

Write your name here	
Surname	Other names
Centre Number	Candidate Number
Edexcel GCE 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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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, $^{24}_{12}\text{Mg}$ and $^{25}_{12}\text{Mg}$, 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 $^{25}_{12}\text{Mg}^{2+}$ has more protons than $^{24}_{12}\text{Mg}^{2+}$.
- ☐ 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, I₂. Which of the following shows the number of iodine **atoms** in 0.025 g of I₂?

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

- ☐ 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, NaNO₃?

- ☐ A $2\text{Na(s)} + \text{N}_2\text{(g)} + 3\text{O}_2\text{(g)} \rightarrow 2\text{NaNO}_3\text{(s)}$
- ☐ B $\text{Na(s)} + \frac{1}{2}\text{N}_2\text{(g)} + 1\frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{NaNO}_3\text{(s)}$
- ☐ C $\text{Na(s)} + \text{N(g)} + 3\text{O(g)} \rightarrow \text{NaNO}_3\text{(s)}$
- ☐ D $\text{Na(g)} + \frac{1}{2}\text{N}_2\text{(g)} + 1\frac{1}{2}\text{O}_2\text{(g)} \rightarrow \text{NaNO}_3\text{(g)}$

(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 $\frac{1}{4}\text{CH}_4\text{(g)} \rightarrow \frac{1}{4}\text{C(g)} + \text{H(g)}$
- ☐ B $\text{CH}_4\text{(g)} \rightarrow \text{C(s)} + 2\text{H}_2\text{(g)}$
- ☐ C $\text{CH}_4\text{(g)} \rightarrow \text{C(g)} + 4\text{H(g)}$
- ☐ D $\text{CH}_4\text{(g)} \rightarrow \text{C(g)} + 2\text{H}_2\text{(g)}$

(Total for Question 5 = 1 mark)



N 3 5 1 3 1 A 0 3 2 4

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 ?

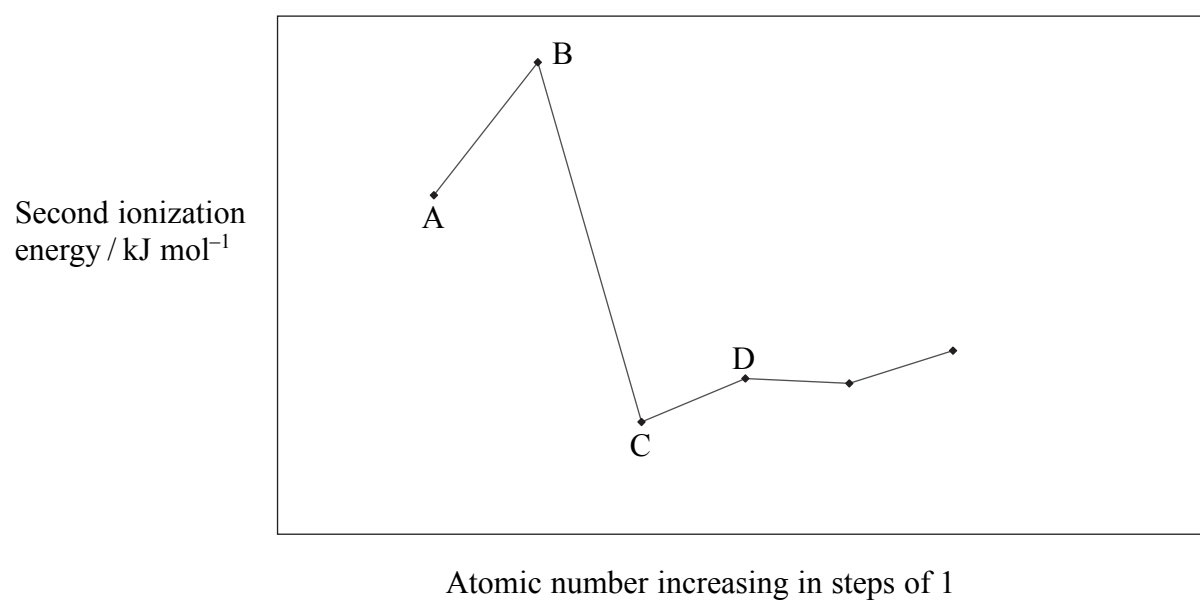
(1)

- ☐ 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)



N 3 5 1 3 1 A 0 5 2 4

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, C₈H₁₈, is cracked?

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

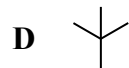
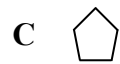
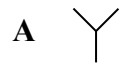
(Total for Question 13 = 1 mark)

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



N 3 5 1 3 1 A 0 7 2 4

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



(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
$$\begin{array}{ccccccc} & & \text{H} & & \text{CH}_3 & & \\ & & | & & | & & \\ \text{CH}_3 & - & \text{C} & - & \text{CH}_2 & - & \text{C} & - & \text{H} \\ & & | & & | & & \\ & & \text{Cl} & & \text{CH}_3 & & \end{array}$$
- ☐ B
$$\begin{array}{ccccccc} & & \text{Cl} & & & & \text{CH}_3 \\ & & | & & & & | \\ \text{H} & - & \text{C} & - & \text{CH}_2 & - & \text{CH}_2 & - & \text{CH}_2 & - & \text{C} & - & \text{CH}_3 \\ & & | & & & & | & & \\ & & \text{Cl} & & & & \text{CH}_3 & & \end{array}$$
- ☐ C
$$\begin{array}{ccccccc} & & \text{Cl} & & \text{CH}_3 & & \\ & & | & & | & & \\ \text{CH}_3 & - & \text{C} & - & \text{CH}_2 & - & \text{CH}_2 & - & \text{C} & - & \text{CH}_3 \\ & & | & & | & & \\ & & \text{H} & & \text{CH}_3 & & \end{array}$$
- ☐ D
$$\begin{array}{ccccccc} & & \text{Cl} & & \text{Cl} & & \\ & & | & & | & & \\ \text{CH}_3 & - & \text{C} & - & \text{CH}_2 & - & \text{CH}_2 & - & \text{C} & - & \text{CH}_3 \\ & & | & & | & & \\ & & \text{CH}_3 & & \text{CH}_3 & & \end{array}$$

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



N 3 5 1 3 1 A 0 9 2 4

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, $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, 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, $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$, 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)

.....

.....

.....



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

(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)



(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)



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

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 $24 \text{ dm}^3 \text{ mol}^{-1}$ 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)



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

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:.....

.....

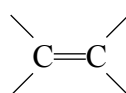
Result with hex-1-ene:.....

.....

- (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)

.....

.....

.....

.....



- (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 $4.18 \text{ J g}^{-1} \text{ °C}^{-1}$.

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

$$\text{energy transferred} = \text{mass} \times \text{specific heat capacity} \times \text{temperature change.}$$

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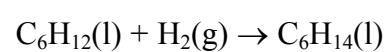
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- (iv) A student suggested that the results would be more accurate if a thermometer which read to 0.1°C was used. Explain why this would **not** improve the accuracy of the result. A calculation is **not** required.

(1)

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



- (i) What catalyst is used in this reaction?

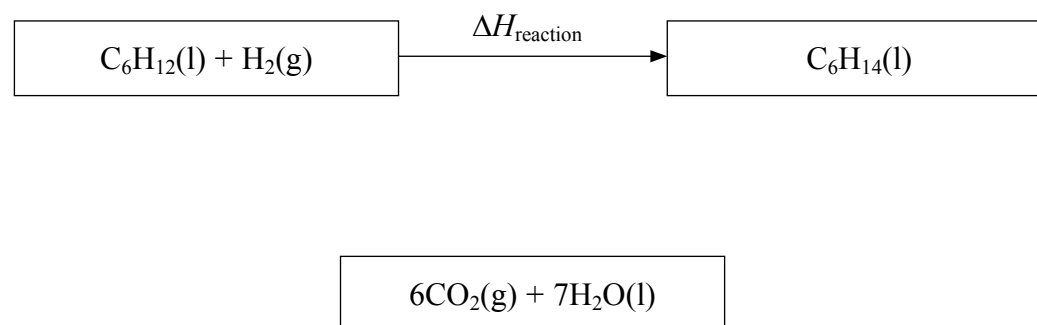
(1)

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

Substance	Enthalpy change of combustion /kJ mol ⁻¹
Hex-1-ene, C ₆ H ₁₂	-4003
Hydrogen, H ₂	-286
Hexane, C ₆ H ₁₄	-4163

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

(3)



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



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

Reaction	Standard enthalpy change / kJ mol ⁻¹
C ₃ H ₆ + H ₂ → C ₃ H ₈	-125
C ₄ H ₈ + H ₂ → C ₄ H ₁₀	-126
C ₅ H ₁₀ + H ₂ → C ₅ H ₁₂	-126

Explain why the values are so similar.

(1)

(Total for Question 18 = 17 marks)



19 Chloroethane, $\text{C}_2\text{H}_5\text{Cl}$, 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, $\text{CH}_2=\text{CHCl}$, 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)



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

*(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)

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.....

