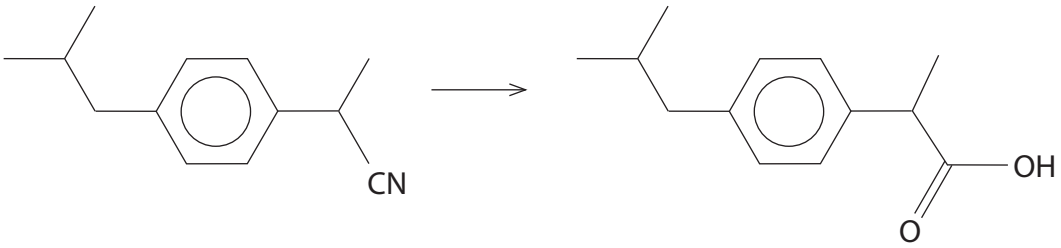
Reaction 1



Reaction 2



Reaction 3



Give:

The reagents for **Reaction 1**

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The reagents and conditions for **Reaction 3**

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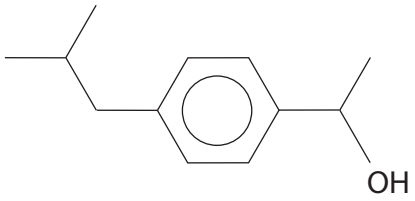
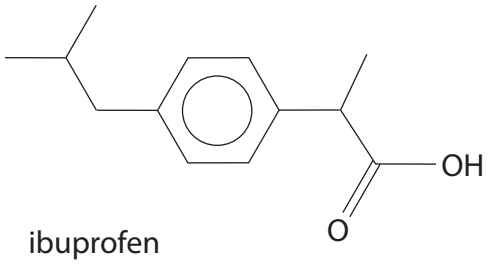
.....

(iii) Using your Data Booklet, explain how infrared spectroscopy can be used to distinguish between the two structures shown below.

(2)





ibuprofen

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(d) Ibuprofen is a chiral molecule and only one of its enantiomers is biologically active. However, although the synthesis produces a racemic mixture, an isomerase enzyme in the body converts the inactive enantiomer into the active enantiomer.

(i) Explain the term 'chiral molecule'.

(1)

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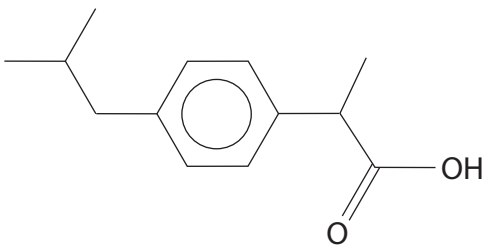
(ii) Mark with an asterisk (*) the chiral centre on the structure of ibuprofen below.

(1)



(iii) Explain the term 'racemic mixture'.

(1)

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(iv) Suggest **two** benefits that arise from the isomerization of the inactive enantiomer of ibuprofen.

(2)

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(Total for Question 20 = 18 marks)

21 (a) The following method was used to estimate the concentration of ethanol in an aqueous solution, **Q**, prepared by the fermentation of sucrose.

25 cm^3 of **Q** was measured using a pipette and transferred to a 250 cm^3 volumetric flask; the flask was made up to the mark with distilled water and mixed thoroughly, forming a diluted solution, **R**.

25 cm^3 samples of **R** were mixed with an equal volume of a 0.200 mol dm^{-3} potassium dichromate(VI) solution and excess dilute sulfuric acid.

The mixture was allowed to stand for several hours and then the amount of unreacted potassium dichromate(VI) was determined by titration against a 0.255 mol dm^{-3} iron(II) ammonium sulfate solution. The mean titre was 23.85 cm^3.

(i) Use the ionic half-equations below to write the full ionic equation for the reaction between potassium dichromate(VI) and iron(II) ammonium sulfate.

State symbols are not required.

(1)

$$Fe^{3+} + e^- \rightarrow Fe^{2+}$$

$$Cr_2O_7^{2-} + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$$

(ii) Calculate the number of moles of potassium dichromate(VI) that remained **unreacted** after standing for several hours with solution **R**.

(2)

(iii) Calculate the number of moles of potassium dichromate(VI) that reacted with the ethanol while standing for several hours with solution **R**.

(2)

(iv) Write an ionic half-equation for the oxidation of ethanol to ethanoic acid.

Use your equation, and the half-equation for the reduction of dichromate(VI) ions, to show that 3 mol of ethanol are oxidized by 2 mol of potassium dichromate(VI).

(2)

.....

.....

(v) Calculate the concentration of ethanol (in mol dm^{-3}) in solution **Q**.

(3)

*(b) The indicator used in this titration was barium diphenylamine sulfonate, which turns from deep purple to colourless at the end-point.

Identify the ion responsible for turning the indicator from deep purple to colourless at the end-point.

By considering the type of reaction involved when this ion reacts with barium diphenylamine sulfonate, suggest how barium diphenylamine sulfonate acts as an indicator in this titration. Note that complex formation does **not** occur. The detailed reactions of this particular indicator are **not** required.

(3)

*(c) This method of determining ethanol concentration does not give very reliable results, although the titration is very accurate.

Suggest **one** reason why this might be the case, explaining how the measured concentration would differ from the actual concentration of the ethanol.

(3)

(Total for Question 21 = 16 marks)

TOTAL FOR SECTION B = 50 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

22

Metal Complexes

Complexes involve ligands forming dative covalent bonds with a central cation; the number of dative covalent bonds is the coordination number of the cation in the complex. Complexes may be positive, negative or neutral. The ligands may be neutral or negatively charged, but are never positively charged. The ligands must have a lone pair of electrons. In some complexes the central atom is neutral, as is the case with nickel carbonyl which is used in the Mond process for the purification of nickel:

$$Ni(s) + 4CO(g) \rightleftharpoons Ni(CO)_4(g)$$

The formation of complexes is typical of transition metals but other elements also form complexes. Zinc, which is a d block element but not a transition metal, and aluminium, which is a Group 3 element, both form complexes. Transition metal complexes are usually coloured, but if the interaction between the ligand and the central ion is very strong, then the resulting complex may well be colourless. This is the case with the complex $[FeF_6]^{3-}$.

The ligand in a complex affects its redox properties and this is apparent from considering the relevant standard electrode potentials. For example, with copper(II) species:

$$[Cu(H_2O)_6]^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) + 6H_2O(l) \qquad E^{\ominus} = +0.34\ V$$

$$[Cu(H_2O)_2(NH_3)_4]^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) + 2H_2O(l) + 4NH_3(aq) \qquad E^{\ominus} = -0.05\ V$$

Complexes are industrially important, for example in the purification of nickel mentioned above and in the extraction of gold which involves the complex $[Au(CN)_2]^-$.

Complex formation is used in estimating the concentrations of metal ions in solution. Examples of this are the use of EDTA in titration and dimethylglyoxime in gravimetric analysis. Complexes are also used in qualitative analysis, for example, in Tollens' reagent. This reagent is usually prepared by the addition of sodium hydroxide solution to an aqueous solution of silver nitrate followed by aqueous ammonia. The resulting solution contains diamminesilver(I) ions.

(a) The hydrated copper(II) ion is classed as a complex but the hydrated sodium ion is not. By considering the interaction between the water molecules and the sodium ion, explain why the hydrated sodium ion is **not** considered to be a complex.

(2)

(b) Suggest how the aluminium ion is able to form dative covalent bonds in its complexes such as $[AlF_6]^{3-}$.

(1)

*(c) (i) Transition metal complexes are usually coloured. Explain how the colours occur.

(4)

(ii) Why are zinc complexes such as $[Zn(NH_3)_4]^{2+}$ colourless?

(1)

(iii) Suggest why the strong interactions between the F^- ligands and Fe^{3+} ion result in the complex $[FeF_6]^{3-}$ being colourless.

(2)

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(d) Use the standard electrode potentials given in the passage to predict whether it is feasible for thiosulfate ions, $S_2O_3^{2-}$, to reduce copper(II) ions to copper. Consider the case when the copper(II) ions are dissolved in water, and when they are dissolved in aqueous ammonia. Give chemical equations to support your answer.

(3)

The relevant redox reaction for thiosulfate ions is

$$S_4O_6^{2-}(aq) + 2e^- \rightleftharpoons 2S_2O_3^{2-}(aq) \qquad E^{\ominus} = +0.09\ V$$

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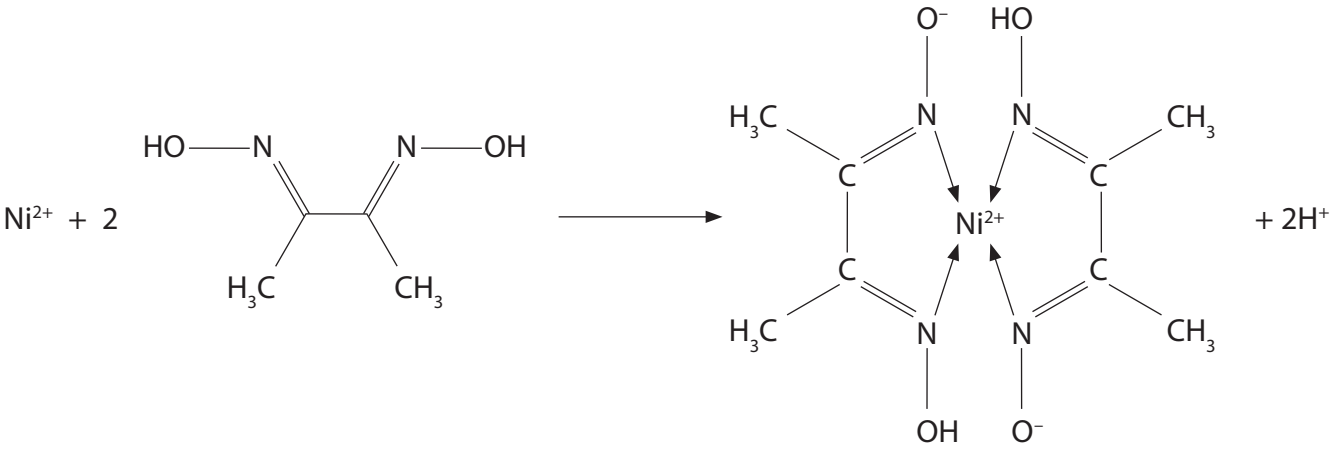
.....

(e) The proportion of nickel in nisil, an alloy of nickel and silicon used in thermocouples, may be determined by the following gravimetric analysis.

Finely ground nisil is dissolved in concentrated hydrochloric acid and, after neutralization, excess dimethylglyoxime dissolved in ethanol is added to the solution formed. The resulting red precipitate is filtered, washed, dried and weighed. The equation for the formation of the precipitate is



(i) State the coordination number of the nickel in the complex ion.

(1)

.....

(ii) In an experiment, 1.02 g of nisil formed 4.82 g of the complex. Calculate the percentage by mass of nickel in the alloy. The molar mass of the complex is 288.7 g mol^{-1}.

(2)

(f) Suggest why the nickel carbonyl complex is used to purify nickel ores.

(1)

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(g) Use the equilibria below to explain why ammonia is used to prepare Tollens' reagent, as described in the passage.

(3)

$2Ag^+(aq) + 2OH^-(aq) \rightleftharpoons Ag_2O(s) + H_2O(l)$ Equilibrium 1

$Ag^+(aq) + 2NH_3(aq) \rightleftharpoons Ag(NH_3)_2^+(aq)$ Equilibrium 2

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(Total for Question 22 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 7 3 A 0 2 8 2 8

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Mark Scheme (Results)

June 2014

GCE Chemistry 6CH05/01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	D		**1**

Question Number	Correct Answer	Reject	Mark
2	C		**1**

Question Number	Correct Answer	Reject	Mark
3	C		**1**

Question Number	Correct Answer	Reject	Mark
4	C		**1**

Question Number	Correct Answer	Reject	Mark
5	D		**1**

Question Number	Correct Answer	Reject	Mark
6 (a)	B		**1**
6 (b)	C		**1**

Question Number	Correct Answer	Reject	Mark
7	D		**1**

Question Number	Correct Answer	Reject	Mark
8	D		**1**

Question Number	Correct Answer	Reject	Mark
9	C		**1**

Question Number	Correct Answer	Reject	Mark
10	A		**1**

Question Number	Correct Answer	Reject	Mark
11	A		**1**

Question Number	Correct Answer	Reject	Mark
12	B		**1**

Question Number	Correct Answer	Reject	Mark
13	B		**1**

Question Number	Correct Answer	Reject	Mark
14 (a)	A		**1**
14 (b)	D		**1**

Question Number	Correct Answer	Reject	Mark
15	A		**1**

Question Number	Correct Answer	Reject	Mark
16	C		**1**

Question Number	Correct Answer	Reject	Mark
17	D		**1**

Question Number	Correct Answer	Reject	Mark
18	B		**1**

Section B

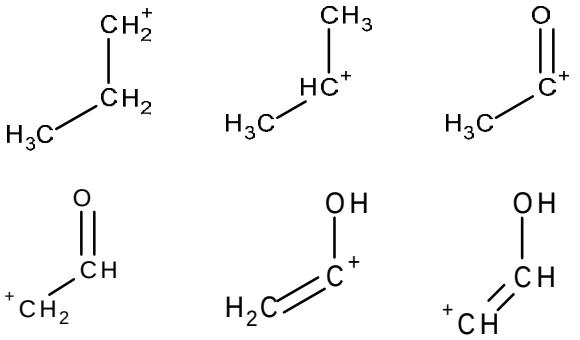
Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	So that only the water formed in the combustion is absorbed by X / measured. ALLOW 'reacts with X' for 'absorbed by X' OR Otherwise the mass / amount of the water measured will be too high	Reacts with A References to Y	**1**

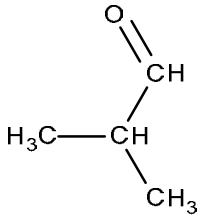
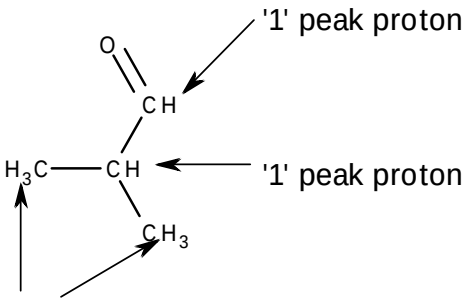
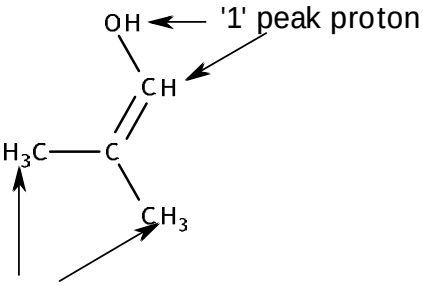
Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	(Anhydrous) Calcium chloride / $CaCl_2$ / Magnesium sulphate / $MgSO_4$ / silica gel / sodium sulphate / Na_2SO_4 ALLOW Phosphorus(V) oxide / phosphorus pentoxide / P_4O_{10} / P_2O_5 / Silica beads	Sulfuric acid Calcium oxide Silica / SiO_2 anhydrous copper(II) sulfate	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	Soda lime OR calcium hydroxide / $Ca(OH)_2$ **and** sodium hydroxide / NaOH ALLOW sodium hydroxide / NaOH / potassium hydroxide / KOH / Calcium oxide / CaO	Limewater	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iv)	The methods below illustrate the allocation of marks. But the first four marks may be scored by any correct method. **Method 1** mol CO_2 = 8.8/44 = 0.2 (= mol C) **(1)** mol H_2O = 3.6/18 = 0.2 mol H = 2 x mol H_2O = 0.4 **(1)** mass O = 3.6 – (12 x 0.2 + 1 x 0.4) = 0.8 (g) **(1)** mol O = 0.8/16 = 0.05 **(1)** **Method 2** Mass H = 3.60 x 2/18 = 0.40 (g) = 0.40 / 1 = 0.40 (mol) **(1)** Mass C = 8.80 x 12/44 = 2.4 (g) = 2.4 / 12 = 0.20 (mol) **(1)** Mass O = 3.60 – (0.40 + 2.4) = 0.80(g) **(1)** = 0.80 / 16 = 0.05 (mol) **(1)** Empirical formula = C_4H_8O **(1)** TE on incorrect moles but the ratio **must** be whole number IGNORE use of O_2 for O in the 'words' Correct empirical formula with some working at each stage scores full marks **but** Correct empirical formula with **no** working or **unclear and non-scoring** working scores final mark only		**5**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	(Molecular ion is m/e =) 72 (= M_r of **A**) **(1)** Molecular formula = C_4H_8O **(1)** No TE on incorrect molecular ion	Structural Or Displayed Or Molecular ion	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	Any three of (1 mark for each structure)  ALLOW structural formulae (eg CH_3CO^+) IGNORE Position of positive charge Penalise omission of charge or negative charge once $C_3H_7^+$ and /or $C_2H_3O^+$ scores 1 if no scoring structure		**3**

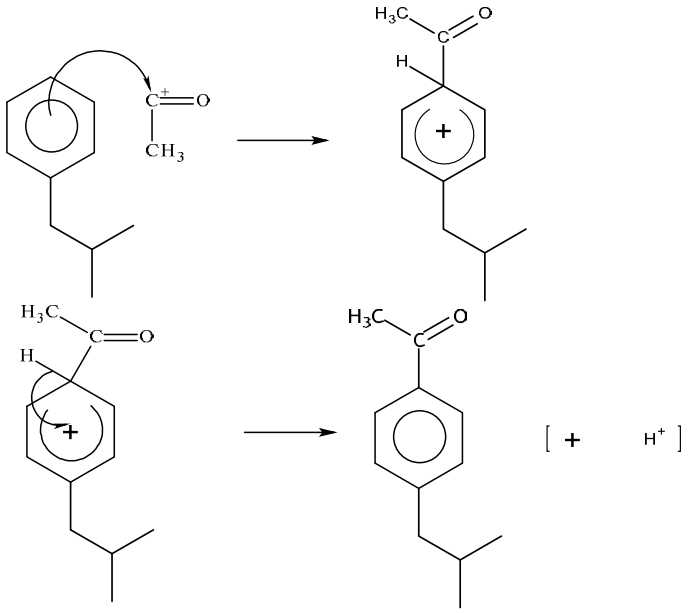
Question Number	Acceptable Answers		Reject	Mark
***19 (c)**	Structure of **A** (1)  Three (proton/H) environments (1) **Identify** the 6 protons in one environment and 1 each in the other two (1) No TE on incorrect structures except propan-2-ol : scores MP3 only	OR diagram (1)  6 proton label (1) **both** 1 proton labels (1) ALLOW enol structure  6 proton label (1) **both** 1 proton labels (1)		**3**

Total for Question 19 = 16 marks

Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	Overall **yield** higher OR Reduces use of solvents (ALLOW chemicals / reactants) OR Less loss of chemicals OR Less waste products IGNORE References to Energy / fuel / CO_2 References to atom economy More efficient conversion Fewer side products		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	Lowers (operating) temperature / energy (requirements) OR Less fuel needed IGNORE References to catalyst properties such as 'lowers E_a', 'can be re-used' Atom economy		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(i)	$CH_3COCl + AlCl_3 \rightarrow CH_3CO^+ + AlCl_4^-$ Structural formulae not required Positive charge may be anywhere on the electrophile. IGNORE Curly arrows even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(ii)	 TE on incorrect electrophile in (b)(i) If benzene used instead of substituted benzene OR If final product is not 1,4 only MP 1 and 2 can be scored Curly arrow from on or within the circle to positively charged carbon ALLOW Curly arrow from anywhere within the hexagon Arrow to **any** part of the electrophile including to the + charge (which can be anywhere on the electrophile) **(1)** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe ALLOW dotted horseshoe **(1)** Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure of a stable molecule **(1)** Correct Kekulé structures score full marks Ignore any involvement of $AlCl_4^-$ in the final step	Curly arrow on or outside the hexagon Partial bonds to H and CH_3 unless part of a 3D with a wedge bond	**3**

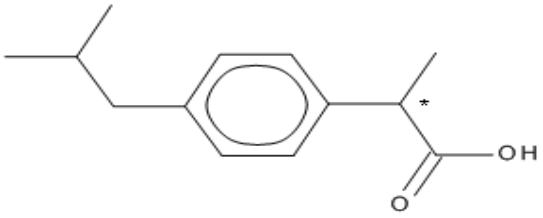
Question Number	Acceptable Answers	Reject	Mark
20 (b)(iii)	No HCl formed (as a by-product) OR Ethanoic acid easier to recover ALLOW Reverse arguments IGNORE Chlorine containing product References to ozone layer, acid rain, global warming Atom economy	Chlorine	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	Catalyst (more) easily recovered / separated OR can be filtered OR Facilitates the use of flow (rather than batch) systems IGNORE references to properties of catalysts		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	**Reaction 1** (red) phosphorus / P / P_4 and iodine / I_2 ALLOW PI_3 / HI **(1)** **Reaction 3** Hydrochloric acid / HCl(aq) or sulfuric acid / H_2SO_4 (aq) **(1)** **and** reflux / heat **(1)** Award second mark for Acid / H^+ / H_3O^+ **and** reflux OR NaOH(aq) / KOH(aq) **(1)** (reflux) **then** acidify with HCl(aq) or H_2SO_4 (aq) **(1)** IGNORE Omission of states throughout	NaI + H_2SO_4 PI_5 Just H^+ / H_3O^+ reflux / heat without acid or with warm or <50°C	

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iii)	C=O / carbonyl group (only) in carboxylic acid / ibuprofen **(1)** Absorption / peak at 1725 - 1700 (cm^{-1}) **(1)** If no other mark has been awarded, then ALLOW (for 1 mark) OH in both but in alcohol 3750 - 3200 (cm^{-1}) but in carboxylic acids 3300 to 2500 (cm^{-1})	ketone 1700 - 1680 (cm^{-1}) Single values rather than ranges	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(i)	(A chiral molecule is) non-superimposable on its mirror image. ALLOW Asymmetric (tetrahedral) carbon atom / has a carbon atom bonded to **four** different groups / atoms IGNORE Has two enantiomers Functional (as in functional groups) Reference to rotation of plane polarized light	molecules / species (for groups)	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(ii)	 ALLOW any clear indication of chiral carbon		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(iii)	(A racemic mixture is) an equimolar mixture of the two enantiomers / (optical) isomers ALLOW (for equimolar mixture) equal amounts / concentrations / volumes / proportions OR 50:50 mixture	Just 'no effect on plane polarised light'	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(iv)	Any two of 1. All the ibuprofen is useful (rather than half) 2. No need for separation of isomers / enantiomers 3. No need for a more complex synthesis forming just one enantiomer 4. Sometimes one enantiomer has negative effects 5. Smaller dosage may be used ALLOW (For point 4 above) Dose / inactive isomer is less likely to be harmful IGNORE Reference to cost / yield / atom economy / side effects		**2**

Total for Question 20 = 18 marks

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 6Fe^{3+} + 7H_2O$ Ignore state symbols even if incorrect	Any answers with electrons even if balanced	**1**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	Ignore SF except 1 SF – penalise this and/or rounding errors once only in (a)(ii) – (v) Moles of Fe^{2+} reacting in titration $= 23.85 \times 10^{-3} \times 0.255$ $= 6.08175 \times 10^{-3}$ mol * **(1)** Moles of $Cr_2O_7^{2-}$ that reacted in titration = answer * ÷ 6 $= 6.08175 \times 10^{-3} \div 6$ $= 1.013625 \times 10^{-3}$ mol **(1)** Correct answer with no working scores 2		**2**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iii)	Moles of $Cr_2O_7^{2-}$ at start $= 25 \times 10^{-3} \times 0.200$ $= 5 \times 10^{-3}$ mol** **(1)** Moles of $Cr_2O_7^{2-}$ that reacted with ethanol = answer ** – answer 21(a)(ii) $= 5 \times 10^{-3} - 1.013625 \times 10^{-3}$ $= 3.986375 \times 10^{-3}$ mol **(1)** Correct answer with no working scores 2		**2**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iv)	$CH_3CH_2OH + H_2O \rightarrow CH_3COOH + 4H^+ + 4e^-$ **(1)** 3 mol of ethanol needs 12 mol electrons supplied by 2 mol potassium dichromate(VI) ALLOW Use of oxidation numbers of C and Cr OR Use of ratio of electrons lost and gained OR Balanced equation: $3CH_3CH_2OH + 2Cr_2O_7^{2-} + 16H^+ \rightarrow 3CH_3COOH + 4Cr^{3+} + 11H_2O$ **(1)** IGNORE Uncancelled species including the 12 electrons in the last equation	Use of [O] **Just** 3 mol of ethanol reacts with 2 mol $Cr_2O_7^{2-}$	**2**

Question Number	Acceptable Answers	Reject	Mark
21 (a)(v)	Moles of ethanol that reacted with potassium dichromate(VI) = ans. 21(a)(iii) x 3 ÷ 2 = 5.9795625×10^{-3} mol **(1)** Concentration in **Q** = previous answer x 10 x 40 = 2.391825 mol dm^{-3} **(2)** (1 mark for x 10 or x 40 and 1 mark for completion of calculation Correct answer with no working scores 3		**3**

Question Number	Acceptable Answers	Reject	Mark
***21(b)**	Fe^{2+} / iron(II) **(1)** And any TWO of: Barium diphenylamine sulfonate is a **redox** indicator ALLOW reaction is **redox** **(1)** Barium diphenylamine sulfonate / indicator is reduced by iron(II) OR Iron(II) is oxidized by barium diphenylamine sulfonate / indicator OR Barium diphenylamine sulfonate / indicator oxidized by potassium dichromate(VI) OR Potassium dichromate(VI) is reduced by Barium diphenylamine sulfonate / indicator **(1)** The oxidized form / oxidation product of barium diphenylamine sulfonate is purple OR the reduced form is colourless ALLOW Oxidised and reduced form of the indicator have different colours **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
***21(c)**	**EITHER** **MP1** Difficult to know when reaction is complete OR Difficult to know when all the ethanol has been oxidized (to ethanoic acid) OR Some ethanol only oxidized to ethanal ALLOW Some ethanol is oxidized by air **(1)** **MP2** (depends on MP1 correct or 'ethanol evaporates') So less potassium dichromate(VI) will be used up **(1)** **MP3** (depends on MP1 or MP2 or 'ethanol evaporates') Ethanol concentration will appear low **(1)** **OR** Other compounds in the fermented solution (e.g. aldehydes) are oxidized also. **(1)** So more potassium dichromate(VI) will be used up **(1)** Ethanol concentration will appear high **(1)**	Ethanol evaporates Transfer losses / spillages Not all sugar fermented	**3**

Total for Question 21 = 16 marks
Total for Section B = 50 marks

Section C

Question Number	Acceptable Answers	Reject	Mark
22 (a)	Oxygen atoms in water molecules have δ− charge. **(1)** Which form electrostatic / ion-dipole attractions with sodium (ion). **(1)** ALLOW for one mark copper(II) ions form dative covalent bonds but sodium ions do not (**both** needed)	 Ionic bonds / attractions Intermolecular forces Hydrogen bonds	**2**

Question Number	Acceptable Answers	Reject	Mark
22 (b)	Additional (dative covalent bond) lone pairs are accommodated in vacant (3)d orbitals / (3)d sub-shell ALLOW Vacant **higher** energy orbitals / sub-shells IGNORE 3s/3p	'Partially filled' for 'vacant'	**1**

Question Number	Acceptable Answers	Reject	Mark
***22 (c)(i)**	(3)d orbitals / (3)d subshell split (by the attached ligands) **(1)** Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy (d orbital(s) / levels) ALLOW d—d transitions occur /electrons are excited **(1)** Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light **(1)** Reflected / transmitted / remaining light is coloured / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen **(1)** Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell is split Emitted	**4**

Question Number	Acceptable Answers	Reject	Mark
22 (c)(ii)	Zn (3)d orbitals are / (3)d subshell is **full / complete** (so d−d transitions are not possible) / Zinc is $3d^{10}$	Zn does not have partially filled d subshell	**1**

Question Number	Acceptable Answers	Reject	Mark
22 (c)(iii)	(d−d) energy gap is large **(1)** the energy absorbed is outside the visible region / in the UV region **(1)** Stand alone marks		**2**

Question Number	Acceptable Answers	Reject	Mark
22 (d)	**<u>Method 1: cell emfs</u>** For the reaction $Cu(H_2O)_6^{2+}(aq) + 2S_2O_3^{2-}(aq)$ $\rightarrow Cu(s) + 6H_2O(l) + S_4O_6^{2-}(aq)$ * $E^{\ominus}_{cell} = +0.34 - 0.09 = (+)0.25$ (V) **and** (Positive so) reaction is feasible **(1)** For the reaction $Cu(H_2O)_2(NH_3)_4^{2+}(aq) + 2S_2O_3^{2-}(aq)$ $\rightarrow Cu(s) + 2H_2O(l) + 4NH_3(aq) + S_4O_6^{2-}(aq)$ ** $E^{o}_{cell} = -0.05 - 0.09 = -0.14$ (V) **and** (Negative so) reaction is not feasible **(1)** If both values correct but feasibility omitted or incorrect award 1 mark **Both** equations (* & **) correct IGNORE Omission of H_2O and states from the equations **(1)** **<u>Method 2: anticlockwise rule</u>** Place the reactions in order of increasing (more positive) $E^{\ominus}$ values and check which reaction occurs in the anticlockwise direction. **(1)** $S_4O_6^{2-}(aq) + 2e^- \rightarrow 2S_2O_3^{2-}(aq)$ $E^o = +0.09$ V $Cu(H_2O)_6^{2+}(aq) + 2e^- \rightarrow Cu(s) + 6H_2O(l)$ $E^{\ominus} = 0.34$ V Reaction is feasible (desired reaction proceeds in anticlockwise direction) **(1)** $Cu(H_2O)_2(NH_3)_4^{2+}(aq) + 2e^-$ $\rightarrow Cu(s) + 2H_2O(l) + 4NH_3(aq)$ $E^o = -0.05$ V $S_4O_6^{2-}(aq) + 2e^- \rightarrow 2S_2O_3^{2-}(aq)$ $E^o = +0.09$ V Reaction is not feasible (proceeds in the opposite direction). **(1)**	electrons in equations	**3**

Question Number	Acceptable Answers	Reject	Mark
22 (e)(i)	(coordination number =) 4 / four		**1**

Question Number	Acceptable Answers	Reject	Mark
22 (e)(ii)	Amount of complex = 4.82 / 288.7 (= 0.0166955 mol) Mass of nickel = 58.7 x 4.82 / 288.7 = 0.98003 g **(1)** % Nickel in alloy = 100 x 0.98 / 1.02 = 96.08 % **(1)** Correct answer with no working scores 2 Ignore SF except 1 ALLOW TE unless %>100 Use of A_r(Ni) = 59 (gives 96.57%)		**2**

Question Number	Acceptable Answers	Reject	Mark
22 (f)	Nickel carbonyl is a gas (so can be easily separated from impurities).		**1**

Question Number	Acceptable Answers	Reject	Mark
22 (g)	Silver(I) oxide is precipitated in alkaline solution OR Silver(I) ions need to be in solution OR (Ammonia) prevents precipitation of silver(I) oxide **(1)** Formation of diamminesilver(I) lowers concentration of Ag^+(aq) OR Equilibrium 2 shifts to the right by addition of ammonia **(1)** (lower [Ag^+]) causes equilibrium 1 to shift to the left **(1)** IGNORE Omission of oxidation state of silver		**3**

Total for Question 22 = 20 marks

Total for Section C = 20 marks

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Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Tuesday 17 June 2014 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
6CH05/01R

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 4 2 9 8 9 R A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 In which of the following ions does the metal have an oxidation number of +2?

☒ **A** MnO_4^{2-}

☒ **B** VO^{2+}

☒ **C** $[Fe(CN)_6]^{4-}$

☒ **D** $[CrCl_2(H_2O)_4]^{+}$

(Total for Question 1 = 1 mark)

2 Sulfur dioxide reacts with hydrogen sulfide to form water and sulfur. By considering the changes in the oxidation numbers of sulfur, it can be deduced that, in this reaction

☒ **A** 1 mol of sulfur dioxide oxidizes 2 mol of hydrogen sulfide.

☒ **B** 1 mol of sulfur dioxide reduces 2 mol of hydrogen sulfide.

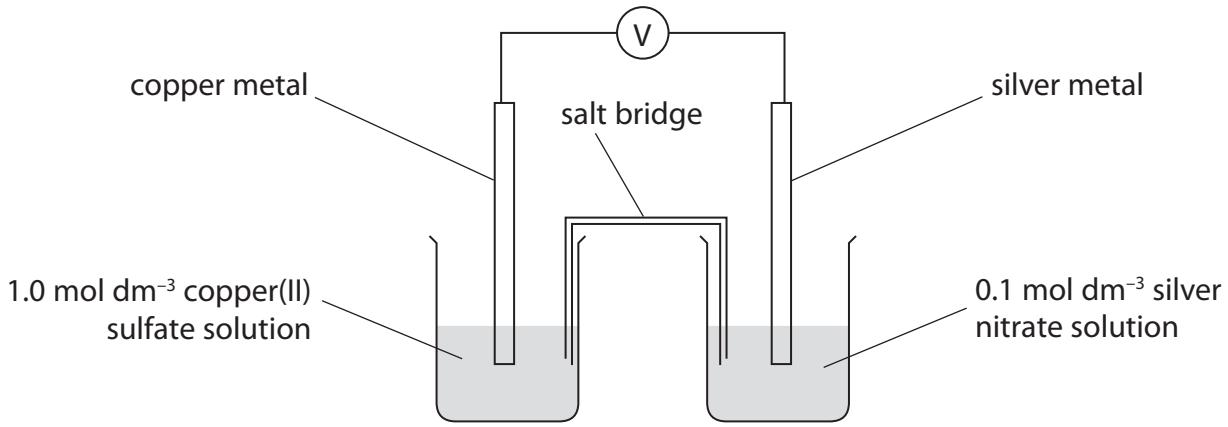
☒ **C** 2 mol of sulfur dioxide oxidizes 1 mol of hydrogen sulfide.

☒ **D** 2 mol of sulfur dioxide reduces 1 mol of hydrogen sulfide.

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 The diagram below shows a cell set up between a standard copper metal / copper(II) ion electrode and a silver metal / silver(I) ion electrode in which the silver ion concentration is 0.1 mol dm^{-3}.



At 298 K, the emf of this cell was +0.40 V. The electrode potential of the copper metal / copper(II) ion electrode is +0.34 V. What is the electrode potential of this silver metal / silver(I) ion electrode?

☒ **A** −0.74 V

☒ **B** −0.06 V

☒ **C** +0.06 V

☒ **D** +0.74 V

(Total for Question 3 = 1 mark)

4 For the reaction

$$Zn(s) + Cu^{2+}(aq) \rightarrow Cu(s) + Zn^{2+}(aq)$$

$E^{\ominus}_{cell}$ is positive. From this it can be deduced that, for this reaction,

☒ **A** ΔS_{total} and $\ln K$ are positive.

☒ **B** ΔS_{total} and $\ln K$ are negative.

☒ **C** ΔS_{total} is positive and $\ln K$ is negative.

☒ **D** ΔS_{total} is negative and $\ln K$ is positive.

(Total for Question 4 = 1 mark)

5 Sodium thiosulfate was used to determine the concentration of iodine by titration.

(a) The sodium thiosulfate solution was prepared by dissolving 4.5 g of sodium thiosulfate in water and making the solution up to 250 cm^3 in a volumetric flask. The volumetric flask is accurate to ± 0.3 cm^3 so, to match this accuracy, the mass of the sodium thiosulfate should be accurate to at least

(1)

☒ **A** ± 0.5 g

☒ **B** ± 0.05 g

☒ **C** ± 0.005 g

☒ **D** ± 0.0005 g

(b) With the sodium thiosulfate in the burette, what is the colour of the solution in the conical flask at the end-point of the reaction?

(1)

☒ **A** Blue-black

☒ **B** Colourless

☒ **C** Red-brown

☒ **D** Yellow

(Total for Question 5 = 2 marks)

6 In a hydrogen-oxygen fuel cell, hydrogen is

☒ **A** oxidized at the anode.

☒ **B** oxidized at the cathode.

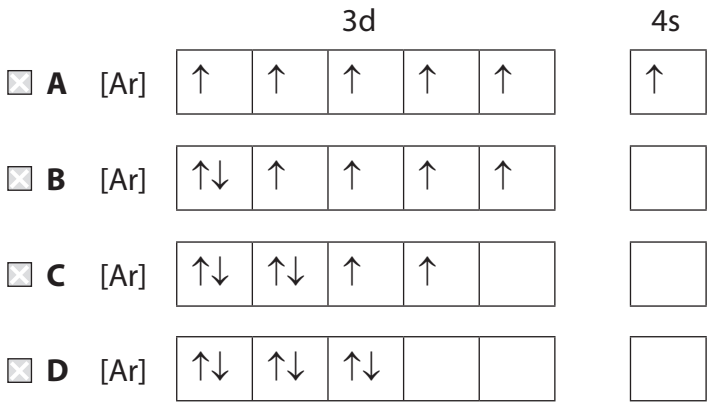
☒ **C** reduced at the anode.

☒ **D** reduced at the cathode.

(Total for Question 6 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

7 The electronic configuration of iron is $[Ar]3d^6 4s^2$. What is the electronic configuration of the iron(II) ion, Fe^{2+}?



(Total for Question 7 = 1 mark)

8 Chromium has the electronic configuration $[Ar]3d^5 4s^1$. Which of the following compounds is **unlikely** to exist?

- ☒ **A** K_3CrO_4
- ☒ **B** CrO_2Cl_2
- ☒ **C** $KCrO_2Cl$
- ☒ **D** $KCrO_4$

(Total for Question 8 = 1 mark)

9 The shapes of the complexes $[CrCl_4]^-$ and $[CuCl_2]^-$ are

	$[CrCl_4]^-$	$[CuCl_2]^-$
☒ **A**	tetrahedral	linear
☒ **B**	square planar	linear
☒ **C**	tetrahedral	V-shaped
☒ **D**	square planar	V-shaped

(Total for Question 9 = 1 mark)

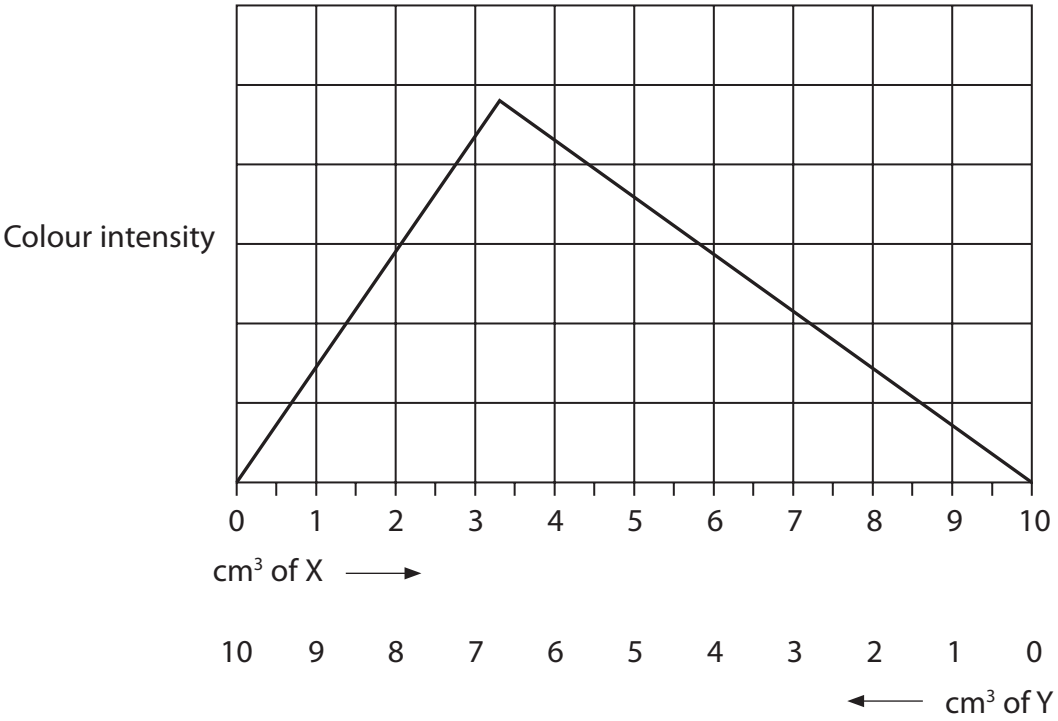
10 When EDTA is added to $[Cu(NH_3)_4]^{2+}$ in aqueous solution, the copper(II)-EDTA complex, $[Cu(EDTA)]^{2-}$, predominates in the resulting solution.

This is **best** explained by the fact that when $[Cu(EDTA)]^{2-}$ is formed from $[Cu(NH_3)_4]^{2+}$

- ☒ **A** there are much stronger bonds between the ligands and the copper(II) ion.
- ☒ **B** the reaction has a low activation energy.
- ☒ **C** the reaction is exothermic.
- ☒ **D** the total number of particles on the right-hand side of the equation is greater than on the left.

(Total for Question 10 = 1 mark)

11 The graph below shows the variation in the colour intensity of different solutions formed by mixing a 0.05 mol dm^{-3} solution of a metal ion **X** and a 0.05 mol dm^{-3} solution of a complexing agent **Y**, in the proportions shown on the graph.



The most likely formula of the complex formed is

- ☒ **A** X_2Y
- ☒ **B** XY_2
- ☒ **C** XY_3
- ☒ **D** X_3Y

(Total for Question 11 = 1 mark)

12 When benzene reacts with fuming sulfuric acid, which species is most likely to be the electrophile?

☒ **A** H_3O^+

☒ **B** SO_3

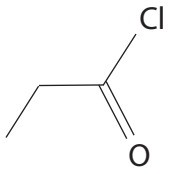
☒ **C** HSO_4^-

☒ **D** SO_4^{2-}

(Total for Question 12 = 1 mark)

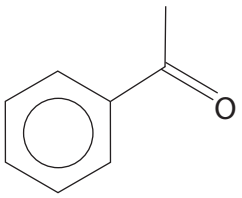
13 Benzene reacts with propanoyl chloride in the presence of a suitable catalyst.

The skeletal formula of propanoyl chloride is

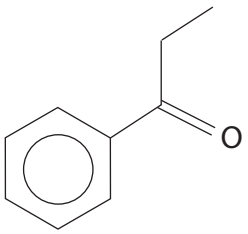


What is the organic product of this reaction?

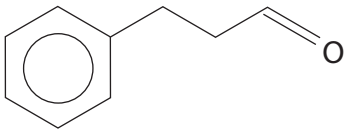
☒ **A**



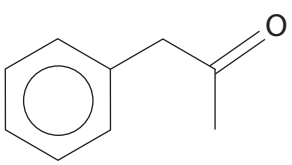
☒ **B**



☒ **C**



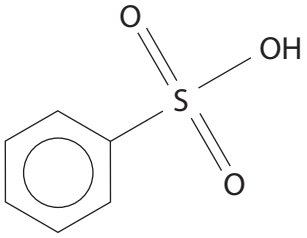
☒ **D**



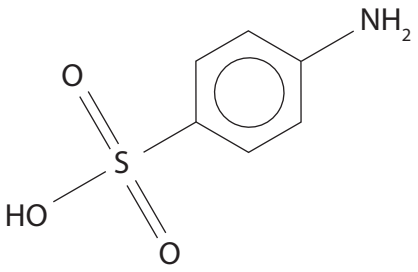
(Total for Question 13 = 1 mark)

14 Excess dilute sulfuric acid is added to phenylamine. What is the product of the reaction?

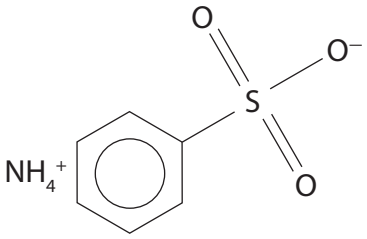
☒ **A**



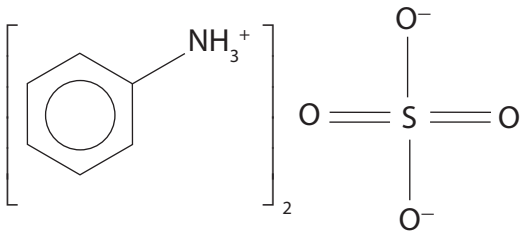
☒ **B**



☒ **C**



☒ **D**



(Total for Question 14 = 1 mark)

15 Butylamine (T_b = 77.8 °C) has a higher boiling temperature than propylamine (T_b = 47.7 °C). This is because the

- ☒ **A** hydrogen bonds of butylamine are stronger than the hydrogen bonds of propylamine.
- ☒ **B** London forces of butylamine are stronger than the hydrogen bonds of propylamine.
- ☒ **C** London forces of butylamine are stronger than the London forces of propylamine.
- ☒ **D** C—H bonds of butylamine are stronger than the C—H bonds of propylamine.

(Total for Question 15 = 1 mark)

16 Ninhydrin is used in thin-layer chromatography to help with the identification of amino acids. This is because the ninhydrin

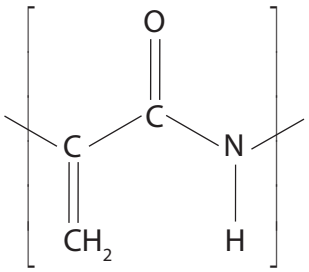
- ☒ **A** reacts with amino acids to form a compound which has an intense colour.
- ☒ **B** reacts with amino acids to form compounds each of which has a characteristic colour.
- ☒ **C** increases the separation of the amino acids on the chromatogram.
- ☒ **D** ensures that the mobile phase maintains a nearly constant pH for all the amino acids.

(Total for Question 16 = 1 mark)

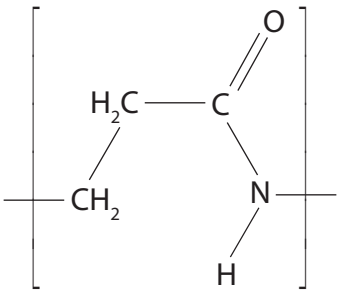
Use this space for any rough working. Anything you write in this space will gain no credit.

17 The monomer of the addition polymer poly(propenamide) is $CH_2{=}CHCONH_2$. The repeat unit of the polymer is

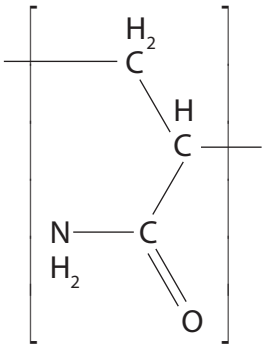
☒ **A**



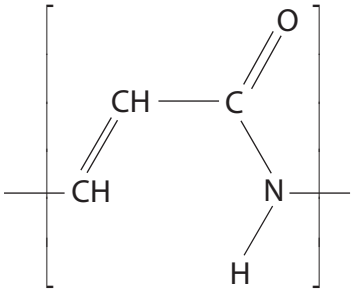
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

18 15 cm^3 of a gaseous hydrocarbon requires 90 cm^3 of oxygen for complete combustion, both volumes being measured at 15 °C and 1 atm. The formula of the hydrocarbon is

☒ **A** C_4H_6

☒ **B** C_4H_8

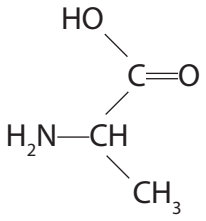
☒ **C** C_4H_{10}

☒ **D** impossible to calculate without knowing the molar volume of gases under these conditions.

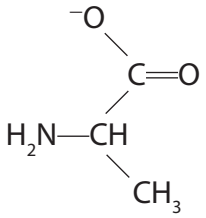
(Total for Question 18 = 1 mark)

19 In an aqueous solution with a pH of 12, the amino acid alanine exists mainly as

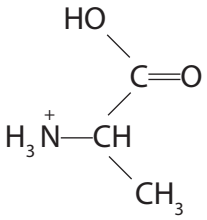
☒ **A**



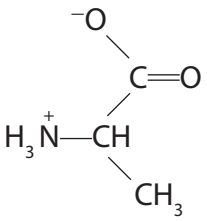
☒ **B**



☒ **C**



☒ **D**



(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20 (a) When iron(II) sulfate is dissolved in water, the iron(II) ions are slowly oxidized to iron(III) ions by oxygen dissolved in the water.

(i) Write the two ionic half-equations for this redox reaction in **acid** conditions. State symbols are not required.

(1)

(ii) Hence write the overall ionic equation for the reaction. State symbols are not required.

(1)

(b) 6.90 g of iron(II) sulfate crystals ($FeSO_4.7H_2O$) was dissolved in distilled water and the solution made up to 250 cm^3 in a volumetric flask. After 24 hours, 25.0 cm^3 portions of this solution were pipetted into a conical flask and titrated against acidified potassium manganate(VII) solution with a concentration of 0.0195 mol dm^{-3}. The mean titre was 24.90 cm^3.

(i) Write the ionic equation showing that 1 mol of manganate(VII) ions oxidizes 5 mol of iron(II) ions in acid conditions. State symbols are not required.

(1)

(ii) What is the colour of the solution in the conical flask at the end-point of the titration?

(1)

.....

*(iii) Calculate the amount of Fe^{2+} ions in 250 cm^3 of the solution after it had been left to stand for 24 hours. Hence calculate the percentage of the iron(II) ions that had been oxidized between the preparation of the solution and the titration. The molar mass of $FeSO_4.7H_2O$ is 277.9 g mol^{-1}.

(5)

(iv) Suggest, with an explanation, the appropriate number of significant figures to give for the answer to (b)(iii).

(1)

.....

.....

.....

(c) The most stable oxidation states in iron compounds are +2 and +3, but others do exist, for example in the ferrate(VI) ion, FeO_4^{2-}. The ionic half-equation for the conversion of ferrate(VI) to iron(III) is

$$FeO_4^{2-}(aq) + 8H^+(aq) + 3e^- \rightleftharpoons Fe^{3+}(aq) + 4H_2O(l) \qquad E^{\ominus} = +2.20\ V$$

(i) Ferrate(VI) decomposes in neutral or acid solution, but is stable in alkali. Suggest why this is so.

(1)

.....

.....

.....

(ii) Write the equation for the disproportionation of iron(III) into iron(II) and ferrate(VI) in aqueous solution. State symbols are not required.

(2)

(iii) Use standard electrode potential values to determine the thermodynamic feasibility of this disproportionation.

(2)

(Total for Question 20 = 15 marks)

21 Chromium is a typical transition metal: it forms complexes, coloured compounds and exists in a range of stable oxidation states. Chromium and some of its compounds also show catalytic properties.

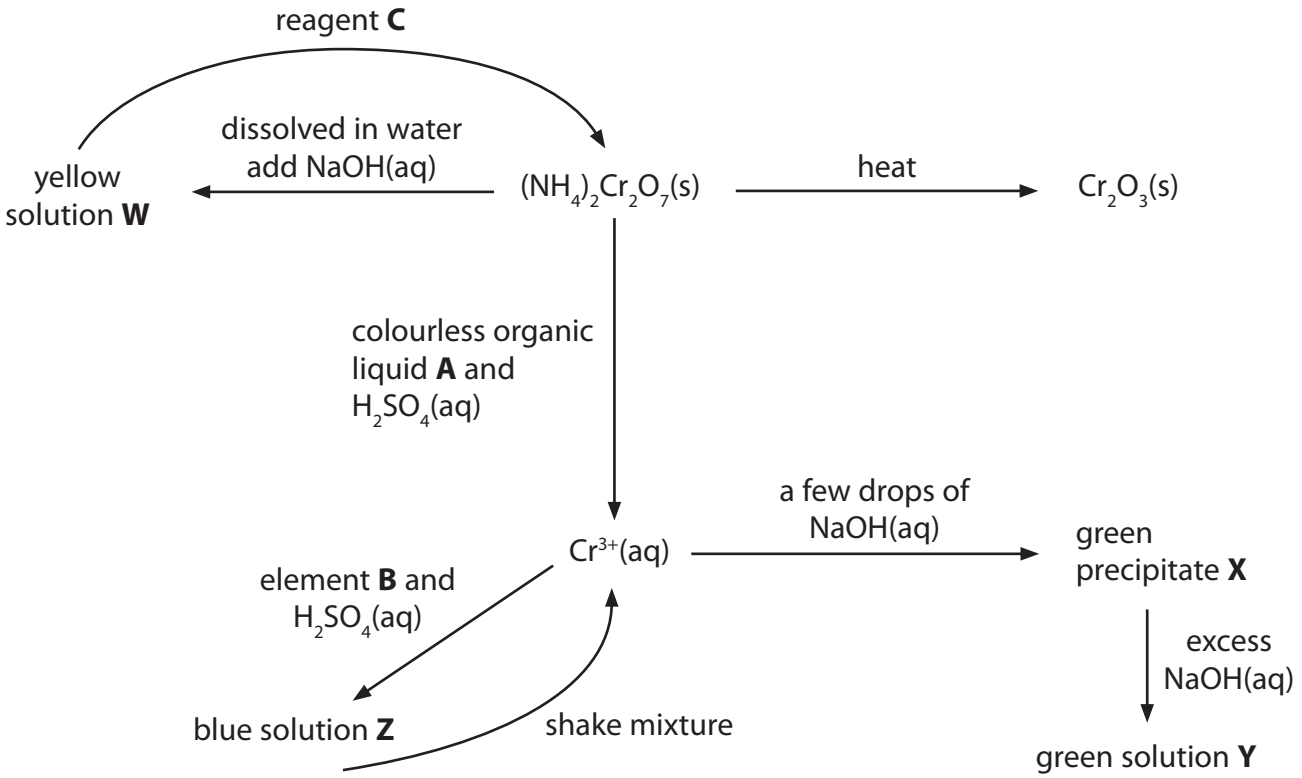
(a) Define the term **transition metal**.

(1)

.....

.....

(b) The diagram below summarises some reactions of chromium compounds.



(i) Identify, by name (including the oxidation state where appropriate) or formula, the species containing **chromium** in the sequence.

(4)

W .....

X .....

Y .....

Z .....

(ii) Identify, by name or formula, suitable reagents for the sequence.

(3)

A .....

B .....

C .....

(iii) Write the ionic equation for the reaction between $(NH_4)_2Cr_2O_7$ and NaOH to form the yellow solution. State symbols are not required.

(1)

(iv) When $(NH_4)_2Cr_2O_7$ is heated, steam and nitrogen are formed as well as Cr_2O_3. Write the equation for this reaction. State symbols are not required.

Explain why this is a redox reaction, stating any changes in oxidation numbers that occur.

(3)

Equation

Explanation .....

.....

.....

.....

.....

(v) Explain how shaking solution **Z** re-forms $Cr^{3+}(aq)$.

(1)

.....

.....

.....

(c) If excess aqueous ammonia is added to $Cr^{3+}(aq)$, the ammonia acts as a ligand and the resulting green solution contains a chromium species which is different from the one found in **Y**.

(i) Explain the term 'ligand'.

(2)

.....

.....

.....

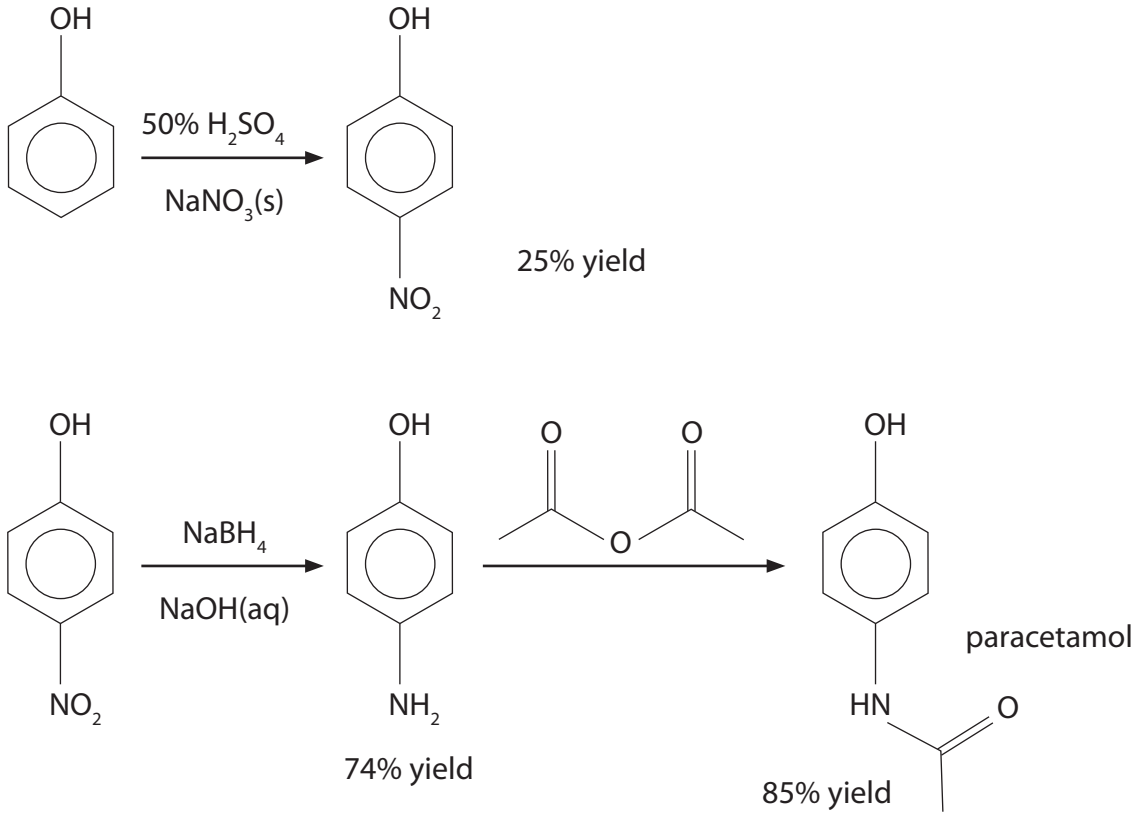
.....

(ii) Write an equation for the reaction that occurs, showing **all** the ligands involved for both the chromium species in the reaction. State symbols are not required.

(2)

(Total for Question 21 = 17 marks)

22 Paracetamol is a mild painkiller which also reduces the temperature of patients with fever, actions known as analgesic and antipyretic respectively. The reaction scheme below summarises a laboratory synthesis of paracetamol starting from phenol. The yields shown are for the particular product of each step in the synthesis.



(a) The nitration of benzene is an electrophilic substitution reaction that requires concentrated nitric and sulfuric acids.

(i) Write an equation for the formation of the electrophile by the reaction between concentrated nitric and concentrated sulfuric acids.

(2)

(ii) Give the mechanism for the formation of nitrobenzene from benzene.

(3)

(iii) Explain why phenol is nitrated in much milder conditions than benzene.

(2)

(iv) Suggest why the yield for the nitration of phenol is so low.

(1)

(v) Suggest an alternative to $NaBH_4$ that could be used in aqueous solution.

(1)

(vi) Calculate the overall yield of the synthesis.

(1)

(b) The paracetamol, prepared by the synthesis shown at the start of the question, may be purified by recrystallization. In this process, the paracetamol is dissolved in a minimum volume of hot water, the hot mixture filtered, the filtrate cooled and the resulting crystals filtered and dried. The table below summarises the solubility of paracetamol in water at various temperatures.

Temperature / °C	5	10	20	95
Solubility / g / 100 g	0.82	0.94	1.3	5.2

(i) Explain the purpose of each of the filtrations in the recrystallization of paracetamol.

(2)

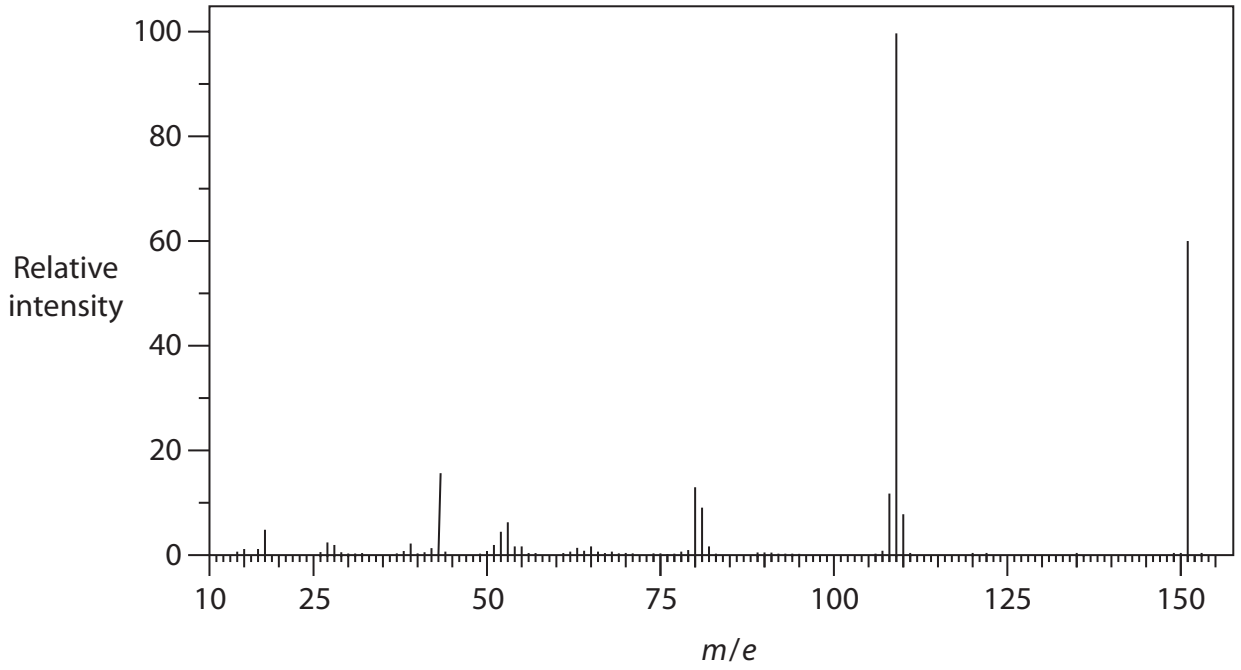
(ii) From the temperatures given in the table, choose the pair of temperatures that will give the highest yield of paracetamol from the recrystallization. Explain your choice.

(2)

(iii) Name the technique that could be used in a **school** laboratory to check the purity of the recrystallized paracetamol.

(1)

(c) The mass spectrum of paracetamol is shown below.



(i) Label the molecular ion peak, with an **M**, on the mass spectrum.

(1)

(ii) Suggest the formula of an ion that could cause the peak at *m/e* = 43.

(1)

(d) Paracetamol is highly toxic: overdosing causes irreversible liver damage. Despite this, paracetamol is readily available from pharmacies and even supermarkets. Suggest **one** control measure that sellers might employ to reduce the risk to paracetamol users.

(1)

.....

.....

(Total for Question 22 = 18 marks)

TOTAL FOR SECTION B = 50 MARKS

SECTION C

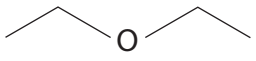
Answer ALL the questions. Write your answers in the spaces provided.

23

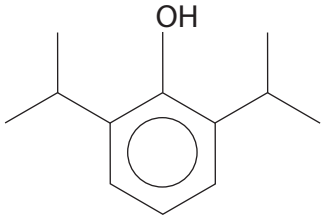
Anaesthetics

Substances have been used to relieve or eliminate pain during medical procedures for well over two thousand years. However, uncertainty about the nature and purity of the plant extracts being used and in standardising their application prompted Fallopius, a leading sixteenth century physician, to complain 'When soporifics are weak, they are useless, and when strong, they kill'. Modern analytical techniques have all but eliminated these problems.

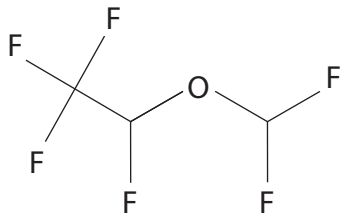
Anaesthetics are divided into two broad categories: general anaesthetics, which cause a reversible loss of consciousness, and local anaesthetics, which result in the absence of pain sensation in the area where they are applied. General anaesthetics may be delivered by inhalation or injection, while local anaesthetics may be injected or applied directly to the surface. The structures of some anaesthetics are shown below.



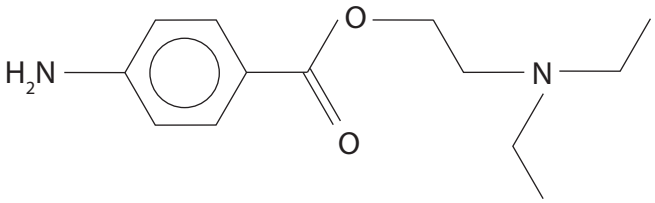
Ethoxyethane (T_b = 34.5 °C)



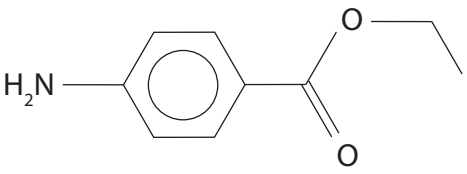
Propofol



Desflurane (T_b = 23.5 °C)



Procaine



Benzocaine

Ethoxyethane was first synthesized in 1540 by distilling a mixture of ethanol and concentrated sulfuric acid. Although its anaesthetic properties were established at this time, it was not until the nineteenth century that it was used as an inhalational general anaesthetic in medical procedures. However, ethoxyethane is highly flammable and has unpleasant side effects, so it has been entirely replaced by compounds like desflurane in modern medical practice. Propofol is a general anaesthetic which is administered by injection.

Procaine and benzocaine are local anaesthetics and are examples of aminoester anaesthetics.

(a) (i) Explain why ethoxyethane has a lower boiling temperature than ethanol (T_b = 78.5 °C) even though an ethanol molecule has fewer electrons. A detailed explanation of the forces involved is **not** required.

(3)

*(ii) Desflurane is approximately 3700 times more potent as a greenhouse gas than carbon dioxide and it has been estimated that the worldwide use of inhalational anaesthetics contributes the equivalent of 1 million cars to global warming.

Suggest **three** factors that might be considered before deciding whether this type of general anaesthetic should be banned.

(3)

(iii) Suggest why desflurane is much more stable than ethoxyethane and why the chemical stability of desflurane **increases** its potential to cause damage to the environment.

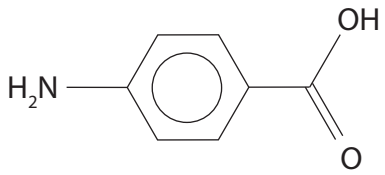
(2)

*(b) Procaine is often used by dentists and administered by injection. Due to the presence of the amine groups, procaine is a basic compound.

Explain why the presence of an amine group makes a compound basic and hence compare the effect of each amine group on the basicity of procaine.

(3)

(c) The aminoester, benzocaine, is a local anaesthetic used in creams and cough drops. It can be made from 4-aminobenzoic acid, the structure of which is shown below.



4-aminobenzoic acid

(i) One possible preparation of benzocaine would be from 4-aminobenzoic acid using ethanol and a sulfuric acid catalyst. Suggest a **disadvantage** of this method.

(1)

.....

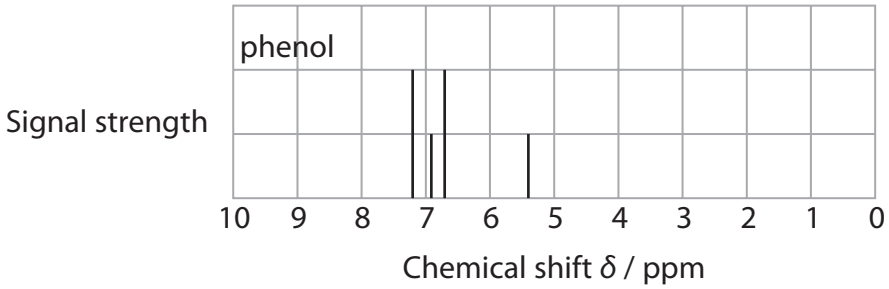
.....

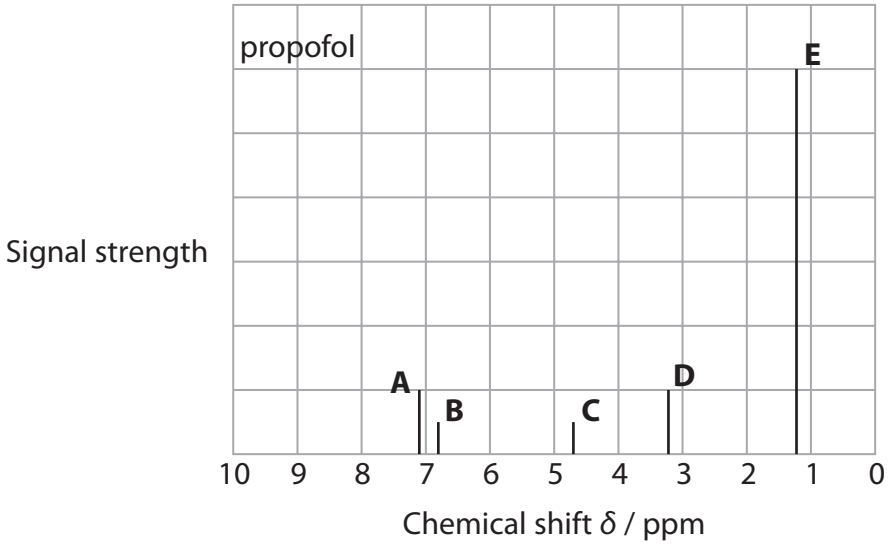
(ii) Suggest an alternative two-stage synthesis of benzocaine from 4-aminobenzoic acid. The reagents used must be identified and the structure of the intermediate compound given.

(3)

(d) The structure of an anaesthetic may be determined by proton nmr spectroscopy, while its purity may be established by high performance liquid chromatography.

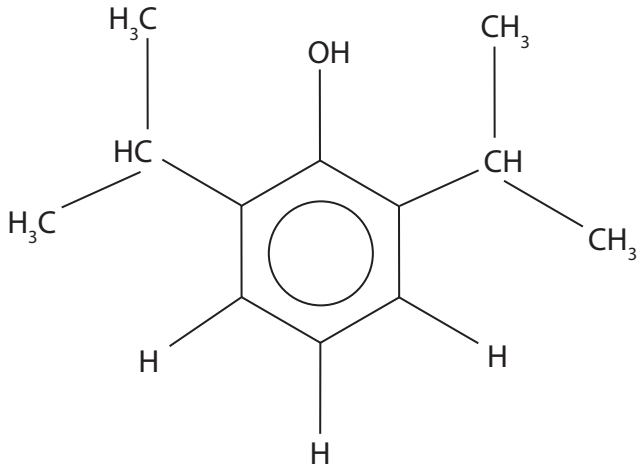
(i) Low resolution nmr spectra for phenol and for propofol are shown below. In these simplified spectra, the signal strength is proportional to the number of protons of each type, but only within each spectrum.





Use the phenol spectrum and your Data Booklet to identify the protons of propofol responsible for each of the peaks (**A** to **E**) in its nmr spectrum. Label **all** of the protons in the diagram below.

(3)



(ii) Explain why high performance liquid chromatography, rather than nmr, is used to show that an anaesthetic contains no trace impurities.

(2)

(Total for Question 23 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass **atomic symbol** name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 8 9 R A 0 2 8 2 8

PMT

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Mark Scheme (Results)

June 2014

International GCE Chemistry
(6CH05/01R)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		1

Question Number	Correct Answer	Reject	Mark
2	A		1

Question Number	Correct Answer	Reject	Mark
3	D		1

Question Number	Correct Answer	Reject	Mark
4	A		1

Question Number	Correct Answer	Reject	Mark
5 (a)	C		1
5 (b)	B		1

Question Number	Correct Answer	Reject	Mark
6	A		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	D		1

Question Number	Correct Answer	Reject	Mark
9	A		1

Question Number	Correct Answer	Reject	Mark
10	D		1

Question Number	Correct Answer	Reject	Mark
11	B		1

Question Number	Correct Answer	Reject	Mark
12	B		1

Question Number	Correct Answer	Reject	Mark
13	B		1

Question Number	Correct Answer	Reject	Mark
14	D		1

Question Number	Correct Answer	Reject	Mark
15	C		1

Question Number	Correct Answer	Reject	Mark
16	A		1

Question Number	Correct Answer	Reject	Mark
17	C		1

Question Number	Correct Answer	Reject	Mark
18	B		1

Question Number	Correct Answer	Reject	Mark
19	B		1

Section B

Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	$Fe^{2+} \rightarrow Fe^{3+} + e^{(-)}$ $½O_2 + 2H^+ + 2e^{(-)} \rightarrow H_2O$ OR $O_2 + 4H^+ + 4e^{(-)} \rightarrow 2H_2O$ ALLOW Reversible arrows Equations in other direction Electrons subtracted on LHS of first equation Multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	$½O_2 + 2H^+ + 2Fe^{2+} \rightarrow 2Fe^{3+} + H_2O$ OR $O_2 + 4H^+ + 4Fe^{2+} \rightarrow 4Fe^{3+} + 2H_2O$ ALLOW Multiples Reversible arrows Ignore state symbols even if incorrect No TE from 20(a)(i)	Equation in the wrong direction, even with reversible sign	1

Question Number	Acceptable Answers	Reject	Mark
20 (b)(i)	$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
20 (b)(ii)	(Pale) pink	Purple / mauve	1

Question Number	Acceptable Answers	Reject	Mark
***20 (b)(iii)**	Amount of MnO_4^- = 24.90 x 0.0195 x 10^{-3} = 4.8555 x 10^{-4} (mol)* **(1)** Amount of Fe^{2+} = answer * x 5 in 25 cm^3 = 4.8555 x 10^{-4} x 5 = 2.42775 x 10^{-3} (mol) So in 250 cm^3 = 2.42775 x 10^{-2} (mol) **(1)** (M_r ($FeSO_4.7H_2O$) = 277.9) **ROUTE 1 (via moles)** Amount of Fe^{2+} used to prepare the solution = 6.90 / 277.9 = 2.4829 x 10^{-2} (mol) **(1)** EITHER % of Fe^{2+} remaining at titration = 100 x 2.42775 x 10^{-2} / 2.4829 x 10^{-2} = 97.7785 (%) **(1)** % Oxidized = 100 – 97.7785 = 2.221 (%) **(1)** OR Amount oxidized = 2.4829 x 10^{-2} – 2.42775 x 10^{-2} = 5.516 x 10^{-4} (mol) **(1)** % Oxidized = 5.516 x 10^{-4} x 100 / 2.4829 x 10^{-2} = 2.221 (%) **(1)** **ROUTE 2 (via mass)** mass from titration = 2.42775 x 10^{-2} x 277.9 = 6.7467 (g) **(1)** % of Fe^{2+} remaining at titration = 100 x 6.7467 / 6.9 = 97.7785 (%) **(1)** % Oxidized = 100 – 97.7785 = 2.221 (%) **(1)** Ignore SF except 1 SF unless justified in b(iv) Correct answer no working scores 5 marks 90.22% obtained from failure to multiply by 10 scores 4 marks		5

Question Number	Acceptable Answers	Reject	Mark
20 (b)(iv)	3 (significant figures) because all the data (except A_r(H)) is given to 3 SF OR 2 (significant figures) because the least precise data (A_r(H)) is 2 SF OR 2 (significant figures) because the data is to three figures. After processing only two figures are certain. OR 1 (significant figure) because of the subtraction of two similar numbers.		1

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	Alkali neutralizes the acid shifting the equilibrium to the left OR Alkali neutralizes the acid so E value for half cell becomes less (than +2.20 V) ALLOW 'Reacts with' and 'removes' for 'neutralizes' IGNORE Just "shifts equilibrium to the left"		1

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	$4Fe^{3+} + 4H_2O \rightarrow 3Fe^{2+} + FeO_4^{2-} + 8H^+$ OR Multiples Species **(1)** balance **(1)** Ignore state symbols even if incorrect		2

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iii)	Required half cell value is $E^{\ominus}$ = (+)0.77 **(1)** $E^{\ominus}_{cell}$ = (0.77 – 2.20 =) −1.43 V ($E^{\ominus}_{cell}$ negative so disproportionation) not feasible **(1)** TE on calculated negative value of $E^{\ominus}_{cell}$ No TE on positive value for $E^{\ominus}_{cell}$ OR Correct application of anti-clockwise rule e.g. $Fe^{3+}(aq) + e^{-} \rightleftharpoons Fe^{2+}(aq)$ $E^{\ominus}$ = +0.77 V $FeO_4^{2-}(aq) + 8H^{+}(aq) + 3e^{-} \rightleftharpoons Fe^{3+}(aq) + 4H_2O(l)$ $E^{\ominus}$ = +2.20 V Equations in order of increasing $E^{\ominus}$ value **and** arrows shown **(1)** Anti-clockwise rule shows top reaction moves left and bottom reaction moves right so disproportionation not feasible **(1)**		2

Total for Question 20 = 15 marks

Question Number	Acceptable Answers	Reject	Mark
21 (a)	(A transition metal) forms **ions / oxidation states** with partially filled / incomplete d orbital(s) / d sub-shell		1

Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	**W** = chromate(VI) (ion) / CrO_4^{2-} **(1)** **X** = chromium(III) hydroxide / $Cr(OH)_3$ / $Cr(OH)_3(H_2O)_3$ **(1)** **Y** = hexahydroxochromate(III) (ions) / $[Cr(OH)_6]^{3-}$ /tetrahydroxochromate(III) (ions) / $[Cr(OH)_4]^-$ / $[Cr(H_2O)_2(OH)_4]^-$ **(1)** **Z** = chromium(II) (ions) / chromium(II) sulfate / Cr^{2+} / $Cr^{2+}(aq)$ / $[Cr(H_2O)_6]^{2+}$ **(1)** ALLOW Name or formula of the compounds IGNORE Omission of square brackets around complexes	Names without oxidation numbers.	4

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)	**A** = ethanol / C_2H_5OH / ethanal / CH_3CHO OR any primary or secondary alcohol or any aldehyde **(1)** **B** = zinc / Zn ALLOW magnesium / Mg **(1)** **C** = any acid (name or formula) **(1)** IGNORE Omission of (aq) with acid formula Concentration of acid	CH_3COH Alkali metals Tin / Sn H^+ or H_3O^+ or acid	3

Question Number	Acceptable Answers	Reject	Mark
21 (b)(iii)	$Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$ OR Multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
21 (b)(iv)	$(NH_4)_2Cr_2O_7 \rightarrow Cr_2O_3 + N_2 + 4H_2O$ Allow multiples **(1)** Chromium is reduced from (+)6 to (+)3 **(1)** Nitrogen is oxidized from −3 to 0 **(1)** Penalise use of 'changes' / 'increases' / 'decreases' for 'oxidises' or 'reduces' once only		3

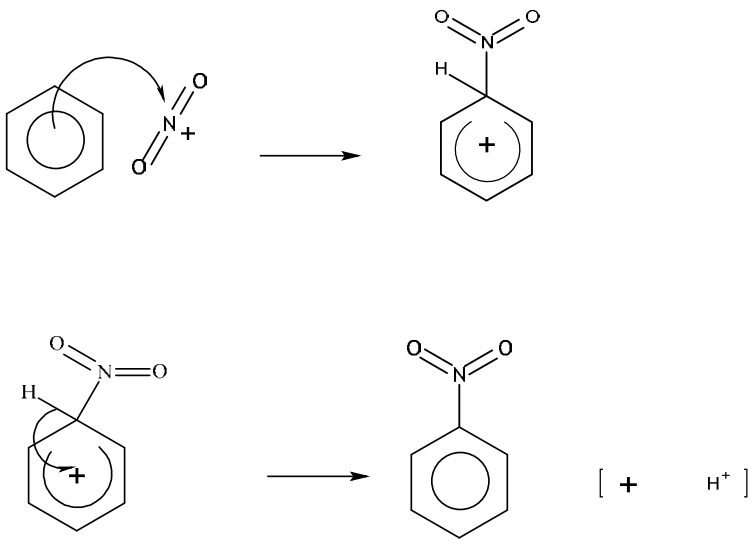
Question Number	Acceptable Answers	Reject	Mark
21 (b)(v)	(chromium(II) ions) oxidized by (oxygen in the) air ALLOW Just 'oxygen'		1

Question Number	Acceptable Answers	Reject	Mark
21 (c)(i)	(A ligand is a) molecule or (negative) ion with a (lone) pair (of electrons) ALLOW Species / Compound / group **(1)** Which forms a dative covalent bond with a (central) metal ion or atom (to form a complex) **(1)** ALLOW (if no other marked scored) Electron pair donor	Positive ion	2

Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	$Cr(H_2O)_6^{3+} + 6NH_3 \rightarrow Cr(NH_3)_6^{3+} + 6H_2O$ ALLOW $Cr(H_2O)_6^{3+} + 4NH_3 \rightarrow Cr(NH_3)_4(H_2O)_2^{3+} + 4H_2O$ Correct formula for ammine **(1)** Rest of the equation correct **(1)**	Cr^{3+} and $Cr^{3+}(aq)$	2

Total for Question 21 = 17 marks

Question Number	Acceptable Answers	Reject	Mark
22 (a)(i)	$HNO_3 + 2H_2SO_4 \rightarrow H_3O^+ + 2HSO_4^- + NO_2^+$ OR $HNO_3 + H_2SO_4 \rightarrow H_2O + HSO_4^- + NO_2^+$ OR 2-step version of these involving $H_2NO_3^+$ Correct electrophile **(1)** correct equation(s) **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
22 (a)(ii)	 OR NO_2^+ as electrophile TE on incorrect electrophile in (a)(i) Curly arrow from on or within the circle to positively charged nitrogen ALLOW Curly arrow from anywhere within the hexagon Arrow to any part of the electrophile including to the + charge **(1)** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe **(1)** Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure **(1)** Correct Kekulé structures score full marks Ignore any involvement of anion in the final step		3

Question Number	Acceptable Answers	Reject	Mark
22 (a)(iii)	Benzene ring in phenol has higher electron density ALLOW O / OH donates electron density to the (benzene) ring **(1)** Because **lone pair** of electrons on (phenol) oxygen is donated to / overlaps with / interacts with (π electrons of benzene) ring **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
22 (a)(iv)	Substitution may also occur at the 2 / 6 ring positions / ortho position ALLOW 'other' / 3 / 5 / meta ring positions / isomers ALLOW further substitution occurs IGNORE By-products formed		1

Question Number	Acceptable Answers	Reject	Mark
22 (a)(v)	Tin /Sn & (conc.) hydrochloric acid / HCl(aq) ALLOW Iron/ Fe for tin ALLOW HCl for HCl(aq)	$LiAlH_4$ / $NaBH_4$	1

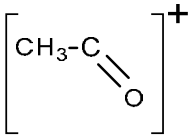
Question Number	Acceptable Answers	Reject	Mark
22 (a)(vi)	Yield = (100 x 0.25 x 0.74 x 0.85) = 15.725 / 15.73 / 15.7 / 16 (%)	16.0 and other rounding errors	1

Question Number	Acceptable Answers	Reject	Mark
22 (b)(i)	**Insoluble** impurities are removed by the hot filtration **(1)** **Soluble** impurities are removed by the cold filtration **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
22 (b)(ii)	5ºC and 95ºC **(1)** Because the lowest proportion (ALLOW 'amount') of paracetamol remains in solution (at the end) **(1)** IGNORE Just 'greatest difference in temperature'		2

Question Number	Acceptable Answers	Reject	Mark
22 (b)(iii)	Measure melting temperature ALLOW TLC (with UV light) Ignore Must melt over range of 2ºC Data = data book value	Boiling temperature HPLC	1

Question Number	Acceptable Answers	Reject	Mark
22 c(i)	Peak at m/e = 151 clearly labelled **M** ALLOW Alternative labels		1

Question Number	Acceptable Answers	Reject	Mark
22 c(ii)	43 =  OR CH_3CO^+ / $C_2H_3O^+$ ALLOW $CONH^+$ Ignore position of charges	$C_3H_7^+$ uncharged species	1

Question Number	Acceptable Answers	Reject	Mark
22 (d)	Limit number of tablets sold OR Give (oral) advice at the point of sale OR Use packs with tablets individually wrapped ALLOW Reduce the (tablet) dose	Only sell on prescription / doctor's advice Label packet	1

Total for Question 22 = 18 marks

Section C

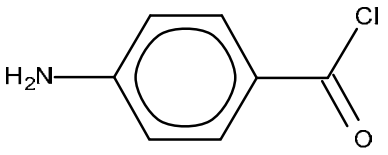
Question Number	Acceptable Answers	Reject	Mark
23 (a)(i)	ethanol has hydrogen bonding (as well as London / dispersion (allow van der Waals) forces) **(1)** ethoxyethane has van der Waals forces only / London forces and dipole-dipole forces / mainly London forces **(1)** so more energy is needed to separate ethanol molecules than ethoxyethane (molecules) ALLOW Hydrogen bonding is stronger **(1)**	London forces **only**	3

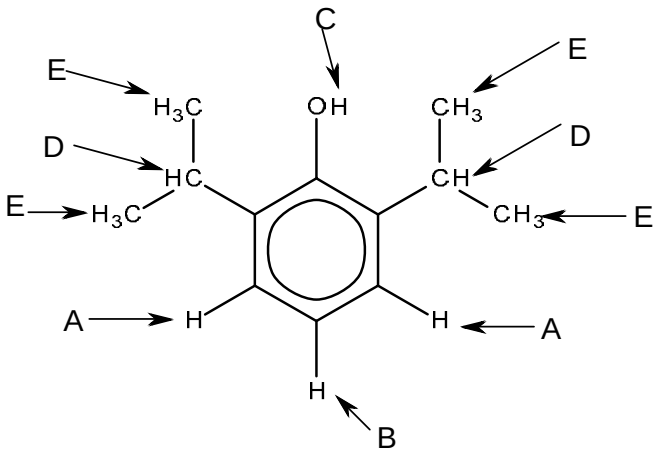
Question Number	Acceptable Answers	Reject	Mark
***23 (a)(ii)**	Any **three** of 1. 1 m cars sounds large but represents a small proportion of global cars 2. industrial / domestic power sources produce more man-made CO_2 3. Side-effects of alternative anaesthetics 4. Unacceptable not to use anaesthetics 5. Possibility of capturing anaesthetics at point of use 6. Possibility of using a different type of anaesthetic		3

Question Number	Acceptable Answers	Reject	Mark
23 (a)(iii)	C–F bonds much stronger (than C–H bonds) **(1)** Desflurane remains in the atmosphere for longer (and so act as a greenhouse gas, because it is stable) **(1)**		2

Question Number	Acceptable Answers	Reject	Mark
***23 (b)**	(A base is a proton acceptor) Basicity due to lone pair (of electrons) on the nitrogen(s) **(1)** Stand Alone Mark **EITHER** Lone pair of the nitrogen bonded to the benzene ring is much less basic **(1)** Because lone pair of the nitrogen bonded to the benzene ring interacts with / overlaps the π electrons of the ring **(1)** **OR** lone pair of nitrogen bonded to the alkyl groups more basic **(1)** Because of the positive inductive effect of the (three) alkyl groups **(1)**		3

Question Number	Acceptable Answers	Reject	Mark
23 (c)(i)	Equilibrium mixture is formed (so yield is low) ALLOW Reversible reaction IGNORE Rates The ammonium salt of the ester would be formed	Just 'yield is low' Reaction does not go to completion	1

Question Number	Acceptable Answers	Reject	Mark
23 (c)(ii)	PCl_5 /phosphorus(V) chloride / phosphorus pentachloride / PCl_3 /phosphorus(III) chloride / phosphorus trichloride / $SOCl_2$ / thionyl dichloride / thionyl chloride **(1)** Intermediate is 4-aminobenzoyl chloride /  **(1)** Add ethanol **(1)** Third mark dependent on the second (or near miss) If final structure is given, it must be correct	Ethanol and acid	3

Question Number	Acceptable Answers	Reject	Mark
23 (d)(i)	 Score a peak fully correct if **all** associated protons are correctly identified and none is incorrectly identified. All 5 peaks correct **(3)** Any 3 or 4 correct **(2)** Any 2 correct **(1)**		3

Question Number	Acceptable Answers	Reject	Mark
23 (d)(ii)	In HPLC there will be one peak for each component of the mixture OR In HPLC there would only be one peak if pure **(1)** In nmr the peaks due to impurities are more likely to be hidden by peaks of the main compound / indistinguishable from background noise **(1)**		2

Total for Question 23 = 20 marks
Total for Section C = 20 marks

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Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Tuesday 17 June 2014 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
WCH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P42979A

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6/6/5/5/

P 4 2 9 7 9 A 0 1 3 2

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 In which of the following compounds is there an element with the same oxidation number as that of chromium in $K_2Cr_2O_7$?

☒ **A** Cl_2O_7

☒ **B** $Na_3Fe(CN)_6$

☒ **C** K_2MnO_4

☒ **D** $CaTiF_6$

(Total for Question 1 = 1 mark)

2 Chlorine exists in oxidation states from −1 to +7. For which of the following compounds is a reaction resulting in the disproportionation of chlorine **impossible**?

☒ **A** NaClO

☒ **B** $NaClO_2$

☒ **C** $NaClO_3$

☒ **D** $NaClO_4$

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

3 The standard reduction potential of the system

$$Sn^{4+}(aq) + 2e^- \rightleftharpoons Sn^{2+}(aq)$$

is $E^{\ominus} = +0.15$ V.

(a) What are the components of the half-cell required to measure the standard reduction potential of this system?

(1)

	Ion(s) in the solution	Metal electrode
☒ **A**	Sn^{2+}	tin
☒ **B**	Sn^{4+}	tin
☒ **C**	Sn^{2+} and Sn^{4+}	tin
☒ **D**	Sn^{2+} and Sn^{4+}	platinum

(b) A standard $[Sn^{4+}(aq)]$, $[Sn^{2+}(aq)]$ half cell is connected to a standard hydrogen electrode. At the hydrogen electrode

(1)

☒ **A** hydrogen gas is oxidized to hydrogen ions.

☒ **B** hydrogen ions are oxidized to hydrogen gas.

☒ **C** hydrogen gas is reduced to hydrogen ions.

☒ **D** hydrogen ions are reduced to hydrogen gas.

(Total for Question 3 = 2 marks)

4 In an ethanol / oxygen fuel cell, the ethanol is

☒ **A** oxidized at the positive electrode.

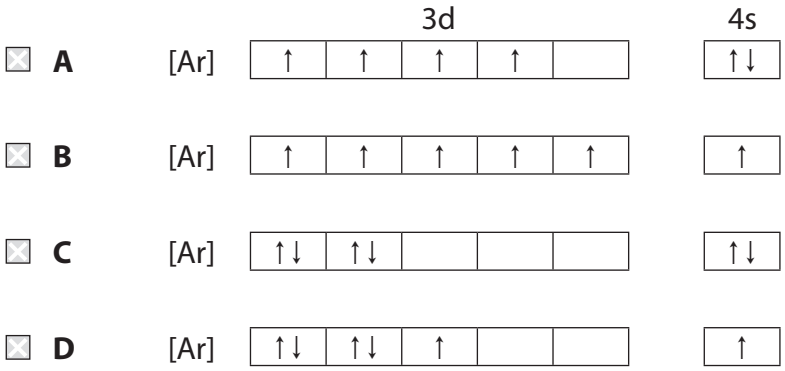
☒ **B** oxidized at the negative electrode.

☒ **C** reduced at the positive electrode.

☒ **D** reduced at the negative electrode.

(Total for Question 4 = 1 mark)

5 The electronic configuration of the element chromium is



(Total for Question 5 = 1 mark)

6 Iodide ions are oxidized by peroxodisulfate ions in aqueous solution:

$$2I^- + S_2O_8^{2-} \rightarrow I_2 + 2SO_4^{2-}$$

This reaction is catalysed by Fe^{3+} ions. The mechanism is most likely to involve

- **A** I^- reducing Fe^{3+} to an intermediate which is then oxidized by $S_2O_8^{2-}$.
- **B** I^- oxidizing Fe^{3+} to an intermediate which is then reduced by $S_2O_8^{2-}$.
- **C** $S_2O_8^{2-}$ oxidizing Fe^{3+} to an intermediate which is then reduced by I^-.
- **D** $S_2O_8^{2-}$ reducing Fe^{3+} to an intermediate which is then oxidized by I^-.

(Total for Question 6 = 1 mark)

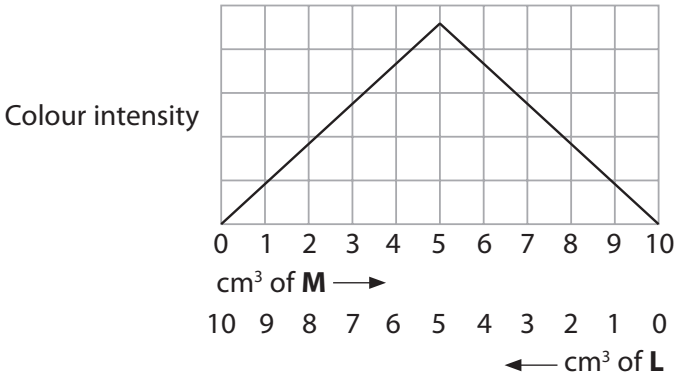
Use this space for any rough working. Anything you write in this space will gain no credit.

7 A transition metal ion, **M**, reacts with a complexing agent, **L**, to form a coloured complex with the formula $\mathbf{ML_2}$.

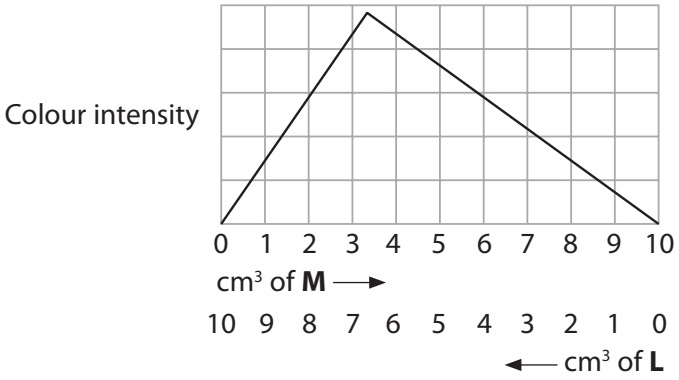
Portions of a 0.05 mol dm^{-3} solution of **M** were mixed with portions of a 0.05 mol dm^{-3} solution of **L**, so that the total volume of the resulting mixture was always 10 cm^3. The colour intensities of the complex in these mixtures were measured using a colorimeter.

What would the graph of the results look like?

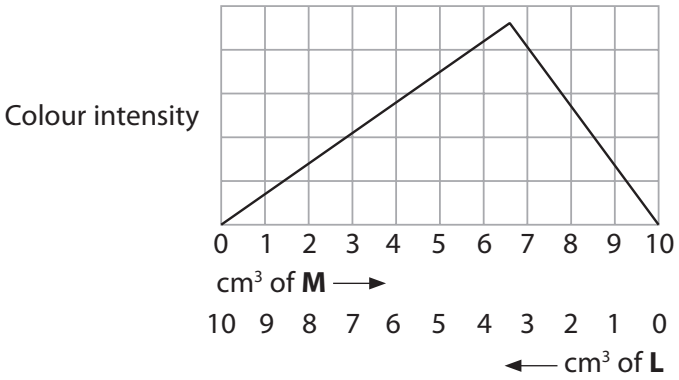
☒ **A**



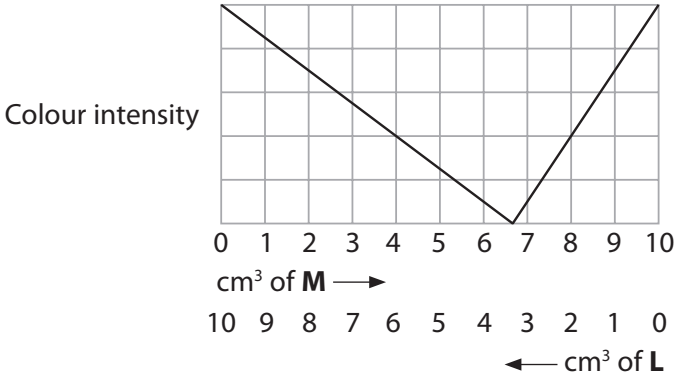
☒ **B**



☒ **C**



☒ **D**



(Total for Question 7 = 1 mark)

8 When concentrated hydrochloric acid is added to an aqueous solution of copper(II) sulfate, the blue solution changes to green then yellow. The change in colour is due to

- ☒ **A** the formation of chlorine in the solution.
- ☒ **B** the gradual replacement of the sulfate ion ligands by chloride ions.
- ☒ **C** the gradual replacement of the water ligands by chloride ions.
- ☒ **D** the reduction of the copper(II) ions to copper(I) ions.

(Total for Question 8 = 1 mark)

9 Dilute hydrochloric acid and dilute aqueous sodium hydroxide are added in excess to separate samples of chromium(III) hydroxide. What would be observed?

	Addition of HCl(aq)	Addition of NaOH(aq)
☒ **A**	green solution	green solution
☒ **B**	green solution	green solid
☒ **C**	green solid	green solution
☒ **D**	green solid	green solid

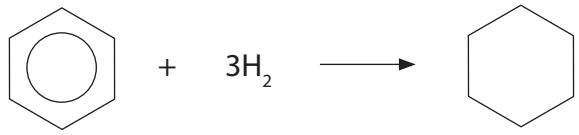
(Total for Question 9 = 1 mark)

10 The reaction between hydrogen and benzene is normally very slow but it speeds up in the presence of finely divided nickel. The nickel

- ☒ **A** acts as a homogeneous catalyst by acting as an electron pair acceptor in the formation of an electrophile.
- ☒ **B** acts as a homogeneous catalyst by acting as an electron pair donor in the formation of an electrophile.
- ☒ **C** acts as a heterogeneous catalyst by providing active sites on which the reaction occurs.
- ☒ **D** reacts with the hydrogen to form nickel(II) hydride which then reacts with the benzene.

(Total for Question 10 = 1 mark)

11 When the enthalpy change for the hydrogenation of benzene to cyclohexane



is compared to the calculated enthalpy change for the hydrogenation of the theoretical compound cyclohexa-1,3,5-triene to cyclohexane, benzene is calculated to have a stabilization energy of 150 kJ mol^{-1}. This means that

☒ **A** the enthalpy change for the hydrogenation of benzene is +150 kJ mol^{-1}.

☒ **B** the enthalpy change for the hydrogenation of benzene is −150 kJ mol^{-1}.

☒ **C** the enthalpy change for the conversion of benzene to cyclohexa-1,3,5-triene is +150 kJ mol^{-1}.

☒ **D** the enthalpy change for the conversion of benzene to cyclohexa-1,3,5-triene is −150 kJ mol^{-1}.

(Total for Question 11 = 1 mark)

12 Nitrobenzene is prepared by heating benzene and a mixture of concentrated nitric and sulfuric acids under reflux at 55°C. If the temperature rises above 55°C, the yield of nitrobenzene is reduced. This is because, at temperatures above 55°C, the

☒ **A** benzene evaporates.

☒ **B** nitrating mixture decomposes.

☒ **C** nitrobenzene reacts to form benzenesulfonic acid.

☒ **D** nitrobenzene reacts to form dinitrobenzene.

(Total for Question 12 = 1 mark)

13 Dilute sulfuric acid was added to a sample of phenylamine until the reaction was just complete. The resulting mixture was poured onto a watch-glass and allowed to stand in a warm place for about 24 hours. At the end of this time, the watch-glass contained

☒ **A** no residue.

☒ **B** a liquid inorganic residue.

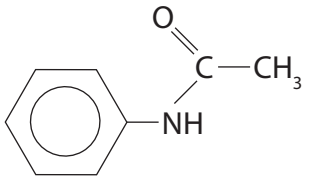
☒ **C** a liquid organic residue.

☒ **D** a white solid.

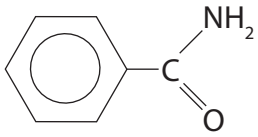
(Total for Question 13 = 1 mark)

14 When ethanoyl chloride is added to phenylamine at room temperature, the main organic product of the reaction is

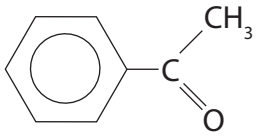
☒ **A**



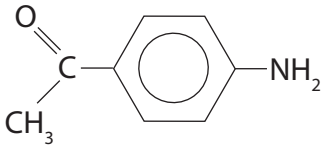
☒ **B**



☒ **C**



☒ **D**



(Total for Question 14 = 1 mark)

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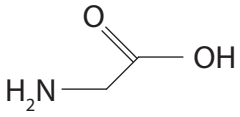
15 Glycine (2-aminoethanoic acid) is the simplest amino acid. The structure of glycine is



Which of the following is **not** true about glycine?

☒ **A** Glycine is a white crystalline solid at room temperature.

☒ **B** A glycine molecule is non-superimposable on its mirror image.

☒ **C** Glycine reacts with ninhydrin to form a purple compound.

☒ **D** Glycine molecules form condensation polymers with other amino acids.

(Total for Question 15 = 1 mark)

16 The mass spectrum of a compound, **Z**, has a peak at *m/e* = 43. Which of the following could **not** be **Z**?

☒ **A** $CH_3COCH_2CH_3$

☒ **B** $CH_3CH_2CH_2CHO$

☒ **C** $CH_3CH_2CH_2COCH_3$

☒ **D** $CH_3CH_2COCH_2CH_3$

(Total for Question 16 = 1 mark)

17 The low resolution proton nmr spectrum of a compound contains only two peaks. The compound could be

☒ **A** butan-1-ol

☒ **B** butan-2-ol

☒ **C** 2-methylpropan-1-ol

☒ **D** 2-methylpropan-2-ol

(Total for Question 17 = 1 mark)

18 A compound, **G**, has the following properties:

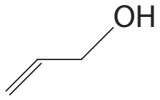
G reacts with phosphorus(V) chloride to form hydrogen chloride.

G reacts by addition with hydrogen in the presence of a nickel catalyst.

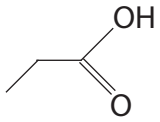
G reacts with sodium hydroxide to form an ionic solid.

Compound **G** could be

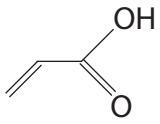
☒ **A**



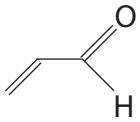
☒ **B**



☒ **C**



☒ **D**



(Total for Question 18 = 1 mark)

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19 In the first stage of the synthesis of methyl 3-nitrobenzoate, methyl benzoate, $C_6H_5COOCH_3$, is prepared by the reaction of benzoic acid with methanol in the presence of concentrated sulfuric acid. When the reaction is complete, the sulfuric acid is neutralized by the addition of aqueous sodium carbonate. The simplest way of obtaining the impure methyl benzoate from this mixture will be

☒ **A** refluxing.

☒ **B** solvent extraction.

☒ **C** filtration.

☒ **D** recrystallization.

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20 The table below shows some ions of vanadium that are stable in aqueous solution.

Ion	Oxidation number of vanadium	Colour in aqueous solution
$V(H_2O)_6^{2+}$		violet
$V(H_2O)_6^{3+}$		green
VO^{2+}		blue
VO_2^{+}	+5	yellow

(a) (i) Complete the table above by adding the missing oxidation numbers.

(1)

(ii) Complete the electronic configuration of the element vanadium and hence explain the highest oxidation number shown by vanadium.

(2)

Electronic configuration of the element vanadium:

[Ar] .....

Explanation of the highest oxidation number

.....

.....

.....

*(iii) Explain why $V(H_2O)_6^{3+}$ is coloured.

(4)

(iv) Suggest why the +5 oxidation state of vanadium exists as VO_2^+ in aqueous solution, rather than $V(H_2O)_6^{5+}$.

(2)

(v) If $V(H_2O)_6^{5+}$ did exist in aqueous solution, would it be coloured? Explain your answer.

(1)

(b) (i) Sulfur dioxide dissolves in water to form sulfuric(IV) acid, H_2SO_3.

Determine the feasibility of using sulfur dioxide dissolved in water to reduce $VO^{2+}(aq)$ to $V^{3+}(aq)$. Quote the relevant half equations and standard electrode potentials from page 15 of the Data Booklet and write the overall equation for the reaction.

(3)

(ii) Write an ionic equation for the disproportionation of vanadium in oxidation state +3 to vanadium in oxidation states +2 and +4.

(1)

(iii) Calculate the E_{cell} for this disproportionation and hence determine its feasibility.

(2)

(Total for Question 20 = 16 marks)

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21 Limestone is an important industrial raw material. The chemically important component of limestone is calcium carbonate and the proportion of this compound determines the quality of the material.

One method of determining the proportion of calcium carbonate in limestone involves dissolving the limestone in acid and precipitating the calcium ions as calcium ethanedioate. The precipitate is filtered and then re-dissolved in dilute sulfuric acid. The concentration of ethanedioate ions is determined by titration with a solution of potassium manganate(VII) of known concentration.

In one such determination, 1.77 g of limestone produced 250 cm^3 of calcium ethanedioate solution and 25.0 cm^3 samples of this solution were titrated at about 70 °C with potassium manganate(VII) solution of concentration 0.0205 mol dm^{-3}. The mean titre was 24.55 cm^3.

(a) (i) State the appearance of the titration mixture at the end-point.

(1)

.....

(ii) Complete the ionic equation for this titration.

(1)

$$2MnO_4^- + 5C_2O_4^{2-} + \text{.....}H^+ \rightarrow \text{.....}Mn^{2+} + \text{.....}CO_2 + \text{.....}H_2O$$

*(iii) Calculate the percentage by mass of calcium carbonate in the limestone. Show your working and give your final answer to **three** significant figures.

(5)

(b) (i) Before the calcium ethanedioate is re-dissolved, it is washed in deionized or distilled water. Explain why this step is necessary and the effect its omission would have on the titration.

(2)

.....

.....

.....

.....

.....

(ii) The table below summarises the tolerances on the measuring apparatus used in this experiment.

Complete the table by calculating the percentage error for each piece of apparatus to **two** significant figures.

(2)

Apparatus	Value	Maximum total error on the stated value	Percentage error on the stated value
Balance	1.77 g	±0.01 g	
Volumetric flask	250 cm^3	±0.12 cm^3	
Pipette	25 cm^3	±0.06 cm^3	
Burette	24.55 cm^3	±0.10 cm^3	

(iii) Using the method in (a), it was found that 2.00 g of a **different** sample of limestone contained 0.015 mol of calcium carbonate.

Use the data from (b)(ii), and the fact that the solubility of calcium ethanedioate in water is 0.0067 g dm^{-3}, to calculate whether the fact that some calcium ethanedioate remains in solution has a significant effect on the accuracy of this **second** calcium carbonate determination. Assume that the combined volume of the filtrate and the washings is approximately 500 cm^3.

(3)

.....

.....

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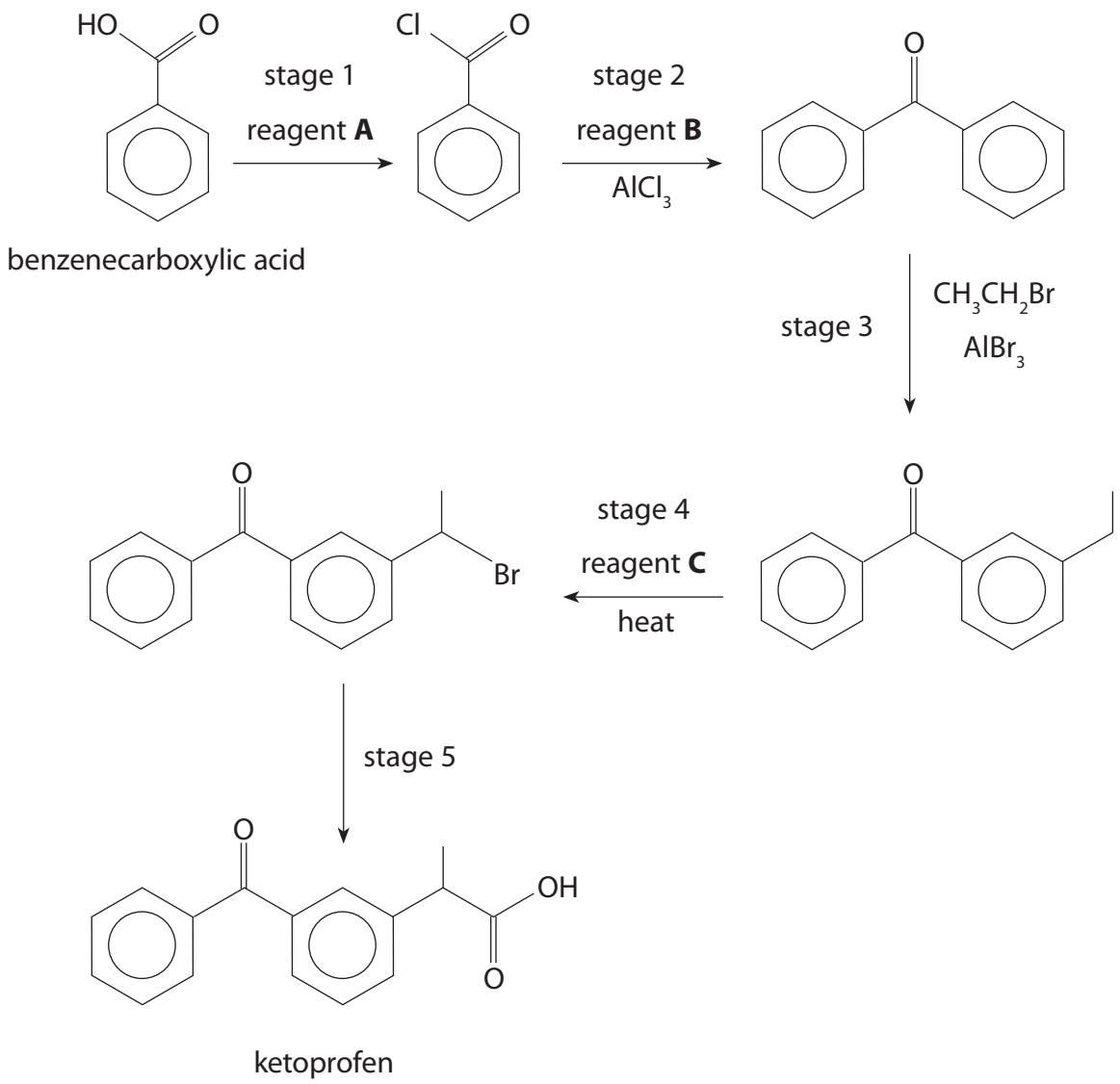
.....

(Total for Question 21 = 14 marks)

22 Ketoprofen is an analgesic used in the treatment of arthritis-related inflammatory pains. A synthesis of ketoprofen from benzenecarboxylic acid is shown below.



(a) Identify reagents **A**, **B** and **C** by name or formula.

(3)

A .....

B .....

C .....

(b) Stage 3 is an electrophilic substitution.

(i) Write an equation for the formation of the electrophile and explain the role of the $AlBr_3$ in this process.

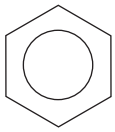
(2)

.....

.....

(ii) Complete the mechanism for the electrophilic substitution in stage 3. You need only show the benzene ring on the right of the structure. This is given below.

(3)



(c) The first step of stage 5 of the synthesis is the addition of a carbon atom to the chain. One way of achieving this is to replace the bromine atom with a nitrile group in a nucleophilic substitution.

(i) Suggest the name or formula of a reagent that could be used in this nucleophilic substitution. Suggest a suitable solvent in which to carry out the reaction.

(2)

.....

.....

(ii) The second step of stage 5 is the conversion of the nitrile into ketoprofen. State the reagent or reagents required.

(1)

.....

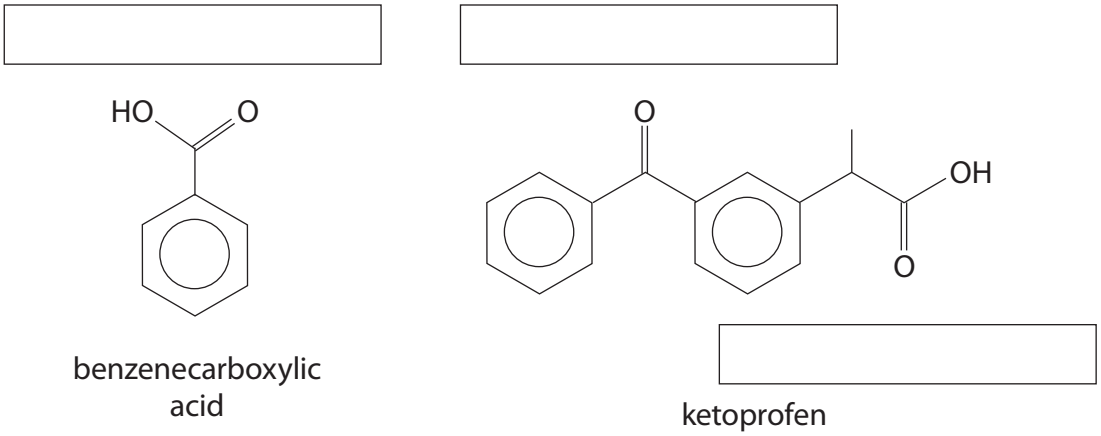
.....

.....

(d) Benzenecarboxylic acid and ketoprofen have different infrared spectra.

(i) In the diagram below, insert in the boxes the wavenumber **ranges** for the infrared absorptions due to C=O groups in benzenecarboxylic acid and ketoprofen.

(3)



benzenecarboxylic acid

ketoprofen

(ii) Explain how these absorptions can be used to distinguish between the two compounds.

(1)

.....

.....

.....

.....

(Total for Question 22 = 15 marks)

23 10 cm^3 of a gaseous hydrocarbon, C_xH_y, was mixed with excess oxygen and ignited. The total gas volume was measured at room temperature and pressure before and after combustion, and it was found that it had contracted by 20 cm^3. On shaking the remaining gases with excess potassium hydroxide solution, the total gas volume contracted by a further 40 cm^3.

The equation for the complete combustion of C_xH_y is

$$C_xH_y + (x + (y/4))O_2 \rightarrow xCO_2 + (y/2)H_2O$$

(a) Explain why the volume of gas contracts after combustion.

(1)

.....

.....

(b) Explain why the volume of gas contracts after shaking with excess potassium hydroxide.

(1)

.....

.....

(c) Calculate the molecular formula of C_xH_y.

(3)

(Total for Question 23 = 5 marks)

TOTAL FOR SECTION B = 50 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

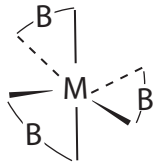
24

Stereoisomerism

Stereoisomerism occurs when species have the same formula and their atoms are bonded in the same sequence, but the spatial orientation of the atoms is different. Stereoisomers that are non-superimposable mirror images are optical isomers, or enantiomers. These have identical chemical and physical properties, apart from their effect on plane-polarized light. Optical isomerism arises most simply when a tetrahedral atom has four different groups bonded to it, but the presence of such a system does not necessarily result in an optical isomer.

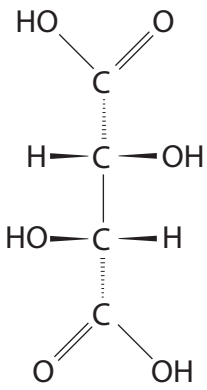
Stereoisomers that are not enantiomers are called diastereoisomers. Complex optically active species can be diastereoisomers, but a more familiar example is found with geometric isomers. In organic chemistry, geometric isomerism may arise when there is an energetic barrier to free rotation. Restricted rotation occurs with double bonds, because a π bond is formed by the *lateral* overlap of p orbitals, and also with cyclic compounds. Diastereoisomers have different physical properties and can be separated by conventional techniques.

Stereoisomerism is not confined to organic chemistry. Inorganic compounds may also show stereoisomerism and it is a particular feature of transition metal complexes. The simplest geometric isomers in transition metal complexes occur in square planar complexes ML_2N_2 and octahedral complexes ML_4N_2, where M is the metal ion and L and N are ligands. Geometric isomerism also occurs with octahedral complexes of the type ML_3N_3. The most important optical isomers of transition metals are octahedral complexes of the type MB_3 where B is a bidentate ligand; the structure of an enantiomer of MB_3 is shown below. The stability of complexes with polydentate ligands makes them easier to prepare.

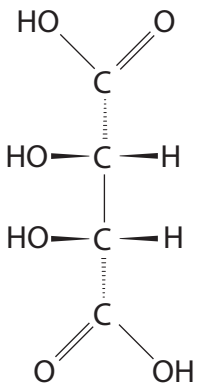


Because many biochemical reactions are stereospecific, stereoisomerism is of great importance in the pharmaceutical industry. Wherever possible, the industry aims to synthesize specific isomers.

(a) 2,3-dihydroxybutanedioic acid (tartaric acid) exists in three isomeric structures, **X**, **Y** and **Z**, two of which are shown below.



X



Z

Isomer **X** occurs in many plants including grapes, bananas and tamarinds.

(i) Circle the chiral centres of isomer **X** on the diagram.

(1)

(ii) Draw the structure of isomer **Y**, which is an enantiomer of **X**.

(1)

(iii) How can plane-polarized light be used to distinguish the enantiomers **X** and **Y**?

(2)

(iv) Suggest, with a reason, whether or not nuclear magnetic resonance could be used to distinguish between the enantiomers **X** and **Y**.

(1)

(v) An important use of **X** is in the preparation of other chiral molecules. One example is the substitution of the alcohol groups by bromine atoms.

State and explain what may be deduced about the mechanism of this reaction if the product is also chiral.

(2)

(vi) Isomer **Z** is a diastereoisomer. Suggest why it is not an optical isomer, even though it has two asymmetric carbon atoms.

(1)

(b) (i) Suggest why the lateral overlap that forms a π bond results in a barrier to free rotation about a carbon-carbon double bond.

(2)

(ii) Draw the geometric isomers of 1,2-dichlorocyclohexane.

(1)

(c) Cisplatin, $[PtCl_2(NH_3)_2]$, is an example of a stereospecific anti-cancer drug.

(i) Draw the structure of cisplatin and its geometric isomer.

(1)

(ii) Explain the term 'stereospecific drug'.

(1)

*(iii) Suggest **three** reasons why the pharmaceutical industry prefers to use stereospecific synthetic routes.

(3)

(d) The ethanedioate ion, $C_2O_4^{2-}$, is an example of a bidentate ligand.

(i) Explain the term 'bidentate ligand'.

(1)

.....

.....

.....

(ii) Explain why the complexes formed with bidentate ligands are generally more stable than those with monodentate ligands.

(1)

.....

.....

.....

(iii) The complex, $[Fe(C_2O_4)_3]^{3-}$, exists as two enantiomers. Use the information in the passage to draw the two enantiomers.

(2)

(Total for Question 24 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 7 9 9 A 0 3 2 3 2

PMT



Mark Scheme (Results)

Summer 2014

IAL Chemistry (WCH05/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		1

Question Number	Correct Answer	Reject	Mark
2	D		1

Question Number	Correct Answer	Reject	Mark
3(a)	D		1
(b)	A		1

Question Number	Correct Answer	Reject	Mark
4	B		1

Question Number	Correct Answer	Reject	Mark
5	B		1

Question Number	Correct Answer	Reject	Mark
6	A		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	C		1

Question Number	Correct Answer	Reject	Mark
9	A		1

Question Number	Correct Answer	Reject	Mark
10	C		1

Question Number	Correct Answer	Reject	Mark
11	C		1

Question Number	Correct Answer	Reject	Mark
12	D		1

Question Number	Correct Answer	Reject	Mark
13	D		1

Question Number	Correct Answer	Reject	Mark
14	A		1

Question Number	Correct Answer	Reject	Mark
15	B		1

Question Number	Correct Answer	Reject	Mark
16	D		1

Question Number	Correct Answer	Reject	Mark
17	D		1

Question Number	Correct Answer	Reject	Mark
18	C		1

Question Number	Correct Answer	Reject	Mark
19	B		1

Total for Section A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	<table><tr><th>Ion</th><th>Oxidation number of vanadium</th></tr><tr><td>$V(H_2O)_6^{2+}$</td><td>+2</td></tr><tr><td>$V(H_2O)_6^{3+}$</td><td>+3</td></tr><tr><td>VO^{2+}</td><td>+4</td></tr><tr><td>VO_2^{+}</td><td>(+5)</td></tr></table> All three correct **(1)** IGNORE omission of '+'		1

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	Electronic configuration of V: $[Ar]3d^3\ 4s^2$ ALLOW $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^3\ 4s^2$ $[Ar]\ 4s^2 3d^3$ $1s^2\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^3$ IGNORE Additional [Ar] **(1)** 5 electrons in valence shell / available for bonding ALLOW 5 electrons in outer shell (So max ON = +5) OR Uses the 2 4s and 3 3d electrons **(1)** ALLOW Lose 5 electrons (to form Ar structure) No TE on incorrect electronic configuration except $3d^5$ ($4s^0$) IGNORE Stability of +5 oxidation state	Gives electronic structure of Ar Loss of electrons from a (single) d orbital	2

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	(3)d orbitals / (3)d subshell split (by the attached ligands) **(1)** Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy d orbital(s) / levels) ALLOW d—d transitions occur **(1)** Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light **(1)** Reflected / transmitted / remaining light is coloured / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen **(1)** Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell is split Emitted	4

Question Number	Acceptable Answers	Reject	Mark
20(a)(iv)	V^{5+} is (small &) **high**ly charged /has a (very) **high** charge density **(1)** Would polarize / distort H_2O / H_2O electron clouds / O–H bond ALLOW O-H bond weakening / breaking OR Deprotonation **(1)** IGNORE References to ionization energy of V / highly electropositive	 Just 'Polarize' Ionic bonds	2

Question Number	Acceptable Answers	Reject	Mark
20(a)(v)	No. Because V^{5+} has no d electrons / d sub-shell is empty / d orbital**s** are empty. IGNORE Any mention of 4s V^{5+} has no partially filled d orbitals		1

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	Either **Method 1 (using equations)** $4H^+ + SO_4^{2-} + 2e^- \rightarrow H_2SO_3 + H_2O$ E^o = **+**0.17 (V) $VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$ E^o = **+**0.34 (V) **(1)** $2VO^{2+} + H_2SO_3 \rightarrow 2V^{3+} + SO_4^{2-} + H_2O$ **(1)** E_{cell} (SO_2) = 0.34 – 0.17 = (+)0.17 (V) AND So reduces V(IV) to V(III) / reaction is feasible **(1)** **OR** **Method 2 (using anticlockwise rule)** When half reactions are placed in order (more negative first) $4H^+ + SO_4^{2-} + 2e^- \rightarrow H_2SO_3 + H_2O$ E^o = +0.17 V $VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$ E^o = +0.34 V Required reaction 'goes' in anticlockwise direction Arrows on half equations and explanation **(2)** $2VO^{2+} + H_2SO_3 \rightarrow 2V^{3+} + SO_4^{2-} + H_2O$ **(1)**	Use of thiosulphate half cell =0 Uncancelled electrons Uncancelled electrons	3

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	$2V^{3+} + H_2O \rightarrow V^{2+} + VO^{2+} + 2H^+$ ALLOW $V(H_2O)_6^{3+}$ and $V(H_2O)_6^{2+}$		1

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	(Relevant electrode potentials are $VO^{2+} + 2H^+ + e^- \rightarrow V^{3+} + H_2O$ $E^o = +0.34$ V $V^{3+} + e^- \rightarrow V^{2+}$ $E^o = -0.26$ V) E_{cell} (disproportionation) $= (-0.26 - 0.34) =$ **-0.6(0)** (V) **(1)** E_{cell} negative so disproportionation not (thermodynamically) feasible. **(1)** TE for second mark only if value given		2

Total for Question 20 = 16 marks

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	(pale) pink OR First permanent pink Ignore 'Colourless to'	purple	1

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	$2MnO_4^- + 5C_2O_4^{2-} + \mathbf{16}H^+ \rightarrow \mathbf{2}Mn^{2+} + \mathbf{10}CO_2 + \mathbf{8}H_2O$		1

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	Amount MnO_4^- = 24.55 x .0205 x 10^{-3} **(1)** = 5.03275 x 10^{-4} mol (ans *) Amount $C_2O_4^{2-}$ in 25 cm^3 = ans. * x 5 /2 = 5.03275 x 10^{-4} x 5/2 **(1)** = 1.2581875 x 10^{-3} mol In 250 cm^3 = 1.2581875 x 10^{-2} mol (ans **) **(1)** = amount Ca^{2+} = amount $CaCO_3$ Mass $CaCO_3$ = (ans**) x 100.1 = 1.2581875 x 10^{-2} x 100.1 **(1)** = 1.2594457 g (ans***) % $CaCO_3$ = 100 x (ans***) / 1.77 = 71.15512 = 71.2 (%) **(1)** ALLOW Final answer 71.1 / 71.2 / 71.3 scores 5 marks Final answer must be to 3 SF (max 4 if not) Until final answer ignore SF except 1 SF (penalise once) TE at each stage unless mass $CaCO_3$ > 1.77 NOTE Use of ethanedioate mass of 88 in step 4 gives final answer of 62.6% (max 4) Use of calcium ethanedioate mass of 128.1 / 128 in step 4 gives final answer of 91.0% (max 4)		5

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	Excess ethanedioate (ions in the solution) must be removed **(1)** ALLOW Remove ethanedioic acid Otherwise more $KMnO_4$ will be used (in the titration) / bigger titre **(1)** MP2 dependent on MP1	Impurities Acid	2

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)			2

Apparatus	**Value**	**Maximum total error on the stated value**	**Percentage error on the stated value**
Balance	1.77 g	±0.01 g	0.56 (0.56497)
Volumetric flask	250 cm^3	±0.12 cm^3	0.048
Pipette	25 cm^3	±0.06 cm^3	0.24
Burette	24.55 cm^3	±0.10 cm^3	0.41 (0.40733)

All % calculations correct **(2)**
Any two or three calculations correct **(1)**

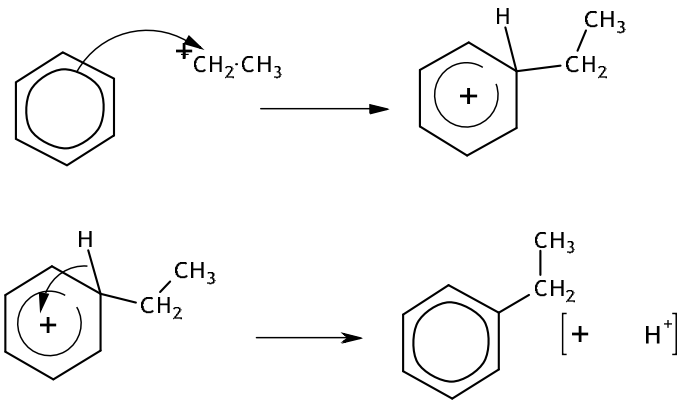
1 mark lost if 2 or more correct answers are not given to 2 SF

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	**First mark** EITHER Max. mass of CaC_2O_4 precipitated = 0.015 x 128.1 = 1.9215 g OR 0.0067/2 = 0.00335 g remains in solution **(1)** **Second Mark** % error = 100 x 0.00335 / (1.9215 + 0.00335) = 100 x 0.00335 / 1.92485 = 0.174040 = 0.174 % ALLOW % error = 100 x 0.00335 / 1.9215 = 0.174343 = 0.174 % If M_r (CaC_2O_4) = 128 used = 0.174479 % **(1)** **Third Mark** Error comparable to / smaller than apparatus uncertainty / less than the worst / less than the balance / less than the total And so acceptable **(1)** IGNORE SF but penalise incorrect rounding once NOTE No TE for mark 2 from mark 1 BUT TE for mark 3. Accept reverse argument for large percentage.		3

Total for Question 21 = 14 marks

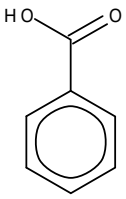
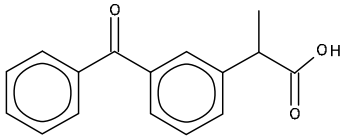
Question Number	Acceptable Answers	Reject	Mark
22(a)	**A** = PCl_5 / phosphorus(V) chloride / phosphorus pentachloride / PCl_3 / phosphorus(III) chloride / phosphorus trichloride / $SOCl_2$ / thionyl chloride / thionyl dichloride **(1)** **B** = benzene / C_6H_6 or ring structures **(1)** **C** = bromine / Br_2 **(1)**	Bromine water / Bromine and $FeBr_3$	3

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	$CH_3CH_2Br + AlBr_3 \rightarrow CH_3CH_2^+ + AlBr_4^-$ **(1)** ALLOW $C_2H_5^+$ + sign anywhere on formula of electrophile ($AlBr_3$ is an) electron pair acceptor / lone pair acceptor / Lewis acid / Friedal-Crafts catalyst **(1)** ALLOW polarizes C-Br bond IGNORE Halogen carrier	Accepts electrons Just 'catalyst'	2

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	 TE on incorrect electrophile in (b)(i) Curly arrow from on or within the circle to positively charged carbon ALLOW Curly arrow from anywhere within the hexagon Arrow to **any** part of the electrophile including to the + charge **(1)** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe ALLOW dotted horseshoe **(1)** Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure **(1)** Correct Kekulé structures score full marks Ignore any involvement of AlX_4^- in the final step NOTE $C_2H_5^+$ as electrophile can score all 3 marks	Curly arrow on or outside the hexagon Partial bonds to H and CH_3	3

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	KCN / potassium cyanide / NaCN / sodium cyanide **(1)** In ethanol (dependent on mark 1) ALLOW alcohol / aqueous ethanol / aqueous alcohol **(1)** ethanolic or alcoholic KCN (etc) scores both marks BUT CN^- / HCN in ethanol scores second mark	cyanide / CN^- HCN	2

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	Name / formula of any strong aqueous acid OR named strong aqueous alkali followed by acidification Ignore heat / reflux / dilute / conc	H^+ / H_3O^+	1

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	1700-1680 (cm$^-$)  benzenecarboxylic acid 1700-1680 (cm$^-$)  ketoprofen 1725-1700 1 mark for each correct range / reverse range Single numbers within range = max 2 marks		3

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	Only (the carboxylic acid group in) ketoprofen will give a peak at 1725 – 1700 cm^{-1} ALLOW Ketoprofen has 2 absorptions whilst benzenecarboxylic acid has one Correct TE identifying a unique range	 Just ketoprofen has more peaks	1

Total for Question 22 = 15 marks

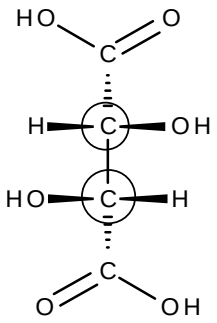
Question Number	Acceptable Answers	Reject	Mark
23(a)	Volume of CO_2 is less than volume of oxygen (and only other product is water). OR Fewer moles / molecules of gaseous products (than reactants).		1

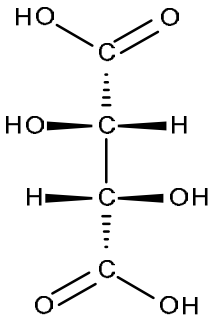
Question Number	Acceptable Answers	Reject	Mark
23(b)	Potassium hydroxide / KOH absorbs **CO_2** OR **CO_2** reacts with potassium hydroxide / KOH OR **CO_2** dissolves in potassium hydroxide / KOH		1

Question Number	Acceptable Answers	Reject	Mark
23(c)	So $10x = 40$ $x = 4$ **(1)** So $10 + 10(x + (y/4)) - 10x = 20$ $10(y/4) = 10$ $y = 4$ **(1)** $C_xH_y = C_4H_4$ **(1)** Correct formula with no working or explanation scores 3		3

Total for Question 23 = 5 marks
Total for Section B = 50 marks

Section C

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	 Circles around **both** asymmetric centres needed ALLOW Any correct labelling		1

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	 ALLOW Any (correct) representation of carboxylic acid groups (e.g. COOH / CO_2H) Any orientation of carboxylic acid groups Fischer diagrams ONLY if labelled as such		1

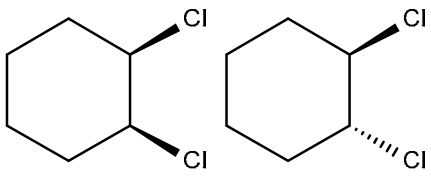
Question Number	Acceptable Answers	Reject	Mark
24(a)(iii)	The enantiomers will rotate the plane of plane-polarized light **(1)** Mark 1 must see rotate, plane and polarized (equally) in opposite directions ALLOW Clockwise and anticlockwise / left and right / + and **(1)** IGNORE Different directions		2

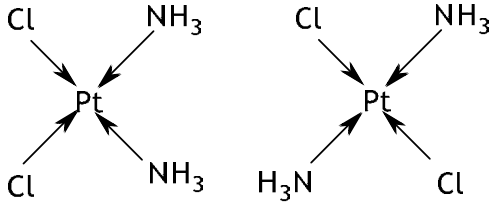
Question Number	Acceptable Answers	Reject	Mark
24(a)(iv)	No because the proton / H environments are the same (in both enantiomers) ALLOW No, the same peaks / spectrum		1

Question Number	Acceptable Answers	Reject	Mark
24(a)(v)	(S_N2) Because nucleophile must **attack** only from one side (of the molecule) / from the opposite side (to the leaving group) **OR** (Not S_N1) Because nucleophile would **attack** on both sides (of the intermediate) (and form a racemic mixture) **(1)** Substitution must be S_N2 **OR** Substitution cannot be S_N1 **(1)** NOTE For mark 1 IGNORE references to structure of intermediate		2

Question Number	Acceptable Answers	Reject	Mark
24(a)(vi)	Superimposable on its mirror image (allow enantiomer / isomer) / it has a plane of symmetry ALLOW The molecule is identical to its mirror image (Two chiral centres produce) equal but opposite rotation (of plane polarized light)	Centre of symmetry	1

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Rotation (about the bond) reduces (lateral) overlap **(1)** to an energetically less favourable alignment OR so bond weaker OR (π) bond breaks **(1)**	π bond restricts rotation Double bond breaks	2

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	 Both structures needed ALLOW Hydrogens to be shown Perspective diagrams		1

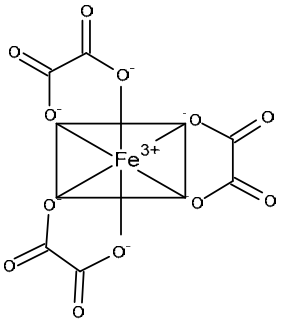
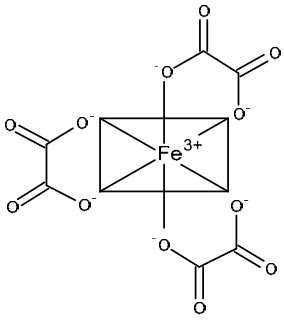
Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	 Both structures needed Dative covalent bonds need not be shown.		1

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	One of: Only one isomer is (biochemically) active One isomer is more active than the other One isomer is beneficial but the other has a negative effect Different isomers have different (biochemical) properties		1

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	Any **three** from: 1. Avoids waste of substances (compounds, solvents etc) (used in the synthesis) ALLOW No waste product(s). 2. Avoids any need to separate enantiomers. 3. Unwanted enantiomer(s) might have negative effects / be toxic / harmful. 4. (Synthesising specific isomers results in) more effective / lower dosage of medicines. IGNORE Cost / yield / atom economy / (harmful) side effects	Just 'easier to prepare'	3

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	A bidentate ligand occupies two coordination positions (around a central ion) OR Can donate / has two lone pairs that can bond (separately) (to the central ion) OR Can form two dative bonds		1

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	(Conversion of a monodentate ligand complex to a bidentate ligand complex) increases the number of particles so ΔS_{tot} / ΔS_{sys} / entropy increases	Bidentate complexes have higher entropy	1

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	  1 mark for each structure Penalise incorrect charges once only ALLOW Complexes with overall 3 $^-$ For 1 mark 2 optical isomers with non displayed C_2O_4 linked		2

Total for Question 24 = 20 marks
Total for Section C = 20 marks

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Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Tuesday 20 January 2015 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
WCH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P45045A

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5/5/5/5/2/1/

P 4 5 0 4 5 A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Manganese forms a complex with carbon monoxide, with the formula $Mn_2(CO)_{10}$. The oxidation number of manganese in $Mn_2(CO)_{10}$ is

☒ **A** 0

☒ **B** +2

☒ **C** +5

☒ **D** +10

(Total for Question 1 = 1 mark)

---

2 The reduction of nitrate(V) ions by aluminium in alkaline conditions may be represented by the equation below.

$$x\ NO_3^- + y\ Al + a\ OH^- + b\ H_2O \rightarrow x\ NH_3 + y\ Al(OH)_4^-$$

From the change in the oxidation numbers of nitrogen and aluminium, it can be deduced that the values of x and y are

☒ **A** x = 3 and y = 2

☒ **B** x = 2 and y = 3

☒ **C** x = 8 and y = 3

☒ **D** x = 3 and y = 8

(Total for Question 2 = 1 mark)

---

3 Which of the following is correct for the standard hydrogen electrode?

☒ **A** The temperature is kept at 273 K.

☒ **B** Sulfuric acid with a concentration of 0.5 mol dm^{-3} is used.

☒ **C** The metal electrode is copper foil.

☒ **D** The hydrogen pressure is 1 atmosphere.

(Total for Question 3 = 1 mark)

---

4 The standard electrode potentials of two electrode systems are given below.

$$Cr^{3+}(aq) + 3e^- \rightleftharpoons Cr(s) \qquad E^{\ominus} = -0.74\ V$$

$$Cd^{2+}(aq) + 2e^- \rightleftharpoons Cd(s) \qquad E^{\ominus} = -0.40\ V$$

Calculate the $E^{\ominus}_{cell}$ for the reaction

$$2Cr(s) + 3Cd^{2+}(aq) \rightarrow 3Cd(s) + 2Cr^{3+}(aq)$$

☒ **A** −0.34 V

☒ **B** +0.34 V

☒ **C** −0.28 V

☒ **D** +0.28 V

(Total for Question 4 = 1 mark)

5 The calculated $E^{\ominus}$ for a reaction is positive but no reaction occurs when the reagents are mixed under standard conditions. It can be deduced that

☒ **A** the reaction is thermodynamically feasible and the reaction mixture is kinetically stable.

☒ **B** the reaction is thermodynamically feasible and the reaction mixture is kinetically unstable.

☒ **C** the reaction mixture is thermodynamically and kinetically stable.

☒ **D** the reaction mixture is thermodynamically stable and kinetically unstable.

(Total for Question 5 = 1 mark)

6 The electronic configuration of the iron(II) ion, Fe^{2+}, is

		3d					4s
☒ **A**	[Ar]	↑↓	↑	↑			↑↓
☒ **B**	[Ar]	↑	↑	↑	↑		↑↓
☒ **C**	[Ar]	↑	↑	↑	↑	↑	↑
☒ **D**	[Ar]	↑↓	↑	↑	↑	↑	

(Total for Question 6 = 1 mark)

7 Transition metal compounds often have catalytic properties. The **best** explanation for this is that

☒ **A** transition metal compounds usually have a much larger surface area than other metal compounds.

☒ **B** transition metal ions readily promote electrons to higher energy levels by absorbing electromagnetic radiation in the visible region.

☒ **C** relatively small amounts of energy are required to change the oxidation state of a transition metal.

☒ **D** the ionization energies of transition metals are much lower than those of other metals.

(Total for Question 7 = 1 mark)

8 What are the shapes of the dichlorocuprate(I) ion, $CuCl_2^-$, and the tetrachlorochromate(III) ion, $CrCl_4^-$?

	$CuCl_2^-$	$CrCl_4^-$
☒ **A**	V shaped	tetrahedral
☒ **B**	linear	tetrahedral
☒ **C**	V shaped	square planar
☒ **D**	linear	square planar

(Total for Question 8 = 1 mark)

9 When dilute aqueous ammonia is added to an aqueous solution of a metal ion, a green precipitate is formed which dissolves slowly in excess ammonia to form a green solution. What is the metal ion present in the original solution?

☒ **A** Ni^{2+}

☒ **B** Fe^{2+}

☒ **C** Cu^{2+}

☒ **D** Cr^{3+}

(Total for Question 9 = 1 mark)

10 The iron(II) ion forms complexes with monodentate ethanoate ions and bidentate ethanedioate ions. The complexes with ethanedioate ions are more stable. What is the best explanation for this?

☒ **A** Ethanedioate ions form stronger bonds than ethanoate ions with iron(II) ions.

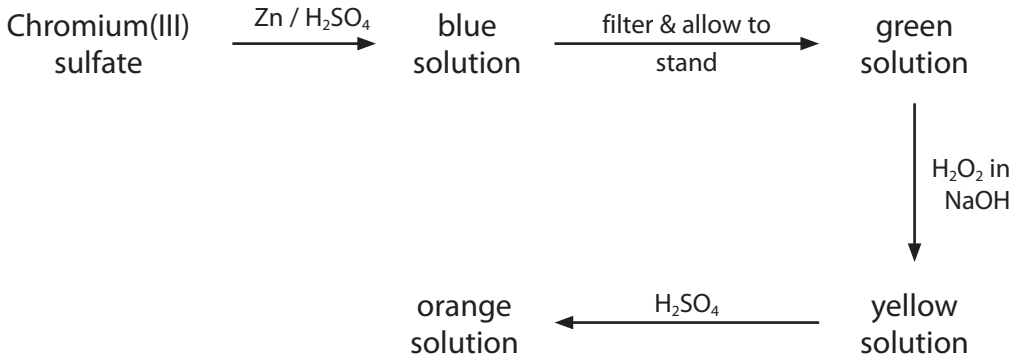
☒ **B** Ethanedioic acid is a stronger acid than ethanoic acid.

☒ **C** The formation of the ethanedioate complex produces more particles in solution.

☒ **D** Ethanedioic acid forms stronger hydrogen bonds than ethanoic acid.

(Total for Question 10 = 1 mark)

11 The diagram below summarises a sequence of reactions involving chromium compounds.



How many different oxidation states of chromium are involved in this sequence?

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 5

(Total for Question 11 = 1 mark)

12 All the bond angles in the benzene molecule are 120°. Which of the following provides the best evidence for this?

- ☒ **A** Valence shell electron pair repulsion theory
- ☒ **B** X-ray diffraction
- ☒ **C** High resolution nuclear magnetic resonance
- ☒ **D** Infrared spectroscopy

(Total for Question 12 = 1 mark)

13 Benzene burns with a very smoky flame. This is evidence for the extent to which the benzene molecule is

- ☒ **A** delocalised.
- ☒ **B** stabilised.
- ☒ **C** unsaturated.
- ☒ **D** activated.

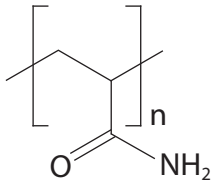
(Total for Question 13 = 1 mark)

14 When bromine water is added to benzene, no reaction occurs. However, when bromine water is added to an aqueous solution of phenol, a white precipitate with an antiseptic smell is formed. What is the explanation for this difference?

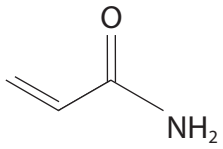
- ☒ **A** Bromine is a powerful electrophile.
- ☒ **B** The benzene ring in phenol is activated.
- ☒ **C** The reaction of phenol with bromine is similar to the iodoform reaction.
- ☒ **D** The OH group in phenol is much more acidic than that in ethanol.

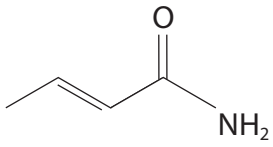
(Total for Question 14 = 1 mark)

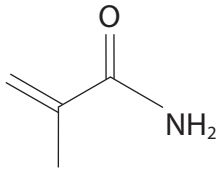
15 The repeat unit of a polymer is shown below.

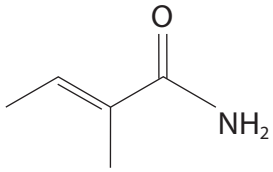


What is the structure of the monomer?

☒ **A** 

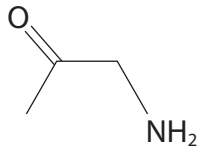
☒ **B** 

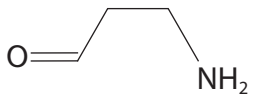
☒ **C** 

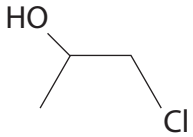
☒ **D** 

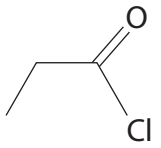
(Total for Question 15 = 1 mark)

16 An organic compound reacts with dilute sulfuric acid to form a colourless solution which produces a white solid on evaporation. It also gives a pale yellow solid on reaction with iodine in sodium hydroxide. The compound is

☒ **A** 

☒ **B** 

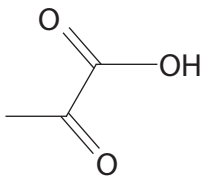
☒ **C** 

☒ **D** 

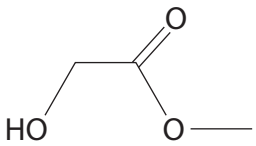
(Total for Question 16 = 1 mark)

17 An organic compound produces steamy fumes with phosphorus(V) chloride but does **not** react with 2,4-dinitrophenylhydrazine. The compound is

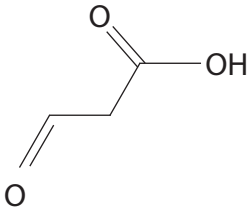
☒ **A**



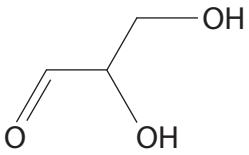
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

18 In the mass spectrum of an organic compound, the molecular ion occurs at *m/e* = 86.

Which of the following could be the **empirical formula** of the compound?

- ☒ **A** C_6H_{14}
- ☒ **B** $C_5H_{10}N$
- ☒ **C** $C_5H_{12}O$
- ☒ **D** C_5H_7F

(Total for Question 18 = 1 mark)

19 The high resolution proton nmr spectrum of propan-1-ol, $CH_3CH_2CH_2OH$, contains four peaks. What is the splitting pattern of the four peaks?

[Where 1 represents a singlet, 2 represents a doublet, etc.]

- ☒ **A** 3 2 2 1
- ☒ **B** 3 4 3 1
- ☒ **C** 3 6 3 1
- ☒ **D** 3 6 4 2

(Total for Question 19 = 1 mark)

20 Which of the following techniques would be the **least** effective as a control measure to reduce risk when heating a flammable liquid?

The use of

- ☒ **A** an electrical heater.
- ☒ **B** a fume cupboard.
- ☒ **C** a small quantity of the liquid.
- ☒ **D** a reflux condenser.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Brass is an alloy of copper and zinc, often with traces of other metals. The copper content of brass can be determined by dissolving the metal in concentrated nitric acid and measuring, by titration, the concentration of the copper(II) ions formed.

(a) When concentrated nitric acid reacts with copper, the copper dissolves and one of the products is dinitrogen tetroxide, N_2O_4.

(i) Use the data on page 15 of the Data Booklet to write the ionic half-equations for this reaction of copper with concentrated nitric acid. State symbols are not required.

(2)

(ii) Write the overall equation for the reaction of copper with concentrated nitric acid and calculate $E^{\ominus}_{cell}$ for the reaction. State symbols are not required.

(2)

(iii) State **one** observation that you would expect to make when copper dissolves in concentrated nitric acid.

(1)

.....

.....

(b) 1.35 g of a sample of rivet brass was dissolved in concentrated nitric acid. The resulting mixture was boiled and then allowed to cool before being transferred to a volumetric flask. The solution was made up to 250 cm^3 with distilled water and mixed thoroughly.

Excess potassium iodide solution was added to 25.0 cm^3 samples of this solution, and the liberated iodine determined by titration with a solution of sodium thiosulfate of concentration 0.0505 mol dm^{-3}. The mean titre was 26.35 cm^3.

(i) Write the **ionic** equation for the reaction of the copper(II) ions with iodide ions to form copper(I) iodide and iodine. State symbols are not required.

(1)

(ii) Write the **ionic** equation for the reaction of iodine with thiosulfate ions. State symbols are not required.

(1)

(iii) Use the equations in (b)(i) and (b)(ii) to show that the amount of copper(II) ions is equal to the amount of thiosulfate ions.

(1)

.....

.....

.....

(iv) Calculate the percentage by mass of copper in the sample of rivet brass.

(4)

(c) (i) The reaction mixture in (b) was boiled before being transferred to a volumetric flask. This removed dissolved nitrogen oxides which would otherwise oxidize the iodide ions.

Explain the effect that omitting this step would have on the value obtained for the percentage of copper.

(2)

(ii) Any nitrogen oxides that remain after boiling can be removed by the addition of urea. When this was done, the mean titre changed by 0.25 cm^3.
By considering the uncertainties in the various measurements, explain whether the addition of urea is worthwhile.

(2)

(d) Both copper and zinc are d-block elements, but only copper is a transition metal.

(i) Explain the term **d-block element**.

(1)

(ii) Explain why copper is classed as a transition metal but zinc is not.

(1)

*(iii) Explain why the complexes of copper(II) ions are coloured.

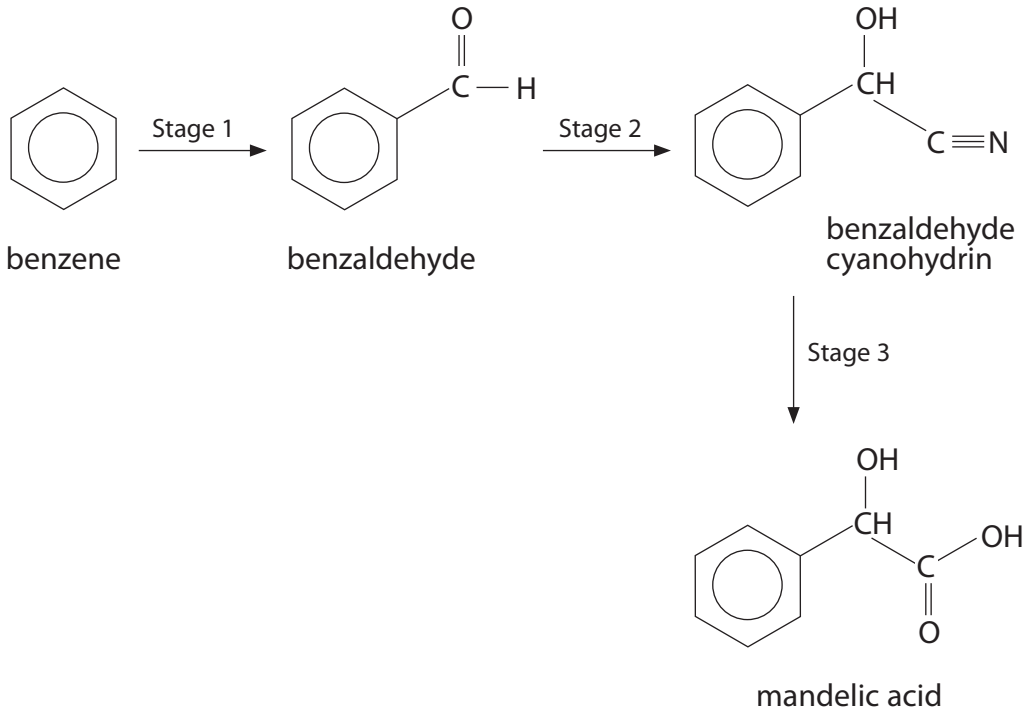
(4)

(iv) Although zinc is not a transition metal, zinc(II) ions form complexes. Explain why these complexes are colourless.

(1)

(Total for Question 21 = 23 marks)

22 Mandelic acid, 2-hydroxy-2-phenylethanoic acid, has a long history of medical use as an antibiotic and as a component of some cosmetic face creams. It was first obtained from an extract of bitter almonds and 'Mandel' is the German word for almond. Mandelic acid can be synthesized from benzene in the sequence shown below.



(a) (i) Use your knowledge of electrophilic substitution to suggest the identity of the electrophile in Stage 1 of the synthesis.

(1)

.....

(ii) Write the mechanism for the electrophilic substitution in Stage 1, using the electrophile that you have given in (a)(i).

(3)

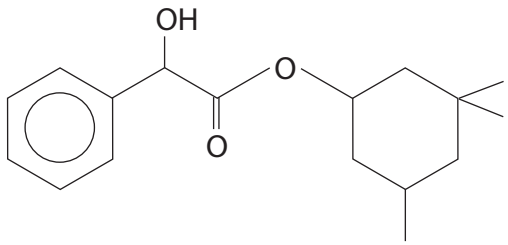
(iii) State the reagents and conditions required for Stage 2. You may assume that the reaction is carried out at a suitable temperature.

(2)

(iv) State the reagent (or reagents) required for Stage 3.

(1)

(b) Cyclandelate is a vasodilator (causes blood vessels to dilate) used in the treatment of arteriosclerosis (hardening of artery walls). The structure of cyclandelate is shown below.



(i) Suggest a single stage synthesis of cyclandelate from mandelic acid. Draw the skeletal formula of the organic compound that would be required and state any essential reagents and conditions.

(3)

(ii) Suggest a disadvantage of using the synthesis that you have suggested in (b)(i) for the large scale manufacture of cyclandelate.

(1)

(iii) An alternative **two** stage synthesis of cyclandelate was proposed. This involved reacting mandelic acid with phosphorus(V) chloride. Explain why this suggestion is unsatisfactory.

(1)

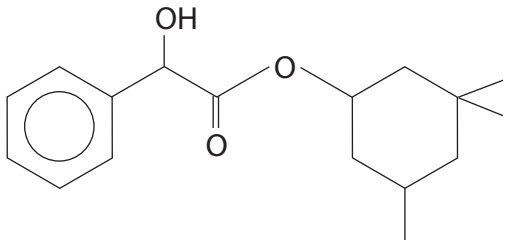
.....

.....

(c) Cyclandelate has **three** asymmetric carbon atoms.

(i) Circle these three asymmetric carbon atoms on the structure below.

(2)



(ii) Explain the possible problem that the presence of asymmetric carbon atoms might cause with the medical applications of cyclandelate.

(2)

.....

.....

.....

.....

.....

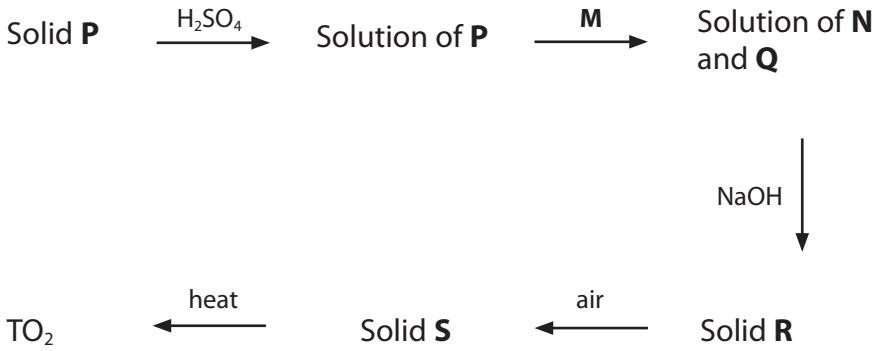
(Total for Question 22 = 16 marks)

23 Compound **P** is a very dark purple solid which gives a lilac flame in a flame test.

A sample of **P** was dissolved in dilute sulfuric acid to form a purple solution. A gaseous hydrocarbon, **M**, was bubbled into this solution which rapidly formed a colourless solution, containing an organic compound, **N**, and an inorganic compound, **Q**.

When aqueous sodium hydroxide was added to **Q**, a very pale brown precipitate, **R**, formed. **R** darkened on standing in air to form a dark brown solid, **S**, which was filtered off and heated to form a dark brown metal oxide, TO_2.

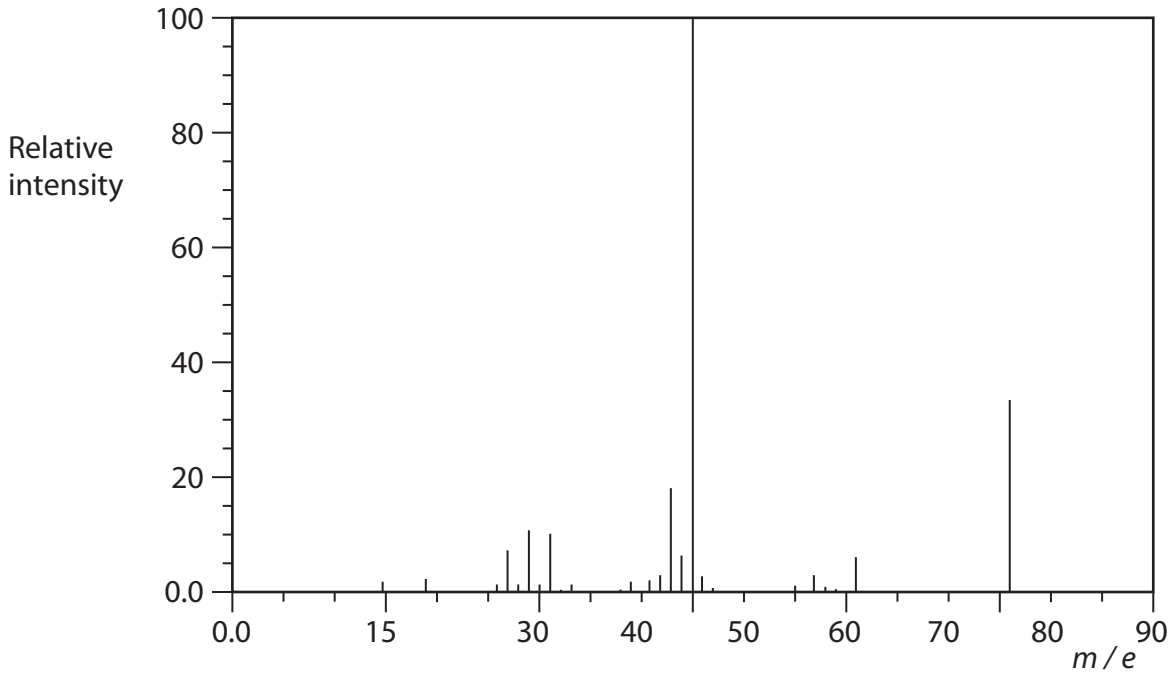
The reaction sequence is summarised below.



(a) Analysis of TO_2 showed that it contained 36.82% by mass of oxygen. Calculate the molar mass of the metal, T, and hence identify T. You **must** show your working.

(3)

(b) The mass spectrum of the organic product **N**, formed when **M** is reacted with the solution of **P**, is shown below.



(i) Label the molecular ion on the mass spectrum and deduce the molar mass of **N**.

(1)

.....

(ii) Identify, by name or formula, **M** and **N**.

(2)

M	
N	

(c) (i) Write an **ionic** equation for the formation of the very pale brown precipitate, **R**.
Include state symbols in your answer.

(2)

(ii) Suggest an equation for the conversion of the dark brown solid, **S**, to TO_2.
State symbols are not required.

(2)

(d) Write the formula of the cation in **P** and hence give the formula of compound **P**.

(2)

.....

.....

.....

(Total for Question 23 = 12 marks)

TOTAL FOR SECTION B = 51 MARKS

SECTION C

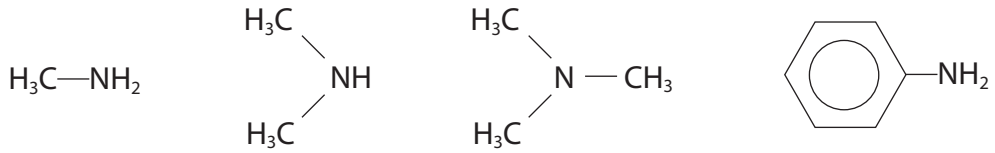
Answer ALL the questions. Write your answers in the spaces provided.

24

Organic Nitrogen Chemistry

Organic compounds that contain nitrogen are vital to life, but are also important in everyday applications of chemistry.

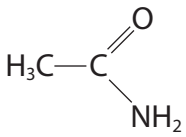
The simplest organic nitrogen compounds are amines, which may be regarded as derivatives of ammonia in which one or more of the hydrogen atoms of ammonia have been replaced by an alkyl group or an aryl group. Some simple amines are shown below.



methylamine dimethylamine trimethylamine phenylamine (aniline)

Amines with one alkyl group are called primary, with two alkyl groups secondary and with three alkyl groups tertiary. Because of the presence of nitrogen, the physical and chemical properties of alkyl amines are similar to those of ammonia but the similarities are less marked with phenylamine.

Amides are carboxylic acid derivatives which have a carbonyl group adjacent to an amine group. The simplest amide is ethanamide:



ethanamide

Because the two groups are adjacent, the chemical properties of amides are different from those of amines.

Amino acids are compounds with an amine group and a carboxylic acid group. The presence of these two functional groups gives amino acids properties that are also different from those of amines. The great significance of the amino acids is their ability to form polymers called polypeptides, leading to the formation of proteins, the building blocks of life. To form polypeptides, amino acids are joined by the amide group, sometimes called the peptide link.

(a) Methylamine boils at 267 K and dissolves in water to form an alkaline solution.

(i) Explain why methylamine has a higher boiling temperature than ammonia. A detailed description of the forces involved is **not** required.

(2)

*(ii) Explain why primary amines are soluble in water but their solubility decreases as molar mass increases.

(3)

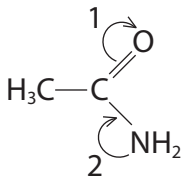
(iii) Write an equation for the reaction of methylamine with water to produce an alkaline solution. State symbols are not required.

(1)

(iv) Suggest why dimethylamine is more basic than methylamine and why both are **much** more basic than phenylamine.

(3)

(b) The interaction of the carbonyl group and the amine group in ethanamide may be shown by the following diagram.



(i) Explain what each of the two arrows represents.

(2)

Arrow 1 .....

.....

Arrow 2 .....

.....

(ii) Draw a diagram showing the ethanamide molecule if the changes indicated by the arrows go to completion.

(1)

(iii) Suggest why the carbonyl group in an amide does not react with 2,4-dinitrophenylhydrazine.

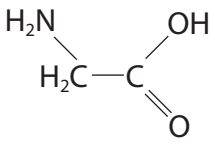
(1)

.....

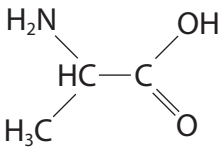
.....

.....

(c) The structures of the two simplest amino acids are shown below.



glycine



alanine

(i) Draw the structures of the **two** compounds, called dipeptides, that can be formed when glycine and alanine combine. Any double bonds **must** be displayed.

(2)

(ii) In practice, glycine and alanine do not combine readily. Suggest a reason for this.

(1)

*(iii) Describe in outline how a mixture of amino acids can be separated **and** identified using thin layer chromatography. You may assume that a suitable solvent is available.

(3)

(Total for Question 24 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 5 0 4 5 A 0 2 8 2 8

PMT

edexcel

Mark Scheme (Results)

January 2015

Pearson Edexcel International Advanced level in Chemistry (WCH05) Paper 01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	A		1

Question Number	Correct Answer	Reject	Mark
2	D		1

Question Number	Correct Answer	Reject	Mark
3	D		1

Question Number	Correct Answer	Reject	Mark
4	B		1

Question Number	Correct Answer	Reject	Mark
5	A		1

Question Number	Correct Answer	Reject	Mark
6	D		1

Question Number	Correct Answer	Reject	Mark
7	C		1

Question Number	Correct Answer	Reject	Mark
8	B		1

Question Number	Correct Answer	Reject	Mark
9	D		1

Question Number	Correct Answer	Reject	Mark
10	C		1

Question Number	Correct Answer	Reject	Mark
11	B		1

Question Number	Correct Answer	Reject	Mark
12	B		1

Question Number	Correct Answer	Reject	Mark
13	C		1

Question Number	Correct Answer	Reject	Mark
14	B		1

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	A		1

Question Number	Correct Answer	Reject	Mark
17	B		1

Question Number	Correct Answer	Reject	Mark
18	D		1

Question Number	Correct Answer	Reject	Mark
19	C		1

Question Number	Correct Answer	Reject	Mark
20	B		1

Total for Section A = 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Penalise omission of charge on NO_3^- only once in (a)(i) and (a)(ii) Penalise an incorrect coefficient in (a)(i) and (a)(ii) once only $Cu^{2+} + 2e^{(-)} \rightarrow Cu$ ($E^\ominus = +0.34$ V) **(1)** $2NO_3^- + 4H^+ + 2e^{(-)} \rightarrow N_2O_4 + 2H_2O$ ($E^\ominus = +0.80$ V) ALLOW multiples equations reversed reversible / double-headed arrows 2 NO_2 for N_2O_4 **(1)** IGNORE $E^\ominus$ at this point State symbols even if incorrect	Alternative nitrate(V) reductions	2

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	$Cu + 2NO_3^- + 4H^+ \rightarrow Cu^{2+} + N_2O_4 + 2H_2O$ ALLOW multiples reversible / double-headed arrows 2 NO_2 for N_2O_4 **(1)** No TE for equation from incorrect half-equations $E^\ominus_{cell}$ (= +0.80 − 0.34) = (+)0.46 (V) **(1)** TE for $E^\ominus_{cell}$ value on incorrect selection of half-equations IGNORE State symbols even if incorrect	uncancelled electrons	2

Question Number	Acceptable Answer	Reject	Mark
21(a)(iii)	Brown fumes / gas OR Green solution ALLOW (pale) yellow fumes / gas OR effervescence / bubbling / fizzing OR blue solution IGNORE modifiers of blue IGNORE References to copper dissolving	Colourless gas bubbles	1

Question Number	Acceptable Answer	Reject	Mark
21(b)(i)	In (b)(i) and (b)(ii) penalise (correct) non-ionic equations once. $Cu^{2+} + 2I^- \rightarrow CuI + \frac{1}{2}I_2$ OR $2Cu^{2+} + 4I^- \rightarrow Cu_2I_2 + I_2$ ALLOW $Cu^{2+} + I^- \rightarrow Cu^+ + \frac{1}{2}I_2$ OR $2Cu^{2+} + 2I^- \rightarrow 2Cu^+ + I_2$ OR Multiples IGNORE State symbols even if incorrect	$Cu(NO_3)_2 + 2KI \rightarrow CuI + \frac{1}{2}I_2 + 2KNO_3$	1

Question Number	Acceptable Answer	Reject	Mark
21(b)(ii)	$I_2 + 2S_2O_3^{2-} \rightarrow 2I^- + S_4O_6^{2-}$ OR Multiples	$2Na_2S_2O_3 + I_2 \rightarrow Na_2S_4O_6 + 2KI$	1

Question Number	Acceptable Answer	Reject	Mark
21(b)(iii)	2 mol Cu^{2+} forms 1 mol I_2 which reacts with 2 mol $S_2O_3^{2-}$ OR Multiples in this explanation OR Any clear explanation in words No TE on incorrect equations in (b)(i) and (b)ii)	**Just** re-writing the equations.	1

Question Number	Acceptable Answer	Reject	Mark
21(b)(iv)	mol $S_2O_3^{2-}$ in 25 cm^3 = 0.0505 x 26.35 /1000 = 1.330675 x 10^{-3} ans* **(1)** mol Cu^{2+} in 250 cm^3 = mol Cu in sample = 10 x ans* **(1)** = 1.330675 x 10^{-2} ans** mass Cu = ans** x 63.5 = 1.330675 x 10^{-2} x 63.5 **(1)** = 0.84498 (g) ans*** % copper in rivet brass = 100 x ans***/ 1.35 = 62.591/ 62.6 % **(1)** Correct answer with no working scores 4 If incorrect ratio used then max 3 Answers >100% max 3 IGNORE SF except one Do not penalise correct intermediate rounding		4

Question Number	Acceptable Answer	Reject	Mark
21(c)(i)	More iodine would be formed **(1)** (Titre / volume of thiosulfate would be larger) so (calculated) % copper would be higher **(1)** Second mark dependent on first		2

Question Number	Acceptable Answer	Reject	Mark
21(c)(ii)	**MP1 and MP2 are stand alone** **Marking Point 1** Percentage difference in the titres is (approximately) 100 x 0.25/26.35 = 0.94877 / 0.95% **(1)** **Marking Point 2** This MP should only be awarded if the candidate appreciates that the addition of urea **improves** experimental accuracy. The percentage error in the burette reading is (±)100 x 0.1/26.35 = (±)0.3795% **and** so change is a significant improvement OR Difference in titres is greater than uncertainty / error in burette reading OR Calculation any other **specific** apparatus uncertainty **and** use of urea has a significant effect OR Error without urea is significant when compared with the typical apparatus uncertainty (so the addition of urea improves accuracy) **(1)**	1.9% Total apparatus error greater than effect of urea	2

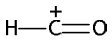
Question Number	Acceptable Answer	Reject	Mark
21(d)(i)	(When the electronic structure is built up according to the *aufbau* rules) the last electron goes into the (3)d-subshell / one of the d-orbitals / the d-orbitals	Just 'electrons present in (3)d-subshell outer / valence electrons are in d-subshell shell for subshell	1

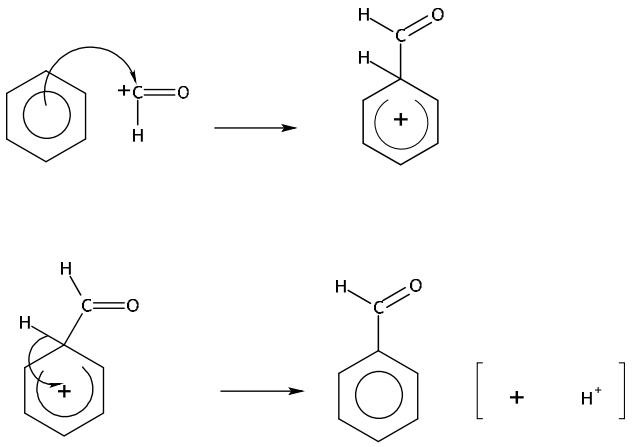
Question Number	Acceptable Answer	Reject	Mark
21(d)(ii)	copper forms (one or more stable) ions having partially filled (3)d orbitals / subshell (but zinc does not) OR Zinc does not form an ion with a partially filled 3(d) orbital/subshell (but copper does)	3d shell Just 'zinc only forms an ion with a full 3d subshell'	1

Question Number	Acceptable Answer	Reject	Mark
21(d)*(iii)	Penalise use of orbital (singular) once only in (d)(iii) and (d)(iv) (3)d orbitals / (3)d subshell split (by the attached ligands) **(1)** Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy d orbital(s) / levels ALLOW d—d transitions occur **(1)** Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light **(1)** Reflected / transmitted / remaining light is coloured / yellow / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen **(1)** No mention of (3)d then max 3 IGNORE reference to electrons relaxing / dropping to the ground state	Orbital / shell is split d-d splitting emitted	4

Question Number	Acceptable Answer	Reject	Mark
21(d)(iv)	(3)d subshell / (all) (3)d orbitals of zinc(II) are full (so electron transitions are not possible) Ignore No unpaired electrons	(3)d orbital full Full 3d subshell is not split	1

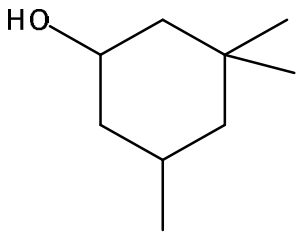
Total for Question 21 = 23 marks

Question Number	Acceptable Answer	Reject	Mark
22(a)(i)	 OR non-displayed structure (with atoms in any order) ALLOW Positive charge on any part of the structure OR Outside bracketed structure / formula	HCOCl / methanoyl chloride	1

Question Number	Acceptable Answer	Reject	Mark
22 (a)(ii)	 TE on incorrect electrophile in (a)(i) Positive charge on any part of the electrophile Curly arrow from on or within the circle to positively charged carbon ALLOW Curly arrow from anywhere within the hexagon Arrow to any part of the CHO^+ including to the + charge Non-displayed electrophile **(1)** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** some part of the positive charge must be within the horseshoe Ignore structure of side chain for this mark **(1)** Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized fully correct structure including correctly bonded substituent Substituent may be non-displayed **(1)** Correct Kekulé structures score full marks Ignore any involvement of AlX_4^- (or similar) in the formation of the final structure	Curly arrow on or outside the hexagon Dotted bonds to H and CHO **unless** clearly a dots & wedge 3-D structure COH for CHO	3

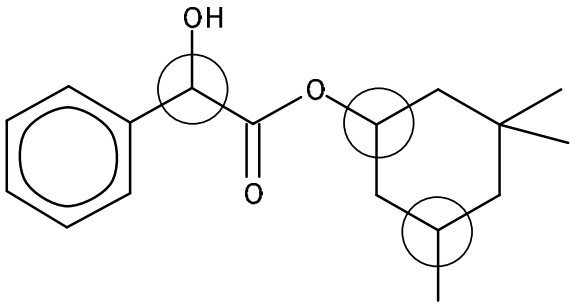
Question Number	Acceptable Answer	Reject	Mark
22(a)(iii)	hydrogen cyanide / HCN **(1)** potassium (or sodium) cyanide / KCN / NaCN ignore pH = 8 **(1)** OR KCN / NaCN **(1)** H_2SO_4 / HCl ignore concentrations and pH = 8 **(1)** OR HCN **(1)** NaOH / pH = 8 **(1)** ALLOW names or formula throughout	 NaOH NaOH	2

Question Number	Acceptable Answer	Reject	Mark
22(a)(iv)	Hydrochloric acid / HCl(aq) OR Sulfuric acid / H_2SO_4(aq) OR sodium hydroxide / NaOH / potassium hydroxide / KOH **and** followed by any **strong** acid / H^+ ALLOW HCl / H_2SO_4 / name or formula of any **strong** acid IGNORE Water / H_2O Concentrated Dilute		1

Question Number	Acceptable Answer	Reject	Mark
22(b)(i)	The first two marks are stand alone  **(1)** (Concentrated) sulfuric acid ALLOW Any named strong acid / correct formula with or without state symbol IGNORE Dilute / water **(1)** (Heat under) reflux **(1)** Condition mark dependent on the reagent mark being awarded or near miss.	OH bonded to ring the wrong way around Benzene ring H^+ / H_3O^+ Just 'heat'	3

Question Number	Acceptable Answer	Reject	Mark
22(b)(ii)	The esterification / reaction is reversible / an equilibrium (So yield is low) ALLOW Does not go to completion IGNORE References to cost/rate No TE on an incorrect reaction in (b)(i)		1

Question Number	Acceptable Answer	Reject	Mark
22(b)(iii)	PCl_5 reacts with both OH groups		1

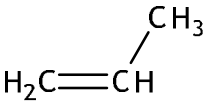
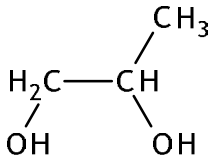
Question Number	Acceptable Answer	Reject	Mark
22(c)(i)	 All three correct scores 2 marks Two correct from three scores 1 mark More than three circled scores max 1 mark ALLOW Any clear labelling Any ring containing only one correct carbon		2

Question Number	Acceptable Answer	Reject	Mark
22(c)(ii)	**Any two from** Only one isomer may be (more) active One isomer (or more) may have a negative effect ALLOW Side effects Different isomers have different (biochemical) properties ALLOW higher dosage required to obtain sufficient amount of active isomer (so expensive) If no other mark is scored Separation of isomers needed OR Low yield can score 1 IGNORE References to **just** 'cost'	Geometric / structural isomers	2

Total for Question 22 = 16 marks

Question Number	Acceptable Answer	Reject	Mark
23(a)	Molar mass of TO_2 = 100 x 32 / 36.82 **(1)** = 86.9093 **(1)** Molar mass of T = 86.9093 – 32 = 54.9 (g mol^{-1}) (hence T is manganese / Mn) **(1)** **OR** Amount of O (in 100g) = 36.82 /16 = 2.3013 mol **(1)** ∴ mol T = 1.1506 weighs 100 – 36.82 = 63.18 g **(1)** 1 mol T weighs 63.18 / 1.1506 = 54.909 g (hence T is manganese / Mn) **(1)** **OR** Percentage of Mn 100 – 36.82 = 63.18 **(1)** Number of moles of Mn = 63.18/54.9 = 1.15 **(1)** Number of moles of oxygen = 36.82/16 = 2.3 (hence TO_2 is MnO_2) **(1)** ALLOW Calculations based on moles of O_2 Correct answer with no working scores **zero**		3

Question Number	Acceptable Answer	Reject	Mark
23(b)(i)	Molecular ion labelled in any way on the mass spectrum **and** Molar mass = 76 (g mol^{-1})		1

Question Number	Acceptable Answer	Reject	Mark
23(b)(ii)	**M**  / CH_2CHCH_3 / propene ALLOW prop-1-ene **(1)** **N**  / $CH_2OHCHOHCH_3$ / propane-1,2-diol ALLOW propan-1,2-diol / 1,2-propan(e)-diol **(1)** IGNORE C_3H_6 and $C_3H_8O_2$		2

Question Number	Acceptable Answer	Reject	Mark
23(c)(i)	IGNORE H_2O ligands in c)i) & c)ii) $Mn^{2+}(aq) + 2OH^-(aq) \rightarrow Mn(OH)_2(s)$ Equation **(1)** States **(1)** ALLOW use of T for Mn states mark for non-ionic equation OR for unbalanced equation with correct species		2

Question Number	Acceptable Answer	Reject	Mark
23(c)(ii)	$MnO_2.nH_2O \rightarrow MnO_2 + nH_2O$ OR $Mn(OH)_4 \rightarrow MnO_2 + 2H_2O$ LHS (1) RHS (1) ALLOW use of T for Mn ALLOW for 1 mark $Mn(OH)_2 + ½O_2 \rightarrow MnO_2 + H_2O$		2

Question Number	Acceptable Answer	Reject	Mark
23(d)	K^+ IGNORE 'potassium ion' **(1)** $KMnO_4$ **(1)** TE on cation given for MP1	Just 'K'	2

Total for Question 23 = 12 marks
Total for Section B = 51 marks

Section C

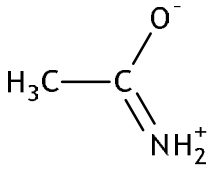
Question Number	Acceptable Answer	Reject	Mark
24(a)(i)	(Both have hydrogen bonds) methylamine has stronger London / dispersion / induced dipole(-induced dipole) / van der Waals forces **(1)** As it has more electrons ALLOW greater surface area **(1)** ALLOW (Both have hydrogen bonds) stronger hydrogen bonds in methylamine because of electron donating effect of the methyl group ..... **(1)** ... makes the nitrogen lone pair more available **(1)** IGNORE just 'hydrogen bonds stronger' If no other marks are scored then 'both molecules have hydrogen bonds **and** London forces' scores 1 mark		2

Question Number	Acceptable Answer	Reject	Mark
24(a)*(ii)	Amines form hydrogen bonds with water (molecules) **(1)** As molar mass (of the amine) increases, the size / strength of the London forces/ dispersion / induced dipole(-induced dipole) / van der Waals forces (between amine molecules) increase ALLOW The size of the hydrophobic group increases **(1)** So the energy needed to break the London forces (of the amines) increases (becomes more and more similar to the energy released in forming hydrogen bonds) OR the nett gain in / release of energy becomes (progressively) smaller **(1)** IGNORE References to hydrophilic groups		3

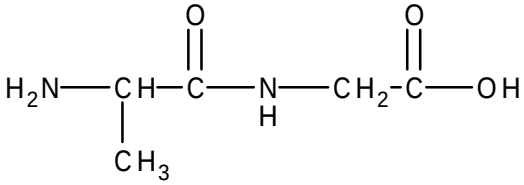
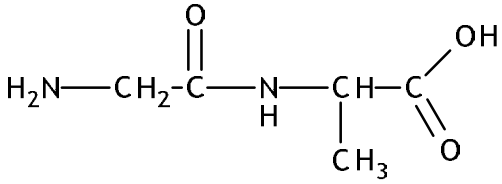
Question Number	Acceptable Answer	Reject	Mark
24(a)(iii)	$CH_3NH_2 + H_2O \rightleftharpoons CH_3NH_3^+ + OH^-$ ALLOW $\rightarrow$ for $\rightleftharpoons$ & $CH_3NH_3^+$ OH^- IGNORE Position of charges		1

Question Number	Acceptable Answer	Reject	Mark
24(a)(iv)	Basic strength depends on the (donation / availability of) the lone pair (of electrons on the nitrogen atom) ALLOW Basic strength depends on the ability of a nitrogen atom to accept a proton **(1)** Methyl groups are electron donating (so lone pair donation increases / lone pair more available) **(1)** **Lone pair** of (nitrogen on) phenylamine interacts with π / delocalised electrons of the benzene ring (so lone pair donation decreases / lone pair less available) ALLOW **Lone pair** delocalised into the (benzene) ring 'Non-bonding electron pair' for lone pair **(1)**	N becomes more electronegative Just 'electron pair'	3

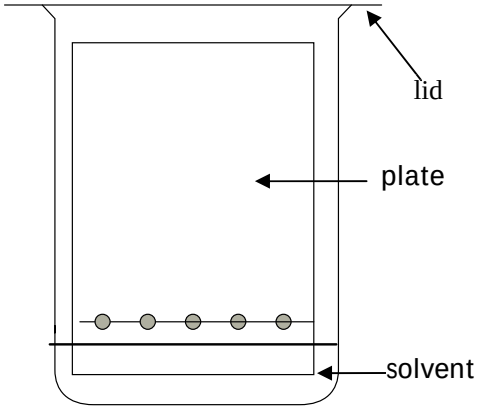
Question Number	Acceptable Answer	Reject	Mark
24(b)(i)	If neither answer refers to an electron **pair** then max 1 for this item **Arrow 1** Movement of **π electron pair** / **π electrons** (to oxygen atom) OR Movement of a pair of electrons from the double bond **(1)** **Arrow 2** Movement of **lone pair** / **non-bonded pair** of electrons (from the nitrogen) (to C—N bond) **(1)** If **neither** of these marks is scored then 'each arrow shows the movement of an electron **pair**' scores 1 mark	Just "breaking of the π bond"	2

Question Number	Acceptable Answer	Reject	Mark
24(b)(ii)			1

Question Number	Acceptable Answer	Reject	Mark
24(b)(iii)	(The electron movement shown above means that) the carbonyl carbon has a smaller (partial) positive charge than an aldehyde or ketone ALLOW no positive charge OR carbonyl carbon is resistant to **nucleophilic** attack		1

Question Number	Acceptable Answer	Reject	Mark
24(c)(i)	One mark for each structure with fully displayed, structural or skeletal formulae and in any orientation   Penalise lack of displayed double bonds once only ALLOW If continuation bonds added to the dimers max 1. Two fully correct polymer structures **(1)**		2

Question Number	Acceptable Answer	Reject	Mark
24(c)(ii)	The amine group (of glycine & alanine) is protonated & cannot act as a nucleophile ALLOW (Glycine & alanine) form zwitterions IGNORE References to activation energy		1

Question Number	Acceptable Answer	Reject	Mark
24(c)*(iii)	Dot samples of the amino acid mixture (and known amino acids) on the plate and dip the plate in the solvent (1) Use of ninhydrin to make amino acids visible / as a developer (1) Compare distance travelled of mixture components and known amino acids OR Compare R_f with data book values (1) The first mark may be awarded for a suitable diagram e.g.  ALLOW 'Paper' or 'glass slide' for 'plate' IGNORE Omission of lid in diagram.	Amino acids dissolved in mobile phase solvent	3

Total for Section C = 19 marks
Total for paper = 90 marks

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Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Monday 15 June 2015 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P45073RA

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6/6/6/6/1/2/

P 4 5 0 7 3 R A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following is a redox reaction?

☒ **A** $Cr_2O_7^{2-} + 2OH^- \rightarrow 2CrO_4^{2-} + H_2O$

☒ **B** $[Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow [CuCl_4]^{2-} + 6H_2O$

☒ **C** $4OH^- + 4MnO_4^- \rightarrow 4MnO_4^{2-} + 2H_2O + O_2$

☒ **D** $[Fe(H_2O)_6]^{3+} + 3OH^- \rightarrow [Fe(H_2O)_3(OH)_3] + 3H_2O$

(Total for Question 1 = 1 mark)

2 The oxidation state of nickel is **not** +2 in

☒ **A** $[Ni(CO)_4]$

☒ **B** $[Ni(H_2O)_4(OH)_2]$

☒ **C** $[Ni(NH_3)_6]^{2+}$

☒ **D** $[Ni(CN)_4]^{2-}$

(Total for Question 2 = 1 mark)

3 Which of the statements about a standard hydrogen electrode, for which $E^{\ominus} = 0$ V, is correct?

☒ **A** A suitable solution for use in the electrode is hydrochloric acid with a concentration of 0.1 mol dm^{-3}.

☒ **B** The pressure of the hydrogen has no effect on the value of $E^{\ominus}$.

☒ **C** The metal used in the electrode is platinum.

☒ **D** The temperature is 273 K.

(Total for Question 3 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

4 The table below gives the standard electrode potentials of three half cells.

System	$E^{\ominus}$ / V
$H^+(aq) + e^- \rightleftharpoons \frac{1}{2}H_2(g)$	0.00
$Ag^+(aq) + e^- \rightleftharpoons Ag(s)$	+0.80
$Ag^{2+}(aq) + e^- \rightleftharpoons Ag^+(aq)$	+1.98

From these data it may be deduced that, under standard conditions,

☒ **A** Ag is a stronger reducing agent than H_2.

☒ **B** Ag^{2+} ions are stronger oxidizing agents than H^+ ions.

☒ **C** Ag^+ ions will disproportionate.

☒ **D** Ag^+ ions will react with H^+ ions.

(Total for Question 4 = 1 mark)

5 The value of E_{cell} indicates whether the cell reaction is thermodynamically feasible.
Which of the following is a correct statement about E_{cell}?

☒ **A** E_{cell} is directly proportional to the equilibrium constant.

☒ **B** E_{cell} is directly proportional to the entropy change of the system, ΔS_{system}.

☒ **C** E_{cell} is directly proportional to the total entropy change, ΔS_{total}.

☒ **D** The value of ln E_{cell} is directly proportional to the total entropy change, ΔS_{total}.

(Total for Question 5 = 1 mark)

6 In a methanol fuel cell, the following half-reaction occurs

$$CH_3OH(l) + H_2O(l) \rightarrow 6H^+(aq) + CO_2(g) + 6e^-$$

The half-reaction occurring in the other half of the fuel cell is

☒ **A** $H_2(g) + O_2(g) + 2e^- \rightarrow 2OH^-(aq)$

☒ **B** $2H^+(aq) + \frac{1}{2}O_2(g) + 2e^- \rightarrow H_2O(l)$

☒ **C** $2OH^-(aq) \rightarrow H_2(g) + O_2(g) + 2e^-$

☒ **D** $H_2O(l) \rightarrow 2H^+(aq) + \frac{1}{2}O_2(g) + 2e^-$

(Total for Question 6 = 1 mark)

7 Which of the following statements about fuel cells is **not** true?

☒ **A** Reactants must constantly be fed into the cell when it is in use.

☒ **B** Fuel cells are 100% efficient.

☒ **C** Fuel cells convert chemical energy directly into electrical energy.

☒ **D** Fuel cells produce electricity more efficiently than a diesel generator.

(Total for Question 7 = 1 mark)

8 Copper(II) ions combine with three molecules of 1,2-diaminoethane, $NH_2CH_2CH_2NH_2$, to form a complex ion.

A bond angle, N — Cu — N, in this complex is

☒ **A** 120°

☒ **B** 109.5°

☒ **C** 107°

☒ **D** 90°

(Total for Question 8 = 1 mark)

9 Which of the following does **not** have a central metal ion having six bonds and an oxidation state of +2?

☒ **A** $[Cu(C_2O_4)_3]^{4-}$

☒ **B** $[Co(CN)_5(H_2O)]^{3-}$

☒ **C** $[Fe(CN)_6]^{3-}$

☒ **D** $[Zn(OH)_4(H_2O)_2]^{2-}$

(Total for Question 9 = 1 mark)

10 The reaction

$$[Fe(H_2O)_6]^{2+} + H_2O \rightarrow [Fe(H_2O)_5(OH)]^{+} + H_3O^{+}$$

is an example of

☒ **A** oxidation.

☒ **B** reduction.

☒ **C** ligand exchange.

☒ **D** acid-base behaviour.

(Total for Question 10 = 1 mark)

11 Hydrated crystals of a compound have the formula $CrCl_3(H_2O)_6$.
A solution containing one mole of the compound reacts with two moles of silver nitrate to form two moles of silver chloride.
The complex chromium ion in the compound is most likely to be

☒ **A** $[Cr(H_2O)_3Cl_3]^{3+}$

☒ **B** $[Cr(H_2O)_4Cl_2]^{+}$

☒ **C** $[Cr(H_2O)_5Cl]^{2+}$

☒ **D** $[Cr(H_2O)_6]^{3+}$

(Total for Question 11 = 1 mark)

12 A **heterogeneous** catalyst is often preferred to a **homogenous** catalyst for an industrial process because

☒ **A** it is easily separated from the products.

☒ **B** it has empty d-orbitals.

☒ **C** it has more than one oxidation state.

☒ **D** it cannot be poisoned.

(Total for Question 12 = 1 mark)

13 In the reaction of benzene with chloromethane, aluminium chloride is added because it reacts with

☒ **A** benzene to produce an electrophile.

☒ **B** benzene to produce a nucleophile.

☒ **C** chloromethane to produce a nucleophile.

☒ **D** chloromethane to produce an electrophile.

(Total for Question 13 = 1 mark)

14 The reaction below can be catalysed by either Fe^{2+} ions or Fe^{3+} ions.

$$S_2O_8^{2-}(aq) + 2I^-(aq) \rightarrow 2SO_4^{2-}(aq) + I_2(aq)$$

This is because

☒ **A** both reactants can react with Fe^{2+} ions.

☒ **B** both reactants can react with Fe^{3+} ions.

☒ **C** $S_2O_8^{2-}$ ions can be oxidized by Fe^{3+} ions and I^- ions can be reduced by Fe^{2+} ions.

☒ **D** $S_2O_8^{2-}$ ions can be reduced by Fe^{2+} ions and I^- ions can be oxidized by Fe^{3+} ions.

(Total for Question 14 = 1 mark)

15 The enthalpy changes of the reactions below are similar. The equilibrium constants for the two reactions are K_1 and K_2 respectively.

Reaction 1 $[Cu(H_2O)_6]^{2+}(aq) + EDTA^{4-}(aq) \rightleftharpoons [Cu(EDTA)]^{2-}(aq) + 6H_2O(l)$

Reaction 2 $[Cu(H_2O)_6]^{2+}(aq) + 4Cl^-(aq) \rightleftharpoons [CuCl_4]^{2-}(aq) + 6H_2O(l)$

The value of K_1 is greater than K_2 because

☒ **A** ΔS_{system} is much more positive in Reaction 1.

☒ **B** $\Delta S_{surroundings}$ is much more positive in Reaction 1.

☒ **C** the $EDTA^{4-}$ is more highly charged than Cl^-.

☒ **D** a lower concentration of $EDTA^{4-}$ is needed than Cl^-.

(Total for Question 15 = 1 mark)

16 Which of the following reacts with benzene under suitable conditions to form $C_6H_5COC_6H_5$?

☒ **A** C_6H_5CHO

☒ **B** C_6H_5COOH

☒ **C** $C_6H_5CH_2OH$

☒ **D** C_6H_5COCl

(Total for Question 16 = 1 mark)

17 Benzene is converted to benzenesulfonic acid, $C_6H_5SO_3H$, by reaction with

☒ **A** sulfuric(IV) acid, H_2SO_3.

☒ **B** sulfuric(VI) acid, H_2SO_4.

☒ **C** sulfur dioxide dissolved in sulfuric(IV) acid.

☒ **D** sulfur trioxide dissolved in sulfuric(VI) acid.

(Total for Question 17 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

18 Benzene reacts with chlorine to produce 1,2,3,4,5,6-hexachlorocyclohexane, $C_6H_6Cl_6$, by

☒ **A** free radical addition.

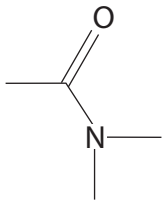
☒ **B** free radical substitution.

☒ **C** electrophilic addition.

☒ **D** electrophilic substitution.

(Total for Question 18 = 1 mark)

19 The skeletal formula of an organic compound is shown below.



This compound is

☒ **A** an amino acid.

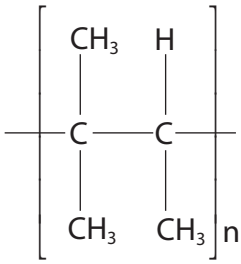
☒ **B** an amide.

☒ **C** a primary amine.

☒ **D** a secondary amine.

(Total for Question 19 = 1 mark)

20



Which is the IUPAC name for the monomer which reacts to make the polymer shown above?

☒ **A** 2-methylbut-1-ene

☒ **B** 2-methylbut-2-ene

☒ **C** 1,2-dimethylpropene

☒ **D** 1,1,2-trimethylethene

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 (a) The table below shows the first and second ionization energies of nickel, copper and zinc.

Element	1st ionization energy / kJ mol^{-1}	2nd ionization energy / kJ mol^{-1}
Ni	737	1753
Cu	746	1958
Zn	906	1733

(i) Complete the electronic configurations for an atom of nickel and an atom of copper.

(2)

Ni: $1s^2\ 2s^2\ 2p^6$ .....

Cu: $1s^2\ 2s^2\ 2p^6$ .....

*(ii) The values for the first ionization energies of copper and nickel are similar, but the values of the second ionization energies are significantly different.

Explain how these data give evidence for the electronic configuration of a copper atom.

(2)

.....

.....

.....

.....

.....

.....

(iii) Suggest why you might expect the **third** ionization energies of the three elements to increase from nickel to zinc.

(1)

.....

.....

.....

(b) (i) $Cu^+(aq)$ ions are not stable in solution and undergo a disproportionation reaction.

Suggest an equation for this reaction, including state symbols.

(1)

(ii) Suggest in what way the **appearance** of CuI is similar to that of ZnI_2.

Give a reason for this similarity.

(2)

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(c) Explain why zinc is **not** classified as a transition element.

(1)

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.....

.....

(Total for Question 21 = 9 marks)

22 This question is about vanadium and its ions.

(a) Consider the data below.

Electrode system	Standard electrode potential $E^{\ominus}$ / V
$V^{2+}(aq)\,\vert\,V(s)$	–1.18
$V^{3+}(aq), V^{2+}(aq)\,\vert\,Pt$	–0.26

(i) Draw a labelled diagram showing how to set up a cell, using the two electrode systems in the table above, in order to measure $E^{\ominus}_{cell}$.
Include standard conditions in your labelling.