(Total for Question 19 = 16 marks)

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



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[illegible]

* Lanthanide series

* Actinide series

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)	$\text{MgCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{MgCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g})$ ALLOW $\text{MgCO}_3(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ All formulae and balancing (1) State symbols - mark independently; can be given even if eg MgCl_2 formula incorrect or for $\text{H}_2\text{CO}_3(\text{aq})(1)$ $\text{CO}_3^{2-}(\text{s}) + 2\text{H}^+(\text{aq}) \rightarrow \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ (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 $\text{MgCl}_2(\text{s})$) Just "exothermic"	2

Question Number	Acceptable Answers	Reject	Mark
16 (c) (i)	Moles acid = $((25 \times 2 / 1000)) = 0.05 / 0.050 / 5 \times 10^{-2}$ Ignore units and sf		1

Question Number	Acceptable Answers	Reject	Mark
16 (c) (ii)	Mass $\text{Mg CO}_3 = ((0.05 \times 84.3 \div 2)) = 2.1075 / 2.108 / 2.11 / 2.1$ (g) ALLOW TE from (c)(i) and (a) ALLOW Moles acid $\times 84.3 \div 2$ 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 = $(203.3 \times 0.025) / 5.08(25)\text{g}$ (1) yield = $\frac{(3.75 \times 100)}{5.08} = 74\%$ (1) OR Mol magnesium chloride = $\frac{3.75}{203.3}$ = 0.018445/0.01845/0.0184/0.018 (1) yield = $\frac{(100 \times 0.01845)}{0.025}$ = 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) <i>Mark can be given if answer here refers to bond strength and the answer above is included in (ii)</i>	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 2 nd 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)	$(100 \times 20) = 2 \times 10^{-3}(\text{g})$ 10 ⁶ ALLOW 0.002(g) 1/500 (g) 2 x 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 ₃ SO ₃ any order (1) Correct answer, no working (3) If O omitted, giving NH ₃ S (2)		3

Question Number	Acceptable Answers	Reject	Mark
17 (a) (ii)	NH ₃ SO ₃ (any order) since molar mass = empirical formula mass/ since empirical formula mass = 97/ with some other justification TE from (i) N ₂ H ₆ S 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

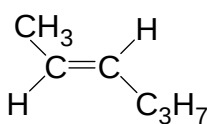
Question Number	Acceptable Answers	Reject	Mark
17 (b) (ii)	$\frac{66}{24\,000} = 2.75 \times 10^{-3} / 0.00275 / 0.0028$	0.003	1

Question Number	Acceptable Answers	Reject	Mark
17 (b) (iii)	1 mol sulfamic acid $\rightarrow$ 0.5 mol H₂ OR ratio sulfamic acid : hydrogen gas = 2:1 OR 5.5×10^{-3} (moles) = $(2 \times 2.75 \times 10^{-3})$ (moles) OR TE using ratio calculated from (ii) (1) Each H₂ 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)	$2\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{H}_2\text{O} + \text{CO}_2$ ALLOW $\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{HCO}_3^-$ $2\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{H}_2\text{CO}_3$		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 / Cl₂ 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 $(50 \times 46 \times 4.18) = 9614(\text{J})/$ 9.614 kJ (if converted to kJ units must be stated) ALLOW 9610 / 9600 /9.61 kJ /9.6 kJ	$(50.32 \times 46 \times 4.18) =$ 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 = $0.32/86 = (3.72 \times 10^{-3})$ (1) $(9614/ 3.72 \times 10^{-3}) = 2584000 \text{ J}/ 2584 \text{ kJ}$ (1) $\Delta H = -2600 \text{ kJ mol}^{-1}$ /-2 600 000 J mol⁻¹ / $-2.6 \times 10^6 \text{ J mol}^{-1}$ (1) Allow TE: 0.32g in (i) (gives 61.53J), $\Delta H = -17 \text{ kJ mol}^{-1}$ /-17 000 J mol⁻¹ /-1.7x10⁴ J mol⁻¹ 50.32g in (i) (gives 9676J) $\Delta H = -2600 \text{ kJ mol}^{-1}$ /-2 600 000 J mol⁻¹ /-2.6x10⁶ 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 /H₂O 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

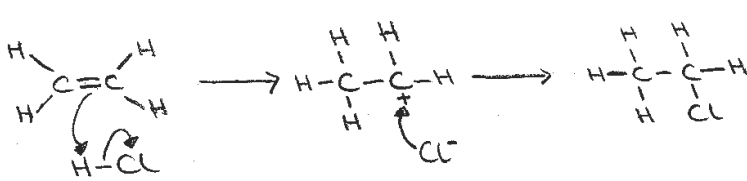
Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	Left hand arrow, pointing down, labelled ΔH_c hex-1-ene + ΔH_c hydrogen/ -4003-286/-4289 OR Pointing up with signs given above reversed (1) Right hand arrow pointing down labelled ΔH_c hexane / -4163 OR Pointing up with signs given above reversed (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. ($\Delta H_{\text{reaction}} - 4163 = -4003 - 286$ / or words applying Hess' law correctly) $\Delta H_{\text{reaction}} = -126$ however obtained(1) TE: If arrows point up and signs are not reversed $\Delta H_{\text{reaction}} = +126$ 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 $-\text{CH}=\text{CH}- + \text{H}_2 \rightarrow -\text{CH}_2-\text{CH}_2-$ 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

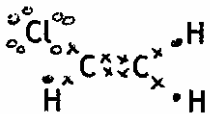
Question Number	Acceptable Answers	Reject	Mark
19 (a) (i)	Reagent: chlorine/ Cl_2 (1) Condition: uv/ sunlight (1) ALLOW light Mark independently Ignore reference to temp and pressure if given with uv light. If answers reversed/both on one line 1 out of 2	Cl Just "heat"	2

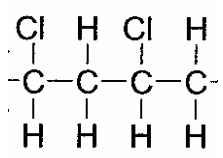
Question Number	Acceptable Answers	Reject	Mark
19 (a) (ii)	(free) radical (1) Substitution (1) Mark independently		2

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 Cl₂ instead of HCl (forming 1,2 - dichloroethane) Max 1 for addition of Cl₂ instead of HCl forming chloroethane	Attack by Cl^{δ-} or Cl[•] 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 C₄ 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 C₂H₄ drawn correctly Second mark can be given if C₂H₅Cl 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 on C3 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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Surname	Other names
Centre Number	Candidate Number
Edexcel GCE 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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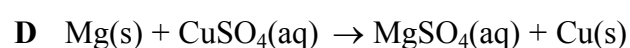
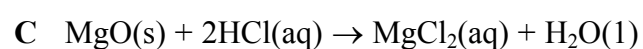
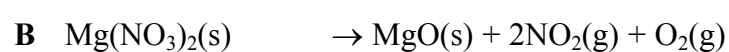
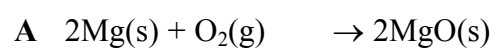
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SECTION A

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) Which equation is **not** balanced?

(1)

☐ A

☐ B

☐ C

☐ D

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

(1)

☐ A

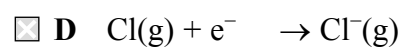
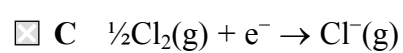
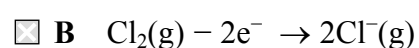
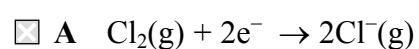
☐ B

☐ C

☐ D

(Total for Question 1 = 2 marks)

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



(Total for Question 2 = 1 mark)



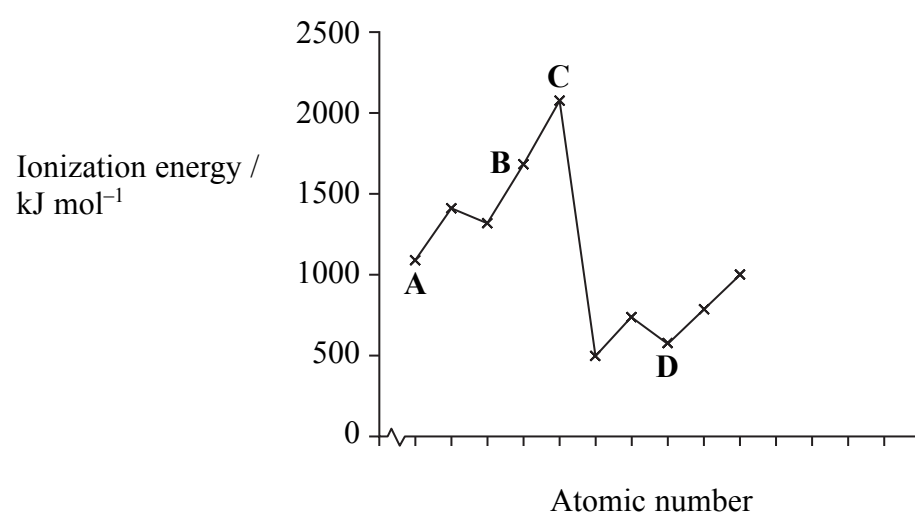
N 3 5 6 9 1 A 0 3 2 8

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

- ☐ A $\text{Mg}^+(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + \text{e}^-$
- ☐ B $\text{Mg}(\text{g}) \rightarrow \text{Mg}^{2+}(\text{g}) + 2\text{e}^-$
- ☐ C $\text{Mg}^+(\text{g}) + \text{e}^- \rightarrow \text{Mg}^{2+}(\text{g})$
- ☐ D $\text{Mg}(\text{g}) + 2\text{e}^- \rightarrow \text{Mg}^{2+}(\text{g})$

(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^+

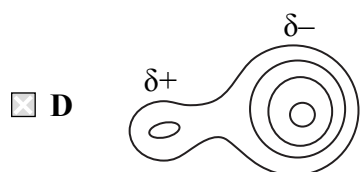
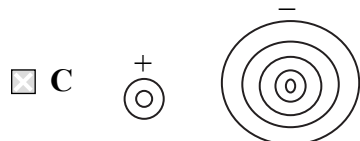
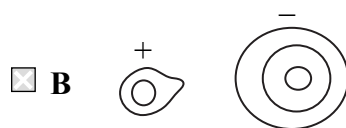
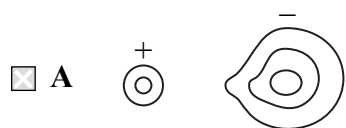
☐ D K^+

(Total for Question 5 = 1 mark)



N 3 5 6 9 1 A 0 5 2 8

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



(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)

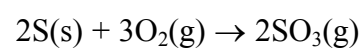
8 A sample of gas was prepared for use in helium-neon lasers. It contained 4 g of helium and 4 g of neon. What is the ratio of helium atoms to neon atoms in the sample?

- ☐ 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.



0.9 mol of $\text{O}_2\text{(g)}$ reacted completely with excess sulfur. What volume, in dm^3 , of sulfur trioxide would form?