(3)

(ii) Write an equation for the reaction in this cell. State symbols are not required.

(2)

(b) (i) Complete the table below with the missing standard electrode potentials.
Use the table starting on page 14 of your Data Booklet.

(1)

Electrode system	Standard electrode potential $E^{\ominus}$ / V
$[VO^{2+}(aq) + 2H^{+}(aq)], [V^{3+}(aq) + H_2O(l)]\,\vert\,Pt$	
$[VO_2^{+}(aq) + 2H^{+}(aq)], [VO^{2+}(aq) + H_2O(l)]\,\vert\,Pt$	
$I_2(aq), 2I^{-}(aq)\,\vert\,Pt$	+0.54
$[2H^{+}(aq) + O_2(g)], [H_2O_2(aq)]\,\vert\,Pt$	+0.68

(ii) The colours of the different oxidation states of vanadium are shown below.

Oxidation state	Colour
+5	yellow
+4	blue
+3	green
+2	violet

For each of the following experiments, **A** and **B**, calculate the $E^{\ominus}$ value for the proposed reaction. Use your answers to predict whether or not a reaction occurs in each case.

Give the formula of the vanadium product formed where a reaction occurs and give **one** observation you would make in each experiment.

(6)

Experiment A: Hydrogen peroxide is added to an aqueous solution containing VO_2^+ ions.

Experiment B: An aqueous solution of potassium iodide is added to an aqueous solution containing VO^{2+} ions.

(c) An experiment was carried out to determine the percentage purity of a sample of ammonium vanadate(V), NH_4VO_3.

An impure sample of ammonium vanadate(V) with mass 0.150 g was dissolved in dilute sulfuric acid. This produced a solution containing VO_2^+ ions. Excess zinc powder was added to the solution, and this reduced the VO_2^+ ions to V^{2+} ions.

The solution containing V^{2+} ions was titrated with potassium manganate(VII) of concentration 0.0200 mol dm^{-3}. The manganate(VII) ions oxidized the V^{2+} back to VO_2^+. The volume of potassium manganate(VII) required was 35.50 cm^3.

(i) The manganate(VII) ions react as shown:

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

Show, by writing the appropriate half equation or otherwise, that 5 mol V^{2+} react with 3 mol MnO_4^-.

(1)

(ii) Calculate the number of moles of manganate(VII) ions used in the titration.

(1)

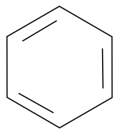
(iii) Calculate the number of moles of VO_2^+ in the original solution, and hence the percentage purity of the sample of NH_4VO_3. Give your answer to **three** significant figures.

Molar mass of NH_4VO_3 = 116.9 g mol^{-1}.

(3)

(Total for Question 22 = 17 marks)

23 Benzene is sometimes represented as Structure **X**, shown below, called a Kekulé structure after the chemist who suggested it.



Structure **X**

(a) What structural feature of benzene shows that Structure **X** is not an accurate representation?

(1)

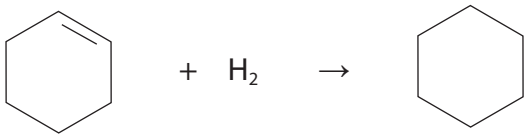
.....

.....

.....

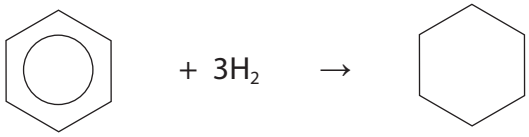
.....

(b) The enthalpy changes for the formation of cyclohexane from cyclohexene and from the actual structure of benzene are given below.



$+ \ H_2 \rightarrow$

$\Delta H = -118 \text{ kJ mol}^{-1}$



$+ \ 3H_2 \rightarrow$

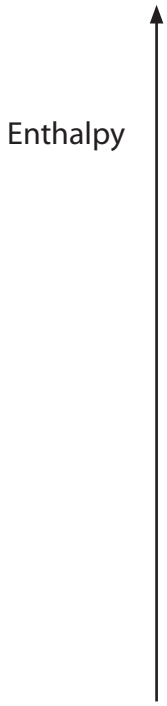
$\Delta H = -205 \text{ kJ mol}^{-1}$

(i) Use the necessary data to estimate the enthalpy change for the theoretical conversion of Structure **X** to cyclohexane.

(1)

(ii) On the enthalpy level diagram below, draw labelled horizontal lines to show the relative enthalpies of the actual structure of benzene, Structure **X** and cyclohexane. Add an arrow to show the enthalpy change from Structure **X** to benzene and calculate the value of this enthalpy change in kJ mol^{-1}. Write this value next to your arrow.

(2)



*(iii) Explain the difference in the arrangement of the electrons between benzene and Structure **X**.

(2)

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.....

.....

(c) Benzene reacts with bromine in the presence of a catalyst of iron(III) bromide.

Write a mechanism for the reaction of benzene with bromine to form bromobenzene. Include an equation to show the involvement of the catalyst.

(4)

(d) (i) State **two** observations which would be made when phenol reacts with bromine water.

(2)

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(ii) Write the equation for this reaction showing the structure of the organic product.

(2)

*(iii) Explain why phenol can react with either bromine or with bromine water without a catalyst.

(2)

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(Total for Question 23 = 16 marks)

24 Benzene can be converted to phenylamine, $C_6H_5NH_2$, in two steps.

$$C_6H_6 \xrightarrow{\text{Step 1}} C_6H_5NO_2 \xrightarrow{\text{Step 2}} C_6H_5NH_2$$

(a) (i) Name the **two** reagents needed in Step 1.

(1)

.....

(ii) Suggest why the temperature should not be allowed to go above 55 °C in Step 1.

(1)

.....

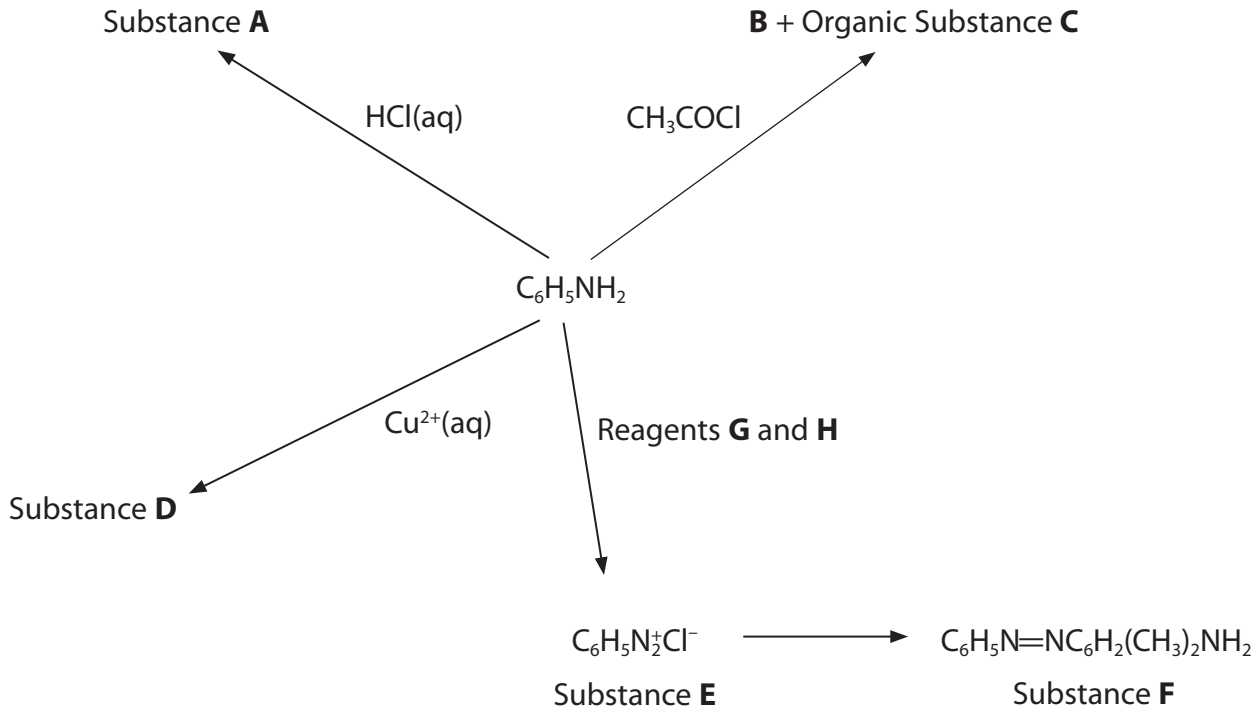
.....

(iii) Identify the **two** reagents used to carry out the reduction in Step 2.

(1)

.....

(b) Some reactions of phenylamine are shown below.



(i) Give the formula of Substance **A**.

(1)

.....

(ii) Draw the displayed formula of the organic Substance **C**.

You need not display the benzene ring.

(1)

(iii) Substances **D** and **F** are both brightly coloured but for different reasons. Classify Substances **D** and **F**.

(2)

Substance **D** .....

Substance **F** .....

(iv) Name Substance **E**.

(1)

.....

(v) What **two** Substances, **G** and **H**, are required in the conversion of phenylamine to Substance **E**?

(1)

.....

(vi) Suggest the structural formula of the substance which reacts with Substance **E** to form Substance **F**.

(1)

(Total for Question 24 = 10 marks)

TOTAL FOR SECTION B = 52 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

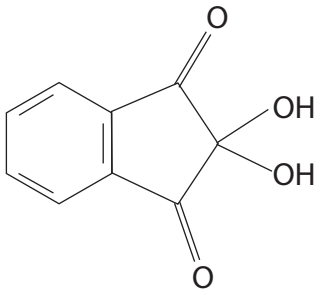
25 Read the passage below carefully and answer the questions which follow.

The general formula of most naturally occurring amino acids can be written $RCH(NH_2)COOH$, though in some amino acids, such as proline, the nitrogen atom is part of a five-membered ring. Amino acids are water soluble, though the extent of their solubility varies. All but one of the naturally occurring amino acids show optical activity.

The formula of the R group for some naturally occurring amino acids is shown below.

Amino acid	Formula of R group
serine	$-CH_2OH$
lysine	$-(CH_2)_4NH_2$
phenylalanine	$-CH_2C_6H_5$
leucine	$-CH_2CH(CH_3)_2$
iso-leucine	$-CH(CH_3)CH_2CH_3$
alanine	$-CH_3$

Mixtures of amino acids can be separated by electrophoresis. This method depends on amino acids moving different distances through paper or gel when an electric field is applied. They can also be separated by chromatography. Ninhydrin, shown below, is the chemical which is used to locate the position of the amino acids on chromatograms.



Ninhydrin detects ammonia and primary and secondary amines. When it reacts with primary amines, a deep blue or purple colour is produced in a complex series of reactions. With proline, a yellow compound forms.

Ninhydrin is widely used to detect fingerprints. Sweat secretions from ridges on the finger contain dipeptides and proteins. These are left on porous surfaces such as paper, and react with ninhydrin.

When ninhydrin reacts with amino acids, carbon dioxide is released from the carboxylic acid group. Archaeologists have used this reaction to release the carbon from proteins in ancient bones, and, by comparing the proportions of carbon and nitrogen in the remains, they have obtained evidence for the diets of these animals.

(a) (i) At a pH of 5.68, serine exists as a zwitterion. Draw the formula of serine at this pH.

(1)

*(ii) At pH 5.68, serine and lysine can be separated by electrophoresis. By considering the structures of the amino acids at this pH, suggest why this separation occurs.

(2)

*(b) Serine is very soluble in water, whilst phenylalanine is much less soluble. Explain the difference, disregarding any effect of zwitterion formation.

(2)

(c) The naturally occurring amino acid which does not show optical activity is not shown in the table. Give the formula of the R group for this acid.

(1)

(d) The optical activity of equimolar solutions of naturally occurring samples of leucine and iso-leucine can be measured in an experiment using plane-polarized light.

(i) What measurement is made to show the optical activity of amino acids?

(1)

.....

(ii) By considering the structures of iso-leucine and leucine, explain why iso-leucine has more stereoisomers than leucine.

Amino acid	Formula of R group
leucine	$-CH_2CH(CH_3)_2$
iso-leucine	$-CH(CH_3)CH_2CH_3$

(1)

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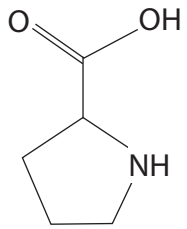
.....

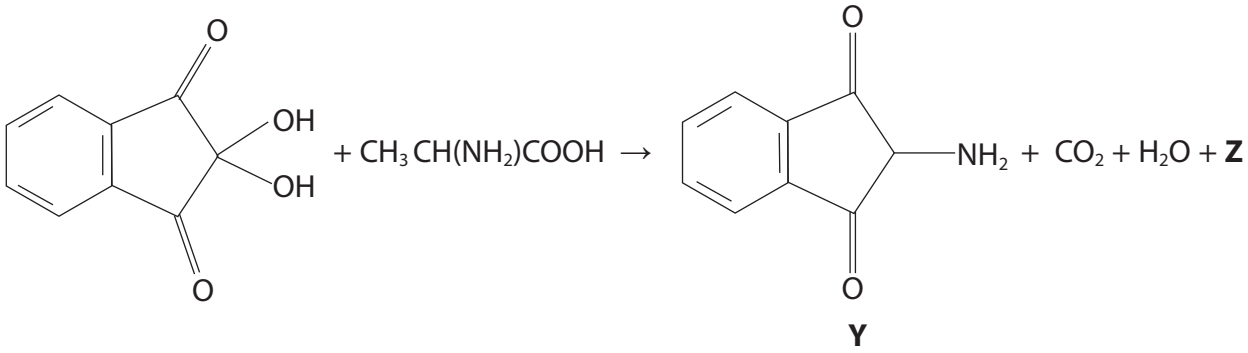
(e) The amino acid proline, shown below, does not contain a primary amine group, but it can still form peptide bonds.



Draw the structure of the dipeptide formed when the carboxylic acid group of alanine reacts with proline. Circle the peptide group on your drawing.

(2)

(f) The first steps of the reaction of ninhydrin with alanine can be summarised in the equation shown below.

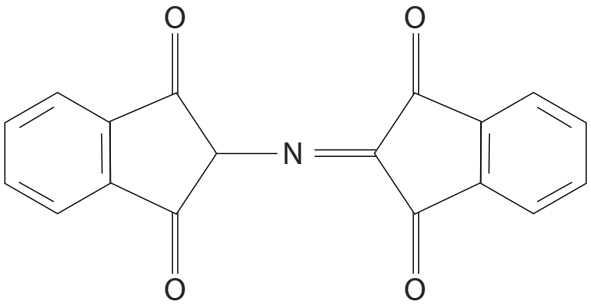


Y

(i) By balancing the equation, suggest the structural formula of the product **Z**.

(1)

(ii) In the final stage, **Y** reacts with another molecule of ninhydrin to form a dye, **Q**, shown below.



What is the molecular formula of **Q**?

(1)

(iii) On combustion, 1.000 g of **Q** produces 2.614 g carbon dioxide, 0.2673 g water and 0.04620 g nitrogen.

Use these data to calculate the percentage composition by mass of **Q**, and hence its empirical formula. Show whether your answer is consistent with the molecular formula of **Q**.

(4)

(iv) Evidence for the structure of **Q** is obtained from data in its mass spectrum, and the number of peaks in its low resolution nmr spectrum.

Suggest **one** piece of evidence from **each** type of spectroscopy which would support the structure shown in (f)(ii). Give data where appropriate.

(2)

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.....

(Total for Question 25 = 18 marks)

TOTAL FOR SECTION C = 18 MARKS

TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
						1.0 H hydrogen 1											4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 5 0 7 3 R A 0 2 8 2 8

PMT

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Mark Scheme (Results)

Summer 2015

GCE Chemistry (6CH05/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		1

Question Number	Correct Answer	Reject	Mark
2	A		1

Question Number	Correct Answer	Reject	Mark
3	C		1

Question Number	Correct Answer	Reject	Mark
4	B		1

Question Number	Correct Answer	Reject	Mark
5	C		1

Question Number	Correct Answer	Reject	Mark
6	B		1

Question Number	Correct Answer	Reject	Mark
7	B		1

Question Number	Correct Answer	Reject	Mark
8	D		1

Question Number	Correct Answer	Reject	Mark
9	C		1

Question Number	Correct Answer	Reject	Mark
10	D		1

Question Number	Correct Answer	Reject	Mark
11	C		1

Question Number	Correct Answer	Reject	Mark
12	A		1

Question Number	Correct Answer	Reject	Mark
13	D		1

Question Number	Correct Answer	Reject	Mark
14	D		1

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	D		1

Question Number	Correct Answer	Reject	Mark
17	D		1

Question Number	Correct Answer	Reject	Mark
18	A		1

Question Number	Correct Answer	Reject	Mark
19	B		1

Question Number	Correct Answer	Reject	Mark
20	B		1

Section B

Question Number	Acceptable Answers	Reject	Mark
21a(i)	Ni: $(1s^2\ 2s^2 2p^6)\ 3s^2 3p^6\ 3d^8\ 4s^2$ (1) Cu: $(1s^2\ 2s^2 2p^6)\ 3s^2 3p^6\ 3d^{10} 4s^1$ (1) ALLOW capital letters, subscripts for superscripts ALLOW 4s before 3d Penalise omission of $3s^2 3p^6$ once only if rest is correct		2

Question Number	Acceptable Answers	Reject	Mark
21a*(ii)	First electron removed is from **4s** (in both atoms) (1) Second electron in Cu (is harder to remove so it is) EITHER closer to nucleus/in inner shell OR less shielded (1) IGNORE Comments about second electron being in full shell/ in a 3d shell/in a 3d orbital Reference to $3d^{10}$ stability		2

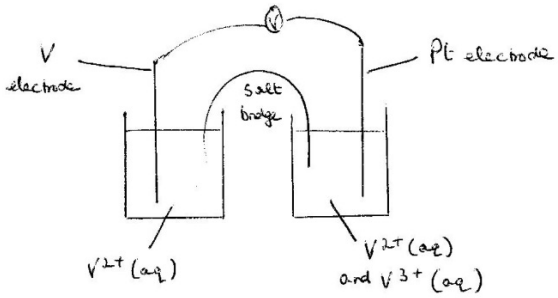
Question Number	Acceptable Answers	Reject	Mark
21a(iii)	(attraction on (3d) electrons increases due to) number of protons increasing / nuclear charge increasing IGNORE The charge density of the 2^+ ions increases Effective nuclear charge		1

Question Number	Acceptable Answers	Reject	Mark
21b(i)	$2Cu^{+}(aq) \rightarrow Cu(s) + Cu^{2+}(aq)$ IGNORE Eqm sign for $\rightarrow$	Reverse equation Any equation involving electrons	1

Question Number	Acceptable Answers	Reject	Mark
21b(ii)	Both white ALLOW (both) Colourless (1) COMMENT Ignore states eg solution/precipitate As have $3d^{10}$ / have a full 3d sub-shell /**ALL** 3d orbitals are full (1) IGNORE Does not have partially filled d orbitals They do not absorb light No d-d transitions occur		2

Question Number	Acceptable Answers	Reject	Mark
21c	(Zinc) does not form a (stable) **ion** with incompletely/partially filled d orbitals ALLOW d sub-shell for d orbitals The only (stable) **ion** formed by zinc has full d sub-shell It does not form a (stable) oxidation state with incompletely/partially filled d orbitals	Element has full d shells.	1

Total for Question 21 = 9 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)			3
	Beaker with V electrode in solution containing $V^{2+}(aq)$ AND beaker containing $V^{2+}(aq)$ and $V^{3+}(aq)$ with Pt electrode N.B. Both solution levels must be shown (1)		
	Labelled salt bridge AND connections to voltmeter ALLOW Suitable name or formula of salt for label	Salt bridge neither dipping into nor touching solution unless penalised in MP1	
	ALLOW Salts eg NaCl in salt bridge (1)	Salt bridge containing an alkali/acid	
	Ion concentrations = 1 mol dm^{-3} ALLOW M for mol dm^{-3} Concentrations given in one beaker only (1)	1 mole of V^{2+} and 1 mole of V^{3+}	
	Beaker positions may be reversed Ignore references to temperature and pressure		

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	**First mark** $2V^{3+} + V \rightarrow 3V^{2+}$ Balanced equation, either direction ALLOW Eqm sign for $\rightarrow$ IGNORE State symbol even if incorrect (1) **Second mark** Correct direction ALLOW If balancing is incorrect or e^- included in equation (1)	e^- included	2

Question Number	Acceptable Answers		Reject	Mark
22b(i)	$([VO^{2+}(aq) + 2H^+(aq)], [V^{3+}(aq) + H_2O(l)] \mid Pt)$	+0.34		1
	$([VO_2^+(aq) + 2H^+(aq)], [VO^{2+}(aq) + H_2O(l)] \mid Pt)$	+1.00		
	Sign and value needed			

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	**A:** (+)0.32 (V) (1) VO^{2+} (may be shown as a product in an overall equation) (1) EITHER Bubbles / effervescence (of colourless gas) OR Colour changes (from yellow) to blue TE on negative E_{cell} for 'stays yellow' ALLOW (from yellow) to green if justified by partial reduction (1) **B:** −0.2(0) (V) (1) no change / stays blue (1) If B = +0.2 or other positive value allow colour change from blue to green or brown. EITHER Consistent use of rule that reaction occurs when E_{cell} is positive OR Consistent use of rule that no reaction occurs when E_{cell} negative ALLOW If implied but not stated specifically (1)	Violet Stays violet	6

Question Number	Acceptable Answers	Reject	Mark
22c(i)	$V^{2+} + 2H_2O \rightarrow VO_2^{+} + 4H^{+} + 3e^{-}$ OR Ox number of V increases by 3, ox number of Mn decreases by 5 ALLOW Balanced full equation $5V^{2+} + 3MnO_4^{-} + 4H^{+} \rightarrow$ $5VO_2^{+} + 3Mn^{2+} + + 2H_2O$	Reverse equation unless used to deduce final correct equation.	1

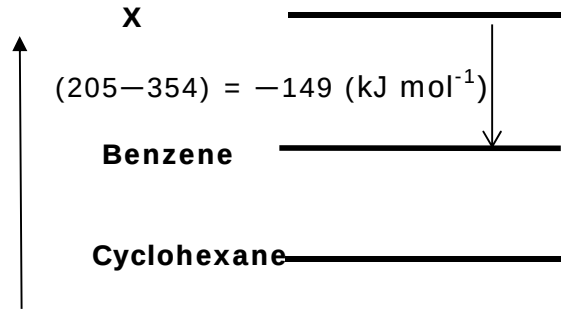
Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	(35.50 x 0.0200/1000) = $7.1(0) \times 10^{-4}$ / 0.00071		1

Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	**In final answer** **92.2 scores 3 marks** **33.2 scores 2 marks** (ratio inverted) **55.3 scores 2 marks** (ratio 1:1) METHOD 1 Mol V^{2+} reacting = $7.10 \times 10^{-4} \times 5/3$ = **1.18333×10^{-3}** = mol VO_2^+ TE on answer to (c)(ii) (1) Mass NH_4VO_3 = $(1.183 \times 10^{-3} \times 116.9)$ = **0.1382927** g TE from 4.26×10^{-3} =0.497994 (1) % purity = (0.1382927x 100/ 0.150) = (92.19333) = **92.2%** TE from 0.497994 = 33.2% (1) METHOD 2 If 100% pure, moles of NH_4VO_3 $=0.150/116.9=1.283 \times 10^{-3}$ (1) Mol V^{2+} reacting = $7.10 \times 10^{-4} \times 5/3$ = **1.18333×10^{-3}** = mol VO_2^+ TE on answer to (c)(ii) (1) % purity = $=1.18333 \times 10^{-3} \times 100/1.283 \times 10^{-3}$ = **92.2%** (1) ALLOW TE at each step provided that each number used is to at least 2sf	x 3/5 = 4.26×10^{-4}	3

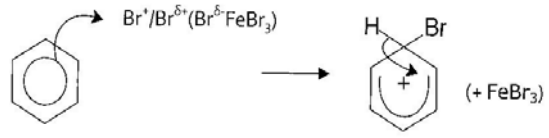
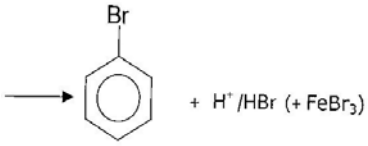
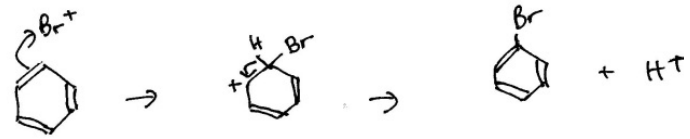
Total for Question 22 = 17 marks

Question Number	Acceptable Answers	Reject	Mark
23(a)	All carbon to carbon bonds same length/ longer C-C and shorter C=C not present IGNORE Just "benzene has a delocalised ring" Benzene does not have C=C double bonds Any references to shape/ bond angles		1

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	(3 x -118) = -354 (kJ mol^{-1})		1

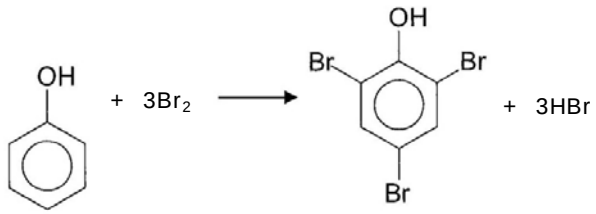
Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	 **First mark** Relative levels with names or formulae (1) **Second mark** Value —149 (kJ mol^{-1}) + arrow in correct direction ALLOW double-headed arrow (1) TE from value in (b)(ii) IGNORE $3H_2$ if shown / cyclohexene / other arrows/values	Diagram inverted scores 0 +149	2

Question Number	Acceptable Answers	Reject	Mark
23(b)*(iii)	The p/pi-/Π/6 electrons (of carbon) (1) are delocalised in benzene (but not in **X**) (1)		2

Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark:** $FeBr_3 + Br_2 \rightarrow FeBr_4^- + Br^+$ OR $Br\text{-}Br + FeBr_3 \rightarrow Br^{\delta+}\ldots\ldots Br^{\delta-}FeBr_3$ (1) Ignore state symbols even if wrong **Second, third and fourth marks:** **Either**   Arrow from benzene ring electrons (from **inside** the hexagon) to **Br^+ / $Br^{\delta+}$** (….. $Br^{\delta-}FeBr_3$) (1) Correctly drawn intermediate with delocalisation covering at least three carbon atoms, but not the carbon atom bonded to the bromine , with the positive charge shown inside the horseshoe The bonds to H and Br may be dotted (1) Arrow from / close to C-H **bond** to inside the hexagon **and** H^+ / HBr as product (1) **OR**  Use of Kekulé structure for benzene and intermediate with arrow from C=C double bond to **Br^+ / $Br^{\delta+}$** (….. $Br^{\delta-}FeBr_3$) (1) Correctly drawn intermediate with + charge on the C atom next to the C bonded to H and Br	Gap in wrong place	4

	The bonds to H and Br may be dotted (1) Arrow from / close to C-H **bond** to bond beside + charged C **and** H^+ / HBr as product (1) Each marking point is independent		

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	Bromine goes colourless OR It/the mixture goes from brown to colourless ALLOW Red-brown/ Orange/ yellow/ combinations of these colours Bromine is decolorised (1) White precipitate/solid forms / Steamy fumes (1) IGNORE Antiseptic smell Gets hot	Goes clear Red to colourless Bromine is discoloured Effervescence	2

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	 Organic product with structure shown (1) Rest of equation correct ALLOW C_6H_5OH or Kekule for phenol (1) $C_6H_5OH + 3Br_2 \rightarrow C_6H_2Br_3OH + 3HBr$ Scores MP2 only Substitution of 1Br or 2Br in any position in balanced equation scores MP2 only.		2

Question Number	Acceptable Answers	Reject	Mark
***23(d)(iii)**	**Lone pair of electrons on oxygen** (may be shown on a diagram) **and** EITHER overlaps with pi cloud OR Feeds into / donates into / interacts with benzene ring (1) Activating benzene ring / increasing electron density of ring / making attack by **electrophiles** easier (1) COMMENT 'Lone pair of electrons on oxygen increases electron density of ring' scores (2) ALLOW benzene becomes a better nucleophile for MP2	OH group overlaps Just 'making it more reactive'.	2

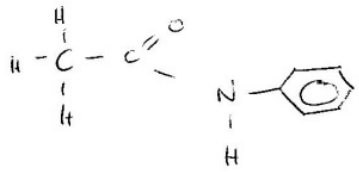
Total for Question 23 = 16 marks

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	Concentrated nitric acid AND concentrated sulfuric acid ALLOW 'concentrated nitric and sulfuric acids' Concentrated HNO_3 and concentrated H_2SO_4	Extra reagents	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	To prevent multiple substitutions/ to stop di- or trinitrobenzene forming ALLOW To stop further substitution (of NO_2)/ further nitration IGNORE further reaction	Further **addition** of nitro groups	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(iii)	Tin/ Sn AND **concentrated** HCl/ **concentrated** hydrochloric acid ALLOW Iron/Fe or Zn/Zinc for tin Conc for concentrated	Dilute HCl	1

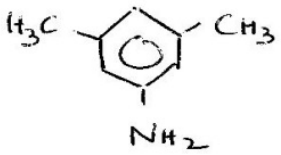
Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	$C_6H_5NH_3^+Cl^-$ ALLOW $C_6H_5NH_3Cl$		1

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	 ALLOW C_6H_5 for benzene Undisplayed CH_3	Skeletal formula Structural formula	1

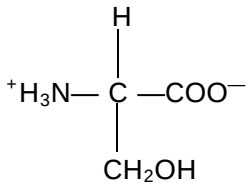
Question Number	Acceptable Answers	Reject	Mark
24(b)(iii)	**D** (transition metal) complex ion ALLOW Transition metal complex / copper complex IGNORE Formulae of ions (1) **F** (azo) dye / azo compound / diazo compound ALLOW diazonium compound molecule for compound (1)		2

Question Number	Acceptable Answers	Reject	Mark
24b(iv)	Benzenediazonium chloride ALLOW Phenyldiazonium chloride	Benzadiazonium chloride Diazonium salt	1

Question Number	Acceptable Answers	Reject	Mark
24b(v)	$HCl + NaNO_2$ OR Hydrochloric acid + Sodium nitrite / nitrate(III) OR alternative cation to Na^+ IGNORE HNO_2 Concentration of HCl	$HCl + HNO_2$	1

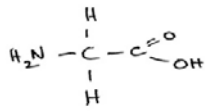
Question Number	Acceptable Answers	Reject	Mark
24b(vi)	 ALLOW any substitution positions $C_6H_3(CH_3)_2NH_2$ H- $C_6H_2(CH_3)_2NH_2$ Kekule structure	$C_6H_2(CH_3)_2NH_2$	1

Total for Question 24 = 10 marks

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	 OR $HOCH_2CH(NH_3^+)CO_2^-$ ALLOW Charge on NH_3 shown on N atom		1

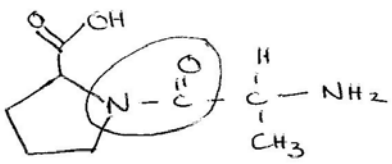
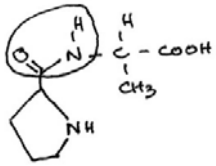
Question Number	Acceptable Answers	Reject	Mark
***25(a)(ii)**	**EITHER** At pH 5.68 both NH_2 groups on lysine will be NH_3^+ / lysine has an overall positive charge while serine has no overall charge (1) So only lysine will move to negative terminal / in an electric field (1) **OR** lysine has a greater positive charge (than serine) (1) Lysine will move faster / further in an electric field (1) ALLOW They have different charges so will move different distances/ at different speeds 1 mark max IGNORE Answers based on molecular mass		2

Question Number	Acceptable Answers	Reject	Mark
***25(b)**	**COMMENT** Ignore references to H bonds from amino and carboxyl groups and assume that "phenylalanine cannot form H bonds" refers to R group in the compound. Serine has an OH (alcoholic) group which can form H bonds with water (1) Benzene ring in phenylalanine is bulky /is large and non-polar / is hydrophobic / London forces between phenylalanine molecules are significant ALLOW van der Waals etc for London ALLOW If MP1 is not scored, 'phenylalanine cannot form H bonds with water' can score MP2 (1)	VdW / id-id	2

Question Number	Acceptable Answers	Reject	Mark
25(c)	H, -H, H- ALLOW $NH_2CH_2CO_2H$ / NH_2CH_2COOH 		1

Question Number	Acceptable Answers	Reject	Mark
25(d)(i)	(Measure) the amount of / angle of / degree of /extent of rotation (of plane of polarization/ plane polarized light) IGNORE direction they rotate the light	Just "polarimetry"	1

Question Number	Acceptable Answers	Reject	Mark
25(d)(ii)	(Leu has 1 chiral C but) Ile has 2 chiral C / 2 asymmetric C atoms OR The R group in Ile contains a chiral C (Leu has 2 optical isomers but Ile has 4 optical isomers) ALLOW Ile has (1) more chiral C (than leu) Chiral centres shown on formulae	Leu has no chiral C	1

Question Number	Acceptable Answers	Reject	Mark
25(e)	 CON circled with N as part of ring (1) Fully correct structure (1) ALLOW -CH(CH_3)NH_2 shown skeletally **OR** Dipeptide using NH_2 from alanine and COOH from proline, with correct structure and CONH circled **This scores max (1)** 	Just N-C circled	2

Question Number	Acceptable Answers	Reject	Mark
25(f)(i)	CH_3CHO / CH_2CHOH ALLOW Displayed or semi-displayed formula C_2H_4O	CH_3COH (unless with correct structure)	1

Question Number	Acceptable Answers	Reject	Mark
25(f)(ii)	$C_{18}H_9NO_4$		1

Question Number	Acceptable Answers	Reject	Mark
25(f)(iii)	**Several methods are possible.** **Amount of O should have been calculated and final answer should be consistent with masses/mols in calculation. There should be evidence of working at each stage for 4 marks** **MP1** 2.614 g CO_2 contain 0.7129 g C 0.2673 g H_2O contain 0.0297 g H OR 2.614 g CO_2 contain 0.059409 mol CO_2 0.2673 g H_2O contain 0.01485 mol H_2O (1) **MP2** Mass O in Q = (1.00 – 0.7129- 0.0297 -0.04620) = **0.2112** g (1) % mol/100g ratio C 71.29 5.94 18 H 2.97 2.97 9 N 4.62 0.33 1 O 21.12 1.32 4 **MP3** Number of moles of each element OR Number of mol in 100g Allow TE for incorrect mol of H – see calculation below (1) **MP4** Ratio stated must follow from numbers in calculation (so empirical formula is consistent with the molecular formula of **Q**) (1) **OR** **Calculation following error in H scores max (3)** If mass H is wrongly calculated as 0.01485 g, then mass O will be 0.22605 (TE for MP2) (1) % mol/100g ratio C 71.29 5.94 18 H 1.48 1.48 4.5 N 4.62 0.33 1 O 22.60 1.41 4.27		4

	Number of moles of each element (TE for MP3) (1) Ratio stated and empirical formula said not to be consistent (TE for MP4) (1)		

Question Number	Acceptable Answers	Reject	Mark
25(f)(iv)	Mass of molecular ion in mass spectrum = 303 / any sensible fragment with mass eg 302 / 158 / 145 or smaller fragment (1) ALLOW Molecular ion based on formula in f(i) Number of peaks in nmr = 2 / 3 ALLOW 5 (1)	4	2

Total for Question 25 = 18 marks

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Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Monday 15 June 2015 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
WCH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P45074A

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5/5/5/4/1/

P 4 5 0 7 4 A 0 1 2 8

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 The oxidation number of oxygen in hydrogen peroxide, H_2O_2, is

☒ **A** +2

☒ **B** 0

☒ **C** –1

☒ **D** –2

(Total for Question 1 = 1 mark)

2 Copper reacts with nitrate ions, NO_3^-, in acid conditions to form copper(II) ions and nitrogen(IV) oxide.

By considering the changes in the oxidation numbers of copper and nitrogen, it can be deduced that the redox reaction involves

☒ **A** 1 mol of copper reacting with 2 mol of nitrate ions.

☒ **B** 2 mol of copper reacting with 1 mol of nitrate ions.

☒ **C** 1 mol of copper reacting with 4 mol of nitrate ions.

☒ **D** 4 mol of copper reacting with 1 mol of nitrate ions.

(Total for Question 2 = 1 mark)

3 The E_{cell} for a reaction is +1.00 V. What can be deduced about this reaction?

☒ **A** At equilibrium there will be mainly reactants.

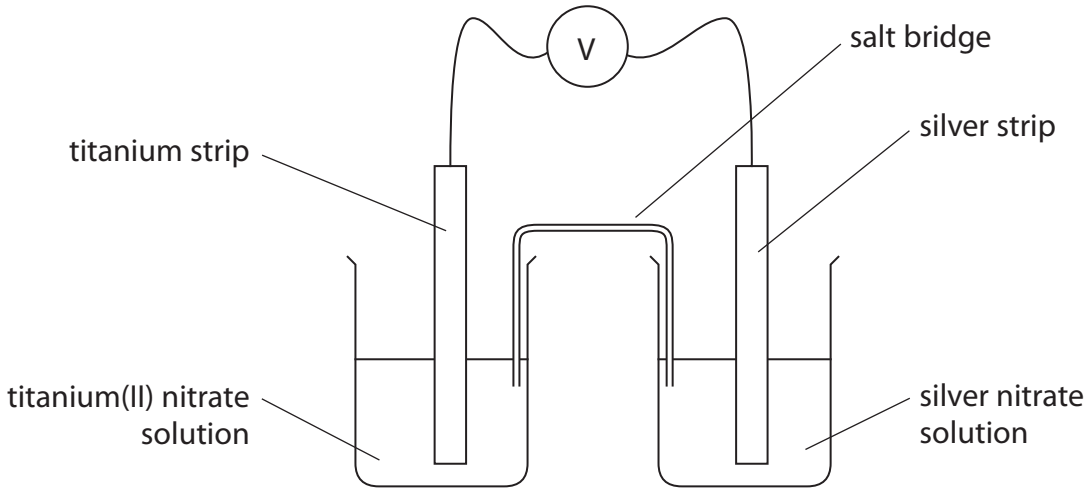
☒ **B** At equilibrium there will be mainly products.

☒ **C** At equilibrium there will be approximately equal amounts of reactants and products.

☒ **D** It is impossible to estimate the relative amounts of reactants and products at equilibrium because the E_{cell} was not measured under standard conditions.

(Total for Question 3 = 1 mark)

4 The cell shown in the diagram below was set up.



The emf of this cell under standard conditions is +2.43 V.
The $E^{\ominus}$ value for the $Ag^{+}(aq)|Ag(s)$ half cell is +0.80 V.

What is the $E^{\ominus}$ value for the $Ti^{2+}(aq)|Ti(s)$ half cell?

☒ **A** +3.23 V

☒ **B** +1.63 V

☒ **C** −1.63 V

☒ **D** −3.23 V

(Total for Question 4 = 1 mark)

5 In the hydrogen-oxygen fuel cell, oxygen is

☒ **A** oxidized at the negative electrode.

☒ **B** oxidized at the positive electrode.

☒ **C** reduced at the negative electrode.

☒ **D** reduced at the positive electrode.

(Total for Question 5 = 1 mark)

6 The electronic configuration of the element vanadium is

		3d					4s
☒ **A**	[Ar]	↑↓	↑↓	↑			
☒ **B**	[Ar]	↑	↑	↑	↑	↑	
☒ **C**	[Ar]	↑	↑	↑	↑		↑
☒ **D**	[Ar]	↑	↑	↑			↑↓

(Total for Question 6 = 1 mark)

7 Transition metals typically form a number of ions which are stable in aqueous solution. The **best** explanation for this property is that

☒ **A** the differences in the successive ionization energies are similar to the differences in hydration enthalpies of the ions.

☒ **B** all the ions are formed by the removal of electrons from the d subshell.

☒ **C** the ionization energies of transition metals are low.

☒ **D** the hydration enthalpies of transition metal ions are always more exothermic than those of ions of s and p block metals.

(Total for Question 7 = 1 mark)

8 Which of the following species **never** combine with ligands to form complexes?

☒ **A** Positively charged ions of d block elements.

☒ **B** Neutral atoms of d block elements.

☒ **C** Negatively charged ions of d block elements.

☒ **D** Positively charged ions of p block elements.

(Total for Question 8 = 1 mark)

9 Transition metal complexes are formed when ethanedioate ions and ethanoate ions are added separately to aqueous solutions of transition metal ions.

The complexes formed by the bidentate ethanedioate ligands are more stable than the complexes formed by the monodentate ethanoate ligands. This is because

- ☒ **A** ethanedioate ligands form stronger bonds with the metal ion of a complex than do ethanoate ligands.
- ☒ **B** the formation of ethanedioate complexes increases the number of particles in the solution.
- ☒ **C** ethanedioic acid is a stronger acid than ethanoic acid.
- ☒ **D** ethanedioic acid is a weaker acid than ethanoic acid.

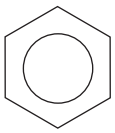
(Total for Question 9 = 1 mark)

10 If the temperature of the nitration of benzene is allowed to rise too high, dinitration and trinitration can occur. This is evidence that the

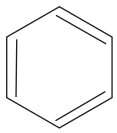
- ☒ **A** nitro group is electron withdrawing.
- ☒ **B** nitro group is electron donating.
- ☒ **C** delocalisation energy of nitrobenzene is greater than that of benzene.
- ☒ **D** delocalisation energy of nitrobenzene is less than that of benzene.

(Total for Question 10 = 1 mark)

11 The benzene molecule may be represented in two ways:



structure I



structure II

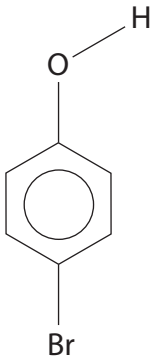
Which of the following does **not** provide evidence that **structure I** is the better representation of benzene?

- ☒ **A** Infrared spectroscopy
- ☒ **B** High performance liquid chromatography
- ☒ **C** Thermochemistry
- ☒ **D** X-ray diffraction

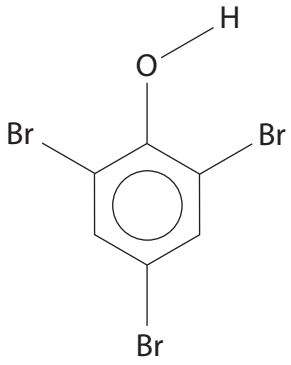
(Total for Question 11 = 1 mark)

12 When phenol, C_6H_5OH, reacts with excess bromine water, the organic product is

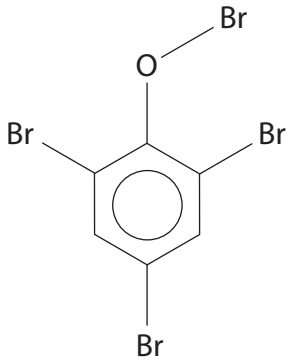
☒ **A**



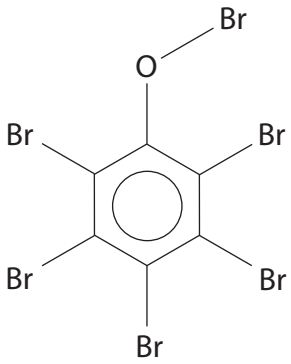
☒ **B**



☒ **C**



☒ **D**



(Total for Question 12 = 1 mark)

13 Ammonia, butylamine and phenylamine are dissolved in separate samples of water to form solutions of the same concentration. The pH of each solution was measured.

The order of **increasing** pH will be

☒ **A** ammonia < butylamine < phenylamine

☒ **B** butylamine < ammonia < phenylamine

☒ **C** phenylamine < ammonia < butylamine

☒ **D** phenylamine < butylamine < ammonia

(Total for Question 13 = 1 mark)

14 Aromatic amines may be converted into benzenediazonium ions. What are the most suitable reagents and conditions for this reaction?

	Reagent 1	Reagent 2	Temperature / °C
☒ **A**	$NaNO_2$	sulfuric acid	+55
☒ **B**	$NaNO_3$	hydrochloric acid	+5
☒ **C**	$NaNO_2$	hydrochloric acid	+5
☒ **D**	$NaNO_3$	sulfuric acid	+55

(Total for Question 14 = 1 mark)

15 The repeat unit of the polymer formed from ethane-1,2-diol and ethanedioic acid is

☒ **A** $-OCH_2CH_2OOCCO-$

☒ **B** $-OCH_2CH_2OCOOCO-$

☒ **C** $-OCH_2OOCCH_2CO-$

☒ **D** $-OCCH_2CH_2OOCO-$

(Total for Question 15 = 1 mark)

16 Poly(ethenol) is an example of

☒ **A** an addition polymer that is soluble in water.

☒ **B** an addition polymer that is insoluble in water.

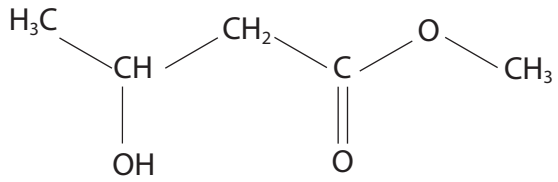
☒ **C** a condensation polymer that is soluble in water.

☒ **D** a condensation polymer that is insoluble in water.

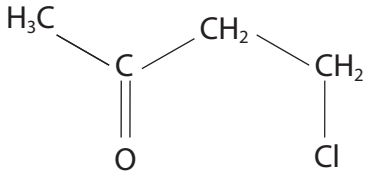
(Total for Question 16 = 1 mark)

17 A compound gives an orange precipitate with 2,4-dinitrophenylhydrazine, Brady's reagent, but does **not** react with ammonia in the cold.
The compound could be

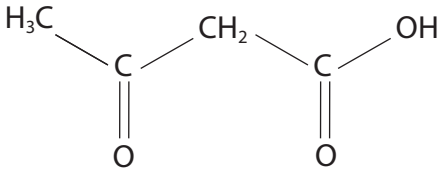
☒ **A**



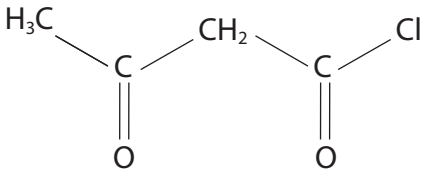
☒ **B**



☒ **C**



☒ **D**



(Total for Question 17 = 1 mark)

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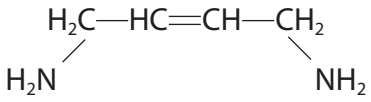
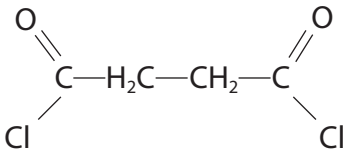
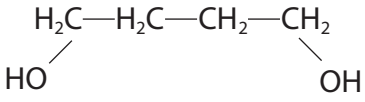
18 Three compounds are possible monomers in the formation of a polymer:

I	
II	
III	

Which of the following compounds could **not** react in the stated combination to form a polymer?

☒ **A** I alone

☒ **B** I in combination with II

☒ **C** II in combination with III

☒ **D** I in combination with III

(Total for Question 18 = 1 mark)

19 Pentan-3-one reacts with 2,4-dinitrophenylhydrazine to form a derivative which has a melting temperature of 156 °C.

A student attempted to synthesise pentan-3-one, and converted some of the product into the same derivative. The student's derivative melted gradually from 148 °C to 158 °C.

It is most likely that the student had synthesised

☒ **A** pure pentan-3-one.

☒ **B** impure pentan-3-one.

☒ **C** approximately equal amounts of two carbonyl derivatives, one with a melting temperature of 148 °C and the other with a melting temperature of 158 °C.

☒ **D** a compound that was not a ketone.

(Total for Question 19 = 1 mark)

20 The purification of organic compounds prepared in aqueous mixtures often involves solvent extraction. Desirable properties of the solvent used include that it is

☒ **A** fully miscible in water and has a high boiling temperature.

☒ **B** fully miscible in water and has a low boiling temperature.

☒ **C** immiscible in water and has a high boiling temperature.

☒ **D** immiscible in water and has a low boiling temperature.

(Total for Question 20 = 1 mark)

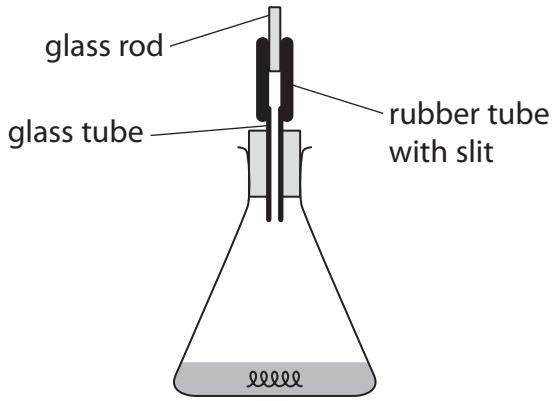
TOTAL FOR SECTION A = 20 MARKS

SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

21 Steel is the world's most important structural metal; it is strong and cheap but it corrodes rapidly if unprotected. In its simplest form, steel is an alloy of iron and carbon.

(a) The following method was used to determine the percentage of iron in a sample of wire. Exactly 1.25 g of the wire was placed in a conical flask and about 50 cm^3 of dilute sulfuric acid (an excess) was added. The flask was closed as shown in the diagram below.



When all of the iron in the wire had been converted to iron(II) sulfate, the contents of the flask were used to make 250.0 cm^3 of solution with distilled water.

25.00 cm^3 portions of this final solution were placed in a conical flask, acidified with an equal volume of dilute sulfuric acid and then titrated with a potassium manganate(VII) solution of concentration 0.0195 mol dm^{-3}. The mean titre was 22.15 cm^3.

(i) Write the equation for the reaction between iron and dilute sulfuric acid. Include state symbols in your answer.

(1)

(ii) Suggest why the conical flask was not left open, and how the labelled part of the apparatus shown in the diagram works.

(2)

(iii) State the essential steps of the procedure for making up the reaction mixture to 250.0 cm^3 for use in the titration.

(3)

(iv) Write the **ionic** equation for the titration reaction to show that 5 mol of iron(II) ions react with 1 mol of manganate(VII) ions. State symbols are not required.

(1)

(v) Calculate the percentage by mass of iron in the wire. Give your answer to **three** significant figures.

(4)

(vi) Describe the colour change at the end-point of the titration.

(1)

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.....

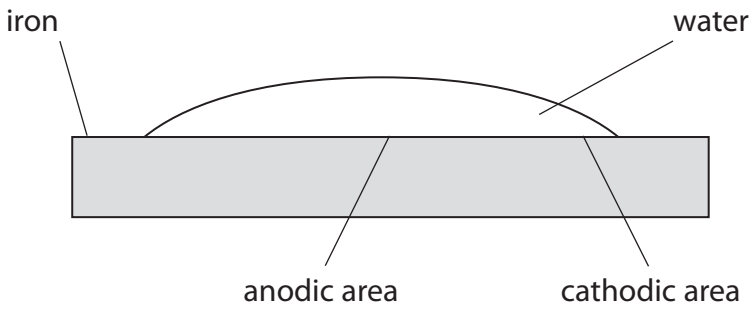
(vii) One student who carried out this experiment forgot to acidify the mixture in the conical flask before the titration.

A brown precipitate formed before the end-point.

Identify the brown precipitate and explain how this error affects the titration value.

(3)

(b) The rusting of iron is an electrochemical process. A piece of iron with a droplet of water on its surface operates as an electrochemical cell. In the first stage of corrosion, iron is oxidized to iron(II) ions in the anodic area and the electrons produced travel to the cathodic area where oxygen from the air is reduced.



(i) From the information about standard electrode potentials on pages 14 and 15 of the Data Booklet, write the ionic half equations for the reactions taking place at the anodic area and at the cathodic area. State symbols are not required.

(2)

Anodic area

Cathodic area

(ii) Calculate $E^{\ominus}_{cell}$ for the overall reaction in (b)(i).

(1)

(iii) By considering the rusting mechanism described in part (b), suggest why the presence of salt in the water droplet speeds up rusting.

(1)

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(iv) The corrosion of oil pipelines made of steel is prevented by connecting the pipeline to magnesium blocks. Suggest how this method works.

(1)

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(Total for Question 21 = 20 marks)

22 Crystals of copper(II) sulfate dissolve in water to form a blue solution, **A**. When dilute aqueous ammonia is added to this solution, a pale blue precipitate, **B**, forms which dissolves in excess aqueous ammonia to form a dark blue solution, **C**.

(a) (i) Give the **formula** of the copper species in **A**, **B** and **C**. You should include all of the ligands present in each species.

(3)

A .....

B .....

C .....

(ii) Explain why solution **A** is coloured.

(4)

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(iii) Explain why solution **A** is a different colour to solution **C**.

(2)

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(b) A more concentrated solution of **C** may be prepared by using concentrated aqueous ammonia in place of dilute aqueous ammonia. The crystalline sulfate of **C** may be obtained by cooling the mixture in an ice bath and adding ethanol. The filtered crystals may be recrystallized using ethanol as the solvent.

The steps of the recrystallization are summarised below. In the spaces provided, explain the purpose of each step, referring particularly to any words in **bold** type.

(5)

Step 1 The solid was dissolved in the **minimum** amount of hot ethanol.

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Step 2 The **hot** solution was **filtered**.

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Step 3 The filtrate was cooled in an **ice bath**.

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Step 4 The mixture was **filtered** using **suction filtration**.

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(Total for Question 22 = 14 marks)

23 This question is about an unknown organic compound, **Q**.

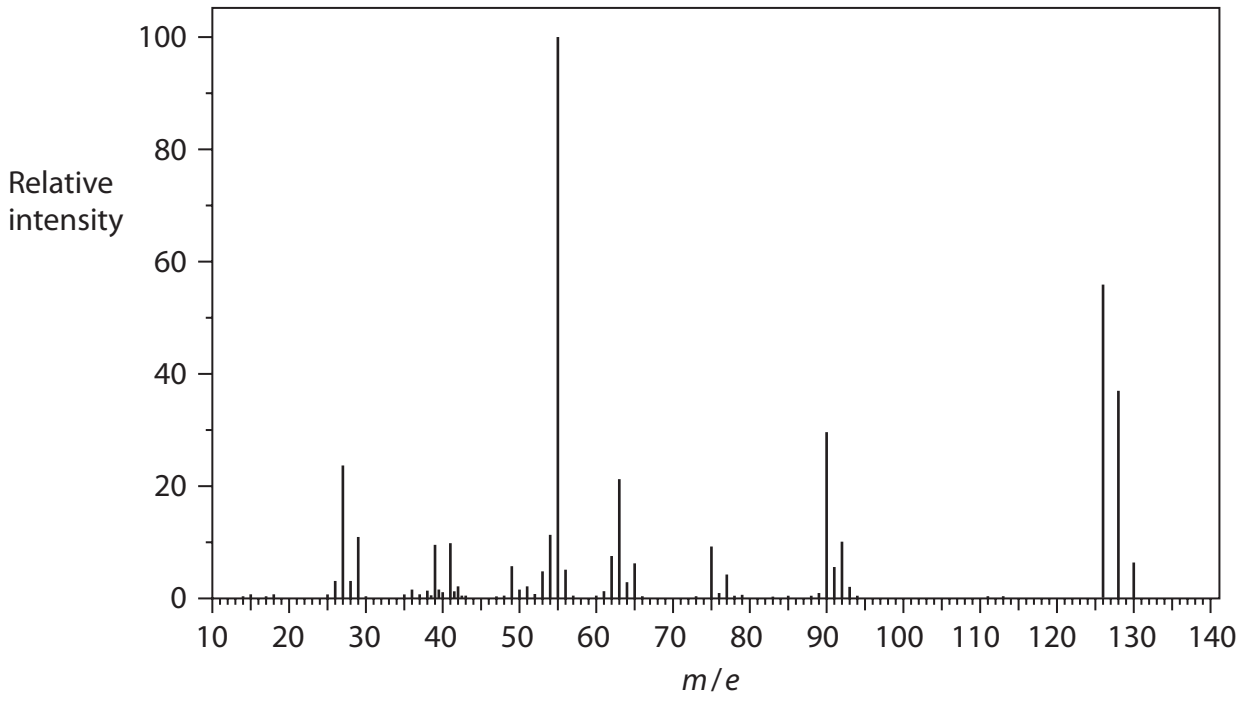
The percentage composition by mass of **Q** is

carbon = 37.8%; hydrogen = 6.30%; chlorine = 55.9%.

(a) Calculate the empirical formula of **Q**.

(2)

(b) The mass spectrum of **Q** is shown below.



(i) Use your answer to part (a) and the mass spectrum to deduce the molecular formula of **Q**.

(1)

.....

(ii) Explain why there are three peaks in the molecular ion region (*m*/*e* from 126 to 130) of the mass spectrum of **Q**.

(2)

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(iii) State why the peak at *m*/*e* = 126 is the highest of the three peaks in the molecular ion region.

(1)

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*(iv) **Q** reacts with aqueous sodium hydroxide to form an organic compound, **R**.

The functional groups of compound **R** are on different carbon atoms.

Compound **R** reacted slowly with sodium, producing a total of one mole of hydrogen gas per mole of **R**.

When compound **R** was heated under reflux with excess acidified sodium dichromate(VI), an organic compound, **S**, was formed.
Compound **S** reacted rapidly with sodium, producing a total of 0.5 mol of hydrogen gas per mole of **S**.

Draw the **displayed** formulae of the two possible structures for compound **S**.
Explain how your structures are consistent with these data.

(5)

Structure I	Structure II

Explanation .....

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(v) Compound **S** reacted with iodine dissolved in aqueous sodium hydroxide, producing a pale yellow precipitate with an antiseptic smell.

Identify the pale yellow precipitate and hence identify which of the structures that you have given in (b)(iv) is compound **S**. Explain your reasoning.

(2)

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(vi) **Name** compound **R** and give the equation for its reaction with sodium.

(3)

R = ...

Equation

(Total for Question 23 = 16 marks)

TOTAL FOR SECTION B = 50 MARKS

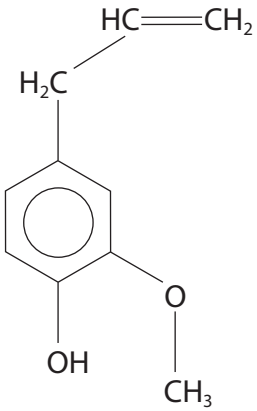
SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

24

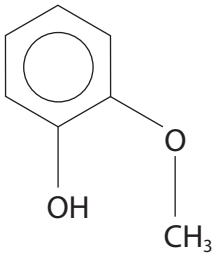
Oil of cloves

Oil of cloves is a traditional remedy for toothache; it is a topical treatment, which means that it is applied externally. The main active ingredient of oil of cloves is eugenol, which also gives cloves their characteristic smell. The structure of eugenol is shown below.



eugenol

(a) A student suggested that eugenol could be prepared by an electrophilic substitution of 2-methoxyphenol, which is produced in the gut of desert locusts. This compound is one of the main components of the pheromones that cause locust swarming. The structure of 2-methoxyphenol is shown below.



2-methoxyphenol

(i) Use your knowledge of electrophilic substitution reactions to suggest the structure of an electrophile that might be used in this reaction.

(1)

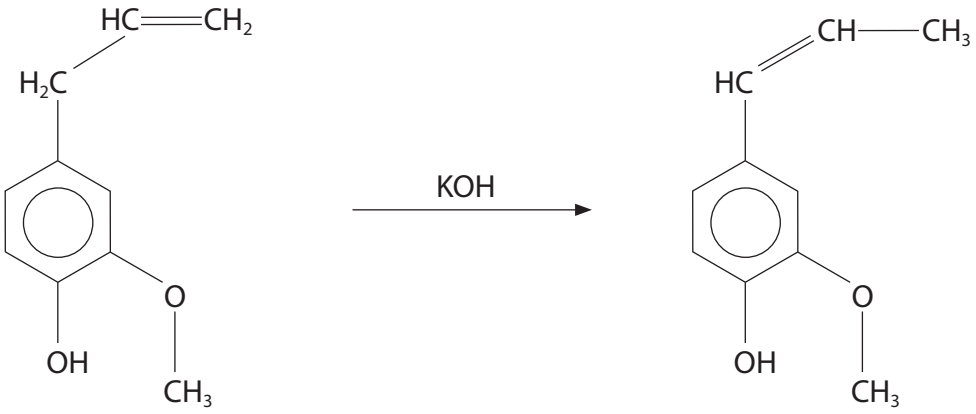
(ii) Suggest an organic compound that could be used to produce the electrophile that you have given in (a)(i).

(1)

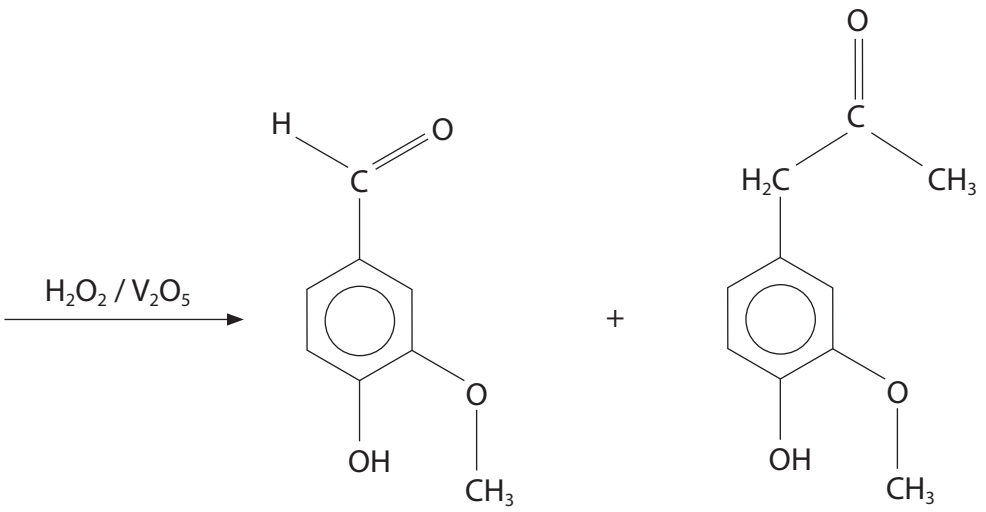
(iii) Write the mechanism for the electrophilic substitution to prepare eugenol from 2-methoxyphenol, using the electrophile that you have given in (a)(i).

(3)

(b) Eugenol has been used in the manufacture of vanillin, the compound responsible for the flavour of vanilla. The process involves the conversion of eugenol to its isomer isoeugenol, which is then oxidized by hydrogen peroxide with a vanadium(V) oxide catalyst.



eugenol isoeugenol



vanillin methyl vanillyl ketone

(i) Isoeugenol exists as two stereoisomers, whereas eugenol has just one structure. State the type of stereoisomerism shown by isoeugenol and explain why it can show this type of stereoisomerism, whereas eugenol does not.

(2)

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.....

*(ii) Discuss whether or not high resolution proton nmr spectroscopy could be used to distinguish between eugenol and a single isomer of isoeugenol.

You should consider the numbers of peaks in the spectra, their splitting patterns and the areas under the peaks. You are **not** expected to suggest chemical shift values.

(4)

(iii) Suggest, in outline, a mechanism by which vanadium(V) oxide acts as a catalyst for the reaction between hydrogen peroxide and isoeugenol to form vanillin. You are **not** expected to give equations for the mechanism.

(2)

(iv) A student suggested that the infrared spectroscopy data on page 5 of the Data Booklet could be used to show whether the purified vanillin contains a trace of methyl vanillyl ketone.

Explain the basis of this idea and suggest why it may not work in practice.

(2)

(c) The Zeisel method for determining the purity of vanillin involves estimating the percentage by mass of methoxy group (CH_3O) in the sample and comparing this with the percentage in pure vanillin.

In a sequence of reactions, each methoxy group produces iodine which is estimated by titration with a sodium thiosulfate solution of known concentration. The Zeisel sequence is

Step 1 $ROCH_3 + HI \rightarrow ROH + CH_3I$

Step 2 $CH_3I + Br_2 \rightarrow CH_3Br + IBr$

Step 3 $IBr + 3H_2O + 2Br_2 \rightarrow HIO_3 + 5HBr$

Step 4 $IO_3^- + 5I^- + 6H^+ \rightarrow 3I_2 + 3H_2O$

Step 5 $I_2 + 2S_2O_3^{2-} \rightarrow S_4O_6^{2-} + 2I^-$

(i) Deduce the number of moles of thiosulfate ions that are equivalent to one mole of methoxy group. Explain your answer.

(2)

(ii) A sample of vanillin was found to have 20.09% by mass of methoxy group. Calculate the percentage purity of the vanillin.

(3)

(Total for Question 24 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 5 0 7 4 A 0 2 8 2 8

PMT

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Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH05/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	C		1

Question Number	Correct Answer	Reject	Mark
2	A		1

Question Number	Correct Answer	Reject	Mark
3	B		1

Question Number	Correct Answer	Reject	Mark
4	C		1

Question Number	Correct Answer	Reject	Mark
5	D		1

Question Number	Correct Answer	Reject	Mark
6	D		1

Question Number	Correct Answer	Reject	Mark
7	A		1

Question Number	Correct Answer	Reject	Mark
8	C		1

Question Number	Correct Answer	Reject	Mark
9	B		1

Question Number	Correct Answer	Reject	Mark
10	A		1

Question Number	Correct Answer	Reject	Mark
11	B		1

Question Number	Correct Answer	Reject	Mark
12	B		1

Question Number	Correct Answer	Reject	Mark
13	C		1

Question Number	Correct Answer	Reject	Mark
14	C		1

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	A		1

Question Number	Correct Answer	Reject	Mark
17	B		

Question Number	Correct Answer	Reject	Mark
18	D		

Question Number	Correct Answer	Reject	Mark
19	B		

Question Number	Correct Answer	Reject	Mark
20	D		

Total for Section A = 20 marks

Section B

Question Number	Acceptable Answer	Reject	Mark
21(a)(i)	$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$ OR $Fe(s) + 2H^+(aq) \rightarrow Fe^{2+}(aq) + H_2(g)$ OR ionic equations including sulfate ions OR multiples		1

Question Number	Acceptable Answer	Reject	Mark
21(a)(ii)	Otherwise the Fe^{2+} formed will oxidize ALLOW So air / oxygen cannot enter the flask To prevent reaction with air /oxygen **(1)** Hydrogen can escape through the slit OR So pressure does not build up **(1)** IGNORE Acid spray	Iron/steel oxidized	2

Question Number	Acceptable Answer	Reject	Mark
21(a)(iii)	Transfer the reaction mixture to a ($250\ cm^3$) **volumetric**/**graduated** flask ALLOW standard flask **(1)** (Rinse conical flask and) add washings to the volumetric flask **(1)** Make solution up to the mark (with distilled water/sulfuric acid) **and then** mix ALLOW any indication of mixing **(1)** IGNORE Filtration	Using other liquids	3

Question Number	Acceptable Answer	Reject	Mark
21(a)(iv)	$5Fe^{2+} + MnO_4^- + 8H^+ \rightarrow 5Fe^{3+} + Mn^{2+} + 4H_2O$ OR multiples Ignore state symbols even if incorrect		1

Question Number	Acceptable Answer	Reject	Mark
21(a)(v)	Amount MnO_4^- = 22.15 x 0.0195 /1000 **(1)** = 4.31925×10^{-4} ans* Amount Fe^{2+} = 5 x ans* **(1)** = 2.159625×10^{-3} ans** Mass of iron in wire = 10 x ** x 55.8 **(1)** = 1.20507 (g) ans*** % purity = 100 x ans*** / 1.25 = 96.40566 = 96.4 % **(1)** Ignore rounding errors until final answer Correct answer (96.4%) with or without working scores 4 ALLOW Use of Ar(Fe) = 56 when Amount MnO_4^- = 22.15 x 0.0195 /1000 **(1)** = 4.31925×10^{-4} ans* Amount Fe^{2+} = 5 x ans* **(1)** = 2.159625×10^{-3} ans** Mass of iron in wire = 10 x ** x 56 **(1)** Mass of iron in wire = 1.20939 % purity = 96.7512 = 96.8 % **(1)** Ignore intermediate rounding until final answer Correct answer (96.8%) with or without working scores 4 TE on each stage in the calculation % purity > 100 scores max 2	Answer not to 3 SF Answer not to 3 SF	4

Question Number	Acceptable Answer	Reject	Mark
21(a)(vi)	Colourless / pale yellow to (pale) pink / first permanent pink	Purple Just '(pale) pink'	1

Question Number	Acceptable Answer	Reject	Mark
21(a)(vii)	(More manganate(VII) is needed to oxidize Fe^{2+}, so) titre will be larger **(1)** Stand alone mark Because the Mn oxidation number changes from 7 to 4 (rather than 2) OR Mn accepts fewer electrons per mole **(1)** (Brown precipitate is) manganese(IV) oxide / MnO_2 ALLOW $Mn(OH)_4$ **(1)** IGNORE References to inaccurate / inconsistent titre values	$Mn(OH)_2$	3

Question Number	Acceptable Answer	Reject	Mark
21(b)(i)	Anodic area: $Fe^{2+} + 2e(^-) \rightleftharpoons Fe$ ($E^\ominus = -0.44$ V) OR $Fe \rightleftharpoons Fe^{2+} + 2e(^-)$ **(1)** Cathodic area: $O_2 + 2H_2O + 4e(^-) \rightleftharpoons 4OH^-$ ($E^\ominus = +0.40$ V) **(1)** ALLOW $\frac{1}{2}O_2 + 2H^+ + 2e(^-) \rightleftharpoons H_2O$ ($E^\ominus = +1.23$ V) Penalise omission of electrons or use of cell diagrams once only Anode and cathode reversed max 1. IGNORE State symbols even if incorrect Single arrow in equations		2

Question Number	Acceptable Answer	Reject	Mark
21(b)(ii)	$E^{\ominus}_{cell}$ = (+)0.40 – (−0.44) = (+)0.84 (V) ALLOW $E^{\ominus}_{cell}$ = (+)1.23 – (−0.44) = (+)1.67 (V) Correct answer with no working scores 1		1

Question Number	Acceptable Answer	Reject	Mark
21(b)(iii)	Dissolved salt makes the **water** a better conductor (of ions) OR The **solution** acts like a salt bridge OR Makes it an (effective) electrolyte OR Improves the flow of ions through the **solution** ALLOW Improves the flow of electrons through the **metal**	Improves the flow of ions through the metal Improves the flow of electrons through the solution	1

Question Number	Acceptable Answer	Reject	Mark
21(b)(iv)	Magnesium has a more negative $E^{\ominus}$ (allow more reactive) **and** so reduces the Fe^{2+} OR suppresses the oxidation of iron OR forces the iron (in the absence of oxygen) to act as the cathode ALLOW Mg corrodes / oxidizes in preference to / faster than (the Fe / steel) OR Magnesium acts as a sacrificial anode	Just 'sacrificial protection'	1

Total for Question 21 = 20 marks

Question Number	Acceptable Answer	Reject	Mark
22(a)(i)	$[Cu(H_2O)_6]^{2+}$ ALLOW $[Cu(H_2O)_4]^{2+}$ **(1)** $Cu(H_2O)_4(OH)_2$ ALLOW $Cu(OH)_2$ **(1)** $[Cu(NH_3)_4(H_2O)_2]^{2+}$ ALLOW $[Cu(NH_3)_4]^{2+}$ **(1)** ALLOW Ligand in any order Omission of square brackets	$Cu^{2+}(aq)$ $[Cu(NH_3)_6]^{2+}$	3

Question Number	Acceptable Answer	Reject	Mark
22(a)(ii)	(3)d orbitals / (3)d subshell split (by the attached ligands) **(1)** Electrons are promoted (from lower to higher energy d orbital(s) / levels) OR Electrons move from lower to higher energy (d orbital(s) / levels) ALLOW d—d transitions occur /electrons are excited **(1)** Absorbing energy /photons of a certain frequency (in the visible region) ALLOW Absorbing light **(1)** Reflected / transmitted / remaining light is coloured / in the visible region ALLOW Complementary colour seen Reflected / transmitted / remaining light / frequency is seen **(1)** Penalise omission of (3)d once only. Ignore reference to electrons relaxing / dropping to the ground state	Orbital / shell / subshells split d—d splitting Emitted ‘Reverse’ for ‘complementary’	4

Question Number	Acceptable Answer	Reject	Mark
22(a)(iii)	The (different) ligands split the (3)d orbitals / subshell to a different extent **(1)** (So) the energy absorbed / reflected / transmitted is different OR Radiation (ALLOW light) is at a different frequency **(1)**	Orbital / shell / subshells unless penalised in 22(a)(ii) Emitted unless penalised in 22(a)(ii)	2

Question Number	Acceptable Answer	Reject	Mark
22(b)	Any 5 of the following: **Step 1**: Minimum amount of solvent to minimise the amount of solid complex left in solution (when it recrystallizes) ALLOW To form a saturated solution (of **C**) OR So the solution is as concentrated as possible **(1)** **Step 2**: (**hot**) So maximum amount / most of complex remains in (hot) solution OR To avoid the premature formation the crystals in the funnel **(1)** (**filter**) To remove **insoluble / undissolved** impurities **(1)** Step 3: To ensure that **maximum** amount of solid crystallizes ALLOW To obtain a better yield (of crystals) **(1)** Step 4: To remove **soluble / dissolved** impurities **(1)** So that the filtered solid is dry ALLOW So that filtration is fast **(1)**	Speed up crystallization Remove insoluble impurities	5

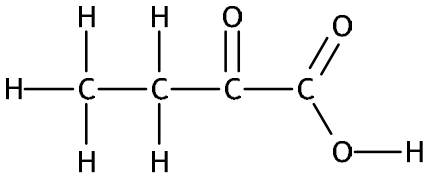
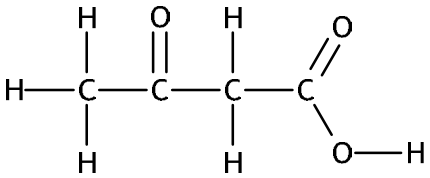
Total for Question 22 = 14 marks

Question Number	Acceptable Answer	Reject	Mark
23(a)	<table><tr><td></td><td>C</td><td>H</td><td>Cl</td></tr><tr><td>%</td><td>37.8</td><td>6.30</td><td>55.9</td></tr><tr><td>mol</td><td>37.8/12 = 3.15</td><td>6.3/1 = 6.3</td><td>55.9/35.5 = 1.575</td></tr><tr><td>ratio</td><td>2</td><td>4</td><td>1</td></tr></table> **(1)** **(1)** (hence C_2H_4Cl) IGNORE Molecular formula		2

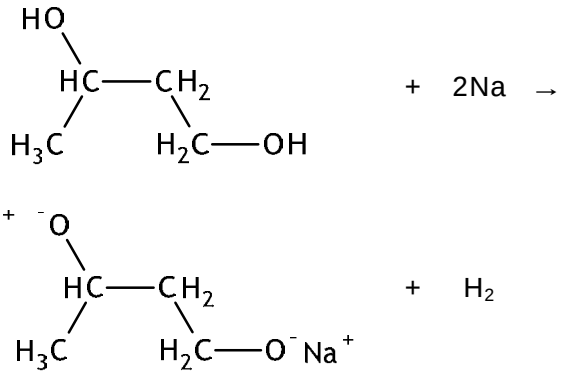
Question Number	Acceptable Answer	Reject	Mark
23(b)(i)	$C_4H_8Cl_2$		1

Question Number	Acceptable Answer	Reject	Mark
23(b)(ii)	All three correct scores 2 Any two correct scores 1 (The following combinations of chlorine isotopes occur in **Q**:) ^{35}Cl and ^{35}Cl (with MS peak at 126) ^{35}Cl and ^{37}Cl (with MS peak at 128) ^{37}Cl and ^{37}Cl (with MS peak at 130) ALLOW Any representations of pairs of chlorine atoms If none of the above marks is scored then A molecule of **Q** has **two** chlorine atoms and the **two** isotopes are present scores 1	Just 'chlorine has isotopes' Any reference to carbon-13	2

Question Number	Acceptable Answer	Reject	Mark
23(b)(iii)	^{35}Cl is more abundant than ^{37}Cl	^{35}Cl is more stable	1

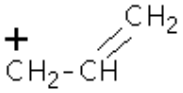
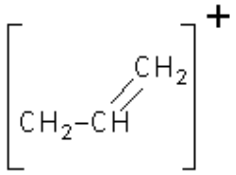
Question Number	Acceptable Answer	Reject	Mark
23(b)*(iv)	 (2-oxobutanoic acid) **(1)**  (3-oxobutanoic acid) **(1)** ALLOW CH_3 and OH **Explanation** (in any order) R must be a diol / have 2 OH group **(1)** Each **OH group** reacts with sodium to give 0.5 mol of H_2 **(1)** Because the amount of H_2 is halved both OH groups are oxidized but one is oxidized to a carboxylic acid / COOH and the other to a ketone group ALLOW Because the amount of H_2 is halved only one of the two OH groups remains **(1)**		5

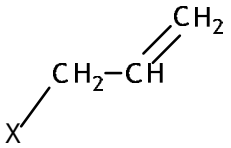
Question Number	Acceptable Answer	Reject	Mark
23(b)(v)	(yellow precipitate) is iodoform / triiodomethane / CHI_3 **(1)** IGNORE "Iodoform test" positive iodoform test given by $CH_3CO(-R)$ / methyl ketone (so S must be 3-oxobutanoic acid / structure identified from (b)(iv)) ALLOW $CH_3CHOH(-R)$ /secondary 2-ol if this structure is given in 23b(iv) **(1)**		2

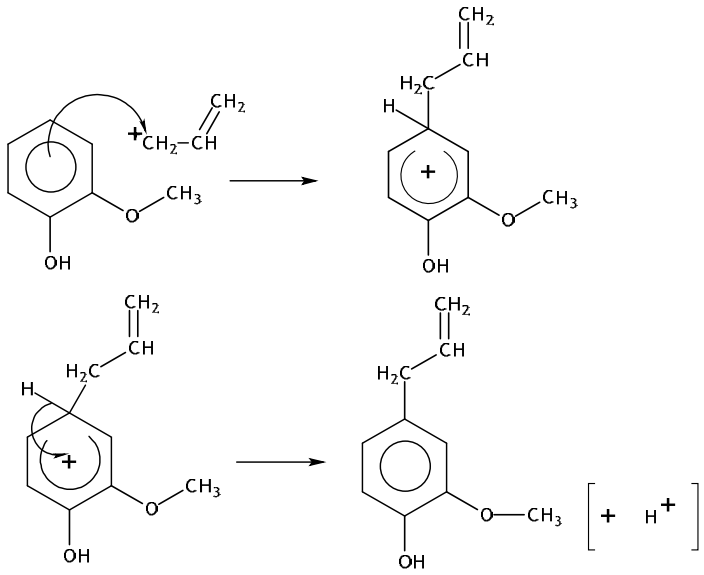
Question Number	Acceptable Answer	Reject	Mark
23(b)(vi)	butane-1,3-diol ALLOW butan-1,3-diol (1)  Any reasonable representation of the organic product (1) Balanced equation (1) These two marks may be awarded for equation involving **any** diol **COMMENT** Do not penalise O-Na for final structure		3

Total for Question 23 = 16 marks
Total for Section B = 50 marks

Section C

Question Number	Acceptable Answer	Reject	Mark
24(a)(i)	 or  ALLOW Positive charge on any part of the carbocation Structural / fully displayed / skeletal formulae		1

Question Number	Acceptable Answer	Reject	Mark
24(a)(ii)	 X = Cl / Br / I OR structural / fully displayed / skeletal formulae OR 3- chloro/bromo/iodo prop(-1-)ene No TE on incorrect electrophile in (a)(i)	name without '3'	1

Question Number	Acceptable Answer	Reject	Mark
24 (a)(iii)	 TE on incorrect electrophile in (a)(i) If benzene used instead of substituted benzene OR If final product not 1,2,4 only MP1 & 2 scored Curly arrow from on / within the circle to positive C ALLOW Curly arrow from anywhere within the hexagon Arrow to **any** part of the electrophile including to the + charge (which can be anywhere on electrophile), OR Arrow to a point at least half the distance between ring and electrophile **(1)** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe. IGNORE substituent errors (incorrect position on ring or bond to substituent) at this marking point ALLOW dotted horseshoe **(1)** Curly arrow from C—H bond to anywhere in the benzene ring reforming delocalized structure of a correct stable molecule. Ignore any involvement of $AlCl_4^-$ in the final step **(1)** Correct Kekulé structures score full marks	Curly arrow on or outside the hexagon Partial bonds to H or CH_3 except for dot and wedge in 3-D structure	3

Question Number	Acceptable Answer	Reject	Mark
24(b)(i)	Stand alone marks Geometric / *E*-*Z* / cis-trans isomerism **(1)** Because isoeugenol has (two) different groups attached to each of the carbon atoms of the double bond ALLOW Because eugenol has two hydrogen atoms on one of the carbon atoms in the C=C **(1)** IGNORE References to the barrier to free rotation about the C=C	Optical isomerism	2

Question Number	Acceptable Answer	Reject	Mark
24(b)*(ii)	If no other mark is scored 'both eugenol and isoeugenol have eight peaks' scores 1 Candidates are only expected to interpret the spectra using knowledge of the (n+1) rule. **EITHER** The only (significant) difference is likely to be (in the peak areas / heights) due to the protons on the alkene chain **(1)** This mark may be awarded if the use of the alkene chain is indicated but not stated Both will have three sets of peaks due to the three sets of protons on the alkene chain **(1)** The alkene chain will give two doublets and a quintet in both isomers **(1)** In isoeugenol the doublets will have different peak areas / heights under the peaks / peak heights in ratio 1:3 whereas in eugenol the doublets will be the same height **(1)** **OR** Eugenol has areas / heights in the ratio 2:1:2:1:1:1:1:3 **(1)** and isoeugenol has peak areas / heights in the ratio 3:1:1:1:1:1:1:3 **(1)** The alkene chain will give two doublets and a quintet in both isomers **(1)** In isoeugenol the doublets will have different peak areas / heights under the peaks / peak heights in ratio 1:3 whereas in eugenol the doublets will be the same height **(1)** **OR** The only (significant) difference likely to be in the splitting pattern of the peaks due to the protons on the alkene chain **(1)** In eugenol the protons at the end of the alkene chain are in different environments so eugenol will have four sets of peaks whereas isoeugenol will have three sets of peaks **(1)**		4

24(b)*(ii) (cont)	In eugenol the alkene chain will give three doublets and a quintet **(1)** In isoeugenol the alkene chain will give two doublets and a quintet **(1)**		

Question Number	Acceptable Answer	Reject	Mark
24(b)(iii)	V_2O_5 oxidizes isoeugenol / alkene substituent (to the aldehyde & ketone) (and V(V) is reduced to a lower oxidation state) OR Explanation in terms of isoeugenol reducing V_2O_5 **(1)** H_2O_2 oxidizes vanadium back to the +5 oxidation state **(1)** Mechanism with H_2O_2 oxidizing V_2O_5 as the first step scores max 1 If no other mark is scored 'vanadium(V) is reduced then oxidized' scores 1 Ignore any reference to adsorption and desorption on the surface.	Just 'V_2O_5 oxidizes'	2

Question Number	Acceptable Answer	Reject	Mark
24(b)(iv)	Vanillin has an aldehyde group, suggesting a peak in the range 1740-1720 (cm^{-1}) whereas methyl vanillyl ketone has a ketone group suggesting a peak in the range 1700-1680 (cm^{-1}) (The peaks occur at different wavenumbers so the ketone peak could be seen) **(1)** These are general ranges and might overlap in the particular spectra OR Vanillin is an aromatic aldehyde OR Concentration of the ketone might be too small for the peak to be observed **(1)**		2

Question Number	Acceptable Answer	Reject	Mark
24(c)(i)	6 (moles of $S_2O_3^{2-}$ per mole CH_3O) **(1)** Stand alone mark In the sequence $ROCH_3 \equiv CH_3I \equiv IBr \equiv HIO_3 \equiv 3I_2 \equiv 6S_2O_3^{2-}$ **(1)**	Partial sequences	2

Question Number	Acceptable Answer	Reject	Mark
24(c)(ii)	Mr (vanillin) = 152 **(1)** **EITHER** % CH_3O in pure vanillin = 100 x 31/152 = 20.3947% **(1)** % purity of the vanillin = 100 x 20.09 / 20.3947 = 98.5058% **(1)** **OR** 20.09% weighs 31 So 100% weighs 100 x 31/20.09 = 154.31 So apparent molar mass = 154.31 **(1)** Therefore % purity is 152 x 100/154.31 = 98.5058% **(1)** **OR** Apparent mass CH_3O = 100 x 20.09/152 = 30.5368 **(1)** Therefore % purity is 100 x 30.5368 /31 = 98.5058% **(1)** Correct answer with no working scores 3 IGNORE SF except 1 SF		3

Total for Question 24 = 20 marks
Total for Section C = 20 marks

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Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Wednesday 27 January 2016 – Afternoon
Time: 1 hour 40 minutes

Paper Reference
WCH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 4 6 9 4 1 A 0 1 2 8

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following elements is both a d-block element and a transition element?

☒ **A** Calcium

☒ **B** Copper

☒ **C** Scandium

☒ **D** Zinc

(Total for Question 1 = 1 mark)

2 The following complexes have different shapes.

A $[Ag(NH_3)_2]^+$

B $[CrCl_4]^-$

C $[Ni(H_2NCH_2CH_2NH_2)_3]^{2+}$

D $[Pt(NH_3)_2Cl_2]$

(a) Which complex is square-planar?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which complex has geometric isomers?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 2 = 2 marks)

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3 This question is about water, and equimolar aqueous solutions of ammonia, butylamine and phenylamine.

The order of **increasing** pH is

☒ **A** phenylamine, butylamine, ammonia, water.

☒ **B** water, ammonia, butylamine, phenylamine.

☒ **C** water, phenylamine, ammonia, butylamine.

☒ **D** ammonia, phenylamine, butylamine, water.

(Total for Question 3 = 1 mark)

4 What are the colours of the complex ions formed by copper(II) ions with butylamine and chloride ions?

	$[Cu(C_4H_9NH_2)_4(H_2O)_2]^{2+}$	$[CuCl_4]^{2-}$
☒ **A**	blue	yellow
☒ **B**	blue	green
☒ **C**	yellow	blue
☒ **D**	yellow	green

(Total for Question 4 = 1 mark)

5 Iron(III) ions form a more stable complex with EDTA than with water. What is the **best** explanation for this?

☒ **A** Iron(III) ions form stronger bonds with EDTA than with water.

☒ **B** Iron(III) ions form more bonds with EDTA than with water.

☒ **C** ΔS_{system} is positive for the formation of the EDTA complex from $[Fe(H_2O)_6]^{3+}$.

☒ **D** $\Delta H_{reaction}$ is positive for the formation of the EDTA complex from $[Fe(H_2O)_6]^{3+}$.

(Total for Question 5 = 1 mark)

6 What is the relationship between the equilibrium constant, K, and $E^{\ominus}_{cell}$ for a reaction?

- ☒ **A** K is directly proportional to $\ln E^{\ominus}_{cell}$
- ☒ **B** K is directly proportional to $E^{\ominus}_{cell}$
- ☒ **C** $\ln K$ is inversely proportional to $E^{\ominus}_{cell}$
- ☒ **D** $\ln K$ is directly proportional to $E^{\ominus}_{cell}$

(Total for Question 6 = 1 mark)

7 What is the order of **increasing** reducing power of the ions Cr^{2+}, Fe^{2+} and V^{2+}?
Use items 20, 54 and 26 on pages 14 and 15 of your Data Booklet.

- ☒ **A** V^{2+}, Cr^{2+}, Fe^{2+}.
- ☒ **B** Cr^{2+}, V^{2+}, Fe^{2+}.
- ☒ **C** Fe^{2+}, V^{2+}, Cr^{2+}.
- ☒ **D** Fe^{2+}, Cr^{2+}, V^{2+}.

(Total for Question 7 = 1 mark)

8 Which of the following **cannot** disproportionate?

- ☒ **A** I_2
- ☒ **B** Cu^+
- ☒ **C** H_2O_2
- ☒ **D** MnO_4^-

(Total for Question 8 = 1 mark)

9 Dichromate(VI) ions, $Cr_2O_7^{2-}$ in dilute sulfuric acid, react with ethanol, CH_3CH_2OH, on warming to form chromium(III) ions and ethanal, CH_3CHO. The half equation for this oxidation of ethanol is

$$CH_3CH_2OH \longrightarrow CH_3CHO + 2H^+ + 2e^-$$

What is the mole ratio of dichromate(VI) ions to ethanol in this redox reaction?

- ☒ **A** 3:1
- ☒ **B** 2:3
- ☒ **C** 3:2
- ☒ **D** 1:3

(Total for Question 9 = 1 mark)

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10 These are four successive ionization energies (in kJ mol^{-1}) of four different elements.
Which could be those of a transition element?

☒ **A** 658 1310 2653 4175 9573

☒ **B** 578 1817 2745 11578 14831

☒ **C** 738 1451 7733 10541 13629

☒ **D** 496 4563 6913 9544 13352

(Total for Question 10 = 1 mark)

11 Hydrated chromium(III) chloride, $CrCl_3.6H_2O$, exists in several isomeric forms with varying numbers of chloro and water ligands.

A solution containing 0.10 mol of one of these isomers reacts with excess silver nitrate.
0.20 mol of silver chloride, AgCl, is precipitated immediately.
The formula of the complex ion in this isomer is

☒ **A** $[Cr(H_2O)_6]^{3+}$

☒ **B** $[CrCl(H_2O)_5]^{2+}$

☒ **C** $[CrCl_2(H_2O)_4]^{+}$

☒ **D** $[CrCl_3(H_2O)_3]$

(Total for Question 11 = 1 mark)

12 A solution is prepared for use in the standard half cell $Fe^{3+}(aq), Fe^{2+}(aq)|Pt$.

What is the mole ratio of the solids iron(II) sulfate, $FeSO_4$, and iron(III) sulfate, $Fe_2(SO_4)_3$, which should be dissolved to make the solution for this cell?

☒ **A** 2:1

☒ **B** 1:1

☒ **C** 1:2

☒ **D** 3:2

(Total for Question 12 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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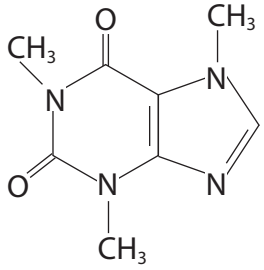
13 The structure of caffeine, $C_8H_{10}O_2N_4$, is



Which functional group is **not** present?

- ☒ **A** ketone
- ☒ **B** alkene
- ☒ **C** amide
- ☒ **D** amine

(Total for Question 13 = 1 mark)

14 The overall reaction between ethanoyl chloride and ethylamine to form N-ethyl ethanamide is best classified as

- ☒ **A** free radical substitution.
- ☒ **B** nucleophilic substitution.
- ☒ **C** free radical addition.
- ☒ **D** nucleophilic addition.

(Total for Question 14 = 1 mark)

15 Four isomers with the formula $C_4H_9NH_2$ are

A 1-aminobutane, $CH_3CH_2CH_2CH_2NH_2$

B 2-aminobutane, $CH_3CH_2CH(NH_2)CH_3$

C 1-amino-2-methylpropane, $(CH_3)_2CHCH_2NH_2$

D 2-amino-2-methylpropane, $(CH_3)_3CNH_2$

(a) Which isomer is chiral?

(1)

- ☒ **A**
- ☒ **B**
- ☒ **C**
- ☒ **D**

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(b) Which isomer gives a **low** resolution proton nmr spectrum with the fewest peaks?

(1)

☒ **A**

☒ **B**

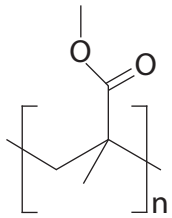
☒ **C**

☒ **D**

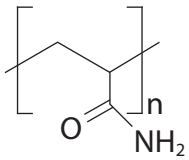
(Total for Question 15 = 2 marks)

16 The formulae of four synthetic polymers, **W**, **X**, **Y** and **Z**, are given below.

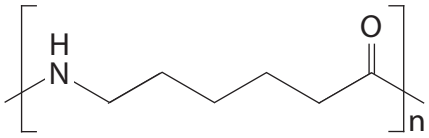
W Poly(methyl-2-methylpropenoate)



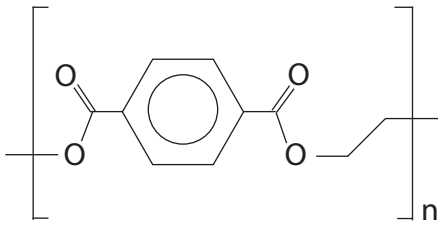
X Poly(propenamide)



Y Poly(amide 6)



Z Poly(ethylene terephthalate)



Which polymers are made by condensation polymerization reactions?

☒ **A** **W** and **Z**

☒ **B** **X** and **Y**

☒ **C** **Y** and **Z**

☒ **D** **W** and **X**

(Total for Question 16 = 1 mark)

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17 All naturally occurring amino acids exist as crystalline solids.
The **best** explanation for this is that amino acids

- ☒ **A** have large numbers of electrons.
- ☒ **B** form hydrogen bonds.
- ☒ **C** form ionic bonds.
- ☒ **D** are symmetrical so the molecules can pack closely in the lattice.

(Total for Question 17 = 1 mark)

18 When recrystallization is used to purify a solid, which of the following statements is true?

- ☒ **A** Soluble impurities are removed by filtering the hot solution.
- ☒ **B** Insoluble impurities are removed by filtering the hot solution.
- ☒ **C** All impurities must be insoluble in the solvent used.
- ☒ **D** All impurities must be soluble in the solvent used.

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer all the questions. Write your answers in the spaces provided.

19 Methanol fuel cells have significant advantages over hydrogen fuel cells.

The half equations for the methanol fuel cell are

$$CO_2 + 6H^+ + 6e^- \rightleftharpoons CH_3OH + H_2O \quad E^{\ominus} = +0.02\,V$$

$$\tfrac{1}{2}O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O \quad E^{\ominus} = +1.23\,V$$

(a) Use your knowledge of the hydrogen electrode to draw a labelled diagram of the half cell that could be used to measure the oxygen electrode potential.

Include the conditions needed for the standard electrode potential to be measured.

(3)

(b) Write the overall equation for the methanol fuel cell reaction.
State symbols are not required.

(1)

(c) Calculate the emf of this methanol cell.

(1)

*(d) Suggest **one** advantage and **one** disadvantage of a methanol fuel cell compared to a hydrogen fuel cell.

(2)

(Total for Question 19 = 7 marks)

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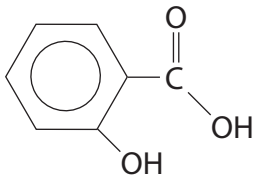
20 This question is about the naturally occurring substance, 2-hydroxybenzoic acid, which can be extracted from the bark of willow trees.



(a) Give the molecular formula of 2-hydroxybenzoic acid.

(1)

(b) The presence of the carboxylic acid group in 2-hydroxybenzoic acid is shown by the fact that it neutralizes sodium carbonate solution.

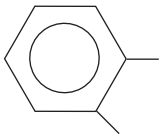
Write the equation for this neutralization. State symbols are not required.

(2)

(c) The 2-hydroxybenzoic acid forms a hydrogen bond within the molecule.

(i) Complete the formula below to show this hydrogen bonding by displaying all the remaining atoms and bonds.

(1)



*(ii) Will the melting temperature of 4-hydroxybenzoic acid be higher or lower than that of 2-hydroxybenzoic acid? Justify your answer.

(2)

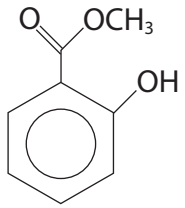
(d) Phenol and 2-hydroxybenzoic acid react with excess bromine water in a similar way.

Suggest the structural formula and name of the organic product formed when excess bromine water reacts with 2-hydroxybenzoic acid.

(2)

Name .....

(e) The main chemical present in oil of wintergreen is methyl 2-hydroxybenzoate which is a liquid at room temperature.



(i) Give the chemicals and conditions needed to prepare methyl 2-hydroxybenzoate from 2-hydroxybenzoic acid in a **single** step reaction.

(2)

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*(ii) Because methyl 2-hydroxybenzoate is sparingly soluble in water, it is extracted from the reaction mixture using ethyl ethanoate.

Explain why methyl 2-hydroxybenzoate is sparingly soluble in water.

(3)

(iii) The solution of methyl 2-hydroxybenzoate in ethyl ethanoate is washed and then dried.

Suggest the chemicals needed for these steps.

Justify your suggestions.

(3)

(iv) State how methyl 2-hydroxybenzoate is separated from ethyl ethanoate.

(1)

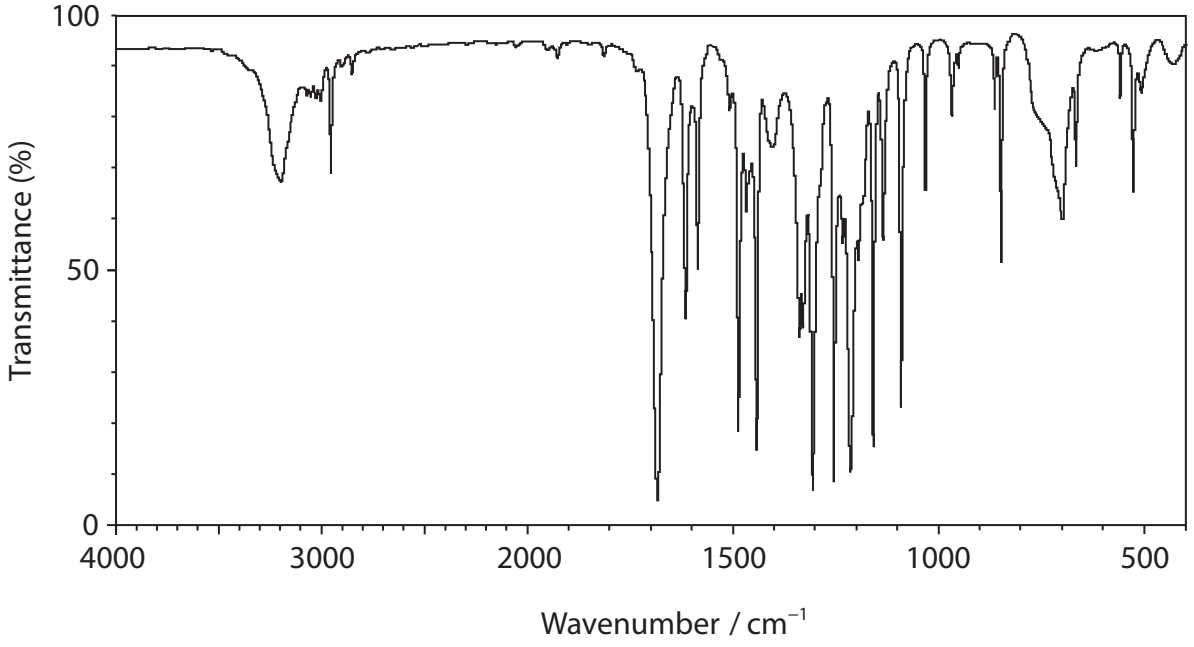
(v) The identity of methyl 2-hydroxybenzoate can be confirmed by infrared spectroscopy.

Which of the infrared spectra below is given by methyl 2-hydroxybenzoate and which by 2-hydroxybenzoic acid?

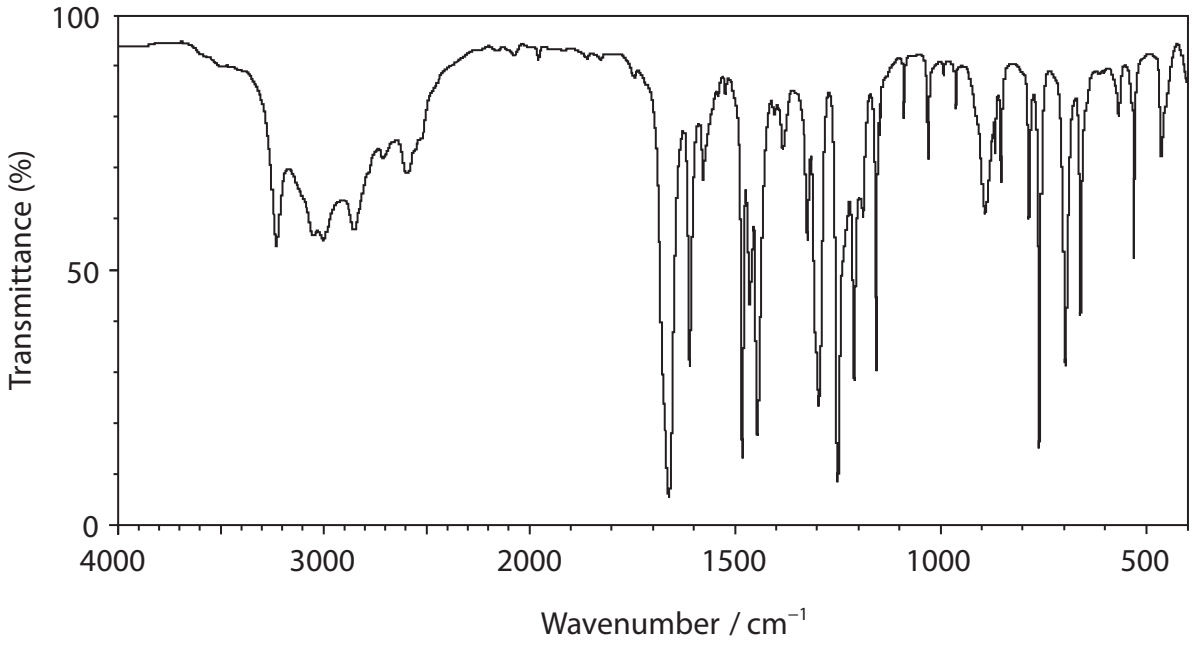
Justify your answer by identifying the bond responsible for a distinguishing absorption. Give the wavenumber range for this absorption.

(2)

Spectrum A



Spectrum B



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(vi) Calculate the **volume** of methyl 2-hydroxybenzoate produced from 9.00 g of 2-hydroxybenzoic acid, assuming the yield for this reaction is 60%, and the other reagents are present in excess.

DATA

Molar mass of 2-hydroxybenzoic acid = 138 g mol^{-1}

Molar mass of methyl 2-hydroxybenzoate = 152 g mol^{-1}

Density of methyl 2-hydroxybenzoate = 1.174 g cm^{-3}

(3)

(Total for Question 20 = 22 marks)

21 This question is about the element chromium and some of its compounds.

(a) (i) Complete the electronic configuration of the chromium atom, using the s, p, d notation.

(1)

[Ar] .....

*(ii) State how this electronic configuration of the chromium atom is unusual compared with most other transition metals.

Give **two** reasons why chromium has this electronic configuration.

(2)

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(b) (i) A solution containing chromium(II) ions can be produced in the laboratory by reducing a solution of potassium dichromate(VI) using zinc in 50% hydrochloric acid. This reaction takes place in two steps. Dichromate(VI) ions are reduced to chromium(III) ions and the chromium(III) ions are then reduced to chromium(II) ions.

Use the relevant standard reduction potentials from page 17 or standard electrode potentials on pages 14 and 16 of the Data Booklet to calculate $E^{\ominus}_{cell}$ for each step.

Use your $E^{\ominus}_{cell}$ values to explain why both steps are spontaneous.

(3)

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.....

(ii) State the colour changes you would expect to see during this reaction.

(1)

.....

.....

(iii) A student suggests that the hydrogen produced by the reaction of the zinc with hydrochloric acid in this experiment is a serious risk. Evaluate the student's suggestion.

(1)

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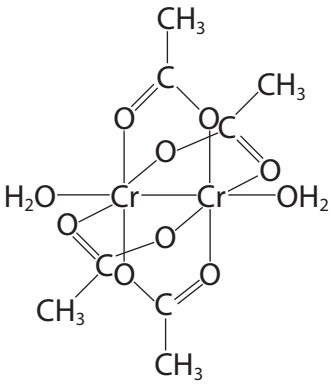
(c) Chromium(II) ions in aqueous solution are quickly oxidized by the oxygen in air. One method of stabilising chromium(II) ions is by adding a solution of sodium ethanoate, forming a complex, $[Cr_2(CH_3CO_2)_4(H_2O)_2]$. This complex may be represented by the structure below.



(i) What type of ligand is the ethanoate ion in this complex?

(1)

.....

(ii) State the type of bonding which occurs between the ligands and the chromium(II) ions.

(1)

.....

(iii) Suggest **two** unusual features in the structure and bonding of this complex.

(2)

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(iv) This complex is red.
Explain why the colour of chromium(II) ethanoate is different from that of $Cr(H_2O)_6^{2+}(aq)$.

(2)

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(v) Predict the number and relative areas of the peaks in the **low** resolution proton nmr spectrum of $Cr_2(CH_3CO_2)_4(H_2O)_2$.

Justify your answers.

(2)

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(d) An experiment is carried out to check the oxidation number of chromium in chromium(II) ethanoate $Cr_2(CH_3CO_2)_4(H_2O)_2$.

1.00 g (2.66×10^{-3} mol) of chromium(II) ethanoate is dissolved in 25 cm^3 of 1.00 mol dm^{-3} sulfuric acid.

The solution is diluted with distilled water until the volume is 250 cm^3.

25.0 cm^3 portions of the diluted solution are titrated with 0.00750 mol dm^{-3} potassium manganate(VII).

Calculate the volume of potassium manganate(VII) needed to oxidize the chromium(II) ions present in each 25.0 cm^3 portion to the +6 oxidation state. The manganese is reduced to the +2 oxidation state.

Comment on your answer and suggest how the experiment could be improved to give a more suitable titre.

(5)

Comment .....

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(Total for Question 21 = 21 marks)

TOTAL FOR SECTION B = 50 MARKS

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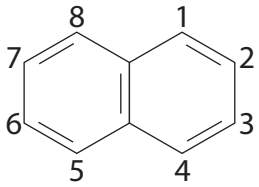
SECTION C

Answer all the questions. Write your answers in the spaces provided.

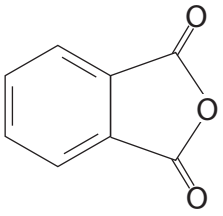
22 Naphthalene is a white solid traditionally used in mothballs and is extracted from coal tar. It is an arene which can be represented by the formula below.



Although it is an aromatic compound, naphthalene has carbon to carbon bonds of different lengths.

Like benzene, naphthalene undergoes electrophilic substitution. Substitution usually occurs at one of the carbons 1, 4, 5 or 8 and naphthalene reacts under milder conditions than benzene.

Oxidation of naphthalene, using oxygen gas with vanadium(V) oxide catalyst at about 650 K, produces phthalic anhydride:



(a) State which physical method would be used to determine the lengths of the carbon to carbon bonds in naphthalene.

(1)

.....

(b) Use your knowledge of benzene to draw an alternative way of representing the structure of naphthalene. Explain what this structure represents and how it arises.

(3)

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(c) Naphthalene is nitrated using a mixture of concentrated nitric and sulfuric acids. Write a mechanism for this reaction. Include one or more equations to show how the electrophile is formed.

(4)

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(d) 1.28 g of naphthalene is completely burned in oxygen.

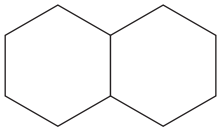
Write the equation for the combustion of naphthalene. State symbols are not required.

Calculate the volume of carbon dioxide produced, measured at room temperature and pressure.

1 mol of a gas occupies 24.0 dm^3 at room temperature and pressure.

(3)

(e) Suggest the reagent and appropriate conditions for the synthesis of decalin from naphthalene.



Decalin

(2)

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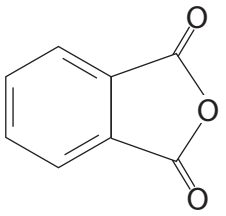
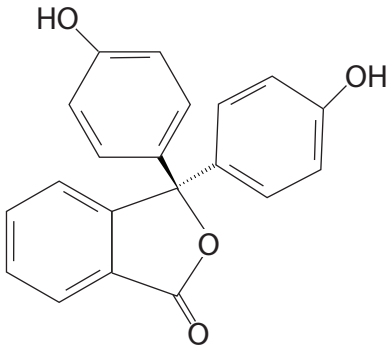
(f) When phenol is heated with phthalic anhydride in the presence of the catalyst concentrated sulfuric acid, the indicator phenolphthalein is formed.



Phthalic anhydride



Phenolphthalein

(i) When phenol reacts with phthalic anhydride to form phenolphthalein, state the inorganic product of the reaction.

(1)

.....

(ii) When phenolphthalein is colourless it can be represented as H_2In.

At very low pH, H_3In^+ is formed which is orange.

Between pH 9 and 12, In^{2-} is formed which has the familiar pink colour.

By referring to the structure of phenolphthalein given above, suggest how these two ions are formed.

(2)

H_3In^+ .....

.....

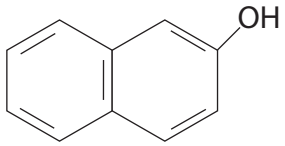
.....

In^{2-} .....

.....

.....

(g) Coal tar also contains 2-naphthol.



2-naphthol and phenol react with phenylamine in a similar way to form dyes.

Suggest a synthesis of a chemical dye starting with 2-naphthol and phenylamine.

You should include chemicals and conditions for your reactions.

Suggest the structural formula of your dye.

(4)

(Total for Question 22 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds damstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

January 2016

Pearson Edexcel International Advanced Level in Chemistry (WCH05) Paper 01 - General Principles of Chemistry II (including synoptic assessment)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A

Question Number	Correct Answer	Reject	Mark
1	**B**		1

Question Number	Correct Answer	Reject	Mark
2(a)	**D**		1

Question Number	Correct Answer	Reject	Mark
2(b)	**D**		1

Question Number	Correct Answer	Reject	Mark
3	**C**		1

Question Number	Correct Answer	Reject	Mark
4	**A**		1

Question Number	Correct Answer	Reject	Mark
5	**C**		1

Question Number	Correct Answer	Reject	Mark
6	**D**		1

Question Number	Correct Answer	Reject	Mark
7	**C**		1

Question Number	Correct Answer	Reject	Mark
8	**D**		1

Question Number	Correct Answer	Reject	Mark
9	**D**		1

Question Number	Correct Answer	Reject	Mark
10	**A**		1

Question Number	Correct Answer	Reject	Mark
11	**B**		1

Question Number	Correct Answer	Reject	Mark
12	**A**		1

Question Number	Correct Answer	Reject	Mark
13	**A**		1

Question Number	Correct Answer	Reject	Mark
14	**B**		1

Question Number	Correct Answer	Reject	Mark
15(a)	**B**		1

Question Number	Correct Answer	Reject	Mark
15(b)	**D**		1

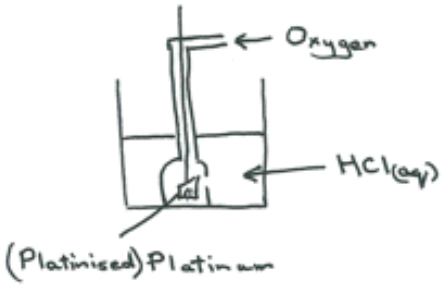
Question Number	Correct Answer	Reject	Mark
16	**C**		1

Question Number	Correct Answer	Reject	Mark
17	**C**		1

Question Number	Correct Answer	Reject	Mark
18	**B**		1

TOTAL FOR SECTION A = 20 Marks

Section B

Question Number	Correct Answer	Reject	Mark
19(a)	Mark independently  Glassware with oxygen **and** 1 atm pressure Tube carrying oxygen must be open at the bottom **but** not after the feed at the top **(1)** (Platinised) platinum/Pt (electrode) **and** 298 K/ 25°C **(1)** Hydrochloric acid/HCl(aq), **covering** some of the electrode **and** 1 mol dm^{-3} OR 1 mol dm^{-3} H^+ covering electrode **(1)** A fully correct hydrogen electrode **2max**	Sulfuric acid	3

Question Number	Correct Answer	Reject	Mark
19(b)	$CH_3OH + 1½O_2 \rightarrow CO_2 + 2H_2O$ OR multiples	Uncancelled electrons, H^+ ions and **H_2O**	1

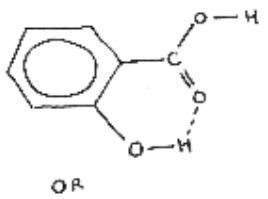
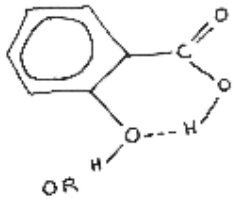
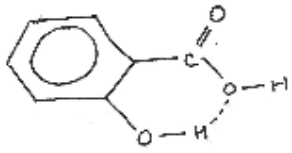
Question Number	Correct Answer	Reject	Mark
19(c)	$E^{\ominus}_{cell}$ = +1.23 – 0.02 = (+) 1.21 (V)	- 1.21 (V)	1

Question Number	Correct Answer	Reject	Mark
19(d)	**Additional Comment** Note that the words advantage and disadvantage are not required **(Advantages)** Any one from: Easier to store/transport than hydrogen (as a liquid rather than a gas) OR Methanol can be produced from waste / methanol is renewable OR Energy per volume is greater **(1)** IGNORE Hydrogen is flammable/ explosive **(Disadvantages)** Any one from: Produces CO_2 OR Low efficiency OR Limited power/energy **(1)** OR Lower emf/E value IGNORE Land used up in producing methanol instead for crops		2

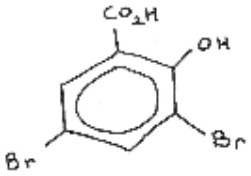
(Total for Question 19 = 7 marks)

Question Number	Correct Answer	Reject	Mark
20(a)	$C_7H_6O_3$ IGNORE Any other formulae eg $C_6H_4OHCOOH$		1

Question Number	Correct Answer	Reject	Mark
20(b)	$NaCO_3$ scores 0 $2C_6H_4OHCOOH + Na_2CO_3 \rightarrow 2C_6H_4OHCOO^{(-)}Na^{(+)} + CO_2 + H_2O$ Entities **(1)** Balancing correct entities/H_2CO_3/$C_7H_6O_3$ ALLOW Incorrect hydrogens in organic formula on both sides **(1)** ALLOW other correct formulae for 2-hydroxybenzoic acid Fully correct ionic equation (2) IGNORE State symbols even if incorrect	H_2CO_3/ $C_7H_6O_3$	2

Question Number	Correct Answer	Reject	Mark
20(c)(i)	 OR  OR  Ignore bond angles around H ALLOW Two hydrogen bonds within one molecule between **phenol** and **carboxylate** groups		1

Question Number	Correct Answer	Reject	Mark
20(c)(ii)	**First mark** 4-hydroxybenzoic acid has a higher melting temperature with some attempt at justification which may not be correct **(1)** **Second mark** EITHER There are (more) hydrogen bonds between molecules OR chains of molecules held together by hydrogen bonds OR So more hydrogen bonds have to be broken OR More energy is needed to break the extra hydrogen bonds OR The intramolecular hydrogen bonds in 2-hydroxybenzoic acid do not need to be broken **(1)** Or reverse argument	Lower/same melting temperature loses first mark	2

Question Number	Correct Answer	Reject	Mark
20(d)	**Scroll down answer to check name first**  OR COOH for carboxylic acid group **(1)** 3,5-dibromo-2-hydroxybenzoic acid ALLOW 2-hydroxy-3,5-dibromobenzoic acid **(1)** TE for name on their incorrect mono/di/tri/tetra substituted product for **1** max	Look out for substitution of the **phenol group or the carboxylic acid group 0 out of 2**	2

Question Number	Correct Answer	Reject	Mark
20(e)(i)	Methanol **(1)** (Concentrated) sulfuric acid ALLOW (concentrated) hydrochloric acid IGNORE Acidic conditions **And** Heat/reflux/warm/any temperature above 25°C Second mark dependent on an alcohol in MP1 **(1)**	Nitric acid	2

Question Number	Correct Answer	Reject	Mark
20 (e)(ii)	Methyl 2-hydroxybenzoate molecules are held together by (strong) London/ dispersion forces IGNORE Dipole forces and hydrogen bonds **(1)** Less / limited hydrogen bond **between** water and methyl 2-hydroxybenzoate (so sparingly soluble) **(1)** The hydrogen bonding between water molecules is (very) strong **(1)** Insufficient energy released to break hydrogen bonds in water/ London forces in methyl 2-hydroxybenzoate **(1)** (Some of the) hydrogen bonds are internal in methyl 2-hydroxybenzoate **(1)** The oxygens in methyl 2-hydroxybenzoate can form hydrogen bonds to the hydrogens of water molecules OR The hydrogen on the oxygen in methyl 2-hydroxybenzoate can form hydrogen bonds to the oxygens of water molecules **(1)**		3

Question Number	Correct Answer	Reject	Mark
20 (e)(iii)	ALLOW Correct formulae for names **First mark** Sodium hydrogencarbonate (solution) ALLOW Sodium carbonate (solution) IGNORE water **(1)** **Second mark** to neutralise/ remove remaining acids **(1)** IGNORE references to saturated sodium chloride solution to reduce solubility of ester **Third mark** (Dried with) (anhydrous) sodium sulfate OR magnesium sulfate OR calcium sulfate OR calcium chloride **(1)**	Anything else	3

Question Number	Correct Answer	Reject	Mark
20 (e)(iv)	Distillation OR Distil off the ethyl ethanoate ALLOW Fractional distillation/redistillation	Steam distillation Solvent extraction	1

Question Number	Correct Answer	Reject	Mark
20(e)(v)	**First marking point** A is methyl 2-hydroxybenzoate OR B is 2-hydroxybenzoic acid **and** a bond / wavenumber considered (eg O-H, C-O, C=O, C-H in CH_3) **(1)** **Second marking point** This is independent of the first mark Any one bond with wavenumber from: In spectrum B the carboxylic acid OH between 3300 and 2500 (cm^{-1}) In spectrum A no broad peak between 3300 and 2500 (cm^{-1}) In spectrum A, C-O (benzoate) between 1150-1100 (cm^{-1}) and/or 1310-1250 (cm^{-1}) In spectrum A alkyl C-H between 2962 – 2853 (cm^{-1}) **(1)** IGNORE In spectrum A phenol/OH peak between 3300 and 3100 (cm^{-1}) OR C-H arene	C=O in acid/ ester	2

Question Number	Correct Answer	Reject	Mark
20(e)(vi)	moles of 2-hydroxybenzoic acid = $\frac{9.00}{138}$ = 0.0652 **and** moles of methyl 2-hydroxybenzoate = 0.6 x 0.0652 = 0.0391 **(1)** Mass of methyl 2-hydroxybenzoate = 0.0391 x 152 = 5.948 (g) **(1)** Volume of methyl 2-hydroxybenzoate = 5.948/1.174 = 5.066 = 5.07 cm^3 Correct volume with no working 3 marks **(1)** ALLOW Internal TE s eg For 100% gives 9.91(3) g and 8.44(4) cm^3 **(2)** IGNORE SF		3

(Total for Question 20 = 22 marks)

Question Number	Correct Answer	Reject	Mark
21(a)(i)	$3d^5\ 4s^1$ /$4s^1\ 3d^5$ ALLOW Complete configuration $1s^2 2s^2 2p^6 3s^2 3p^6 4s^1 3d^5$ ALLOW Capitals and subscripts		1

Question Number	Correct Answer	Reject	Mark
21 (a)(ii)	It is $4s^1$ rather than $4s^2$ because with two of the reasons below $3d^5$/ half-filled 3d sub shell is particularly stable **(1)** The paired electrons repel **(1)** All six electrons are in separate orbitals (minimizing repulsion) **(1)** ALLOW The energy required to promote/ transfer 4s to 3d is small OR The energy difference between 4s and 3d is small **(1)**		2

Question Number	Correct Answer	Reject	Mark
21(b)(i)	($E^{\ominus}$ $Zn^{2+}(aq)\vert\ Zn(s)$ = -0.76 V $E^{\ominus}$ $Cr^{3+}(aq)$, $Cr^{2+}(aq)\vert Pt$ = -0.41 V $E^{\ominus}$ [$Cr_2O_7^{2-}(aq)$ + $7H^+(aq)$], [$2Cr^{3+}(aq)$ + $7H_2O(l)$]$\vert Pt$ = +1.33 V) If no other mark is scored, data scores (1) however shown Calculation of $E^{\ominus}_{cell}$ values: $E^{\ominus}_{cell}$ for first step = 1.33 – -0.76 = (+)2.09 (V) **(1)** $E^{\ominus}_{cell}$ for second step = -0.41 – -0.76 = (+)0.35 (V) **(1)** As (both) values are positive, (both) reactions are spontaneous/feasible **(1)** Third mark is independent		3

Question Number	Correct Answer	Reject	Mark
21(b)(ii)	**Orange** to **green** to **blue** IGNORE qualifying words eg pale blue		1

Question Number	Correct Answer	Reject	Mark
21 (b)(iii)	The small amount of hydrogen produced (does not present a serious risk) ALLOW “Less” for small amount Indication of ventilation		1

Question Number	Correct Answer	Reject	Mark
21(c)(i)	It is bridging/ bidentate ligand	Polydentate	1

Question Number	Correct Answer	Reject	Mark
21(c)(ii)	Dative (covalent) (bonds)/ co-ordinate (bonds)		1

Question Number	Correct Answer	Reject	Mark
21 (c)(iii)	**Any two from:** Chromium atoms/ ions are covalently bonded/bonded to each other OR Two (chromium) ions/ chromium atoms in the complex **(1)** Each ethanoate ligand forms bonds to two different atoms/ ions **(1)** Ethanoate ions are not normally bidentate ligands **(1)** ALLOW Contains both monodentate and bidentate ligands **(1)** Allow six ligands **and** complex not octahedral **(1)**	Just "two different ligands"	2

Question Number	Correct Answer	Reject	Mark
21 (c)(iv)	The energies of the d electron levels are split to different extents (by different ligands) ALLOW d-d (orbitals) splitting is different OR d-d transitions are different **(1)** So different energy/ frequency/ wavelength light absorbed **(1)**	… (just) transmitted	2

Question Number	Correct Answer	Reject	Mark
21(c)(v)	There are two peaks as two different hydrogen environments **(1)** EITHER The areas due to hydrogen in water molecules compared to hydrogen in ethanoate ions is in the ratio 1 to 3/ 4 to 12 OR As there are 4 hydrogen atoms in water and 12 hydrogen atoms in ethanoate ions **(1)**		2

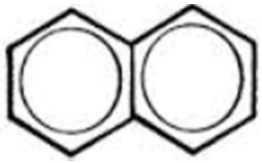
Question Number	Correct Answer	Reject	Mark
21(d)	**First mark** Dilution factor: moles of chromium(II) ethanoate in 25.0 cm^3 = $\frac{2.66 \times 10^{-3}}{10}$ = 2.66×10^{-4} **(1)** **Second mark** Ratio of manganate(VII) to chromium 4 mol manganate(VII) react with 5 mol of chromium (II) OR 8 mol mangante(VII) react with 5 mol of chromium(II) ethanoate **(1)** **Third mark** moles of manganate(VII) ion = $\frac{4 \times 5.32 \times 10^{-4}}{5}$ OR $\frac{8 \times 2.66 \times 10^{-4}}{5}$ = 4.256×10^{-4} **(1)** **Fourth mark** Volume of manganate(VII) solution = $\frac{4.256 \times 10^{-4}}{0.00750} \times 1000$ = 56.75 cm^3 **(1)** Correct answer no working (4) 28.375 cm^3 gets (3) **Fifth mark** This is unsuitable/ inaccurate because it requires refilling the burette hence increasing burette error OR Better to use more concentrated potassium manganate(VII) OR less chromium ethanoate **(1)**		5

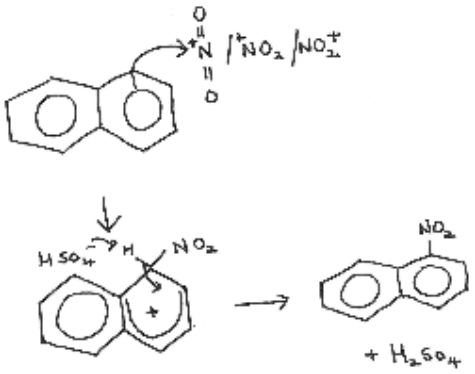
(Total for Question 21 = 21 marks)

TOTAL FOR SECTION B = 50 Marks

Section C

Question Number	Correct Answer	Reject	Mark
22(a)	X-ray diffraction/crystallography	X-rays alone X radiation IR/UV/nmr	1

Question Number	Correct Answer	Reject	Mark
22(b)	Mark independently **First mark:**  ALLOW Single ring and two double bonds Single ring around all atoms **(1)** **Second mark:** EITHER electrons delocalised (around the ring(s)) OR pi system around all (10) carbon atoms **(1)** **Third mark:** EITHER overlap of p-orbitals OR p/ pi-/π/ 10 (ALLOW pie) electrons **(1)** ALLOW six electrons if single ring and two double bonds shown Phthalic anhydride structure **2 max**	Single ring and three double bonds delocalised orbitals	3

Question Number	Correct Answer	Reject	Mark
22(c)	**First mark** Formation of nitronium ion (may combine equations) **(1)** $2H_2SO4 + HNO_3 \rightarrow$ $^+NO_2/NO_2^+ + H_3O^+ + 2HSO_4^-$ OR $H_2SO4 + HNO_3 \rightarrow$ $^+NO_2/NO_2^+ + H_2O + HSO4^-$ OR $H2SO4 + HNO3 \rightarrow H_2NO_3^+ + HSO_4^-$ **And** $H2NO_3^+ \rightarrow NO_2^+ + H_2O$ **Charges are needed for first mark**  TE on incorrect electrophile If benzene used instead of naphthalene **3 max** Do not penalise the use of Phthalic anhydride Correct Kekulé structures score full marks ALLOW multiple nitrations		4

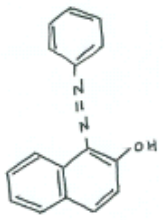
	Second mark Curly arrow from on or within the circle to (positive) N ALLOW Curly arrow from anywhere within the hexagon Arrow to **any** part of the electrophile including to the + charge (which can be anywhere on electrophile), OR Arrow to a point at least half the distance between ring and electrophile **(1)**	Curly arrow on or outside the hexagon	
	Third mark Intermediate structure including charge with horseshoe covering at least 3 carbon atoms, **and** facing the tetrahedral carbon **and** with some part of the positive charge within the horseshoe. ALLOW dotted horseshoe **(1)** IGNORE displayed nitro group even if incorrect A single lapse of omitting internal circle or double bonds in 3rd or 4th mark	Partial bonds to H or Subs group	
	Fourth mark If final product not 1, 4, 5 or 8 MP4 cannot be scored Curly arrow from C—H bond to anywhere in the ring reforming delocalised structure of a correct stable molecule. **(1)** IGNORE Absence of $HSO_4^-/H_2SO_4/H^+$	H_2 / H product	

Question Number	Correct Answer	Reject	Mark
22(d)	$C_{10}H_8$ This mark can be awarded if the molar mass of naphthalene has been used as 128 even if the skeletal formula in the equation has been used **(1)** $C_{10}H_8 + 12O_2 \rightarrow 10CO_2 + 4H_2O$ **(1)** ALLOW The balanced equation with skeletal formula of naphthalene scores both marks Ignore state symbols even if incorrect Number of moles of naphthalene $= \frac{1.28}{128} = 0.01(00)$ Volume of gas = 10 x 0.01 x 24.0 = 2.4(0) dm^3 /2400 cm^3 **(1)** ALLOW TE on incorrect formula of naphthalene for max 2		3

Question Number	Correct Answer	Reject	Mark
22(e)	Hydrogen /H_2 **(1)** **Second mark is consequential on Hydrogen** Heat/any specified temperature above 100^oC **And** nickel/ Ni /platinum/ Pt/ palladium / Pd catalyst **(1)**	H alone loses first mark but not second	2

Question Number	Correct Answer	Reject	Mark
22(f)(i)	Water/H_2O		1

Question Number	Correct Answer	Reject	Mark
22(f)(ii)	(In strong acid) an oxygen (in the C−O/C=O/O−H bond) will protonate/gain H/H^+ **(1)** (In alkali) a proton is lost from each/both phenol group(s) ALLOW (In alkali) a proton/hydrogen/ H/H^+ is lost from phenol group(s) **(1)**		2

Question Number	Correct Answer	Reject	Mark
22(g)	Phenylamine is added to a mixture of sodium nitrite/ sodium nitrate(III)/ $NaNO_2$ **and** (dilute) hydrochloric acid/ HCl/ sulfuric acid/ H_2SO_4 ALLOW nitrous acid/ HNO_2 **(1)** at 5°C/between 0 and 10°C/ at 10°C/ or less than 10 °C ALLOW ice bath ALLOW any temperature or range of temperatures within that range **(1)** (A mixture of 2-naphthol and) aqueous sodium hydroxide/alkali is added to produce a dye **(1)**  OR rings in hexagons ALLOW $C_6H_5N_2$ group at any carbon except fused carbons **(1)**	Just sodium nitrate	4

(Total for Question 22 = 20 marks)

TOTAL FOR PAPER = 90 Marks

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Write your name here

Surname	Other names

Pearson Edexcel
International Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry
Advanced
Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Wednesday 22 June 2016 – Morning
Time: 1 hour 40 minutes

Paper Reference
WCH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P46665A

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6/6/6/3/3/3/1/e2/

P 4 6 6 6 5 A 0 1 3 2

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 What are the oxidation states of vanadium in the ions shown?

	VO_2^+	VO^{2+}	VO_3^-
☒ **A**	+3	+2	+5
☒ **B**	+1	+2	−1
☒ **C**	+5	+4	+7
☒ **D**	+5	+4	+5

(Total for Question 1 = 1 mark)

2 The conditions of concentration and temperature required for the standard electrode potential of the hydrogen electrode to be exactly 0.0 V are

	Concentration	Temperature
☒ **A**	1 mol dm^{-3} $H^+(aq)$	273 K
☒ **B**	1 mol dm^{-3} $H^+(aq)$	298 K
☒ **C**	0.5 mol dm^{-3} H_2SO_4 (aq)	273 K
☒ **D**	0.5 mol dm^{-3} H_2SO_4 (aq)	298 K

(Total for Question 2 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

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3 Excess potassium iodide solution is added to acidified potassium manganate(VII) solution. The reaction taking place is

$$2MnO_4^- + 16H^+ + 10I^- \rightarrow 2Mn^{2+} + 5I_2 + 8H_2O$$

The iodine produced is titrated, with sodium thiosulfate solution in the burette.

$$2S_2O_3^{2-} + I_2 \rightarrow S_4O_6^{2-} + 2I^-$$

(a) The mole ratio of MnO_4^- to $S_2O_3^{2-}$ is

(1)

☒ **A** 1:2

☒ **B** 1:5

☒ **C** 2:5

☒ **D** 5:1

(b) The titration is carried out **without** starch indicator.

The colour change at the end point of the titration is

(1)

☒ **A** brown to yellow.

☒ **B** purple to colourless.

☒ **C** purple to brown.

☒ **D** yellow to colourless.

(Total for Question 3 = 2 marks)

Use this space for any rough working. Anything you write in this space will gain no credit.

4 Methanol can be used as the fuel in a fuel cell.

The half-equations for the reactions taking place in acidic conditions are

$$CO_2 + 6H^+ + 6e^- \rightleftharpoons CH_3OH + H_2O \qquad \text{half-equation } \mathbf{1}$$

$$\tfrac{1}{2}O_2 + 2H^+ + 2e^- \rightleftharpoons H_2O \qquad \text{half-equation } \mathbf{2}$$

The standard electrode potential of half-equation **1** is +0.02 V.

$E^{\ominus}_{cell}$ for the fuel cell is +1.21 V.

(a) The standard electrode potential of half-equation **2** is

(1)

☒ **A** +1.19 V

☒ **B** −1.19 V

☒ **C** +1.23 V

☒ **D** −1.23 V

(b) The half-equations for the reactions taking place in alkaline conditions are

$$CO_2 + 5H_2O + 6e^- \rightleftharpoons CH_3OH + 6OH^-$$

$$\tfrac{1}{2}O_2 + H_2O + 2e^- \rightleftharpoons 2OH^-$$

The value for $E^{\ominus}_{cell}$ in alkaline conditions is exactly the same as $E^{\ominus}_{cell}$ in acidic conditions. This is because the

(1)

☒ **A** acid and alkali are catalysts.

☒ **B** $E^{\ominus}$ values for the half-equations are the same.

☒ **C** temperature and pressure are the same.

☒ **D** overall reaction is the same.

(Total for Question 4 = 2 marks)

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5 What are the shapes of the complexes $[CuCl_2]^-$ and $[Pt(NH_3)_2Cl_2]$?

	$[CuCl_2]^-$	$[Pt(NH_3)_2Cl_2]$
☒ **A**	V shaped	square planar
☒ **B**	V shaped	tetrahedral
☒ **C**	linear	square planar
☒ **D**	linear	tetrahedral

(Total for Question 5 = 1 mark)

6 An aqueous solution of copper(II) sulfate, containing $[Cu(H_2O)_6]^{2+}$ ions, is reacted with solutions containing other ligands.

The most stable complex ions will be produced when the water molecules are replaced by

☒ **A** ammonia molecules.

☒ **B** chloride ions.

☒ **C** EDTA ions.

☒ **D** 1,2-diaminoethane molecules.

(Total for Question 6 = 1 mark)

7 Zinc hydroxide reacts with acids to form $[Zn(H_2O)_6]^{2+}$ ions and with alkalis to form $[Zn(OH)_4]^{2-}$ ions.

From this information, it can be deduced that zinc hydroxide is

☒ **A** only acidic.

☒ **B** only basic.

☒ **C** amphoteric.

☒ **D** not acidic, basic or amphoteric.

(Total for Question 7 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

8 Acidified sodium potassium tartrate solution was mixed with hydrogen peroxide solution in a boiling tube.

When pink cobalt(II) chloride solution was added to the mixture, there was rapid effervescence as carbon dioxide was produced and the solution turned green.

$$C_4H_4O_6^{2-} + 5H_2O_2 + 2H^+ \rightarrow 4CO_2 + 8H_2O$$

After a few seconds, the effervescence stopped and the solution turned back to pink.

From these observations it can be deduced that the cobalt(II) ions are acting as

☒ **A** a catalyst.

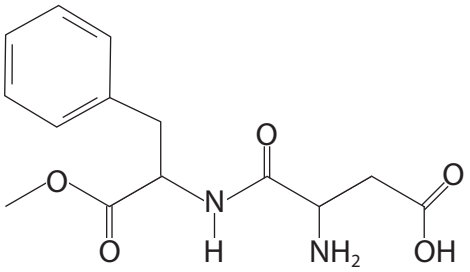
☒ **B** a dehydrating agent.

☒ **C** an oxidizing agent.

☒ **D** a reducing agent.

(Total for Question 8 = 1 mark)

9 The structure of aspartame, an artificial sweetener, is shown below.



The functional groups in a molecule of aspartame are

☒ **A** alkene, amine, carboxylic acid, ester and ketone.

☒ **B** alkene, amide, amine, carboxylic acid and ester.

☒ **C** amine, arene, carboxylic acid, ester and ketone.

☒ **D** amide, amine, arene, carboxylic acid and ester.

(Total for Question 9 = 1 mark)

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10 How many compounds are there which have a benzene ring and the structural formula $C_6H_3(NO_2)_3$?

☒ **A** 3

☒ **B** 4

☒ **C** 5

☒ **D** 6

(Total for Question 10 = 1 mark)

11 When amines dissolve in water they form

☒ **A** a neutral solution.

☒ **B** an acidic solution.

☒ **C** an alkaline solution.

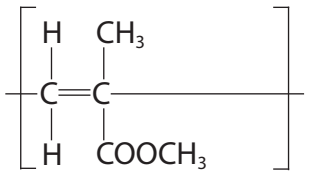
☒ **D** a zwitterion.

(Total for Question 11 = 1 mark)

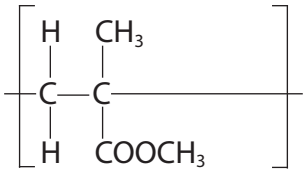
12 Methyl methacrylate has the structure $CH_2{=}C(CH_3)COOCH_3$.

The repeat unit for poly(methyl methacrylate) is

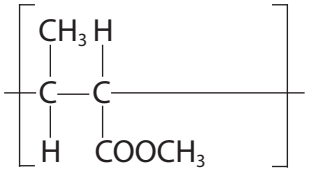
☒ **A**



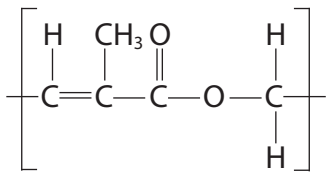
☒ **B**



☒ **C**



☒ **D**



(Total for Question 12 = 1 mark)

13 A mixture of amino acids is best separated and identified using

☒ **A** chromatography.

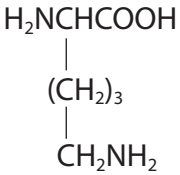
☒ **B** infrared spectroscopy.

☒ **C** mass spectrometry.

☒ **D** solvent extraction.

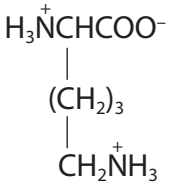
(Total for Question 13 = 1 mark)

14 Lysine is an amino acid and its structure is shown below.

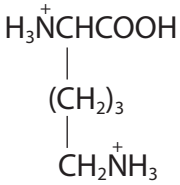


In a solution at pH 1.0, lysine will exist as

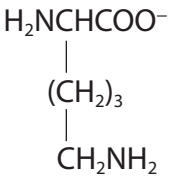
☒ **A**



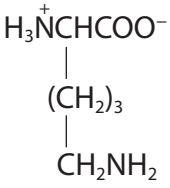
☒ **B**



☒ **C**



☒ **D**



(Total for Question 14 = 1 mark)

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15 How many different peaks due to hydrogen atoms would you expect to see in a **low** resolution proton nmr spectrum of 2,2-dimethylpropanal?

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 10

(Total for Question 15 = 1 mark)

16 One reason for using steam distillation, rather than fractional distillation, to separate a liquid from a mixture is because the liquid

☒ **A** decomposes below its boiling temperature.

☒ **B** has a boiling temperature of 100 °C.

☒ **C** is flammable.

☒ **D** is soluble in water.

(Total for Question 16 = 1 mark)

17 Complete combustion of a hydrocarbon produced 1.76 g of carbon dioxide and 0.720 g of water.

The molecular formula of a hydrocarbon which is consistent with these data is

☒ **A** C_2H_6.

☒ **B** C_3H_8.

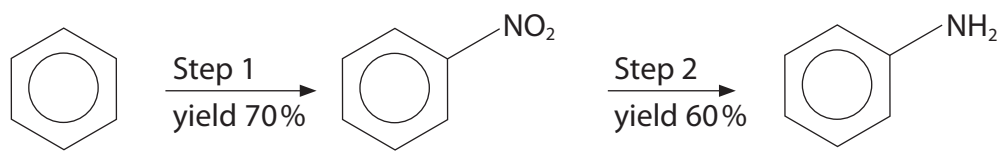
☒ **C** C_4H_8.

☒ **D** C_6H_6.

(Total for Question 17 = 1 mark)

Use this space for any rough working. Anything you write in this space will gain no credit.

18 Phenylamine can be produced from benzene by the reaction sequence below.



benzene
$M_r = 78$

phenylamine
$M_r = 93$

The mass of phenylamine, to 2 decimal places, produced from 3.90 g of benzene is

☒ **A** 1.95 g.

☒ **B** 2.79 g.

☒ **C** 3.26 g.

☒ **D** 4.65 g.

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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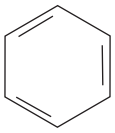
SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

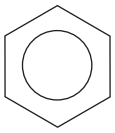
19 This question is about benzene and some of its compounds.

*(a) In 1865, Kekulé suggested that the benzene molecule was a six-membered carbon ring with alternate double and single bonds.



However, this suggestion did not fully explain the structure and stability of benzene.

State and explain **three** different types of evidence that led to this structure of benzene being rejected, in favour of benzene with a ring of delocalised electrons.



(3)

(b) Benzene reacts with a mixture of concentrated nitric acid and concentrated sulfuric acid to form nitrobenzene.

(i) Give the mechanism for this reaction, including an equation for the formation of the electrophile.

(4)

(ii) The preparation of nitrobenzene is usually carried out between 50 °C and 60 °C.

Explain why the temperature used should not be higher or lower.

(2)

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(c) Benzene reacts with pure bromine when heated under reflux in the presence of a Friedel-Crafts catalyst. Phenol reacts with bromine water at room temperature.

(i) Write the equation for the reaction between phenol and **excess** bromine water.

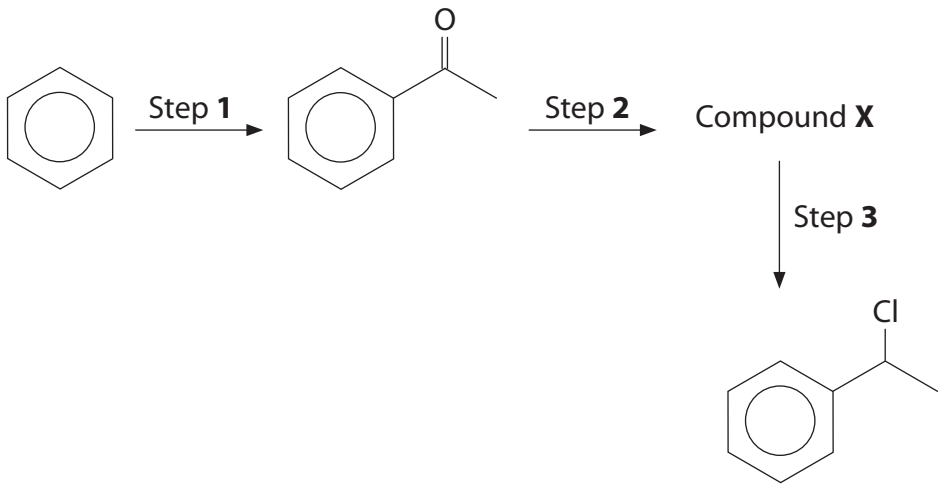
(2)

*(ii) Explain why phenol reacts with bromine under much milder conditions than those required for the reaction between benzene and bromine.

(2)

(d) 1-chloro-1-phenylethane is found in some fruits, such as apples, and is used to make fragrances.

It can be synthesised from benzene in three steps.



1-chloro-1-phenylethane

(i) Identify, by name or formula, the reagent and catalyst used in Step **1**.

(2)

.....

.....

(ii) Draw the structure for Compound **X**.

(1)

(iii) Identify, by name or formula, the reagent used in Step **2**.

(1)

.....

(iv) Identify, by name or formula, the reagent used in Step **3**.

(1)

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(Total for Question 19 = 18 marks)

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20 Manganese exists in different oxidation states which can be interconverted, using suitable oxidizing and reducing agents.

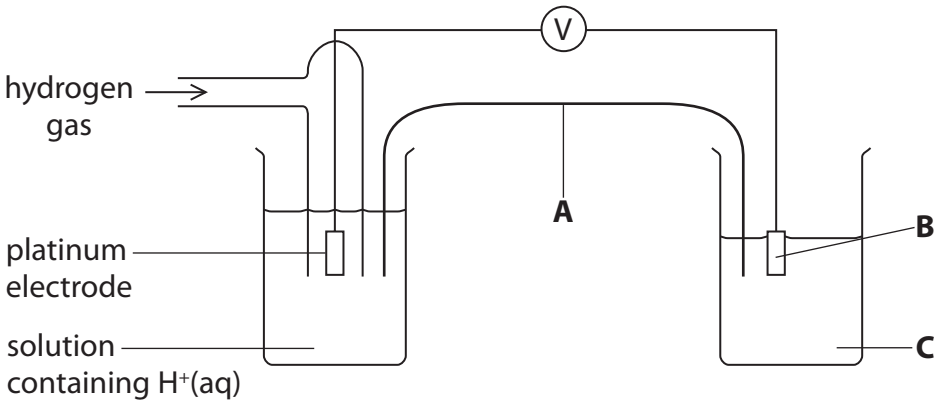
(a) Use relevant standard electrode potential values, from page 17 of the Data Booklet, to complete the table below in which two $E^{\ominus}$ values are missing.

(1)

Half-equation	$E^{\ominus}$ / V
$MnO_4^-(aq) + e^- \rightleftharpoons MnO_4^{2-}(aq)$	
$MnO_4^{2-}(aq) + 2H_2O(l) + 2e^- \rightleftharpoons MnO_2(s) + 4OH^-(aq)$	
$Mn^{3+}(aq) + e^- \rightleftharpoons Mn^{2+}(aq)$	+1.49
$MnO_4^-(aq) + 8H^+(aq) + 5e^- \rightleftharpoons Mn^{2+}(aq) + 4H_2O(l)$	+1.51
$BiO_3^-(aq) + 6H^+(aq) + 2e^- \rightleftharpoons Bi^{3+}(aq) + 3H_2O(l)$	+1.60
$Fe^{3+}(aq) + e^- \rightleftharpoons Fe^{2+}(aq)$	+0.77

(b) The apparatus below is used to measure the standard electrode potential of

$$Mn^{3+}(aq) + e^- \rightleftharpoons Mn^{2+}(aq)$$



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Identify, by name or formula, the substances needed in the salt bridge and the right-hand half-cell to measure the standard electrode potential.

The measurement is made at 298 K and 1 atm. State the other essential condition for solution **C**.

(4)

A Salt bridge containing a solution of .....

B Electrode made of .....

C Solution containing .....

Essential condition .....

(c) Manganate(VII) ions, MnO_4^-, can be made by oxidizing manganese(II) ions with bismuthate(V) ions, BiO_3^-, in acid solution.

(i) Use the information in (a) to write the overall ionic equation for this reaction. State symbols are not required.

(2)

(ii) Hence calculate $E^{\ominus}_{cell}$ for this reaction. Include a sign and units in your answer.

(1)

*(d) Iron(II) ions in solution are oxidized by the air to iron(III) ions.

The amounts of iron(II) and iron(III) ions in solution can be found by using titrations with acidified potassium manganate(VII) which only reacts with the iron(II) ions.

$$MnO_4^- + 5Fe^{2+} + 8H^+ \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

- 25.0 cm^3 portions of a solution **A**, containing a mixture of iron(II) and iron(III) ions, were acidified and titrated with potassium manganate(VII) solution of concentration 0.0195 mol dm^{-3}.
- The mean titre was 16.80 cm^3.
- About 150 cm^3 of solution **A** was reacted with excess zinc, which reduced the iron(III) ions to iron(II) ions. The excess zinc was filtered off.
- 25.0 cm^3 portions of this reduced solution, which contained iron(II) ions but no iron(III) ions were acidified and titrated with potassium manganate(VII) solution of concentration 0.0195 mol dm^{-3}.
- The mean titre was 18.20 cm^3.

Calculate the **mass** of iron(II) ions and **the mass of** iron(III) ions in 500 cm^3 of the original solution **A**.

(5)

(Total for Question 20 = 13 marks)

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21 Chromium is in the d-block of the Periodic Table and it is a transition metal.

(a) Scandium is also in the d-block of the Periodic Table but it is not a transition metal.

Explain, by giving any relevant electronic configurations, why scandium is **not** a transition metal.

(3)

(b) When a few drops of aqueous ammonia are added to an aqueous solution of chromium(III) ions, a green precipitate of chromium(III) hydroxide is formed.

Complete the ionic equation for this reaction. State symbols are not required.

(2)

$[Cr(H_2O)_6]^{3+}$ + ... NH_3 →

(c) Explain, in terms of oxidation numbers of chromium, whether or not each of these two reactions are redox.

$Cr_2O_7^{2-} + 14H^+ + 6Fe^{2+} \rightarrow 2Cr^{3+} + 7H_2O + 6Fe^{3+}$ **Reaction 1**

$2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$ **Reaction 2**

(2)

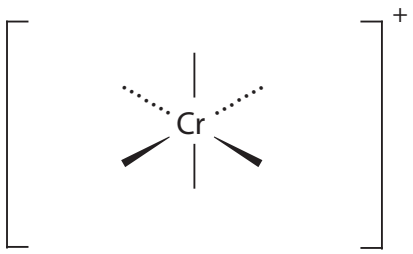
(d) Chromium(III) chloride can exist in aqueous solution as three possible complex ions with different numbers of free chloride ions.

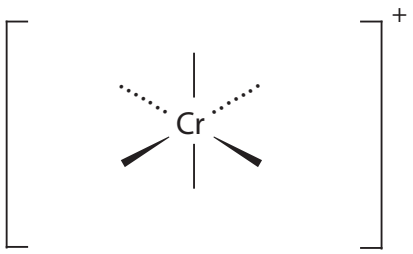
	Complex ion	Free chloride ions
X	$[Cr(H_2O)_6]^{3+}$	$3Cl^-$
Y	$[CrCl(H_2O)_5]^{2+}$	$2Cl^-$
Z	$[CrCl_2(H_2O)_4]^{+}$	Cl^-

(i) There are two possible structures for complex ion **Z**.

Complete the diagrams below to show the two possible structures for complex ion **Z**.

(2)





(ii) Name the type of bond between the ligands and the chromium(III) ion and explain how it is formed.

(2)

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(iii) The formula of the complex ion present in the solution is found by adding aqueous silver nitrate to the solution. This only reacts with the free chloride ions to form a precipitate of silver chloride.

$$Ag^+(aq) + Cl^-(aq) \rightarrow AgCl(s)$$

The precipitate is then filtered, washed, dried and weighed.

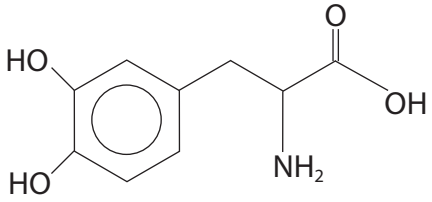
In an experiment, 0.012 mol of one of the forms of chromium(III) chloride was used and 3.44 g of silver chloride was formed.

Deduce the formula of the complex ion. You must show your working.

(3)

(Total for Question 21 = 14 marks)

22 The drug 3,4-dihydroxyphenylalanine, *L*-DOPA, is used in the treatment of Parkinson's disease.



(a) Give the molecular formula for *L*-DOPA.

(1)

.....

(b) Suggest the organic product of the reaction between *L*-DOPA and **excess** ethanoyl chloride.

(1)

(c) Give a chemical reaction and its result that can be used to show the presence of the carboxylic acid group in *L*-DOPA.

(2)

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(d) Molecules of *L*-DOPA can polymerize to form a polyamide by condensation.

Draw two repeat units of the polyamide formed from *L*-DOPA.

(2)

(Total for Question 22 = 6 marks)

TOTAL FOR SECTION B = 51 MARKS

SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

23

Coloured substances

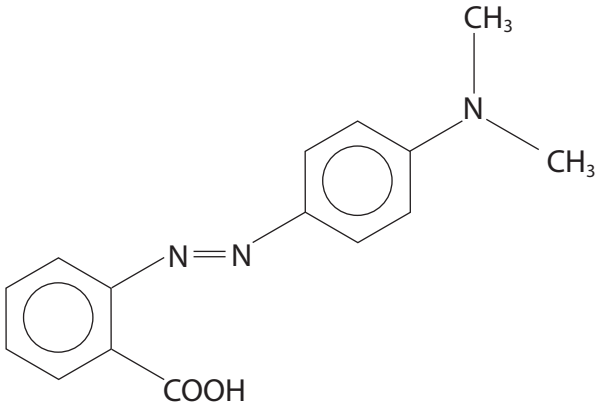
Coloured substances, both natural and synthetic, have long been of interest to the human race. For example, there are over 130 minerals that have been used as gemstones.

The corundum minerals, which include rubies and sapphires, are mainly aluminium oxide. Rubies have some of the aluminium ions replaced by chromium(III) ions and they range in colour from pink to deep red. Sapphires occur in many different colours including blue, yellow, purple, orange and green.

Diamond is an allotrope of carbon. It is the hardest naturally occurring substance. Diamonds are often colourless but the presence of nitrogen atoms in natural diamonds gives them a brown or yellow colour, whilst the presence of boron gives them a blue colour.

Dyes and pigments have been developed as colouring materials. Dyes are applied as a solution, whilst pigments are solids that are ground into a fine powder and made into a suspension with a suitable liquid.

Methyl red is an azo dye and is used as an indicator. Its structure is



Prussian Blue, $Fe_4[Fe(CN)_6]_3$, (discovered in 1704) is a deep blue colour and was one of the first synthetic pigments. It is used as a pigment in paints.

Colour can arise in many different ways; for example, the colours seen in flame tests and in transition metal compounds.

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(a) (i) Explain why complex ions containing chromium(III) ions are coloured.

(4)

(ii) Sapphires have the same type of structure as rubies.

Suggest why sapphires and rubies have different colours.

(1)

*(b) Carbon exists as diamond and graphite. Explain, in terms of structure and bonding, why diamond is much harder than graphite.

(3)

(c) (i) The standard enthalpy changes of combustion for diamond and graphite are shown below.

$$C(\text{diamond}) + O_2(g) \rightarrow CO_2(g) \quad \Delta H_c^{\ominus} = -395.4 \text{ kJ mol}^{-1}$$

$$C(\text{graphite}) + O_2(g) \rightarrow CO_2(g) \quad \Delta H_c^{\ominus} = -393.5 \text{ kJ mol}^{-1}$$

Calculate the enthalpy change for the conversion of diamond to graphite. Use your answer to draw an enthalpy level diagram for the combustion of diamond and graphite.

(2)

(ii) Explain which factor, other than enthalpy change, must be considered to show which allotrope is thermodynamically more stable.

(1)

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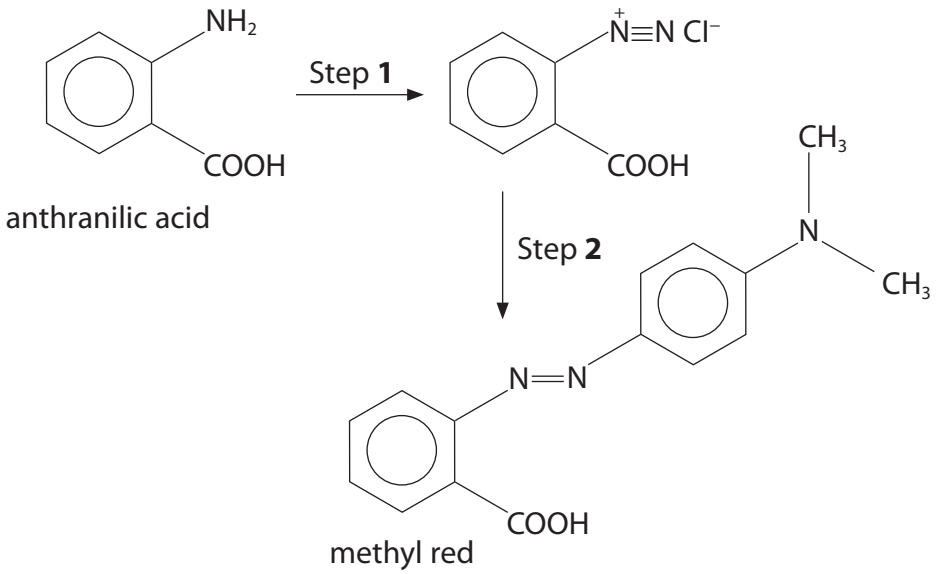
(d) The indicator methyl red, can be formed in two steps, starting from anthranilic acid.



(i) State the reagents and condition needed for Step **1**.

(2)

.....

.....

(ii) Step **2** involves a reaction which is similar to the reaction of diazonium ions with phenol. Suggest the structure of the organic compound which reacts with the diazonium ion in Step **2** to form methyl red.

(1)

(iii) Use information from page 19 of the Data Booklet to suggest the type of acid-alkali titration for which methyl red indicator would be most suitable. Justify your answer.

(2)

.....

.....

.....

.....

(e) Prussian Blue contains the $[Fe(CN)_6]^{4-}$ ion.

(i) The $[Fe(CN)_6]^{4-}$ ion is formed when aqueous potassium cyanide is added to an aqueous solution containing Fe^{2+} ions.

Write the equation and state the type of reaction taking place when $[Fe(CN)_6]^{4-}$ is formed in this way.

(2)

Type of reaction.....

(ii) State the oxidation number of the iron ions shown in bold in $\mathbf{Fe}_4[Fe(CN)_6]_3$

(1)

.....

(Total for Question 23 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 90 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

Summer 2016

Pearson Edexcel
International Advanced Level
in Chemistry (WCH05) Paper 01
General Principles of Chemistry II

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	D		**(1)**

Question Number	Correct Answer	Reject	Mark
2	B		**(1)**

Question Number	Correct Answer	Reject	Mark
3(a)	B		**(1)**

Question Number	Correct Answer	Reject	Mark
3(b)	D		**(1)**

Question Number	Correct Answer	Reject	Mark
4(a)	C		**(1)**

Question Number	Correct Answer	Reject	Mark
4(b)	D		**(1)**

Question Number	Correct Answer	Reject	Mark
5	C		**(1)**

Question Number	Correct Answer	Reject	Mark
6	C		**(1)**

Question Number	Correct Answer	Reject	Mark
7	C		**(1)**

Question Number	Correct Answer	Reject	Mark
8	A		**(1)**

Question Number	Correct Answer	Reject	Mark
9	D		**(1)**

Question Number	Correct Answer	Reject	Mark
10	A		**(1)**

Question Number	Correct Answer	Reject	Mark
11	C		**(1)**

Question Number	Correct Answer	Reject	Mark
12	B		**(1)**

Question Number	Correct Answer	Reject	Mark
13	A		**(1)**

Question Number	Correct Answer	Reject	Mark
14	B		**(1)**

Question Number	Correct Answer	Reject	Mark
15	A		**(1)**

Question Number	Correct Answer	Reject	Mark
16	A		**(1)**

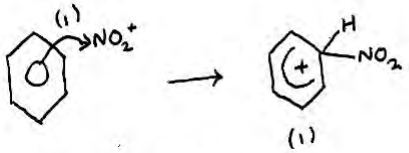
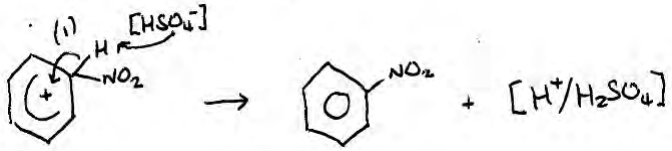
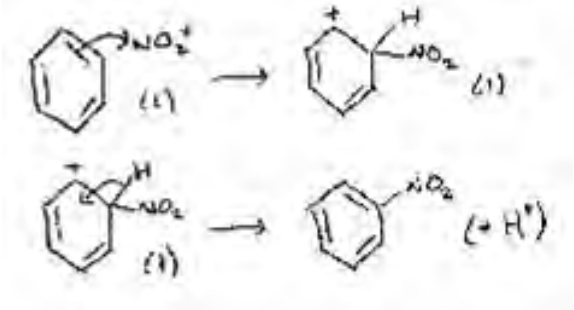
Question Number	Correct Answer	Reject	Mark
17	C		**(1)**

Question Number	Correct Answer	Reject	Mark
18	A		**(1)**

Section B

Question Number	Acceptable Answers	Reject	Mark
19*(a)	ALLOW reverse arguments for Kekule structure Any **three** points from **Type of reaction** Benzene reacts by (mostly electrophilic) substitution OR does not react by (electrophilic) addition OR Benzene does not react like alkenes / does not decolourise bromine water ALLOW Other suitable reactions / benzene needs a catalyst /halogen carrier to react with bromine **(1)** **Di-substitution** There are only 3 isomers of di-substituted compounds (not 4) OR Some di-substituted compounds are the same, e.g. 1,2 and 1,6 **(1)** **Thermochemical** Benzene's (standard) enthalpy (change) of **hydrogenation** is less exothermic than if it had (three localised C=C) double bonds / is not three times the value for three (localised C=C) double bonds ALLOW Benzene is more stable by ~150 kJ mol^{-1} OR stated enthalpies (of hydrogenation) −205 to −210 kJ mol^{-1} for benzene and −360 kJ mol^{-1} for 3 (localised C=C) double bonds OR (Standard) enthalpy (change) of combustion is less exothermic than if it had three (localised C=C) double bonds	Additional incorrect points Nucleophilic substitution Lower / just 'different' hydration Lower / just 'different' Just "less"	**(3)**

	ALLOW (Standard) enthalpy (change) of formation of benzene is less endothermic than that of "cyclohexa-1,3,5-triene" **(1)** IGNORE Just 'thermodynamically more stable' **X-ray diffraction** – does not need to be mentioned The C-C bond lengths in benzene are mid-way between that of a single bond and a double bond / are all the same length OR Benzene is a regular hexagon (and Kekule structure is not) **(1)** IGNORE Bond angles are the same **Infrared** The infrared spectrum for benzene has a peak for an aromatic C=C at a different wavenumber / absorption / frequency to an alkene C=C OR Benzene has peaks at 1600, 1580, 1500, 1450 (cm−1) rather than 1669 – 1645 (cm−1) ALLOW Benzene has no peak for alkene C=C / 1669 – 1645 (cm−1) **(1)** IGNORE different C-H absorptions / just 'different peaks to alkenes' IGNORE References to NMR **Electron density map** Benzene shows an even spread of electrons **(1)**	C-H bond	

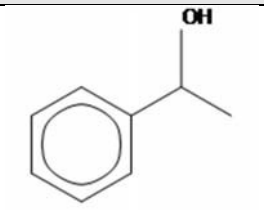
Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	$H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_2O + HSO_4^-$ OR $H_2SO_4 + HNO_3 \rightarrow H_2NO_3^+ + HSO_4^-$ **and** $H_2NO_3^+ \rightarrow NO_2^+ + H_2O$ OR $2H_2SO_4 + HNO_3 \rightarrow NO_2^+ + H_3O^+ + 2HSO_4^-$ IGNORE state symbols, even if incorrect **(1)**   Curly arrow from on or within the circle to N of NO_2^+ ALLOW curly arrow from anywhere **within** the hexagon ALLOW curly arrow towards any part of the NO_2^+, including to the + charge **(1)** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms **and** facing the tetrahedral carbon **and** some part of the positive charge must be within the horseshoe **(1)** Curly arrow from C-H bond to anywhere in the hexagon reforming the delocalised structure **(1)** Correct Kekulé structures score full marks 	Half arrow heads Curly arrow on or outside the hexagon Dotted bonds to H and NO2 unless as part of a 3D structure Curly arrow from H	**(4)**

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	Higher temperature causes multiple substitution of NO_2 groups / formation of dinitrobenzene / formation of trinitrobenzene ALLOW further nitration / substitution **(1)** IGNORE decomposition of benzene / nitrobenzene / addition of NO_2 groups At lower temperature reaction is (too) slow **(1)** IGNORE References to activation energy / reaction does not occur at low temperature	Different isomers of nitrobenzene	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	 Formula of organic product **(1)** Rest of equation correct **(1)** ALLOW Br on any 3 carbon atoms ALLOW $C_6H_5OH + 3Br_2 \rightarrow C_6H_2(OH)Br_3 + 3HBr$ for both marks, allow $C_6H_2(Br_3)OH$, ignore missing brackets ALLOW correct balanced equations to form mono or di substituted product for 1 mark ALLOW Kekulé structures IGNORE position of bond to OH if vertically above or below the ring / name of product / state symbol	OH-C of benzene on lhs or rhs	**(2)**

Question Number	Acceptable Answers	Reject	Mark
***19(c)(ii)**	**MP1** **Lone pair of electrons on oxygen** (may be shown on a diagram) **and** EITHER Overlaps with pi cloud /delocalised electrons / delocalised system OR Feeds into / donates into / interacts with (benzene) ring /delocalised electrons / delocalised system OR Increases the electron density of the (benzene) ring **(1)** **MP2** (Increased electron density) makes the ring more susceptible to electrophilic attack ALLOW phenol is a better nucleophile **(1)**	More electro-negative	**2**

Question Number	Acceptable Answers	Reject	Mark
19(d)(i)	If name and formula are given, both must be correct Ethanoyl chloride / CH_3COCl **(1)** aluminium chloride / $AlCl_3$ / iron(III) chloride / $FeCl_3$ Conditional on correct reagent or a 'near miss' eg acyl chloride ALLOW corresponding bromides **(1)** NOTE Reagent and catalyst in either order and they do not need to state which they are IGNORE Friedel-Crafts catalyst / Lewis acid catalyst / any solvent mentioned	Just aluminium or iron Additional reagents	**(2)**

Question Number	Acceptable Answers	Reject	Mark
19(d)(ii)	 ALLOW skeletal **/** displayed / structural formulae or any combination of these e.g. $C_6H_5CH(OH)CH_3$		**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(d)(iii)	If name and formula are given both must be correct Lithium aluminium hydride / $LiAlH_4$ / lithium tetrahydridoaluminate((III)) / sodium borohydride / sodium tetrahydridoborate / $NaBH_4$ IGNORE solvents / temperature, even if incorrect	Hydrogen with or without any catalyst Water, if $LiAlH_4$	**(1)**

Question Number	Acceptable Answers	Reject	Mark
19(d)(iv)	If name and formula are given, both must be correct Phosphorus(V) chloride / phosphorus pentachloride / PCl_5 / phosphorus(III) chloride / phosphorus trichloride / PCl_3 / phosphorus and chlorine / P and Cl_2 thionyl chloride /$SOCl_2$ / conc hydrochloric acid / HCl **and** zinc chloride / $ZnCl_2$ / zinc / Zn No TE on 19(d)(ii)	Just (Conc.) hydrochloric acid / HCl	**(1)**

(Total for Question 19 =18 marks)

Question Number	Acceptable Answers		Reject	Mark
20(a)	$MnO_4^-(aq) + e^- \rightleftharpoons MnO_4^{2-}(aq)$	+0.56	Missing +	**(1)**
	$MnO_4^{2-}(aq) + 2H_2O(l) + 2e^- \rightleftharpoons MnO_2(s) + 4OH^-(aq)$	+0.59		
	Both correct for the mark			

Question Number	Acceptable Answers	Reject	Mark
20(b)	If name and formula are given, both must be correct **A** (Salt bridge containing a solution of) potassium nitrate / KNO_3 ALLOW potassium chloride / KCl / sodium chloride / NaCl /sodium nitrate / $NaNO_3$ **(1)** **B** (Electrode made of) platinum /Pt **(1)** **C** (Solution containing) manganese(II) **and** manganese(III) ions /Mn^{2+} **and** Mn^{3+} ions ALLOW Soluble salts of manganese(II) and manganese(III) ions **(1)** (Essential condition) **stand alone mark** 1 mol dm^{-3} ALLOW this if written in **C** ALLOW '1 molar' / 1M / equal concentrations of Mn^{2+} **and** Mn^{3+} / manganese(II) **and** manganese(III) ions **(1)** IGNORE any temperature or pressure	KI NaI Incorrect unit eg mol dm^3	**(4)**

Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	$2Mn^{2+} + 5BiO_3^- + 14H^+ \rightarrow 2MnO_4^- + 5Bi^{3+} + 7H_2O$ All correct formulae on both sides ALLOW ⇌ **(1)** Balancing correct formulae Conditional on all formulae correct ALLOW multiples **(1)** IGNORE state symbols, even if incorrect IGNORE other equations as working before final equation IGNORE electrons left in if they have been crossed through **Note:** Balanced equation with uncancelled electrons or uncancelled H^+ ions / H_2O scores **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	(E^o_{cell} = 1.60 – 1.51 =) +0.09 V Sign, value and unit required TE on incorrect starting oxidation state of manganese For Mn^{2+} to Mn^{3+} (E^o_{cell} = 1.60 – 1.49 =) +0.11 V For MnO_2 to MnO_4^{2-} (E^o_{cell} = 1.60 – 0.59 =) +1.01 V For MnO_4^{2-} to MnO_4^- (E^o_{cell} = 1.60 – 0.56 =) +1.04 V	+0.1 V	**(1)**

Question Number	Acceptable Answers	Reject	Mark
20*(d)	NOTE This calculation involves 8 individual mathematical operations (see 1 to 8 below), 4 on each titration and an additional subtraction. The first mark is awarded for the first operation finding the number of moles of Fe^{2+} ions from one of the titrations. The second mark is awarded after three further operations and then each subsequent mark for every other operation. The subtractions scores 1 mark on its own. One possible suggested solution is as follows For the original solution of **A** 1. Moles of MnO_4^- which reacts with 25 cm^3 of original solution **A** $= \frac{16.80 \times 0.0195}{1000}$ $= 3.276 \times 10^{-4}$ (mol) **(1)** 2. Moles of Fe^{2+} in original solution = Answer to 1 x 5 $= 1.638 \times 10^{-3}$ (mol) AND 3. Moles of Fe^{2+} in 500 cm^3 of original solution **A** = Answer to 2 x 20 $= 3.276 \times 10^{-2}$ (mol) AND 4. Mass of Fe2+ in 500 cm^3 of original solution **A** = Answer to 3 x 55.8 = 1.828 (g) **(1)** ALLOW The three operations (x 5, x 20 and x 55.8) in any order. A_r Fe = 56 (instead of 55.8)		**(5)**

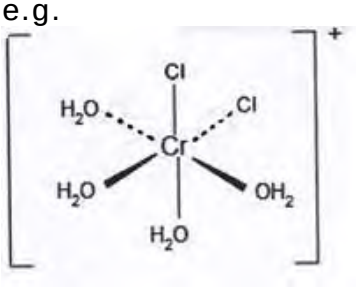
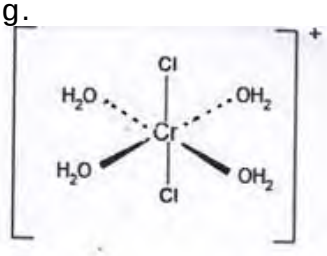
	For the fully reduced solution of **A** 5. Moles of MnO_4^- which reacts with 25 cm^3 of reduced solution $= \frac{18.20 \times 0.0195}{1000}$ = 3.549 x 10-4 (mol) AND 6. Moles of Fe^{2+} in the fully reduced solution **A** = Answer to 1 x 5 = 1.7745 x 10-3 (mol) **(1)** 7. Moles of Fe^{2+} in 500 cm3 of the fully reduced solution **A** = Answer to 6 x 20 = 3.549 x 10-2 (mol) AND 8. Mass of Fe^{2+} in 500 cm^3 of reduced solution Y = Answer to 7 x 55.8 = 1.980342 (g) **(1)** Mass of Fe^{3+} in original solution = Answer to 8 - Answer to 7 = 0.15288 (g) **(1)** ALLOW The three operations (x 5, x 20 and x 55.8) in any order. A_r Fe = 56 (instead of 55.8) ALLOW other methods IGNORE SF except 1SF		**(5)**

(Total for Question 20 = 13 marks)

Question Number	Acceptable Answers	Reject	Mark
21(a)	Transition metals form at least one **ion** with an incomplete **d**-subshell / partially filled d orbital(s) ALLOW forms an **ion** with unpaired **d** electron(s) OR Scandium **only** forms an **ion** with an empty **d**-subshell / all **d** orbital**s** are empty OR Scandium does not form an **ion** with an incomplete **d**-subshell / partially filled d orbital(s) **(1)** Scandium (only) forms Sc^{3+} ALLOW Sc only has one oxidation state (in compounds) **(1)** Sc^{3+} is [Ar] OR Sc is $[Ar]3d^1 4s^2$ / $[Ar]4s^2 3d^1$ **and** loses all three outer electrons ALLOW [Ar] written out as $1s^2 2s^2 2p^6 3s^2 3p^6$ **(1)**	d shell sub-shell / orbital other than 3d	**(3)**

Question Number	Acceptable Answers	Reject	Mark
21(b)	$[Cr(H_2O)_6]^{3+}$ + **3**NH_3 → $Cr(OH)_3$ + $3H_2O$ + $3NH_4^+$ OR $[Cr(H_2O)_6]^{3+}$ + **3**NH_3 → $[Cr(OH)_3(H2O)_3]$ + $3NH_4^+$ Correct formula of chromium(III) hydroxide ALLOW $[Cr(H_2O)_3(OH)_3]$ **(1)** IGNORE square brackets Rest of equation and balancing Conditional on correct formula of chromium(III) hydroxide **(1)** IGNORE state symbols even if incorrect	Any equation where NH_3 replaces water ligands	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(c)	ALLOW oxidation numbers written by formulae in equations **First mark** **Reaction 1** is a redox reaction as chromium decreases / changes in oxidation number from (+)6 / VI to (+)3 / III **(1)** **Second mark** **Reaction 2** is not a redox reaction as chromium has oxidation number (+)6(+) / VI in CrO_4^{2-} and $Cr_2O_7^{2-}$ / reactant and product / both species **(1)** IGNORE change in oxidation number of iron		**(2)**

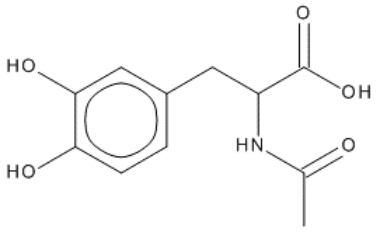
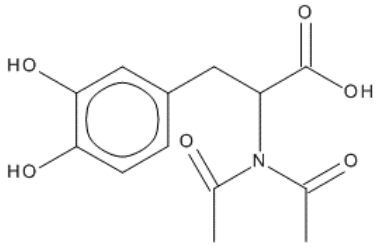
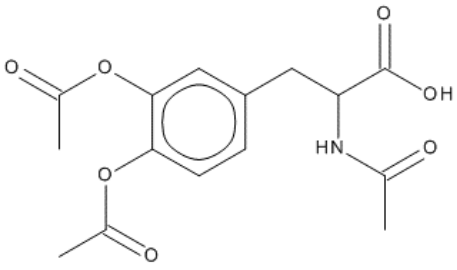
Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	In both complexes: IGNORE charges on ions (Cl^- or Cr^{3+}) inside the brackets IGNORE exact position of dative bond from the water Any complex ion showing the two chloride ligands in the 'cis' positions where Cl-Cr-Cl bond angle is 90° e.g.  **(1)** Any complex ion showing the two chloride ligands in the 'trans' positions where Cl-Cr-Cl bond angle is 180° e.g.  **(1)** ALLOW for one mark two diagrams with correct chlorine, but no water OR two diagrams with correct water, but no chlorines ALLOW for one mark two diagrams with Cl_2 instead of Cl		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(d)(ii)	dative(covalent) ALLOW co-ordinate (covalent/ bonding) **(1)** (formed from) the lone pair (of electrons) on the oxygen / chloride ion / ligand / water (to the chromium ion) **(1)** ALLOW "pair of electrons" for "lone pair" IGNORE element / molecule / atom		**2**

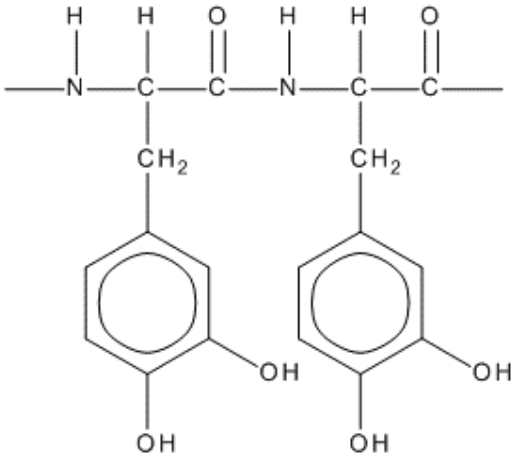
Question Number	Acceptable Answers	Reject	Mark
21(d)(iii)	Working is essential mol of AgCl = 3.44/143.4 = 0.023989 **(1)** ratio Cr^{3+} : (free Cl^{-}) (= 0.012: 0.023989) = 1 : 2 ALLOW this written in words **(1)** so, $[CrCl(H2O)5]^{2+}$ / (ion) **Y** (is formed) **(1)** ALLOW structure of **Y** drawn IGNORE SF except 1SF ALLOW for two marks **Y** if 178.8 used for M_r **X** if 107.8 / 82.5 used for M_r If no other mark is awarded: ALLOW 1 mark for just $[CrCl(H_2O)_5]^{2+}$ / (ion) **Y** (is formed)	No TE on incorrect moles	**3**

(Total for Question 21 = 14 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)	$C_9H_{11}NO_4$ ALLOW any order eg $C_9H_{11}O_4N$ IGNORE any additional structural formulae as working		**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(b)	Must have N linked to CH_3CO  OR  OR CH_3CO linked to N and Os on benzene ring e.g.  ALLOW any combination of skeletal, displayed or structural formulae IGNORE bond angles	Ethanoyl group joined to COOH group to form an anhydride	**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(c)	In each pair, the observation is conditional on a correct or 'near miss' reagent Any matching pair from: Sodium carbonate / Na_2CO_3 / sodium hydrogencarbonate / $NaHCO_3$ ALLOW other (metal) carbonates **(1)** Effervescence/ fizzing/ bubbles Gas turns lime-water cloudy **(1)** IGNORE "gas given off" OR Add ethanol/ alcohol **and** H_2SO_4/ strong acid **(1)** Fruity smell/ pear drops / "glue smell" **(1)** ALLOW 1 mark for sodium/ Na **and** fizzing ALLOW 1 mark for phosphorus(V) chloride/PCl_5 **and** steamy white fumes IGNORE equations, even if incorrect IGNORE indicators	Incorrect formulae Additional incorrect tests Incorrect gas eg hydrogen	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(d)	 amide group (CONH) **(1)** extension bonds (can be solid or dotted) **and** rest of structure correct with OH groups on carbon atoms 3 and 4 relative to the CH_2 **(1)** ALLOW any combination of displayed/ skeletal / structural formulae ALLOW Kekulé structures IGNORE bond angles / brackets and n	Additional O in amide group One repeat unit / more than 2 repeat units	**(2)**

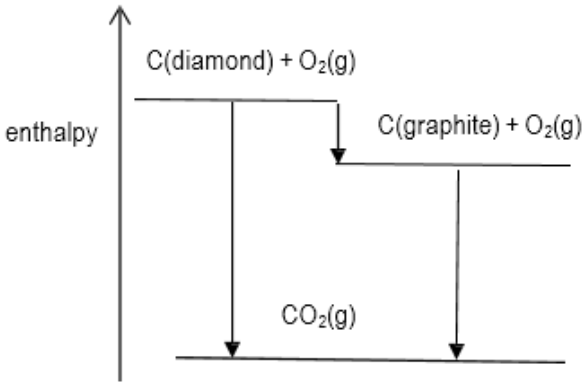
(Total for Question 22 = 6 marks)

Section C

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	**First mark** d-subshell splits / d-orbital**s** split (in energy) / d energy level(s) split(s) (by the ligands) **(1)** **Second mark** Electron(s) promoted / excited (from lower) to higher energy levels / electron(s) move (from lower) to higher energy d orbitals ALLOW d-d transitions **(1)** **Third mark** Absorbing photons / energy of a certain frequency (in visible region) ALLOW absorbing light **(1)** **Fourth mark** Transmitted / remaining light is coloured ALLOW complementary colour is seen ALLOW reflected / transmitted / remaining light is seen **(1)** IGNORE "opposite" colour / reference to electrons relaxing / dropping to the ground state	Penalise omission of (3)d once only. d-**orbital**/d-**shell** splits d-d splitting Just 'absorbing photons/energy' Emitted	**(4)**

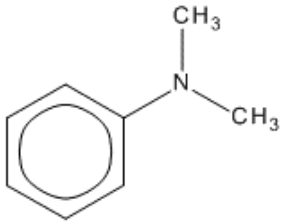
Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	Sapphires / rubies / they contain different (metal) ions OR Electron transfer between different metal ions OR The colour is caused by charge transfer ALLOW some of the aluminium ions / Al^{3+} have been replaced by chromium(III) ions / Cr^{3+} ALLOW d-orbitals are split with a different energy gap ALLOW different number of electrons in d- subshell ALLOW different oxidation states (of chromium) have different colours IGNORE Different ligands	Different oxidation states of aluminium	**(1)**

Question Number	Acceptable Answers	Reject	Mark
***23(b)**	**First mark** – diamond In diamond each carbon atom is **covalently** bonded to four other carbon atoms (in 3 dimensions) ALLOW diamond exists as a giant covalent structure with a tetrahedral arrangement **(1)** Second mark - graphite Graphite has London / dispersion / van der Waals' forces **between the layers** **(1)** Third mark - comparison The (covalent) bonds in diamond are stronger than the (London / dispersion / van der Waals' / (intermolecular) forces in graphite OR Reverse argument **(1)** ALLOW these marks on labelled diagrams	Ionic / metallic bonding / any intermolecular forces Hydrogen bonding London forces in diamond	**(3)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	ΔH_r C(diamond) → C(graphite) +O2(g) +O2(g) -395.4 -393.5 CO2(g) $\Delta H = -395.4 - (-393.5)$ $= -1.9$ (kJ mol^{-1}) ALLOW O2(g) missing from cycle Correct answer, with or without cycle **(1)** Diagram must be consistent with sign in calculation One enthalpy level diagram  Both combustions to CO2 **and** graphite below diamond **(1)** IGNORE missing enthalpy label and axis / O_2 / state symbols IGNORE activation energy curve	-2 (kJ mol^{-1}) Incorrect units Two energy diagrams	**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(ii)	ΔS_{system} needed to give ΔS_{total} (which must be positive) ALLOW ΔS_{system} and ΔS_{total} needed ALLOW If ΔS_{total} is positive, reaction is (thermodynamically) feasible IGNORE references to activation energy / kinetic inertness		**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	sodium nitrite / sodium nitrate(III) / $NaNO_2$ **and** hydrochloric acid / HCl / sulfuric acid / H_2SO_4 ALLOW nitrous acid / HNO_2 (and hydrochloric acid / HCl) **(1)** IGNORE concentration of hydrochloric acid at 5 ^{o}C/ between 0 and 10 ^{o}C. Conditional on correct or 'near miss' reagents ALLOW any temperature or range of temperatures within range /ice bath / less than 5/10°C **(1)**	Just sodium nitrate HNO_3 Incorrect formula with correct name or vice versa Conc H_2SO_4	**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	 ALLOW skeletal formula	Missing 'ring' Structure including OH	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(iii)	**Note** First mark can only be awarded if there is a partial justification Strong acid-weak alkali ALLOW strong acid-strong alkali / named suitable acids and alkalis e.g. hydrochloric acid and (aqueous) ammonia ALLOW base for alkali **(1)** Conditional on M1 pK_{in} (for methyl red) is 5.1 / pH range (for methyl red) is 4.2-6.3 **and** this lies (wholly) within the vertical part of the titration curve ALLOW pH at the end / equivalence point corresponds with the pH range (for methyl red) ALLOW pK_{in} corresponds with the pH at the equivalence /end point (of the titration) / is in the middle of the vertical part of the titration curve ALLOW Indicator changes colour (entirely) within vertical part of the titration curve **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(e)(i)	$[Fe(H_2O)_6]^{2+} + 6CN^- \rightarrow [Fe(CN)_6]^{4-} + 6H_2O$ OR $[Fe(H_2O)_6]^{2+} + 6KCN \rightarrow [Fe(CN)_6]^{4-} + 6K^+ + 6H_2O$ OR $[Fe(H_2O)_6]^{2+} + 6KCN \rightarrow K_4[Fe(CN)_6] + 2K^+ + 6H_2O$ OR $Fe^{2+} + 6CN^- \rightarrow [Fe(CN)_6]^{4-}$ OR $Fe^{2+} + 6KCN \rightarrow K_4[Fe(CN)_6] + 2K^+$ **(1)** IGNORE missing square brackets on complexes / state symbols Ligand exchange / ligand substitution / ligand replacement **(1)** Mark independently		**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(e)(ii)	(+)3 / 3+ / III / iron(III) ALLOW Fe^{3+}		**(1)**

(Total for Question 23 = 19 marks)

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Chemistry

Advanced

Unit 5: General Principles of Chemistry II – Transition Metals and Organic Nitrogen Chemistry (including synoptic assessment)

Wednesday 22 June 2016 – Morning
Time: 1 hour 40 minutes

Paper Reference
6CH05/01

You must have: Data Booklet

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 90.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P46661A

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3/6/6/3/5/5/e2

P 4 6 6 6 1 A 0 1 3 2

PEARSON

SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which of the following gives the oxidation states of manganese in the ions shown?

		MnO_4^{2-}	MnO_3^-
☒	**A**	+7	+6
☒	**B**	+6	+5
☒	**C**	+7	+5
☒	**D**	+6	+6

(Total for Question 1 = 1 mark)

2 Which of the following gives the electrodes and electrolyte that are used in an alkaline hydrogen fuel cell?

		Electrodes	Electrolyte
☒	**A**	graphite	potassium hydroxide solution
☒	**B**	graphite	water with a little salt
☒	**C**	platinum	potassium hydroxide solution
☒	**D**	platinum	water with a little salt

(Total for Question 2 = 1 mark)

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3 Which of the following **cannot** be used to detect alcohol in a breathalyser test?

☒ **A** Fractional distillation

☒ **B** Fuel cell

☒ **C** Infrared spectroscopy

☒ **D** Reduction of dichromate(VI) ions

(Total for Question 3 = 1 mark)

4 A titration using potassium manganate(VII) in dilute sulfuric acid can be used to determine the percentage of

☒ **A** aspirin in aspirin tablets.

☒ **B** chlorine in bleach.

☒ **C** copper in an alloy.

☒ **D** iron(II) sulfate in iron tablets.

(Total for Question 4 = 1 mark)

5 Which of the following gives the electronic configurations for a chromium atom and a chromium(II) ion?

		Cr	Cr^{2+}
☒	**A**	$[Ar]3d^4 4s^2$	$[Ar]3d^4$
☒	**B**	$[Ar]3d^5 4s^1$	$[Ar]3d^4$
☒	**C**	$[Ar]3d^4 4s^2$	$[Ar]3d^2 4s^2$
☒	**D**	$[Ar]3d^5 4s^1$	$[Ar]3d^3 4s^1$

(Total for Question 5 = 1 mark)

6 Aqueous sodium hydroxide and aqueous ammonia are added to separate solutions of the same metal ion. The observations are shown in the table below.

Reagent added	A few drops	Excess
NaOH(aq)	green precipitate	green precipitate remains
NH_3(aq)	green precipitate	green precipitate dissolves to form a blue solution

The metal ion is

☒ **A** Cr^{3+}(aq).

☒ **B** Fe^{2+}(aq).

☒ **C** Fe^{3+}(aq).

☒ **D** Ni^{2+}(aq).

(Total for Question 6 = 1 mark)

7 The reaction between cerium(IV) ions and thallium(I) ions is very slow.

$$2Ce^{4+}(aq) + Tl^{+}(aq) \rightarrow 2Ce^{3+}(aq) + Tl^{3+}(aq)$$

Which of these ions could catalyse this reaction?

☒ **A** Al^{3+}

☒ **B** Fe^{3+}

☒ **C** Na^{+}

☒ **D** Zn^{2+}

(Total for Question 7 = 1 mark)

8 Which of these hydroxides is amphoteric?

☒ **A** $Cu(OH)_2$

☒ **B** $Mg(OH)_2$

☒ **C** $Ni(OH)_2$

☒ **D** $Zn(OH)_2$

(Total for Question 8 = 1 mark)

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9 During a titration between acidified manganate(VII) ions and sulfate(IV) ions, the manganate(VII) ions are reduced to manganese(II) ions and the sulfate(IV) ions are oxidized to sulfate(VI) ions.

The mole ratio of manganate(VII) ions to sulfate(IV) ions in this reaction is

☒ **A** 5:2

☒ **B** 7:4

☒ **C** 2:5

☒ **D** 4:7

(Total for Question 9 = 1 mark)

10 The total number of compounds with the structural formula $C_6H_3CH_3(NO_2)_2$, which contain a benzene ring, is

☒ **A** four.

☒ **B** five.

☒ **C** six.

☒ **D** seven.

(Total for Question 10 = 1 mark)

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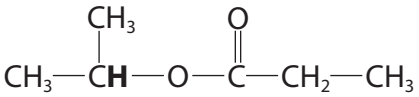
11 This question is about the ester shown below.



(a) The number of peaks seen in the **low** resolution proton nmr spectrum of this ester is

(1)

☒ **A** two.

☒ **B** three.

☒ **C** four.

☒ **D** five.

(b) The peak in the **high** resolution proton nmr spectrum corresponding to the proton in **bold** on the structure above will

(1)

☒ **A** not be split.

☒ **B** be split into three peaks.

☒ **C** be split into four peaks.

☒ **D** be split into seven peaks.

(Total for Question 11 = 2 marks)

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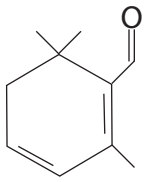
12 Safranal is one of the substances that contributes to the aroma of saffron.



Separate samples of safranal were tested with bromine water, 2,4-dinitrophenylhydrazine and Fehling's solution.

What are the final observations when safranal is tested with each of those reagents?

	Bromine water	2,4-dinitrophenylhydrazine	Fehling's solution
☒ **A**	orange solution	orange solution	red precipitate
☒ **B**	colourless solution	orange precipitate	red precipitate
☒ **C**	orange solution	orange solution	blue solution
☒ **D**	colourless solution	orange precipitate	blue solution

(Total for Question 12 = 1 mark)

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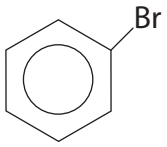
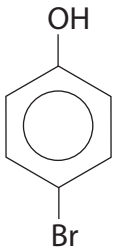
13 The structure of the organic product of the reaction between phenol and excess bromine water is

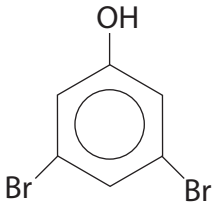
☒ **A**



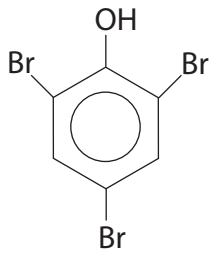
☒ **B**



☒ **C**



☒ **D**



(Total for Question 13 = 1 mark)

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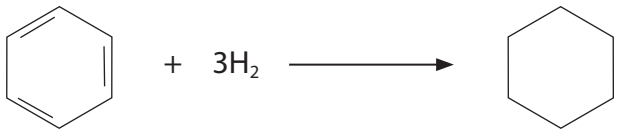
14 If it is assumed that the structure of benzene has three localised double bonds (structure **X**), the calculated standard enthalpy change of hydrogenation is -360 kJ mol^{-1}.



structure **X**

The actual standard enthalpy change of hydrogenation of benzene is -208 kJ mol^{-1}.

From these data, it can be deduced that the

- ☒ **A** actual benzene structure is kinetically more stable than structure **X** as it requires a high activation energy to react.
- ☒ **B** actual benzene structure is thermodynamically more stable than structure **X** as it has a lower enthalpy content.
- ☒ **C** structure **X** is kinetically unstable as it undergoes addition reactions at room temperature.
- ☒ **D** structure **X** is thermodynamically more stable than the actual benzene structure as the standard enthalpy change of hydrogenation is more exothermic.

(Total for Question 14 = 1 mark)

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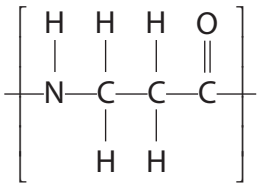
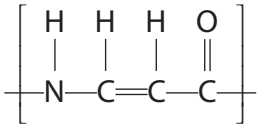
15 The repeat unit for poly(propenamide) is

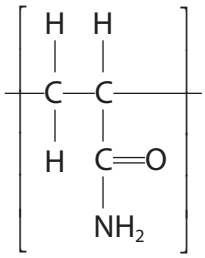
☒ **A**



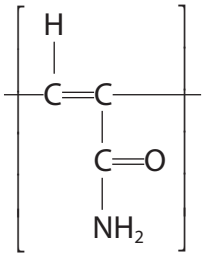
☒ **B**



☒ **C**



☒ **D**



(Total for Question 15 = 1 mark)

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16 The structures of three amino acids are shown in the table.

Amino acid	Structure
cysteine	$HSCH_2CH(NH_2)COOH$
glycine	H_2NCH_2COOH
threonine	$CH_3CH(OH)CH(NH_2)COOH$

The tripeptide glycine-cysteine-threonine is

☒ **A** $H_2NCH_2CONHCH(CH(OH)CH_3)CONHCH(CH_2SH)COOH$

☒ **B** $H_2NCH_2CONHCH(CH_2SH)CONHCH(CH(OH)CH_3)COOH$

☒ **C** $H_2NCH(CH(OH)CH_3)CONHCH(CH_3SH)CONHCH_2COOH$

☒ **D** $H_2NCH(CH_2SH)CONHCH_2\ CONHCH(CH(OH)CH_3)COOH$

(Total for Question 16 = 1 mark)

17 The amino acid alanine, $H_2NCH(CH_3)COOH$, exists as a solid at room temperature.

The most important reason for this is that it

☒ **A** exists as a zwitterion.

☒ **B** forms hydrogen bonds.

☒ **C** is amphoteric.

☒ **D** has strong London forces.

(Total for Question 17 = 1 mark)

18 Complete combustion of a hydrocarbon produced 0.66 g of carbon dioxide and 0.225 g of water.

Which of the following molecular formulae is consistent with these data?

☒ **A** C_3H_6.

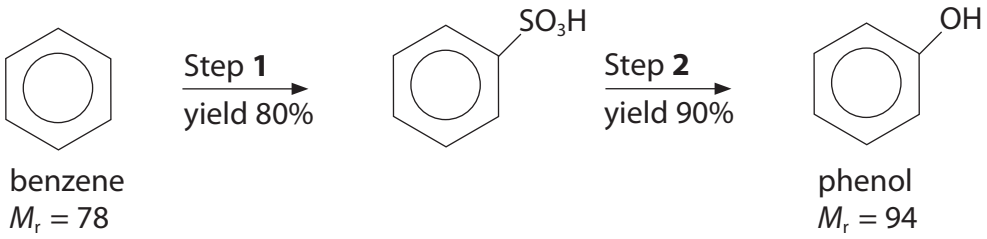
☒ **B** C_3H_8.

☒ **C** C_6H_6.

☒ **D** C_6H_{10}.

(Total for Question 18 = 1 mark)

19 Phenol can be produced from benzene as shown in the reaction sequence below.



benzene
$M_r = 78$

phenol
$M_r = 94$

The mass of phenol, to 2 decimal places, produced from 3.90 g of benzene is

☒ **A** 3.38 g.