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

- ☐ 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 $0.100 \text{ mol dm}^{-3} \text{ NaCl(aq)}$
- ☐ B 20.00 cm^3 of $0.050 \text{ mol dm}^{-3} \text{ NaCl(aq)}$
- ☐ C 20.00 cm^3 of $0.050 \text{ mol dm}^{-3} \text{ MgCl}_2\text{(aq)}$
- ☐ D 13.33 cm^3 of $0.050 \text{ mol dm}^{-3} \text{ MgCl}_2\text{(aq)}$

(Total for Question 10 = 1 mark)

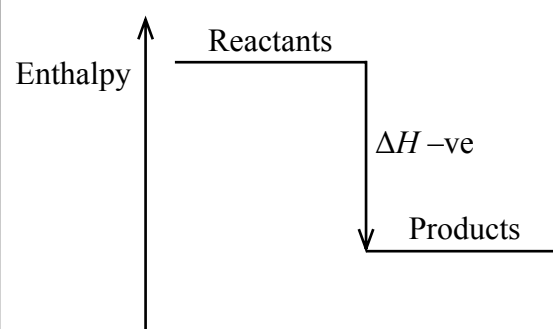
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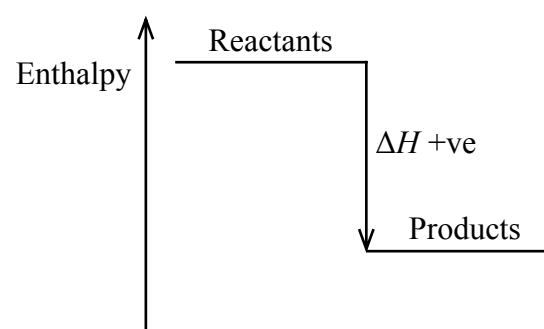
N 3 5 6 9 1 A 0 7 2 8

11 Which of these diagrams correctly represents an endothermic reaction?

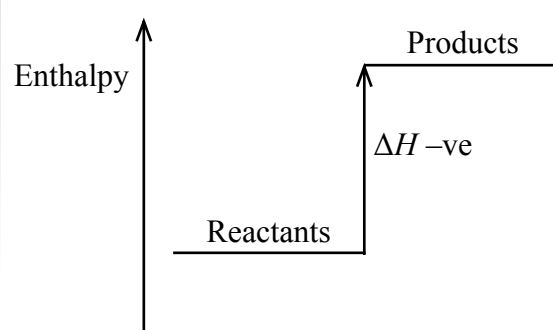
☐ A



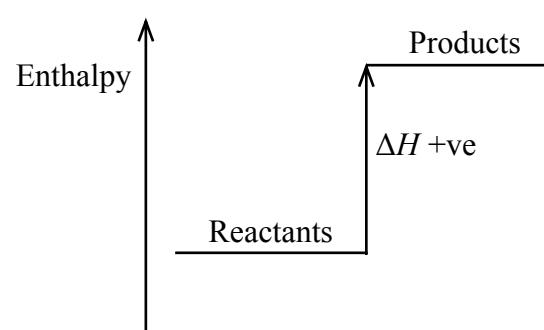
☐ B



☐ C



☐ D



(Total for Question 11 = 1 mark)

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

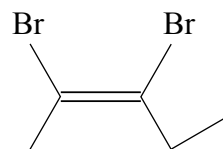
- ☐ A The two ends of a molecule cannot rotate relative to each other, about the axis of the double bond.
- ☐ B They are twice as strong as a carbon-carbon single bond.
- ☐ C They have a higher electron density than a single bond.
- ☐ D They consist of a sigma bond and a pi bond.

(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?



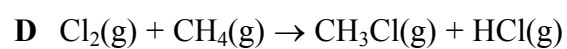
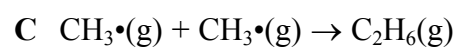
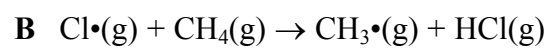
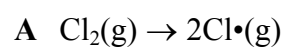
- ☐ A *E*-2,3-dibromopent-2-ene
- ☐ B *E*-2,3-dibromopent-3-ene
- ☐ C *Z*-2,3-dibromopent-3-ene
- ☐ D *Z*-2,3-dibromopent-2-ene

(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) 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)

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

(2)



(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)

(ii) Suggest why aqueous solutions of calcium chloride, $\text{CaCl}_2(\text{aq})$, and barium chloride, $\text{BaCl}_2(\text{aq})$, of the same molar concentration, have different electrical conductivities.

(1)

(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)

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

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

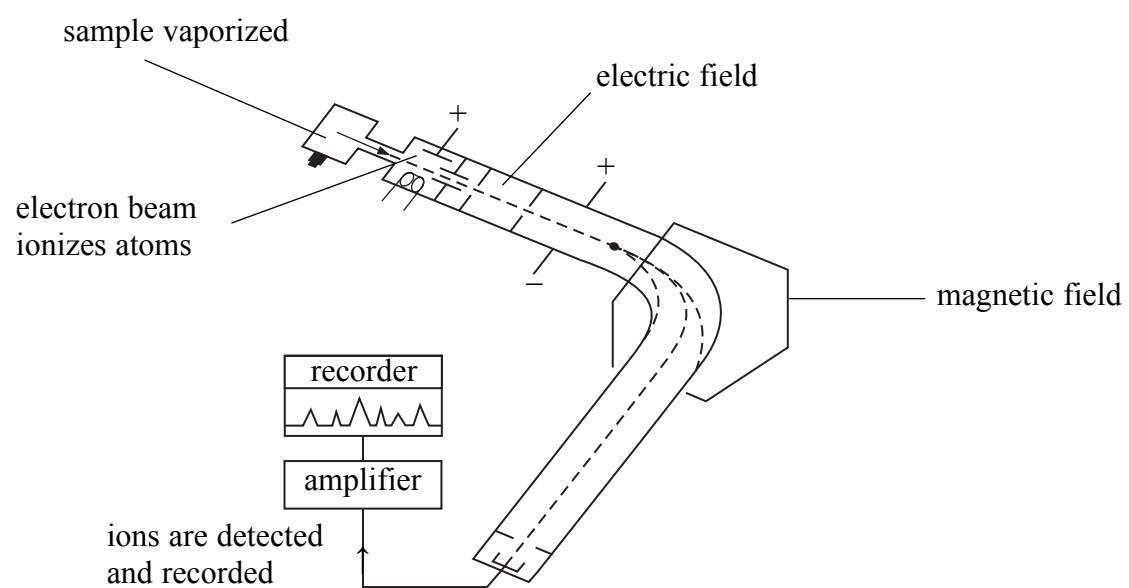
(1)

(Total for Question 15 = 15 marks)



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

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)

.....

.....

.....

.....

(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)

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

(1)

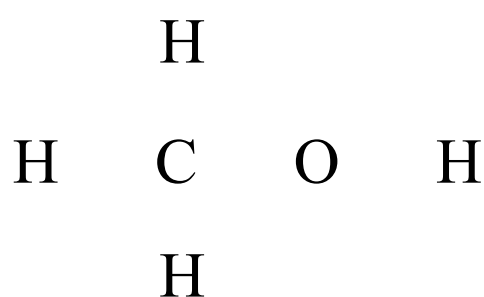
(Total for Question 16 = 9 marks)



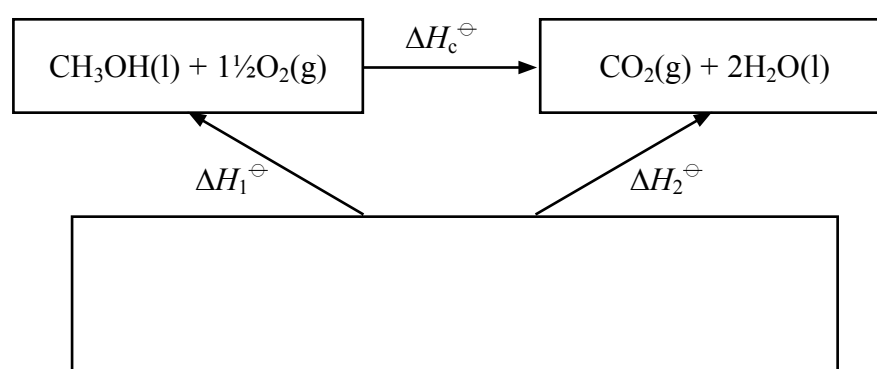
17 This question is about methanol and the energy changes that accompany some of its reactions.

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

(2)



- (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, $\Delta H_c^\ominus$.

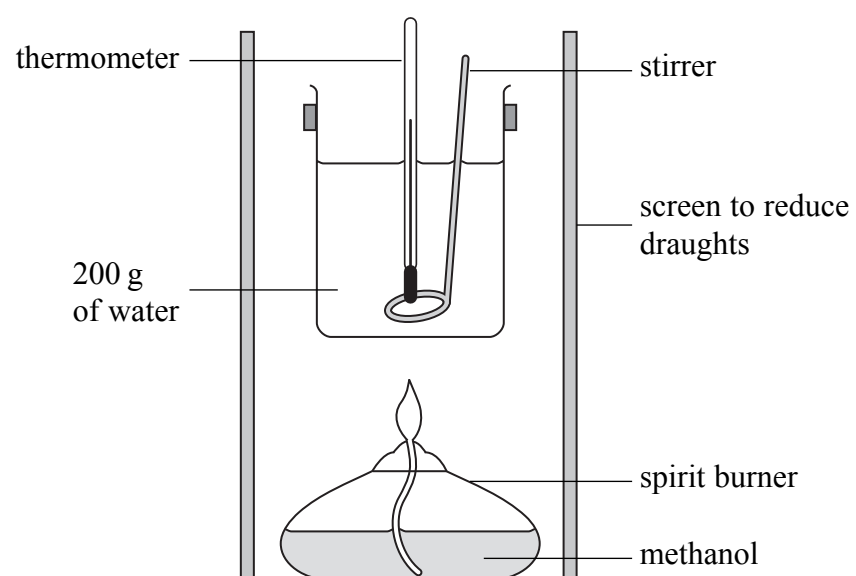
	$\Delta H_f^\ominus/\text{kJ mol}^{-1}$
$\text{CO}_2(\text{g})$	−393.5
$\text{H}_2\text{O}(\text{l})$	−285.8
$\text{CH}_3\text{OH}(\text{l})$	−239.1

(2)



N 3 5 6 9 1 A 0 1 7 2 8

- (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 $20.7\text{ }^{\circ}\text{C}$ and the mass of methanol burnt was 0.848 g .