☒ **B** 3.76 g.

☒ **C** 4.23 g.

☒ **D** 4.70 g.

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

20 Vanadium exists in different oxidation states which can be interconverted using suitable oxidising and reducing agents.

(a) Use relevant standard electrode potential values, on page 14 of the Data Booklet, to complete the table below in which two $E^{\ominus}$ values are missing.

(1)

Half-equation	$E^{\ominus}$ / V
$V^{2+}(aq) + 2e^- \rightleftharpoons V(s)$	
$V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$	
$VO^{2+}(aq) + 2H^+(aq) + e^- \rightleftharpoons V^{3+}(aq) + H_2O(l)$	+0.34
$I_2(aq) + 2e^- \rightleftharpoons 2I^-(aq)$	+0.54
$VO_2^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l)$	+1.00

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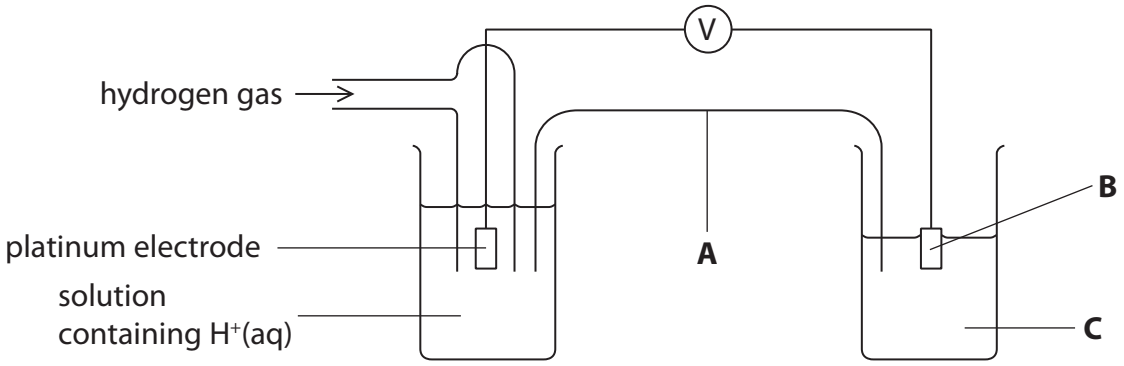
(b) The standard electrode potential of $V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$ is measured using the apparatus below.



(i) Identify, by name or formula, the substances needed in the salt bridge and the right-hand half-cell to measure the standard electrode potential.

(3)

A Salt bridge containing a solution of

.....

B Electrode made of

.....

C Solution containing

.....

(ii) State the **three** standard conditions needed for this measurement.

(2)

1 .....

2 .....

3 .....

*(c) A solution containing iodide ions, I^-, was added to an acidified solution containing vanadium(V) ions, VO_2^+.

Predict the oxidation state of the vanadium ions left at the end of the reaction. Justify your prediction by calculating the $E_{cell}^{\ominus}$ for any relevant reaction(s).

Write the ionic equation for any reaction(s) occurring. State symbols are not required.

(5)

(Total for Question 20 = 11 marks)

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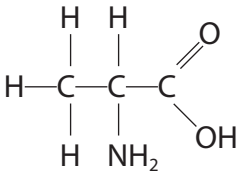
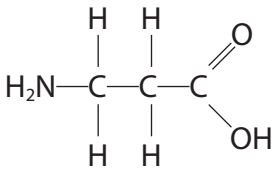
21 (a) The structures of 2-aminopropanoic acid and 3-aminopropanoic acid are shown.



2-aminopropanoic acid



3-aminopropanoic acid

(i) Explain how the **low** resolution proton nmr spectra of these two amino acids differ.

(2)

.....

.....

.....

.....

(ii) Explain whether or not 3-aminopropanoic acid is chiral.

(1)

.....

.....

(iii) Write ionic equations for the reaction of 3-aminopropanoic acid with

(2)

H^+ ions

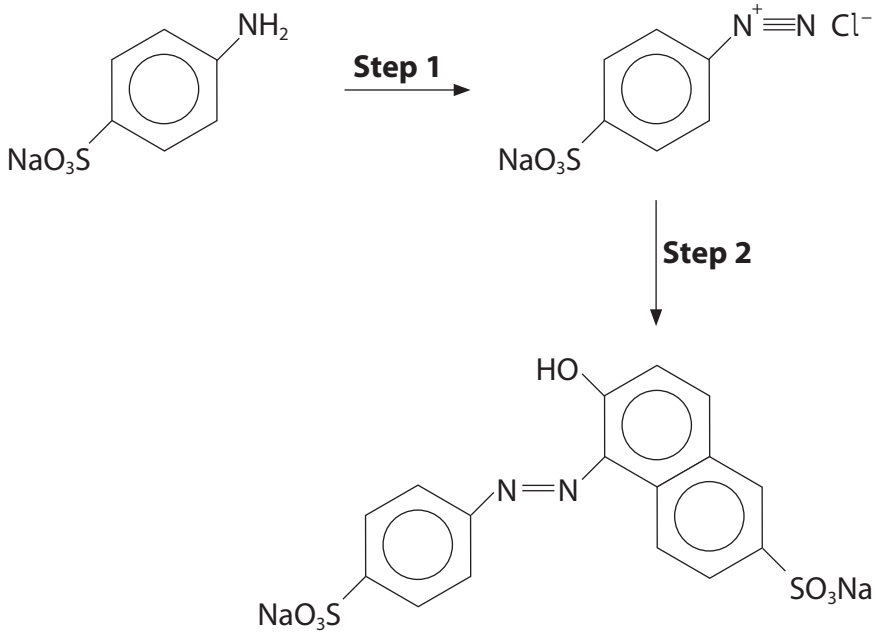
OH^- ions

(iv) Draw two repeat units of the polymer formed when 3-aminopropanoic acid polymerizes.

(1)

(b) The food colouring E110 is also known as Sunset Yellow.

It can be synthesised as shown below.



Sunset Yellow

(i) Give the reagents and condition for **Step 1**.

(2)

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(ii) Draw the structure of the reagent needed for **Step 2**.

(1)

(iii) Explain why Sunset Yellow can exist as geometric isomers.

(1)

*(iv) Describe the essential steps of the method that you would use to prepare a pure, dry sample of the solid Sunset Yellow from an impure sample of the food colouring. You may assume that ethanol is a suitable solvent for this method.

(4)

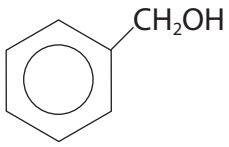
(v) Suggest how you could check that a sample of Sunset Yellow is pure.

(1)

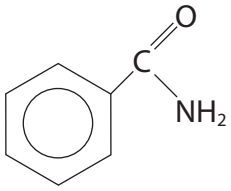
.....

.....

(c) Explain how a chemist could use phenylmethanol to synthesise a sample of benzamide in three steps.



phenylmethanol



benzamide

Include the reagents for the steps in the synthesis and draw the structures of **all** the intermediates.

(5)

(Total for Question 21 = 20 marks)

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22 Copper and zinc are both in the d-block of the Periodic Table. Copper forms compounds that contain Cu^+ and Cu^{2+} ions but zinc only forms compounds that contain Zn^{2+} ions.

(a) Complete the electronic configurations of the Cu^{2+} ions and Zn^{2+} ions and hence explain why copper is classified as a transition metal but zinc is not.

(2)

Cu^{2+} [Ar] .....

Zn^{2+} [Ar] .....

.....

.....

.....

.....

(b) Some photochromic glasses contain silver(I) and copper(I) chlorides.

Explain, with the aid of an equation, why these photochromic glasses go darker in sunlight.

(2)

.....

.....

.....

.....

(c) Copper forms a complex ion with the formula $[CuCl_4]^{2-}$. This has the same shape as $[Pt(NH_3)_2Cl_2]$.

Draw the shape of the $[CuCl_4]^{2-}$ ion and state the type of bonding between the ligands and the metal ion.

(2)

Shape

Bonding.....

(d) The $[CuCl_2]^-$ ion is formed by boiling a solution of copper(II) chloride with copper turnings and concentrated hydrochloric acid.

(i) Write an equation for this reaction. State symbols are not required.

(1)

(ii) State the meaning of the term **disproportionation** and explain whether or not this reaction to form the $[CuCl_2]^-$ ion is a disproportionation reaction.

(2)

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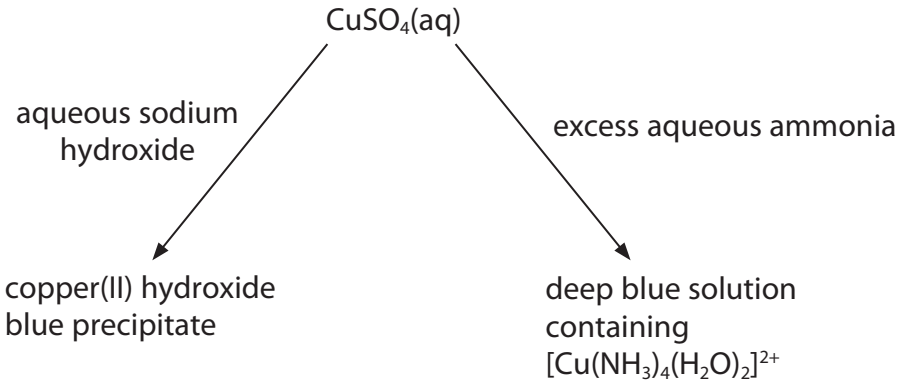
(iii) Explain why the $[CuCl_2]^-$ ions are colourless.

(2)

(e) Copper(II) sulfate solution reacts with aqueous sodium hydroxide and with aqueous ammonia.



(i) Write the **ionic** equation for the reaction of copper(II) sulfate solution with aqueous sodium hydroxide. Include state symbols.

(1)

(ii) State the type of reaction occurring overall when excess aqueous ammonia is added to copper(II) sulfate solution.

(1)

(f) 1,2-diaminoethane is a bidentate ligand. It reacts with copper(II) ions in aqueous solution.

$$[Cu(H_2O)_6]^{2+} + 3H_2NCH_2CH_2NH_2 \rightleftharpoons [Cu(H_2NCH_2CH_2NH_2)_3]^{2+} + 6H_2O$$

(i) State what is meant by the term **bidentate**.

(1)

.....

.....

(ii) Explain, in terms of entropy, why the reaction takes place.

(2)

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(Total for Question 22 = 16 marks)

TOTAL FOR SECTION B = 47 MARKS

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SECTION C

Answer ALL the questions. Write your answers in the spaces provided.

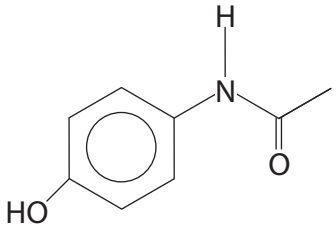
23

Analgesics

Analgesics are taken to relieve the symptoms of pain.

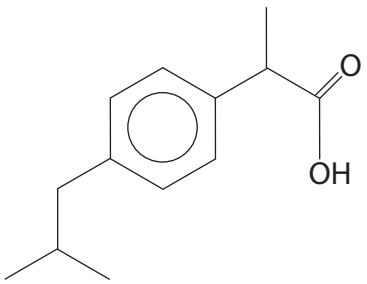
Paracetamol

This has been synthesised in a three-step process since the 1950s.



Ibuprofen

This was first synthesised in the 1960s from propanoic acid. That process involved six steps and produced more waste than the required drug.



It is now manufactured in a three-step process.
Some data about these two analgesics are given in the table below.

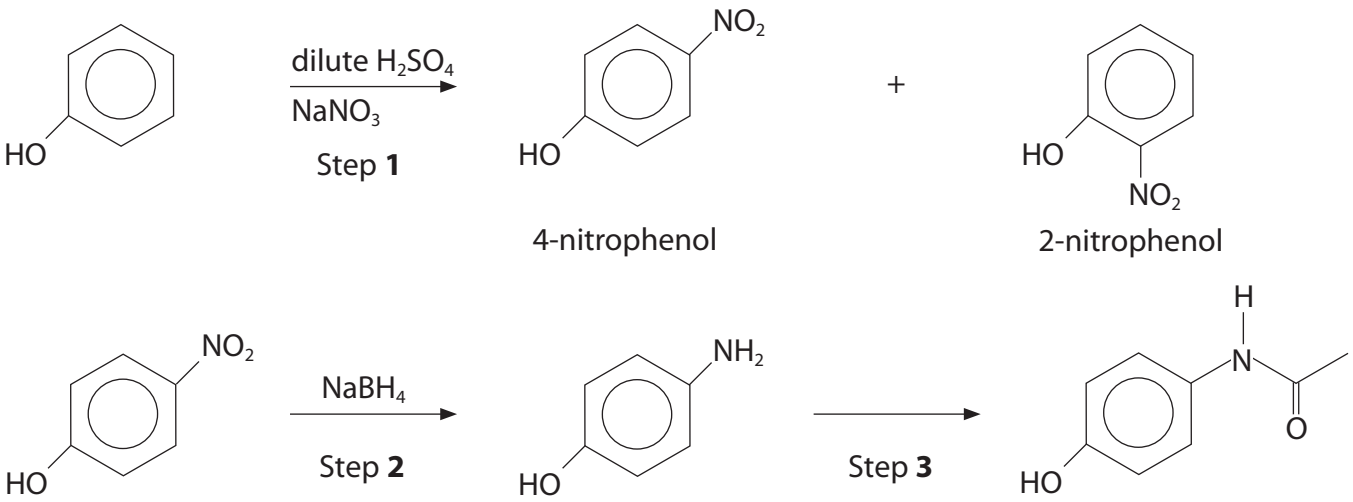
Analgesic	Molecular formula	Molar mass / g mol^{-1}
paracetamol	$C_8H_9NO_2$	151
ibuprofen	$C_{13}H_{18}O_2$	206

(a) **Name** the functional group in paracetamol, other than the phenol group.

(1)

.....

(b) Paracetamol is made from phenol in a three-step process.



(i) In a typical nitration of an arene, the electrophile is formed as shown below.

HNO_3 + H_2SO_4 → $H_2NO_3^+$ + HSO_4^- **Equation 1**

....

$H_2NO_3^+ \rightarrow H_2O + NO_2^+$ **Equation 2**

Identify the acid-base conjugate pairs in **Equation 1**. Write your answers on the dotted lines under the equation.

(1)

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(ii) Give a mechanism for the nitration of phenol by NO_2^+ to form 4-nitrophenol.

(3)

(iii) Explain why phenol is nitrated much more readily than benzene.

(2)

(iv) State the type of reaction taking place in Step **2**.

(1)

(v) Suggest a reagent for Step **3**.

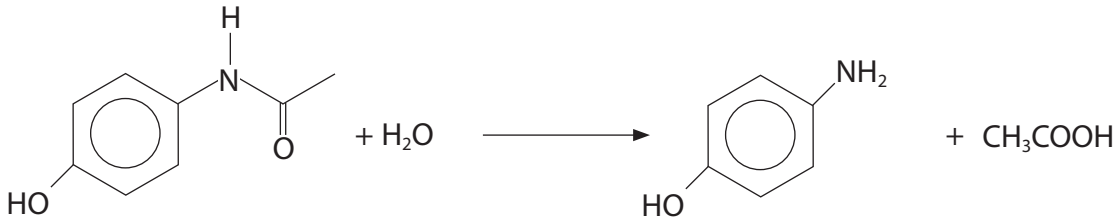
(1)

(vi) 2-nitrophenol has a melting temperature of 46 °C and 4-nitrophenol has a melting temperature of 114 °C.

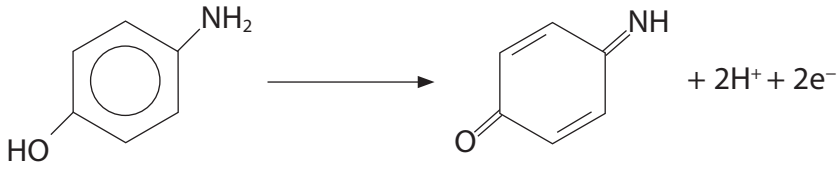
Suggest, in terms of intermolecular forces, why these two compounds have different melting temperatures.

(2)

(c) Paracetamol can be hydrolysed to form 4-aminophenol and ethanoic acid.



The amount of 4-aminophenol produced can be determined using a redox titration. The half-equation for the oxidation of 4-aminophenol is given below.



The oxidizing agent is ammonium cerium(IV) sulfate and ferroin indicator is used to detect the end-point of the titration. During the reaction, the Ce^{4+} ions are reduced to Ce^{3+} ions.

(i) Write the overall equation for the reaction between Ce^{4+} ions and 4-aminophenol.

(1)

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(ii) In an experiment, 0.500 g of a tablet containing paracetamol was hydrolysed and the solution was made up to 100 cm^3.

20.0 cm^3 portions of the resulting solution were titrated with 0.100 mol dm^{-3} ammonium cerium(IV) sulfate solution.

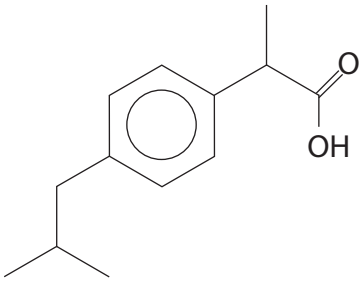
The mean titre was 12.60 cm^3.

Calculate the percentage, by mass, of paracetamol in the tablet.

(5)

(d) (i) Identify the chiral carbon atom in ibuprofen with an asterisk (*).

(1)



(ii) Suggest a problem in the manufacture of a single isomer of a chiral drug and describe a way that the pharmaceutical industry might overcome this problem.

(2)

.....

.....

.....

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.....

(e) Ibuprofen was originally made in a six-step process but is now made in a three-step process.

Suggest a specific environmental reason why the manufacturing process was changed.

(1)

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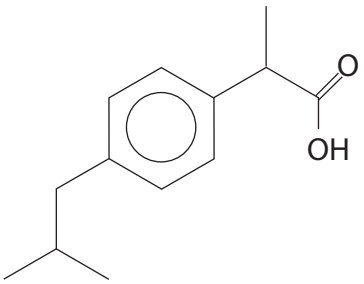
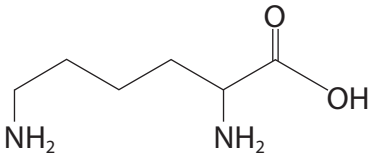
(f) Ibuprofen is not very soluble in water. It can be made into an ionic, soluble salt by reacting it with lysine.



Ibuprofen



Lysine

Draw the structures of **both** the cation and the anion in the soluble salt formed when ibuprofen reacts with lysine.

(2)

(Total for Question 23 = 23 marks)

TOTAL FOR SECTION C = 23 MARKS

TOTAL FOR PAPER = 90 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

Summer 2016

Pearson Edexcel GCE
in Chemistry (6CH05) Paper 01
General Principles of Chemistry II

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		**(1)**

Question Number	Correct Answer	Reject	Mark
2	C		**(1)**

Question Number	Correct Answer	Reject	Mark
3	A		**(1)**

Question Number	Correct Answer	Reject	Mark
4	D		**(1)**

Question Number	Correct Answer	Reject	Mark
5	B		**(1)**

Question Number	Correct Answer	Reject	Mark
6	D		**(1)**

Question Number	Correct Answer	Reject	Mark
7	B		**(1)**

Question Number	Correct Answer	Reject	Mark
8	D		**(1)**

Question Number	Correct Answer	Reject	Mark
9	C		**(1)**

Question Number	Correct Answer	Reject	Mark
10	C		**(1)**

Question Number	Correct Answer	Reject	Mark
11a	C		**(1)**

Question Number	Correct Answer	Reject	Mark
11b	D		**(1)**

Question Number	Correct Answer	Reject	Mark
12	B		**(1)**

Question Number	Correct Answer	Reject	Mark
13	D		**(1)**

Question Number	Correct Answer	Reject	Mark
14	B		**(1)**

Question Number	Correct Answer	Reject	Mark
15	C		**(1)**

Question Number	Correct Answer	Reject	Mark
16	B		**(1)**

Question Number	Correct Answer	Reject	Mark
17	A		**(1)**

Question Number	Correct Answer	Reject	Mark
18	D		**(1)**

Question Number	Correct Answer	Reject	Mark
19	A		**(1)**

Section B

Question Number	Acceptable Answers	Reject	Mark
20(a)	$V^{2+}(aq) + 2e^- \rightleftharpoons V(s)$ −1.18 (V) $V^{3+}(aq) + e^- \rightleftharpoons V^{2+}(aq)$ −0.26 (V) Both correct		**(1)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	**A** (salt bridge containing saturated solution of) potassium nitrate / KNO_3 ALLOW potassium chloride / KCl / sodium chloride / NaCl /sodium nitrate / $NaNO_3$ **(1)** **B** (electrode) platinum /Pt **(1)** **C** (solution containing) vanadium(II) **and** vanadium(III) ions / V^{2+} **and** V^{3+} ions ALLOW compounds of V^{2+} **and** V^{3+} **(1)** IGNORE any concentrations	KI / NaI vanadium	**(3)**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	298 K / 25°C (temperature) 1 atm / 100 kPa /101 kPa / 1 bar (pressure) ALLOW atmospheric pressure IGNORE hydrogen / gas 1 mol dm^{-3} (all concentrations) ALLOW this if written in (b)(i) ALLOW '1 molar' / 1M / equal concentrations of V^{2+} **and** V^{3+} / vanadium(II) **and** vanadium(III) ions All **3** correct **(2)** Any **2** correct **(1)**	298°K / 273 K / 0°C / room temperature wrong pressure units eg 100 Pa wrong concentration units eg 1 mol	**(2)**

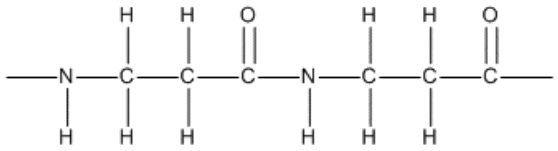
Question Number	Acceptable Answers	Reject	Mark
20(c)	**First mark – stand alone** vanadium(IV) / V(IV) / (+)4 (oxidation state) ALLOW V^{4+} **(1)** IGNORE VO^{2+} **Second mark** $E^{\ominus}_{cell}$ (= 1.00 – 0.54) = (+)0.46 (V) **(1)** **Third mark** $2VO_2^+ + 4H^+ + 2I^- \rightarrow 2VO^{2+} + 2H_2O + I_2$ ALLOW multiples / ⇌ **(1)** IGNORE any working before this equation **Fourth mark** For the reduction of V (IV) to V (III) $E^{\ominus}_{cell}$ (= 0.34 – 0.54) = −0.2(0) (V) OR $E^{\ominus}_{cell}$ for the reaction between VO^{2+} and I^- is negative (so V(IV) is not reduced to V(III)) OR I_2/I^- electrode potential / SEP / $E^{\ominus}$ value is more positive than the VO^{2+}/V^{3+} value (so V(IV) is not reduced to V(III)) OR VO^{2+}/V^{3+} electrode potential / SEP / $E^{\ominus}$ value is less positive than the I_2/I^- value (so V(IV) is not reduced to V(III)) **(1)** IGNORE equation for VO^{2+} and I^- **Fifth mark – stand alone** $E^{\ominus}_{cell}$ is positive / greater than 0 so (first) reaction is feasible **and** $E^{\ominus}_{cell}$ is negative / less than 0 so (second) reaction is not feasible ALLOW spontaneous for feasible **(1)** IGNORE incorrect values provided the signs are correct	Mention of iodide ions reduced Incorrect value	**(5)**

Total for Question 20 = 11 marks

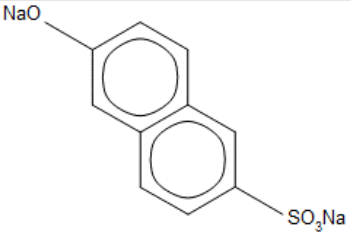
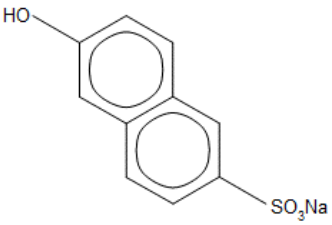
Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	2-aminopropanoic acid has peak ratio 3:2:1:1 (in any order) **(1)** 3-aminopropanoic acid has peak ratio 2:2:2:1 (in any order) **(1)** If no other mark is awarded, allow for 1 mark: 1 stated difference between the peak ratios e.g. only 2-aminopropanoic acid has a peak with area / height 3 IGNORE splitting patterns / chemical shift values even if incorrect	They have different numbers of peaks negates 1 mark only	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	Not chiral, as there is no carbon atom with 4 different atoms or groups attached ALLOW Not chiral, as there is no asymmetric carbon atom / there is a plane of symmetry in the molecule / there are two hydrogens attached to (both) carbons IGNORE there is no chiral carbon atom / does not have any enantiomers IGNORE Not chiral, as mirror image is superimposable / it does not have a non-superimposable mirror image	Species /molecules	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	ALLOW skeletal / displayed / structural formulae or any combination of these ALLOW CO_2H for COOH / C_2H_4 or $(CH_2)_2$ for CH_2CH_2 $^+H_3NCH_2CH_2COO^- + H^+ \rightarrow {}^+H_3NCH_2CH_2COOH$ ALLOW $H_2NCH_2CH_2COOH + H^+ \rightarrow {}^+H_3NCH_2CH_2COOH$ **(1)** $^+H_3NCH_2CH_2COO^- + OH^- \rightarrow H_2NCH_2CH_2COO^- + H_2O$ ALLOW $H_2NCH_2CH_2COOH + OH^- \rightarrow H_2NCH_2CH_2COO^- + H_2O$ **(1)** ALLOW (1) for just 2 correct organic products ALLOW (1) for 2 correct equations using 2-aminopropanoic acid		**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iv)	 Extension bonds must be present and can be solid or dotted ALLOW $(CH_2)_2$ / C_2H_4 ALLOW structural / skeletal / displayed formulae or any combination of these e.g. $-NH(CH_2)_2CONH(CH_2)_2CO-$ IGNORE brackets / n	Use of 2-aminopropanoic acid 1 repeat unit /more than 2 repeat units	**(1)**

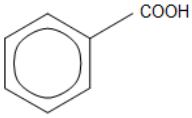
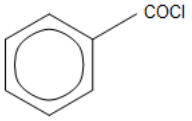
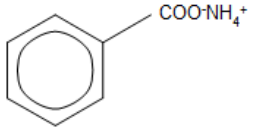
Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	sodium nitrite / sodium nitrate(III) / $NaNO_2$ **and** hydrochloric acid / HCl / sulfuric acid / H_2SO_4 ALLOW nitrous acid / HNO_2 (and hydrochloric acid / HCl) **(1)** IGNORE concentration of hydrochloric acid at 5 °C/ between 0 and 10 °C. Conditional on correct or 'near miss' reagents ALLOW any temperature or range of temperatures within range /ice bath / less than 5/10°C **(1)**	Just sodium nitrate Incorrect formula with correct name or vice versa Conc H_2SO_4	**(2)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	 ALLOW $-O^-$ (Na^+) / $-SO_3^-$ Na^+ 	Covalent bond between Na and O O–H– / OH– attached to benzene ring	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	Restricted rotation around N=N ALLOW no rotation ALLOW restricted / no rotation around the nitrogen / azo bridge ALLOW restricted / no rotation around the double bond	the molecule does not rotate limited rotation restricted / no rotation around C=C	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Dissolve it in the minimum amount of hot ethanol /solvent **(1)** Filter whilst still hot (to remove the insoluble impurities) ALLOW this mark if hot is omitted and it follows M1 and is followed by cool **(1)** Cool / use an ice bath (and allow crystals to form) **(1)** Filter **and** dry the crystals ALLOW any method of filtration / any suitable method of drying e.g. on filter paper / leave to dry / in a (warm) oven / put in a desiccator **(1)** IGNORE wash with ethanol /water	Add ethanol /solvent then heat To remove soluble impurities To remove insoluble impurities Use of an anhydrous salt for drying unless in a desiccator	**(4)**

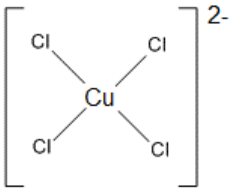
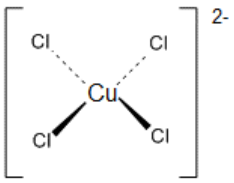
Question Number	Acceptable Answers	Reject	Mark
21(b)(v)	Compare the melting temperature with Data Book / known / literature value OR It has a sharp melting temperature OR Melting temperature is ± 2°C of the Data Book / known / literature value OR (Thin layer) chromatography has a single (yellow) spot IGNORE references to spectroscopy / HPLC / GC	boiling temperature	**(1)**

Question Number	Acceptable Answers	Reject	Mark
21(c)	IGNORE conditions unless in Reject column / mechanisms / equations ALLOW names or formulae for reagents but both must be correct if given **First step** Potassium / sodium dichromate((VI)) /$K_2Cr_2O_7$ / $Na_2Cr_2O_7$ / $Cr_2O_7^{2-}$ **and** (dilute) sulfuric acid / H^+/ acidified **(1)** ALLOW MnO_4^- / H^+ **First intermediate - stand alone**  ALLOW $–CO_2H$ / displayed formula **(1)** IGNORE formation of an aldehyde **Second step – from benzoic acid** phosphorus(V) chloride / PCl_5 / phosphorus(III) chloride / PCl_3 / thionyl chloride /$SOCl_2$ **(1)** **Second intermediate – stand alone**  ALLOW COCl displayed **(1)** **Third step – from benzoyl chloride** (concentrated) ammonia **(1)** **Alternative route for last 3 marks** **Second step – from benzoic acid** ammonium carbonate /ammonia **(1)** **Second intermediate**  ALLOW COO^- displayed / $COONH_4$ with no charges **(1)** **Third step – from ammonium benzoate** Heat OR phosphorus(V) oxide /P_2O_5/P_4O_{10} **(1)**	hydrochloric acid / HCl / concentrated H_2SO_4 just ‘benzoic acid’ hydrochloric acid/HCl Just ‘benzoyl chloride’ Ethanol Additional reagents	**(5)**

Total for Question 21 = 20 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)	**First mark** Electronic configurations: Cu^{2+} is [Ar] $3d^9$ **and** Zn^{2+} is [Ar] $3d^{10}$ IGNORE $4s^0$ / full electronic configuration of Ar **(1)** **Second mark** If both EC are correct: EITHER Copper (is a transition element because it) forms a (stable) **ion** with an incompletely / partially filled **d**-subshell / orbital(s) ALLOW forms an **ion** with unpaired **d** electron(s) OR Zinc only forms an **ion** with a full **d**-subshell / all **d** orbital**s** full **(1)** If one or both EC are incorrect: Copper (is a transition element because it) forms a (stable) **ion** with an incompletely filled **d**-subshell / orbital(s) **and** zinc only forms an **ion** with a full **d**-subshell / all **d** orbital**s** full **(1)**	d shell sub-shell / orbital other than 3d	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(b)	$CuCl + AgCl \rightleftharpoons CuCl_2 + Ag$ OR $Cu^+ + Ag^+ \rightleftharpoons Cu^{2+} + Ag$ OR $CuCl + Ag^+ \rightleftharpoons Cu^{2+} + Ag + Cl^-$ ALLOW → **(1)** IGNORE state symbols / half-equations **Stand alone mark** (Equilibrium moves to the right in sunlight) producing silver **(1)** IGNORE copper(II) compounds	Copper (metal)/ copper(I) compounds	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(c)	Shape – square planar  or  ALLOW bonds with or without arrows ALLOW Cls joined by lines in a square ALLOW tetrahedral shape **(1)** IGNORE brackets and/or charges Bonding - dative (covalent) /co-ordinate ALLOW shown on diagram as arrows from Cl to Cu **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	$Cu + CuCl_2 + 2HCl \rightarrow 2[CuCl_2]^- + 2H^+$ OR $Cu + Cu^{2+} + 4Cl^- \rightarrow 2[CuCl_2]^-$ OR $Cu + [Cu(H_2O)_6]^{2+} + 4Cl^- \rightarrow 2[CuCl_2]^- + 6H_2O$ OR $Cu + [Cu(H_2O)_6]^{2+} + 4HCl \rightarrow 2[CuCl_2]^- + 6H_2O + 4H^+$ OR $Cu + CuCl_2 + 2Cl^- \rightarrow 2[CuCl_2]^-$ IGNORE state symbols, even if incorrect / missing brackets		**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	Disproportionation is the simultaneous oxidation and reduction of a (single) species / atom / element / ion (to form 2 different oxidation states) **(1)** IGNORE reactant / substance / molecule / compound Not disproportionation because two different species (of copper) are oxidised and reduced OR Not disproportionation as (start with 2 different oxidation states of copper and) only produces 1 oxidation state ALLOW Disproportionation is the other way around / this is reverse disproportionation / comproportionation **(1)**		**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(d)(iii)	The d-subshell is full / d^{10} OR **all** d orbital**s** are full ALLOW d shell is full **(1)** d-d transitions cannot take place OR Electrons cannot move between **d** orbitals OR Electrons cannot be promoted / excited to higher **d** orbital(s) **(1)** IGNORE just 'movement to different energy level'	d orbital any number other than 3(d) d-subshell / d orbitals do not split	**(2)**

Question Number	Acceptable Answers	Reject	Mark
22(e)(i)	State symbols **are** required IGNORE missing square brackets $Cu^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s)$ OR $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(s) + 6H_2O(l)$ OR $[Cu(H_2O)_6]^{2+}(aq) + 2OH^-(aq) \rightarrow Cu(OH)_2(H_2O)_4(s) + 2H_2O(l)$ OR $Cu^{2+}(aq) + 2OH^-(aq) + 4H_2O(l) \rightarrow Cu(OH)_2(H_2O)_4(s)$ ALLOW equations with $[Cu(H_2O)_4]^{2+}(aq)$	Equations with NaOH / Na^+/ SO_4^{2-} ions	**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(e)(ii)	Ligand exchange / ligand substitution / ligand replacement	Acid/base reaction Deprotonation	**(1)**

Question Number	Acceptable Answers	Reject	Mark
22(f)(i)	Ligand has 2 atoms that can form (co-ordinate / dative covalent) bonds (to the metal ion) ALLOW Has 2 lone pairs that form (co-ordinate / dative covalent) bonds ALLOW Has 2 lone pairs that it donates (to the metal ion) ALLOW Forms 2 (co-ordinate / dative covalent) bonds (to the metal ion)	2 ligands attached to the ion Ionic bond Just 'has 2 lone pairs'	**(1)**

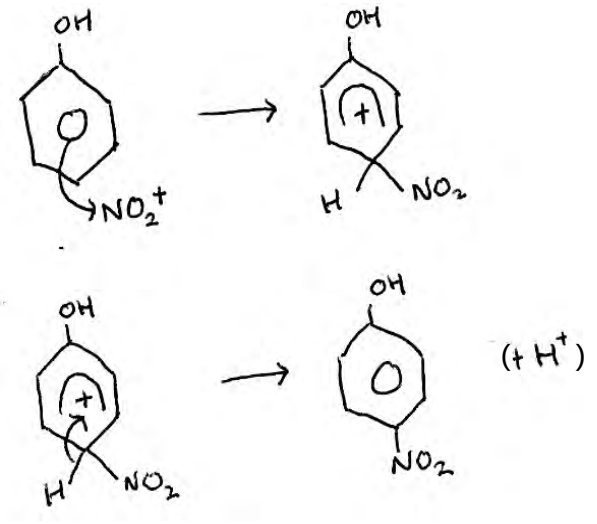
Question Number	Acceptable Answers	Reject	Mark
22(f)(ii)	**First mark** (there are) more particles / moles / species on the right (of the equation) OR (there is an increase from) 4 particles / moles / species on the left of the equation to 7 on the right **(1)** **Second mark** (so) ΔS_{system} increases / is positive (and the reaction is thermodynamically feasible) ALLOW ΔS_{total} is positive / increasing (and the reaction is thermodynamically feasible) ALLOW (there is) an increase in entropy (and the reaction is thermodynamically feasible) **(1)** IGNORE Just 'disorder increases'	Molecules / atoms Incorrect numbers of particles / moles	**(2)**

Total for Question 22 = 16 marks

Section C

Question Number	Acceptable Answers	Reject	Mark
23(a)	(acid) amide / N-substituted amide / N-substituted ethanamide / secondary (substituted) amide / substituted amide IGNORE benzene / arene / phenyl	Amine / amino acid / carboxylic acid / acid / ester	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	(HNO_3 + H_2SO_4 → $H_2NO_3^+$ + HSO_4^-) base/ base 1 acid/ acid 2 conjugate acid/ acid 1 conjugate base/ base 2 ALLOW any labels that connect the correct acid/base pairs, including linking lines		**(1)**

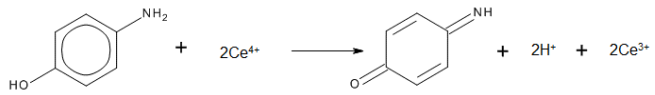
Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	If benzene used instead of phenol OR if final product is not 4-nitrophenol (max 2)  **First mark** Curly arrow from on or within the circle to the N of NO_2^+ ALLOW curly arrow from anywhere within the hexagon ALLOW curly arrow to any part of the NO_2^+ including to the + charge **(1)** **Second mark** Intermediate structure including charge with horseshoe covering at least 3 carbon atoms **and** facing the tetrahedral carbon **and** some part of the positive charge must be within the horseshoe ALLOW dotted horseshoe **(1)** **Third mark** Curly arrow from C—H bond to anywhere in the hexagon, reforming the delocalised structure **(1)** IGNORE any involvement of HSO_4^- in the final step Correct Kekule structures score full marks	Lone pair on N Curly arrow on or outside the hexagon Dotted bonds to H and NO_2 unless as part of a 3-D structure Curly arrow from H	**(3)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(iii)	**Lone pair of electrons on oxygen** (may be shown on a diagram) **and** EITHER overlaps with pi cloud /delocalised electrons / delocalised system OR Feeds into / donates into / interacts with (benzene) ring /delocalised electrons / delocalised system ALLOW Increases the electron density of the (benzene) ring **(1)** (Increased electron density) makes the ring more susceptible to electrophilic attack ALLOW phenol is a better nucleophile **(1)**	Ring is more electro-negative	**(2)**

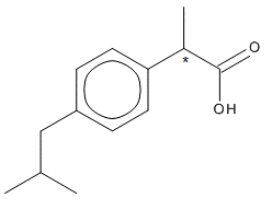
Question Number	Acceptable Answers	Reject	Mark
23(b)(iv)	Reduction ALLOW redox	Hydrogenation	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(v)	ethanoyl chloride / CH_3COCl / ethanoic anhydride / $(CH_3CO)_2O$ If name and formula are given, both must be correct ALLOW displayed / skeletal formulae IGNORE acid chloride / acid anhydride	ethanoic acid / CH_3COOH	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(b)(vi)	Hydrogen bonds present in both compounds ALLOW if this is clearly implied e.g. 4-nitrophenol forms more hydrogen bonds than 2-nitrophenol **(1)** 4-nitrophenol forms intermolecular hydrogen bonds **and** 2-nitrophenol forms intramolecular hydrogen bonds (so less intermolecular hydrogen bonds) ALLOW this shown in diagrams / a clear description **(1)** IGNORE references to other intermolecular forces		**(2)**

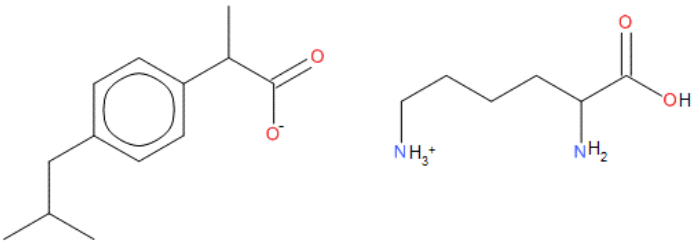
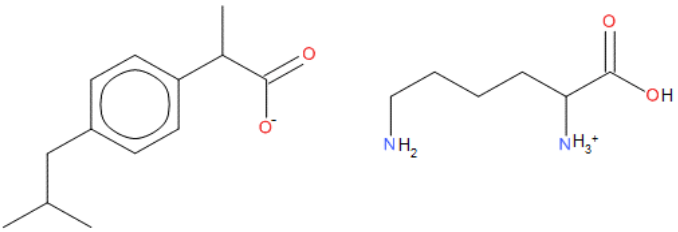
Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	 OR $HOC_6H_4NH_2 + 2Ce^{4+} \rightarrow OC_6H_4NH + 2H^+ + 2Ce^{3+}$	electrons left in equation	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(c)(ii)	95.1(3)% with or without working scores **(5)** mol Ce^{4+} used = 12.60x0.100/1000 = 1.260×10^{-3} **(1)** mol 4-aminophenol in 20.0 cm^3 = $1.260 \times 10^{-3}/2$ = 6.30×10^{-4} TE on mole ratio in (c)(i) **(1)** mol 4-aminophenol/paracetamol in 100 cm^3 = 6.30×10^{-4} x 5 = 3.15×10^{-3} TE on mol in 20.0 cm^3 **(1)** mass paracetamol in 100 cm^3 = 3.15×10^{-3} x 151 = 0.47565 (g) TE from mol in 100 cm^3 **(1)** % paracetamol **=** $\frac{0.47565}{0.500} \times 100$ = 95.1(3)(%) TE from mass paracetamol in 100cm^3 as long as answer is less than 100% **(1)** IGNORE SF except 1SF ALLOW alternative methods	Incorrect units once only	**(5)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	 ALLOW other ways of indicating the correct carbon atom eg with a circle	Circle covering additional carbon atoms More than one carbon atom indicated	**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	Mark independently **First mark** Any one problem from: Producing a single enantiomer / isomer gives low atom economy / gives (a lot of / 50%) waste / low yield (of required isomer) OR Separating the two enantiomers / isomers is difficult / expensive / uses (a lot of) energy **(1)** IGNORE just 'a racemic mixture is formed' / unwanted isomer may be harmful / toxic / have side effects **Second mark** Any one solution from: Produce a single isomer by using enzymes / bacteria / a biological catalyst / a chiral catalyst / chiral synthesis / asymmetric synthesis / stereospecific synthesis OR Use a (natural) chiral molecule as a starting material ALLOW Use of S_N2 instead of S_N1 **(1)** IGNORE remove harmful /unwanted products	Combinatorial chemistry Passing reactants over reagents on polymer supports	**(2)**

Question Number	Acceptable Answers	Reject	Mark
23(e)	Any **one** reason from: (The three step synthesis will) Increase atom economy / reduce waste OR Increase / give a higher (percentage) yield OR Use less energy / fuel ALLOW reverse argument for the six step synthesis IGNORE references to costs / raw materials / efficiency / pollution		**(1)**

Question Number	Acceptable Answers	Reject	Mark
23(f)	 OR  ALLOW carboxylate ion shown as  ALLOW Anion as shown and the cation with two NH_3^+ groups / cation shown as a protonated zwitterion Anion **(1)** Cation **(1)**	Charges outside brackets, once only, if both ions are correct and there are no charges inside the bracket	**(2)**

Total for Section C = 23 marks

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Edexcel Chemistry – A2 Grade Boundaries

6CH04 – General Principles of Chemistry I: Rates, Equilibria and Further Organic Chemistry

Season	Full UMS	A*	A	B	C	D	E
IAL - June 2015	78	73	68	63	58	53	48
June 2015	84	78	72	66	60	55	50
IAL - Jan 2015	85	78	71	64	57	50	43
June 2014	81	69	69	63	57	51	46
IAL - June 2014	86	80	74	68	62	56	50
R - June 2014	83	77	71	65	59	54	49
IAL - Jan 2014	86	79	72	65	58	51	44
June 2013	79	74	69	63	57	51	46
R - June 2013	81	75	69	62	56	50	44
Jan 2013	85	79	73	67	61	55	49
June 2012	82	75	68	61	54	48	42
Jan 2012	81	75	69	63	57	52	47
June 2011	88	80	72	64	56	49	42
Jan 2011	76	70	64	58	52	46	40
June 2010	85	77	69	61	53	45	38
Jan 2010	68	62	56	50	44	38	33

6CH05 – General Principles of Chemistry II: Transition Metals and Organic Nitrogen Chemistry

Season	Full UMS	A*	A	B	C	D	E
IAL - June 2015	72	66	60	54	48	42	36
June 2015	80	74	68	62	57	52	47
IAL - Jan 2015	70	64	58	52	46	40	34
June 2014	75	68	61	54	48	42	36
IAL - June 2014	70	64	58	52	47	42	37
R - June 2014	77	70	63	56	49	42	35
IAL - Jan 2014	81	73	65	57	50	43	36
June 2013	86	80	74	67	60	53	47
R - June 2013	76	69	62	55	48	41	35
Jan 2013	85	77	69	61	53	46	39
June 2012	79	73	67	61	55	49	43
Jan 2012	88	80	72	64	56	49	42
June 2011	79	73	67	61	55	49	43
Jan 2011	79	72	65	58	51	44	38
June 2010	80	73	66	59	53	47	41

Merged Unit 6s
June 10 - June 16

Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 6: Chemistry Laboratory Skills II

Sample Assessment Material
Time: 1 hour 15 minutes

Paper Reference
WCH06/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Answer ALL the questions. Write your answers in the spaces provided.

1 (a) Compound **Z** is a crystalline solid that contains a nickel cation and one type of anion. Complete the table below.

	Test	Observation	Inference
(i)	Add dilute sulfuric acid to compound **Z**	Bubbles of a colourless gas are released. The gas turns limewater milky and a ..... coloured solution is formed **(1)**	Name of gas released is ..... Formula of anion in **Z** is ..... **(2)** Formula of the complex ion formed is $[Ni(H_2O)_6]^{2+}(aq)$
(ii)	Add concentrated hydrochloric acid to the solution containing $[Ni(H_2O)_6]^{2+}$ ions	Yellow-brown solution forms	Formula of the complex ion formed is ..... **(1)**
(iii)	Add a few drops of dilute aqueous ammonia to the solution containing $[Ni(H_2O)_6]^{2+}$ ions	Green precipitate forms	Formula of the precipitate formed is ..... **(1)**
(iv)	Add excess dilute aqueous ammonia to the solution containing $[Ni(H_2O)_6]^{2+}$ ions until no further change is observed	.... **(1)**	Formula of the complex ion formed is $[Ni(NH_3)_6]^{2+}$

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(b) A 10.0 cm^3 sample of a solution containing $[Ni(H_2O)_6]^{2+}$ ions was titrated with a solution of concentration 0.010 mol dm^{-3} with respect to the ligand $EDTA^{4-}$ ions. The equation for the reaction is

$$[Ni(H_2O)_6]^{2+} + EDTA^{4-} \rightarrow [Ni(EDTA)]^{2-} + 6H_2O$$

(i) The mean titre of the solution containing $EDTA^{4-}$ ions was 24.20 cm^3. Use this information, and the equation above, to calculate the concentration in mol dm^{-3} of the solution containing $[Ni(H_2O)_6]^{2+}$ ions.

(2)

(ii) Assuming the total error in the measurement of the mean titre is ±0.10 cm^3, calculate the percentage error in this titre.

(1)

(iii) A similar solution, containing the same concentration of $[Ni(H_2O)_6]^{2+}$ ions, also contained a small amount of an impurity, copper(II) sulfate.

Suggest what effect this impurity would have on the titre. Justify your answer.

(2)

.....

.....

.....

.....

(Total for Question 1 = 11 marks)

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2 A colourless liquid, compound **X**, was extracted from raspberries. **X** has the molecular formula $C_{10}H_{12}O_2$ and contains a benzene ring.

(a) What would you expect to see if a sample of compound **X** was burned in air?

(1)

.....

.....

(b) A series of tests was carried out on compound **X**. In each test, state what you can deduce about the structure of compound **X** from the results described.

(i) **X** forms a white precipitate with aqueous bromine solution.

(1)

.....

.....

(ii) **X** forms an orange precipitate with 2,4-dinitrophenylhydrazine.

(1)

.....

.....

(iii) Fehling's (or Benedict's) solution remains blue when warmed with compound **X**.

(1)

.....

.....

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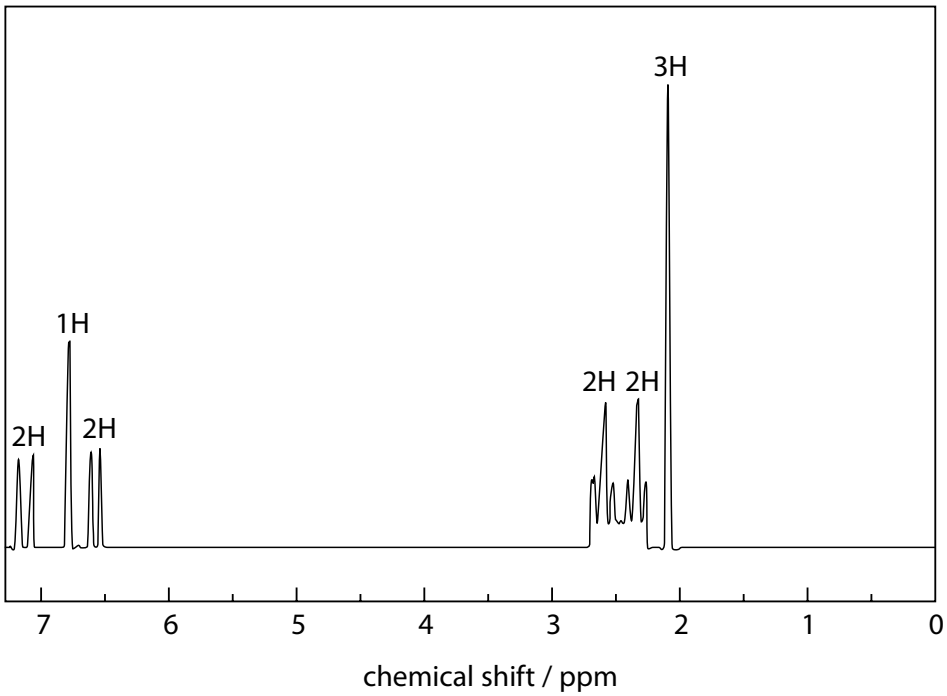
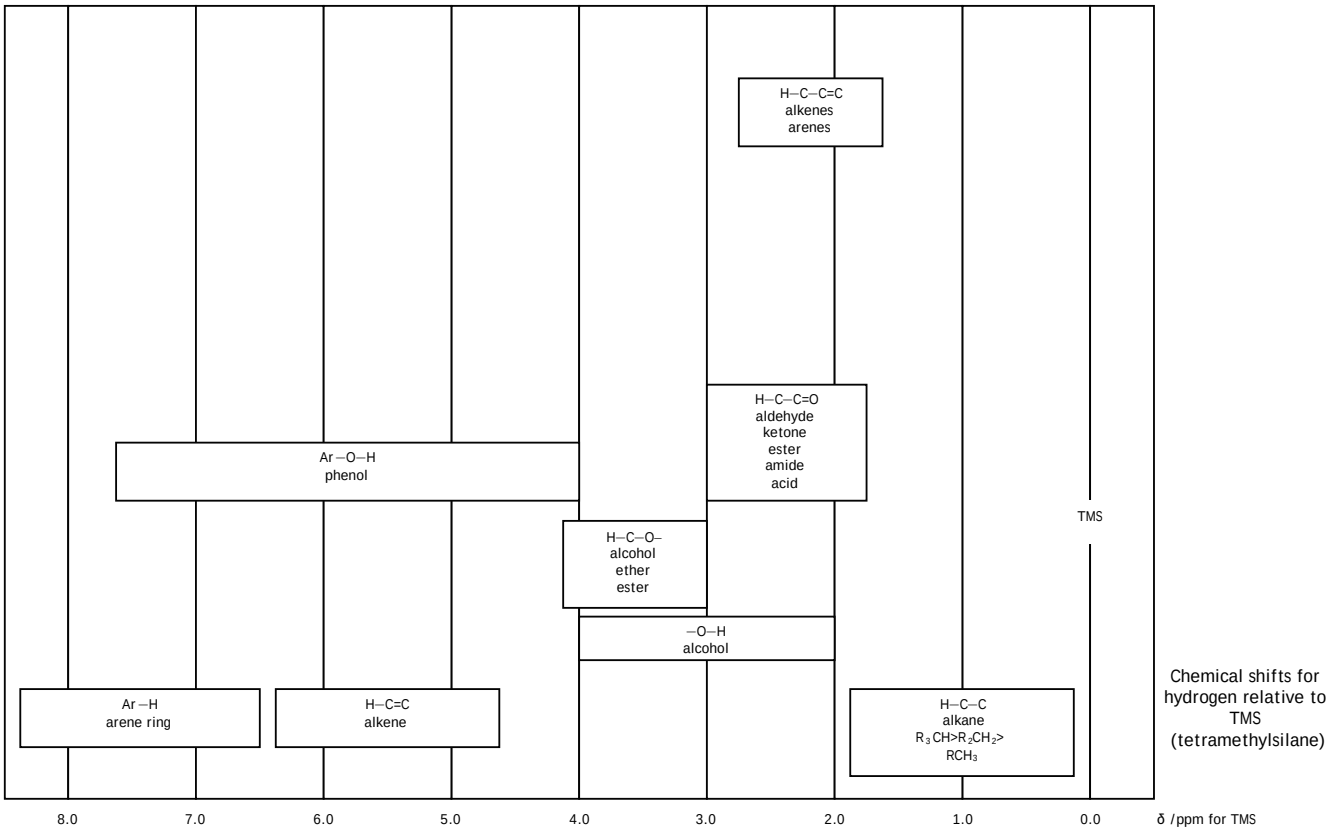
(c) The high resolution proton nmr spectrum of compound **X** is shown below. This spectrum shows that there are six different proton environments in the molecule of **X**. The relative number of hydrogen atoms in each environment is indicated on the spectrum. Use this spectrum, the data below and your answers to (a) and (b) to help answer the questions that follow.



Nuclear Magnetic Resonance



Chemical shifts for hydrogen relative to TMS (tetramethylsilane)

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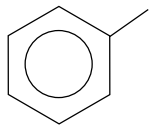
(i) Which hydrogen atoms in compound **X** are most likely to have caused the peaks at 6.5 ppm and 7.2 ppm?

(1)

.....

(ii) Compound **X** has a side chain containing four carbon atoms attached to the benzene ring. Show all the atoms on this side chain and label each hydrogen environment on the side chain with its splitting pattern.



(3)

.....

.....

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.....

(iii) Suggest the structural formula of **X**.

(1)

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(d) Compound **X** can be extracted from raspberries by steam distillation. Draw a labelled diagram of the apparatus you could use to carry out this steam distillation.

(3)

(Total for Question 2 = 12 marks)

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3 Glucose can be oxidized using acidified potassium manganate(VII). The kinetics of the reaction can be studied using the procedure outlined below.

1. Measured volumes of glucose solution, sulfuric acid and water were added to a conical flask.
2. A measured volume of potassium manganate(VII) solution was added to the flask. The mixture was gently swirled and a stopwatch started.
3. The time taken for the mixture in the flask to change colour was recorded and the initial rate of the reaction was then calculated.
4. The experiment was repeated using different volumes of the solutions.

The results of the experiments are shown in the table below.

Experiment	Glucose / cm^3	Sulfuric acid / cm^3	Potassium manganate(VII) / cm^3	Water / cm^3	Initial rate / mol dm^{-3} s^{-1}
A	20.0	20.0	10.0	0.0	1.0×10^{-5}
B	20.0	20.0	5.0	5.0	5.0×10^{-6}
C	10.0	20.0	10.0	10.0	9.8×10^{-6}
D	10.0	10.0	10.0	20.0	4.9×10^{-6}

(a) (i) Which piece of equipment should be used to measure out the volumes used in each experiment? Justify your choice.

(2)

.....

.....

.....

.....

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(ii) What colour change would you see in step 3?

(2)

From ..... to .....

(iii) Explain why water was added to the flask in experiments B, C and D.

(1)

.....

.....

(iv) Suggest a technique that could be used to continuously monitor the change in concentration of potassium manganate(VII) during the reaction.

(1)

.....

.....

(v) State the order with respect to glucose, sulfuric acid and potassium manganate(VII) and hence write the rate equation for the reaction.

(3)

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(b) Experiment A was repeated at different temperatures and the time taken for the potassium manganate(VII) to change colour was recorded. The results were processed to find values of 1/temperature and ln (rate constant) and these are shown in the table below.

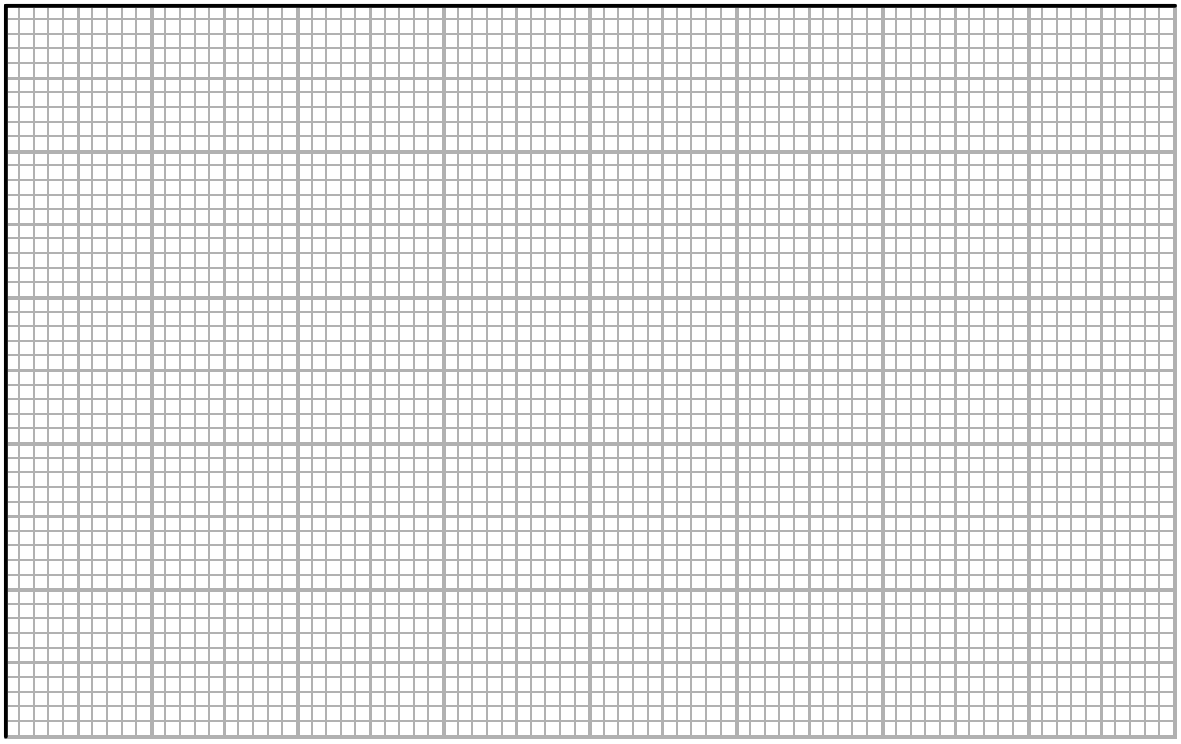
Experiment	1 / temperature / K^{-1}	ln (rate constant)
E	3.00×10^{-3}	−1.60
F	3.10×10^{-3}	−2.60
G	3.21×10^{-3}	−3.75
H	3.35×10^{-3}	−5.20

(i) Plot a graph of ln (rate constant) against 1 / temperature on the axes below.

(3)

1 / temperature / K^{-1}

ln (rate constant)



(ii) Calculate the gradient of the graph.

(1)

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(iii) Use your answer to (ii) and the relationship below to calculate the activation energy, E_a, for this reaction. Include a sign and units in your answer.

$$\text{Gradient} = \frac{-E_a}{R}$$

$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

(2)

(Total for Question 3 = 15 marks)

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4 The procedure outlined below can be used to extract caffeine from tea.

1. Add 25 g of tea, 10 g of calcium carbonate and 250 cm^3 of water to a large beaker.
2. Gently boil the mixture for 15 minutes.
3. While the mixture is still warm, filter using suction filtration.
4. Transfer the filtrate to a separating funnel and separate the caffeine from the aqueous mixture using solvent extraction, with dichloromethane as the solvent.
5. Dry the extract.
6. Remove the solvent.

[Density of dichloromethane = 1.32 g cm^{-3}]

(a) (i) Outline how to carry out the solvent extraction in **step 4**, to obtain a solution of caffeine dissolved in dichloromethane.

(3)

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(ii) How would you dry the extract in **step 5**? Include the name of a suitable drying agent in your answer.

(2)

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(b) (i) The solvent dichloromethane is harmful and can enter the body through inhalation and skin absorption. Suggest a possible way to minimise each of these risks when using dichloromethane.

(2)

Inhalation .....

.....

Skin absorption .....

.....

(ii) Suggest a suitable way to remove the solvent in **step 6**.

(1)

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(c) The extraction can also be carried out using liquid carbon dioxide. Suggest an advantage of using this rather than dichloromethane.

(1)

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(d) A student carrying out this extraction obtained 85 mg of caffeine. Calculate the percentage by mass of caffeine obtained from the sample of tea used.

(2)

(e) Caffeine obtained in this way is often a pale green solid, due to impurities. State the name of another technique you could use to further purify the caffeine.

(1)

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.....

(Total for Question 4 = 12 marks)

TOTAL FOR PAPER = 50 MARKS

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S 4 5 3 6 5 A 0 1 6 1 6

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

PMT

General marking guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of Quality of Written Communication, are being assessed. The strands are as follows:
    i. ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
    ii. select and use a form and style of writing appropriate to purpose and to complex subject matter
    iii. organise information clearly and coherently, using specialist vocabulary when appropriate.

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Using the Mark Scheme

Examiners should NOT give credit for incorrect or inadequate answers, but allow candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected, it may still be creditworthy.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/	Means that the responses are alternatives and either answer should receive full credit.
()	Means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Bold	Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq	(error carried forward)(transfer error)(consequential) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

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Question Number	Acceptable Answer	Reject	Mark
1(a)(i)	Green IGNORE qualifications of green such as light/dark/emerald. **(1)** Carbon dioxide ALLOW CO_2. **(1)** CO_3^{2-} ALLOW HCO_3^- **(1)**	Blue-green Turquoise	**(3)**

Question Number	Acceptable Answer	Mark
1(a)(ii)	$[NiCl_4]^{2-}$ ALLOW -2 for 2- $NiCl_4^{2-}$ $[Ni(Cl)_4]^{2-}$ $Ni(Cl)_4^{2-}$ $[Ni(H_2O)_2Cl_4]^{2-}$ $[NiCl_6]^{4-}$	**(1)**

Question Number	Acceptable Answer	Mark
1(a)(iii)	$Ni(OH)_2$/$Ni(H_2O)_4(OH)_2$/ $Ni(OH)_2$ $(H_2O)_4$/ $[Ni(H_2O)_4(OH)_2]$/ $[Ni(OH)_2$ $(H_2O)_4]$	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(a)(iv)	Blue solution (forms) ALLOW lavender blue solution and any other shade of blue. OR (Green) precipitate dissolves.	 Blue-green Precipitate dissolves to give incorrect coloured solution	**(1)**

Question Number	Acceptable Answer	Mark
1(b)(i)	24.2/1000 x 0.01 = 2.42 x 10^{-4} (mol) **(1)** Concentration of $[Ni(H_2O)_6]^{2+}$ ions = 2.42 x 10^{-4} x 100 = 0.0242 (mol dm^{-3}) **(1)** ALLOW TE on number of moles. Correct answer alone scores both marks. IGNORE significant figures except 1.	**(2)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(ii)	0.1/24.2 x 100 = (±) 0.413% /(±) 0.41 % /(±) 0.4%	4 or more SF	**(1)**

Question Number	Acceptable Answer	Reject	Mark
1(b)(iii)	(Mean) titre would be greater. **(1)** $EDTA^{(4-)}$ would also complex to/react with Cu^{2+}/$[Cu(H_2O)_6]^{2+}$/$CuSO_4$ /copper ions/copper sulphate. **(1)** Both marks are stand alone.	More needed to react with unspecified impurity	**(2)**

Total for Question 1 = 11 Marks

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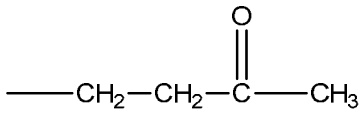
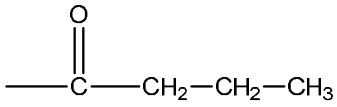
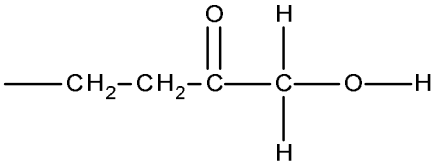
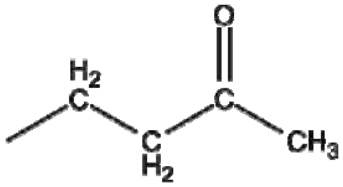
Question Number	Acceptable Answer	Reject	Mark
2(a)	Smoky/sooty flame IGNORE reference to yellow flame.	White smoke	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(b)(i)	It contains a phenol group/has OH attached to benzene ring. ALLOW hydrox**yl** group attached to benzene ring. ALLOW 'is a phenol'. ALLOW drawn benzene ring with OH.	Just OH group Hydrox**ide** group	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(b)(ii)	It could be an aldehyde or a ketone/contains a carbonyl group. ALLOW C=O.	Either aldehyde or ketone on its own	**(1)**

Question Number	Acceptable Answer	Mark
2(b)(iii)	**X** is a ketone ALLOW aromatic ketone. ALLOW R-CO-R. ALLOW not an aldehyde if both ketone and aldehyde mentioned in b(ii).	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(c)(i)	(Hydrogen atoms/protons on) benzene ring/phenyl group/arene ring.	Hydrogen atoms in phenol	**(1)**

Question Number	Acceptable Answer	Reject	Mark
2(c)(ii)	To score any marks in this question the side chain must be: (a)  OR (b)  OR (c)  Ketone on correct carbon Structure (a) or structure (c) **(1)** ALLOW displayed or skeletal ALLOW $CH_2CH_2COCH_3$ IGNORE presence or position of OH on the benzene ring  triplet triplet singlet Both triplets labelled. **(1)** Singlet labelled. **(1)**	Any other side chain scores zero for 2c(ii)	**(3)**

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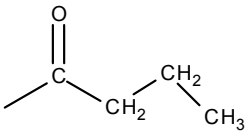
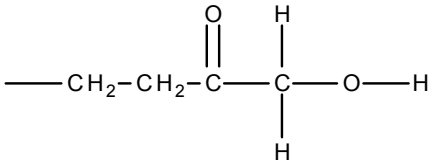
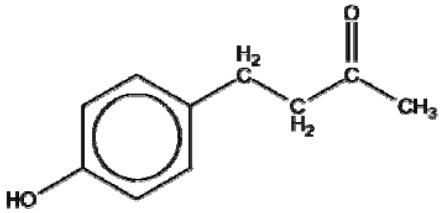
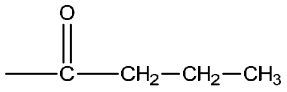
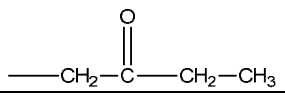
Question Number	Acceptable Answer	Mark
2(c)(ii) continued	ALLOW If the side chain is (b) the triplet CH_2 next to the C=O correctly labelled scores one mark.  triplet **(1)** If the side chain is (c) the triplets, both labelled, score the mark.  triplet triplet **(1)**	

Question Number	Acceptable Answer	Reject	Mark
2(c)(iii)	 IGNORE position of OH and side chain on the ring. ALLOW displayed or skeletal. ALLOW $C_6H_4(OH)CH_2CH_2COCH_3$. ALLOW TE if one of the following side chains is carried forward from 2c(ii):  OR 	TE for any other side chain	**(1)**

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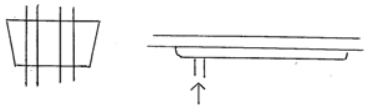
Question Number	Acceptable Answer	Reject	Mark
2(d)	Steam source with delivery tube to flask with the steam passing into the liquid in the flask. IGNORE incorrectly positioned safety vents in the steam generator. OR Flask being heated and containing water (and raspberries). **(1)** Condenser with water jacket in correct position and with correct direction of water flow shown. **(1)** Collection vessel. **(1)** Minus 1mark if apparatus does not work (e.g. sealed or leaky joints)  Correctly drawn reflux apparatus scores 1 mark. IGNORE fractionating columns. Collection vessel may be any shape of flask, test tube or cylinder.	Steam delivered above the liquid in the flask Unlabelled liquid in the flask	**(3)**

Total for Question 2 = 12 Marks

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Question Number	Acceptable Answer	Reject	Mark
3(a)(i)	Burette/(graduated/volumetric) pipette **(1)** Allows accurate/precise measurement. **(1)** OR Measuring cylinder. **(1)** Allows you to do multiple experiments quickly/accurate enough (to determine orders). **(1)** IGNORE Ease of use. Cylinder allows variety of different volumes to be measured.	Dropping/teat pipette	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(ii)	Pink/purple **(1)** To colourless **(1)** Reverse order scores 1 mark.	Lilac Clear for colourless	**(2)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(iii)	To keep the (overall) volume constant/50 cm^3 OR So the concentration of each reactant is proportional to the volume used.	Any other volume quoted	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(a)(iv)	(Monitor change in concentration of MnO_4^- using) colorimetry. OR Titrate with reducing agent/named reducing agent, e.g. Fe^{2+}.	Just observing the intensity of the colour Electrical conductivity pH meter Just 'titrate'	**(1)**

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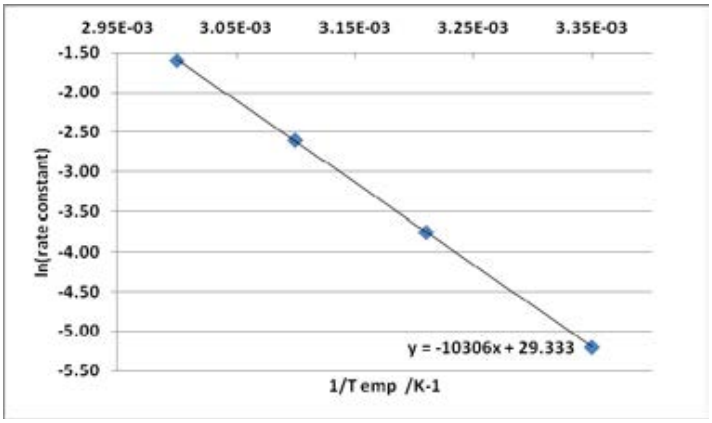
Question Number	Acceptable Answer	Reject	Mark
3(a)(v)	0 order with respect to glucose 1st order with respect to sulfuric acid 1st order with respect to potassium manganate (VII) All 3 correct scores 2 marks 2 correct scores 1 mark 0 or 1 correct scores 0 marks **(2)** Rate/r/R = $k[MnO_4^-][H^+]([C_6H_{12}O_6]^0)$ **(1)** ALLOW full formulae or names in rate equation. If formulae given they must be correct. ALLOW 'K' for 'k'. ALLOW TE from incorrect orders for last mark.	Rate equation for rate	**(3)**

Question Number	Acceptable Answer	Mark
3(b)(i)	 Suitable linear scales. **(1)** IGNORE units. Points plotted correctly. **(1)** Straight line of best fit drawn. **(1)**	**(3)**

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Question Number	Acceptable Answer	Reject	Mark
3(b)(ii)	Gradient = -10300 ALLOW any value in the range -9600 to -11000 IGNORE units even if incorrect	Positive gradient	**(1)**

Question Number	Acceptable Answer	Reject	Mark
3(b)(iii)	E_A = (-) gradient from b(ii) x 8.31 **(1)** E_A = Value to at least 2 significant figures with units. **(1)** Units must be correct. Correct value: E_A = -(-10300) x 8.31 = 85593 J mol^{-1}/85.6 kJ mol^{-1} Correct answer with no working scores both marks. Gradient / E_A/ $kJmol^{-1}$ -9600 / 79.8 -9700 / 80.6 -9800 / 81.4 -9900 / 82.3 -10000 / 83.1 -10100 / 83.9 -10200 / 84.8 -10300 / 85.6 -10400 / 86.4 -10500 / 87.3 -10600 / 88.1 -10700 / 88.9 -10800 / 89.7 -10900 / 90.6 -11000 / 91.4	Negative E_A	**(2)**

Total for Question 3 = 15 Marks

Question Number	Acceptable Answer	Reject	Mark
4(a)(i)	Any **three** from: Shake/mix. **(1)** Release pressure/open stopper (from time to time). **(1)** Remove lower/dichloromethane layer by opening tap/using teat pipette. OR Decant the top layer/remove top layer with teat pipette. To score this mark it must be clear that the bottom layer is the layer required. **(1)** Repeat extraction with additional solvent. **(1)**	Just 'add the dichloromethane' Just 'separate the liquids'	**(3)**

Question Number	Acceptable Answer	Reject	Mark
4(a)(ii)	Add named drying agent (anhydrous) calcium chloride/magnesium sulfate/sodium sulphate. **(1)** ALLOW silica gel. IGNORE desiccators. (Allow to stand) decant/filter (to separate drying agent) **(1)** Both marks are stand alone.	Sulfuric acid KOH NaOH Heat with drying Agent Dry with filter paper	**(2)**

Question Number	Acceptable Answer	Mark
4(b)(i)	Carry out in fume cupboard/hood chamber/well-ventilated lab. **(1)** IGNORE gas/face masks. Wear (protective) gloves. **(1)** IGNORE lab coat and eye protection.	**(2)**

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Question Number	Acceptable Answer	Reject	Mark
4(b)(ii)	Distillation/evaporate under reduced pressure/rotary evaporation. ALLOW fractional distillation. IGNORE recrystallisation.	Just evaporate	**(1)**

Question Number	Acceptable Answer	Reject	Mark
4(c)	CO_2 is less harmful/not harmful/ less hazardous/not hazardous/ less irritant/not irritant/ non-flammable/ non-toxic/evaporates easily/easily removed. IGNORE comments regarding ozone layer or global warming.	Just CO_2 safer/less risky	**(1)**

Question Number	Acceptable Answer	Reject	Mark
4(d)	85mg = 0.085g **(1)** % caffeine = 0.085/25 x 100 = 0.34% **(1)** ALLOW TE on incorrect mass. Correct answer alone scores both marks. IGNORE significant figures except 1 mark.	% caffeine>100%	**(2)**

Question Number	Acceptable Answer	Reject	Mark
4(e)	Recrystallisation ALLOW column chromatography. ALLOW sublimation.	Distillation	**(1)**

Total for Question 4 = 12 marks

Total for Paper = 50 marks

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Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced
Unit 6B: Chemistry Laboratory Skills II
Alternative

Friday 14 May 2010 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH08/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/7/2/

N 3 6 5 0 8 A 0 1 1 6

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Answer ALL the questions. Write your answers in the spaces provided.

1 Compound **A** is a salt containing one cation and one anion. Complete the following table by filling in the **inferences** column.

	Test	Observations	Inferences	
(a)	Observe the appearance of **A**.	**A** is a yellow crystalline solid.		**(1)**
(b)	Carry out a flame test on **A**.	Persistent bright yellow flame colour.		**(1)**
(c)	Add 5 cm^3 of dilute sulfuric acid to 0.5 g of **A**.	**A** dissolves to form an orange solution.	Ions formed are	**(1)**
(d)	To the solution obtained in (c), add about 10 drops of ethanol and warm the mixture gently.	Orange solution turns green.		**(2)**
(e)	Divide the green solution from (d) into two equal portions. To one portion add sodium hydroxide solution a little at a time until in excess.	Green precipitate forms which dissolves in excess sodium hydroxide to form a green solution.	Green precipitate is .... Green ions formed in solution are	**(2)**

	Test	Observations	Inferences	
(f)	To the second portion of the solution, add zinc powder.	The solution turns pale blue.	Pale blue ions formed are ..... Role of zinc	(2)
(g)	Filter the mixture formed in (f) to remove the excess zinc and then shake the filtrate vigorously.	The pale blue solution turns green.	Green ions formed are ..... Explanation	(2)

(Total for Question 1 = 11 marks)

2 **P** and **Q** are different organic compounds, each of which has **three** carbon atoms and only **one** functional group.

(a) Complete the table below by filling in the inferences column. In each case you should state what the test and observation tell you about the **original** compound **P**.

	Test	Observation	Inferences about compound **P**	
(i)	Add a small amount of dry phosphorus(V) chloride to 1 cm^3 of **P**.	Steamy fumes form which turn damp blue litmus paper red.		**(1)**
(ii)	Add about 2 cm^3 of sodium carbonate solution to 1 cm^3 of **P**.	No reaction occurs.		**(1)**
(iii)	Add about 2 cm^3 of sodium hydroxide solution to 10 drops of **P**. Then add a solution of iodine in potassium iodide, drop by drop, until the iodine is just in excess. Warm the mixture in a water bath.	A pale yellow precipitate with an antiseptic smell forms.		**(1)**

(iv) Use the information above to identify, by name or formula, the compound **P**.

(1)

(v) The mass spectrum of **P** has a peak at *m/e* = 45. Identify the species responsible for this peak and explain how this species is formed from **P**.

(2)

.....

.....

.....

.....

(b) Complete the table below by filling in the inferences column.

	Test	Observation	Inferences
(i)	Add a small amount of dry phosphorus(V) chloride to 1 cm^3 of **Q**.	Steamy fumes form which turn damp blue litmus paper red.	Steamy fumes are ....
(ii)	Add about 2 cm^3 of sodium carbonate solution to 1 cm^3 of **Q**.	Vigorous effervescence occurs and the gas evolved turns limewater milky.	Functional group in compound **Q** is ....

(1)

(1)

(iii) Use the information above to identify, by name or formula, the compound **Q**.

(1)

(Total for Question 2 = 9 marks)

3 The purity of a sample of iron from a blast furnace may be determined by titration. The iron is contaminated with carbon and calcium silicate.

A known mass of the impure iron is dissolved in dilute sulfuric acid to form a solution containing iron(II) ions. Portions of this solution are titrated with a solution of potassium manganate(VII) of known concentration.

The steps of the experimental procedure are as follows.

1. Approximately 1.5 g of a sample of the impure iron, in the form of a fine powder, was accurately weighed. The results are shown in **Table 1**.

2. The iron was transferred to a 250 cm^3 conical flask to which 50 cm^3 of dilute sulfuric acid (an excess) was added. The mixture was warmed to about 60 °C and then allowed to stand until the reaction was complete.

3. The mixture in step 2 was filtered and the residue was washed with a small volume of the dilute sulfuric acid.

4. All of the filtrate in step 3 was transferred to a 250 cm^3 volumetric flask. A further 50 cm^3 of the dilute sulfuric acid was added and then the volume was made up to the mark with distilled water. The resulting solution was mixed thoroughly.

5. 25.0 cm^3 portions of the solution in step 4 were transferred to clean conical flasks and titrated with a potassium manganate(VII) solution of concentration 0.0220 $mol\,dm^{-3}$. The results are shown in **Table 2**.

(a) Write an **ionic** equation for the reaction between iron and dilute sulfuric acid. State symbols are **not** required.

(1)

(b) How would you know when the reaction between the iron and the dilute sulfuric acid was complete?

(1)

.....

.....

(c) The results of the experiment are given in the tables below.

Table 1

Mass of weighing bottle + impure iron	11.22 g
Mass of empty weighing bottle	9.74 g
Mass of impure iron	1.48 g

Table 2

Solution in the burette: 0.0220 mol dm^{-3} potassium manganate(VII)
Solution in the flask: 25.00 cm^3 of solution containing iron(II) ions (step 5)

Titration number	Trial	1	2	3	4
Burette reading (final) / cm^3	30.00	23.10	24.80	24.45	23.20
Burette reading (initial) / cm^3	6.65	0.05	2.10	1.45	0.25
Titre / cm^3	23.35				
Titres used (✓or ×)	×				

(i) Complete **Table 2** by filling in the missing data. Then mark with a tick (✓) those titres that will be used in the calculation of the mean titre and mark with a cross (×) any titres that will be discarded.

(2)

(ii) Calculate the mean titre in cm^3.

(1)

(iii) The ionic half-equations for the reactions of the iron(II) ions and the manganate(VII) ions are given below.

$$Fe^{2+} \rightarrow Fe^{3+} + e^-$$

$$MnO_4^- + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$$

Calculate the mass of iron in the original sample of impure iron and hence calculate the percentage by mass of iron in the sample.

[The relative atomic mass of iron is 55.8]

(4)

(d) Name the pieces of apparatus used to measure the 25.0 cm^3 solution containing iron(II) ions in step 5 and the 50 cm^3 sulfuric acid in steps 2 and 4.

Explain why different apparatus is used in each case.

(2)

To measure 25.0 cm^3 of solution .....

To measure 50 cm^3 sulfuric acid .....

Explanation .....

.....

.....

.....

.....

(e) Suggest why it was necessary to add such a large excess of sulfuric acid.

(1)

.....

.....

.....

(f) State how you would detect the end-point of the titration.

(1)

.....

.....

(g) Explain why it is incorrect to use hydrochloric acid instead of sulfuric acid in this titration.

(2)

.....

.....

.....

.....

(Total for Question 3 = 15 marks)

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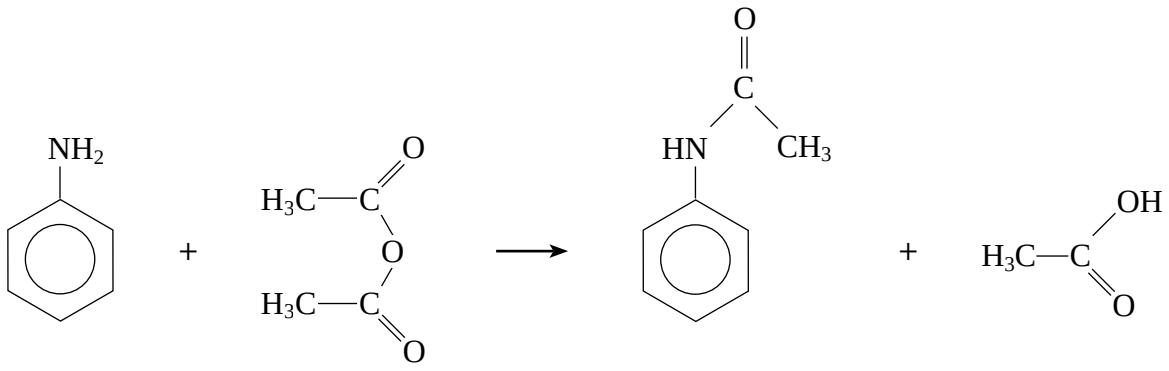
4 *N*-phenylethanamide may be prepared in the laboratory by reacting ethanoic anhydride with phenylamine; both the reactants and the products are flammable. The equation for the reaction is shown below.



***N*-phenylethanamide**

A student is asked to prepare pure *N*-phenylethanamide starting from 9.00 g of phenylamine.

(a) Calculate the minimum mass, in grams, of ethanoic anhydride required to react completely with 9.00 g of phenylamine.

[Molar masses / g mol^{-1}: $C_6H_5NH_2$ = 93.0; $CH_3COOCOCH_3$ = 102]

(2)

(b) **The steps of the experimental procedure are as follows.**

1. Mix the amount of ethanoic anhydride calculated in (a) with 10 g of glacial (pure) ethanoic acid in a round-bottom flask and add a further 1 g of the ethanoic anhydride.
2. Cool the flask from step 1 in a beaker of cold water and add 9.00 g of phenylamine, drop by drop, with gentle shaking.
3. Add anti-bumping granules and reflux the mixture from step 2 for 30 minutes.
4. Pour the liquid from the reflux flask into a beaker containing 100 cm^3 of distilled water and allow the mixture to stand until no more crystals are formed.
5. Filter the crystals under reduced pressure using a Buchner funnel and flask, washing the crystals with cold water.
6. Transfer the crystals to a boiling tube and dissolve them in the minimum volume of boiling water. Filter the hot solution using a glass filter funnel, cool the filtrate in a beaker of ice-cold water and filter the crystals formed using a Buchner funnel and flask.
7. Dry the crystals between filter papers and then by storing them in a desiccator.
8. Weigh the dry crystals and calculate the yield.

(i) Explain why, in step 1, the student is told to add a further 1 g of the ethanoic anhydride to the calculated mass so that it is in excess.

(1)

.....

.....

.....

(ii) Explain why, in step 2, the phenylamine is added drop by drop and the mixture immersed in cold water.

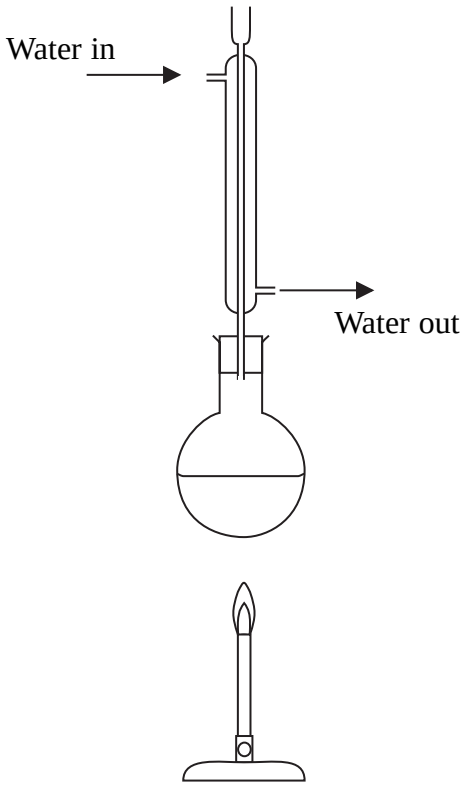
(1)

.....

.....

.....

(iii) The student set up the apparatus for the reflux (step 3) as shown in the diagram below.



The apparatus has been incorrectly set up in TWO ways. State and explain these mistakes and how they should be corrected. You may assume that the apparatus is suitably clamped and that the reaction mixture contains anti-bumping granules.

(4)

.....

.....

.....

.....

.....

.....

.....

.....

(iv) Draw a labelled diagram of a Buchner funnel and flask (step 5).

State how the reduced pressure is achieved (an explanation of this is **not** required).

(3)

Diagram

Reduced pressure is achieved by .....

.....

.....

(c) A student obtained 7.49 g of *N*-phenylethanamide from 9.00 g of phenylamine. Calculate the percentage yield.

[Molar masses / g mol^{-1}: $C_6H_5NH_2$ = 93.0; $C_6H_5NHCOCH_3$ = 135]

(2)

(d) Yields of less than 100% are often explained as being due to '**transfer losses**'.

Explain this term by referring to the recrystallization of *N*-phenylethanamide in steps 6 and 7.

(1)

.....

.....

.....

.....

(e) Another student reported a yield of greater than 100%. Assuming that the student used the correct amounts of reagents and carried out the calculation correctly, suggest a reason for this result.

(1)

.....

.....

.....

(Total for Question 4 = 15 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

N 3 6 5 0 8 A 0 1 6 1 6

PMT

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Mark Scheme (Results)
June 2010

GCE

GCE Chemistry (6CH08/01)

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Summer 2010

Publications Code UA023646

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Question Number	Acceptable Answers	Reject	Mark
1 (a)	Compound contains a transition metal (ion) / Compound contains chromate((VI)) / CrO_4^{2-} Allow any yellow salt (name or correct formula) Allow 'transition element / metal (present)' Ignore d block Ignore any cation included	Dichromate oxides Cr^{6+}	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)	Sodium (ions) present / Na^+	Na Anion	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c)	dichromate(VI) / dichromate / $Cr_2O_7^{2-}$ / $2CrO_4^{2-} + 2H^+ \rightarrow Cr_2O_7^{2-} + H_2O$ Ignore references to the other ions present (Na^+, $2H^+$, SO_4^{2-}) No TE	Cr(VI) Cr^{6+}	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (d)	$Cr_2O_7^{2-}$ / dichromate((VI))(allow Cr(VI)) is reduced (by the ethanol) / the ethanol is oxidized (by $Cr_2O_7^{2-}$ (allow Cr(VI))) / the ethanol forms ethanal / ethanoic acid **(1)** Cr^{3+} / chromium(III) / Cr(III) formed **(1)** Allow fully balanced ionic half-equation **(2)** No TE	Cr^{6+}	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (e)	**Precipitate** chromium(III) hydroxide / $Cr(OH)_3$ / $Cr(OH)_3(H_2O)_3$ **(1)** **Solution** chromate(III) / tetrahydroxochromate(III) / hexahydroxochromate(III) / $Cr(OH)_4^-$ / $Cr(OH)_6^{3-}$ **(1)** Allow hydrated forms / CrO_2^- / CrO_3^{3-} Allow chromium hydroxide if Cr^{3+} Allow $Cr(OH)_5^{2-}$ Ignore number of water ligands	Cr_2O_3 Cr^{3+} $Cr^{3+}(aq)$	**2**

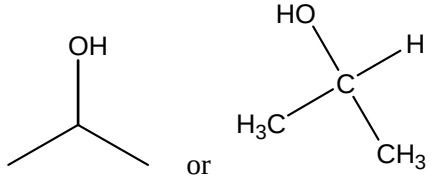
Question Number	Acceptable Answers	Reject	Mark
1 (f)	**Pale blue ions** Cr^{2+} / $Cr(H_2O)_n^{2+}$ chromium(II) / Cr(II) **(1)** **Role of zinc** Reducing agent / Reduces / Reduction / providing electrons **(1)**	Cu^{2+}	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (g)	**Green ions** Cr^{3+}/ chromium(III) / Cr(III) **(1)** **Explanation** The Cr^{2+} / chromium(II) / Cr(II) (allow 'blue species') is oxidized by (oxygen in) the air **(1)** Ignore water ligands Allow oxidized by oxygen		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(i)	OH / hydroxyl group present OR Compound could be an alcohol / OH or a carboxylic acid / COOH	Hydroxide / OH^- alcohol / carboxylic acid alone	**1**

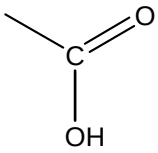
Question Number	Acceptable Answers	Reject	Mark
2 (a)(ii)	**P** is (an alcohol) not a carboxylic acid Allow **P** is an alcohol if in (a)(i) **P** is described as "an alcohol or a carboxylic acid" Ignore primary and/or secondary	Alcohol without three carbons	**1**

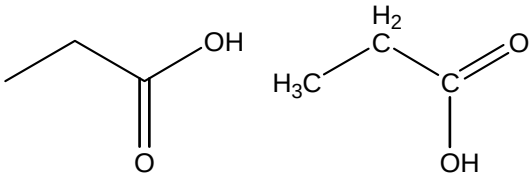
Question Number	Acceptable Answers	Reject	Mark
2 (a)(iii)	**P** contains the group $CH_3CH(OH)-$ / P is a 2-ol Allow **P** is propan-2-ol / secondary alcohol	**P** is a methylketone / ethanol / methyl alcohol	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iv)	**P** is propan-2-ol / $CH_3CH(OH)CH_3$  No TE on earlier incorrect answer	Molecular formula only	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(v)	Peak is caused by $(CH_3CHOH)^+$ / $C_2H_5O^+$ / $CH_2CH_2OH^+$ **(1)** stand alone (molecular ion (of propan-2-ol) will fragment by) loss of one CH_3 group / $CH_3^\bullet$ / CH_3 radical **(1)** Second mark can be awarded **only** if ion has relative mass of 45 Allow the molecule fragments (instead of molecular ion) Allow equations with charge not balanced	Formula without positive charge Breaking C-C bond on its own CH_3^+	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(i)	Hydrogen chloride / HCl Allow hydrochloric acid / HCl(aq)	HCl **and** $POCl_3$	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(ii)	**Q** is a carboxylic acid / COOH /  Allow CO_2H / propanoic acid / carboxylic alone	Carboxylate	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b)(iii)	**Q** is propanoic acid / CH_3CH_2COOH / $CH_3CH_2CO_2H$ / C_2H_5COOH 		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)	$Fe + 2H^+ \rightarrow Fe^{2+} + H_2$ $Fe + 2H_3O^+ \rightarrow Fe^{2+} + H_2 + H_2O$ Ignore state symbols and correct sulfate formulae	Non ionic equation	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)	Effervescence / fizzing stopped/no more bubbles of gas given off Allow no more gas given off	All iron dissolved Steamy fumes (for gas)	**1**

Question Number	Acceptable Answers	Mark
3 (c)(i)	<table><tr><td>**Titre / cm^3**</td><td>23.35</td><td>23.05</td><td>22.70</td><td>23.00</td><td>22.95</td><td>**(1)**</td></tr><tr><td>**Titres used (✓ or ×)**</td><td>×</td><td>✓</td><td>×</td><td>✓</td><td>✓</td><td>**(1)**</td></tr></table> Ignore omission of trailing zeros	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(ii)	$((23.05 + 23.00 + 22.95) \div 3) = 23.00$ (cm^3) Allow 23 / 23.0 TE from (c)(i)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(iii)	(A) Moles MnO_4^- (in titre) = 23.00 x10^{-3} x .022 = 5.06 x 10^{-4} **(1)** (B) Moles Fe^{2+} in 250 cm^3 = 10 x 5 x Answer in (A) (= 0.0253) **(1)** (C) Mass of Fe = Answer in B x 55.8 (= 0.0253 x 55.8 =1.41 (g)) **(1)** (D) % iron =100 x answer in C ÷ 1.48 (= 95.4 %) **(1)** Ignore SF except 1 SF Ignore correct intermediate rounding of calculated values Allow 56 for A_r of iron (95.7 %) Allow TE from (c)(i) and (ii) Correct answers with no working score full marks	% > 100 %	**4**

Question Number	Acceptable Answers	Reject	Mark
3 (d)	**Iron(II) ions:** Pipette and **sulfuric acid**: measuring cylinder **(1)** both needed for the mark An exact volume of iron(II) ion solution is needed but only an approximate volume of /excess sulfuric acid **(1)** The second mark may be awarded if a burette and measuring cylinder are given Allow any recognisable spelling of pipette, eg pipet	Just pipette more accurate than measuring cylinder	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (e)	To ensure that the manganate(VII) ions were fully reduced (to manganese(II)) Or To ensure MnO_2 is not precipitated Allow Large number of H^+ ions required **in (**titration) **equation** 8 moles H^+ ions required (per mol Fe^{2+} in titration) To prevent oxidation of Fe^{2+} by (oxygen in) air or by water To prevent hydrolysis	To ensure complete reaction	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (f)	First permanent pink colour Allow (colourless) solution turns pink	Purple to pink Turns purple	**1**

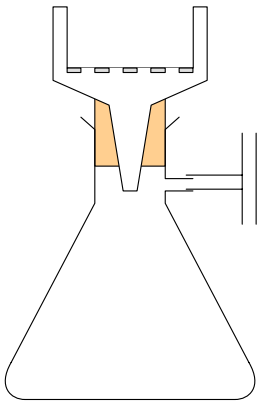
Question Number	Acceptable Answers	Reject	Mark
3 (g)	HCl / Cl^- will be oxidized (to chlorine) by the manganate(VII) **OR** HCl / Cl^- will react with manganate(VII) to form chlorine **(1)** So the reaction of the iron(II) ions with manganate(VII) will not be quantitative/titre will be too high **(1)** Allow permanganate / manganate (for manganate(VII)) Ignore references to toxicity of chlorine	HCl / Cl^- strong reducing agent / oxidised by Fe^{2+} Just chlorine formed Titration values inaccurate	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (a)	Amount of phenylamine = 9/93 / 0.0968 (mol) **(1)** = amount of ethanoic anhydride Mass ethanoic anhydride =102 x 9/93 = 9.87 (g) **(1)** Ignore SF except 1 SF Correct answer with no working scores full marks Mr values reversed scores max 1 **only** if a mole calculation is clearly shown		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (b)(i)	To ensure that all the **phenylamine** reacts	So ethanoic anhydride is in excess To ensure complete reaction	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (b)(ii)	Reaction is exothermic / produces heat Allow reaction is vigorous so that the temperature does not increase (too much) Ignore references to the reaction being violent, dangerous, explosive etc		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (b)(iii)	**Mistake:** The condenser water flow is wrong way round so air may be trapped/jacket will not be full of water **(1)** Allow cooling not so effective / flammable liquid might escape **Correction** Reverse the flow of water **(1)** **Mistake:** **Flammable** liquids are being heated with a Bunsen/naked flame **(1)** **Correction** so the Bunsen burner should be replaced by a hot plate (allow water bath) **(1)** **OR** **Mistake:** Heating with a Bunsen **too strong** (so glass may crack) **(1)** **Correction** Use micro-burner/gauze **(1)**		**4**

Question Number	Acceptable Answers	Reject	Mark
4 (b)(iv)	 Funnel (conical allowed) with grid / line / horizontal filter paper **(1)** Side-arm conical flask (with valve or connection to a pump) **(1)** **Reduced pressure achieved by:** Flow of water through the pump/valve/can be shown in diagram (reduces pressure in the flask) **(1)** Allow using a (vacuum / suction) pump connected to side-arm (connection may be shown in diagram)**(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
4 (c)	Mass of N-phenylethanamide if 100% yield = 135 x 9/93 **(1)** = 13.06 g Yield = 100 x 7.49/13.06 = 57.3 % **(1)** **Alternatively** Moles phenylamine =9/93 = 0.0968 Moles N-phenylethanamide = 7.49/135 = 0.0555 **(1)** Yield = 100 x .0555/.0968 = 57.3 % **(1)** Correct answer with no working scores **(2)** Ignore sf except 1 sf Yields greater than 100 % score zero	100 x 7.49/9 = 83.2 % (0)	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (d)	Some of the *N*-phenylethanamide will remain on the filter paper/will be deposited on the sides of the glassware/in solution (and will not be recovered by filtration)		**1**

Question Number	Acceptable Answers	Reject	Mark
4 (e)	The product was not dry / was damp / water (still) present Ignore reference to impurities present		**1**

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Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced
Unit 6B: Chemistry Laboratory Skills II
Alternative

Wednesday 19 January 2011 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH08/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/5/2/2/

N 3 7 9 5 5 A 0 1 1 2

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Answer ALL the questions. Write your answers in the spaces provided.