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

$$\text{Energy transferred (J)} = \text{mass of water} \times 4.18 \times \text{temperature change}$$

(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.

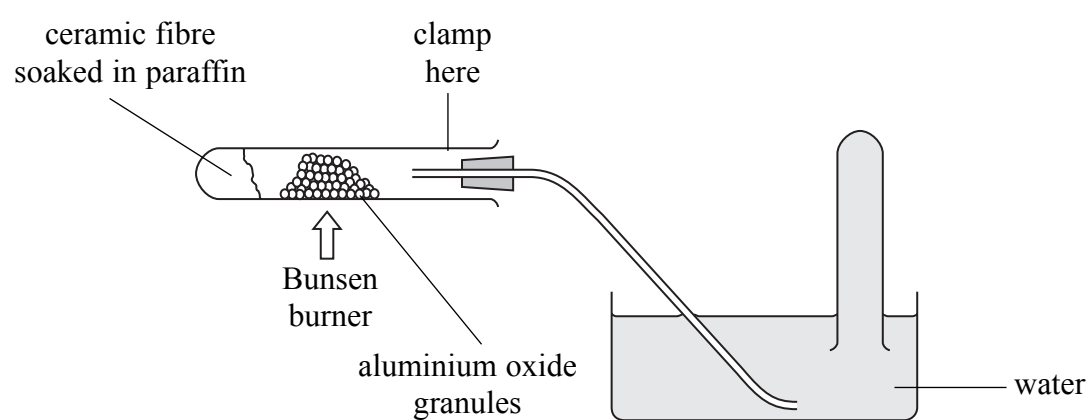
(i) Name a raw material from which liquid paraffin can be obtained.

(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.

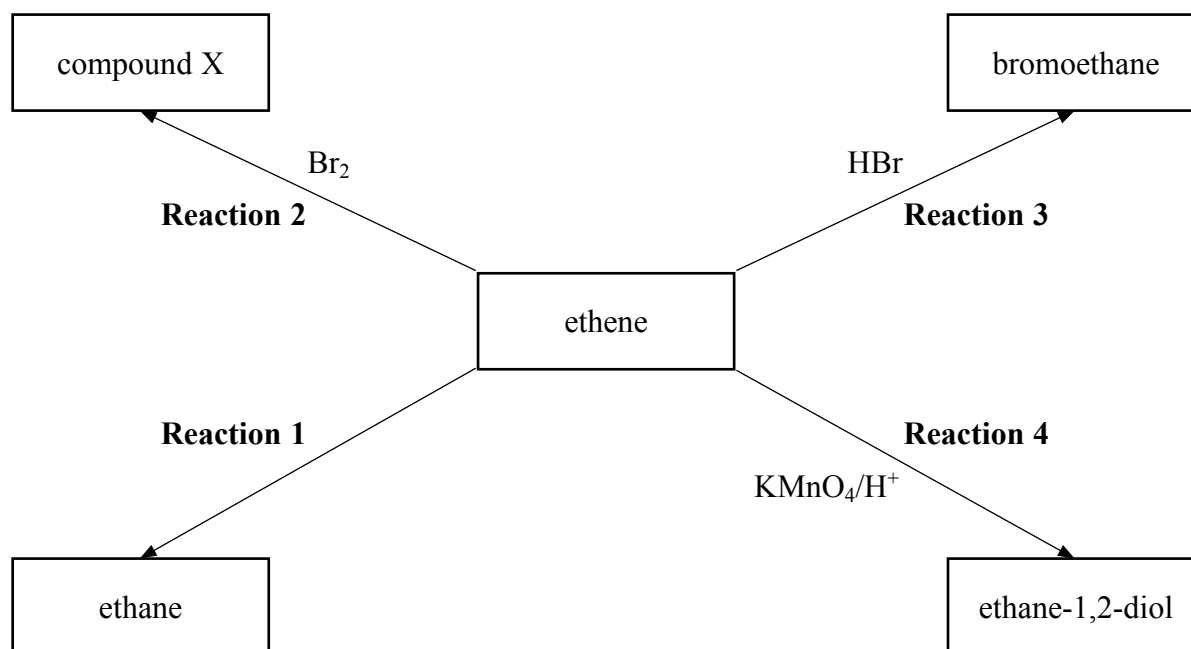


State TWO of the **risks** of using the apparatus in this way and suggest how you would amend the set-up to minimise each risk.

(4)



(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 KMnO₄(aq) was shaken with ethene.

(1)

From..... to.....



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

(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)

.....

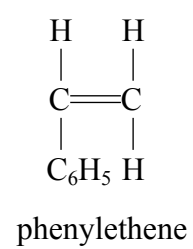
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- (d) The formula of the alkene phenylethene, often called styrene, is shown below. It can be used to make the polymer poly(styrene).



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

(2)



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

(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)



(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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N 3 5 6 9 1 A 0 2 7 2 8

[illegible]

* Lanthanide series

* Actinide series

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

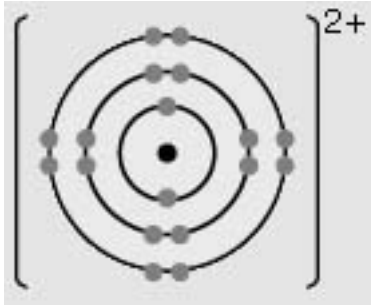
Question Number	Correct Answer	Mark
13	D	1

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 = 0.100×40 (= 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 = $(4.0/1000) \times 1000000$ = 4000 (ppm) (1) OR Mass of calcium ions in 1 kg = 0.100×40.1 (= 4.01) (g) (1) Hence 4.01 g per 1000 g of solution So ppm = $(4.01/1000) \times 1000000$ = 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

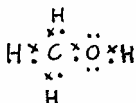
Question Number	Acceptable Answers	Reject	Mark
16 (b)(i)	(Electric field) accelerates ions		1

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 = $(135 \times 9.01 + 136 \times 10.81 + 137 \times 12.32 + 138 \times 67.86) / 100$ (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 $(^{79}\text{Br}-^{79}\text{Br})^{(+)}$ and $(^{81}\text{Br}-^{79}\text{Br})^{(+)}$ / $(^{79}\text{Br}-^{81}\text{Br})^{(+)}$ and $(^{81}\text{Br}-^{81}\text{Br})^{(+)}$ (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) + 2H₂(g) + 2O₂(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)	$\Delta H_c^\ominus = -\Delta H_1^\ominus + \Delta H_2^\ominus$ (1) $= (2 \times -285.8 + -393.5) - (-239.1)$ $= -726$ (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)	$20.7 \times 200 \times 4.18 = 17305(.2)$ (J) ignore sf except 1 sf i.e. 20000 OR $20.7 \times 200 \times 0.00418 = 17.305(2)$ 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)	$17305.2/0.0265 = -653000 \text{ (J mol}^{-1}\text{) (3sf)}$ OR $-653 \text{ (kJ mol}^{-1}\text{) (3sf)}$ 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

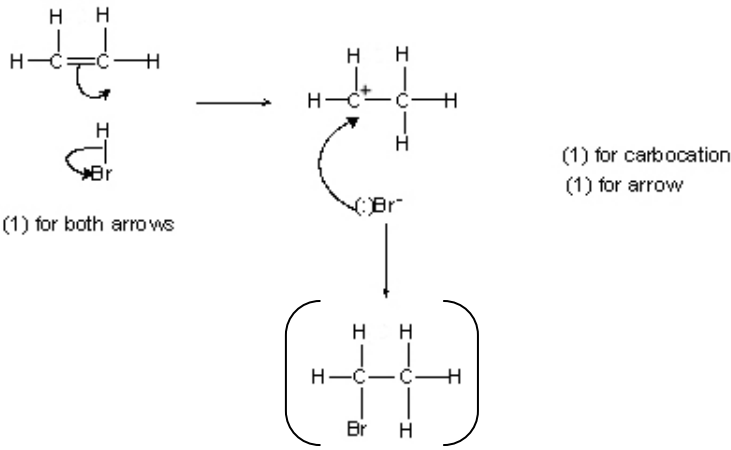
Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	use of high temperatures / heat (in the absence of air) / thermal decomposition / catalysts (1) Either to break large molecules / to form smaller molecules / to break bonds in large molecules / to break carbon-carbon bonds (1) OR producing alkenes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

Question Number	Acceptable Answers	Reject	Mark
18 (a)(iii)	Risks (2) Amendments (2)		4

Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	Reagent - Hydrogen/H₂ (1) Catalyst - Nickel/Ni/palladium/Pd/platinum/Pt (1) Mark independently		2

Question Number	Acceptable Answers	Reject	Mark
18 (b)(ii)	1,2 - dibromoethane (1) ignore punctuation <pre> H H H — C — C — H Br Br (1) </pre> Mark independently Allow CH₂BrCH₂Br	1,2 - bromoethane dibromoethane Skeletal formula C₂H₄Br₂	2

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

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	 (1) for both arrows (1) for carbocation (1) for arrow 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 Br₂ 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)	$\begin{array}{cccc} \text{H} & \text{C}_6\text{H}_5 & \text{H} & \text{C}_6\text{H}_5 \\ & & & \\ -\text{C} & -\text{C} & -\text{C} & -\text{C}- \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array}$ 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 CO₂ 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 biodegradability / 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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Unit 1: The Core Principles of Chemistry

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Candidates may use a calculator.	Total Marks
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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

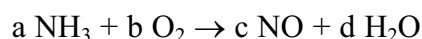
Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☐. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☐.