1 Compound **X** is a coloured hydrated salt, containing two cations and one anion, which dissolves in water to give a coloured solution.

(a) What can you infer from the fact that compound **X** is coloured?

(1)

.....

(b) Compound **X** contains potassium ions. State what you would see when a flame test is performed on **X**.

(1)

.....

(c) The following tests are performed on an aqueous solution of **X**.
Complete the 'Inference(s)' column in the following table.

	Test	Observation(s)	Inference(s)	
(i)	Acidify with hydrochloric acid; add barium chloride solution.	White precipitate	Formula of the white precipitate	**(1)**
(ii)	Add sodium hydroxide solution until in excess.	Grey-green precipitate which is soluble in excess sodium hydroxide to give a deep green solution	Formula of the grey-green precipitate ..... Formula of the deep green ion	**(1)** **(1)**
(iii)	Make alkaline with sodium hydroxide solution; add hydrogen peroxide solution and boil.	Yellow solution	Formula of the yellow ion	**(1)**
(iv)	Acidify the solution from (iii) with dilute hydrochloric acid.	Orange solution	Formula of the orange ion	**(1)**
(v)	Add ethanol to the product from (iv) and distil off organic product **Y** as it is formed.	Orange solution turns green	Formula of the green ion	**(1)**

(d) Compound **X** contains z moles of water of crystallization per mole of compound.
On the basis of your results, complete the formula for compound **X**.

(1)

..... . zH_2O

(e) The organic product **Y** from test (c)(v) is an aldehyde. It was tested as shown in the table below. State the observations that you would make.

	Test	Observation(s)	
(i)	Addition of 2,4-dinitrophenylhydrazine solution (Brady's reagent).		**(1)**
(ii)	Addition of Tollens' reagent (ammoniacal silver nitrate solution).		**(1)**

(Total for Question 1 = 11 marks)

2 The derivation of rate equations is an important part of the process of discovering a reaction mechanism.

The experiment detailed in this question is part of an investigation into the mechanism of the iodination of propanone:

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

The reaction is catalysed by hydrogen ions. The rate equation is

$$\text{rate} = k[CH_3COCH_3]^a \ [H^+]^b \ [I_2]^c$$

where a, b and c are the orders with respect to the species shown in the rate equation.

The experiment is carried out as follows:

1. Propanone, hydrochloric acid and water are placed in a flask in a constant-temperature water bath.

2. Once the temperatures of the mixture and the bath have come to equilibrium, a solution of iodine in potassium iodide is added by pipette and a clock started.

3. At suitable time intervals, a known volume of reaction mixture is transferred using a pipette into a series of flasks, numbered 1 to 6. Each flask contains sodium hydrogencarbonate solution which quenches the reaction.

4. The mixture in each of the flasks is titrated with a standard solution of sodium thiosulfate.

The equation for the reaction of iodine with thiosulfate ions is

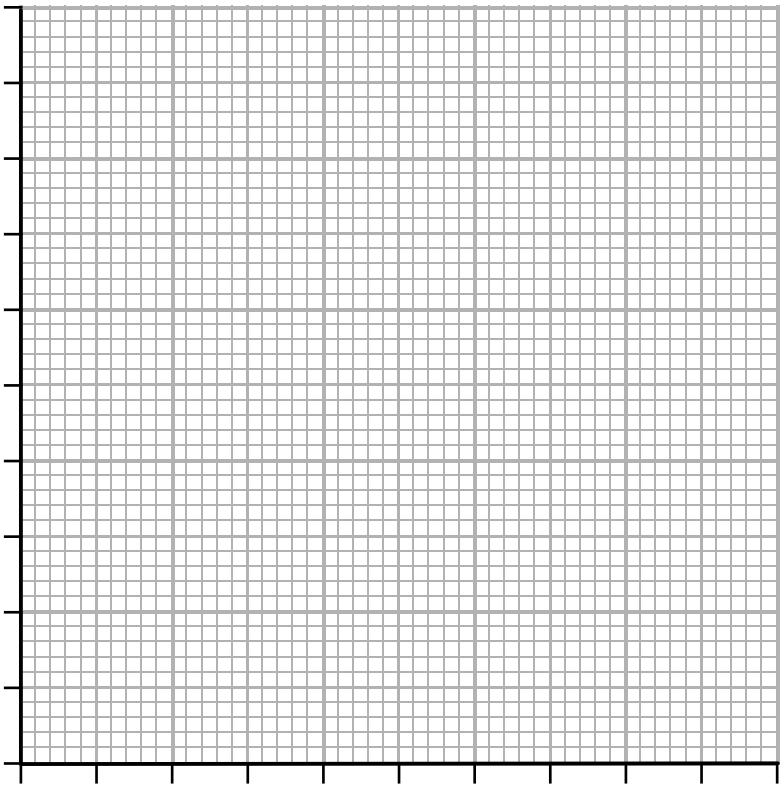
$$I_2(aq) + 2S_2O_3^{2-}(aq) \rightarrow 2I^-(aq) + S_4O_6^{2-}(aq)$$

(a) The following data were obtained from an experiment carried out at 25 °C.

Flask number	1	2	3	4	5	6
Time / min	3	6	9	12	15	18
Volume of sodium thiosulfate / cm^3	16.8	13.9	10.8	7.8	5.4	2.7

(i) Plot a graph of the volume of sodium thiosulfate solution against time.

(4)



(ii) The graph enables the determination of the order of reaction with respect to iodine. Explain why it is not necessary to calculate the actual concentration of the iodine in this experiment.

(1)

.....

.....

.....

(iii) The propanone and the hydrochloric acid are used in large excess in the reaction. Explain why this is necessary in order to find the value of *c*, the order with respect to iodine, in the rate equation.

(2)

.....

.....

.....

.....

(iv) State, with a reason, the value of c.

(2)

(b) (i) Name the indicator used in the iodine-thiosulfate titration and describe the colour change at the endpoint.

(2)

(ii) The indicator is not added at the start of the titration. State at which stage of the titration you would add the indicator.
Explain why it is not added at the start.

(2)

(c) Explain why the titres obtained at 15 and at 18 minutes are the least accurate.

(1)

(d) In another similar experiment, the concentration of propanone was doubled and as a result the gradient of the graph also doubled. Deduce the value of a, the order with respect to propanone in the rate equation, and justify your answer.

(2)

(e) Suggest, with a reason, another practical technique which can be used to follow the progress of the reaction

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

(2)

.....

.....

.....

.....

(Total for Question 2 = 18 marks)

3 Azo dyes are made in large quantities from benzene, C_6H_6, via nitrobenzene, $C_6H_5NO_2$, and phenylamine, $C_6H_5NH_2$.

(a) The preparation of nitrobenzene requires benzene to be warmed under reflux at about 55 °C with a mixture of concentrated nitric and sulfuric acids. Some information about these substances is given below:

Benzene: immiscible with water; highly flammable; extremely toxic by ingestion or inhalation; known carcinogen.

Concentrated nitric acid: miscible with water; causes severe burns to eyes and skin; strong oxidizing agent. The acid contains about 30% water by volume.

Concentrated sulfuric acid: miscible with water; causes severe burns to eyes and skin; strong oxidizing agent; dilution with water is very exothermic and can be dangerous.

(i) Nitric acid is placed in a suitable flask and sulfuric acid is added slowly with cooling of the flask. Explain why cooling is necessary.

(2)

(ii) Benzene is added slowly to the acid mixture, which is then warmed at 55 °C for 45 minutes under reflux with vigorous stirring of the reaction mixture.

Explain why the reflux condenser is necessary and also why the mixture is vigorously stirred.

(2)

(iii) State, with a reason, **one** other precaution (other than wearing a laboratory coat or safety goggles) that would be necessary when undertaking this preparation.

(2)

(iv) The reaction mixture is then poured into a large excess of cold water, the liquid nitrobenzene layer is separated and washed with sodium carbonate solution. Explain why this washing is necessary.

(1)

.....

.....

(v) The nitrobenzene layer is dried before being finally distilled to purify it. Identify a suitable drying agent.

(1)

.....

.....

(vi) Draw the apparatus used to distil the nitrobenzene and collect the fraction boiling between 207 °C and 211 °C.

(4)

(b) Nitrobenzene is then reduced to phenylamine, $C_6H_5NH_2$, and the phenylamine is diazotized by reaction with nitrous acid at a temperature between 0 °C and 10 °C. Nitrous acid is generated in the reaction mixture from sodium nitrite and hydrochloric acid. Reaction of the diazonium compound with an alkaline solution of a phenol will produce a solid azo dye, which is purified by recrystallization.

(i) Explain why nitrous acid is made in the reaction mixture rather than being obtained from a chemical supplier.

(2)

(ii) Explain why the temperature must not be lower than 0 °C nor higher than 10 °C.

(2)

(c) Purification by recrystallization requires the following steps:

1. The azo dye is dissolved in a minimum volume of hot solvent.
2. The solution is filtered hot through a pre-heated funnel.
3. The solution is cooled and filtered using a Buchner funnel.
4. The solid is washed with a small amount of cold solvent.
5. The solid is dried in a desiccator.

(i) Explain why a **minimum** volume of hot solvent is used in step 1.

(1)

(ii) Explain the purpose of step 2 and why the funnel must be pre-heated.

(2)

.....

.....

.....

.....

(iii) Explain the purpose of step 4.

(1)

.....

.....

.....

(iv) Suggest a reason why it is preferable to dry the solid in a desiccator rather than in an oven.

(1)

.....

.....

(Total for Question 3 = 21 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

N 3 7 9 5 5 A 0 1 2 1 2

PMT

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Mark Scheme (Results)
January 2011

GCE

GCE Chemistry (6CH08/01)

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January 2011

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear

  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter

  iii) organise information clearly and coherently, using specialist vocabulary when appropriate.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1 (a)	Transition metal compound / transition metal ion ALLOW *d*-block compound / d-block ion	Any specific ion; transition **metal;** transition **element;** d-block **element.**	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)	Lilac ALLOW mauve or pale purple or violet		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c) (i)	$BaSO_4$ Ignore any state symbols		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c) (ii)	$Cr(OH)_3$ OR $[Cr(OH)_3(H_2O)_3]$ OR $[Cr(H_2O)_3\ (OH)_3]$ **(1)** $Cr(OH)_6^{3-}$ **(1)**	 $Cr(OH)_4^-$; CrO_3^{3-}	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (c) (iii)	CrO_4^{2-}		**1**

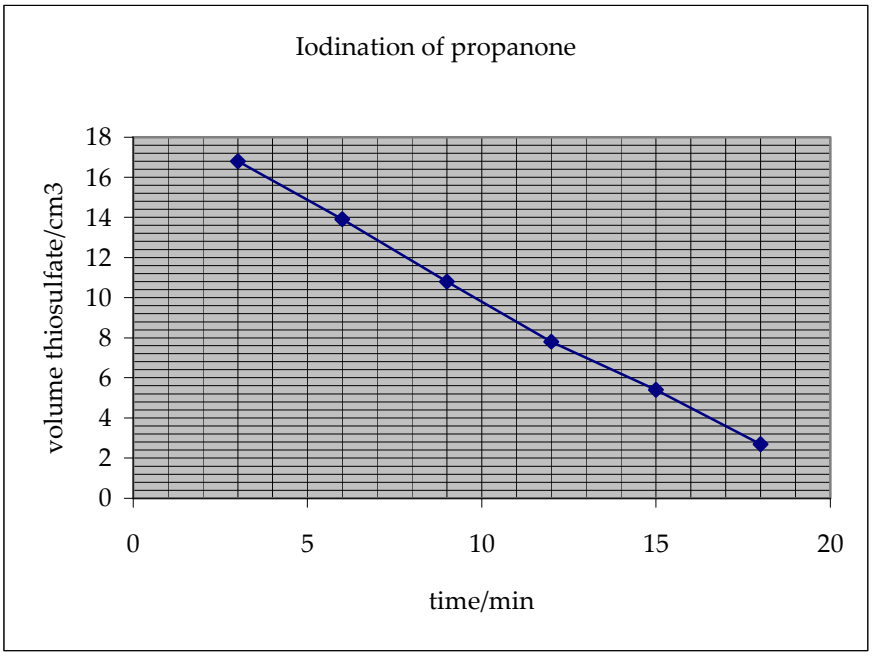
Question Number	Acceptable Answers	Reject	Mark
1 (c) (iv)	$Cr_2O_7^{2-}$	Cr^{3+}	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (c) (v)	$[Cr(H_2O)_6]^{3+}$ OR Cr^{3+} **Max 3 if names given instead of formulae for all parts of (c)**		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (d)	$K_2SO_4.Cr_2(SO_4)_3.zH_2O$ (ALLOW z = 24) OR $KCr(SO_4)_2.zH_2O$ (ALLOW z = 12) OR $K_2Cr_2(SO_4)_4.zH_2O$ (ALLOW z = 24)	P for K $KCrS_2O_8$	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (e) (i)	Yellow / orange / orange-red **precipitate** ALLOW yellow / orange **solid**	red	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (e) (ii)	Silver (mirror OR precipitate OR solid) OR black precipitate/solid		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (i)	 labelled axes **(1)** units do not have to be shown sensible graduations **(1)** points correctly plotted **(1)** suitable best-fit straight line **(1)** not a curve or point-to-point. Ignore any extrapolation beyond the end two points.		**4**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (ii)	The concentration of iodine is proportional to the titre		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (iii)	Propanone and hydrogen ion concentrations are approximately constant during the reaction **(1)** the order (observed is therefore) that of the iodine alone **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a) (iv)	(Straight line shows) rate is independent of concentration OR rate is constant OR gradient is constant **(1)** zero order **(1)** stand-alone		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (i)	Starch (solution) **(1)** blue OR black OR blue-black solution turns colourless **(1)** colour **change needed**		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b) (ii)	When the solution is pale yellow / straw coloured **(1)** starch not added initially because it forms an **insoluble** complex / compound / substance **(1)**	near OR at endpoint	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (c)	Titres are small **so** the relative / percentage error is high(er)	Points are not on the line	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)	One OR first order **(1)** stand alone (because) doubling its (constant) concentration in the rate equation also doubles the rate **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (e)		Dilatometry	**2**

Technique **(1)**	Reason **(1)**
Colorimetry	Iodine is coloured
Conductivity	Increase in concentration of ions
ALLOW	
pH	Increase in concentration of hydrogen ions
Acid base titration	Increase in concentration of hydrogen ions
Silver nitrate titration	Increase in concentration of Iodide ions

Question Number	Acceptable Answers	Reject	Mark
3 (a) (i)	To avoid the temperature rising too much OR the reaction is exothermic **(1)** as the sulphuric acid is diluted by the water in nitric acid **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (ii)	Prevents escape of benzene / volatile liquids **(1)** reactants are **immiscible/do not mix/form separate layers** (so they need to be stirred to make reaction rate acceptable) **(1)**	Escape of non-volatile liquid; escape of H_2SO_4	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (iii)	EITHER benzene is toxic **(1)** so use fume cupboard **(1)** OR benzene is harmful by skin absorption **(1)** so wear gloves **(1)** OR acids corrosive **(1)** so wear gloves **(1)** OR Benzene / nitrobenzene is flammable **(1)** so use heating mantle / water bath **(1)** The method and the reason must be linked for both marks.	Lab coats / goggles	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (iv)	Sodium carbonate removes / neutralizes (residual) acid		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (v)	(anhydrous) sodium sulphate / magnesium sulphate OR (anhydrous) calcium chloride OR silica gel	(Anhydrous) Copper sulphate; cobalt chloride; conc H_2SO_4.	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a) (vi)	Distillation flask + heat (the word, or sand- or oil-bath, or mantle) **(1)** thermometer + still-head **(1)** thermometer should be in approximately the correct place air condenser / water condenser (ignore direction of water flow) **(1)** receiver **(1)** Allow correct fractional distillation apparatus. apparatus badly drawn **- 1** apparatus closed **- 1** Reflux apparatus correctly drawn scores **(1)** only.	Water bath Thermometer on the liquid	**4**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (i)	Unstable / decomposes (easily) **(1)** At room temperature / cannot be stored / transported (from supplier) **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (ii)	< 0 °C reaction is too slow **(1)** ALLOW mixture freezes > 10 °C diazonium compound decomposes / hydrolyses **(1)**	low yield evaporates	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c) (i)	To prevent (much of the) azo dye remaining in solution on cooling OR Gives a saturated solution	maximize yield	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c) (ii)	Removes **insoluble** impurities **(1)** to prevent crystallization (of the azo dye) **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c) (iii)	Removes **soluble** impurities (from crystal surface)		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c) (iv)	Decomposition could occur if the compound were to be heated OR compound might melt		**1**

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Edexcel GCE

Chemistry

Advanced
Unit 6B: Chemistry Laboratory Skills II
Alternative

Tuesday 7 June 2011 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH08/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P38481A

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7/7/5/2/

P 3 8 4 8 1 A 0 1 1 2

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Answer ALL the questions. Write your answers in the spaces provided.

1 Solid **W** is a blue salt containing a transition metal complex cation and one anion.

(a) Give the formulae of **two** different transition metal ions which can form blue complex cations.

(2)

.....

(b) Complete the following table.

	Test	Observation	Inference(s)	
(i)	Heat compound **W**.	.....	Water	**(1)**
(ii)	Test any gas evolved with moist red litmus paper.	Red litmus paper turns blue	.....	**(1)**

(iii) Suggest **two** sources of the water which was given off when a pure dry sample of **W** was heated.

(2)

.....

.....

(c) The following tests are carried out on **separate** portions of an aqueous solution of **W**.

Complete the table.

Note: in the third column, the **formula** of the ion, molecule or compound giving rise to the observation is required.

	Test	Observation	**Formula**	
(i)	Add concentrated hydrochloric acid slowly,	..... -coloured precipitate	$Cu(OH)_2$	**(1)**
	until in excess.	green-yellow solution	.....	**(1)**
(ii)	Acidify with dilute hydrochloric acid and then add barium chloride solution.	white precipitate	.....	**(1)**
(iii)	Add dilute sulfuric acid until the solution is pale blue; then add potassium iodide solution.	white precipitate	.....	**(1)**
		in a brown solution	.....	**(1)**

(d) Suggest the **formula** of the complex cation in an aqueous solution of compound **W**.

(1)

.....

(Total for Question 1 = 12 marks)

2 The tertiary halogenoalkane 2-chloro-2-methylpropane reacts with hydroxide ions in solution as follows:

$$(CH_3)_3CCl + OH^- \rightarrow (CH_3)_3COH + Cl^-$$

The progress of the reaction can be followed by titrating the reaction mixture with a solution of hydrochloric acid of known concentration.

In an experiment designed to determine the order of the reaction, the following procedure was used.

1. 250 cm^3 of an ethanolic solution of 2-chloro-2-methylpropane, of concentration 0.100 mol dm^{-3}, was placed in a flask in a water bath at 25 °C. 250 cm^3 of aqueous sodium hydroxide solution, also of concentration 0.100 mol dm^{-3}, was placed in a similar flask in the same water bath. The temperature of the solutions was allowed to reach 25 °C.
2. A series of conical flasks were prepared, each containing about 40 cm^3 of propanone.
3. The reaction was started by mixing the halogenoalkane solution and the sodium hydroxide solution in a large flask in the water bath. A clock was started as the solutions were mixed.
4. At intervals, a 25 cm^3 pipette was used to withdraw samples of the reaction mixture. Each sample was added to a flask containing propanone and the time was noted. The propanone slows but does not completely stop the reaction.
5. Each sample was titrated immediately with a solution of hydrochloric acid of concentration 0.0500 mol dm^{-3}, using methyl orange as the indicator.

(a) (i) What colour change would you see at the end point of the titration?

(1)

.....

(ii) Explain why it is necessary to titrate the samples **immediately** after they have been withdrawn from the reaction mixture. State the effect, if any, on the titre if this were not done.

(2)

.....

.....

.....

(b) Suggest why it is necessary to use a solvent of aqueous ethanol rather than water alone for this reaction.

(1)

.....

.....

.....

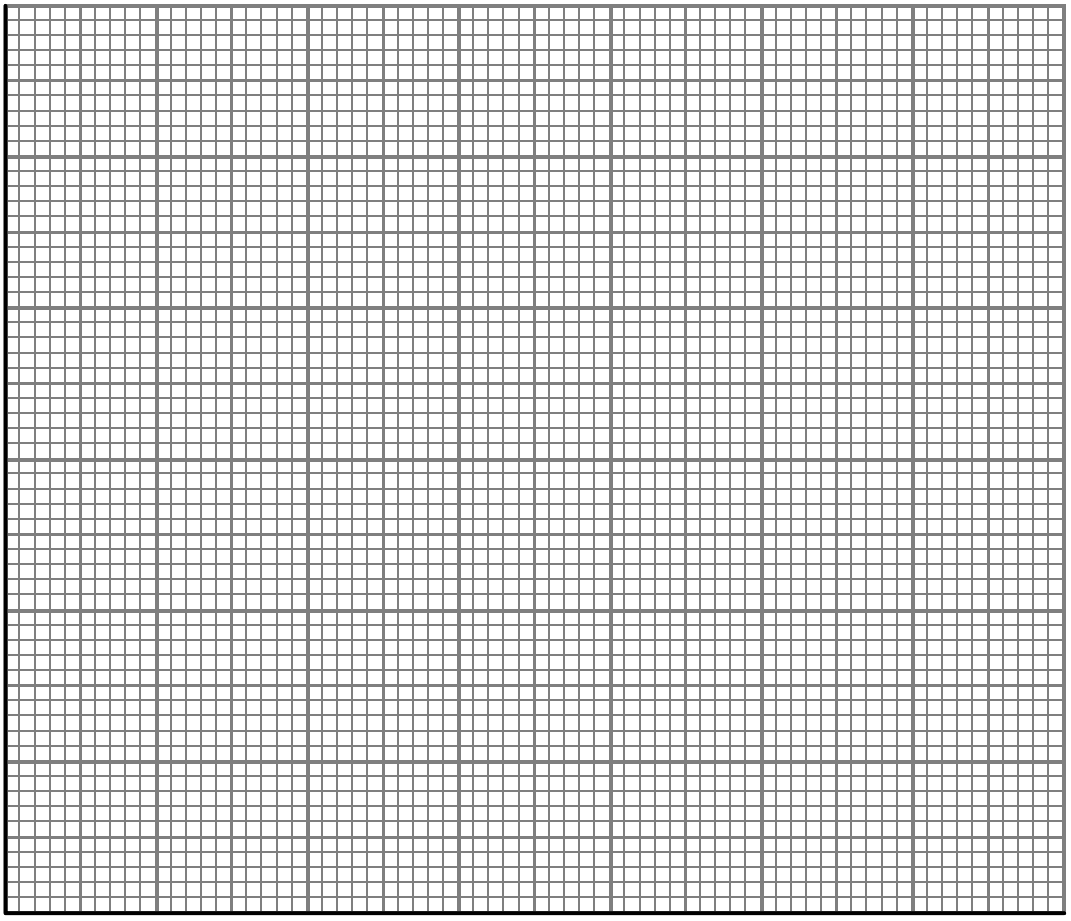
(c) In an experiment which was carried out as described above, the following data were obtained.

Time/min	1	5	12	20	32	49	65
Volume of HCl/cm^3	25.5	22.5	18.5	15.5	11.5	8.0	5.5

(i) Using the axes below, plot a suitable graph of these data.

(2)

Volume of HCl/cm^3



Time/min

(ii) Show **two** successive half-life measurements on your graph and write their values below.

(2)

First half-life .....

Second half-life .....

(iii) Explain how your answers to (ii) show that this reaction is first order.

(1)

.....

.....

(iv) Give the units of the rate constant for this reaction.

(1)

.....

(v) Because the initial concentrations of the reactants are the same, it is not possible to tell whether the rate equation is of the form

$$\text{rate} = k[(CH_3)_3CCl]$$

or of the form $\text{rate} = k[OH^-]$

Suggest a further experiment which could be carried out to show that it is in fact first order with respect to the halogenoalkane.

(2)

.....

.....

.....

(d) In a further experiment to investigate the hydrolysis, a solution of 2-chloro-2-methylpropane in aqueous ethanol was prepared at room temperature. The pH of this solution was measured at intervals using narrow-range pH paper. The reaction occurring is

$$(CH_3)_3CCl + H_2O \rightarrow (CH_3)_3COH + H^+ + Cl^-$$

(i) Suggest what the initial pH of the mixture would be. Justify your answer.

(1)

.....

.....

(ii) The pH rapidly falls to 2 or lower. Explain why this confirms that the rate of the hydrolysis of 2-chloro-2-methylpropane is independent of the hydroxide ion concentration in the reaction

$$(CH_3)_3CCl + OH^- \rightarrow (CH_3)_3COH + Cl^-$$

(2)

(iii) Assuming that the reaction rate follows the rate equation

$$\text{rate} = k[(CH_3)_3CCl]$$

write the equation for the rate-determining step.

(2)

(Total for Question 2 = 17 marks)

3 Propyl ethanoate is an ester which has a smell similar to that of bananas or pears. It can be made in the laboratory from propan-1-ol and ethanoic acid. The equation for the reaction is

$$CH_3COOH + CH_3CH_2CH_2OH \rightleftharpoons CH_3COOCH_2CH_2CH_3 + H_2O$$

Procedure

1. Propan-1-ol (50 cm^3) and ethanoic acid (50 cm^3) are mixed thoroughly in a 250 cm^3 round-bottomed flask.
2. Concentrated sulfuric acid (10 cm^3) is added drop by drop to the mixture, keeping the contents of the flask well-shaken and cooled in an ice-water bath.
3. When the acid has all been added, a reflux condenser is fitted to the flask and the mixture gently boiled over an electric heating mantle for about 30 minutes.
4. The mixture is cooled, and the apparatus rearranged for distillation. The crude ester (about 60 cm^3) is distilled off.
5. The distillate is placed in a separating funnel and shaken with about half its volume of 30% sodium carbonate solution, with the pressure being released at intervals. The lower aqueous layer is then discarded.
6. The crude ester is shaken in a separating funnel with about half its volume of 50% calcium chloride solution, which removes unreacted alcohol. The lower layer is discarded.
7. The ester is run into a clean, dry flask containing some anhydrous calcium chloride and swirled.
8. The ester is filtered into a clean, dry flask, with a few anti-bumping granules, and distilled. The fraction boiling between 100 °C and 103 °C is collected.

(a) (i) Explain why the concentrated sulfuric acid is added slowly with **cooling**.

(1)

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.....

.....

(ii) Explain why the mixture is heated **under reflux** for **about 30 minutes**.

(2)

Under reflux.....

.....

For about 30 minutes.....

.....

(iii) What is the **main** function of the sulfuric acid in this reaction?

(1)

.....

(iv) Suggest the identity of **two** impurities that might be present in the crude distillate from step 4.

(2)

.....

.....

(v) What data would you need about propyl ethanoate to be sure that the instruction in step 5 to discard the lower layer is correct?

(1)

.....

(vi) Step 5 requires that you release the pressure at intervals. Explain why the pressure in the funnel increases.

(2)

.....

.....

.....

.....

(vii) Explain why anhydrous calcium chloride is added in step 8 and state how the appearance of the liquid changes when this stage is complete.

(2)

.....

.....

.....

.....

(viii) What is the reason for adding anti-bumping granules in step 8?

(1)

.....

.....

(b) (i) Use the data in the table below to show, by calculating the numbers of moles, which reactant is in excess.

(2)

Substance	Density / g cm^{-3}	Molar mass / g mol^{-1}
Ethanoic acid	1.05	60.1
Propan-1-ol	0.804	60.1

(ii) The mass of the ester collected was 35.0 g. Calculate the percentage yield of the ester propyl ethanoate.

Assume the molar mass of propyl ethanoate is 102 g mol^{-1}.

(2)

(c) A student who carried out this experiment, according to the instructions, obtained a product that boiled at 95 °C. The student suspected that the alcohol originally provided was not propan-1-ol, but was 2-methylpropan-2-ol, since that would have given an ester with this boiling temperature.

(i) Draw the structural formula for the ester that is formed from the reaction of ethanoic acid with 2-methylpropan-2-ol.

(1)

(ii) Suggest a simple test-tube experiment that the student could carry out on the original alcohol to see if the suspicion could be correct. Give the reagents used and the expected result for both propan-1-ol and 2-methylpropan-2-ol. Explain why the results are different.

(4)

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(Total for Question 3 = 21 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
																	(18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

* Lanthanide series

* Actinide series

P 3 8 4 8 1 A 0 1 2 1 2

PMT

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Mark Scheme (Results)

June 2011

GCE Chemistry (6CH08) Paper 01
Chemistry Laboratory Skills (WA)

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June 2011
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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1 (a)	**Two** of Cu^{2+},Cr^{2+}, Co^{2+}, Ni^{2+} **(2)** ALLOW $[Cr(H_2O)_6]^{2+}$; $[Cu(H_2O)_6]^{2+}$; $[Cu(H_2O)_4]^{2+}$, $[Cu(NH_3)_4]^{2+}$, $[Cu(H_2O)_2(NH_3)_4]^{2+}$ $[Ni(NH_3)_6]^{2+}$, $[Ni(NH_3)_4]^{2+}$, $[Co(H_2O)_6]^{2+}$ any other blue **complex** ion e.g. VO^{2+}. If **two** correct names are given award **(1)** Two different ammines (different number of ammonia ligands) of the same metal ion **(1)** only Ignore any names	Any blue **compound** containing these ions.	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(i)	Steam / water vapour / colourless liquid on (cool parts of) test tube	Any test for water vapour, e.g. $CoCl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(ii)	Ammonia / **contains** ammonium (ion)/ammonium salt/ammonia ligand/ethylenediamine (ligand) ALLOW correct formulae		**1**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(iii)	Water evolved could come from hydration / water of crystallization **(1)** or from ligand water **(1)** which could be shown in a formula	The crystals are damp	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(i)	(Any) blue **(1)** $CuCl_4^{2-}$ / $CuCl_3^-$ **(1)**	$CuCl_2$; names	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (c)(ii)	$BaSO_4$	Barium sulphate, SO_4^{2-}	**1**

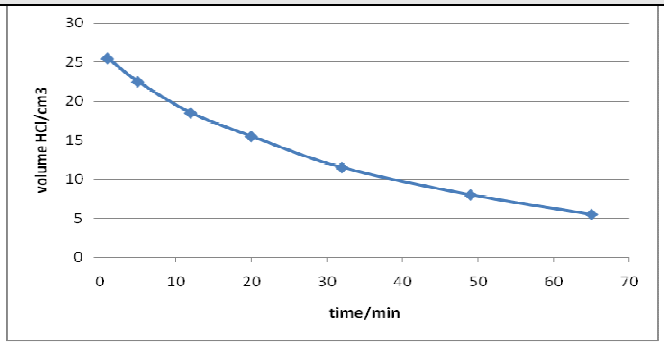
Question Number	Acceptable Answers	Reject	Mark
1 (c)(iii)	CuI / Cu_2I_2 **(1)** I_2 / I_3^- **(1)** If names correctly given allow **(1)**	Copper(I) iodide, CuI_2 Iodine	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (d)	$[Cu(NH_3)_x(H_2O)_{6-x}]^{2+}$, x = 1 – 4 ALLOW the following: x = 5 or 6 $[Cu(NH_3)_4]^{2+}$ $[Cu(H_2O)_2(NH_3)_4]^{2+}[SO_4^{2-}]$ but **both** charges must be present	$[Cu(H_2O)_2(NH_3)_4]SO_4$	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(i)	Yellow to orange **(1)** must have colour change	Red as final colour	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (a)(ii)	(Propanone) slows (but does not stop) reaction **(1)**; there must be an implication of the rate falling (so if flask is left,) titre would be too low **(1)** as stand-alone mark	Reaction stops; reaction keeps on going	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (b)	**Halogenoalkane/organic compound:** immiscible with / insoluble in water OR form two layers with water OR more soluble in ethanol than in water	Ethanol a better solvent	**1**

Question Number	Acceptable Answers	Mark
2 (c)(i)	 Sensible scale and points correct **(1)** Smooth / best fit line **(1)**	**2**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(ii)	27 (min) **(1)** 29 (min) **(1)** Consequential on the graph. Sum of half-lives for second value award first mark only		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(iii)	(reaction is first order because) half-life is constant/half-lives are the same/half-lives are similar. **Stand-alone** independent of (c)(ii)		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(iv)	min^{-1} ALLOW s^{-1}		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c)(v)	Increase concentration of halogenoalkane (keeping all other conditions the same) **(1)** show that the rate increases **proportionally (1)** OR increase concentration of hydroxide ions (keeping all other conditions the same) **(1)** show that the rate is the same **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (d)(i)	**pH 7** because no acid is present **ALLOW:** water **only** is present pH value must be present for credit	Neutral	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)(ii)	Hydrolysis is rapid in the absence of (added) hydroxide ions/in very low concentration of hydroxide ions/in water alone **(1)** **thus** $[OH^-]$ does not affect the rate **(1) conditional** on the first mark		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (d)(iii)	$(CH_3)_3C\text{-}Cl \rightarrow (CH_3)_3C^+ + Cl^-$ correct carbocation **(1)** remainder of the equation correctly balanced **(1)** If the whole of the mechanism is given mark the first step only and ignore all else.		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	Prevents splashing (of acid) / prevents mixture getting hot/prevents loss of volatile compounds OR Reaction exothermic / vigorous		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	Under reflux: Prevents **loss of** reactants / products / reaction mixture / volatile substances / flask contents **(1)** For about 30 minutes: Reaction is slow / has high E_a / to allow **equilibrium** to be reached / to allow maximum yield **(1)**	Goes to completion	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iii)	Catalyst / lowers activation energy ALLOW references to removing water	Solvent	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iv)	Any **two** from: water propan(-1-)ol / alcohol ethanoic acid sulphuric acid **(2)**	Ethanol or other incorrect alcohol	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(v)	Density		**1**

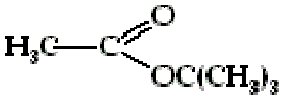
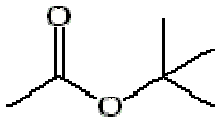
Question Number	Acceptable Answers	Reject	Mark
3 (a)(vi)	**Acid/**sulphuric acid/ethanoic acid reacts with sodium carbonate **(1)** giving carbon dioxide gas **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(vii)	Removes water/drying agent **(1)** becomes clear **(1)**	dehydrating agent becomes colourless	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(viii)	Ensures smooth boiling / even boiling / even heating (of liquid)	Prevents bumping alone; safe boiling	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	Mass of ethanoic acid = 50 x 1.05 = 52.5(g) Moles of ethanoic acid = 52.5 / 60.1 = 0.874 **(1)** Mass of propan-1-ol = 50 x 0.804 = 40.2(g) Moles of propan-1-ol = 40.2 / 60.1 = 0.669 **(1)** Ignore sig fig except 1, penalize once. ALLOW (1) if one correct mass calculated. If a statement is made that propan-1-ol is in excess give **(1)** if there are words to show that the moles of each substance have been calculated correctly. If there are numbers but no words then **(0)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b) (ii)	Max. mass of ester is 0.669 x 102 = 68.2(g) **(1)** % yield 100 x 35 / 68.2 = 51.3(%) **(1)** ALLOW 51.2 or 51.0 or 51 depending on their rounding if the working is correct ALLOW max. 1 if the moles of ethanoic acid are used giving: 0.874 x 102 = 89.1(g), 100 x 35 / 89.1 = 39.3(%)		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (c) (i)	 **(1)** Accept CH_3- etc **OR**  **OR** $CH_3COOC(CH_3)_3$ **OR** $CH_3CO_2C(CH_3)_3$		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c) (ii)	EITHER: Add alcohol to **acidified** potassium dichromate((VI)) solution (and heat) **(1)** propan-1-ol gives colour change orange to green **(1)** (both colours needed) 2-methylpropan-2-ol shows no colour change/ stays orange **(1)** primary alcohols can be oxidized OR tertiary alcohols cannot **(1)** Second mark could be awarded for the use of Tollens'/Benedict's on the reaction **product** with the correct result. OR: Add alcohol to **acidified** potassium manganate((VII)) solution (and heat) **(1)** propan-1-ol gives colour change purple to colourless **(1)** (both colours needed) 2-methylpropan-2-ol shows no colour change/ stays purple **(1)** primary alcohols can be oxidized whereas tertiary alcohols cannot **(1)** OR: Add alcohol to conc HCl solution **(1)** and zinc chloride **(1)** propan-1-ol shows no change / turns milky very slowly **(1)** 2-methylpropan-2-ol turns milky quickly **(1)** Allow the 'milky' mark in the answer for either alcohol. Can be milky/turbid/forms two phases.	Iodoform reaction gives no reaction gives no reaction Precipitate for milky	**4**

TOTAL FOR PAPER = 50 MARKS

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Edexcel GCE

Chemistry

Advanced

Unit 6B: Chemistry Laboratory Skills II Alternative

Monday 16 January 2012 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
6CH08/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P35988A

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7/7/5/5/3/

P 3 5 9 8 8 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 Three compounds **A**, **B** and **C** are subjected to a series of chemical tests. Some information about these compounds is given below.

- The three compounds are isomers with molecular formula C_3H_6O.
- **A** and **B** contain only one functional group, but **C** contains two separate functional groups.
- None of the three compounds contains a ring of atoms.
- In each of the three compounds the oxygen atom is bonded to only one carbon atom.

(a) (i) **A** and **B** are tested separately with 2,4-dinitrophenylhydrazine solution and both give an orange precipitate.

When **A** and **B** are heated separately with a mixture of potassium dichromate(VI) and dilute sulfuric acid, the solution containing **B** turns from orange to green. The solution containing **A** remains orange.

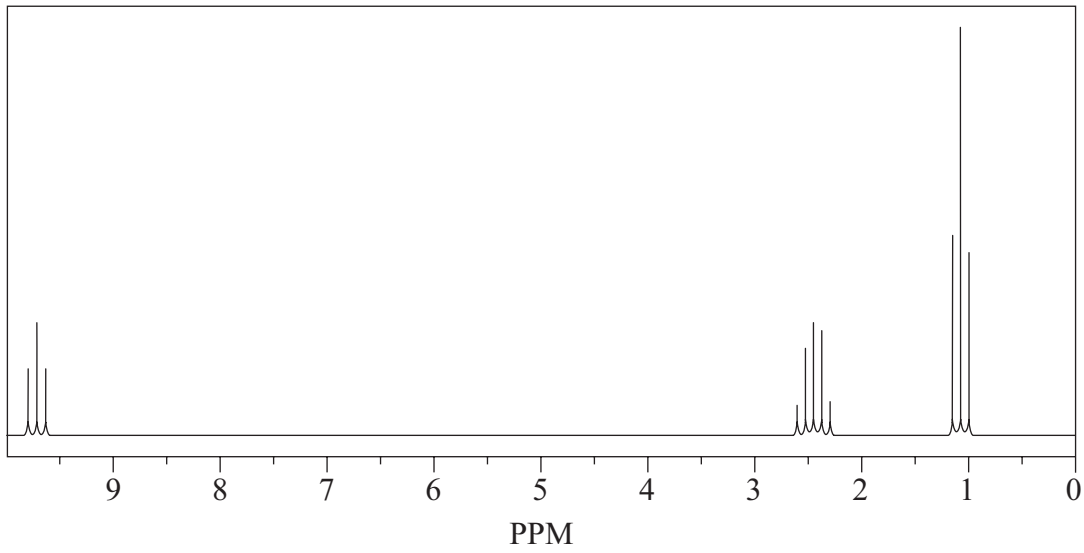
Use these results and the information at the start of the question to deduce displayed formulae for **A** and **B**.

(2)

A

B

(ii)



State whether this is the nmr spectrum of **A** or **B**. Justify your answer.

Explain how the nmr spectrum of the other isomer will differ.

(2)

(b) (i) **C** does **not** react with 2,4-dinitrophenylhydrazine.

When **C** is heated with acidified potassium dichromate(VI), the solution turns from orange to green.

When **C** is shaken with bromine water, the bromine water quickly turns colourless.

Name the **two** functional groups present in **C**.

(2)

.....

.....

(ii) State **two** observations you would expect to make when a small piece of sodium is added to **C**.

(2)

.....

.....

.....

.....

(iii) Draw **two** possible displayed formulae for **C** which are consistent with the above information.

(2)

(Total for Question 1 = 10 marks)

2 A green crystalline solid, **D**, dissolves in water to give a pale green solution.

(a) When dilute sodium hydroxide is added to the solution of **D**, a green precipitate, **E**, is observed.

When ammonia solution is added to the solution of **D**, the same green precipitate, **E**, forms which does **not** dissolve in excess ammonia solution.

Identify, by name or formula, substance **E**.

(1)

.....

(b) When a solution of **D** is warmed with dilute sodium hydroxide, a gas, **F**, which turns moist red litmus paper blue, is given off.

Identify, by name or formula, the gas **F**.

(1)

.....

(c) When a solution of barium chloride is added to a solution of **D**, a white precipitate, **G**, forms which is insoluble in dilute hydrochloric acid.

Identify, by name or formula, the precipitate **G**.

(1)

.....

(d) Deduce the **formulae** of the **three** ions present in the salt, **D**.

(3)

.....

.....

.....

(Total for Question 2 = 6 marks)

3 The equation for the reaction of iodine with propanone is

$$CH_3COCH_3(aq) + I_2(aq) \rightarrow CH_3COCH_2I(aq) + H^+(aq) + I^-(aq)$$

An experiment was carried out to find the order of reaction with respect to iodine.

50 cm^3 of iodine solution, concentration 0.020 mol dm^{-3}, was added to 25 cm^3 of sulfuric acid, concentration 2.0 mol dm^{-3}, in a conical flask.

25 cm^3 of propanone solution, concentration 2.0 mol dm^{-3}, was added to the mixture and a timer started.

A 10.0 cm^3 sample was removed after one minute. Further 10.0 cm^3 samples were removed every three minutes.

Immediately, each sample was added to 20 cm^3 of sodium hydrogencarbonate solution (an excess). Each sample was then titrated with sodium thiosulfate solution, concentration 0.010 mol dm^{-3}.

(a) (i) Show, by calculation of the number of moles, whether propanone or iodine was in excess.

(2)

(ii) What would be the most suitable piece of apparatus for removing a 10.0 cm^3 sample from the mixture?

(1)

.....

(iii) What would be the most suitable piece of apparatus for measuring 20 cm^3 of the sodium hydrogencarbonate solution?

(1)

.....

(iv) Suggest why each sample was added to sodium hydrogencarbonate solution.
Explain your answer.

(2)

.....

.....

.....

.....

(b) (i) What colour change would you expect to see as the reaction takes place?

(2)

From ..... to .....

(ii) To make the end-point of the titration easier to see, an indicator can be added.

Name the indicator and state the colour change you would expect to see.

(2)

Indicator .....

Colour change from ..... to .....

(iii) At what stage in the titration should this indicator be added?

(1)

.....

.....

(c) The following results were obtained in the experiment.

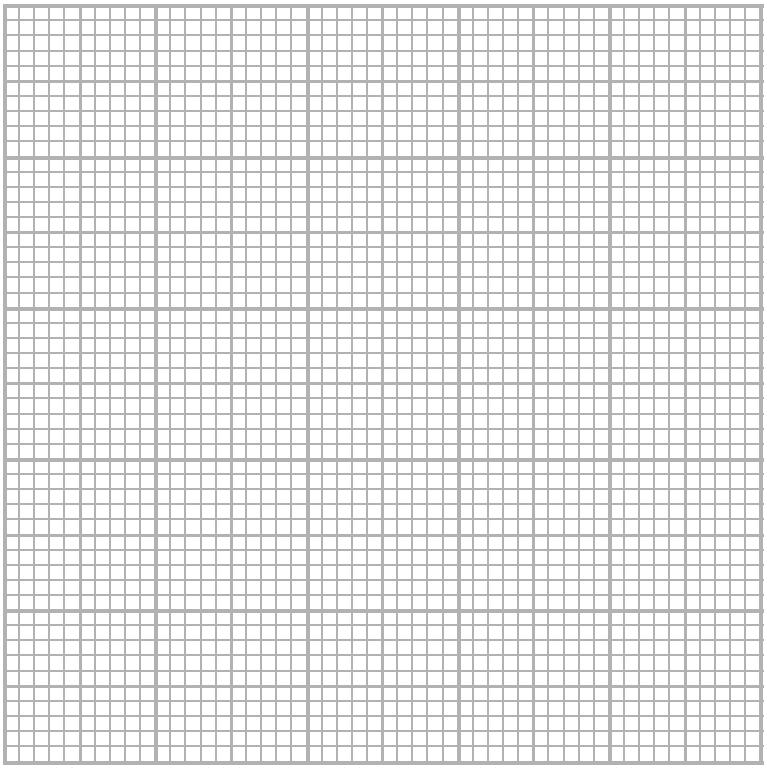
Time / min	Volume of sodium thiosulfate solution / cm^3
1	19.1
4	15.9
7	13.0
10	9.9
13	7.1
16	3.9
19	1.0

(i) Explain why these results can be used to determine the order of the reaction directly, without calculating the corresponding concentrations of iodine in the solution.

(1)

(ii) Plot a graph of the volume of sodium thiosulfate solution on the vertical axis against time on the horizontal axis.

(2)



(iii) Use your graph to deduce the order of the reaction with respect to iodine.

Explain how you arrived at your answer.

(2)

.....

.....

.....

.....

(d) The following rate-determining step for the reaction between propanone and iodine is suggested.

$$CH_3COCH_3 + H^+ \rightarrow CH_3C^+(OH)—CH_3$$

Explain why your order of reaction with respect to iodine is consistent with this rate-determining step.

(1)

.....

.....

(Total for Question 3 = 17 marks)

BLANK PAGE

4 2-ethanoylaminobenzoic acid, $C_9H_9NO_3$, is a compound which emits flashes of light when its crystals are crushed or scraped. It is prepared under strictly supervised conditions.

The steps of the experimental procedure are as follows.

1. Place 3.5 g of 2-aminobenzoic acid, $C_7H_7NO_2$, in a dry 50 cm^3 flask fitted with a reflux condenser.
2. Add 7.0 cm^3 of ethanoyl chloride (an excess) by pouring it carefully down the condenser.
3. Heat slowly to boiling and reflux for 15 minutes.
4. Allow to cool and then add 5 cm^3 of water.
5. Bring the solution back to boiling by heating slowly.
6. Allow the solution to cool slowly at room temperature.
7. Collect the crystals of 2-ethanoylaminobenzoic acid by suction filtration.
8. Recrystallize the 2-ethanoylaminobenzoic acid from a 50% ethanoic acid/water mixture.

(a) Explain how the process of heating under reflux works and why it is often necessary to heat under reflux, as in **step 3**.

(3)

(b) (i) Suggest why water was added (step 4).

(1)

.....

.....

(ii) Suggest why the mixture was cooled before the water was added (step 4).

(1)

.....

.....

(c) (i) Draw a fully labelled diagram of the apparatus used for suction filtration (step 7).

(3)

(ii) Suggest **two** advantages of suction filtration over normal filtration.

(2)

First advantage .....

.....

Second advantage .....

.....

(d) (i) Draw a fully labelled diagram of the apparatus you would use to determine the melting temperature of the 2-ethanoylaminobenzoic acid crystals.

(2)

(ii) Give **two** aspects of the melting temperature determination that would indicate the crystals were pure.

(2)

.....

.....

.....

.....

(e) In the equation for this reaction, the mole ratio of 2-aminobenzoic acid, $C_7H_7NO_2$, and 2-ethanoylaminobenzoic acid, $C_9H_9NO_3$, is 1:1.

In an experiment, 3.5 g of 2-aminobenzoic acid produced 2.35 g of recrystallized 2-ethanoylaminobenzoic acid.

Calculate the percentage yield of the product for this reaction.

(3)

(Total for Question 4 = 17 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 3 5 9 8 8 A 0 1 6 1 6

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Mark Scheme (Results)
January 2012

GCE Chemistry (6CH08) Paper 01
Chemistry Laboratory Skills II (WA)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

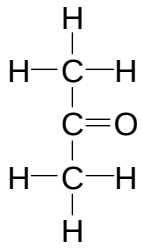
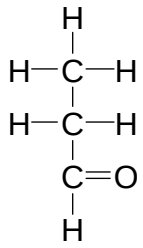
The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

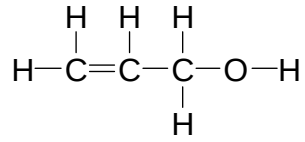
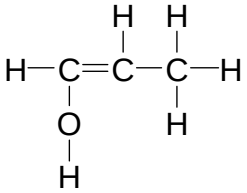
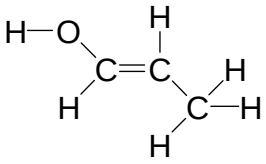
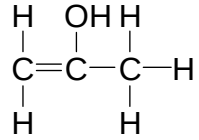
Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1 (a)(i)	**A**  **(1)** **B**  **(1)** ALLOW non-displayed alkyl groups, CH_3, C_2H_5 . ALLOW skeletal formulae. **A** & **B** wrong way round – scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
1 (a)(ii)	**Either** **B** because three (sets of)peaks/ three (proton) environments OR **B** because of 5:3:3 splitting pattern OR Only the aldehyde has a peak greater than 9 ppm **(1)** **Either** **A** would have only one peak/ one (proton) environment **OR** **A** would have singlet **(1)** ALLOW ECF on carbonyls only		**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(i)	Alkene /carbon-carbon double bond /C=C **(1)** (primary or secondary) alcohol ALLOW hydroxyl/hydroxyl **(1)**	Tertiary alcohol/ hydroxide/O-H alone	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(ii)	**Any two from:** Fizzing/bubbling/effervescence **(1)** Sodium dissolves/disappears / decreases in size **(1)** White solid/precipitate formed **(1)**	Gas/hydrogen given off Hisses Sodium sinks Reacts vigorously Exothermic/gets hot	**2**

Question Number	Acceptable Answers	Reject	Mark
1 (b)(iii)	Any two from:  **(1)**  **(1)**  **(1)**  **(1)** ALLOW non-displayed CH_3 and/or OH ALLOW skeletal formulae		**2**

Question Number	Acceptable Answers	Reject	Mark
2 (a)	Iron(II) hydroxide/$Fe(OH)_2$ / $Fe(H_2O)_4(OH)_2$ / $[Fe(H_2O)_4(OH)_2]$ /$Fe(OH)_2\ (H_2O)_4$ / $[Fe(OH)_2\ (H_2O)_4]$ /$Fe(OH)_2xH_2O$	$[Fe(H_2O)_4(OH)_2]^{2+}$ $[Fe(H_2O)_6(OH)_2]$	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (b)	Ammonia (gas)/NH_3 / $NH_{3(g)}$	Ammonium (gas) $NH_4^{(+)}$	**1**

Question Number	Acceptable Answers	Reject	Mark
2 (c)	Barium sulfate/Barium sulphate / $BaSO_4$		**1**

Question Number	Acceptable Answers	Reject	Mark
2 (d)	Fe^{2+} **(1)** NH_4^+ **(1)** SO_4^{2-} **(1)** ALLOW: $FeSO_4.(NH_4)_2SO_4$ (xH_2O) **(2)** $Fe(NH_4)_2(SO_4)_2$ **(2)** ALLOW a formula containing all three ions without charges and unbalanced **(1)**	NH_3 / NH_3^+/ NH_4 If the formula of D is given rather than the ions, the presence of NH_3 scores (0).	**3**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(i)	$\frac{50 \times 0.02}{1000}$ = 0.001 mol I_2 $\frac{25 \times 2}{1000}$ = 0.05 mol $(CH_3)_2CO$ Both quantities correct and propanone in excess **(2)** Both quantities correct but incorrect or missing excess **(1)** One quantity correct **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(ii)	(Graduated) Pipette (+ filler) Accept recognisable spelling e.g pipet	Burette Measuring cylinder	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (a)(iii)	Measuring cylinder Ignore volumes e.g. $25cm^3$ measuring cylinder	Burette/pipette	**1**

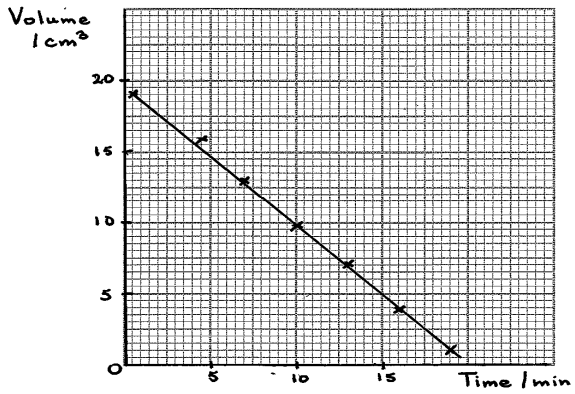
Question Number	Acceptable Answers	Reject	Mark
3 (a)(iv)	To quench /slow /stop the reaction **(1)** By reacting with the sulfuric acid / neutralize (the acid) / remove the H^+ ions **(1)** Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(i)	**From** yellow/orange/red-brown /brown **(1)** **To** colourless / pale yellow **(1)** Second mark is dependent on the first	... to clear /yellow	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(ii)	Starch **(1)** **From** blue / blue-black / black **To** colourless **(1)** Mark independently	From Purple…. …to clear	**2**

Question Number	Acceptable Answers	Reject	Mark
3 (b)(iii)	As the colour of the iodine solution begins to fade/turns pale yellow/straw coloured/just before the end point **(1)**	When colourless / yellow/brown	**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(i)	Iodine concentration is **proportional** to the volume of sodium thiosulfate solution		**1**

Question Number	Acceptable Answers	Reject	Mark
3 (c)(ii)	Axes correctly labelled including units with sensible scales (more than half graph paper used in each direction) **(1)** Points correctly plotted and best fitting straight line drawn **(1)**  Allow - completely correct but axes wrong way round **(1)**	Absence of units Dots joined with straight lines	**2**

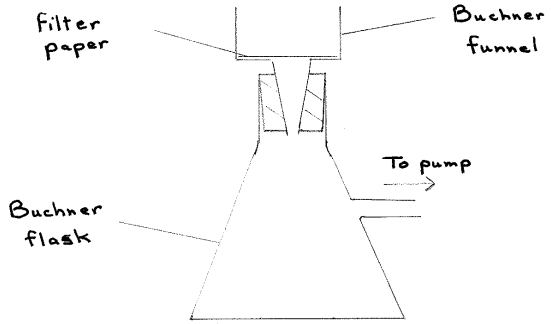
Question Number	Acceptable Answers	Reject	Mark
3 (c)(iii)	reaction is order zero **(1)** rate is constant/gradient is constant/ [iodine] does not affect rate **(1)** Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
3 (d)	Iodine is not involved in the rate determining step, (because order is zero with respect to iodine) If 3ciii is not zero order, the mark is only awarded if the candidate states that the order is inconsistent.		**1**

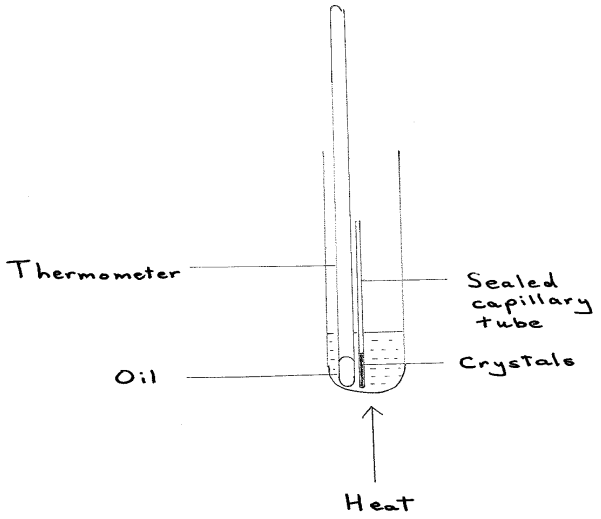
Question Number	Acceptable Answers	Reject	Mark
4 (a)	As liquid(s) vaporise/boil they are cooled and condense back to liquid(s) **(1)** Any **two** from: Used to heat volatile liquids **(1)** Prevents escape of flammable vapours **(1)** Prevents escape of reactants/ products/solvents **(1)** Allows time to react/Allows complete reaction/Allows faster reaction/ increases yield **(1)**	Overcomes activation energy	**3**

Question Number	Acceptable Answers	Reject	Mark
4 (b)(i)	To react with/remove (excess) **ethanoyl chloride** IGNORE references to product(s) dissolving	Dissolve unreacted reagents/excess acid/HCl	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (b)(ii)	Reaction (with water) is exothermic /gives out heat/violent/vigorous Note that the answer may be given in b(i)	Reaction explosive Prevent flask cracking	**1**

Question Number	Acceptable Answers	Reject	Mark
4 (c)(i)	Buchner/side armed flask **(1)** Side arm connected to pump **(1)** Buchner funnel with flat filter paper The filter paper must be labelled or clearly shown above the pores of the funnel **(1)**  	Large gap between funnel and flask Blocked outlet to pump	**3**

Question Number	Acceptable Answers	Reject	Mark
4 (c)(ii)	Faster **(1)** Dries solid/precipitate/crystals OR removes maximum amount of solution **(1)**	Reduces transfer losses Less product lost /higher yield	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (d)(i)	A variety of methods may be used. **Either** Crystals in (sealed) capillary tube **(1)** Thermometer and capillary in (heated) oil/water bath or in 'melting temperature apparatus' heater **(1)** **Or** Crystals balanced on thermometer **(1)** Clamped horizontally in horizontal double glass skinned test tube **(1)**  Note – crystals in a test or boiling tube with a thermometer **in the tube** **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (d)(ii)	Melting temperature should be 'sharp'/over a 1-2 °C range/narrow temperature range **(1)** And at correct value/consistent with literature **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
4 (e)	Number of moles of reactant = 3.5 (1) = 0.02555 137 **Either** Number of moles of product = 2.35 (1) = 0.01313 179 Percentage yield = 0.01313 x 100 0.02555 =51.4/51 % (1) ACCEPT 51.5% **Or** Mass of product = 0.02555 x 179**(1)** = 4.573 g Percentage yield = 2.35 x 100 4.573 = 51.4%/51% **(1)** ACCEPT 51.5% ACCEPT answers to 4 or more sf provided they round to 51.4 or 51.5 Correct answer with no working scores (3) ALLOW internal TE	Answers to 1 sf	**3**

TOTAL FOR PAPER = 50 MARKS

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Edexcel GCE

Chemistry

Advanced

Unit 6B: Chemistry Laboratory Skills II Alternative

Tuesday 22 May 2012 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH08/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P39311A

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Answer ALL the questions. Write your answers in the spaces provided.

1 (a) The colours of aqueous solutions containing chromium(III) chloride and nickel(II) chloride are similar.

What colour are these solutions?

(1)

.....

(b) Tests were carried out on a dilute aqueous solution of chromium(III) chloride. Complete the table below.

You may use **either** names **or** formulae unless only **one** of these is specified.

	Test	Observations	Inferences	
(i)	Add a few drops of dilute sodium hydroxide solution to the chromium(III) chloride solution.	A precipitate forms.	The precipitate is	**(1)**
(ii)	Add dilute sodium hydroxide to the mixture made in (i), until the sodium hydroxide is present in excess.	....	The complex ion $[Cr(OH)_6]^{3-}$ forms.	**(1)**
(iii)	Add a few drops of dilute ammonia to another sample of the chromium(III) chloride solution.	....	The substance containing chromium which is observed on adding the ammonia is	**(2)**

	Test	Observations	Inferences	
(iv)	Continue to add dilute ammonia to the mixture in (iii) until the ammonia is present in excess.	A solution forms.	The **formula** of the chromium containing ion in the solution is	(1)
(v)	Warm another sample of the chromium(III) chloride solution with alkaline hydrogen peroxide solution, which acts as an oxidizing agent. Add sulfuric acid to the resulting mixture.	A yellow solution forms. The solution goes orange when sulfuric acid is added.	The **formula** of the ion causing the yellow colour is ..... The ion causing the orange colour is dichromate(VI), $Cr_2O_7^{2-}$.	(1)

(c) Tests (i) and (ii) above were repeated on an aqueous solution of nickel(II) chloride.

In what way, other than any difference in colour, does the reaction of dilute sodium hydroxide solution with nickel(II) chloride differ from its reactions with chromium(III) chloride?

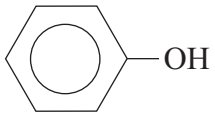
(1)

.....

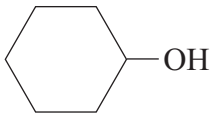
.....

(Total for Question 1 = 8 marks)

2 This question is about some reactions of phenol and cyclohexanol.



phenol



cyclohexanol

(a) Give **two** observations you would make when bromine water is added, drop by drop, to an aqueous solution of phenol.

(2)

.....

.....

(b) (i) What is observed when cyclohexanol is warmed with a mixture of aqueous potassium dichromate(VI) and sulfuric acid?

(1)

.....

(ii) Give the skeletal formula of the organic product of the reaction in (b)(i).

(1)

(iii) What change, if any, is observed when the organic product of the reaction in (b)(i) is mixed with the following reagents?

(2)

2,4-dinitrophenylhydrazine solution

.....

Tollens' reagent

.....

(c) Both phenol and cyclohexanol react with ethanoyl chloride to produce steamy fumes and an ester. Phenol behaves like an alcohol in this reaction.

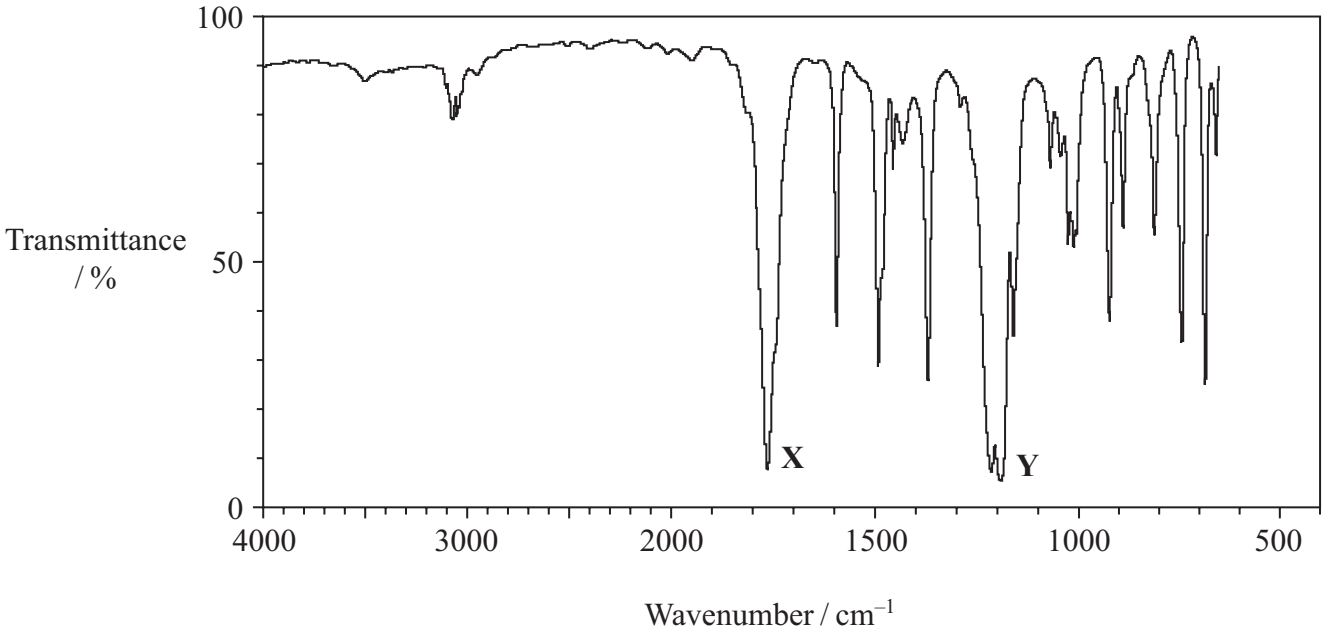
(i) How could you show that the steamy fumes were due to the presence of a hydrogen halide, which in this case is hydrogen chloride?

(2)

.....

.....

(ii) The infrared spectrum below is for the ester produced in the reaction of ethanoyl chloride with phenol.



Bond	Group	Wavenumber range / cm^{-1}
C—H	alkanes	2962 – 2853
	arenes	3030
O—H	alcohols and phenols	3750 – 3200
C—O	ethanoates	1250 – 1190
	benzoates	1310 – 1250 and 1150 – 1100
C═C	arenes	1600, 1580, 1500, 1450
C═O	ketones	1700 – 1680
	esters	1770 – 1715

Identify the bond and group which cause each of the absorptions **X** and **Y**.

(2)

X .....

Y .....

(iii) Draw the structural formula of the ester produced in the reaction of ethanoyl chloride with phenol.

(1)

(Total for Question 2 = 11 marks)

3 Some old coins with a high copper content were analysed as follows.

Procedure

1. The coins were weighed and dissolved in concentrated nitric acid, producing a solution which contained copper(II) nitrate.

2. The solution containing copper(II) nitrate was neutralized by adding sodium carbonate solution until a precipitate of copper(II) carbonate just appeared. Dilute ethanoic acid was then added, drop by drop, until the copper(II) carbonate precipitate just dissolved.

3. The solution containing copper(II) nitrate was transferred to a volumetric flask and made up to 250 cm^3 with distilled water.

4. 25 cm^3 portions of this solution were transferred to separate conical flasks. Then 10 cm^3 of 1.0 mol dm^{-3} potassium iodide (an excess) was added to each flask.

5. The liberated iodine was titrated with 0.125 mol dm^{-3} sodium thiosulfate solution.

(a) One reason why the solution for titration must be neutralized is because sodium thiosulfate reacts with acid as shown below.

$$S_2O_3^{2-} + 2H^+ \rightarrow S + SO_2 + H_2O$$

State **one** observation you would make when an acid reacts with sodium thiosulfate solution.

(1)

.....

.....

(b) (i) What colour is the diluted solution containing copper(II) nitrate?

(1)

.....

(ii) What would you observe in Step 2, before the formation of the copper(II) carbonate precipitate, when the sodium carbonate was added?

(1)

.....

.....

(c) The equation for the reaction producing iodine in Step 4 is shown below.

$$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$$

(i) Give the name of the precipitate formed in this reaction.

(1)

.....

(ii) Suggest, by considering the electronic configuration of the relevant ion, why the precipitate is white.

(1)

.....

.....

.....

(d) The equation for the reaction of thiosulfate ions in the titration is

$$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^{-}(aq)$$

Results:

Mass of coins	2.10 g
Mean (average) volume of 0.125 mol dm^{-3} sodium thiosulfate used in titration	24.40 cm^3

(i) Calculate the number of moles of sodium thiosulfate used in the titration.

(1)

(ii) Calculate the number of moles of Cu^{2+} in the 25 cm^3 samples used for the titration.

(2)

(iii) Hence calculate the mass of copper present in the original mass of coins.

(2)

(iv) What is the percentage of copper in the coins?

(1)

(e) (i) The balance used to weigh the coins produced a **total** error in the weighing of ± 0.01 g. Calculate the percentage error in the weighing.

(1)

(ii) The error in the mean titre of 24.40 cm^3 was ± 0.10 cm^3. Show, by calculation, that the percentage error in the titration reading is less than the percentage error in the balance reading.

(1)

(f) Starch solution can be used to show the end point for this titration, or the titration can be self-indicating.

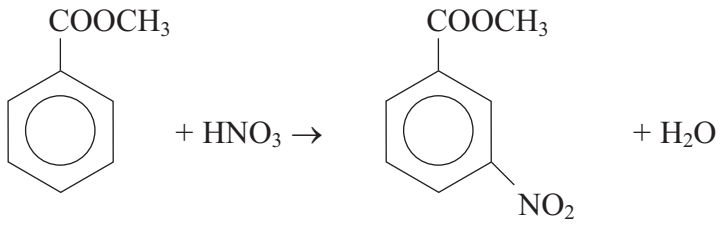
What colour change would be observed at the end point if starch was **not** used?

(1)

.....

(Total for Question 3 = 14 marks)

4 A student attempted to make a sample of methyl 3-nitrobenzoate using the following reaction.



methyl benzoate methyl 3-nitrobenzoate

Procedure

1. Transfer 9 cm^3 of concentrated sulfuric acid into a 100 cm^3 conical flask and cool it to below 10 °C in an ice bath. Add 5.0 g of methyl benzoate, swirling the flask. Mix 3 cm^3 of concentrated nitric acid with 3 cm^3 of concentrated sulfuric acid in another small flask and cool it in ice.

2. Add the mixture of nitric and sulfuric acids, drop by drop, to the methyl benzoate solution, making sure that the temperature stays below 15 °C.

3. Take the mixture out of the ice bath and leave it to stand for 10 minutes at room temperature. Pour the mixture over 40 g of crushed ice and collect the solid product by filtering the mixture under suction. Wash the precipitate, first with cold water, then with ice-cold ethanol. Keep the washings obtained with the ethanol for a further experiment.

4. Purify the impure methyl 3-nitrobenzoate by recrystallization, using ethanol as the solvent, cooling the solution in an ice bath to assist recrystallization.

5. Dry the recrystallized product and determine the yield.

(a) The student wore goggles and a laboratory coat. For each of the processes below, state the hazard and give one further safety precaution which should be taken.

(i) Working with concentrated nitric and sulfuric acids.

(1)

.....

.....

(ii) Carrying out the recrystallization using ethanol.

(1)

.....

.....

(b) What is the purpose of adding sulfuric acid to the nitric acid in this reaction?

(1)

.....

.....

(c) (i) Calculate the number of moles in 5.0 g of methyl benzoate.

Assume the molar mass of methyl benzoate is 136 g mol^{-1}.

(1)

(ii) Methyl benzoate is a liquid at room temperature. What is the volume of 5.0 g of methyl benzoate?

The density of methyl benzoate is 1.09 g cm^{-3}.

(1)

(iii) After recrystallization and drying, 3.4 g of methyl 3-nitrobenzoate was obtained.

Calculate the percentage yield of methyl 3-nitrobenzoate, assuming that an excess of nitric and sulfuric acids was present.

(3)

(d) One reason for the low yield in this experiment is that methyl 2-nitrobenzoate is also formed. This compound dissolves in ethanol and would be present in the ethanol washings from **step 3**. Methyl 2-nitrobenzoate and methyl 3-nitrobenzoate are both pale yellow.

(i) Describe how to make a chromatogram with the ethanol washings from **step 3** in order to separate methyl 2-nitrobenzoate and methyl 3-nitrobenzoate. The chromatogram can be made on a plate covered with a layer of silica, and you may assume that a suitable solvent is available.

(4)

(ii) How would you improve the chromatogram to confirm that both methyl 2-nitrobenzoate and methyl 3-nitrobenzoate are present in the washings? You may show this on a diagram if you prefer.

(1)

(e) The table below gives data about the solubility of methyl 3-nitrobenzoate in two solvents. This data may be used to select the best solvent for recrystallization.

	Solubility of methyl 3-nitrobenzoate / g per 100 g solvent	
Temperature / °C	Solvent 1	Solvent 2
10	6.0	2.0
70	11.0	9.5

(i) Explain why using Solvent 1, rather than Solvent 2, would lead to a lower yield of recrystallized methyl 3-nitrobenzoate.

(1)

(ii) 50 g of Solvent 2 was saturated with methyl 3-nitrobenzoate at 70 °C, and the solution was then cooled to 10 °C. Calculate the mass of methyl 3-nitrobenzoate crystals which would be obtained.

(1)

(f) What method, other than spectroscopy or chromatography, could be used to assess the purity of the methyl 3-nitrobenzoate? How would the result of the experiment indicate if it was pure?

(2)

(Total for Question 4 = 17 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 3 9 3 1 1 A 0 1 6 1 6

PMT

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Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH08) Paper 01
Chemistry Laboratory Skills (WA)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. Questions labelled with an **asterix (*)** are ones where the quality of your written communication will be assessed.

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Correct Answer	Reject	Mark
1(a)	Green ACCEPT any green eg blue-green		**1**

Question Number	Correct Answer	Reject	Mark
1 (b)(i)	Chromium((III)) hydroxide/ $Cr(OH)_3$ /([])$Cr(OH)_3(H_2O)_3$([])/([])$Cr(H_2O)_3(OH)_3$ ([]) If oxidation number is given must be correct	Correct name with incorrect formula and vice versa	**1**

Question Number	Correct Answer	Reject	Mark
1 (b)(ii)	The precipitate dissolves ALLOW the precipitate redissolves/ disappears OR A solution (forms) IGNORE colours of solutions		**1**

Question Number	Correct Answer	Reject	Mark
1(b)(iii)	(green) precipitate forms Allow same precipitate forms **(1)** IGNORE other colours Chromium((III)) hydroxide/$Cr(OH)_3$/ ([])$Cr(OH)_3(H_2O)_3$([]),/([])$Cr(H_2O)_3(OH)_3$] **(1)**		**2**

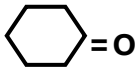
Question Number	Correct Answer	Reject	Mark
1(b)(iv)	([])$Cr(NH_3)_6^{3+}$([]) Allow other numbers of NH_3 with H_2O provided correct charge and 6 ligands	Mixture of NH_3 and OH^- in ligands	**1**

Question Number	Correct Answer	Reject	Mark
1(b)(v)	CrO_4^{2-}	Chromate ((VI))	**1**

Question Number	Correct Answer	Reject	Mark
1(c)	Nickel hydroxide/precipitate doesn't dissolve in excess (sodium hydroxide) ALLOW "Ppt with nickel chloride is insoluble in excess NaOH" "Nickel chloride will not form a solution in excess NaOH" "The precipitate does not redissolve"	Nickel/nickel ion doesn't dissolve in excess "Nickel chloride is insoluble in excess NaOH"	**1**

Question Number	Correct Answer	Reject	Mark
2(a)	**First mark:** Goes (from brown/red-brown/ orange/orange-brown/yellow to) colourless OR (the bromine) is decolorised **(1)** **Second mark:** (White) precipitate forms OR misty/steamy fumes form **(1)** IGNORE Medicinal/antiseptic smell Names of products even if incorrect	Clear for colourless Effervescence White smoke Layers formed	**2**

Question Number	Correct Answer	Reject	Mark
2(b)(i)	(orange to) green/blue/brown IGNORE Initial colour even if incorrect		**1**

Question Number	Correct Answer	Reject	Mark
2(b)(ii)	 Accept displayed / structural formula	$C_6H_{10}O$	**1**

Question Number	Correct Answer	Reject	Mark
2(b)(iii)	(2,4-dinitrophenylhydrazine:) yellow/ orange/red precipitate or yellow/orange/red solid **(1)** both colour and state needed ALLOW Combinations of above colours "Crystals" for solid (Tollens':) no change/no reaction Allow "nothing" (1) If aldehyde in b(ii) –allow TE for 2,4-dnp mark as above and silver mirror with Tollens If carboxylic acid in b(ii) – allow TE for no reaction in either case	Brown	**2**

Question Number	Correct Answer	Reject	Mark
2(c)(i)	React with ammonia (fumes) **(1)** White smoke /white solid **(1)** OR React with silver nitrate (solution) **(1)** (White/cream /yellow) precipitate forms **(1)** IGNORE use of acid-base indicators (litmus, universal indicator)	React with a solution of ammonia White fumes/ white gas Just "silver chloride test"	**2**

Question Number	Correct Answer	Reject	Mark
2(c)(ii)	(X) C=O ester **(1)** (Y) C–O ethanoate **(1)** Two correct bonds with incorrect/no groups **(1)** Two correct groups with incorrect/no bonds **(1)**	 C-O benzoate	**2**

Question Number	Correct Answer	Reject	Mark
2(c)(iii)	CH_3-C=O | O-C_6H_5 ALLOW skeletal, displayed, $CH_3COOC_6H_5$ and $C_6H_5OCOCH_3$ ALLOW C_6H_5 as benzene ring	$C_6H_5COOCH_3$ $C_6H_5OOCCH_3$ Hexagon with no circle for benzene ring	**1**

Question Number	Correct Answer	Reject	Mark
3(a)	(white/yellow) precipitate (of sulfur) /goes cloudy/solid forms ALLOW choking/pungent smell (of sulfur dioxide) IGNORE effervescence/bubbles/gas forms/Gas turns blue litmus red /Heat evolved	Yellow solution Colours other than white or yellow e.g. black solid Smell of bad eggs/ bad smell	**1**

Question Number	Correct Answer	Reject	Mark
3(b)(i)	Blue ACCEPT any blue eg blue-green		**1**

Question Number	Correct Answer	Reject	Mark
3(b)(ii)	Effervescence /fizzing /bubbling IGNORE identity of gas	Just "Gas given off" Effervescence with brown fumes	**1**

Question Number	Correct Answer	Reject	Mark
3(c)(i)	Copper**(I)** iodide Oxidation number is essential	Just "Copper iodide" Oxidation number **after** iodide	**1**

Question Number	Correct Answer	Reject	Mark
3(c)(ii)	(In CuI) the copper (ion) has a full d (sub) shell/does not have an incomplete d (sub) shell/has configuration (3)d^{10} ALLOW Cu^+ has full d orbital(s)	Configuration of element Just "d-d transitions cannot occur" Just "all the shells are full"	**1**

Question Number	Correct Answer	Reject	Mark
3(d)(i)	((24.40 x 0.125) / 1000) = 3.05 x 10^{-3} / 0.00305 (mol) ALLOW 3.1 x 10^{-3} (mol)	 3.00 x 10^{-3} 3.10 x 10^{-3}	**1**

Question Number	Correct Answer	Reject	Mark
3(d)(ii)	Mol I_2 = half answer to (i) **(1)** =1.525 x 10^{-3} Mol Cu^{2+} = 2 x mol I_2 **(1)** =3.05 x 10^{-3} IGNORE sf unless 1 sf Correct final answer without working **(2)**		**2**

Question Number	Correct Answer	Reject	Mark
3(d)(iii)	mass Cu in 25 cm^3 = (63.5 x 3.05 x 10^{-3} = 1.93675 x 10^{-1}) = 1.94 x 10^{-1} / 0.194 (g) **(1)** Mass in original = (1.93675) = 1.94 (g) **(1)** TE for 10x mass in 25 cm^3 Ignore sf except 1 sf ALLOW use of Cu = 64 which gives 1.95 (g) Correct final answer without working **(2)**		**2**

Question Number	Correct Answer	Reject	Mark
3(d)(iv)	% Cu = (1.93675 x 100 / 2.10 = 92.2261) = 92.2 % OR (1.94 x 100) / 2.10 = 92.38095) =92.4% ALLOW TE from use of Cu = 64 which gives 92.9% ALLOW TE from mass of Cu provided less than 100% IGNORE sf except 1 sf		**1**

Question Number	Correct Answer	Reject	Mark
3(e)(i)	(0.01 / 2.10 x 100 = ± 0.4761904) = (±) 0.48 (%) / (±)0.5 (%) IGNORE sf		**1**

Question Number	Correct Answer	Reject	Mark
3(e)(ii)	(0.10 / 24.40 x 100 = 0.4098) = (±) 0.41 (%) / (± 0).4 (%) IGNORE sf If errors in (i) and (ii) are both doubled allow 1 mark in e(ii)	0.40/ 0.409	**1**

Question Number	Correct Answer	Reject	Mark
3(f)	Brown /straw-coloured/yellow to colourless solution/white solid Both colours in change needed	Blue to colourless Red-brown to colourless Clear for colourless	**1**

Question Number	Correct Answer	Reject	Mark
4(a)(i)	Corrosive so wear gloves ALLOW burns skin/damages skin ALLOW exothermic reaction so keep cool/add acids drop by drop	Toxic Irritant/irritates skin	**1**

Question Number	Correct Answer	Reject	Mark
4(a)(ii)	(In)flammable so use water bath/ electric hotplate/keep away from naked flames	Keep away from heat Use fume cupboard	**1**

Question Number	Correct Answer	Reject	Mark
4(b)	(Reacts with nitric acid) to make NO_2^+ /to make nitronium ion/to make an electrophile	To make a nitrating agent/ NO_2/ nitrate/ nitro group/nitrite ion Just “as a catalyst/to speed up reaction” Just “Drying agent” Oxidizing agent Reducing agent Just a correct equation	**1**

Question Number	Correct Answer	Reject	Mark
4(c)(i)	(5.0/ 136 = 0.0367647) =0.0368/ 0.037 (mol) IGNORE sf except 1 sf		**1**

Question Number	Correct Answer	Reject	Mark
4(c)(ii)	(5.0 / 1.09 = 4.587156) = 4.59/ 4.6 (cm^3) IGNORE sf except 1 sf		**1**

Question Number	Correct Answer	Reject	Mark
4(c)(iii)	M_r for product = 181 (1) Max yield = (181 x 0.0367647 = 6.6544118) = 6.65/ 6.7g **(1)** % yield = (3.4/6.6544118 x 100 = 51.09392) = 51.1/ 51 **(1)** OR M_r for product = 181 (1) Moles product = (3.40/181 = 0.0187845) = 0.0188/ 0.019 **(1)** % yield = (0.01878/ 0.036747 x 100 = 51.111854) = 51.1/ 51 **(1)** IGNORE sf except 1 sf ALLOW final answers rounding to 51 which will depend how number of moles is rounded. Working need not be shown, but if incorrect molar mass used max **(2)** TE from (c)(i) and in intermediate stages		**3**

Question Number	Correct Answer	Reject	Mark
4(d)(i)	**First mark:** Use a spot/small drop (of the ethanol washings) **(1)** Then any 3 points from the following: put spot near the bottom of the plate/on a marked line/on a datum line **(1)** Put plate in a sealed container **(1)** with the (suitable) solvent below the spot **(1)** Leave until the solvent has moved to near the top of the plate/till solvent has risen up/until separated **(1)** ALLOW any of these points shown on a diagram. ALLOW use of paper instead of plate IGNORE references to spraying with a reagent to make spots visible	Put the solvent on the plate Put the sample under the solvent level Use of electric current	**4**

Question Number	Correct Answer	Reject	Mark
4(d)(ii)	Add pure samples (of methyl 2-nitrobenzoate and methyl 3-nitobenzoate) to chromatogram and get two spots at different levels corresponding to pure samples This may be shown on a diagram GIVE THE MARK FOR THIS QUESTION IF THIS PROCEDURE IS DESCRIBED IN 4(d)(i) OR measure R_f values on chromatogram of washings and compare with R_f of pure samples	Use of electrophoresis Spectroscopy	**1**

Question Number	Correct Answer	Reject	Mark
4(e)(i)	Higher proportion of product would remain in solution/ more product would stay dissolved/ less product would crystallize out/ product is more soluble in solvent 1 **at room temp**	Solvent is more soluble Just "It dissolves more in solvent 1"	**1**

Question Number	Correct Answer	Reject	Mark
4(e)(ii)	$\frac{(9.5 - 2)}{2}$ =3.75 (g) IGNORE sf except 1 sf		1

Question Number	Correct Answer	Reject	Mark
4(f)	Measure the melting temperature ALLOW measure the boiling temperature / measure the melting and boiling temperature (1) Should be sharp ALLOW Should match data book value (1)	Recrystallization Just "compare with data book"	2

TOTAL FOR PAPER = 50 MARKS

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Surname	Other names

Centre Number | | | | | |

Candidate Number | | | | |

Edexcel GCE

Chemistry

Advanced

Unit 6B: Chemistry Laboratory Skills II Alternative

Thursday 10 January 2013 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
6CH08/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/6/5/3/

P 4 1 2 1 7 A 0 1 1 6

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Answer ALL the questions. Write your answers in the spaces provided.

1 The table shows a series of tests carried out on a soluble crystalline compound **A**, which contains one anion and one cation. For each test, complete the table by filling in the inference column.

	Test	Observation	Inference
(a)	Observe the appearance of **A**.	**Pale** green solid.	..... **(1)**
(b)	Measure the pH of a dilute aqueous solution of **A** using a pH meter.	The pH is 6.0.	The type of reaction that has occurred when **A** dissolved in water is ..... **(1)**
(c)	Add a few drops of dilute sodium hydroxide solution to a solution of **A**.	A green precipitate forms.	The sodium hydroxide is acting as ..... The **formula** of the green precipitate is ..... **(2)**
(d)	Leave a sample of the green precipitate formed in (c) to stand in air.	The green precipitate turns brown on the surface.	The type of reaction that has occurred is ..... The **formula** of the brown precipitate is ..... **(2)**
(e)	Add excess sodium hydroxide solution to a sample of the green precipitate formed in (c).	The green precipitate does not dissolve.	..... **(1)**
(f)	Add barium chloride solution, $BaCl_2(aq)$, acidified with hydrochloric acid, to a solution of **A**.	A white precipitate forms.	The white precipitate is ..... **(1)**

(g) Identify compound **A** by name or formula.

(1)

.....

(Total for Question 1 = 9 marks)

2 Two organic compounds, **X** and **Y**, are colourless liquids. Both compounds contain four carbon atoms and one functional group.

(a) A series of tests was carried out on compound **X**.

(i) When a few drops of 2,4-dinitrophenylhydrazine solution were added to **X**, an orange precipitate was formed. What deduction can be made from the result of this test alone?

(1)

.....

.....

(ii) When **X** was warmed with Fehling's solution, a red precipitate was formed. What further deduction can be made from the result of this test?

(1)

.....

.....

(b) Give the two possible displayed formulae of **X**.

(2)

(c) A series of tests was carried out on compound **Y**.

(i) A dry sample of **Y** reacted with phosphorus(V) chloride, producing steamy fumes. What deduction can be made from the result of this test alone?

(1)

.....

.....

(ii) No reaction was observed when **Y** was added to sodium carbonate solution, $Na_2CO_3(aq)$. What further deduction can be made from the result of this test?

(1)

.....

.....

(iii) A sample of **Y** rotated the plane of plane-polarized light. What deduction can be made about the structure of **Y** from the result of this test?

(1)

.....

.....

(iv) Use your answers to parts (i), (ii) and (iii), and the fact that each molecule of **Y** contains four carbon atoms, to deduce the displayed formula of **Y**.

(1)

(v) Describe what you would expect to **see** if a sample of compound **Y** was added to iodine, I_2, in alkaline conditions.

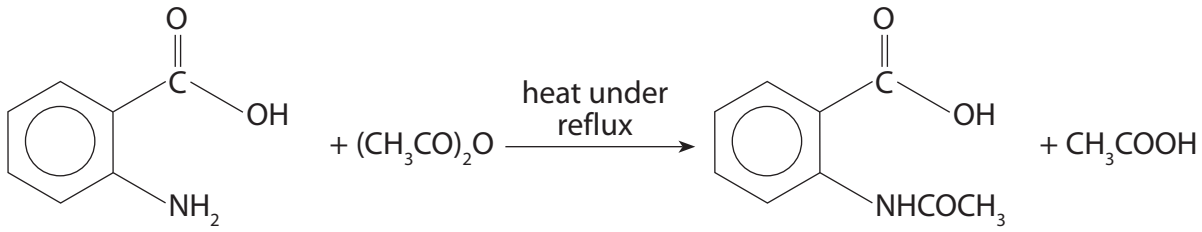
(1)

.....

.....

(Total for Question 2 = 9 marks)

3 The compound 2-ethanoylaminobenzoic acid can be made by reacting 2-aminobenzoic acid with ethanoic anhydride.



2-aminobenzoic acid ethanoic anhydride 2-ethanoylaminobenzoic acid

The steps of the experimental procedure are as follows:

1. Measure out 4.00 g of 2-aminobenzoic acid into a pear-shaped flask. Add ethanoic anhydride.
2. Add anti-bumping granules to the flask, fit a reflux condenser and bring the mixture slowly to the boil. Heat under reflux for 15 minutes.
3. Allow the reaction mixture to cool and add 5 cm^3 of water. Bring the contents of the flask back to the boil and then remove from the heat.
4. Let the reaction mixture cool to room temperature. A pale brown crystalline solid will form.
5. Collect the solid by suction filtration.
6. Purify the solid by recrystallization using ethanoic acid as the solvent.
7. Determine the melting temperature of the dry solid.

(a) (i) Calculate the minimum **volume**, in cm^3, of ethanoic anhydride needed for 4.00 g of 2-aminobenzoic acid to react completely.

[Molar masses / g mol^{-1}: $(CH_3CO)_2O$ = 102; $C_6H_4(NH_2)COOH$ = 137
Density $(CH_3CO)_2O$ = 1.082 g cm^{-3}.]

(3)

(ii) A student obtained 2.97 g of 2-ethanoylaminobenzoic acid from 4.00 g of 2-aminobenzoic acid. Calculate the percentage yield obtained by this student. Give your answer to **two** significant figures.

(3)

(b) (i) When this experiment is carried out, the actual volume of ethanoic anhydride used is greater than that calculated in (a). Suggest why this is so.

(1)

(ii) Anti-bumping granules are added in **step 2**. What would be observed if 'bumping' occurred?

(1)

(iii) Ethanoic anhydride is corrosive to both the skin and the respiratory system. Suggest **two** precautions to minimise the risks when using ethanoic anhydride, other than wearing eye protection and a lab coat.

(2)

(iv) Outline how you would carry out the recrystallization in **step 6**.

(4)

(v) Suggest a reason why the recrystallization will slightly reduce the yield of 2-ethanoylaminobenzoic acid.

(1)

(vi) Draw a labelled diagram of the apparatus that could be used to find the melting temperature of the dry solid in **step 7**.

(2)

(vii) State **two** ways you would use the results from (vi) to check the identity and purity of the product.

(2)

.....

.....

.....

.....

(Total for Question 3 = 19 marks)

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4 The concentration of a solution of sodium dichromate(VI), $Na_2Cr_2O_7$, can be found by titration with a solution containing $Fe^{2+}(aq)$ ions in acidic conditions.

A 20.0 cm^3 sample of a solution of sodium dichromate(VI), of unknown concentration, was titrated with a solution of $Fe^{2+}(aq)$ ions, of concentration 0.0500 mol dm^{-3}. An indicator, diphenylamine, was used. This turned an intense violet colour at the end point.

The titration was repeated several times and some of the results are shown in the table below.

Titration number	1 (trial)	2	3	4
Burette reading (final) / cm^3	21.45	41.35	21.95	
Burette reading (initial) / cm^3	1.20	21.45		21.95
Volume of $Fe^{2+}(aq)$ used / cm^3			20.00	19.80
Titre used to calculate mean (✓)				

(a) Explain why a trial titration (titration 1) is carried out.

(1)

.....

.....

(b) (i) Complete the table and indicate with a tick (✓) those titres most suitable for calculating a mean titre.

Use the titres you have chosen to calculate the mean titre.

(4)

Mean titre = ... cm^3

(ii) Use the equation below, and your mean titre, to calculate the concentration of the sodium dichromate(VI) solution, in mol dm^{-3}.

(3)

$$Cr_2O_7^{2-}(aq) + 6Fe^{2+}(aq) + 14H^+(aq) \rightarrow 2Cr^{3+}(aq) + 6Fe^{3+}(aq) + 7H_2O(l)$$

orange green

(c) Assuming the accuracy of the burette is ± 0.05 cm^3 each time the burette is read, calculate the % error of the titre in **titration 3**.

(1)

(d) Suggest one reason why the indicator diphenylamine is needed, even though the solution in the titration flask changes colour from orange to green when no indicator is used.

(1)

.....

.....

.....

(e) A student carrying out one titration left an air bubble in the tip of the burette before taking the initial reading. This bubble was no longer present when the student took the final reading.

State and explain what effect, if any, this would have on the titre value. What effect would the use of this titre have on the calculated concentration of sodium dichromate(VI)?

(3)

.....

.....

.....

.....

(Total for Question 4 = 13 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 1 2 1 7 A 0 1 6 1 6

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Mark Scheme (Results)

January 2013

GCE Chemistry (6CH08) Paper 01
Chemistry Laboratory Skills (WA)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

General Guidance on Marking

All candidates must receive the same treatment.

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge.

Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the Team Leader must be consulted.

Using the mark scheme

The mark scheme gives:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

1 / means that the responses are alternatives and either answer should receive full credit.
2 ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
3 [ ] words inside square brackets are instructions or guidance for examiners.
4 Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
5 ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- show clarity of expression
- construct and present coherent arguments
- demonstrate an effective use of grammar, punctuation and spelling.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated "QWC" in the mark scheme BUT this does not preclude others.

Question Number	Acceptable answers	Reject	Mark
1(a)	A transition metal (compound/ion) / d block compound/ion (allow element) / Fe^{2+} (compound)/iron(II) salt Ignore: Cr^{3+} Cu^{2+} Ni^{2+} V^{3+}		**1**

Question Number	Acceptable answers	Reject	Mark
1(b)	Hydrolysis / water has removed a proton (from the aqua ion) / Deprotonation / acid base	Ligand exchange Neutralisation Forms a complex ion Hydration	**1**

Question Number	Acceptable answers	Reject	Mark
1(c)	Base / alkali /proton acceptor **(1)** $Fe(OH)_2$ / $Fe(H_2O)_4(OH)_2$ **(1)** ALLOW $Ni(OH)_2$ / $Ni(H_2O)_4(OH)_2$ / $Cr(OH)_3$ / $Cr(H_2O)_3(OH)_3$	Names Cu^{2+}, V^{3+} hydroxides	**2**

Question Number	Acceptable answers	Reject	Mark
1(d)	oxidation **(1)** Allow redox $Fe(OH)_3$ / $Fe(H_2O)_3(OH)_3$ **(1)** Allow $Fe_2O_3.x\ H_2O$	 Fe_2O_3	**2**

Question Number	Acceptable answers	Reject	Mark
1(e)	($Fe(OH)_2$) not amphoteric / no further deprotonation occurs / no ligand substitution occurs Allow (Confirms) compound contains Fe^{2+}		**1**

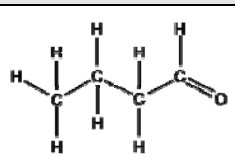
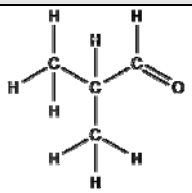
Question Number	Acceptable answers	Reject	Mark
1(f)	Barium sulfate/$BaSO_4$		**1**

Question Number	Acceptable answers	Reject	Mark
1(g)	A is $FeSO_4$ ($.7H_2O$) / iron(II) sulfate Ignore numbers of water.	Iron sulfate	**1**

Total for Q1 = 9 marks

Question Number	Acceptable answers	Reject	Mark
2 (a)(i)	(X) is an aldehyde or ketone / carbonyl compound allow contains a carbonyl group / C=O bond	Just an aldehyde or just a ketone	**1**

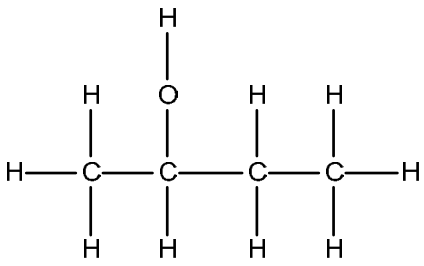
Question Number	Acceptable answers	Reject	Mark
2 (a)(ii)	X is an aldehyde / butanal / (2-)methylpropanal Allow X is not a ketone	Any other named aldehyde	**1**

Question Number	Acceptable answers	Reject	Mark
2(b)	 (1)  (1) Accept skeletal formulae Allow CH_3 and C_2H_5 not displayed	Displayed formulae with missing hydrogen atoms C_3H_7 not displayed	**2**

Question Number	Acceptable answers	Reject	Mark
2 (c)(i)	(Y likely to be an) alcohol or (carboxylic) acid / contains an OH group /contains hydroxyl group	Just an alcohol or just a carboxylic acid Contains hydrox**ide** group	**1**

Question Number	Acceptable answers	Reject	Mark
2(c)(ii)	(Y is) an alcohol / not a carboxylic acid	Contains OH group	**1**

Question Number	Acceptable answers	Reject	Mark
2 (c)(iii)	(Y has) a chiral centre / has a chiral carbon atom / is chiral / non-superimposable mirror images / has optical isomers / is an optical isomer / is an enantiomer Allow asymmetric carbon atom / a carbon atom with four different groups attached	Just optically active Just secondary alcohol	**1**

Question Number	Acceptable answers	Reject	Mark
2 (c)(iv)	 Allow CH_3 and C_2H_5 and OH not displayed Allow structural formula or skeletal formula $CH_3CH(OH)CH_2CH_3$ / $CH_3CH(OH)C_2H_5$		**1**

Question Number	Acceptable answers	Reject	Mark
2 (c)(v)	(Pale) yellow precipitate / solid Both colour and state required. Ignore references to smell.	White precipitate Just triiodomethane will form	**1**

Total for Q2 = 9 marks

Question Number	Acceptable answers	Reject	Mark
3 (a)(i)	Moles of 2-aminobenzoic acid = 4 ÷ 137 / 0.029197 / 0.0292 **(1)** Mass of ethanoic anhydride needed =0.029197 x102 = 2.9781 g **(1)** allow TE from first step Volume of ethanoic anhydride = 2.9781 / 1.082 = 2.7524 cm^3 **(1)** Allow TE from 2nd step Allow any answer that rounds to 2.7 or 2.8 to 2 sf Correct answer alone scores 3 marks **NOTE** The use of 1sf in the moles of 2-aminobenzoic acid loses the first mark even though it gives an answer which rounds to 2.8	**0.03**	**3**

Question Number	Acceptable answers	Reject	Mark
3 (a)(ii)	M_r 2-aminoethanoylbenzoic acid = 179 **(1)** Theoretical yield = 0.029197 mol / = 0.029197 x 179 = 5.2263 g **(1)** % yield = 2.97 ÷ 5.23 x 100/ 0.016592 ÷ 0.029197x100 = 56.828 % = 57 (%) **(1)** correct answer to **2sf** (with no working) scores 3 marks ALLOW TE from 3ai of moles of 2-aminobenzoic acid		**3**

Question Number	Acceptable answers	Reject	Mark
3 (b)(i)	To (try to) make sure all the 2-aminobenzoic acid reacts Comment: allow discussion of small volume measurement	To ensure ethanoic anhydride is in excess To completely dissolve the reactant Ethanoic anhydride is volatile	**1**

Question Number	Acceptable answers	Reject	Mark
3 (b)(ii)	**large** bubbles / liquid rising up condenser / shooting out of the top /uneven boiling / liquids will splash out of flask / liquid will boil up suddenly	Just breaks flask Just "bubbles" Strong bubbling Liquid spills over Liquid sprinkles over Uneven heating Air pockets No smooth boiling Boil vigorously	**1**

Question Number	Acceptable answers	Reject	Mark
3 (b)(iii)	Wear gloves **(1)** (Measure out in) fume cupboard / hood **(1)** Ignore: Wear a mask Allow for second mark In a well ventilated laboratory		**2**

Question Number	Acceptable answers	Reject	Mark
3 (b)(iv)	Dissolve solid in **minimum** (volume) **(1)** Allow: Small volume Ignore: To make a saturated solution of **hot** / **boiling** ethanoic acid / solvent **(1)** (filter hot solution) leave to cool (and recrystallize) **(1)** Filter (wash with ice cold solvent) **and** dry **(1)**	Melt instead of dissolve water Filter and dry with no solid formed in previous steps	**4**

Question Number	Acceptable answers	Reject	Mark
3 (b)(v)	Small amount of product remains in solution (when cool) / after recrystallization) / solid remaining on filter paper / solid remaining in funnel / solution absorbed on filter paper /solid lost during washing with cold solvent.	Just transfer errors Side reactions or incomplete reaction	**1**

Question Number	Acceptable answers	Reject	Mark
3 (b)(vi)	Thermometer with capillary near to bulb **(1)** Allow: Thermometer dipping into solid sample **(max 1)** In a container of **oil** Or In a sand bath Or (Electrically) heated block Or (horizontal) test tube inside boiling tube / double skinned test tube **(1)**	Thermometer above solid sample In water bath	**2**

Question Number	Acceptable answers	Reject	Mark
3(b)(vii)	Compare experimental value to literature / data book value **(1)** Sharp melting temperature / narrow melting temperature range **(1)**		**2**

Total for Q3 = 19 marks

Question Number	Acceptable answers	Reject	Mark
4 (a)	To find the approximate end point / Rough guide to end point / Estimate of end point / as a 'range finder'	To check the method works First titration is inaccurate	**1**

Question Number	Acceptable answers					Reject	Mark
4 (b)(i)	Titration number	1(Trial)	2	3	4		**4**
	Burette reading (final)/ cm^3	21.45	41.35	21.95	**41.75**		
	Burette reading (start)/ cm^3	1.20	21.45	**1.95**	21.95		
	Volume of Fe^{2+} (aq) used / cm^3	**20.25**	**19.90**	20.00	19.80	19.9	
	Titre used to calculate mean (✓)		✓	✓	✓		
	All data correct **(2)** 2 or 3 pieces of data correct **(1)** 0 or 1 piece of data correct **(0)**						
	Ticks, consistent with concordant values **(1)**					First column ticked	
	Mean = 19.9(0) (cm^3) **(1)**						
	Allow transferred error from incorrect ticks Allow correct mean titre even if the ticks are incorrect						

Question Number	Acceptable answers	Reject	Mark
4 (b)(ii)	Moles of Fe^{2+} = (19.90 ÷ 1000) x 0.05 **(1)** = 9.95×10^{-4} (mol) Moles of $Cr_2O_7^{2-}$ = (9.95×10^{-4}) ÷ 6 **(1)** = 1.6583×10^{-4} (mol in 20 cm^3) Allow TE from moles of Fe^{2+} $[Cr_2O_7^{2-}]$ = 1.6583×10^{-4} x 1000 / 20 =8.2917×10^{-3} (mol dm^{-3}) **(1)** Allow TE from moles of $Cr_2O_7^{2-}$ Allow any answer that rounds to 8.3×10^{-3} to 2 sf Ignore sf except 1		**3**

Question Number	Acceptable answers	Reject	Mark
4 (c)	(0.05 x 2) ÷ 20.00 x 100 = 0.5(%)		**1**

Question Number	Acceptable answers	Reject	Mark
4 (d)	(indicator makes) the end point more obvious/easier to see OR (indicator makes) the end point sharper	To find the exact end point	**1**

Question Number	Acceptable answers	Reject	Mark
4 (e)	Titre would appear to be greater **(1)** Because (extra solution needed to fill) the air gap **(1)** (More Fe^{2+} ≡ more $Cr_2O_7^{2-}$), so calculated concentration would be greater (than actual value) **(1)** ALLOW (for third mark only): Increased titre would not be concordant so would not be used to calculate mean. Titre would make no difference to the calculated concentration. **(1)** ALLOW (for third mark only): TE from smaller titre to smaller concentration		**3**

Total for Q4 = 13 marks

PAPER TOTAL= 50 MARKS

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Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced

Unit 6B: Chemistry Laboratory Skills II Alternative

Wednesday 15 May 2013 – Morning
Time: 1 hour 15 minutes

Paper Reference
6CH08/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P41653A

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10/5/6/7/7/

P 4 1 6 5 3 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 (a) Compound **Z** is a crystalline solid that contains a nickel cation and one type of anion. Complete the table below.

	Test	Observation	Inference
(i)	Add dilute sulfuric acid to compound **Z**	Bubbles of a colourless gas are released. The gas turns limewater milky and a ..... coloured solution is formed **(1)**	Name of gas released is ..... Formula of anion in **Z** is ..... Formula of the complex ion formed is $[Ni(H_2O)_6]^{2+}(aq)$ **(2)**
(ii)	Add concentrated hydrochloric acid to the solution containing $[Ni(H_2O)_6]^{2+}$ ions	Yellow-brown solution forms	Formula of the complex ion formed is ..... **(1)**
(iii)	Add a few drops of dilute aqueous ammonia to the solution containing $[Ni(H_2O)_6]^{2+}$ ions	Green precipitate forms	Formula of the precipitate formed is ..... **(1)**
(iv)	Add excess dilute aqueous ammonia to the solution containing $[Ni(H_2O)_6]^{2+}$ ions until no further change is observed	.... **(1)**	Formula of the complex ion formed is $[Ni(NH_3)_6]^{2+}$

(b) A 10.0 cm^3 sample of a solution containing $[Ni(H_2O)_6]^{2+}$ ions was titrated with a solution of concentration 0.010 mol dm^{-3} with respect to the ligand $EDTA^{4-}$ ions. The equation for the reaction is

$$[Ni(H_2O)_6]^{2+} + EDTA^{4-} \rightarrow [Ni(EDTA)]^{2-} + 6H_2O$$

(i) The mean titre of the solution containing $EDTA^{4-}$ ions was 24.20 cm^3. Use this information, and the equation above, to calculate the concentration in mol dm^{-3} of the solution containing $[Ni(H_2O)_6]^{2+}$ ions.

(2)

(ii) Assuming the total error in the measurement of the mean titre is ±0.10 cm^3, calculate the percentage error in this titre.

(1)

(iii) A similar solution, containing the same concentration of $[Ni(H_2O)_6]^{2+}$ ions, also contained a small amount of an impurity, copper(II) sulfate.

Suggest what effect this impurity would have on the titre. Justify your answer.

(2)

.....

.....

.....

.....

(Total for Question 1 = 11 marks)

BLANK PAGE

2 A colourless liquid, compound **X**, was extracted from raspberries. **X** has the molecular formula $C_{10}H_{12}O_2$ and contains a benzene ring.

(a) What would you expect to see if a sample of compound **X** was burned in air?

(1)

.....

.....

(b) A series of tests was carried out on compound **X**. In each test, state what you can deduce about the structure of compound **X** from the results described.

(i) **X** forms a white precipitate with aqueous bromine solution.

(1)

.....

.....

(ii) **X** forms an orange precipitate with 2,4-dinitrophenylhydrazine.

(1)

.....

.....

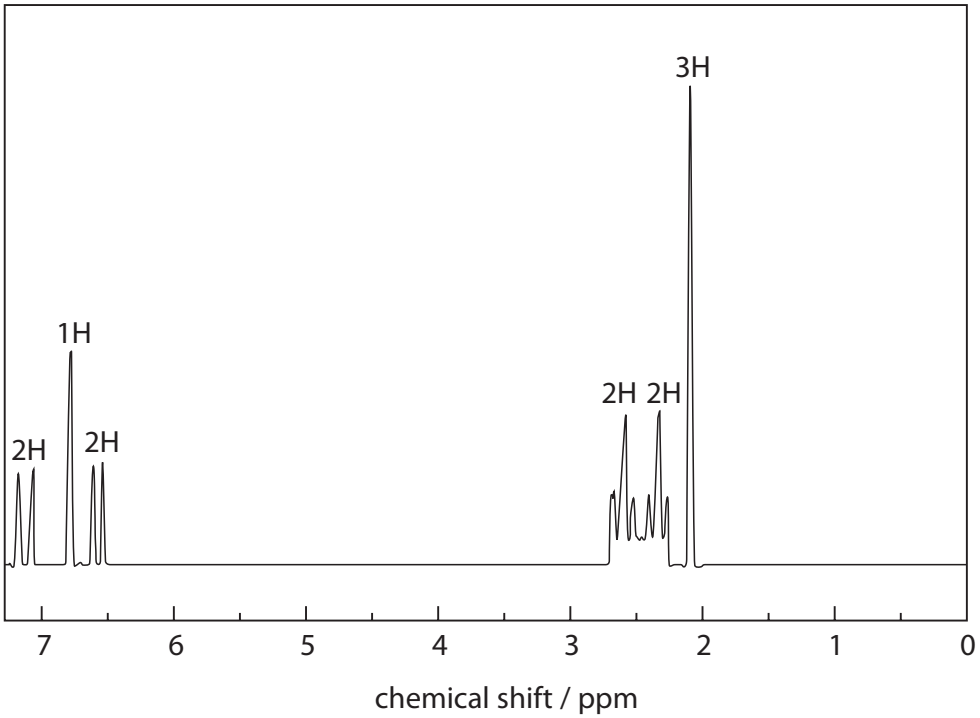
(iii) Fehling's (or Benedict's) solution remains blue when warmed with compound **X**.

(1)

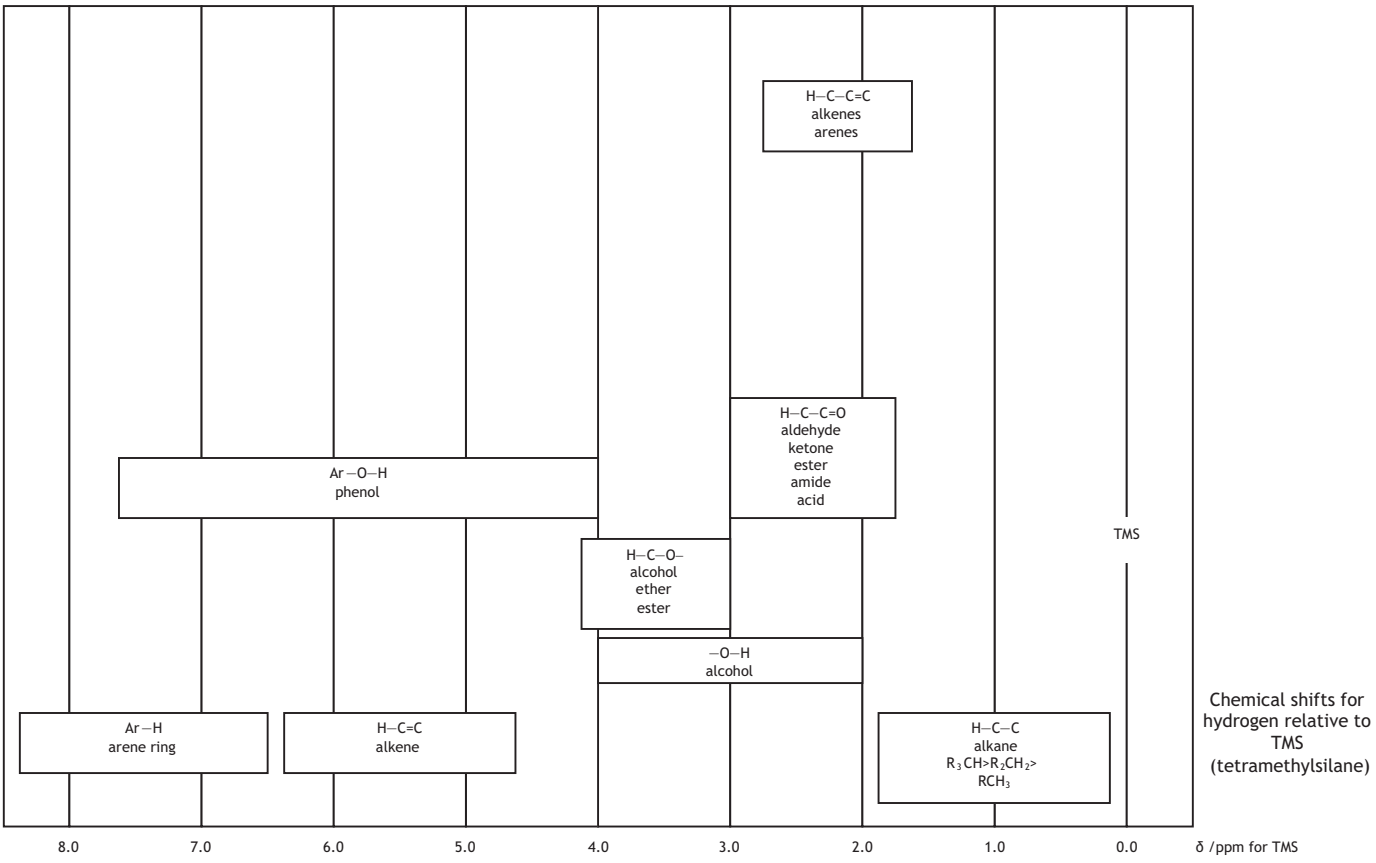
.....

.....

(c) The high resolution proton nmr spectrum of compound **X** is shown below. This spectrum shows that there are six different proton environments in the molecule of **X**. The relative number of hydrogen atoms in each environment is indicated on the spectrum. Use this spectrum, the data below and your answers to (a) and (b) to help answer the questions that follow.



Nuclear Magnetic Resonance

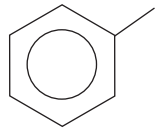


(i) Which hydrogen atoms in compound **X** are most likely to have caused the peaks at 6.5 ppm and 7.2 ppm?

(1)

.....

(ii) Compound **X** has a side chain containing four carbon atoms attached to the benzene ring. Show all the atoms on this side chain and label each hydrogen environment on the side chain with its splitting pattern.



(3)

.....

.....

.....

.....

.....

.....

(iii) Suggest the structural formula of **X**.

(1)

(d) Compound **X** can be extracted from raspberries by steam distillation. Draw a labelled diagram of the apparatus you could use to carry out this steam distillation.

(3)

(Total for Question 2 = 12 marks)

3 Glucose can be oxidized using acidified potassium manganate(VII). The kinetics of the reaction can be studied using the procedure outlined below.

1. Measured volumes of glucose solution, sulfuric acid and water were added to a conical flask.
2. A measured volume of potassium manganate(VII) solution was added to the flask. The mixture was gently swirled and a stopwatch started.
3. The time taken for the mixture in the flask to change colour was recorded and the initial rate of the reaction was then calculated.
4. The experiment was repeated using different volumes of the solutions.

The results of the experiments are shown in the table below.

Experiment	Glucose / cm^3	Sulfuric acid / cm^3	Potassium manganate(VII) / cm^3	Water / cm^3	Initial rate / mol dm^{-3} s^{-1}
A	20.0	20.0	10.0	0.0	1.0×10^{-5}
B	20.0	20.0	5.0	5.0	5.0×10^{-6}
C	10.0	20.0	10.0	10.0	9.8×10^{-6}
D	10.0	10.0	10.0	20.0	4.9×10^{-6}

(a) (i) Which piece of equipment should be used to measure out the volumes used in each experiment? Justify your choice.

(2)

(ii) What colour change would you see in step 3?

(2)

From ..... to .....

(iii) Explain why water was added to the flask in experiments B, C and D.

(1)

.....

.....

(iv) Suggest a technique that could be used to continuously monitor the change in concentration of potassium manganate(VII) during the reaction.

(1)

.....

.....

(v) State the order with respect to glucose, sulfuric acid and potassium manganate(VII) and hence write the rate equation for the reaction.

(3)

(b) Experiment A was repeated at different temperatures and the time taken for the potassium manganate(VII) to change colour was recorded. The results were processed to find values of 1/temperature and ln (rate constant) and these are shown in the table below.

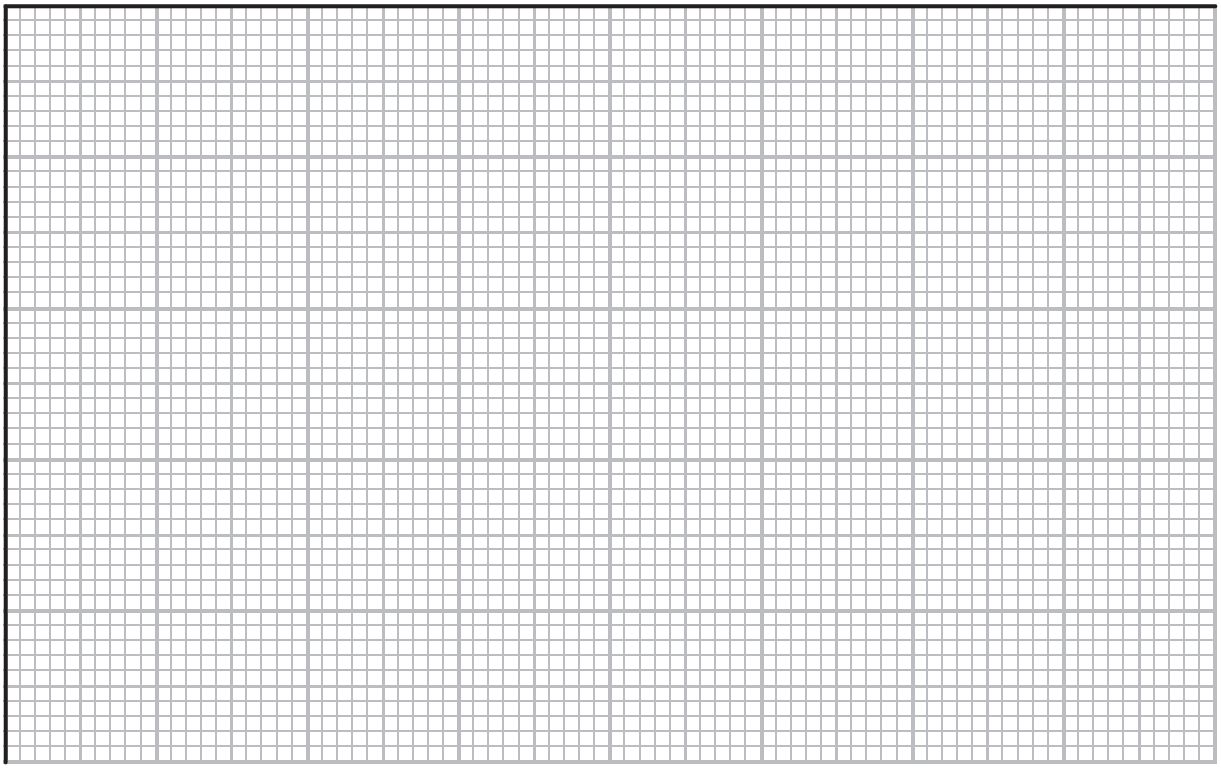
Experiment	1 / temperature / K^{-1}	ln (rate constant)
E	3.00×10^{-3}	–1.60
F	3.10×10^{-3}	–2.60
G	3.21×10^{-3}	–3.75
H	3.35×10^{-3}	–5.20

(i) Plot a graph of ln (rate constant) against 1 / temperature on the axes below.

(3)

1 / temperature / K^{-1}

ln (rate constant)



(ii) Calculate the gradient of the graph.

(1)

(iii) Use your answer to (ii) and the relationship below to calculate the activation energy, E_a, for this reaction. Include a sign and units in your answer.

$$\text{Gradient} = \frac{-E_a}{R}$$

$R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$

(2)

(Total for Question 3 = 15 marks)

4 The procedure outlined below can be used to extract caffeine from tea.

1. Add 25 g of tea, 10 g of calcium carbonate and 250 cm^3 of water to a large beaker.
2. Gently boil the mixture for 15 minutes.
3. While the mixture is still warm, filter using suction filtration.
4. Transfer the filtrate to a separating funnel and separate the caffeine from the aqueous mixture using solvent extraction, with dichloromethane as the solvent.
5. Dry the extract.
6. Remove the solvent.

[Density of dichloromethane = 1.32 g cm^{-3}]

(a) (i) Outline how to carry out the solvent extraction in **step 4**, to obtain a solution of caffeine dissolved in dichloromethane.

(3)

(ii) How would you dry the extract in **step 5**? Include the name of a suitable drying agent in your answer.

(2)

(b) (i) The solvent dichloromethane is harmful and can enter the body through inhalation and skin absorption. Suggest a possible way to minimise each of these risks when using dichloromethane.

(2)

Inhalation .....

Skin absorption .....

(ii) Suggest a suitable way to remove the solvent in **step 6**.

(1)

(c) The extraction can also be carried out using liquid carbon dioxide. Suggest an advantage of using this rather than dichloromethane.

(1)

(d) A student carrying out this extraction obtained 85 mg of caffeine. Calculate the percentage by mass of caffeine obtained from the sample of tea used.

(2)

(e) Caffeine obtained in this way is often a pale green solid, due to impurities. State the name of another technique you could use to further purify the caffeine.

(1)

.....

.....

(Total for Question 4 = 12 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 1 6 5 3 A 0 1 6 1 6

PMT

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Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH08/01
Chemistry Laboratory Skills II
Alternative

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General Guidance on Marking

All candidates must receive the same treatment.

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge.

Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.

When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the Team Leader must be consulted.

Using the mark scheme

The mark scheme gives:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

1 / means that the responses are alternatives and either answer should receive full credit.
2 ( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
3 [ ] words inside square brackets are instructions or guidance for examiners.
4 Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
5 ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- show clarity of expression
- construct and present coherent arguments
- demonstrate an effective use of grammar, punctuation and spelling.

Full marks will be awarded if the candidate has demonstrated the above abilities.

Questions where QWC is likely to be particularly important are indicated "QWC" in the mark scheme BUT this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	Green IGNORE qualifications of green such as light / dark / emerald **(1)** Carbon dioxide ALLOW CO_2 **(1)** CO_3^{2-} ALLOW HCO_3^- **(1)**	Blue-Green Turquoise	**3**

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	$[NiCl_4]^{2-}$ ALLOW -2 for 2- $NiCl_4^{2-}$ $[Ni(Cl)_4]^{2-}$ $Ni(Cl)_4^{2-}$ $[Ni(H_2O)_2Cl_4]^{2-}$ $[NiCl_6]^{4-}$		**1**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iii)	$Ni(OH)_2$ / $Ni(H_2O)_4(OH)_2$ / $Ni(OH)_2$ $(H_2O)_4$ / $[Ni(H_2O)_4(OH)_2]$ / $[Ni(OH)_2$ $(H_2O)_4]$		**1**

Question Number	Acceptable Answers	Reject	Mark
1(a)(iv)	Blue solution (forms) ALLOW lavender blue solution and any other shade of blue OR (Green) precipitate dissolves	 Blue-green Precipitate dissolves to give incorrect coloured solution	**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	$24.2 / 1000 \times 0.01 = 2.42 \times 10^{-4}$ (mol) **(1)** Concentration of $[Ni(H_2O)_6]^{2+}$ ions $= 2.42 \times 10^{-4} \times 100 = 0.0242$ (mol dm^{-3}) **(1)** ALLOW TE on number of moles Correct answer alone scores both marks IGNORE significant figures except 1		**2**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	0.1 / 24.2 x 100 = (±) 0.413% / (±) 0.41 % / (±) 0.4%	4 or more SF	**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	(Mean) titre would be greater **(1)** $EDTA^{(4-)}$ would also complex to / react with Cu^{2+} / $[Cu(H_2O)_6]^{2+}$ / $CuSO_4$ / copper ions / copper sulphate **(1)** Both marks are stand alone.	More needed to react with unspecified impurity	**2**

Total for Question 1 = 11 Marks

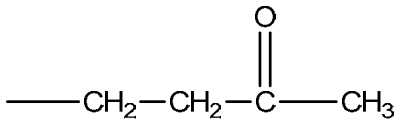
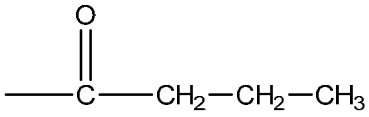
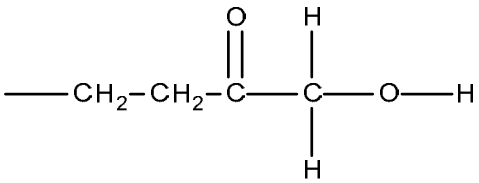
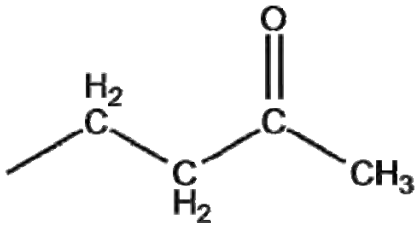
Question Number	Acceptable Answers	Reject	Mark
2(a)	Smoky / sooty flame IGNORE reference to yellow flame	White smoke	**1**

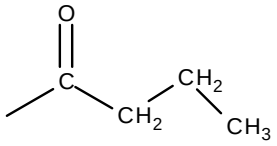
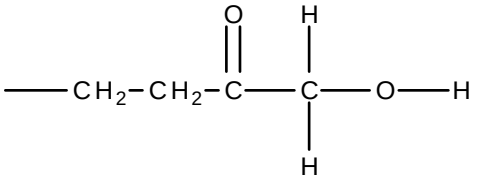
Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	It contains a phenol group / has OH attached to benzene ring ALLOW hydrox**yl** group attached to benzene ring ALLOW "is a phenol" ALLOW drawn benzene ring with OH	Just OH group Hydrox**ide** group	**1**

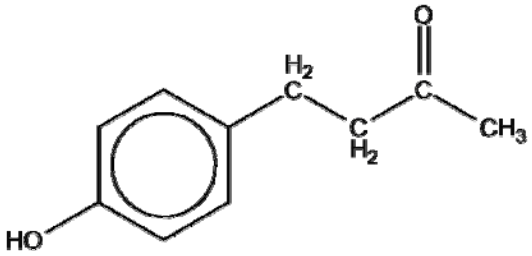
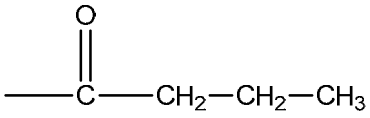
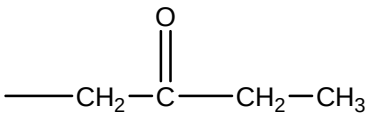
Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	It could be an aldehyde or a ketone / contains a carbonyl group ALLOW C=O	Either aldehyde or ketone on its own	**1**

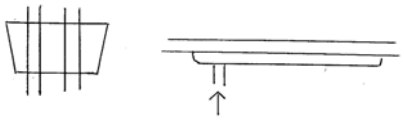
Question Number	Acceptable Answers	Reject	Mark
2(b)(iii)	**X** is a ketone ALLOW aromatic ketone ALLOW R-CO-R ALLOW not an aldehyde if both ketone and aldehyde mentioned in b(ii)		**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	(hydrogen atoms / protons on) benzene ring / phenyl group / arene ring	Hydrogen atoms in phenol	**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	To score any marks in this question the side chain must be: (a)  OR (b)  OR (c)  Ketone on correct carbon Structure (a) Or structure (c) **(1)** ALLOW displayed or skeletal ALLOW $-CH_2CH_2COCH_3$ IGNORE presence or position of –OH on the benzene ring  triplet triplet singlet both triplets labelled **(1)** singlet labelled **(1)** ALLOW If the side chain is (b) the triplet CH_2 next to the C=O correctly labelled scores one mark	Any other side chain scores zero for 2c(ii)	**3**

	 triplet **(1)** If the side chain is (c) the triplets, both labelled, score the mark.  triplet triplet **(1)**		

Question Number	Acceptable Answers	Reject	Mark
2(c)(iii)	 IGNORE position of OH and side chain on the ring ALLOW displayed or skeletal ALLOW $C_6H_4(OH)CH_2CH_2COCH_3$ ALLOW TE if one of the following side chains is carried forward from 2c(ii):  OR 	TE for any other side chain	

Question Number	Acceptable Answers	Reject	Mark
2(d)	Steam source with delivery tube to flask with the steam passing into the liquid in the flask IGNORE incorrectly positioned safety vents in the steam generator OR Flask being heated and containing **water** (and raspberries) **(1)** Condenser with water jacket in correct position and with correct direction of water flow shown **(1)** Collection vessel **(1)** Minus 1 if apparatus does not work (e.g. sealed or leaky joints)  Correctly drawn reflux apparatus scores 1 IGNORE fractionating columns Collection vessel may be any shape of flask, test tube or cylinder	Steam delivered above the liquid in the flask Unlabelled liquid in the flask	**3**

Total for Question 2 = 12 Marks

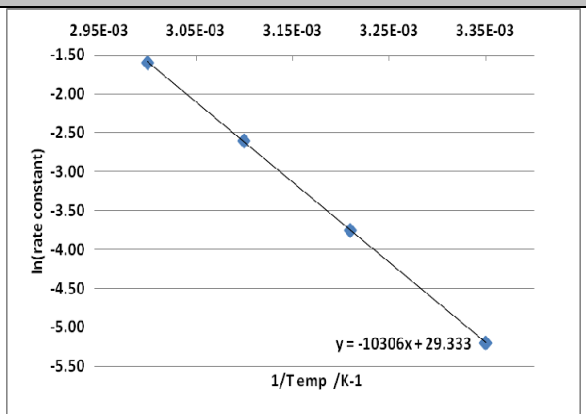
Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	Burette / (graduated / volumetric) pipette **(1)** Allows accurate /precise measurement **(1)** OR measuring cylinder **(1)** Allows you to do multiple experiments quickly / accurate enough (to determine orders) **(1)** IGNORE Ease of use Cylinder allows variety of different volumes to be measured	Dropping / teat pipette	**2**

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	Pink / purple **(1)** To colourless **(1)** Reverse order scores 1	Lilac Clear for colourless	**2**

Question Number	Acceptable Answers	Reject	Mark
3(a)(iii)	To keep the (overall) volume constant/ 50 cm^3 OR So the concentration of each reactant is proportional to the volume used	Any other volume quoted	**1**

Question Number	Acceptable Answers	Reject	Mark
3(a)(iv)	(Monitor change in concentration of MnO_4^- using) colorimetry OR Titrate with reducing agent / named reducing agent e.g. Fe^{2+}	Just observing the intensity of the colour Electrical conductivity pH meter Just “titrate”	**1**

Question Number	Acceptable Answers	Reject	Mark
3(a)(v)	0 order wrt glucose 1st order wrt sulfuric acid 1st order wrt potassium manganate(VII) All 3 correct scores 2 marks 2 correct scores 1 mark 0 or 1 correct scores 0 marks **(2)** Rate/r/R = $k[MnO_4^-][H^+]([C_6H_{12}O_6]^0)$ **(1)** ALLOW full formulae or names in rate equation If formulae given they must be correct ALLOW "K" for "k" ALLOW TE from incorrect orders for last mark	Rate equation for rate	**3**

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	 Suitable linear scales **(1)** IGNORE units Points plotted correctly **(1)** Straight line of best fit drawn **(1)**		**3**

Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	Gradient = – 10300 ALLOW any value in the range -9600 to -11000 IGNORE units even if incorrect	Positive gradient	**1**

Question Number	Acceptable Answers	Reject	Mark
3(b)(iii)	E_A = (-) gradient from b(ii) x 8.31 **(1)** E_A = Value to at least 2 sf with units **(1)** Units must be correct Correct value: E_A = -(-10300) x 8.31 = 85593 J mol^{-1} / 85.6 kJ mol^{-1} Correct answer with no working scores both marks	Negative E_A	**2**

Gradient	E_A/ $kJmol^{-1}$
-9600	79.8
-9700	80.6
-9800	81.4
-9900	82.3
-10000	83.1
-10100	83.9
-10200	84.8
-10300	85.6
-10400	86.4
-10500	87.3
-10600	88.1
-10700	88.9
-10800	89.7
-10900	90.6
-11000	91.4

Total for Question 3 = 15 Marks

Question Number	Acceptable Answers	Reject	Mark
4(a)(i)	Any **three** from: Shake / mix **(1)** Release pressure / open stopper (from time to time) **(1)** Remove lower / dichloromethane layer by opening tap / using teat pipette OR Decant the top layer / remove top layer with teat pipette. To score this mark it must be clear that the bottom layer is the layer required **(1)** Repeat extraction with additional solvent **(1)**	 Just "add the dichloromethane" Just "separate the liquids"	**3**

Question Number	Acceptable Answers	Reject	Mark
4(a)(ii)	Add named drying agent (anhydrous) calcium chloride / magnesium sulfate / sodium sulfate **(1)** ALLOW silica gel IGNORE desiccator (Allow to stand) decant / filter (to separate drying agent) **(1)** Both marks are stand alone	Sulfuric acid KOH NaOH **Heat** with drying agent Dry with filter paper	**2**

Question Number	Acceptable Answers	Reject	Mark
4(b)(i)	Carry out in fume cupboard / hood / chamber / well ventilated lab **(1)** IGNORE gas / face masks Wear (protective) gloves **(1)** IGNORE lab coat and eye protection		**2**

Question Number	Acceptable Answers	Reject	Mark
4(b)(ii)	Distillation / evaporate under reduced pressure / rotary evaporation ALLOW fractional distillation IGNORE recrystallisation	Just evaporate	**1**

Question Number	Acceptable Answers	Reject	Mark
4(c)	CO_2 is less harmful / not harmful / less hazardous / not hazardous / less irritant / not irritant / non-flammable / non-toxic / evaporates easily / easily removed IGNORE comments regarding ozone layer or global warming	Just CO_2 safer/less risky	**1**

Question Number	Acceptable Answers	Reject	Mark
4(d)	85 mg = 0.085 g **(1)** % caffeine = 0.085/25 x 100 = 0.34% **(1)** ALLOW TE on incorrect mass Correct answer alone scores both marks IGNORE sf except 1	% caffeine>100%	**2**

Question Number	Acceptable Answers	Reject	Mark
4 (e)	Recrystallization ALLOW column chromatography ALLOW sublimation	Distillation	**1**

Total for Question 4 = 12 Marks

Total for Paper = 50 Marks

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Chemistry

Advanced

Unit 6: Chemistry Laboratory Skills II

Thursday 16 January 2014 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH06/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

P42975RA

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6/6/6/6/2/2/3/

P 4 2 9 7 5 R A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 Substance **A** is a green solid which dissolves in water to form a green solution. Substance **A** is an ionic compound containing one cation and one anion.

(a) Give the **formulae** of **two** cations which could be responsible for the green colour in the solid.

(2)

.....

(b) A student added dilute sodium hydroxide, drop by drop, to an aqueous solution of **A**. Initially, a green precipitate was formed. The precipitate did not dissolve in excess sodium hydroxide solution. The precipitate darkened on standing to give a brown solid.

(i) Write the **formula** of the cation in substance **A**.

(1)

.....

(ii) Write a **formula** for the green precipitate.

(1)

.....

(iii) Write a **formula** for the brown solid.

(1)

.....

(iv) State the type of reaction involved when the green precipitate turns brown.

(1)

.....

(c) The student added a few drops of acidified potassium manganate(VII) solution to another sample of a solution of **A** in a test tube.

Describe the colour change that occurs.

(1)

.....

.....

(d) The student acidified about 2 cm^3 of a solution of **A** with dilute nitric acid in a test tube and then added a few drops of aqueous silver nitrate solution. A white precipitate was formed.

(i) Give the **formula** of the anion present in **A**.

(1)

.....

(ii) The test in (d)(i) is usually followed by the addition of ammonia solution to test the solubility of the precipitate.

Explain why this is not a useful procedure in this case.

(2)

.....

.....

.....

.....

(Total for Question 1 = 10 marks)

2 Solution **B** is copper(II) sulfate dissolved in water.

(a) When an excess of concentrated hydrochloric acid is added to solution **B**, the colour of **B** changes from blue to yellow.

Give the **formula** of the complex ion responsible for the yellow colour.

(1)

.....

(b) What would you observe as dilute ammonia solution is added, drop by drop, to another sample of solution **B**?

(3)

.....

.....

.....

.....

.....

(c) 20.0 cm^3 of solution **B** was added to excess aqueous potassium iodide solution and the volume made up to 250 cm^3. The following reaction occurred:

$$2Cu^{2+}(aq) + 4I^-(aq) \rightarrow 2CuI(s) + I_2(aq)$$

25.0 cm^3 samples of the resulting mixture were titrated with 0.120 mol dm^{-3} sodium thiosulfate solution. The mean titre was 17.85 cm^3.

(i) Complete the ionic equation for the reaction of thiosulfate ions with iodine. State symbols are not required.

(1)

$$2S_2O_3^{2-} + I_2 \rightarrow \text{.....} + \text{.....}$$

(ii) Calculate the concentration of solution **B**, in mol dm^{-3}.

(3)

(Total for Question 2 = 8 marks)

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3 An ester is hydrolysed in the presence of an acid catalyst forming a carboxylic acid and an alcohol **C**. The alcohol contains four carbon atoms.

In order to investigate the kinetics of this reaction, two solutions, **X** and **Y**, were made up.

Solution **X**: 100 cm^3 of a 0.20 mol dm^{-3} solution of the ester
Solution **Y**: 100 cm^3 of a 0.20 mol dm^{-3} solution of hydrochloric acid

Flasks containing the two solutions were placed in a water bath at 50 °C and when both solutions had reached the temperature of the water bath, the solutions were mixed and a clock started. As soon as the clock was started, a 10 cm^3 sample was taken from the reaction mixture, transferred to a cooled conical flask and titrated with 0.050 mol dm^{-3} sodium hydroxide solution. Other samples were taken at two minute intervals and analysed in the same way.

Results:

Time/min	0	2	4	6	8	10	12	14	16
Titre/cm^3	20.0	23.4	26.2	28.5	30.5	32.1	33.4	34.5	35.5
V = (40 – titre)/cm^3	20.0	16.6	13.8	11.5	9.5	7.9	6.6	5.5	4.5

V is directly proportional to the concentration of the ester remaining in the solution.

(a) Why was each sample cooled before titration?

(1)

.....

(b) Two indicators are available for the titrations: phenolphthalein and methyl orange.
Which one should be used? Give a reason for your answer.

(1)

Indicator .....

Reason .....

.....

(c) (i) Explain why the titre at time zero is 20.0 cm^3 rather than 0.0 cm^3. No calculation is required.

(1)

.....

(ii) Explain why the titre increases as the reaction proceeds.

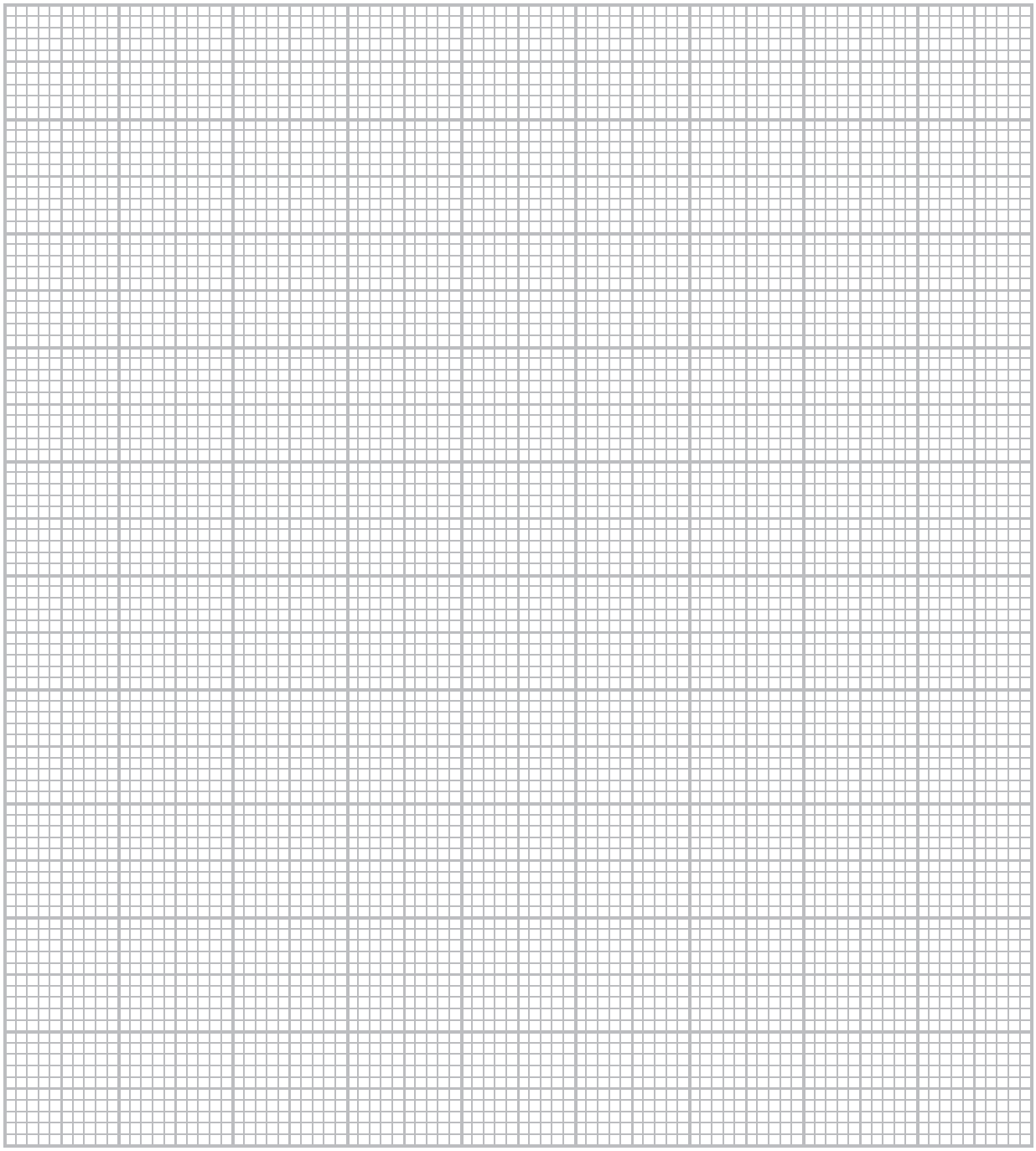
(1)

.....

.....

(d) Plot a graph of **V** on the vertical axis against time on the horizontal axis. Use your graph to determine the order of the reaction by measuring two successive half-lives.

(4)



First half-life .....

Second half-life .....

Order .....

(e) The alcohol **C** is oxidized using potassium dichromate(VI) and dilute sulfuric acid. State the colour change observed.

(1)

From ..... To .....

(f) The oxidation results in the formation of either a carboxylic acid or a ketone.

(i) Suggest a chemical test that could be used to show that the purified product is a carboxylic acid.

Give the observation that you would make when this test is carried out.

(2)

Reagent .....

Observation .....

.....

(ii) Suggest a chemical test that could be used to show that the purified product is a ketone.

Give the observation that you would make when this test is carried out.

(2)

Reagent .....

Observation .....

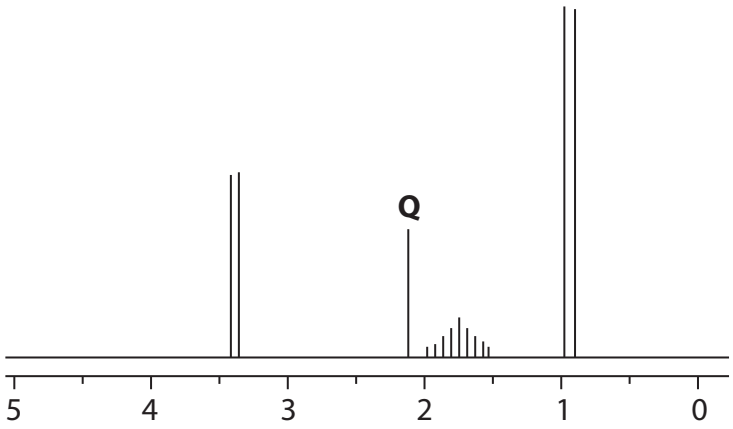
.....

(g) Tests show that **C** is oxidized to a carboxylic acid. What type of alcohol is **C**?

(1)

.....

(h) A simplified nmr spectrum for alcohol **C** is shown below:



(i) What can you conclude from the fact that there are four sets of peaks?

(1)

.....

.....

(ii) Using your answers to (g) and (h)(i), and the fact that alcohol **C** contains four carbon atoms, draw the displayed formula of alcohol **C**.

(1)

(iii) On the displayed formula you have drawn in (h)(ii), circle the atom or group of atoms responsible for the peak labelled **Q**.

(1)

(Total for Question 3 = 17 marks)

4 This question concerns the preparation of an ester, 3-methylbutyl ethanoate. The ester can be produced by the reaction of 3-methylbutan-1-ol and ethanoic anhydride:

$$C_5H_{11}OH + (CH_3CO)_2O \rightarrow CH_3COOC_5H_{11} + CH_3CO_2H$$

Reagents

- 3-methylbutan-1-ol [molar mass = 88.0 g mol^{-1}; density = 0.81 g cm^{-3}]
- ethanoic anhydride

Required product

- 3-methylbutyl ethanoate

  [molar mass = 130.0 g mol^{-1}; boiling temperature = 142 °C]

Safety information

- 3-methylbutan-1-ol is highly flammable
- 3-methylbutyl ethanoate is highly flammable
- ethanoic anhydride is corrosive, causing skin blistering and peeling

The steps of the experimental procedure are as follows:

Step 1 Place 10.0 cm^3 of 3-methylbutan-1-ol in a flask and add a few anti-bumping granules.

Step 2 Set up the apparatus for reflux. Pour 12.5 cm^3 of ethanoic anhydride (a slight excess) down the condenser. Warm the mixture until the reaction starts and then reflux gently for five minutes. Allow the mixture to cool.

Step 3 Transfer the cooled mixture to a separating funnel, leaving the anti-bumping granules in the flask. Add about 25 cm^3 of water and shake the mixture. Allow the two layers to separate and discard the lower aqueous layer. The addition of water converts any unreacted ethanoic anhydride into ethanoic acid.

Step 4 Add about 10 cm^3 of aqueous sodium hydrogencarbonate to the separating funnel and shake carefully. When the vigorous effervescence has finished, insert the stopper and shake the funnel, frequently releasing the pressure. Repeat the washing with further quantities of aqueous sodium hydrogencarbonate until no more gas is produced. Discard the lower aqueous layer each time.

Step 5 Transfer the ester to a conical flask and shake the flask for five minutes with a suitable drying agent.

Step 6 Filter the dried ester directly into a flask. Set up the apparatus for simple distillation, adding a few anti-bumping granules to the flask. Distil off the ester.

(a) State **two** safety precautions, each related to a specific hazard of this experiment. You may assume that eye protection and laboratory coats are being worn and that the experiment was carried out in a fume cupboard.

(2)

Hazard 1 .....

Precaution 1 .....

Hazard 2 .....

Precaution 2 .....

(b) Draw a labelled diagram of the apparatus needed for heating under reflux in **Step 2**. You do not need to show stands or clamps.

(3)

(c) Why are anti-bumping granules added to the flask in **Step 1**?

(1)

.....

.....

(d) What is the purpose of adding aqueous sodium hydrogencarbonate in **Step 4**?

(1)

.....

.....

(e) In the following list of substances, only one would be a suitable drying agent to use in **Step 5**. Identify this drying agent, giving a reason for your choice:

(2)

- concentrated phosphoric(V) acid
- sodium hydroxide solid
- anhydrous sodium sulfate
- concentrated sulfuric acid

Drying agent .....

Reason .....

.....

(f) In **Step 6**, the ester is distilled off. Suggest a suitable temperature range over which to collect the ester.

(1)

From .....°C to .....°C

(g) (i) Calculate the maximum mass of 3-methylbutyl ethanoate that could be obtained in this experiment from 10 cm^3 of 3-methylbutan-1-ol. Give your answer to **three** significant figures.

(3)

(ii) A student carried out the synthesis and obtained 9.45 g of 3-methylbutyl ethanoate. Calculate the percentage yield.

(2)

(Total for Question 4 = 15 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 7 5 R A 0 1 6 1 6

PMT

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Mark Scheme (Results)

January 2014

IAL Chemistry (WCH06/01)
Unit 6: Chemistry Laboratory Skills II

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Correct Answer	Reject	Mark
1(a)	Any **two** from: Fe^{2+} / $Fe(H_2O)_6^{2+}$ Ni^{2+} / $Ni(H_2O)_6^{2+}$ Cr^{3+} / $Cr(H_2O)_6^{3+}$ Allow Cu^{2+} Ignore names As usual: 1 correct and 1 incorrect scores 1 2 correct and 1 incorrect scores 1 3 correct and 1 incorrect scores 2	Cr^{2+} $Cu(H_2O)_6^{2+}$ $Cu(H_2O)_4^{2+}$	**2**

Question Number	Correct Answer	Reject	Mark
1(b)(i)	Fe^{2+} / $Fe(H_2O)_6^{2+}$ Ignore names		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	$Fe(OH)_2$/ $Fe(H_2O)_4(OH)_2$ / $Fe(OH)_2(H_2O)_4$ Ignore names TE if Ni^{2+} in (b)(i) then $Ni(OH)_2$/ $Ni(H_2O)_4(OH)_2$ / $Ni(OH)_2(H_2O)_4$ score 1. No TE for Cr^{3+}		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	$Fe(OH)_3$/ $Fe(H_2O)_3(OH)_3$ / $Fe(OH)_3(H_2O)_3$ Ignore names No TE from (b)(i) ALLOW: Fe_2O_3 with or without water		**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)(iv)	Oxidation / redox (reaction) Additional information may be given and can be ignored, e.g. 'green precipitate undergoes oxidation'. ALLOW: Oxidation and reduction	Just 'reduction'	**1**

Question Number	Acceptable Answers	Reject	Mark
1(c)	Purple to colourless/pale yellow/brown Both required OR Purple (solution) decolourised Allow Pink for purple OR Green to yellow/brown	Colourless to purple Green to purple	**1**

Question Number	Acceptable Answers	Reject	Mark
1(d)(i)	Cl^-(ion) Ignore names: e.g. Chlor**ide** (ion) Iron(II) chloride	Cl $FeCl_2$ Chlor**ine** ion	**1**

Question Number	Acceptable Answers	Reject	Mark
1(d)(ii)	Ammonia reacts with the iron ions to form a precipitate OR A precipitate forms **(1)** **Second mark** (A precipitate of) Iron(II) hydroxide/ Iron(III) hydroxide/ $Fe(OH)_2$/ $Fe(H_2O)_4(OH)_2$/ $Fe(OH)_3$/ $Fe(H_2O)_3(OH)_3$ (forms) OR Obscures the dissolving of the white precipitate (OWTTE e.g. masks precipitate) **(1)** **ALLOW** Precipitate should dissolve but here ammonia is neutralised by nitric acid **(1 max)**		**2**

(Total for Question 1 = 10 marks)

Question Number	Acceptable Answers	Reject	Mark
2(a)	$CuCl_4^{2-}$/$[CuCl_4]^{2-}$ /$(CuCl_4)^{2-}$/$[Cu(Cl)_4]^{2-}$	$CuCl_4$ Correct formula with added H_20	**1**

Question Number	Acceptable Answers	Reject	Mark
2(b)	(pale) blue **precipitate** **(1)** Ignore gelatinous in front of precipitate but not in front of solution in next part. precipitate dissolves (in excess ammonia)/ precipitate disappears/soluble/solution forms **(1)** deep/dark(er)/royal blue(solution) **(1)** deep blue solution forms scores 2nd and 3rd marks Marks stand alone Ignore formulae even if incorrect	Just "blue"	**3**

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	($2S_2O_3^{2-}$ + $I_2 \rightarrow$) $S_4O_6^{2-}$ + $2I^-$ Ignore state symbols even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	mol $S_2O_3^{2-}$ = 17.85 x 0.120/1000 **(1)** = 2.142 x 10^{-3}/0.002142 mol Cu^{2+} = 2.142 x 10^{-3} in 25 cm^3 total mol Cu^{2+} = 2.142 x 10^{-3} x 250/25 **(1)** **=** 2.142 x 10^{-2}/0.02142 [$CuSO_4$] = 2.142 x 10^{-2} x 1000/20.0 = 1.07(1) (mol dm^{-3}) **(1)** Ignore sf except 1 sf Correct answer with no working **(3)** 0.107 (mol dm^{-3}) **2 max** Check unfinished calculation not finished on next page 2nd and 3rd marks can be transferred errors	1 sf 1.0/1	**3**

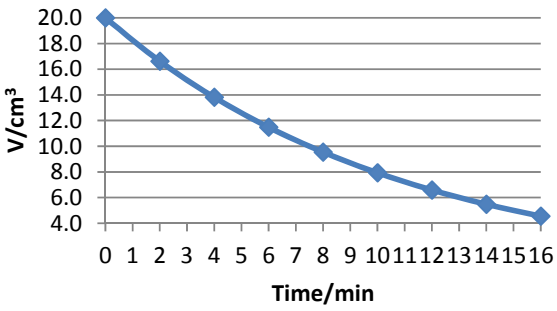
(Total for Question 2 = 8 marks)

Question Number	Acceptable Answers	Reject	Mark
3(a)	To quench/stop/slow the reaction ALLOW freeze IGNORE: to reduce reactivity exothermic reaction/reaction gives our heat		**1**

Question Number	Acceptable Answers	Reject	Mark
3(b)	Phenolphthalein **and** one of the following: (Indicator) range /colour change corresponds to steep change in pH. OR (Indicator) range /colour change corresponds to vertical/steep region of pH titration curve OR (change in) pH range 7.1 - 12/ above 7 OR (change in) pH range of methyl orange is below 7/ range 6.9 - 3 OR pK_{in} is greater than 7, or any number greater than 7 and less than 14. (correct value is 9.3) OR changes colour at/near equivalence point OR carboxylic acid is a weak acid OR weak acid – strong base titration	strong acid – strong base titration	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	Catalyst/hydrochloric acid/HCl reacts with the sodium hydroxide ALLOW Acid in (initial) solution		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	(More) (carboxylic) acid is formed	More product is formed	1

Question Number	Acceptable Answers	Reject	Mark
3(d)	 Axes labelled with quantity and **units** Note unit for time must be min not s **(1)** Points correctly plotted using at least half the graph paper in both dimensions Smooth curve through points **(1)** Allow one mis-plot provided curve is smooth Two half lives found in range 7.2 - 7.8 (mins) Ignore seconds for units (half lives need not be successive) **(1)** First order (this mark depends on two close values in third mark) **(1)** Note: If second half life is 15.2 etc. , then 3rd and 4th marks lost		4

Question Number	Acceptable Answers	Reject	Mark
3(e)	Orange to green/blue/brown Both colours required IGNORE: Qualifications of colour, e.g. dark green	Combinations of blue and green	1

Question Number	Acceptable Answers	Reject	Mark
3(f)(i)	**Correct** names or formulae are acceptable, e.g. sodium hydrogencarbonate (allow sodium bicarbonate)	Indicators sodium hydroxide $NaCO_3$ Loses reagent mark $LiALH_4$ White smoke Just ester formed	2

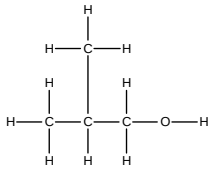
Reagent **(1)**	Observation **(1)**
Na_2CO_3(aq)/$NaHCO_3$ (aq)/$CaCO_3$((s)) Allow solid Na_2CO_3/$NaHCO_3$	Effervescence/ fizzing Allow: Testing gas with limewater which turns cloudy; Neutralises large volume
PCl_5	Misty/steamy/white fumes
Alcohol (+ mineral acid)	Fruity smell
Na / Mg	Effervescence/ fizzing

Question Number	Acceptable Answers	Reject	Mark
3(f)(ii)	2,4-dinitrophenylhydrazine/2,4-DNP(H) /DNP(H)/Brady's reagent **(1)** red/orange/yellow **precipitate** **(1)** Or Iodine and sodium hydroxide **(1)** Yellow precipitate **(1)** Ignore references to antiseptic smell	Colour only Colour only	2

	Ignore references to Tollens, Bendict's, Fehling's and result (ie no TE)		

Question Number	Acceptable Answers	Reject	Mark
3(g)	Primary ALLOW: 1° OR $-CH_2OH$ IGNORE: Names		1

Question Number	Acceptable Answers	Reject	Mark
3(h)(i)	**4 different H / hydrogen / proton environments**	4 different kinds of H 4 different environments	1

Question Number	Acceptable Answers	Reject	Mark
3(h)(ii)	 accept $-OH/CH_3$ ALLOW correct skeletal formula correct structural formula e.g. $CH_3CH(CH_3)CH_2OH$ OR Part structural, part displayed formula OR	Molecular formula OHC/O-H-C where there are clearly two bonds to hydrogen	1

	Vertical bond to OH wherever it finishes		

Question Number	Acceptable Answers	Reject	Mark
3(h)(iii)	H on the OH group OR OH group ALLOW TE for OH/H on wrong isomer	O alone COH	1

(Total for Question 3 = 17 marks)

Question Number	Acceptable Answers	Reject	Mark
4(a)	Hazard: flammable Precaution: keep away from naked flames/ use electrical heating/mantle or use water bath **(1)** Hazard: corrosive Precaution: wear gloves **(1)** Precaution must relate to appropriate hazard 2 correct hazards with no precautions **(0)** IGNORE Use of fume cupboard	Keep away from sources of heat Avoid direct heat	2

Question Number	Acceptable Answers	Reject	Mark
4(b)	Round-bottom/pear shape flask with vertical reflux condenser , drawn or labelled **(1)** Condenser jacket drawn at with water in at bottom, out at top **(1)** Heating source e.g. heating mantle/electric heater/water bath/ oil bath **(1)** ALLOW Water/oil bath heated by Bunsen burner Fully correct distillation apparatus **(1 max)** If both reflux and distillation diagrams drawn, then 2 marks max	Conical flask Bunsen burner Arrow (labelled or unlabelled) Closed apparatus/ large air gaps in wrong places loses an additional mark	3

Question Number	Acceptable Answers	Reject	Mark
4(c)	Prevents superheating/ localised heating ALLOW: Violent boiling OR Promotes smooth/even/uniform boiling OR Promotes smooth/even/uniform heating IGNORE prevents vigorous reactions/(large)bubbles/splashing	Just "stops bumping" Just: Violent reaction Just: Prevent explosion Just: Prevent mixture rising up condenser	1

Question Number	Acceptable Answers	Reject	Mark
4(d)	To remove/react with/neutralize the (unreacted)(ethanoic) **acid**		1

Question Number	Acceptable Answers	Reject	Mark
4(e)	Anhydrous sodium sulfate **(1)** Others would react with/decompose product/ester Sodium sulfate does not react with/ decompose product/ester **(1)** **Second mark depends on first**	Others "too strong" Easiest to separate The only neutral one	2

Question Number	Acceptable Answers	Reject	Mark
4(f)	Start 139-141°C End 143-145°C Both required for the mark	Single temperature	1

Question Number	Acceptable Answers	Reject	Mark
4(g)(i)	Mass 3-methylbutan-1-ol = 0.81 x 10.0 **(1)** = 8.10(g) Mol 3-methylbutan-1-ol = 8.10/88.0 = 0.09204545 Mol product = 0.09205 (0.0920 and 0.092 are both allowed for this step) **(1)** Mass of product = 0.09205 x 130.0 = 12.0 (g) to 3 sf **(1)** Correct answer with no working 3 marks **(3)** With consequential marks, the last mark is lost if the candidate's data is not rounded correctly to 3 sf. 0.09 gives 11.7 **(2 max)** 0.092 gives 12.0 **(3)**	0.09/0.0921	3

Question Number	Acceptable Answers	Reject	Mark
4(g)(ii)	**EITHER** % yield = 9.45/(ans to 4(g)(i)) x 100 **(1)** = correct value **(1)** N.B. correct value: % yield = 9.45/12.0 x 100 = 78.75% = 79% **OR** $\frac{9.45}{130}$ = 0.07269 (mol) **(1)** $\frac{0.07269}{0.09205} \times 100$ = 78.9680% = 79% **(1)** Accept any answer that rounds to 79 to two sf Allow TE from (i) for full credit unless greater than 100% in which case (**1max**)		2

(Total for Question 4 = 15 marks)

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Write your name here

Surname	Other names

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Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 6: Chemistry Laboratory Skills II

Wednesday 14 May 2014 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH06/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/6/3/

P 4 2 9 8 1 A 0 1 1 2

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 **H** is an aqueous solution of chromium(III) sulfate.

(a) What is the colour of the solution?

(1)

.....

(b) Describe what you would **see** when sodium hydroxide solution is added to **H**, drop by drop, until the sodium hydroxide is in excess.

(2)

.....

.....

.....

.....

(c) When hydrogen peroxide is added to the reaction mixture formed in (b), a yellow solution is formed.

Give the formula of the ion responsible for the yellow colour and state the type of reaction which has produced this ion.

(2)

Ion formula .....

Reaction type .....

(Total for Question 1 = 5 marks)

2 A student wishes to measure the E_{cell} value of an electrochemical cell in which the following reaction occurs.

$$Fe(s) + Cu^{2+}(aq) \rightarrow Fe^{2+}(aq) + Cu(s) \quad \textbf{Equation 1}$$

The solutions and apparatus available to the student are listed below.

Solution **A**:	copper(II) sulfate	1.00 mol dm^{-3}
Solution **B**:	iron(II) sulfate	concentration unknown
Solution **C**:	potassium nitrate	saturated
Solution **D**:	barium chloride	saturated

Copper foil electrodes
Iron foil electrodes
Platinum foil electrodes

Voltmeter **W**: low resistance
Voltmeter **X**: high resistance
Ammeter **Y**: low resistance
Ammeter **Z**: high resistance

Beakers
Connecting leads
Crocodile clips
Strips of filter paper

(a) Draw a labelled diagram of the cell that the student should set up to measure E_{cell} for the reaction in **Equation 1**.

Only use items selected from the list above.

(4)

(b) (i) The student measured E_{cell} as +0.79 V. The electrode dipping into the copper(II) sulfate solution was the positive electrode.

For this half-reaction

$$Cu^{2+}(aq) + 2e^- \rightleftharpoons Cu(s) \qquad E^{\ominus} = +0.34\,V$$

where $E^{\ominus}$ is the **standard** electrode potential.

Use the above information to calculate the electrode potential (E) in the student's cell for the half-reaction

$$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s)$$

(2)

(ii) For the half-reaction

$$Fe^{2+}(aq) + 2e^- \rightleftharpoons Fe(s) \qquad E^{\ominus} = -0.44\,V$$

where $E^{\ominus}$ is the **standard** electrode potential.

For this half-reaction, the electrode potential (E) at a particular concentration is related to the standard electrode potential ($E^{\ominus}$) by the equation

$$E = E^{\ominus} + 0.013 \ln [Fe^{2+}] \qquad \textbf{Equation 2}$$

where ln is the natural logarithm and $[Fe^{2+}]$ is the concentration of Fe^{2+} ions in mol dm^{-3}.

Use **Equation 2**, and your answer to (b)(i), to calculate the concentration of Fe^{2+} ions in solution **B**.

(2)

(c) The concentration of another solution of iron(II) sulfate, **Q**, was found by titration. 25.0 cm^3 samples of **Q** were titrated with a solution of acidified potassium manganate(VII), concentration 0.0300 mol dm^{-3}.

The results are as follows:

Titration	Rough	1	2	3
Burette reading (final) / cm^3	25.00	24.40	24.40	25.70
Burette reading (initial) / cm^3	1.00	2.10	1.60	3.30
Titre /cm^3				
Titres used to calculate mean (✓)				

(i) Complete the table and calculate the mean titre. Indicate with a (✓) the titres that you have used in your calculation.

(2)

Mean titre .....

(ii) State the colour change at the end-point.

(1)

.....

(iii) Complete the equation for the reaction occurring during the titration. State symbols are not required.

(2)

$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow$

(iv) Calculate the concentration, in mol dm^{-3}, of the iron(II) sulfate solution, **Q**.

Give your answer to **three** significant figures.

(4)

(v) The concentration of the iron(II) sulfate solution, **Q**, was also measured on a previous day using the method described in part (a).

The concentration was found to be 0.157 mol dm^{-3}.

Calculate the percentage difference between this value and the value you calculated in (c)(iv). You should assume that the correct concentration is 0.157 mol dm^{-3}.

(1)

(vi) In the titration, the volume delivered by the pipette is accurate to ±0.06 cm^3. Each burette reading is accurate to ±0.05 cm^3.

Calculate the percentage error of the pipette for a volume of 25.00 cm^3 and of the burette for your mean titre.

(2)

Pipette .....

Burette .....

(vii) Comment on the magnitudes of the values you have calculated in (c)(v) and (c)(vi).

(1)

.....

.....

.....

.....

(viii) Suggest why the concentration of iron(II) sulfate in solution **Q** calculated in (c)(iv) is lower than the value given in (c)(v).

(1)

.....

.....

.....

.....

(Total for Question 2 = 22 marks)

3 Substance **G** is a colourless organic liquid with one functional group.

(a) A few drops of **G** are tested by the addition of 2,4-dinitrophenylhydrazine solution (Brady's reagent). A **positive** result is obtained.

(i) Describe what you would see when a positive result is obtained for this test.

(1)

.....

(ii) What can you deduce about **G** from this test?

(1)

.....

(b) Substance **G** is tested with Tollens' reagent. The test is **negative**.

(i) Identify the solutions used to make Tollens' reagent.

What condition is essential for this test to work?

What would you see when a **positive** result is obtained?

(4)

Solutions .....

.....

Condition .....

Positive result .....

(ii) Based on the results of the tests in (a)(i) and (b)(i), name the functional group present in **G**.

(1)

.....

(c) A few drops of substance **G** are tested using iodine in the presence of alkali (iodoform test). A positive result is obtained.

(i) What would be **seen** when a positive result is obtained?

(1)

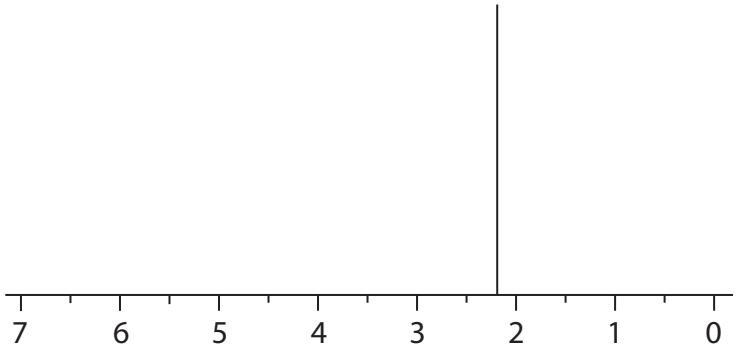
.....

(ii) What information does a positive result give about substance **G**?

(1)

.....

(d) The high resolution nmr spectrum of **G** is shown below.



Give **two** pieces of information about substance **G** that can be deduced from this spectrum. Use this information and your previous deductions to draw the displayed formula of **G**.

(3)

.....

.....

.....

.....

Displayed formula of **G**:

(e) The identity of substance **G** can be confirmed by making a larger quantity of the solid product from the reaction of **G** with 2,4-dinitrophenylhydrazine solution and then purifying the product by recrystallization from ethanol.

(i) The solid product is removed from the solution by filtration under reduced pressure. Give **two** advantages of the use of filtration under reduced pressure compared with normal filtration.

(2)

.....

.....

.....

.....

(ii) Draw a labelled diagram of the apparatus used for filtration under reduced pressure.

(3)

(iii) Outline all the steps of the **recrystallization** procedure. You should assume that the product contains impurities, some of which are very soluble in ethanol and others which are not soluble.

(4)

(iv) How would you use the purified product to confirm the identity of **G**? Practical details are not required.

(2)

(Total for Question 3 = 23 marks)

TOTAL FOR PAPER = 50 MARKS

The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series

* Actinide series

140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 2 9 8 1 A 0 1 2 1 2

PMT

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Mark Scheme (Results)
Summer 2014

IAL Chemistry (WCH06/01)
Chemistry Laboratory Skills II

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

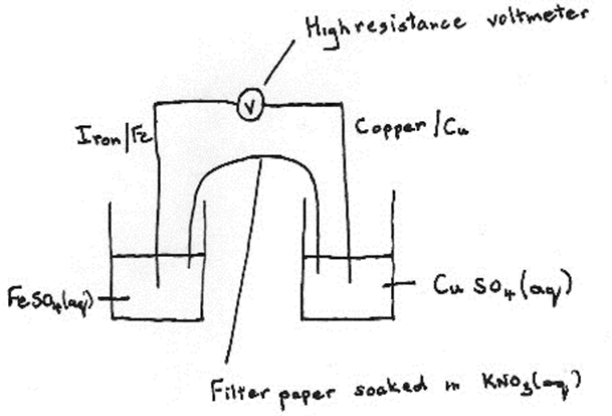
Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1(a)	Green OR Green (Cr^{3+}) IGNORE additional information unless another wrong colour. ALLOW Shades of green like: pale green light green dark green ALLOW Violet / purple / red-violet / red-purple / mauve / ruby-violet / green-violet	Blue Blue-green Grey-green Blue-violet	**1**

Question Number	Acceptable Answers	Reject	Mark
1(b)	Green / grey-green / grey-blue **precipitate / ppt / ppte** (of $Cr(OH)_3$ / $[Cr(H_2O)_3(OH)_3]$) ALLOW recognisable spelling of state eg percipitate **(1)** **Second mark depends on first mark** (or near miss such as incorrect formula of precipitate / incorrect colour of ppt) Dissolves (to give green solution) OR Green solution forms (of $[Cr(OH)_6]^{3-}$) **(1)** IGNORE shades of colour: Light / dark etc	Other wrong descriptions like effervescence Incorrect formula for example $Cr(H_2O)_2(OH)_4]^-$ Dissolves to give a yellow / blue solution Incorrect formula for example CrO_4^{2-}	**2**

Question Number	Acceptable Answers	Reject	Mark
1(c)	CrO_4^{2-} **OR** CrO_4^{-2} **(1)** **Check the charge is correct** IGNORE brackets eg $[CrO_4]^{2-}$ Oxidation / redox (reaction) Ignore references to Cr^{3+}, Cr^{6+}, loss/gain and loss of electrons, deprotonation **(1)** **Mark each part independently.**	CrO_4^{-} $Cr_2O_7^{2-}$ Reduction Reduction / redox Redox / reduction References to Cr^{2+} 'Gain of electrons' alone	**2**

Total for Question 1 = 5 marks

Question Number	Correct Answer	Reject	Mark
2 (a)	 **First mark** Copper half cell Copper electrode dipping into copper(II) sulfate solution / solution **A** / Cu^{2+} (solution) **(1)** **Second mark** Iron half cell Iron electrode dipping into iron(II) sulfate solution/solution **B** / Fe^{2+} (solution) **(1)** Cells can be on either side Note that two platinum electrodes, or copper and iron electrodes the wrong way round loses both of the first two marks. IGNORE charges (in symbols or words) on the electrodes, even if incorrect **Third mark** Salt bridge Strip of **filter paper** with **potassium nitrate** solution / solution **C** dipping into both solutions **(1)** Only penalise electrodes / filter paper not dipping into solutions once. **Fourth mark** Circuit Voltmeter **X** / high resistance voltmeter correctly connected with or without crocodile clips **(1)**	Platinum/ Pt / iron / Fe Electrode Platinum / Pt / copper / Cu Electrode Just 'salt bridge' Any combination of meters Battery or power supply Parallel wire across voltmeter	**4**

Question Number	Correct Answer	Reject	Mark
2(b)(i)	$E_{cell} = E_{Cu} - E_{Fe}$ **(1)** $0.79 = 0.34 - E_{Fe}$ $E_{Fe} = 0.34 - 0.79 = -0.45$ (V) **(1)** Correct answer with no working **(2)** (+)0.45 (V) scores (1) only TE is allowed for wrong working with consistent answer, for example: $E_{cell} = E_{Fe} - E_{Cu}$ $0.79 = E_{Fe} - 0.34$ $E_{Fe} = 0.79 + 0.34 = (+)1.13$ (V) Award second mark only		**2**

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	$-0.45 = -0.44 + 0.013 \ln [Fe^{2+}]$ $\ln [Fe^{2+}] = (-0.45 + 0.44)/0.013$ **(1)** $= -0.769$ $[Fe^{2+}] = \exp(-0.769) = 0.46348$ $= 0.46$ (mol dm^{-3}) **(1)** ACCEPT any answer which gives 0.46 when rounded to 2 sf Correct answer with no working **(2)** 0.76 gives 0.46761 = 0.47 worth (1) ALLOW TE from (b)(i) is allowed. Notice this may mean that the concentration is greater than 10 mol dm^{-3} which is allowed even though impossible. SOME EXAMPLES ARE: +0.45 V gives $\ln[Fe^{2+}] = 68.46$ so $[Fe^{2+}] = 5.4 \times 10^{29}$ Give 1 mark out of 2 for either statement +1.13 V gives $\ln[Fe^{2+}] = 120.769$ so $[Fe^{2+}] = 2.81 \times 10^{52}$ Give 1 mark out of 2 for either statement Internal TE for this part can also be awarded if $\ln[Fe^{2+}]$ has a value and is correctly converted to $[Fe^{2+}]$. It is quite common to get $\ln[Fe^{2+}] = +0.769$ when $[Fe^{2+}] = 2.158 = 2.16$ is worth 1 mark	0.76	**2**

<table>
<tr><th>Question Number</th><th>Acceptable Answers</th><th>Reject</th><th>Mark</th></tr>
<tr><td>2(c)(i)</td><td>
<table>
<tr><th>Titration</th><th>Rough</th><th>1</th><th>2</th><th>3</th></tr>
<tr><td>Burette reading (final) / cm^3</td><td>25.00</td><td>24.40</td><td>24.40</td><td>25.70</td></tr>
<tr><td>Burette reading (initial) / cm^3</td><td>1.00</td><td>2.10</td><td>1.60</td><td>3.30</td></tr>
<tr><td>Titre /cm^3</td><td>24.(00)</td><td>22.3(0)</td><td>22.8(0)</td><td>22.4(0)</td></tr>
<tr><td>Titres used to calculate mean (✓)</td><td></td><td>✓</td><td></td><td>✓</td></tr>
</table>
All four titres correct

Note that the trailing zeroes are not essential (1)

Mean Titre 22.35 (cm^3) (1)

ALLOW TE on titres due to incorrect subtractions</td><td>22.40 / 22.4 / 22.50 / 22.875 (cm^3)</td><td>2</td></tr>
</table>

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	Colourless to (first permanent pale) pink / purple **Both** colours required ALLOW Pale green / light green / green for colourless Pale yellow for colourless	Dark green	**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)(iii)	$(MnO_4^- + 8H^+ + 5Fe^{2+}) \rightarrow Mn^{2+} + 4H_2O + 5Fe^{3+}$ $Mn^{2+} + 4H_2O$... **(1)** ... $+ 5Fe^{3+}$ **(1)** But allow $+ 5e^{(-)}$ on either side of correct balanced equation for 1 max IGNORE state symbols even if incorrect	$+ 5e^{(-)}$ alone	**2**

Question Number	Acceptable Answers	Reject	Mark
2(c)(iv)	mol MnO_4^- = 22.35 x 0.0300/1000 **(1)** = 6.705×10^{-4} mol Fe^{2+} = $6.705 \times 10^{-4} \times 5$ **(1)** = 3.353×10^{-3} $[Fe^{2+}]$ = $3.353 \times 10^{-3} \times 1000/25.0$ **(1)** = 0.1341 = **0.134** (mol dm^{-3}) **to 3 SF** **(1)** Correct answer with no working **(4)** Correct answer not to 3 sf with no working **(3)** ALLOW TE on mean titre in 2c(i) and equation in (iii) 22.5 gives 0.135 22.6 gives 0.136 Internal TEs should also be given if steps of the calculation are omitted. Some will multiply by 1000/22.35 in the last step to give 0.150 which is 3 out of 4 marks 0.15 would be 2 out of 4 marks		**4**

Question Number	Acceptable Answers	Reject	Mark
2(c)(v)	$\frac{(0.157 - \text{answer to 2c(iv)})}{0.157} \times 100$ Correct answer: $\frac{(0.157 - 0.134)}{0.157} \times 100$ = 14.6% IGNORE sf except 1 Some TEs from (iv): 0.135 gives 14.01% 0.136 gives 13.38% 0.150 gives 4.46%		**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)(vi)	Pipette 0.06/25 x 100 = (±) 0.24% **(1)** Burette 0.10/22.35 x 100 = (±) 0.44743 = (±) 0.45% **(1)** ALLOW TE on titre in 2c(i) 22.5 gives = (±) 0.4444 = (±) 0.44% 22.6 gives = (±) 0.44248 = (±) 0.44% But 0.1/25 x 100 = 0.4 does not get a mark So 0.4 with **no working** gets no mark		**2**

Question Number	Acceptable Answers	Reject	Mark
2(c)(vii)	The apparatus error / combined errors is negligible compared to the difference (in concentration). ALLOW Percentage difference in value is bigger than percentage apparatus error. OR Percentage difference is greater than percentage error(s)	Just 'error of pipette is smaller than error of burette' Just 'apparatus error is small' '% error of apparatus is small so both pieces of apparatus are suitable' alone	**1**

Question Number	Acceptable Answers	Reject	Mark
2(c)(viii)	Fe^{2+} is (partially) oxidized (by air / oxygen) (on standing overnight) ALLOW Reverse argument OR iron/Fe (solution) is (partially) oxidized (by air / oxygen) (on standing overnight)	Absorbed moisture overnight so solution more dilute Incomplete reaction Transfer errors Impurities present	**1**

Total for Question 2 = 22 marks

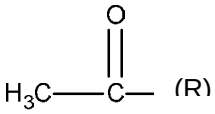
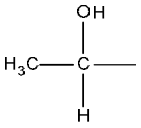
Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	Red /orange / yellow **and** precipitate ALLOW Bright and correct colour Combinations of these colours AND Solid / crystals /ppt /ppte / precipitate (ie recognisable spelling for 'precipitate')	Colour alone Pale yellow Other colour combinations eg red / brown	**1**

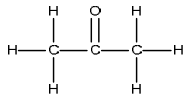
Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	Aldehyde **OR** ketone (both needed) Either order. ALLOW Carbonyl (compound/group) RCOR IGNORE contains C=O or other formulae		**1**

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	**First mark** Solutions: (aqueous) silver nitrate / $AgNO_3$ **(1)** **Second mark** (aqueous) ammonia / NH_3 / NH_4OH **(1)** Reagents in any order. IGNORE NaOH **NOTE** Ammoni(a)cal silver nitrate scores first 2 marks BUT Silver diam(m)ine / $[Ag(NH_3)_2]^+(NO_3^-)$ scores only 1 mark **Third mark** dependant on **any** silver salt and ammonia / ammoni(a)cal silver nitrate / silver diam(m)ine / $[Ag(NH_3)_2]^+$ Condition: Clean test tubes / warm / heat ALLOW heat to below 50^0C **(1)** **Fourth mark** stands alone - independent Positive result: Silver mirror / grey or black precipitate ALLOW Silver (alone) silver solid / silver ppt / ppte / metallic silver OR Silver mirror solution **(1)**	Other silver salts Silver / Ag^+ ions Silver compounds Ammonium / NH_4^+ ions Anything else eg nitric acid Shake vigorously Heat under reflux $20\text{-}25^0C$ Silver colour / silver coloured solution	**4**

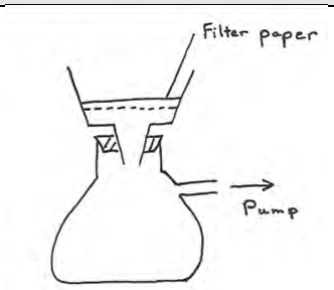
Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	Ketone ALLOW Keytone OR Carbonyl group in a ketone OR C=O in a ketone ALLOW ketone with additional correct general, displayed / structural formulae	Just 'carbonyl group' Just 'C=O'	**1**

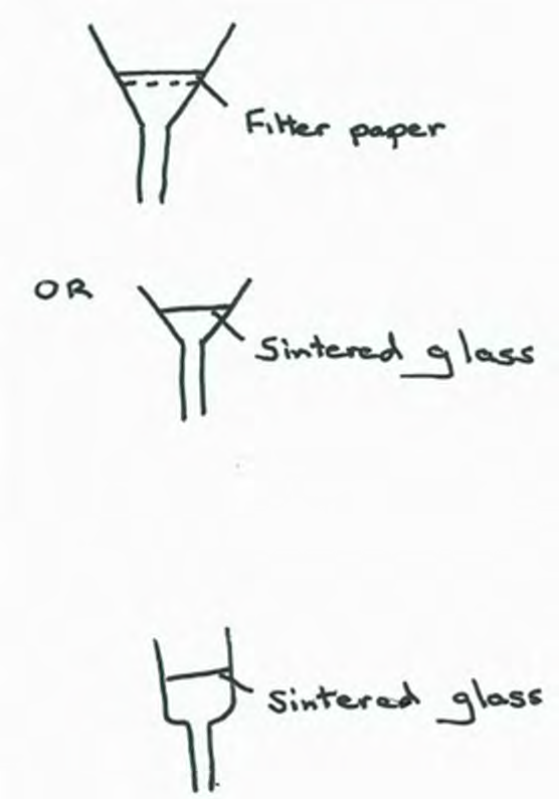
Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	(pale) yellow precipitate / solid / crystals Qualification of yellow is allowed like pale, light, creamy, or bright, but not dark. **Both** colour **and** state ALLOW 'Cloudy yellow' alone OR Recognisable spelling or abbreviations for precipitate like ppt / ppte / percipitate IGNORE antiseptic smell	Dark yellow	**1**

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	Methyl ketone / CH_3CO (group) OR Contains  OR Methyl attached to a carbonyl (group)/C=O OR It is a 2-one ketone	 Secondary alcohol Functional group on second carbon atom	**1**

Question Number	Acceptable Answers	Reject	Mark
3(d)	**First mark** One hydrogen / proton environment OR One kind of hydrogen / proton ALLOW Hydrogen ion for proton **(1)** **Second mark** (Singlet so) no neighbouring hydrogens (on adjacent carbons) OR Chemical shift is correct for a ketone **(1)** **Third mark**  Hydrogens must be shown, but methyl groups do not have to be displayed. **(1)** ALLOW Correct structural or skeletal formula	Just 'it is a singlet' Just 'not split(ted) by any other hydrogen' Chemical shift is the same as a methyl group (alone) Chemical shift is at 2.2 (alone)	**3**

Question Number	Acceptable Answers	Reject	Mark
3(e)(i)	Faster **(1)** Solid / precipitate / crystals are drier OR more solvent / solution / filtrate removed OR Reverse argument for normal filtering **(1)** IGNORE More efficient / more effective / increases yield / more pure Reducing pressure reduces boiling temperature		**2**

Question Number	Acceptable Answers	Reject	Mark
3(e)(ii)	 **First mark** Buchner / side-armed flask **(1)** **Second mark** Side arm connected to pump **and** bung/rubber around neck of funnel OR Quickfit flask funnel shown with clear sealed join and pump labelled  **(1)** ALLOW aspirator for pump, drawings of tap pump IGNORE Blocked outlet to pump **Third mark** Buchner funnel with **flat** filter paper The filter paper must be labelled OR be drawn flat **and** clearly shown	Heated flask Large gap between funnel and flask Pressure pump (alone) Suction (alone) Filter paper which goes up the sides of the funnel Fluted filter paper	**3**

	above the pores of the funnel OR Hirsch funnels see diagrams below  Notice sintered / fitted glass does not need a filter paper IGNORE Blocked outlet to funnel **(1)** Notice heating of funnel / solvent can be ignored		

Question Number	Acceptable Answers	Reject	Mark
3(e)(iii)	**First mark** Dissolve in / mix with MINIMUM / SMALL volume / amount of HOT ethanol / solvent (to dissolve most of the solid / make a saturated solution) **(1)** **Second mark** Filter HOT (to remove insoluble impurities)# AND Cool / allow to crystallize **(1)** **Third mark** Filter (under reduced pressure) (to remove soluble impurities)# AND Wash with COLD / minimum volume of solvent **(1)** **Fourth mark** **Dry** between filter papers / with **paper** towel / in desiccator Both dry **and** method of drying ALLOW Use of **cool / warm** oven OR oven at specified temperature below 100°C Use of hair drier / electric hand drier **(1)** **Note** penalties may be applied: *Penalise use of water only once #If impurities are wrong way round penalise only once Both these penalties can be applied to reduce the mark by 2	Water as solvent* Filter alone (Wash) with water* Drying agents unless in desiccator	**4**

Question Number	Acceptable Answers	Reject	Mark
3(e)(iv)	Measure the melting temperature **(1)** IGNORE References to sharp melting temperature Compare with literature / data (book) / known value **(1)** Second mark conditional on melting temperature mark IGNORE IR spectroscopy and check fingerprint region	Boiling temperature alone Chromatography and compare R_f values If melting temperature is clearly for propanone and not propanone derivative.	**2**

Total for Question 3 = 23 marks

Total for Paper = 50 Marks

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Write your name here

Surname	Other names

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Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 6: Chemistry Laboratory Skills II

Tuesday 27 January 2015 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
WCH06/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A white solid, **A**, has one metal cation, and an anion containing two non-metallic elements.

(a) A flame test is carried out on **A**.

(i) Describe how you would carry out this flame test in the laboratory.

(3)

(ii) A yellow flame is seen. Give the **formula** of the metal ion present.

(1)

(b) Solid **A** dissolves in water to form a colourless solution.

This solution decolorises a dilute aqueous solution of iodine.

Dilute hydrochloric acid is added to a fresh solution of **A**.
A very pale yellow precipitate, **B**, forms slowly and an acidic gas, **C**, is given off.

Gas **C** turns acidified sodium dichromate(VI) from orange to green.

(i) Identify, by name or formula, the precipitate **B** and the gas **C**.

(2)

Precipitate, **B** .....

Gas, **C** .....

(ii) What is the colour of a **dilute** aqueous solution of iodine?

(1)

.....

(iii) Give the **name** of the anion in compound **A**.

(1)

.....

(iv) Give the **formula** of compound **A**.

(1)

.....

(Total for Question 1 = 9 marks)

2 A white solid, **D**, is formed when ethanoyl chloride is added to a concentrated solution of ammonia. The molecular formula of **D** is C_2H_5ON.

When solid **D** is heated with excess aqueous sodium hydroxide solution, ammonia gas is given off and a solution, **E**, is formed.

(a) Ammonia has a distinctive smell. Give **two** other tests, each of a different type, which could be used to show the presence of ammonia. Give the result of each test.

(3)

Test 1 .....

.....

Test 2 .....

.....

(b) Excess dilute sulfuric acid is added to solution **E** and an organic liquid, **F**, is distilled from the mixture.

(i) Draw a labelled diagram of the apparatus used for this distillation.

(2)

(ii) Addition of pure liquid **F** to aqueous sodium carbonate gives effervescence.

Identify liquid **F** by name or formula.

(1)

.....

(c) (i) Give the name and displayed formula of solid **D**.

(2)

Name .....

Displayed formula

(ii) Write an equation for the formation of solid **D** from ethanoyl chloride and concentrated ammonia solution. State symbols are not required.

(1)

(Total for Question 2 = 9 marks)

3 This is an experiment to determine the oxidation number of vanadium in a purple solution, **T**, of a vanadium compound.

Preparation of solution T

Solution **T** was formed when 25.00 cm^3 of a 0.100 mol dm^{-3} solution of sodium vanadate(V), $NaVO_3$, was reduced by heating with excess zinc and dilute sulfuric acid.

When the reduction was complete, the yellow $NaVO_3$ solution had turned purple.

Titration of solution T

The mixture was filtered through glass wool, directly into 50.00 cm^3 of 0.0200 mol dm^{-3} potassium manganate(VII), $KMnO_4$, solution.

Further potassium manganate(VII) solution of the same concentration was added from a burette to this reaction mixture, which was kept at a temperature of about 80 °C. The end point is reached when all the vanadium ions had been oxidized back into vanadate(V) ions by the manganate(VII) ions.

The end point occurred when a further 25.00 cm^3 had been added.

(a) (i) Draw a diagram of the apparatus for carrying out the titration, while **keeping** the titration mixture at about 80 °C.

(2)

(ii) What is removed from the reaction mixture by filtering through glass wool?

(1)

.....

(iii) Suggest why the mixture is filtered directly into potassium manganate(VII) solution before carrying out the rest of the titration.

(1)

.....

.....

.....

(iv) Explain why an indicator is **not** required for this titration.

(1)

.....

.....

.....

.....

(b) (i) Calculate the number of moles of vanadate(V) ions, VO_3^-, in 25.00 cm^3 of a 0.100 mol dm^{-3} solution of sodium vanadate(V), $NaVO_3$.

(1)

(ii) Calculate the **total** volume of potassium manganate(VII) solution.
Hence the **total** number of moles of potassium manganate(VII) used to oxidize the purple vanadium solution, **T**.

(2)

(iii) Complete the half equation for the reduction of manganate(VII) ions to manganese(II) ions.

(1)

$$MnO_4^- + \text{.....}H^+ + \text{.....}e^- \longrightarrow Mn^{2+} + \text{.....}H_2O$$

(iv) By considering either the number of electrons transferred or by using the changes in oxidation numbers, calculate the oxidation number of vanadium in the purple solution, **T**.

You **must** show your working.

(3)

(c) In acidic solution, the vanadate ions, VO_3^- are changed into VO_2^+.
Write an ionic equation for this reaction. State symbols are not required.

(1)

(d) Some standard electrode potentials of tin and vanadium are given below.

$Sn^{2+}(aq)\|Sn(s)$	–0.14 V
$V^{2+}(aq)\|V(s)$	–1.18 V
$V^{3+}(aq),V^{2+}(aq)\|Pt$	–0.26 V
$[VO^{2+}(aq) + 2H^{+}(aq)], [V^{3+}(aq) + H_2O(l)]\|Pt$	+0.34 V
$[VO_2^{+}(aq) + 2H^{+}(aq)], [VO^{2+}(aq) + H_2O(l)]\|Pt$	+1.00 V

Use these values to predict the lowest oxidation number of vanadium that can be produced from VO_2^{+} using tin as the reducing agent. Explain your reasoning.

(2)

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(Total for Question 3 = 15 marks)

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4 Cholesteryl benzoate was the first liquid crystal to be discovered. It can be prepared by the following procedure.

Step 1 Dissolve 1.0 g of cholesterol in 3 cm^3 of pyridine in a conical flask.

Step 2 Add 0.40 cm^3 of benzoyl chloride.

Step 3 Heat the mixture on a steam bath for about 10 minutes.

Step 4 Cool the mixture, and add 15 cm^3 of methanol.

Step 5 Collect the solid cholesteryl benzoate by suction filtration. Rinse the flask and the crude crystals with a little cold methanol.

Step 6 Recrystallize the cholesteryl benzoate using ethyl ethanoate as the solvent.

Some physical data for the chemicals involved are shown below.

	Molar mass / g mol^{-1}	Density / g cm^{-3}	Melting temperature / K	Boiling temperature / K
Cholesterol	386.7			633
Benzoyl chloride	140.6	1.21		470
Cholesteryl benzoate	490.8		423	
Pyridine	79.1			388
Ethyl ethanoate	88.1		190	350

(a) Suggest the apparatus you would use to measure the volume of benzoyl chloride.

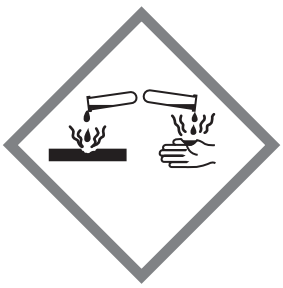
(1)

.....

(b) The warning symbols on a bottle of benzoyl chloride are shown below. Write the meaning of each symbol in the space provided.

(2)





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(c) 1 mol of cholesterol reacts with 1 mol of benzoyl chloride to form 1 mol of cholesteryl benzoate.

(i) Determine which reactant is in excess by calculating how many moles of cholesterol and of benzoyl chloride are used in the preparation.

(3)

(ii) Calculate the percentage yield when 0.65 g of cholesteryl benzoate is obtained.

(2)

(d) Suggest how the mixture is cooled in **Step 4**.

(1)

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.....

(e) Suggest why methanol is added to the cooled mixture in **Step 4**.

(1)

.....

.....

(f) Describe how to carry out the recrystallization to obtain pure dry crystals of cholesteryl benzoate in **Step 6**.

(5)

(g) How would you show that the recrystallized cholesteryl benzoate crystals in **Step 6** are purer than the crude crystals obtained in **Step 5**?