1 The 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



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)

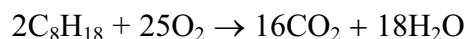
3 The Avogadro constant is $6.0 \times 10^{23} \text{ mol}^{-1}$. Therefore the number of **atoms** in 1 mol of carbon dioxide is

- ☐ 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



(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

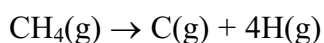
(b) The volume of 1 mol of any gas (measured at room temperature and pressure) is 24 dm^3 . Hence the volume of oxygen (measured at room temperature and pressure) required for the complete combustion of 10 mol of octane is

(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



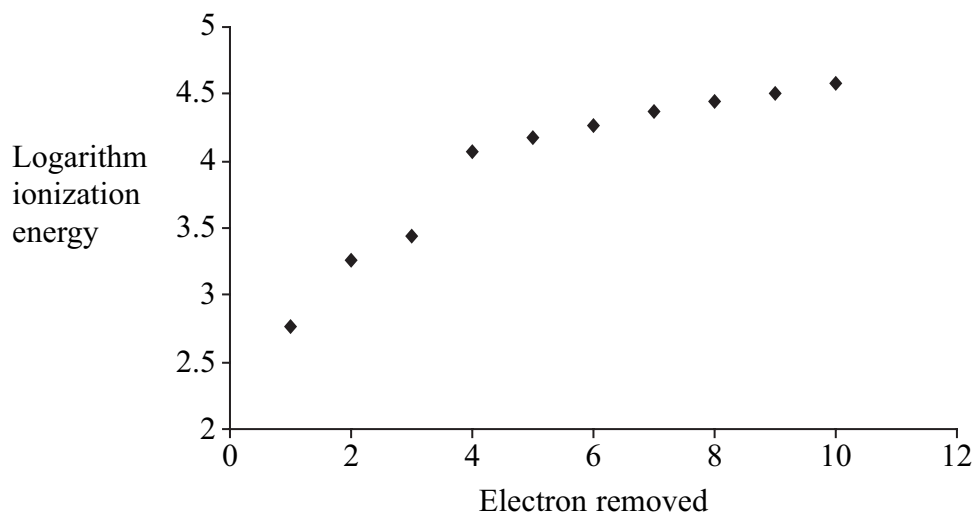
is $+1648 \text{ kJ mol}^{-1}$. Hence the mean bond enthalpy for the C–H bond is

- ☐ A $+329.6 \text{ kJ mol}^{-1}$
- ☐ B $+412.0 \text{ kJ mol}^{-1}$
- ☐ C $+1648 \text{ kJ mol}^{-1}$
- ☐ D $+6592 \text{ kJ mol}^{-1}$

(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** RT₆
- ☐ **C** RT₂
- ☐ **D** R₂T

(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)

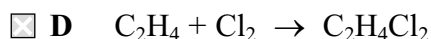
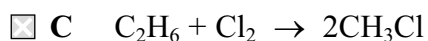
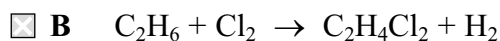
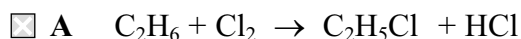
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8 Ethane reacts with chlorine when the substances are exposed to UV radiation.

(a) The equation for this reaction is

(1)



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

(1)

☐ A break the Cl—Cl bond forming $\text{Cl}\cdot$ free radicals.

☐ B break the Cl—Cl bond forming Cl^+ and Cl^- ions.

☐ C break the C—C bond in ethane forming $\text{CH}_3\cdot$ free radicals.

☐ D break a C—H bond in ethane forming $\text{C}_2\text{H}_5\cdot$ free radicals.

(c) The overall reaction between ethane and chlorine is best described as

(1)

☐ A addition.

☐ B homolytic fission.

☐ C heterolytic fission.

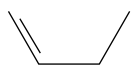
☐ D substitution.

(Total for Question 8 = 3 marks)

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



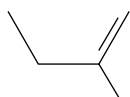
9 This question concerns the following compounds



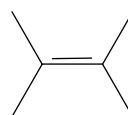
A



B



C



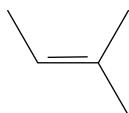
D

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



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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**.

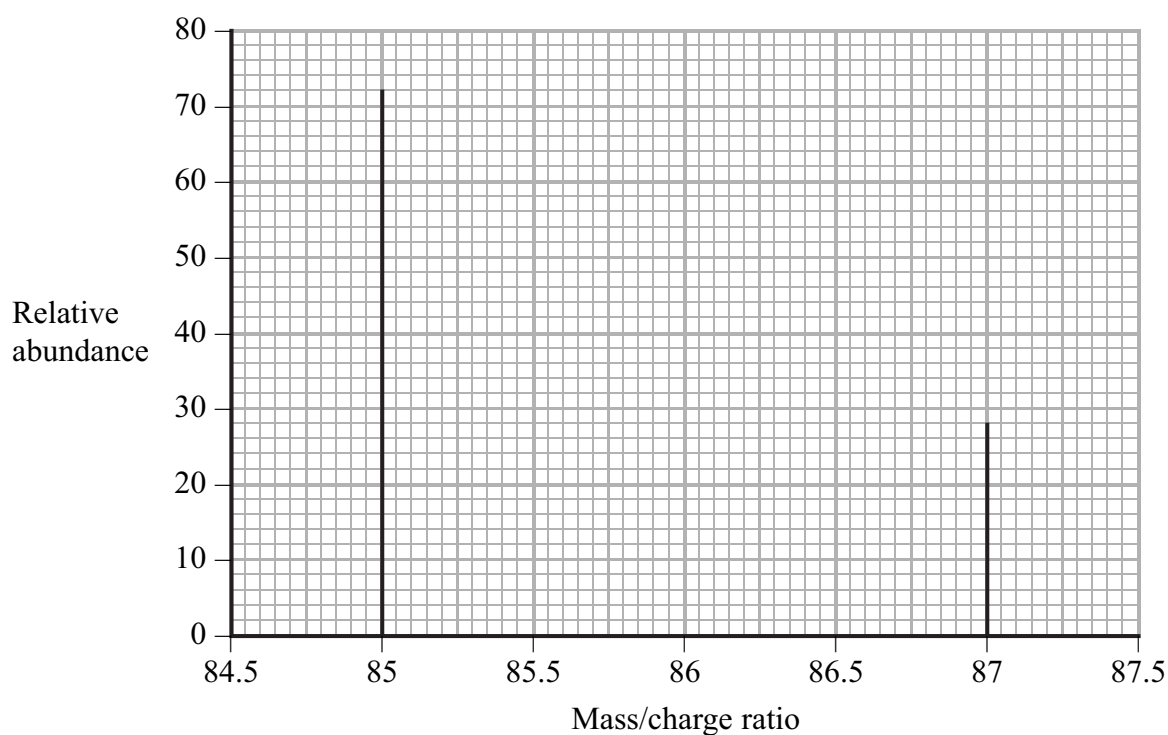
(2)

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(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 cm³ of hydrochloric acid (an excess) in a conical flask. When the reaction was complete, 224 cm³ of carbon dioxide had been collected over water using a 250 cm³ 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)

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- (iii) Calculate the number of moles of carbon dioxide collected in the experiment.

[The molar volume of any gas is 24 000 cm³ 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)



- (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)

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(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)

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(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

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.....

- (ii) State the type and mechanism involved in the typical reaction of alkenes.

(1)

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*(iii) By considering the strength and structure of the π bond, explain why alkenes are more reactive than alkanes.

(2)

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(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)

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.....

(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)

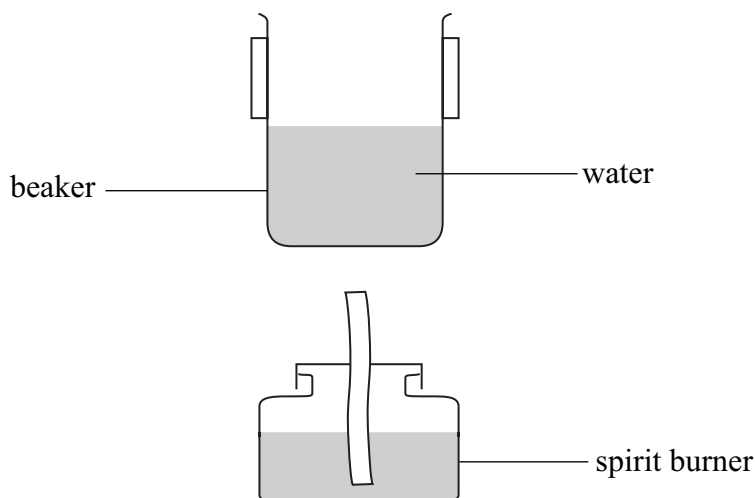
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- 19 The enthalpy change of combustion of ethanol was determined using the apparatus shown in the diagram below. In the experiment, the temperature increase of the water in the beaker is measured when a known mass of the ethanol is burned.



- (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

$$\text{heat energy produced (J)} = \text{mass of water} \times 4.18 \times \text{temperature change}$$

(1)



- (ii) Calculate the number of moles of ethanol burned in this experiment (the formula of ethanol is $\text{C}_2\text{H}_5\text{OH}$).

(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 $-1370 \text{ kJ mol}^{-1}$.

- (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 ₂ H ₅ OH(l)	–1370

(Total for Question 19 = 13 marks)

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



4

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

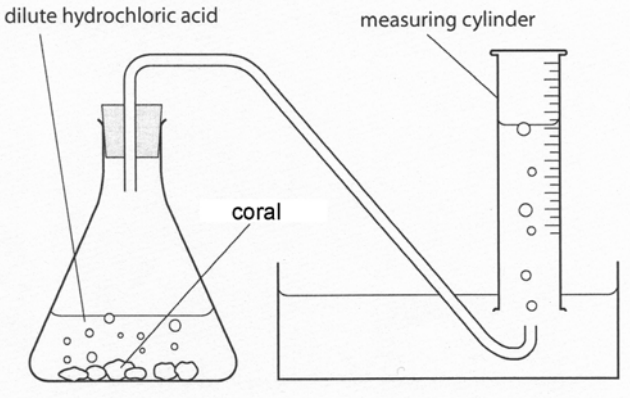
Question Number	Acceptable Answers	Reject	Mark
15 (a)	Average/mean mass of an atom/isotopes (1) (1/12 mass of an atom of) carbon-12 (1) First mark: mention of mean or average mass of either an atom/isotopes <i>IGNORE</i> “weighted” before average or mean <i>IGNORE</i> any mention of “moles” in definition Second mark: any mention of carbon-12 <i>IGNORE</i> any reference to “moles” or “1 mole” at any stage <i>IGNORE</i> 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 <i>ALLOW</i> (Rubidium/it has) “different isotopes” <i>ALLOW</i> 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) <i>IGNORE</i> any units (for example, g/g mol⁻¹/%) NOTE: If 71% abundance used for ⁸⁵Rb and 29% for ⁸⁷Rb, 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)	$\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3$ (Allow atoms in H_2CO_3 in any order) Or $\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}^+ + \text{HCO}_3^-$ Or $\text{H}_2\text{O} + \text{CO}_2 \rightarrow 2\text{H}^+ + \text{CO}_3^{2-}$ Or H_3O^+ in place of H^+ <i>IGNORE STATE SYMBOLS EVEN IF INCORRECT</i>		1

Question Number	Acceptable Answers	Reject	Mark
16 (a) (ii)	$2\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{H}_2\text{O} + \text{CO}_2$ LHS (1) RHS (1) OR $2\text{H}_3\text{O}^+ + \text{CO}_3^{2-} \rightarrow 3\text{H}_2\text{O} + \text{CO}_2$ LHS (1) RHS (1) <i>IGNORE STATE SYMBOLS, EVEN IF INCORRECT</i> <i>IGNORE $\Rightarrow$ arrows</i>	H_2CO_3 as a product $\text{H}^+ + \text{CO}_3^{2-} \rightarrow \text{HCO}_3^-$ 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) <i>IGNORE "heat" beneath conical flask</i> Inverted measuring cylinder with collection over water shown and cylinder above mouth of delivery tube (1) <i>ALLOW</i> 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)	$(224 \div 24000 =) 0.009333/9.333 \times 10^{-3} \text{ (mol)}$ Ignore SF except 1 SF Ignore any incorrect units	“0.009” as answer	1

Question Number	Acceptable Answers	Reject	Mark
16 (b) (iv)	$\text{CaCO}_3(\text{s}) + 2\text{HCl}(\text{aq}) \rightarrow \text{CaCl}_2(\text{aq}) + \text{H}_2\text{O}(\text{l}) + \text{CO}_2(\text{g/aq})$ ALL FOUR state symbols must be correct for this mark		1

Question Number	Acceptable Answers	Reject	Mark
16 (b) (v)	(Mass of 1 mol $\text{CaCO}_3 = 40 + 12 + 3 \times 16 = 100 \text{ g}$ <i>ALLOW</i> just “100” <i>ALLOW</i> any incorrect units <i>ALLOW</i> “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 $\text{CaCO}_3 = 100 \times 0.009333 = 0.9333 \text{ (g)}$ (1) <i>IGNORE</i> 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 $= 100 \times 0.9333 / 1.13 = 82.6\%$ (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 (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: <i>EITHER</i> 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 <i>OR</i> Both equations $\text{Mg} + \text{Cl}_2 \rightarrow \text{MgCl}_2$ and $\text{Mg} + 2\text{HCl} \rightarrow \text{MgCl}_2 + \text{H}_2$ <i>IGNORE</i> state symbols, even if incorrect (1) Second Mark: <i>EITHER</i> The reaction with chlorine has an atom economy which is higher /100% ALLOW “high” <i>OR</i> Any mention of numbers comparing 100 % v. 97.9% (1) <i>IGNORE</i> any comments about yield Mark the two points independently		2

Question Number	Acceptable Answers	Reject	Mark
18 (a)	$\text{C}_{10}\text{H}_{22} \rightarrow \text{C}_7\text{H}_{16} + \text{C}_3\text{H}_6$ ALLOW structural or displayed formulae instead of molecular formulae IGNORE any state symbols, even if incorrect		1

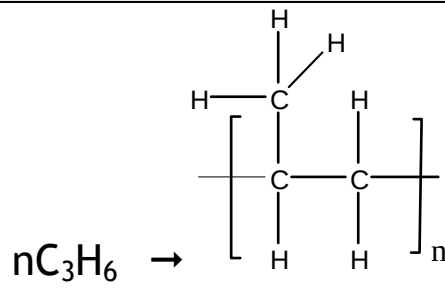
Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	Electrophilic addition <i>BOTH words needed</i> <i>ALLOW</i> “heterolytic” before electrophilic addition		1

Question Number	Acceptable Answers	Reject	Mark
18 (b) (iii)	π bond weaker than σ (bond) / less energy needed to break π bond <i>ALLOW</i> π bond weak(er) / π bond easy to break (1) π - electrons / π bonds (more) accessible (to electrophilic attack) <i>ALLOW</i> 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)	$\begin{array}{ccccc} & \text{H} & & \text{Br} & & \text{H} \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & \\ & \text{H} & & \text{H} & & \text{H} \end{array}$ and $\begin{array}{ccccc} & \text{H} & & \text{H} & & \text{H} \\ & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - \text{Br} \\ & & & & & \\ & \text{H} & & \text{H} & & \text{H} \end{array}$ (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 $\text{C}_3\text{H}_7\text{Br}$ 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)	(1) for both arrows (1) for carbocation (1) for arrow 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^{δ-}	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)	 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) ALLOW CH₃ fully displayed or just as CH₃ 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) <i>ALLOW</i> “rot” or “break down” <i>OR</i> polypropene will not require landfill (as it can decompose in sunlight) <i>OR</i> no need to incinerate /burn <i>IGNORE</i> “good for environment” / “no pollution” (1) (Disadvantage): poly(propene) cannot be used when exposed to (bright) sunlight / UV / outdoors <i>OR</i> 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)	$(q = 250 \times (31.5 - 21.0) \times 4.18 =) \mathbf{10972.5 \text{ (J)}}$ <i>IGNORE</i> sf except 1 sf <i>IGNORE</i> units even if incorrect <i>IGNORE</i> any sign at this stage <i>ALLOW</i> 10.97 (kJ)	10000 (J)	1

Question Number	Acceptable Answers	Reject	Mark
19 (a) (ii)	$(M_r \text{ ethanol}) = 46 \quad \mathbf{(1)}$ $(\text{Mass ethanol burned} = 63.21 - 62.47 =) 0.74 \text{ (g)}$ <i>ALLOW</i> 63.21 – 62.47 as alternative to 0.74 $\mathbf{(1)}$ $(\text{Amount of ethanol} = 0.74 \div 46 =) 0.0161 \text{ (mol)}$ $\mathbf{(1)}$ NOTE: Moles of ethanol are CQ on molar mass and /or mass of ethanol burned <i>IGNORE</i> 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)	$\text{Answer (i)} \div (1000 \times \text{answer (ii)}) \quad \mathbf{(1)}$ NOTE: Be aware of numbers held in calculator not corresponding to what is written in answer Value and negative sign $\mathbf{(1)}$ <i>IGNORE</i> sf except 1 sf NOTE: Answer consistent with (a)(i) and (a)(ii) with no working scores (2) <u>E.g.</u> $10.9725 \div (0.74 \div 46) = - 682 \text{ (kJ mol}^{-1}\text{)}$ <i>ALLOW</i> 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)	$100 \times (1370 - \text{Answer to (iii)}) \div 1370 = \text{value}$ e.g. $100 \times (1370 - 682) \div 1370 = 50.2 \%$	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)	$2 \text{ C(s)} + 3 \text{ H}_2\text{(g)} + \frac{1}{2} \text{ O}_2\text{(g)} \rightarrow \text{C}_2\text{H}_5\text{OH(l)}$ $\downarrow$ $2\text{CO}_2 + 3\text{H}_2\text{O}$ $\downarrow$ $\Delta H_f = 2 \times (-394) + 3 \times (-286) - (-1370)$ $= -276 \text{ (kJ mol}^{-1}\text{)}$ Correct expression or cycle (1) Evidence for both doubling $\Delta H_c^\theta [\text{C}]$ and trebling $\Delta H_c^\theta [\text{H}_2]$ (1) Correct sign and answer (1) Correct answer with no working scores (3) Correct answer with an incorrect cycle (3) <i>IGNORE</i> 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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Centre Number	Candidate Number

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
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Candidates may use a calculator.	Total Marks
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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 In the following outline of the Periodic Table, the letters A to D are **not** the symbols of the elements.

[illegible]

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)

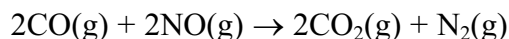
4 For drivers in the UK, the legal limit of the concentration of ethanol (molar mass 46 g mol^{-1}) in the blood is 80 mg per 100 cm^3 . This is equivalent to a concentration of

- ☐ A 17.4 mol dm^{-3}
- ☐ B 1.74 mol dm^{-3}
- ☐ C $0.0174 \text{ mol dm}^{-3}$
- ☐ D $0.00174 \text{ mol dm}^{-3}$

(Total for Question 4 = 1 mark)



- 5 An important reaction which occurs in the catalytic converter of a car is



In this reaction, when 500 cm³ of CO reacts with 500 cm³ 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 cm³
- ☐ B 750 cm³
- ☐ C 1000 cm³
- ☐ 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 $\text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{HCl}(\text{s})$
- ☐ B $\text{Ba}^+(\text{aq}) + \text{SO}_4^-(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$
- ☐ C $\text{Ba}^{2+}(\text{aq}) + 2\text{SO}_4^-(\text{aq}) \rightarrow \text{Ba}(\text{SO}_4)_2(\text{s})$
- ☐ D $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$

(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	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$\text{S}_8(\text{s})$	0
$\text{S}_8(\text{g})$	+103
$\text{S}(\text{g})$	+279

The enthalpy of atomization of sulfur is (in kJ mol^{-1})

- ☐ A $103 \div 8$
- ☐ B $279 \div 8$
- ☐ C 279
- ☐ D $(103 \div 8) + 279$

(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?