(2)

(Total for Question 4 = 17 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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PMT

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Mark Scheme (Results)

January 2015

Pearson Edexcel International Advanced level in Chemistry (WCH06) Paper 01

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	Use of nichrome/platinum wire/rod ALLOW Nickel chromium wire **(1)** Dip wire into (concentrated) hydrochloric acid and then the solid ALLOW Mixing hydrochloric acid with salt then dipping in wire IGNORE References to cleaning wire **(1)** Place in/on (hot/roaring/blue cone of) Bunsen flame (and observe flame colour) This mark is consequential on first and second mark unless **wire / salt** placed in/on (hot/roaring/blue cone of) Bunsen flame (and observe flame colour) **(1)**	Nichrome / platinum alone Nickel / chromium wire Deflagrating / combustion spoon Sulfuric acid **Any** reference to **burn / burning / burned** Use of yellow Bunsen flame Under Bunsen flame In/on Bunsen burner	3

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	Na^+ (ions)	Na alone Sodium (ion) $Na^{2+}/Fe^{2+}/Cr^{3+}$	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	**B** sulfur/S/S_8 **(1)** **C** sulfur dioxide/SO_2/sulfur(IV) oxide **(1)**	Hydrogen sulfide / H_2S	2

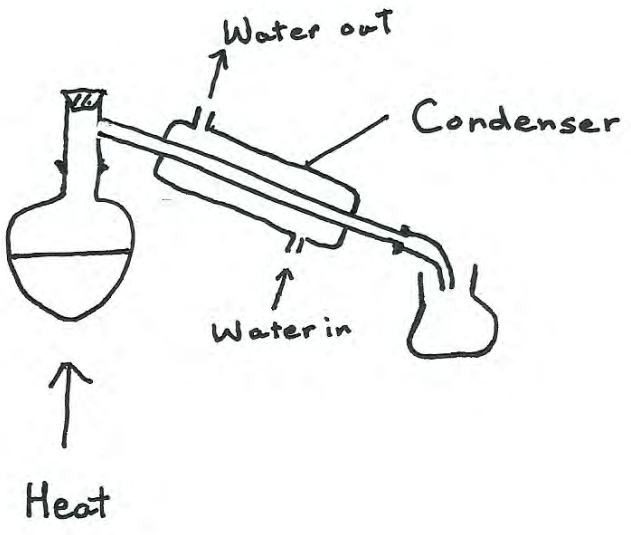
Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	(Pale/light) yellow/straw ALLOW (light/pale) brown/red-brown	Orange/Red Correct colour 'to colourless' Also colourless to correct colour	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(iii)	Thiosulfate	$S_2O_3^{2-}$	1

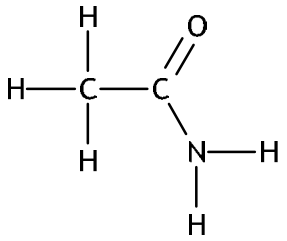
Question Number	Acceptable Answers	Reject	Mark
1(b)(iv)	$Na_2S_2O_3$ ALLOW Na_2SO_3 if sulfite/sulfite(IV)/ sulfate(IV) given in (b)(iii) Any number of H_2O's in the formula COMMENT Any Group 1 or Group 2 metal ion with correct formula	Any additional salt formulae even if with correct answer.	1

Total for Question 1 = 9 marks

Question Number	Acceptable Answers	Reject	Mark
2(a)	Test 1 (Damp/moist red) litmus (paper) / universal indicator / UI / pH (paper) turns blue **(1)** Accept any correctly named acid base indicator (paper) with alkaline colour. Test 2 (Rod/stopper dipped in concentrated/dilute) hydrochloric acid/hydrogen chloride (gas)/HCl ((g)) **(1)** Gives (dense) **white** smoke/ **white** fumes **(1)** ALLOW Other suitable tests e.g. with copper(II) sulfate solution forming blue solution **(2)**	Turns purple Reaction with chlorine or other halogen Steamy/misty fumes White precipitate/solid Smell	3

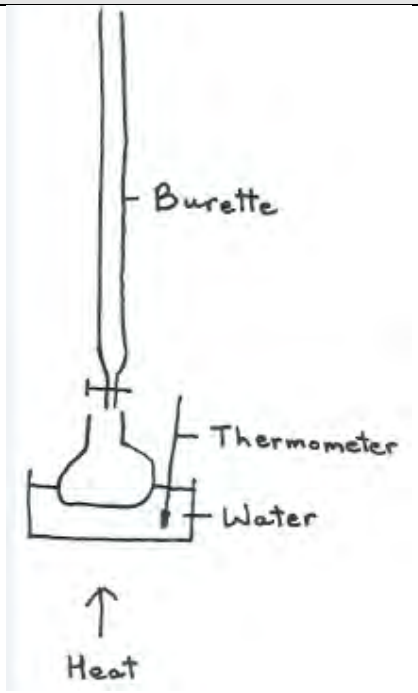
Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	 **First Mark** Heat/arrow (may be directed to any part of the liquid in the flask)/**hot** water bath/**heating / electrical** mantle IGNORE Fractionating column **AND** round bottomed/pear shaped flask **AND** Downward delivery tube **(1)** **Second Mark** Condenser jacket/tube (labelled condenser) **and** water direction and collection Condenser must slope downwards Water in must be below and to the right of water out **(1)** ALLOW Correct unlabelled arrows or just water in/out. Ignore thermometer even if incorrectly placed Ignore air gaps at apparatus joints and accidental lines sealing apparatus.	Reflux apparatus **(0)** 'Reflux' instead of heat Sealed apparatus or open flask	2

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	Ethanoic acid/CH_3CO_2H/ CH_3COOH OR displayed / skeletal formula Ignore carboxylic acid/ RCO_2H/ RCOOH		1

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	**D** is ethanamide ALLOW acetamide **(1)**  **(1)** ALLOW undisplayed CH_3 and or NH_2	Ethylamide Ethamide Ethyl ethanamide	2

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	$CH_3COCl + 2NH_3 \rightarrow CH_3CONH_2 + NH_4Cl$ ALLOW $CH_3COCl + NH_3 \rightarrow CH_3CONH_2 + HCl$ Do check 2s and 3s in all formulae.		1

Total for Question 2 = 9 marks

Question Number	Acceptable Answers	Reject	Mark
3(a)(i)	 Burette and (conical) flask / beaker **and** **Either** Heated water bath / direct heat Can be shown by heat/arrow **(1)** Thermometer in flask / water **(1)** **OR** Heating mantle / hot plate **(1)** With thermostatic control **(1)** ALLOW 1 mark for heating separate from the titration		2

Question Number	Acceptable Answers	Reject	Mark
3(a)(ii)	(The excess / unreacted) **zinc** / **Zn((s))** (is removed) Allow Insoluble zinc Insoluble reactant Zinc Zinc solid / left over	Insoluble impurities Insoluble reactant alone	1

Question Number	Acceptable Answers	Reject	Mark
3(a)(iii)	To prevent it / **T** being oxidized by air / oxygen ALLOW To prevent oxidation OR The vanadium(II) is easily oxidized by air / oxygen OR (As a) large volume / volume greater than 50 cm^3 of potassium manganate(VII) is required		1

Question Number	Acceptable Answers	Reject	Mark
3(a)(iv)	**EITHER** Because the potassium manganate(VII) is self-indicating ALLOW Reaction is self-indicating ALLOW Potassium manganate (VII) changes colour during the reaction/ at the end point. **OR** at the end point a pink / purple solution forms (from a blue/yellow/green solution) ALLOW Modified pink e.g. yellow pink because of the yellow vanadate(V)	Just obvious / clear colour change without potassium manganate(VII)	1

Question Number	Acceptable Answers	Reject	Mark
3(b)(i)	$\frac{25 \times 0.10}{1000} = 2.5 \times 10^{-3}$/0.0025 (mol)		1

Question Number	Acceptable Answers	Reject	Mark
3(b)(ii)	Total volume of 0.02 mol dm^{-3} solution of potassium manganate(VII) = 25 + 50 = 75 cm^3 **(1)** $\frac{(75) \times 0.02}{1000}$ = 1.5 x 10^{-3}/0.0015 (mol) **(1)** ALLOW for 1 mark $\frac{25 \times 0.02}{1000}$ = 5 x 10^{-4}/0.0005 (mol) **OR** $\frac{50 \times 0.02}{1000}$ = 1 x 10^{-3}/0.001 (mol) ALLOW Internal TE for incorrect volume in first calculation for second mark.		2

Question Number	Acceptable Answers	Reject	Mark
3(b)(iii)	$MnO_4^- + 8H^+ + 5e^- \longrightarrow Mn^{2+} + 4H_2O$		1

Question Number	Acceptable Answers	Reject	Mark
3(b)(iv)	**METHOD 1** 2.5×10^{-3} mol of vanadium ions lose $5 \times 1.5 \times 10^{-3} = 7.5 \times 10^{-3}$ mol electrons **(1)** Therefore 1 mol of vanadium ions lose 3 mol of electrons **(1)** As final oxidation state is +5 the oxidation state of vanadium in the purple solution is +2 **(1)** **METHOD 2** Ratio of Mn:V = 0.0015:0.0025 = 3:5 **(1)** Oxidation number of Mn changes by 5 so oxidation number of vanadium must change by 3 **(1)** As final oxidation state is +5 the oxidation state of vanadium in the purple solution is +2 **(1)** **METHOD 3** **First Mark** +2 (with no working) **Second Mark** Working backwards from this: Any mention of transfer of 3 electrons OR $V^{5+} + 3e^{(-)} \rightarrow V^{2+}$ OR $V^{2+} - 3e^{(-)} \rightarrow V^{5+}$ IGNORE $Mn(VII) + 3e^{(-)} \rightarrow Mn(II)$ **Third Mark** 7.5×10^{-3} mols of electrons / change in oxidation number removed from 2.5×10^{-3} V^{3+} OR 7.5×10^{-3} mols of manganate(VII) ion react with 2.5×10^{-3} mols V^{3+} ALLOW TE from (b)(ii) and (iii)		3

Question Number	Acceptable Answers	Reject	Mark
3(c)	$VO_3^- + 2H^+ \longrightarrow VO_2^+ + H_2O$		1

Question Number	Acceptable Answers	Reject	Mark
3(d)	**First Mark** V^{3+} / V(III) / (V) +3 **(1)** **Second Mark** Any of the following calculations : V(IV)/VO^{2+} to V(III)/ V^{3+} = +0.48 (V) OR V(III)/V^{3+} to V(II)/ V^{2+} = -0.12 (V) OR ALLOW V(V)/VO_2^+ to V(IV)/VO^{2+} = +0.66 (V) OR Sn^{2+}(aq)|Sn(s) has a more negative electrode potential than the last two vanadium potentials (so vanadium reduced to V^{3+}) Accept reverse argument OR By the anticlockwise rule if shown with appropriate arrows **(1)**		2

Total for Question 3 = 15 marks

Question Number	Acceptable Answers	Reject	Mark
4(a)	Syringe / (graduated) pipette / burette / micro-pipette / auto pipette / any pipette with a volume of $5cm^3$ or less ALLOW Calculate the mass and use a balance Recognisable spelling of pipette / burette but not biuret.	Measuring cylinder	1

Question Number	Acceptable Answers	Reject	Mark
4(b)	Toxic/poisonous **(1)** Ignore harmful Corrosive/causes burns **(1)** Ignore harmful	Corrosive/causes burns/irritant/dangerous Oxidising/toxic/poisonous /irritant	2

Question Number	Acceptable Answers	Reject	Mark
4(c)(i)	Penalise rounding errors once only in parts (i) and (ii) Number of moles of cholesterol $= \frac{1.0}{386.7} = 2.58598 \times 10^{-3} = 2.59 \times 10^{-3}$ **(1)** Note 2.58×10^{-3} loses this mark as a rounding error but 2.6×10^{-3} is fine Mass of benzoyl chloride = 0.4 x 1.21 = 0.484 (g) **(1)** Number of moles of benzoyl chloride $= \frac{0.484}{140.6} = 3.4424 \times 10^{-3}$ **AND** So benzoyl chloride is in excess / cholesterol is the limiting factor **(1)**		3

Question Number	Acceptable Answers	Reject	Mark
4(c)(ii)	Number of moles of cholesteryl benzoate $= \frac{0.65}{490.8}$ $= 1.3244 \times 10^{-3}$ **(1)** Yield $= \frac{1.32 \times 10^{-3}}{2.59 \times 10^{-3}} \times 100$ $= 51(.1)\%$ Or = 51(.2) ignore SF **(1)** **OR** Expected/maximum mass of cholesteryl benzoate $= 2.59 \times 10^{-3} \times 490.8 = 1.27$ g **(1)** Yield $= \frac{0.65}{1.27}$ $= 51(.1)\%$ Or = 51(.2) ignore SF **(1)** Correct answer no working **(2)**	50.9%	2

Question Number	Acceptable Answers	Reject	Mark
4(d)	Place flask in running **cold** water OR (in an) ice bath / beaker of cold / cool water	Add ice / Put in the fridge Washing with / adding cold water / ice	1

Question Number	Acceptable Answers	Reject	Mark
4(e)	To react with / remove (any residual) benzoyl chloride	Acts as a solvent Removes impurities	1

Question Number	Acceptable Answers	Reject	Mark
4(f)	Dissolve / add / put crystals in **minimum** (volume / amount) **(1)** of hot ethyl ethanoate **(1)** Penalise incorrect solvent e.g. water once only. Filter (hot) **and** allow to cool **(1)** Filter **and** wash with small amount of / cold solvent. **Note** notice if 'solvent' used here and in second marking point, this mark can be given **(1)** **Note** If ethyl ethanoate mentioned here can score second mark above **and** The wrong solvent may be used here e.g. water with the correct initial solvent. This should be separately penalised here. Dry between filter papers / dry in a desiccator ALLOW Keep suction filtration going until crystals are dry Dry in warm oven or **below** 100 °C **(1)**	Wash… …to remove soluble impurities …cold **solution** …to remove insoluble impurities but only penalise soluble / insoluble once Dry in oven alone	5

Question Number	Acceptable Answers	Reject	Mark
4(g)	**Method 1** **First Mark** (The crystals from) step 6 / pure crystals have a sharp (at 150°C / 423 K) melting temperature / melt over 1-2°C OR (The crystals from) step 6 / pure crystals melt within 2°C of / close to the data book value / at 150°C / 423 K **(1)** **Second Mark** (The crystals from) step 5 would melt over a larger temperature range OR Would melt (significantly) more / more than 2°C **and** below the data book value / 150°C / 423 K **(1)** **Method 2** Comparative answers Can score both marks if it clear which step the crystals are prepared in. Two Examples Both melting points measured and the pure sample / step 6 has a sharp**er** melting temperature **(2)** Both melting points measured and the pure sample / step 6 has a melting temperature clos(er) to than data book value / 150°C / 423 K **(1)** The impure sample melts at a temperature below that of the pure sample **(1)** Allow reverse arguments for step 5		2

Total for Question 4 = 17 marks
Total for paper = 50 marks

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Write your name here

Surname	Other names

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International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 6: Chemistry Laboratory Skills II

Friday 15 May 2015 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH06/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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6/6/6/5/

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PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A white solid, **A**, contains one cation and one anion. When water is added slowly, the solid turns blue and then dissolves to form a blue solution, **B**.

(a) When aqueous barium chloride is added to an acidified portion of solution **B**, a white precipitate forms.

(i) Give the **formula** of the anion in **B**.

(1)

.....

(ii) Name a suitable acid for acidifying solution **B** in this test.

(1)

.....

(b) When aqueous ammonia is added to another portion of solution **B**, a blue precipitate forms. When more aqueous ammonia is added, this precipitate dissolves to form a deep blue solution, **C**.

(i) Identify, by name or formula, the blue precipitate.

(1)

.....

(ii) Give the **formula** of the ion responsible for the deep blue colour of solution **C**.

(1)

.....

(c) Give the **formula** of the complex ion which gives the blue colour to solution **B**. Include the ligands in your answer.

(1)

.....

(d) Give the **formula** of the white solid **A**.

(1)

.....

(e) Why is solid **A** white and not coloured blue? Justify your answer.

(2)

.....

.....

.....

(Total for Question 1 = 8 marks)

2 A salt, **P**, contains carbon, hydrogen, oxygen and one metallic element.

(a) When a flame test is carried out on **P**, a yellow flame results.

Give the **formula** of the metal ion in the salt.

(1)

.....

(b) **P** dissolves in water to form a weakly alkaline solution, **Q**, with pH 8.1.

The pH of **Q** can be measured by using a calibrated pH meter or an indicator.

(i) Describe how to calibrate a pH meter.

(2)

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(ii) Name a suitable indicator you could use and state the colour you would expect to observe.

(2)

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.....

(iii) Which of the two methods will give the more accurate value for the pH of **Q**? Justify your answer.

(1)

.....

.....

(c) Some of the solution **Q** is acidified with concentrated hydrochloric acid.

An organic compound, **R**, forms in the solution.

Methanol is added and the mixture warmed, forming a new organic compound **S**.

This mixture is added to sodium carbonate solution in an evaporating basin.
A fruity smell is detected.

(i) Describe and explain what you would **see** as the mixture is added to the sodium carbonate solution.

(2)

.....

.....

.....

.....

(ii) What type of compound is **S**?

(1)

.....

(d) The high resolution proton nuclear magnetic resonance (nmr) spectrum of **S** has only two peaks which are both singlets and have the same area.

Deduce the structural formulae of **S**, **R**, and **P**.

(3)

S

R

P

(Total for Question 2 = 12 marks)

3 Cupronickel is an alloy of copper and nickel. It is used to make 'silver' coins.

A coin is analysed by the following method.

Step 1 It is weighed on a balance which reads to two decimal places and found to have mass 4.00 g.

Step 2 Water is added to the coin in a beaker. Concentrated nitric and sulfuric acids are added and the coin dissolves.

Step 3 When the coin is completely dissolved, the solution is neutralized.

Step 4 The neutral solution is transferred, with the washings, to a 100 cm^3 volumetric flask, made up to the mark with water and mixed thoroughly.

Step 5 10 cm^3 samples of the solution are taken and an excess of potassium iodide is added, producing iodine.

Step 6 The iodine is titrated with 0.200 mol dm^{-3} sodium thiosulfate solution.

(a) Why, in **Step 2**, is water added before, rather than after, the acids?

(1)

.....

.....

(b) What is the colour of an aqueous iodine solution?

(1)

.....

(c) (i) To make the end point of the titration more obvious, an indicator is added just before the colour of the iodine disappears.

Name this indicator.

(1)

.....

(ii) Suggest why the indicator is not added to the iodine solution earlier in the titration.

(1)

.....

.....

(iii) Give the colour change at the end point when the indicator is used in this titration.

(1)

.....

(d) The results for the titrations are shown below.

Titration number	1	2	3	4
Burette reading (final) / cm^3	24.10	47.90	23.55	47.00
Burette reading (initial) / cm^3	0.00	24.10	0.00	23.55
Titre / cm^3				

(i) Complete the table.

(1)

(ii) Which titres should be used to calculate the mean? Explain your choice.

(1)

.....

.....

.....

.....

(iii) Calculate the mean titre.

(1)

(iv) Calculate the percentage by mass of copper in the coin.

Use the equations below.

$2Cu^{2+}(aq) + 4I^{-}(aq) \rightarrow 2CuI(s) + I_2(aq)$

$2S_2O_3^{2-}(aq) + I_2(aq) \rightarrow S_4O_6^{2-}(aq) + 2I^{-}(aq)$

(5)

(v) The uncertainty in each burette reading is ±0.05 cm^3 and the uncertainty in each reading of the balance is ±0.005 g.

Calculate the percentage uncertainty in the third titre value and in the mass measurement. Use your results to decide whether using a balance that weighs to three decimal places would significantly improve the accuracy of the result.

(2)

(Total for Question 3 = 15 marks)

4 Bromobenzene can be prepared from benzene by the following steps.

Step 1 Reflux 20.0 cm^3 of benzene with 6.0 cm^3 of bromine and about 10 g of iron filings, by heating on a water bath at 50 °C.

Step 2 After the reaction has finished, remove the water bath and heat to boiling until no bromine vapour can be seen.

Step 3 Cool the mixture and add 25 cm^3 of ethoxyethane (diethyl ether) to extract the bromobenzene.

Step 4 Wash the ethoxyethane layer with aqueous sodium hydroxide. Separate the ethoxyethane layer.

Step 5 Wash the ethoxyethane layer with water and repeat the separation.

Step 6 Dry the ethoxyethane layer with a suitable drying agent.

Step 7 Decant the dried solution.

Step 8 Distil the separated solution, collecting the fraction boiling around the boiling temperature of bromobenzene, 156 °C.

(a) Calculate the number of moles of bromine, Br_2, used in the experiment.

[Density of bromine 3.1 g cm^{-3}]

(2)

(b) Bromine reacts with iron to form iron(III) bromide, which reacts with bromine to produce the attacking electrophile in **Step 1**.

Write the chemical equations for these reactions.

(2)

(c) Why is the ethoxyethane layer washed with sodium hydroxide solution in **Step 4**?

(1)

.....

.....

(d) Draw a diagram of the apparatus used to separate the ethoxyethane layer from the aqueous layer in **Step 5**. Clearly label the ethoxyethane layer.

[Densities: water 1.0 g cm^{-3}, ethoxyethane 0.7 g cm^{-3}]

(2)

(e) The bromobenzene formed in this reaction can be nitrated to make 2,4-dinitrobromobenzene.

Identify, by name or formula, the chemicals needed for this reaction.

(1)

.....

.....

(f) 2,4-dinitrobromobenzene reacts with hydrazine hydrate to make 2,4-dinitrophenylhydrazine crystals.

The percentage yields for the reactions are:

75% for the formation of bromobenzene from benzene

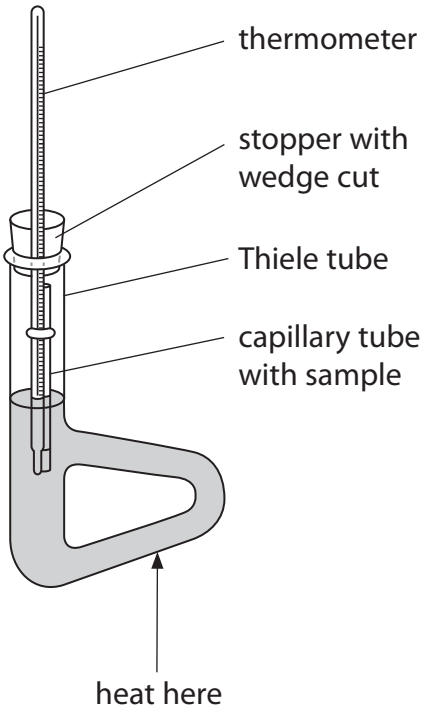
70% for the formation of 2,4-dinitrobromobenzene from bromobenzene

70% for the formation of 2,4-dinitrophenylhydrazine from 2,4-dinitrobromobenzene

Calculate the overall percentage yield of 2,4-dinitrophenylhydrazine from benzene, for this series of reactions.

(1)

(g) The purity of the 2,4-dinitrophenylhydrazine crystals can be checked by carrying out a melting temperature determination using the Thiele tube apparatus shown below.



(i) The capillary tube must be sealed at one end.
Describe how this is done.

(1)

.....

.....

(ii) When crystals are placed in the capillary tube they often stick in the top.
Describe how to ensure the crystals reach the bottom of the capillary tube.

(1)

.....

.....

(iii) Dibutyl phthalate is often used as the liquid in the Thiele tube.

Suggest **two** properties of dibutyl phthalate that make it a suitable liquid for this purpose.

(2)

.....

.....

.....

.....

(iv) The melting temperature for crystals of 2,4-dinitrophenylhydrazine is 201°C.

Suggest the temperature **range** over which you would expect the crystals to melt before and after purification by recrystallization.

(2)

Before recrystallization.....

After recrystallization.....

(Total for Question 4 = 15 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

P 4 4 8 8 4 A 0 1 6 1 6

PMT

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Mark Scheme (Results)

Summer 2015

IAL Chemistry (WCH06/01)

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Question Number	Acceptable Answers	Reject	Mark
1(a)(i)	SO_4^{2-} OR SO_4^{-2}	Sulfate HSO_4^-	1

Question Number	Acceptable Answers	Reject	Mark
1(a)(ii)	(Dilute) hydrochloric (acid)/ HCl(aq) / nitric (acid) / HNO_3(aq) ALLOW HCl / HNO_3 Ignore concentrated/conc	Sulfuric acid H^+ / H_3O^+ Carboxylic acid Hydrogen chloride	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(i)	Water and hydroxide can be in either order If name and formula are given, both must be correct Copper**(II)** hydroxide / $Cu(OH)_2$ / $Cu(H_2O)_4(OH)_2$ ALLOW $Cu(H_2O)_2(OH)_2$ IGNORE Copper hydroxide Square brackets in formula wherever they are	Any other numbers	1

Question Number	Acceptable Answers	Reject	Mark
1(b)(ii)	Water and ammonia can be in either order If name and formula are given, both must be correct $[Cu(NH_3)_4]^{2+}$ OR $[Cu(H_2O)_2(NH_3)_4]^{2+}$ Charge must be included Outer brackets not required IGNORE order of ligands, but numbers must be correct	Any other numbers e.g. $[Cu(NH_3)_6]^{2+}$	1

Question Number	Acceptable Answers	Reject	Mark
1(c)	$Cu(H_2O)_6^{2+}$ OR $Cu(H_2O)_4^{2+}$ IGNORE Square brackets wherever they are	Cu^{2+} $Cu^{2+}(aq)$	1

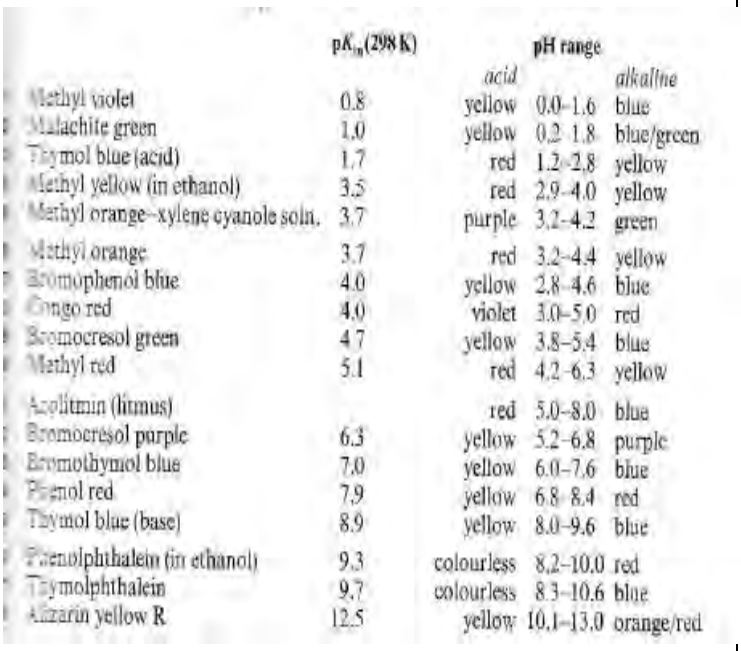
Question Number	Acceptable Answers	Reject	Mark
1(d)	$CuSO_4$ / $Cu^{2+}SO_4^{2-}$ If charges given both must be given correctly	$CuSO_4.5H_2O$	1

Question Number	Acceptable Answers	Reject	Mark
1(e)	Mark independently **First mark** The (3)d sub-shell(s) / (3)d-orbital(s) cannot be split OR No d-d splitting OR No d-d transitions (1) **Second mark** No colour as no ligands present ALLOW No water (of crystallization) present OR Not hydrated / Anhydrous salt IGNORE Use of copper rather than copper ions (1) Reverse arguments involving the addition of water acceptable		2

(Total for Question 1 = 8 marks)

Question Number	Acceptable Answers	Reject	Mark
2(a)	Na^+ OR Na^{+1} OR Na^{1+} IGNORE sodium or sodium ion	Na Any charge other than +1	1

Question Number	Acceptable Answers	Reject	Mark
2(b)(i)	Measure pH/Use of alkaline buffer solution (1) and acidic buffer solution (1) ALLOW Measure pH of a (alkaline) buffer solution... (1) with known pH (1) **ALLOW** Use of acid /alkali / (de-ionized/ distilled / pure) water / **specified** neutral solution (e.g. NaCl(aq)) (1) of known pH (1) **OR** Several solutions of known pH (1) Plot graph of meter reading against (known) pH (to give a calibration curve) (1)	Neutral for pH=7	2

Question Number	Acceptable Answers	Reject	Mark
2(b)(ii)	Universal / full range indicator (paper / solution) (1) Colour changes to (dark) green / blue IGNORE Initial colour (1) **Comment** **ALLOW for 1 mark** Any named indicator from list below **and** its colour in alkali 		2

	pK_{in} (298 K)	pH range		
		acid		*alkaline*
Methyl violet	0.8	yellow	0.0–1.6	blue
Malachite green	1.0	yellow	0.2–1.8	blue/green
Thymol blue (acid)	1.7	red	1.2–2.8	yellow
Methyl yellow (in ethanol)	3.5	red	2.9–4.0	yellow
Methyl orange–xylene cyanole soln.	3.7	purple	3.2–4.2	green
Methyl orange	3.7	red	3.2–4.4	yellow
Bromophenol blue	4.0	yellow	2.8–4.6	blue
Congo red	4.0	violet	3.0–5.0	red
Bromocresol green	4.7	yellow	3.8–5.4	blue
Methyl red	5.1	red	4.2–6.3	yellow
Azolitmin (litmus)		red	5.0–8.0	blue
Bromocresol purple	6.3	yellow	5.2–6.8	purple
Bromothymol blue	7.0	yellow	6.0–7.6	blue
Phenol red	7.9	yellow	6.8–8.4	red
Thymol blue (base)	8.9	yellow	8.0–9.6	blue
Phenolphthalein (in ethanol)	9.3	colourless	8.2–10.0	red
Thymolphthalein	9.7	colourless	8.3–10.6	blue
Alizarin yellow R	12.5	yellow	10.1–13.0	orange/red

Question Number	Acceptable Answers	Reject	Mark
2(b)(iii)	A pH meter because... … difficult to match colour of indicator to pH OR …the colour of universal indicator covers a range of pH ALLOW pH meters measure to at least one decimal place (after calibration) OR pH meter with any reasonable attempt at an explanation e.g. indicators cover a range pH meters give exact values	pH meter alone Any untrue statement about pH meters or indicators	1

Question Number	Acceptable Answers	Reject	Mark
2(c)(i)	**First mark - Observation** Effervescence / bubbles (of gas) (1) IGNORE Test for carbon dioxide Gas evolved (Solid) sodium carbonate dissolves **Second mark - Explanation** because the sodium carbonate reacts with / neutralises **acid**(s) present (to form carbon dioxide) ALLOW carbon dioxide is formed (1)	Incorrect observations e.g. Solid/precipitate forms Negates first mark	2

Question Number	Acceptable Answers	Reject	Mark
2(c)(ii)	Ester OR Methyl ester IGNORE compound (of carboxylic acid and alcohol)		1

Question Number	Acceptable Answers	Reject	Mark
2(d)	**S** CH_3COOCH_3 (1) **R** CH_3COOH (1) **P** $CH_3COO^{(-)}Na^{(+)}$ (1) ALLOW displayed/skeletal formulae ALLOW TE as below: TE from 2(a) TE for **R** and **P** based on their formula for **S** TE for **P** based on their formula for **R** Ignore names even if incorrect	$CH_3COO—Na$	3

(Total for Question 2 = 12 marks)

Question Number	Acceptable Answers	Reject	Mark
3(a)	Sulfuric acid reacts very exothermically with water ALLOW The reaction with acid is exothermic OR (Sulfuric) acid will shoot out of container OR The reaction of water with (sulphuric) acid is vigorous/splashes OR Prevent splashing of acid	nitric acid Prevent splash alone	1

Question Number	Acceptable Answers	Reject	Mark
3(b)	(Pale/straw-coloured) yellow / brown / red-brown	Red/purple/blue/black/blue-black/orange	1

Question Number	Acceptable Answers	Reject	Mark
3(c)(i)	(Freshly prepared) starch (solution)		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(ii)	(If starch is added too early) starch iodine complex formed (doesn't re-dissolve) ALLOW Iodide for iodine ALLOW (Black) solid/precipitate / complex forms OR Insoluble compound forms		1

Question Number	Acceptable Answers	Reject	Mark
3(c)(iii)	From blue-black to colourless ALLOW From blue / black/ dark blue/ deep blue to colourless	...to clear	1

Question Number	Acceptable Answers	Reject	Mark
3(d)(i)	24.1(0) 23.8(0) 23.55 23.45 (cm^3)		1

Question Number	Acceptable Answers	Reject	Mark
3(d)(ii)	The third and fourth / 23.55 and 23.45 (cm^3) **and** They are concordant OR Within ±0.2/0.1 (cm^3) IGNORE Anomalous		1

Question Number	Acceptable Answers	Reject	Mark
3(d)(iii)	23.5(0) (cm^3) ALLOW TE including second titre value, mean = 23.6(0) (cm^3)		1

Question Number	Acceptable Answers	Reject	Mark
3(d)(iv)	Correct answer 74.6% / 75% OR 74.9% (TE from 23.60 average titre) Ignore SF except 1SF With no working **(5)** Number of mol of thiosulfate $= \frac{23.50 \times 0.200}{1000}$ (1) $= 4.70 \times 10^{-3}/0.00470$ **Second mark** EITHER Number of mol of iodine $= \frac{4.70 \times 10^{-3}}{2}$ $= 2.35 \times 10^{-3}/0.00235$ **AND** Number of moles of copper ion $= 2 \times 2.35 \times 10^{-3}$ (1) $= 4.70 \times 10^{-3}/0.00470$ in 10 cm^3 OR From equations amount of iodine is half amount of thiosulfate and amount of copper is twice amount of iodine, so amount of copper equals amount of thiosulfate for this mark Number of moles of copper in solid		5

	= $10 \times 4.70 \times 10^{-3}$ (1) = $4.70 \times 10^{-2}/0.0470$ Mass of copper in solid = $4.70 \times 10^{-2} \times 63.5$ (g) (1) = 2.9845 Percentage copper = $\frac{2.9845 \times 100}{4.00}$ = 74.6125 = 74.6% (1) Using 23.60 by averaging titres 2, 3 and 4 $4.72 \times 10^{-3}/0.00472$ (1) 2.36×10^{-3}0.00236 AND $4.72 \times 10^{-3}/0.00470$ (1) $4.72 \times 10^{-2}/0.0470$ (1) 2.9972 (1) 74.9% (1) Answers greater than 100% max 3		

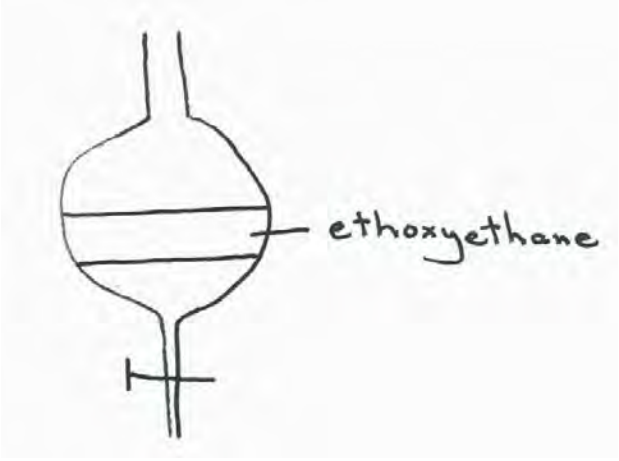
Question Number	Acceptable Answers	Reject	Mark
3(d)(v)	**First Mark** Uncertainty in titre value: $\frac{2 \times 0.05}{23.55} \times 100 =$ (±)0.42/0.425/0.4246% (1) **Second Mark** Uncertainty in the mass measurement: $\frac{2 \times 0.005 \times 100}{4.0} = (\pm)0.25\%$ **OR** $\frac{1 \times 0.005 \times 100}{4.0} = (\pm)0.125\%$ so it would / would not be worth using a 3 dp balance (1) Ignore SF including 1 SF		2

(Total for Question 3 = 15 marks)

Question Number	Acceptable Answers	Reject	Mark
4(a)	Mass of bromine = 6.0 x 3.1 (1) (= 18.6 (g)) Number of moles of bromine = $\frac{6.0 \times 3.1}{2 \times 79.9}$ = 0.116(40) = 0.12 (1) ALLOW Number of moles of bromine = $\frac{18.6}{2 \times 80}$ = 0.11625 = 0.12 Correct answer no working scores (2) IGNORE SF except 1 SF	$\frac{6.0x3.1}{1000}$	2

Question Number	Acceptable Answers	Reject	Mark
4(b)	Mark Independently $2Fe + 3Br_2 \rightarrow 2FeBr_3$ OR multiples (1) $Br_2 + FeBr_3 \rightarrow Br^{\delta+}...Br^{\delta-}FeBr_3$ Allow any attachment between the centre bromine atom and the iron and / or the other bromine atom. e.g. $Br^{\delta+}— Br^{\delta-}$ **.** $FeBr_3$ OR $Br_2 + FeBr_3 \rightarrow Br^+ + FeBr_4^-$ (1) Ignore states even if incorrect	$\rightarrow Br^- + FeBr_4^+$	2

Question Number	Acceptable Answers	Reject	Mark
4(c)	To neutralize / react with HBr (formed) ALLOW To neutralize / react with acid OR To remove / react with bromine	To neutralize (the solution)	1

Question Number	Acceptable Answers	Reject	Mark
4(d)	 Separating funnel which must have narrower neck than the container (capable of taking a stopper) **and** a tap (1) Upper layer ethoxyethane (1)	Burette Filter funnel	2

Question Number	Acceptable Answers	Reject	Mark
4(e)	(Concentrated) nitric acid/ HNO_3 **and** (concentrated) sulfuric acid/ H_2SO_4	 **Dilute** sulfuric acid Any additional chemicals like Ammonia/NH_3 Bromine/Br_2 Sodium hydroxide/NaOH	1

Question Number	Acceptable Answers	Reject	Mark
4(f)	(0.75 x 0.70 x 0.70 x100 =) 36.75 / 36.8 / 37 (%) Correct answer with no working	Any other answers e.g. 36.7 / 37.0 / 40	1

Question Number	Acceptable Answers	Reject	Mark
4(g)(i)	(While rotating the tube) heat one end of the tube in a Bunsen flame (until the glass starts to melt) ALLOW Heat in a flame OR Heat (one end of the) tube		1

Question Number	Acceptable Answers	Reject	Mark
4(g)(ii)	By gently tapping or dropping the tube / rubbing the open end with a milled coin ALLOW Hit / flick tube with finger OR Use (very small) dry crystals IGNORE Shaking / use of wire / sticks / pins / needles	Heat	1

Question Number	Acceptable Answers	Reject	Mark
4(g)(iii)	**Any two from** High boiling temperature/ point (compared with sample melting temperature) OR not volatile Does not decompose / oxidize (at high temperature) Mobile / non-viscous / non-sticky IGNORE Any reference to thermal conductivity and heat capacity **ALLOW** Clear liquid (ignore colourless) High ignition temperature/non-(in)flammable Non-toxic IGNORE Unreactive alone / safety aspects	High melting temperature Just 'does not react with the crystals'	2

Question Number	Acceptable Answers	Reject	Mark
4(g)(iv)	**Before recrystallization** 185 – 201°C A range of at least 5°C ALLOW 180 - 205 ^{o}C A range of at least 5°C (1) **After recrystallization** 199 – 201°C ALLOW 197 - 203°C A range of no more than 4°C (1)	Single temperature Single temperature	2

(Total for Question 4 = 15 marks)

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Surname	Other names

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Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 6: Chemistry Laboratory Skills II

Thursday 28 January 2016 – Afternoon
Time: 1 hour 15 minutes

Paper Reference
WCH06/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 4 6 9 4 2 A 0 1 1 6

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 The inorganic salt **A** has one cation and one anion. Complete the table below.

	Test	Observations	Inferences	
(a)	Observe the appearance of **A**	**A** is a brown powder	The part of the Periodic Table in which the metal element in **A** is likely to be found is	**(1)**
(b)	Dissolve **A** in the minimum volume of concentrated hydrochloric acid	A yellow solution forms	The formula of the **cation** in **A** could be	**(1)**
(c)	Gradually dilute a portion of the solution from (b) with distilled water	The yellow solution turns dark green then pale blue	The formula of the cation in **A** is confirmed as	**(1)**
(d)	Place a sample of solid **A** in a test tube and heat it strongly	A pale green gas is evolved which turns damp blue litmus paper red and then bleaches it A white solid residue remains	The gas is ..... So the anion in **A** is	**(2)**
(e)	Add dilute hydrochloric acid to the white solid obtained in (d) Shake the mixture vigorously	A colourless solution forms The colourless solution turns blue	The white solid is .... The type of reaction which results in the change from colourless to blue is	**(2)**

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(f) Suggest a further test to confirm the identity of the cation in **A**. Give the result of the test.

(2)

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(g) Suggest a test to confirm the identity of the anion in **A**. Give the result of the test.

(2)

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(h) Give the formulae of the ions that give the yellow colour to the solution described in (b), and the green colour to the solution described in (c).

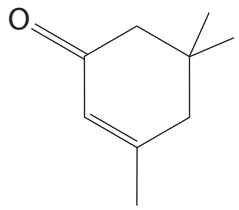
(2)

Yellow colour .....

Green colour .....

(Total for Question 1 = 13 marks)

2 Isophorone is a colourless liquid with a peppermint smell, found in cranberries.
The structure of isophorone is shown below.



(a) There are two functional groups present in isophorone.

Name these functional groups and describe a **chemical** test and its result that could be used to identify each functional group.

(4)

Functional group	Test	Result

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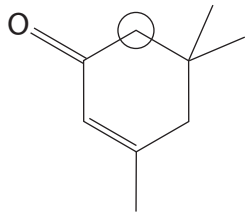
(b) Isophorone has several proton environments that would produce peaks in its proton nuclear magnetic resonance (nmr) spectrum. One of the environments is circled on the structure of isophorone shown below.



(i) The circled proton environment produces a peak in the low resolution nmr spectrum.

State and explain the splitting pattern that you would expect in this peak in the **high** resolution proton nmr spectrum of the molecule.

(1)

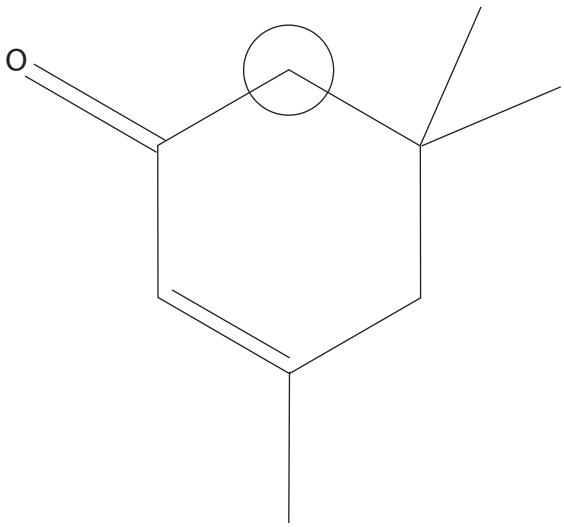
.....

.....

.....

(ii) On the structure of isophorone shown below, circle each of the other proton environments that would produce a peak in the **low** resolution proton nmr spectrum of the molecule. Indicate clearly if any of the proton environments are identical.

(2)



(Total for Question 2 = 7 marks)

3 This question is about a student experiment to prepare crystals of iron(II) sulfate-7-water ($FeSO_4.7H_2O$) and then to determine the number of moles of water of crystallization in the sample which they have prepared.

(a) Each student was given 5.00 g of iron filings which was added to excess dilute sulfuric acid, warmed and allowed to stand until no further reaction occurred. The resulting solution was cooled and filtered, and the required crystals were obtained from the filtrate.

(i) Calculate the minimum volume of dilute sulfuric acid of concentration 2.00 mol dm^{-3} required to react completely with 5.00 g of pure iron filings. The equation for this reaction is

$$Fe(s) + H_2SO_4(aq) \rightarrow FeSO_4(aq) + H_2(g)$$

(2)

(ii) Why was the reaction mixture filtered?

(1)

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(iii) Describe how pure crystals of iron(II) sulfate-7-water are obtained from the filtrate.

(2)

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(iv) One student obtained a yield of 89.5% from this preparation.

Taking the formula of the crystals as $FeSO_4.7H_2O$, calculate the mass of iron(II) sulfate-7-water obtained by this student. Assume that the iron filings were pure.

(3)

(b) A second student dissolved 6.75 g of their prepared crystals in about 150 cm^3 of dilute sulfuric acid in a beaker and used this solution to prepare exactly 250.0 cm^3 of a solution for titration.

25.0 cm^3 samples of this final solution were further acidified with dilute sulfuric acid.

These samples were titrated with potassium manganate(VII) solution to determine the number of moles of water of crystallization per mole of iron(II) sulfate.

(i) Describe in outline how you would prepare the 250.0 cm^3 of the solution for titration from the solution obtained by dissolving 6.75 g of the crystals in 150 cm^3 of dilute sulfuric acid.

(3)

(ii) Suggest what would happen to the solution of iron(II) sulfate if it was prepared using distilled water, rather than dilute sulfuric acid as the solvent. Describe and explain what you would see.

(2)

(iii) Describe the end point of the titration.

(1)

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(iv) Using 6.75 g of their crystals and the method described in (b), the student obtained a mean titre of 25.35 cm^3.

The concentration of the potassium manganate(VII) solution was 0.0195 mol dm^{-3} and the equation for the titration reaction is

$$MnO_4^- + 8H^+ + 5Fe^{2+} \rightarrow Mn^{2+} + 5Fe^{3+} + 4H_2O$$

Calculate the molar mass of the crystals and hence the number of moles of water of crystallization per mole of iron(II) sulfate in the student's crystals. You must show your working.

(4)

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(c) A third student carried out the experiment described in (b) and found that there was 7.1 mol of water of crystallization per mole of the iron(II) sulfate.

(i) The **total** experimental uncertainty associated with the determination of the molar mass is approximately ± 0.9%.

Use these data to show that the result obtained by this student is within this experimental uncertainty.

(2)

(ii) Most of the students in the class obtained values higher than the Data Book value of 7. Suggest a reason for this.

(1)

(Total for Question 3 = 21 marks)

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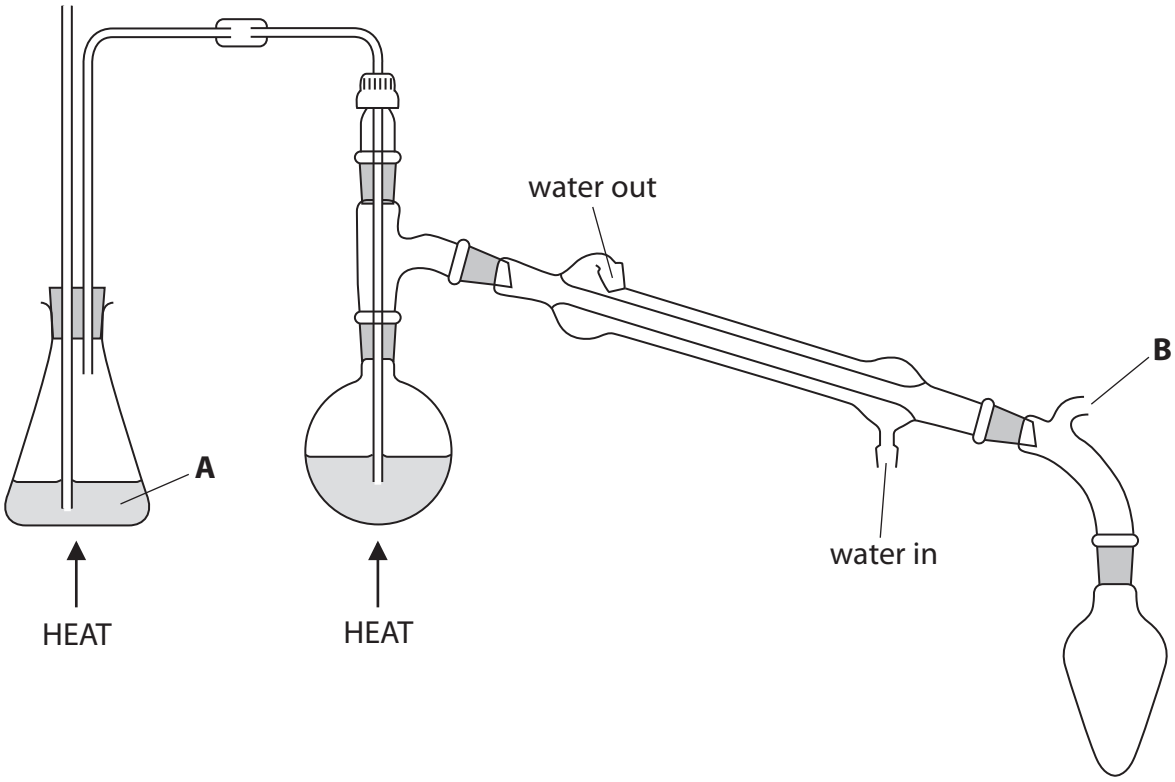
4 Steam distillation is one method used to separate organic compounds from mixtures.

Some information about nitrobenzene is summarised in the table below.

Molecular formula	$C_6H_5NO_2$
Appearance	Oily yellow liquid
Density	1.20 g cm^{-3}
Boiling temperature	211°C
Solubility in water	0.19 g / 100 g of water at 20°C

(a) The diagram below shows a steam distillation apparatus used to extract nitrobenzene from a reaction mixture.



(i) Identify substance **A**.

(1)

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(ii) Explain the purpose of the part of the apparatus labelled **B**.

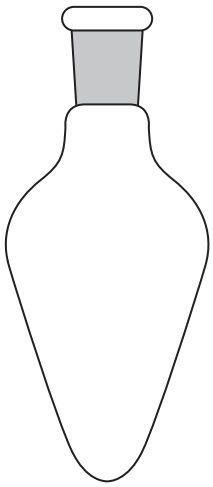
(1)

.....

.....

(iii) On the diagram below, draw and label the contents of the receiver at the end of the steam distillation.

(2)



(b) The nitrobenzene may be further purified by simple distillation.

Describe the steps needed **before** the product of steam distillation can be further distilled. Any apparatus or chemicals needed for these steps should be named but practical details are **not** required.

(3)

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(c) A bottle of nitrobenzene has the hazard labels shown below.

Symbol		
Meaning		

(i) Complete the table above with the meaning of each symbol.

(1)

(ii) Suggest **one** change or addition to the **apparatus** in part (a) that would reduce the risk from **both** these hazards.

(1)

.....

.....

(Total for Question 4 = 9 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

January 2016

Pearson Edexcel International Advanced Level in Chemistry (WCH06) Paper 01 – Chemistry Laboratory Skills II

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Acceptable Answer	Reject	Mark
1(a)	d block OR Transition elements / metals / block ALLOW D block Transitional for transition element / metal		1

Question Number	Acceptable Answer	Reject	Mark
1(b)	Cu^{2+} / copper(II) OR Fe^{3+} / iron(III) OR Cu^{2+} /copper(II) **and** Fe^{3+} / iron(III)	copper / Cu Fe^{2+} / iron(II) iron / Fe	1

Question Number	Acceptable Answer	Reject	Mark
1(c)	Cu^{2+} / copper(II) ALLOW $Cu(H_2O)_6^{2+}$ / $Cu(H_2O)_4^{2+}$	Cu / copper	1

Question Number	Acceptable Answer		Reject	Mark
1(d)	Chlorine / Cl_2	**(1)**	Cl / chloride	2
	Chloride / Cl^-	**(1)**	Cl / chlorine / Cl_2	

Question Number	Acceptable Answer		Reject	Mark
1(e)	copper(I) chloride / CuCl	**(1)**		2
	No TE on 1(c)			
	oxidation / redox (reaction)	**(1)**	Reduction / disproportionation	
	Standalone mark			

Question Number	Acceptable Answer	Reject	Mark
1(f)	(To a solution of **A**) add (dilute aqueous) ammonia / NH_3((aq)) (until no further change) **(1)** (pale blue precipitate dissolves) to form a dark blue solution ALLOW (pale) blue precipitate /solid /crystals **(1)** OR Flame test **(1)** Blue-green / blue /green colour **(1)** OR Add potassium iodide / KI **(1)** Turns brown **(1)** ALLOW Add sodium hydroxide (solution) **(1)** (pale) blue precipitate /solid /crystals (insoluble in excess) **(1)** OR Add zinc / Zn / magnesium / Mg **(1)** Brown solid /crystals / precipitate **(1)** IGNORE Identity of cation at this point No TE on incorrect cations Reagent / flame test mark standalone	Pale green Green ppt	2

Question Number	Acceptable Answer	Reject	Mark
1(g)	(Add dilute nitric acid to a solution of **A** then) add (aqueous) silver nitrate / $AgNO_3$((aq)) **(1)** White precipitate (soluble in dilute aqueous ammonia) **(1)** OR Add **concentrated / conc** sulfuric acid / H_2SO_4 **(1)** Steamy / misty / white fumes **(1)** IGNORE Identity of anion at this point No TE on incorrect anions	Sulfuric acid Additional reagents e.g. NaOH (loses MP1 only) smoke Just 'fumes'	2

Question Number	Acceptable Answer	Reject	Mark
1(h)	(Yellow colour due to) $[CuCl_4]^{2-}$ **(1)** (Green colour due to) $[CuCl_3]^-$ ALLOW $CuCl_2$ / $[CuCl]^+$ OR A mixture of $[Cu(H_2O)_6]^{2+}$ / Cu^{2+}((aq)) **and** $[CuCl_4]^{2-}$ **(1)** IGNORE water ligands on chloro copper ions and $CuCl_2$ Omission of square brackets		2

(Total for Question 1 = 13 marks)

<table>
<tr><th>Question Number</th><th>Acceptable Answer</th><th>Reject</th><th>Mark</th></tr>
<tr><td>2(a)</td><td>
<table>
<tr><th>Functional group</th><th>Test</th><th>Result</th><th></th></tr>
<tr><td rowspan="2">Alkene</td><td>Bromine (water / solution)</td><td>(Brown /orange /yellow to) colourless</td><td rowspan="2">(2)</td></tr>
<tr><td>OR
Acidified potassium manganate(VII)</td><td>(Purple to) colourless</td></tr>
<tr><td>Ketone
ALLOW carbonyl</td><td>2,4-dinitro phenylhydrazine

OR

Brady’s reagent

ALLOW (2,4-)DNP(H)</td><td>Orange / yellow / red and precipitate</td><td>(2)</td></tr>
</table>
For each functional group:
all three points scores 2;
functional group and test reagent alone scores 1;
test and result alone scores 1

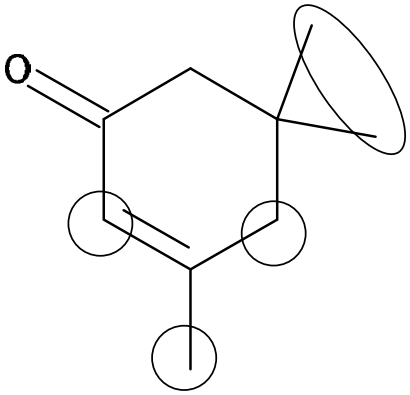
Use of just C=C for alkene and / or just C=O for ketone max 3

IGNORE
Test for aldehyde group with negative result

No TE on incorrect test

If no other marks scored then identifying both functional groups scores 1
</td><td></td><td>4</td></tr>
</table>

Question Number	Acceptable Answer	Reject	Mark
2(b)(i)	Singlet because neither of the adjacent /neighbouring carbon atoms has a hydrogen / proton attached ALLOW Singlet because no adjacent /neighbouring / nearby hydrogen(s) / proton(s) ‘No splitting’ / one peak for ‘singlet’	Just ‘singlet’	1

Question Number	Acceptable Answer	Reject	Mark
2(b)(ii)	 **MP1** (standalone mark) The top methyl group proton environments fully identified **and** linked in some way **(1)** **MP2** The other three proton environments **(1)** MP2 may only be awarded if there are no errors on the rest of the molecule apart from the top methyl groups Likely errors: omission of a proton environment / incorrectly linked proton environments / additional protons ALLOW Any other labels of the proton environments		2

(Total for Question 2 = 7 marks)

Question Number	Acceptable Answer	Reject	Mark
3(a)(i)	Amount of iron = 5.00/55.8 (mol) **(1)** = amount H_2SO_4 (= 0.089606 / 8.9606 x 10^{-2} (mol)) Volume of 2.00 mol dm^{-3} H_2SO_4 required = 5.00/55.8 ÷ 2 = 0.044803 / 4.4803 x 10^{-2} dm^3 OR = 44.803 cm^3 **(1)** If A_r(Fe) = 56, volume = 0.044643 dm^3 (= 44.643 cm^3) TE on incorrect mol IGNORE all SF and rounding errors **except** 1 SF on final answer, and rounding errors affecting final answer	Units incorrect or omitted	2

Question Number	Acceptable Answer	Reject	Mark
3(a)(ii)	To remove **solid** impurities ALLOW Undissolved **solids** OR **Insoluble** impurities	To remove unreacted iron	1

Question Number	Acceptable Answer	Reject	Mark
3(a)(iii)	Evaporate the solution to crystallization point OR until crystals /solids begin to form ALLOW **Concentrate** the solution by evaporation OR Reduce the volume by 25 – 75 % **(1)** (Cover solution and) allow to stand / cool **and** dry crystals between filter papers ALLOW Dry in a **warm** oven / desiccator **(1)** IGNORE Filtering Points relating just to recrystallization	Just 'evaporate the solution' OR Evaporate **all** water OR Distillation Dry the solution T>80°C Hot oven	2

Question Number	Acceptable Answer	Reject	Mark
3(a)(iv)	Mr ($FeSO_4.7H_2O$) = 277.9 ALLOW = 278 **(1)** Maximum yield = 277.9 x 5.00÷55.8 **(1)** = 277.9 x 0.08961 (= 24.901 g) 89.5% yield = 0.895 x 277.9 x 5.00/55.8 = 22.287 (g) OR If A_r(Fe) = 56 and A_r(S) = 32 89.5% yield = 22.215 (g) **(1)** TE at each stage IGNORE SF except 1 SF Correct answer with no working scores 3 **Additional Comment** The 89.5% yield can be applied to the mass of iron, the mass of $FeSO_4.7H_2O$ or the moles of $FeSO_4.7H_2O$ to gain MP3		3

Question Number	Acceptable Answer	Reject	Mark
3(b)(i)	These marks are standalone Transfer solution to a volumetric / graduated / standard flask **(1)** add washings **(1)** Make up to mark / line / 250 cm^3 (with distilled water / dilute sulfuric acid) **and then** mix **(1)** ALLOW Different indication of mixing (e.g. swirl / invert / stir). Mixing **must** follow making up to mark IGNORE reference to weighing bottle and mixing when dissolving solid and washings from the weighing		3

Question Number	Acceptable Answer	Reject	Mark
3(b)(ii)	(Pale green solution turns) yellow /orange / brown OR (Pale green solution forms) yellow /orange / brown (solution / cloudy solution / precipitate **(1)** Because (some of) the iron(II) / Fe^{2+} ions are oxidized (to iron(III) / Fe^{3+}) OR iron(III) / Fe^{3+} ions are formed (from iron(II) / Fe^{2+} ions) ALLOW $Fe(OH)_3$ formed **(1)**	red red Just 'oxidation'	2

Question Number	Acceptable Answer	Reject	Mark
3(b)(iii)	(colourless /pale yellow to first permanent pale) pink	(colourless /pale yellow to purple / mauve purple to pink pink / purple to colourless	1

Question Number	Acceptable Answer	Reject	Mark
3(b)(iv)	Amount of MnO_4^- = 25.35 x 0.0195/1000 **(1)** = 4.94325 x 10^{-4} (mol) (ans*) Amount of Fe^{2+} in 250 cm^3 = 5 x 10 x ans* (ans**) **(1)** = 0.024716 (mol) Mass of 1 mol of $FeSO_4.xH_2O$ = 6.75 ÷ ans** = 273.10 (g) (ans***) **(1)** IGNORE SF except 1 SF up to this point Correct molar mass with no working scores first 3 marks Moles of water of crystallization = (ans*** – 151.9)/18 = 6.7333 = 6.7=7 **(1)** If A_r(Fe) = 56, x = 6.7278 TE at each stage Final answer = 7 with no working scores 0		4

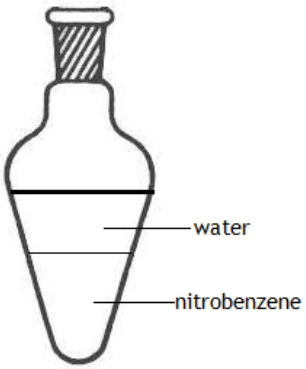
Question Number	Acceptable Answer	Reject	Mark
3(c)(i)	M_r ($FeSO_4.7H_2O$) = 277.9 uncertainty = 277.9 x 0.9/100 = (±)2.501 ALLOW M_r ($FeSO_4.7H_2O$) = 273 (from 3b(iv) is used (uncertainty = (±)2.458) OR M_r ($FeSO_4.7.1H_2O$) = 279.7 is used (uncertainty = (±)2.517) **(1)** (∴ answers = 277.9±2.5 are within experimental uncertainty) Using x = 7.1 gives M_r ($FeSO_4.7H_2O$) = 279.7 **and** this is within the uncertainty range **(1)** If neither mark is scored ALLOW Answer must be an integer so only needs to be in the range 6.6 to 7.4 for 1 mark IGNORE Calculations based on the percentage difference between 7.1 and 7		2

Question Number	Acceptable Answer	Reject	Mark
3(c)(ii)	The crystals were not dry OR Some of the iron(II) had been oxidized (to iron(III)) OR iron(II) / Fe^{2+} ions converted into iron(III) / Fe^{3+} ions IGNORE impurities / transfer errors / titration errors	Titration value too large	1

(Total for Question 3 = 21 marks)

Question Number	Acceptable Answer	Reject	Mark
4(a)(i)	(boiling) water / H_2O OR water /H_2O to produce steam OR Distilled / deionised water	Just 'steam'	1

Question Number	Acceptable Answer	Reject	Mark
4(a)(ii)	Prevents pressure building up (by allowing gases / vapours to escape). ALLOW To prevent explosion 'air' for gases / vapours IGNORE To allow gases / vapours to escape		1

Question Number	Acceptable Answer	Reject	Mark
4(a)(iii)	 Two layers labelled water /H_2O & nitrobenzene / $C_6H_5NO_2$ **(1)** Water on top OR nitrobenzene on bottom **(1)**	Just 'Oily /organic layer' (for nitrobenzene)	2

Question Number	Acceptable Answer	Reject	Mark
4(b)	Use a **separating funnel** to remove the nitrobenzene ALLOW Dropping funnel / teat pipette **(1)** Dry the nitrobenzene **(1)** Using (anhydrous) calcium chloride / $CaCl_2$ OR magnesium sulfate / $MgSO_4$ OR sodium sulfate / Na_2SO_4 OR calcium sulfate / $CaSO_4$ **(1)** IGNORE decanting / distillation	dehydrate copper(II) sulfate cobalt(II) chloride silica gel	3

Question Number	Acceptable Answer	Reject	Mark
4c(i)	Toxic **and** flammable ALLOW Poisonous / poison for toxic and inflammable for flammable	Corrosive Hazardous	1

Question Number	Acceptable Answer	Reject	Mark
4c(ii)	Vent **B** into a fume cupboard / to the outside / through an (open) window / down the drain IGNORE Vent into another container ALLOW Put the apparatus in fume cupboard / carry out in fume cupboard Fume hood / chamber IGNORE water bath / electrical heater / anti bumping granules / gloves		1

(Total for Question 4 = 9 marks)

TOTAL FOR PAPER = 50 Marks

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Write your name here

Surname	Other names

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International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced

Unit 6: Chemistry Laboratory Skills II

Tuesday 17 May 2016 – Morning
Time: 1 hour 15 minutes

Paper Reference
WCH06/01

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 50.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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P 4 6 6 6 6 A 0 1 2 4

PEARSON

Answer ALL the questions. Write your answers in the spaces provided.

1 A series of tests is carried out on aqueous solutions, **X**, **Y** and **Z**. Each solution contains a compound of a different d-block element.

(a) Tests **A** and **B**, described in the table, are carried out on solution **X**.

	Test	Observations
A	To 1 cm^3 of solution **X** in a test tube, add dilute sodium hydroxide solution, drop by drop, until no further change occurs. Shake the test tube gently as you add the dilute sodium hydroxide solution.	A white precipitate forms initially. The white precipitate dissolves in excess sodium hydroxide solution to form a colourless solution.
B	To 1 cm^3 of solution **X** in a test tube, add dilute aqueous ammonia solution, drop by drop, until no further change occurs. Shake the test tube gently as you add the aqueous ammonia solution.	A white precipitate forms initially. The white precipitate dissolves in excess aqueous ammonia solution to form a colourless solution.

(i) Write the formula of the complex ion that is present at the **end** of Test **A**.

(1)

(ii) Write the formula of the complex ion that is present at the **end** of Test **B**.

(1)

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(b) Test **C**, described in the table, is carried out on solution **Y**.

	Test	Observations
C	To 2 cm^3 of solution **Y** in a boiling tube, add dilute sodium hydroxide solution, drop by drop, until no further change occurs. Next add 2 cm^3 more of dilute sodium hydroxide solution and 5 cm^3 of hydrogen peroxide solution. Shake the tube gently and stand it in a beaker of hot water for a few minutes.	A green precipitate forms initially. The green precipitate dissolves to form a green solution. A yellow solution forms.

(i) Write an ionic equation, including state symbols, for the formation of the green precipitate in Test **C**.

(1)

(ii) Give the oxidation numbers, including signs, of the d-block element in Test **C**.

(2)

Before the addition of hydrogen peroxide .....

At the end of Test **C** .....

(c) Test **D**, described in the table, is carried out on solution **Z**.

	Test	Observations
D	To 2 cm^3 of solution **Z** in a test tube, add an equal volume of dilute sodium hydroxide solution. Then add 10 drops of aqueous hydrogen peroxide solution.	An off-white precipitate forms initially. The off-white precipitate darkens.

Give the **formula** of the d-block metal cation present in solution **Z**.

(1)

(Total for Question 1 = 6 marks)

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2 Ethyl ethanoate, $CH_3COOC_2H_5$, is hydrolysed in the presence of a catalyst of dilute hydrochloric acid, HCl(aq), according to the equation below.

$$CH_3COOC_2H_5(l) + H_2O(l) \rightleftharpoons C_2H_5OH(l) + CH_3COOH(l) \qquad \Delta H = +3.5 \text{ kJ mol}^{-1}$$

In an experiment carried out by a teacher to determine the equilibrium constant, K_c, the following steps are carried out.

- 15.0 cm^3 (0.153 mol) of ethyl ethanoate and 10.0 cm^3 dilute hydrochloric acid, concentration 1.00 mol dm^{-3}, are mixed together. In this pre-equilibrium mixture, there is 0.556 mol of water.
- The mixture is left for several days, at room temperature and pressure, to reach equilibrium.
- Using a pipette, several 5.00 cm^3 samples are taken from the 25.0 cm^3 of equilibrium mixture.
- Each 5.00 cm^3 sample is titrated with dilute sodium hydroxide solution from a burette. The concentration of the sodium hydroxide solution is 0.500 mol dm^{-3}.
- The mean titre of sodium hydroxide is 42.40 cm^3. This neutralizes both the hydrochloric acid catalyst **and** the ethanoic acid in 5.0 cm^3 of the equilibrium mixture.

(a) (i) Show that the 25.0 cm^3 of equilibrium mixture contains 0.0960 mol of CH_3COOH.

(3)

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(ii) Deduce the number of moles of each of the other components in the equilibrium mixture.

(3)

Equilibrium moles of C_2H_5OH = ... mol

Equilibrium moles of $CH_3COOC_2H_5$ = ... mol

Equilibrium moles of H_2O = ... mol

(iii) Give the expression for the equilibrium constant, K_c, for the reaction

$$CH_3COOC_2H_5(l) + H_2O(l) \rightleftharpoons C_2H_5OH(l) + CH_3COOH(l)$$

(1)

(iv) The equilibrium constant, K_c, is defined in terms of the concentrations in the equilibrium mixture. However, in this case, K_c can be calculated using moles rather than concentrations.

Calculate the value of K_c from the data in parts (a)(i) and (a)(ii).

Give your answer to **three** significant figures.

(2)

$K_c =$ .....

(v) Explain why it is possible, in this case, to calculate K_c using moles rather than concentrations.

(1)

.....

.....

(b) The experiment was repeated by a student whose value for K_c differed from the value calculated in (a)(iv).

The student made several suggestions to explain this.

State and explain how, if at all, each suggestion would affect the K_c value obtained by the student, compared with that from (a)(iv).

(i) **Suggestion 1** – The concentration of the sodium hydroxide solution used by the student was less than 0.500 mol dm^{-3}.

(2)

How the student's value of K_c compared with that from (a)(iv) .....

.....

Explanation .....

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(ii) **Suggestion 2** – The mixture had been left in a warm part of the laboratory and the equilibrium had been reached at a temperature above room temperature.

(2)

How the student's value of K_c compared with that from (a)(iv) .....

.....

Explanation .....

.....

.....

.....

(c) A second student repeated the original experiment using exactly the same method. However, when using the pipette and the burette, the readings were taken from the **top** of the meniscus.

(i) How, if at all, will this affect the volume of the equilibrium mixture delivered from the pipette? Justify your answer.

(1)

.....

.....

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(ii) How, if at all, will this affect the volume of sodium hydroxide solution delivered from the burette? Justify your answer.

(1)

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.....

.....

(iii) One of the student's titres was 42.60 cm^3 of sodium hydroxide solution.
The burette has a maximum uncertainty of ±0.05 cm^3 for each reading.

Calculate the percentage uncertainty in this titre.

(1)

Percentage uncertainty = ...%

(Total for Question 2 = 17 marks)

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3 Six students attempted to carry out a two-stage synthesis of nitrobenzoic acids starting from ethyl benzoate, $C_6H_5COOCH_2CH_3$.

There are two parts to the synthesis.

- In the first part, ethyl benzoate is hydrolysed to form benzoic acid, C_6H_5COOH.
- In the second part, benzoic acid is nitrated.

Part 1 – Hydrolysis of ethyl benzoate

The students were provided with the method outlined in the steps below.

Step 1 Mix in a flask 6.0 cm^3 ethyl benzoate (density = 1.05 g cm^{-3}) with an excess of aqueous sodium hydroxide solution (made by dissolving 2 g of sodium hydroxide in 25 cm^3 water).

Heat the mixture under reflux for 30 minutes.

Step 2 Pour the contents of the flask into a beaker and add 1 mol dm^{-3} dilute hydrochloric acid until the solution is acidic to universal indicator paper. Crystals of benzoic acid will form.

Step 3 Filter off the crystals under reduced pressure.

Step 4 Dissolve the crystals in the minimum volume of boiling water and then filter.

Step 5 Allow the solution to cool so that crystals of benzoic acid form. Filter off the crystals.

(a) Student **A** followed the method exactly and obtained 0.021 mol of benzoic acid crystals.

Calculate the percentage yield of the benzoic acid obtained by Student **A**.

[Molar mass of ethyl benzoate = 150 g mol^{-1}]

(2)

Percentage yield = ... %

(b) Student **B** dissolved just 1 g of sodium hydroxide instead of 2 g. This student carried on with the experiment.

Show, by calculation, that Student **B** did **not** have an excess of sodium hydroxide.

(2)

.....

.....

(c) Student **C** dissolved 10 g of sodium hydroxide instead of 2 g. This student noticed the mistake and started the experiment again.

Explain why Student **C** did not need to start again.

(1)

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(d) Student **D** decided to miss out **Steps 4** and **5**. This student's mass of crystals was greater than the mass of crystals obtained by Student **A**.

The benzoic acid obtained by Student **A** had fewer impurities than the benzoic acid obtained by Student **D**.

Name the procedure described in step 4 and 5, and explain why the benzoic acid prepared by Student **A** was purer than that obtained by Student **D**.

(1)

(e) Student **E** decided not to carry out **Steps 2**, **3**, **4** and **5**. Instead, Student **E** evaporated off the water after **Step 1** and found that 4.6 g of crystals had been formed, which was more than the mass obtained by Student **A**.

One reason why Student **E** obtained a greater mass of crystals than Student **A** was that the product was not benzoic acid.

Give the structural formula of the organic product that Student **E** obtained.

(1)

(f) Student **F** ran out of time and filtered the solution in **Step 5** before it had cooled properly. A low yield was obtained.

Explain why Student **F**'s failure to cool fully the solution resulted in **a low yield.**

(1)

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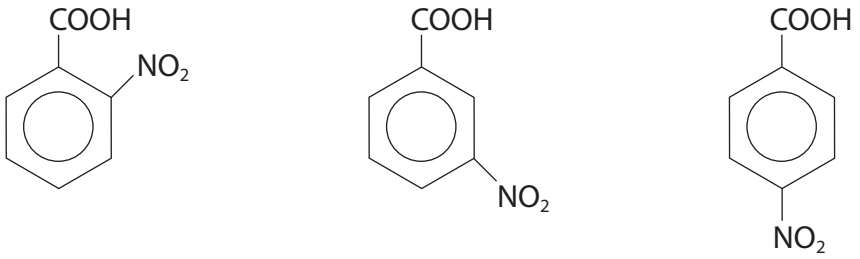
Part 2 – Nitration of benzoic acid

The students nitrated the benzoic acid and used chromatography to separate the three organic products.

The students suspected that the three products were isomers with the structures shown below, labelled **P**, **Q** and **R**.



P **Q** **R**

(g) A student measured the melting temperature range of **one** of the separated products (**Sample 1**).

The student then recrystallized the sample and took the melting temperature range of the recrystallized product (**Sample 2**).

The student's results are shown below.

Sample 1 melting temperature range before recrystallization was 136 °C to 140 °C

Sample 2 melting temperature range after recrystallization was 144 °C to 146 °C

The melting temperatures for the three structural isomers from a database are shown below.

- 2-nitrobenzoic acid (**P**) 148 °C
- 3-nitrobenzoic acid (**Q**) 142 °C
- 4-nitrobenzoic acid (**R**) 241 °C

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(i) Why are the melting temperatures of **Sample 1** and **Sample 2** different?

(1)

.....

.....

(ii) Suggest which isomer is present in these samples. Justify your answer.

(2)

.....

.....

.....

.....

(h) (i) Can the number of peaks in the low resolution proton nmr spectroscopy be used to distinguish between the three isomers **P**, **Q** and **R**?
Justify your answer.

(2)

.....

.....

.....

.....

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.....

(ii) In a mass spectrum, which *m/e* value could be used to confirm that only mono-nitration occurred in this reaction?

(1)

m/e value = ...

(Total for Question 3 = 14 marks)

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4 Vanadium is a transition metal and forms ions in which it has oxidation numbers +2, +3, +4 and +5.

Part 1

Two students want to make solutions containing ions in which vanadium has oxidation numbers of +3 and +4.
Both students start with solid ammonium vanadate(V), NH_4VO_3.

The first student decides to make an aqueous solution containing vanadium(III) ions, $V^{3+}(aq)$.

(a) First, the student heats solid ammonium vanadate(V) to make vanadium(V) oxide, ammonia and steam.

(i) Write a balanced equation for this decomposition of ammonium vanadate(V). State symbols are not required.

(1)

(ii) How would the student confirm that this decomposition is complete?

(1)

.....

.....

(b) The student then reduces the vanadium(V) oxide to vanadium(III) oxide, V_2O_3, by passing hydrogen over the heated oxide.

Identify the hazard associated with this procedure.

(1)

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(c) The student reacts 1.498 g of vanadium(III) oxide, $V_2O_3(s)$, completely with an **excess** of sulfuric acid, $H_2SO_4(aq)$, to make 250 cm^3 of a solution, T, containing aqueous vanadium(III) ions, $V^{3+}(aq)$.

(i) Calculate the concentration, in mol dm^{-3}, of vanadium(III) ions, $V^{3+}(aq)$, in the solution T.

(2)

Concentration = ... mol dm^{-3}

(ii) Give the **formulae** of **two** ions that would be present in high concentration in solution T, apart from vanadium(III) ions, $V^{3+}(aq)$ ions.

(1)

..... ions **and** ..... ions

(d) The second student decides to make a solution containing $VO^{2+}(aq)$ ions, in which vanadium has an oxidation number of +4.

The student dissolves the ammonium vanadate(V) in dilute sulfuric acid. In this solution, the vanadium species is $VO_2^+(aq)$. The student needs to reduce the $VO_2^+(aq)$ ions to $VO^{2+}(aq)$ ions.

The teacher suggests using sulfur dioxide as the reducing agent and supplies the student with the following standard electrode potential values.

$$VO_2^+(aq) + 2H^+(aq) + e^- \rightleftharpoons VO^{2+}(aq) + H_2O(l) \qquad E^{\ominus} = +1.00\ V$$

$$VO^{2+}(aq) + 2H^+(aq) + e^- \rightleftharpoons V^{3+}(aq) + H_2O(l) \qquad E^{\ominus} = +0.34\ V$$

$$SO_4^{2-}(aq) + 4H^+(aq) + 2e^- \rightleftharpoons SO_2(aq) + 2H_2O(l) \qquad E^{\ominus} = +0.17\ V$$

(i) These data suggest that a step-wise reduction of an acidified solution of $VO_2^+(aq)$ ions, using sulfur dioxide, $SO_2(aq)$, will initially produce $VO^{2+}(aq)$ ions and then $V^{3+}(aq)$ ions in solution.

By calculating the relevant $E^{\ominus}_{cell}$ values for any reactions that you predict will occur, show that such a step-wise reduction is possible.

(2)

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(ii) When the student bubbles sulfur dioxide into a solution containing acidified $VO_2^+(aq)$ ions, $VO^{2+}(aq)$ ions are obtained, rather than $V^{3+}(aq)$ ions.

Suggest why $VO^{2+}(aq)$ ions are produced, rather than the $V^{3+}(aq)$ ions predicted in (d)(i).

(1)

.....

.....

.....

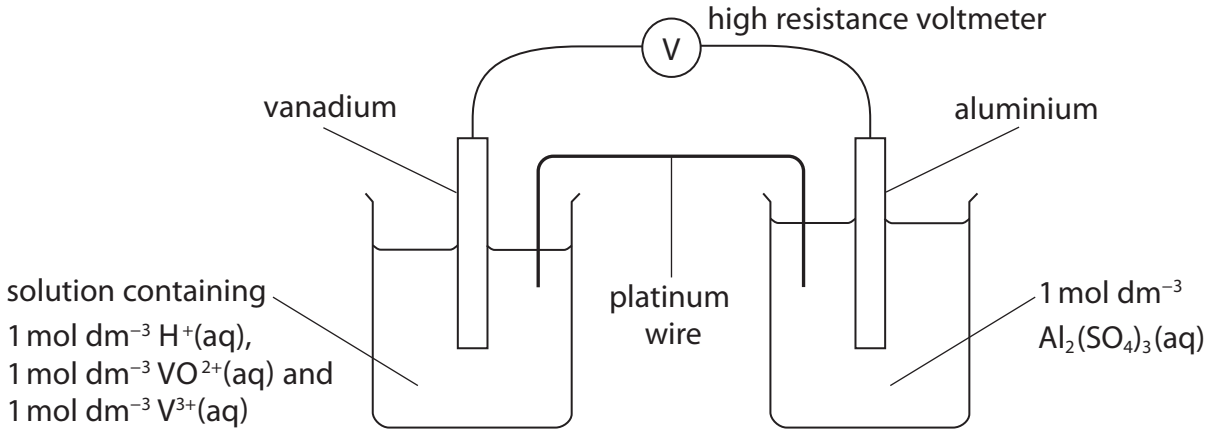
(iii) Construct the overall equation for the reduction of acidified $VO_2^+(aq)$ ions to $VO^{2+}(aq)$ ions by aqueous sulfur dioxide, $SO_2(aq)$.
State symbols are not required.

(1)

Part 2

Having made solutions of $VO^{2+}(aq)$ and $V^{3+}(aq)$ ions, the students decide to measure the standard cell potential between the $VO^{2+}(aq)$ / $V^{3+}(aq)$ and $Al^{3+}(aq)$ / Al(s) half-cells.

The students set up the apparatus below to measure this standard cell potential. The solutions were at 25 °C.



(e) Identify **three** mistakes in the way the cell has been set up and state what modifications should be made to correct them. Write your answers in the table below.

(3)

Mistake in set-up	Modification needed to correct mistake

(Total for Question 4 = 13 marks)

TOTAL FOR PAPER = 50 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8) (18)
							1.0 H hydrogen 1										4.0 He helium 2
(1)	(2)		Key: relative atomic mass / atomic symbol / name / atomic (proton) number									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* Lanthanide series	140 Ce cerium 58	141 Pr praseodymium 59	144 Nd neodymium 60	[147] Pm promethium 61	150 Sm samarium 62	152 Eu europium 63	157 Gd gadolinium 64	159 Tb terbium 65	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	169 Tm thulium 69	173 Yb ytterbium 70	175 Lu lutetium 71
* Actinide series	232 Th thorium 90	[231] Pa protactinium 91	238 U uranium 92	[237] Np neptunium 93	[242] Pu plutonium 94	[243] Am americium 95	[247] Cm curium 96	[245] Bk berkelium 97	[251] Cf californium 98	[254] Es einsteinium 99	[253] Fm fermium 100	[256] Md mendelevium 101	[254] No nobelium 102	[257] Lr lawrencium 103

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Mark Scheme (Results)

Summer 2016

Pearson Edexcel
International Advanced Level
in Chemistry (WCH06) Paper 01
Chemistry Laboratory Skills

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.

( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.

ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities. Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Question Number	Correct Answer	Reject	Mark
1(a)(i)	$[Zn(OH)_4]^{2-}$ OR $[Zn(H_2O)_2(OH)_4]^{2-}$ OR $[Zn(OH)_4(H_2O)_2]^{2-}$ **ALLOW** -2 for 2- as charge $[ZnO_2]^{2-}$ **IGNORE** State symbols, even if incorrect Omission of square brackets	$Zn(OH)_6^{4-}$ $[Zn(H_2O)_4(OH)_2]^{2-}$ $Zn(OH)_2$ $[Zn(H_2O)_2(OH^-)_4]^{2-}$/ any charges on **ligands**	**(1)**

Question Number	Correct Answer	Reject	Mark
1(a)(ii)	$[Zn(NH_3)_4]^{2+}$ OR $[Zn(H_2O)_2(NH_3)_4]^{2+}$ OR $[Zn(NH_3)_4(H_2O)_2]^{2+}$ **IGNORE** State symbols, even if incorrect Omission of square brackets	$[Zn(NH_3)_6]^{2+}$	**(1)**

Question Number	Correct Answer	Reject	Mark
1(b)(i)	$Cr^{3+}(aq) + 3OH^-(aq) \rightarrow Cr(OH)_3(s)$ **OR** $[Cr(H_2O)_6]^{3+}(aq) + 3OH^-(aq) \rightarrow [Cr(OH)_3(H_2O)_3](s) + 3H_2O(l)$ **IGNORE** Omission of square brackets **IGNORE** $Cr^{3+}(aq) + 3NaOH(aq) \rightarrow Cr(OH)_3(s) + 3Na^+(aq)$	One or more incorrect state symbols, e.g. H_2O(**aq**)	**(1)**

Question Number	Correct Answer	Reject	Mark
1(b)(ii)	(Before addition of H_2O_2) +3 ALLOW "3+" / "Cr^{3+}" **(1)** (After addition of H_2O_2) +6 ALLOW "6+" / "Cr^{6+}" **(1)** Penalise omission of the '+' sign once only NOTE: If Cr(III) and Cr(VI) given, award **(1)**		**(2)**

Question Number	Correct Answer	Reject	Mark
1(c)	Mn^{2+} / $[Mn(H_2O)_6]^{2+}$ **IGNORE** Names State symbols, even if incorrect	$Mn(OH)_2$	**(1)**

(Total for Question 1 = 6 marks)

Question Number	Correct Answer	Reject	Mark
2(a)(i)	**EXPECTED ANSWER** **1st mark:** Calculates moles of NaOH to neutralise 5 cm^3 of equilibrium mixture = $\frac{0.500 \times 42.4}{1000}$ = 0.0212 (mol) **(1)** **2nd mark:** Calculates moles of NaOH to neutralize 25 cm^3 of equilibrium mixture = 5 x 0.0212 = 0.106 (mol) **(1)** **3rd mark:** Calculates moles of CH_3COOH in 25 cm^3 of equilibrium mixture = 0.106 – 0.0100 (= 0.0960) **(1)** Mark TE for 2nd and 3rd mark on moles of NaOH calculated **ESSENTIALLY** First mark: Calculates moles of NaOH Second mark: Scaling x 5 Third mark: Subtraction of moles of HCl		**(3)**

	ALTERNATIVE ROUTE ALSO SEEN: **1st mark:** Calculates moles of NaOH to neutralise all the acid in 5.00 cm^3 of the equilibrium mixture = $\frac{0.500 \times 42.4}{1000}$ = 0.0212 (mol) **(1)** **2nd mark:** Calculates moles of HCl in 5.00 cm^3 (= 0.01÷5) = 0.002(00) and finds moles CH_3COOH in 5.00 cm^3 = (0.0212 – 0.002(00) =) = 0.0192 (mol) CH_3COOH in 5.00 cm^3 **(1)** **3rd mark:** Calculates moles of CH_3COOH in 25.0 cm^3 of equilibrium mixture by 5 x 0.0192 (= 0.0960) **(1)** Mark TE for 2nd and 3rd mark on moles of NaOH calculated **NOTE** Alternative approaches are possible **ESSENTIALLY THIS ROUTE:** First mark: Calculates moles of NaOH Second mark: Scaling and subtraction of moles of HCl to find moles CH_3COOH Third mark: Scaling x 5		

Question Number	Correct Answer	Reject	Mark
2(a)(ii)	(Amount of C_2H_5OH) = 0.096(0) **(1)** (amount of $CH_3COOC_2H_5$ = 0.153 – 0.096(0)) = 0.057(0) TE on moles of C_2H_5OH calculated **(1)** (amount of H_2O = 0.556 – 0.096(0)) = 0.46(0) TE on moles of C_2H_5OH calculated **(1)** **Max (2) if answers rounded to 1 S.F.**		**(3)**

Question Number	Correct Answer	Reject	Mark
2(a)(iii)	(K_c =) $\frac{[C_2H_5OH(l)][CH_3COOH(l)]}{[CH_3COOC_2H_5(l)][H_2O(l)]}$ **IGNORE** Missing or incorrect state symbols	Round brackets / missing square brackets	**(1)**

Question Number	Correct Answer	Reject	Mark
2(a)(iv)	Kc = 0.35149 **(1)** = 0.351 **(1)** Answer MUST be given to 3 sf to score M2 Max 1 if ANY units are given TE on moles calculated in (a)(ii) Only TE on an incorrect K_c expression is for omission of H2O(l) – scores max (1)	0.35**2** for 2nd mark	**(2)**

Question Number	Correct Answer	Reject	Mark
2(a)(v)	The volumes (all) cancel OR The number of moles is the same on both sides of the equation OR Same mole ratio OR 1:1 (mole) ratio of components/compounds **ALLOW** Just 'Same number of moles' **IGNORE** 'V is constant' or 'Volumes are all the same' or Just 'units cancel' or 'Kc has no units' or "The volume is the same so they cancel out" or "Moles are (directly) proportional to the concentration"	'Concentrations cancel' scores **(0)**	**(1)**

Question Number	Correct Answer	Reject	Mark
2(b)(i)	(Effect on K_c) – M1 Greater / larger / more / increases / bigger ALLOW Teacher's (Kc) value is smaller / less **(1)** (Explanation) – M2 (Calculated) moles of (ethanoic) **acid** would appear to be greater / more (ethanoic) **acid** For M2 to be awarded, there MUST be mention of more **acid**/ more **CH_3COOH** **(1)** **NOTE** Mark scoring points M1 and M2 independently		**(2)**

Question Number	Correct Answer	Reject	Mark
2(b)(ii)	(Effect on K_c) – M1 Greater / larger / more / increases / bigger ALLOW Teacher's (K_c) value is smaller / less **(1)** (Explanation) – M2 (Forward) reaction is endothermic **OR** Backward / reverse reaction is exothermic **(1)** **NOTE** Mark M1 and M2 independently **IGNORE** Just "ΔH is positive" OR "K_c (only) dependent on temperature" **IGNORE** References to equilibrium position shifting to the right (with increasing temperature)		**(2)**

Question Number	Correct Answer	Reject	Mark
2(c)(i)	(Volume is) less / lower **AND** pipette is calibrated to be measured from the bottom of the meniscus **ALLOW for 2nd part of answer** (volume) should be read from bottom / base of the meniscus OR A diagram showing the bottom of meniscus on the mark		**(1)**

Question Number	Correct Answer	Reject	Mark
2(c)(ii)	(Volume is) same / not changed **AND** (volume from burette) is (difference between) two readings / is measured by difference **ALLOW** Any idea that the error cancels out		**(1)**

Question Number	Correct Answer	Reject	Mark
2(c)(iii)	2 x 0.05 x 100% = (±) 0.23474 (%) 42.60 **IGNORE** S.F. but answer must be rounded correctly **NOTE** 0.2/ 0.23 / 0.235 / 0.2347 / 0.23474 all score the available mark **IGNORE** Any signs or the omission of ± in front of the final answer	(±)0.2**4** /(±)0.23**4** scores **(0)**	**1**

(Total for Question 2 = 17 marks)

Question Number	Correct Answer	Reject	Mark
3(a)	**First, look at answer line. If answer = 50%, award (2) marks.** **1st mark:** Moles of ester (= $\frac{6.0 \times 1.05}{150}$ = $\frac{6.3}{150}$) = 0.042 (mol) **(1)** **2nd mark:** % yield = $\frac{0.021}{0.042} \times 100\%$ = 50 (%) **ALLOW** TE on moles of ester calculated **(1)** ALTERNATIVE ROUTES: **1st mark:** Mass of ester (= 0.021 x 150) = 3.15 (g) **and** Theoretical mass of ester (= 6.0 x 1.05) = 6.30 (g) **2nd mark:** % yield = $\frac{3.15}{6.30} \times 100\%$ = 50 (%) **(1)**	Yield > 100%	**(2)**

	1st mark: Mass of benzoic acid (= 0.021 x 122) = 2.56 (g) **and** Theoretical mass of benzoic acid (= 0.042 x 122) = 5.12 (g) **2nd mark:** % yield = $\frac{2.56}{5.12}$ x 100% = 50 (%) Check all working if answer given differs from 50%		

Question Number	Correct Answer	Reject	Mark
3(b)	**EITHER – via 'moles' NaOH** Moles NaOH = $\frac{1}{40}$ = **0.025** (mol) **(1)** which is less than the moles of ester / which is less than 0.042 (mol) / 0.025 < 0.042 **(1)** For M2, allow TE on moles of ester from 3(a), provided moles of ester is >0.025 **OR – via 'mass' NaOH** (Minimum) mass of NaOH required (= 0.042 x 40) = **1.68** (g) **(1)** which is more than the 1 g of NaOH used **(1)** For M2, allow TE on moles of ester from 3(a), provided moles of ester is >0.025 **NOTE** M2 can only be awarded for linking their answer to the mass / moles required		**(2)**

Question Number	Correct Answer	Reject	Mark
3(c)	(Not necessary as) NaOH in excess OR A bigger excess of NaOH will have no effect **NOTE:** Answer needs to make reference/explain that the NaOH will (still) be in excess		**(1)**

Question Number	Correct Answer	Reject	Mark
3(d)	Recrystallisation **ALLOW** Mis-spellings, as long as meaning remains clear **NOTE** The mark available is for the identification of the technique described	Crystallisation	**(1)**

Question Number	Correct Answer	Reject	Mark
3(e)	C_6H_5COONa **OR** $C_6H_5COO-Na+$ **OR** $C_6H_5CO2-Na+$ **OR** C_6H_5CO2Na **ALLOW** Displayed formula / skeletal formula **IGNORE** Any names	$C_7H_5O_2Na$ $C_6H_5COO-Na$	**(1)**

Question Number	Correct Answer	Reject	Mark
3(f)	Product was still dissolved **OR** Product had not all crystallised / “product had not all precipitated” **ALLOW** Any idea of insufficient time for the crystals to form / product remaining in solution / product left in filtrate / ‘crystals’ remain in solution		**(1)**

Question Number	Correct Answer	Reject	Mark
3(g)(i)	Sample 2 is purer / pure **OR** Sample 1 is less pure / impure **OR** Samples differ in purity **ALLOW** Recrystallisation has removed (some of the) impurities		**(1)**

Question Number	Correct Answer	Reject	Mark
3(g)(ii)	**1st Mark:** The 2-nitro isomer / (compound) **P** **(1)** M1 is a stand-alone mark, subject to only one isomer being suggested **2nd Mark:** Impurities **lower** the melting temperature **OR** Cannot be Q as melting temperature range (of Sample 2) is greater than melting temperature of Q **OR** Cannot be R as melting temperature (range) of R is too high / too far away (from 144°C to 146°C) **(1)** **IGNORE** References to Sample 1's melting range being closest to that of Q	(0) overall **if more than one isomer** suggested References to **boiling** temperatures – no M2	**(2)**

Question Number	Correct Answer	Reject	Mark
3(h)(i)	In P **and** Q there are 5 proton environments / 5 peaks **(1)** In R there are only 3 proton environments / 3 peaks **(1)** (therefore you can only identify R / can't distinguish) **ALLOW** Hydrogen in lieu of proton **IGNORE** Any chemical shift values quoted	If states that all three isomers have 5 peaks, **(0)** overall	**(2)**

Question Number	Correct Answer	Reject	Mark
3(h)(ii)	(m/e value =) 167 **IGNORE** Any other fragments		**(1)**

(Total for Question 3 = 14 marks)

Question Number	Correct Answer	Reject	Mark
4(a)(i)	$2NH_4VO_3 \rightarrow V_2O_5 + 2NH_3 + H_2O$ **ALLOW** Multiples ⇌ sign instead of → **IGNORE** State symbols, even if incorrect		**(1)**

Question Number	Correct Answer	Reject	Mark
4(a)(ii)	Heat to constant mass **OR** Test with indicator paper to show that an alkaline gas / ammonia is no longer being given off **OR** Test with hydrogen chloride / HCl until no more white smoke (observed) **IGNORE** Just 'no more ammonia is given off', **unless** a test is suggested / 'no more steam is given off' / references to smell / references to colour change(s) in the reactant or products / references to (stopping of) "fizzing" or "effervescence" or "bubbles"		**(1)**

Question Number	Correct Answer	Reject	Mark
4(b)	(In air) hydrogen is explosive / hydrogen would catch fire / hydrogen is flammable / hydrogen is inflammable **NOTE** **Need to identify hydrogen by name or by formula (H_2)** **IGNORE** V_2O_3 toxic		**(1)**

Question Number	Correct Answer	Reject	Mark
4(c)(i)	**1st mark – for moles of V^{3+}** Moles V^{3+} (= $\frac{1.498}{149.8}$) x 2 = 0.02(00) **(1)** **2nd mark – for division by 0.25(0)** Concentration of V^{3+}(aq) (= $\frac{0.02(00)}{0.25(0)}$) = 0.08(00) (mol dm^{-3}) **(1)** **ALLOW** TE for M2 from calculated moles of V^{3+} [e.g. answer of 0.04(00) (mol dm^{-3}) scores **(1)** mark] **IGNORE** Incorrect units at any stage Correct answer with no working scores **(2)**		**(2)**

Question Number	Correct Answer	Reject	Mark
4(c)(ii)	• H^+(aq) **or** H_3O^+(aq) **AND** • SO_4^{2-}(aq) **or** HSO_4^-(aq) **NOTE:** Two correct ions are needed for the one mark **IGNORE** Any missing or incorrect state symbols	SO_3^{2-}(aq)	**(1)**

Question Number	Correct Answer	Reject	Mark
4(d)(i)	Marks can be scored in either order: **1st Mark:** States that for VO_2^+ to VO^{2+} OR gives an equation (even if unbalanced) OR Makes reference to the 1st step **and** (E^o_{cell} =) **+0.83** (V) **(1)** **2nd Mark:** States that for VO^{2+} to V^{3+} OR gives an equation (even if unbalanced) OR Makes reference to the 2nd step **and** (E^o_{cell} =) **+0.17** (V) **(1)** Penalise missing + sign once only **NOTE:** If only the e.m.f. values of +0.83 (V) **and** +0.17 (V) are given without any reference to the reactions under consideration, then award **(1)**		**(2)**

Question Number	Correct Answer	Reject	Mark
4(d)(ii)	Activation energy is (too) high **OR** Rate of reaction is (very) slow **ALLOW** Concentrations (of solutions) **not** 1 mol dm−3 / Any references to departure from standard conditions		**(1)**

Question Number	Correct Answer	Reject	Mark
4(d)(iii)	$SO_2 + 2VO_2^+ \rightarrow SO_4^{2-} + 2VO^{2+}$ **ALLOW** Multiples ⇌ sign instead of → **IGNORE** State symbols, even if incorrect or missing	ANY uncancelled H^+, H_2O and e^-	**(1)**

Question Number	Correct Answer	Reject	Mark
4(e)	These answers may be given in any order: **First mark (M1):** Platinum wire (connecting the two solutions) – replace with salt bridge **ALLOW** Any correct description of a salt bridge (e.g. filter paper soaked in KNO3 solution) if the term 'salt bridge' has not been used in answer **(1)** **Second mark (M2):** Vanadium electrode (in left-hand beaker) – replace with platinum/Pt (electrode) **NOTE** This is the only acceptable electrode **(1)** **Third mark (M3):** Al2(SO4)3(aq) solution concentration is 1 mol dm−3 **OR** concentration of Al2(SO4)3(aq) is incorrect – replace with a solution of concentration 0.5 mol dm−3 / solution must be 1 mol dm−3 (concentration) Al3+(aq) / use (1 mol dm−3) Al(NO3)3 **(1)**	Use of KOH / Na2CO3 / any insoluble salt for the salt bridge / just "use a piece of filter paper"	**(3)**

(Total for Question 4 = 13 marks)

TOTAL FOR PAPER = 50 MARKS

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Edexcel Chemistry – A2 Grade Boundaries

6CH04 – General Principles of Chemistry I: Rates, Equilibria and Further Organic Chemistry

Season	Full UMS	A*	A	B	C	D	E
IAL - June 2015	78	73	68	63	58	53	48
June 2015	84	78	72	66	60	55	50
IAL - Jan 2015	85	78	71	64	57	50	43
June 2014	81	69	69	63	57	51	46
IAL - June 2014	86	80	74	68	62	56	50
R - June 2014	83	77	71	65	59	54	49
IAL - Jan 2014	86	79	72	65	58	51	44
June 2013	79	74	69	63	57	51	46
R - June 2013	81	75	69	62	56	50	44
Jan 2013	85	79	73	67	61	55	49
June 2012	82	75	68	61	54	48	42
Jan 2012	81	75	69	63	57	52	47
June 2011	88	80	72	64	56	49	42
Jan 2011	76	70	64	58	52	46	40
June 2010	85	77	69	61	53	45	38
Jan 2010	68	62	56	50	44	38	33

6CH05 – General Principles of Chemistry II: Transition Metals and Organic Nitrogen Chemistry

Season	Full UMS	A*	A	B	C	D	E
IAL - June 2015	72	66	60	54	48	42	36
June 2015	80	74	68	62	57	52	47
IAL - Jan 2015	70	64	58	52	46	40	34
June 2014	75	68	61	54	48	42	36
IAL - June 2014	70	64	58	52	47	42	37
R - June 2014	77	70	63	56	49	42	35
IAL - Jan 2014	81	73	65	57	50	43	36
June 2013	86	80	74	67	60	53	47
R - June 2013	76	69	62	55	48	41	35
Jan 2013	85	77	69	61	53	46	39
June 2012	79	73	67	61	55	49	43
Jan 2012	88	80	72	64	56	49	42
June 2011	79	73	67	61	55	49	43
Jan 2011	79	72	65	58	51	44	38
June 2010	80	73	66	59	53	47	41