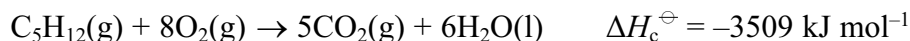
- ☐ A $\text{HI}(\text{g}) \rightarrow \frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{I}_2(\text{s})$
- ☐ B $\text{HI}(\text{g}) \rightarrow \frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{I}_2(\text{g})$
- ☐ C $\text{HI}(\text{g}) \rightarrow \text{H}(\text{g}) + \text{I}(\text{g})$
- ☐ D $\text{HI}(\text{g}) \rightarrow \text{H}^+(\text{g}) + \text{I}^-(\text{g})$

(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



The standard enthalpy change of formation of $\text{CO}_2(\text{g})$ is -394 kJ mol^{-1} and that of $\text{H}_2\text{O}(\text{l})$ 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)

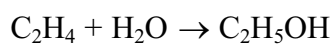
14 Many organic compounds have toxic vapours. For this reason

- ☐ 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}):



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



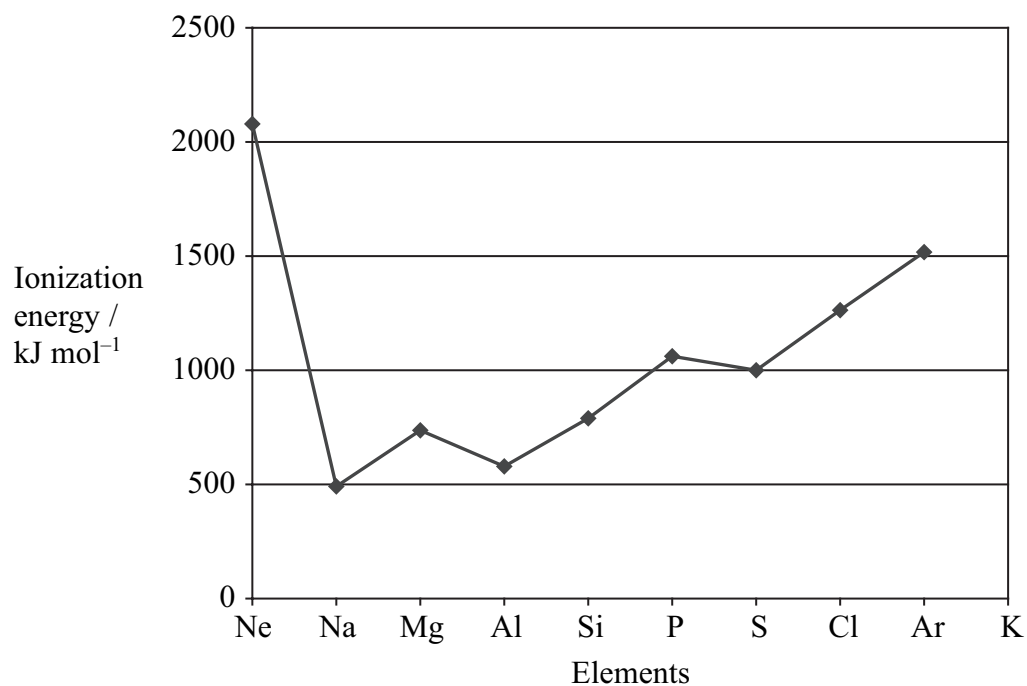
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SECTION B

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)

.....

.....

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.....

.....

.....



(b) Explain why, in moving from Na to Ar, the general trend is for the first ionization energy to increase.

(3)

.....

.....

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.....

.....

(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 cm³ of hydrochloric acid of concentration 1.50 mol dm⁻³.

400 cm³ of hydrogen gas was formed, the volume being measured at room temperature and pressure.

In the calculations that follow, use the following molar masses:

$$\text{Mg} = 24.0 \text{ g mol}^{-1}$$

$$\text{Cl} = 35.5 \text{ g mol}^{-1}$$

(a) Calculate the amount (in moles) of magnesium used.

(1)

(b) Calculate the amount (in moles) of hydrochloric acid used.

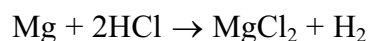
(1)

(c) Calculate the amount (in moles) of hydrogen produced.

[Molar volume of any gas at room temperature and pressure = 24 000 cm³ mol⁻¹]

(1)

(d) Show that the calculated amounts of magnesium, hydrochloric acid and hydrogen are consistent with the following equation for the reaction



(1)



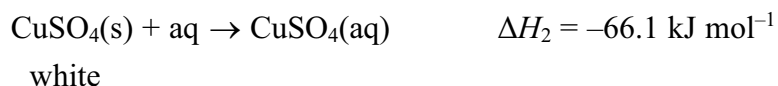
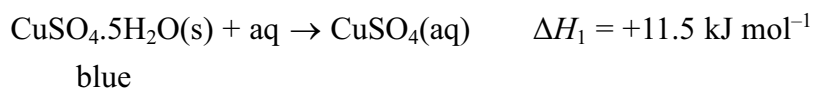
(e) Calculate the maximum mass of magnesium chloride that would be formed in this reaction. Give your answer to **three** significant figures.

(3)

(Total for Question 17 = 7 marks)

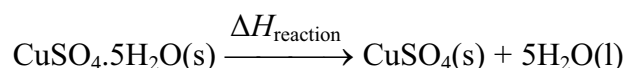


- 18 Copper(II) sulfate exists as blue hydrated crystals and white anhydrous crystals. The enthalpy changes of solution for these two substances may be represented by the following simplified equations:



- (a) (i) Fill in the box and add labelled arrows to complete the Hess cycle to enable you to calculate $\Delta H_{\text{reaction}}$.

(3)



- (ii) Calculate a value for the enthalpy change $\Delta H_{\text{reaction}}$.

(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)

.....

.....

.....

.....





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, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$.

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)

- (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

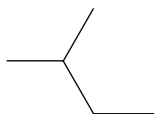
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(Total for Question 18 = 13 marks)

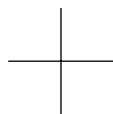


19 This question is about alkanes.

(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)

.....

.....

.....

.....

.....

.....



(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)

.....

.....

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.....

.....

(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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4

P 3 8 4 3 3 A 0 2 4 2 4

Mark Scheme (Results)

June 2011

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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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.

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 $A_r(\text{Mg}) = 24.3$ 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 $\text{Mg} = (0.4 \div 24) = 0.016666 = 0.0167 \text{ (mol)}$ Allow Amount $\text{Mg} = (0.4 \div 24.3) = 0.016461 = 0.0165 \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
17 (b)	Amount $\text{HCl} = 1.5 \times 22.2/1000 = 0.033333 = 0.0333 \text{ (mol)}$ Allow Amount $\text{HCl} = 2 \times \text{answer in (a)}$		1

Question Number	Acceptable Answers	Reject	Mark
17 (c)	Amount of $\text{H}_2 = 400 \div 24\,000 = 0.016666 = 0.0167 \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
17 (d)	Ratio mol $\text{Mg}:\text{HCl}:\text{H}_2 = 0.0167 (0.165) : 0.0333 : 0.0167 = 1:2:1$ 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)	$M_r(\text{MgCl}_2) = 24 + 2 \times 35.5 = 95$ (1) $\text{Mol MgCl}_2 = (\text{mol Mg}) = 0.0166666$ (or 0.0167) (1) $\text{Mass MgCl}_2 = 95 \times 0.0166666 = 1.58$ (g) 3 sf (1) Or $95 \times 0.0167 = 1.59$ (g) 3sf Or $95.3 \times 0.0166666 = 1.59$ Or $95 \times 0.0165 = 1.58$ Or $95.3 \times 0.0165 = 1.57$ Correct answer with no working scores (3) TE on 17(a)		3

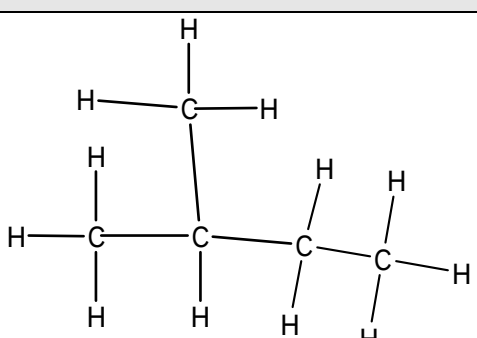
Question Number	Acceptable Answers	Reject	Mark
18 (a) (i)	Product in box: CuSO_4(aq) (1) Either Mark the arrows and then the labels: Two downward arrows (1) labelled with symbols or values with or without units (1) OR Mark each arrow and label separately Downward arrow & ΔH_1 or value (1) Downward arrow & ΔH_2 or value (1) Allow reversed arrows with reversed signs on ΔH Ignore any other labels on the arrows. Ignore $5\text{H}_2\text{O}$ in bottom product $ \begin{array}{ccc} \text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s}) & \xrightarrow{\Delta H_{\text{reaction}}} & \text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \\ & \searrow \Delta H_1 / +11.5 & \swarrow \Delta H_2 / -66.1 \\ & \text{CuSO}_4(\text{aq}) & \end{array} $		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 $\Delta H_{\text{reaction}} = \Delta H_1 - \Delta H_2$ stated or implied $= +11.5 - (-66.1)$ (1) $= (+) 77.6 \text{ (kJ mol}^{-1}\text{)}$ (1) Correct answer alone scores (2) $-77.6 \text{ (kJ mol}^{-1}\text{)}$ 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 $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ 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
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

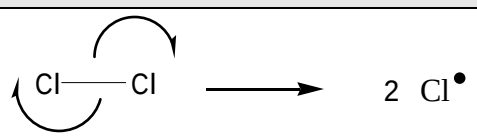
Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	$CH_4 + 1\frac{1}{2}O_2 \rightarrow CO + 2H_2O$ Formulae (1) balance (1) Or multiples Ignore state symbols No TE on any other species		2

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) CO₂ in the atmosphere / CO₂ 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 H₂O 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 <i>incomplete</i> 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)	$\text{CH}_4 + \text{Cl}^\bullet \rightarrow \text{CH}_3^\bullet + \text{HCl}$ (1) $\text{CH}_3^\bullet + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}^\bullet$ (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)	$\text{CH}_3^\bullet + \text{CH}_3^\bullet \rightarrow \text{C}_2\text{H}_6$ / $2\text{CH}_3^\bullet \rightarrow \text{C}_2\text{H}_6$ 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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Surname	Other names
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Centre Number	Candidate Number

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
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Candidates may use a calculator.	Total Marks
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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 In the following outline of the Periodic Table, the letters A to D are **not** the symbols of the elements.

[illegible]

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)

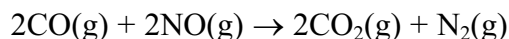
4 For drivers in the UK, the legal limit of the concentration of ethanol (molar mass 46 g mol^{-1}) in the blood is 80 mg per 100 cm^3 . This is equivalent to a concentration of

- ☐ A 17.4 mol dm^{-3}
- ☐ B 1.74 mol dm^{-3}
- ☐ C $0.0174 \text{ mol dm}^{-3}$
- ☐ D $0.00174 \text{ mol dm}^{-3}$

(Total for Question 4 = 1 mark)



- 5 An important reaction which occurs in the catalytic converter of a car is



In this reaction, when 500 cm³ of CO reacts with 500 cm³ 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 cm³
- ☐ B 750 cm³
- ☐ C 1000 cm³
- ☐ 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 $\text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{HCl}(\text{s})$
- ☐ B $\text{Ba}^+(\text{aq}) + \text{SO}_4^-(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$
- ☐ C $\text{Ba}^{2+}(\text{aq}) + 2\text{SO}_4^-(\text{aq}) \rightarrow \text{Ba}(\text{SO}_4)_2(\text{s})$
- ☐ D $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$

(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	$\Delta H_f^\ominus / \text{kJ mol}^{-1}$
$\text{S}_8(\text{s})$	0
$\text{S}_8(\text{g})$	+103
$\text{S}(\text{g})$	+279

The enthalpy of atomization of sulfur is (in kJ mol^{-1})

- ☐ A $103 \div 8$
- ☐ B $279 \div 8$
- ☐ C 279
- ☐ D $(103 \div 8) + 279$

(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?

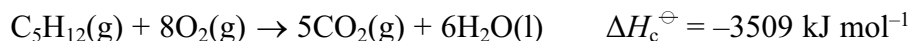
- ☐ A $\text{HI}(\text{g}) \rightarrow \frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{I}_2(\text{s})$
- ☐ B $\text{HI}(\text{g}) \rightarrow \frac{1}{2}\text{H}_2(\text{g}) + \frac{1}{2}\text{I}_2(\text{g})$
- ☐ C $\text{HI}(\text{g}) \rightarrow \text{H}(\text{g}) + \text{I}(\text{g})$
- ☐ D $\text{HI}(\text{g}) \rightarrow \text{H}^+(\text{g}) + \text{I}^-(\text{g})$

(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



The standard enthalpy change of formation of $\text{CO}_2(\text{g})$ is -394 kJ mol^{-1} and that of $\text{H}_2\text{O}(\text{l})$ 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)

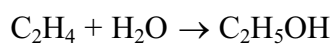
14 Many organic compounds have toxic vapours. For this reason

- ☐ 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}):



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



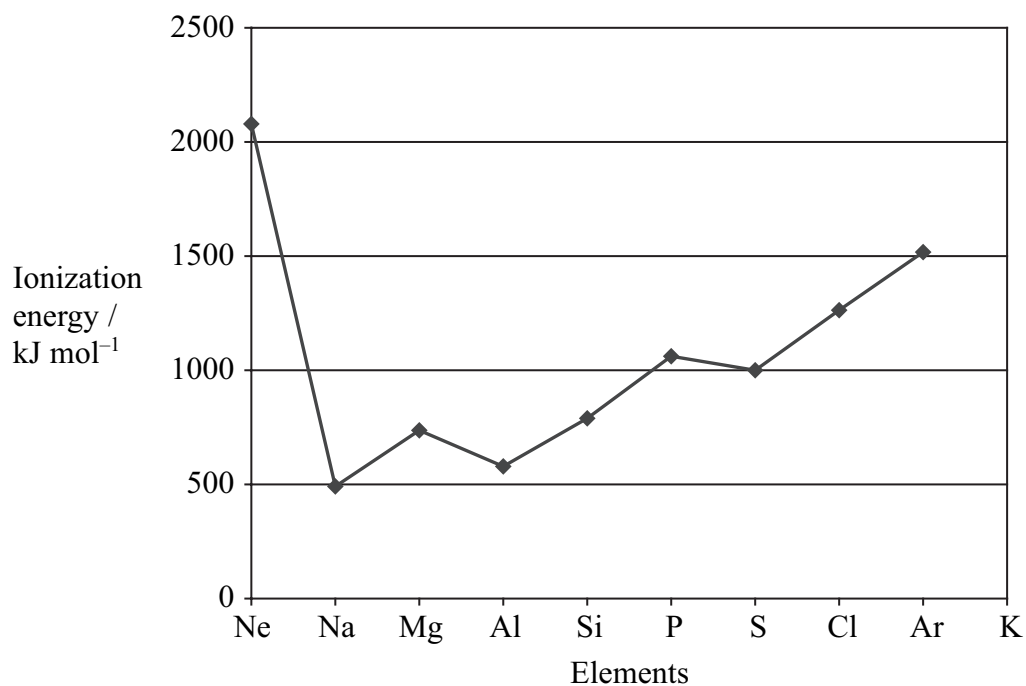
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SECTION B

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)

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(b) Explain why, in moving from Na to Ar, the general trend is for the first ionization energy to increase.

(3)

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(c) Explain why the first ionization energy decreases from P to S.

(2)

.....

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.....

(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 cm³ of hydrochloric acid of concentration 1.50 mol dm⁻³.

400 cm³ of hydrogen gas was formed, the volume being measured at room temperature and pressure.

In the calculations that follow, use the following molar masses:

$$\text{Mg} = 24.0 \text{ g mol}^{-1}$$

$$\text{Cl} = 35.5 \text{ g mol}^{-1}$$

(a) Calculate the amount (in moles) of magnesium used.

(1)

(b) Calculate the amount (in moles) of hydrochloric acid used.

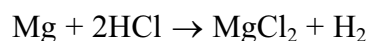
(1)

(c) Calculate the amount (in moles) of hydrogen produced.

[Molar volume of any gas at room temperature and pressure = 24 000 cm³ mol⁻¹]

(1)

(d) Show that the calculated amounts of magnesium, hydrochloric acid and hydrogen are consistent with the following equation for the reaction



(1)



(e) Calculate the maximum mass of magnesium chloride that would be formed in this reaction. Give your answer to **three** significant figures.

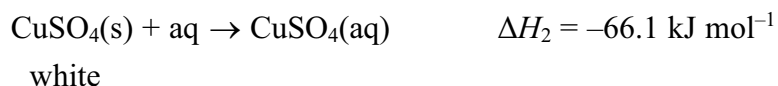
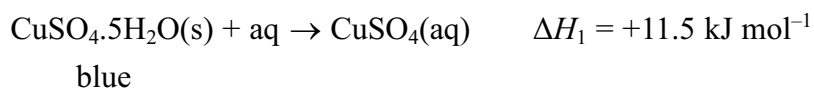
(3)

(Total for Question 17 = 7 marks)



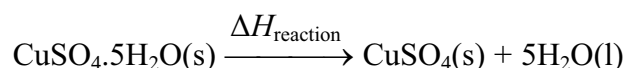
P 3 8 4 3 3 A 0 1 3 2 4

- 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:



- (a) (i) Fill in the box and add labelled arrows to complete the Hess cycle to enable you to calculate $\Delta H_{\text{reaction}}$.

(3)



- (ii) Calculate a value for the enthalpy change $\Delta H_{\text{reaction}}$.

(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)





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, $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s})$.

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

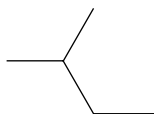
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(Total for Question 18 = 13 marks)

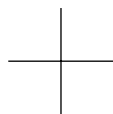


19 This question is about alkanes.

(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)

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(Total for Question 20 = 9 marks)

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



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4

P 3 8 4 3 3 A 0 2 4 2 4

Mark Scheme (Results)

June 2011

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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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.

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 $A_r(\text{Mg}) = 24.3$ 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 $\text{Mg} = (0.4 \div 24) = 0.016666 = 0.0167 \text{ (mol)}$ Allow Amount $\text{Mg} = (0.4 \div 24.3) = 0.016461 = 0.0165 \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
17 (b)	Amount $\text{HCl} = 1.5 \times 22.2/1000 = 0.033333 = 0.0333 \text{ (mol)}$ Allow Amount $\text{HCl} = 2 \times \text{answer in (a)}$		1

Question Number	Acceptable Answers	Reject	Mark
17 (c)	Amount of $\text{H}_2 = 400 \div 24\,000 = 0.016666 = 0.0167 \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
17 (d)	Ratio mol $\text{Mg}:\text{HCl}:\text{H}_2 = 0.0167 (0.165) : 0.0333 : 0.0167 = 1:2:1$ 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)	$M_r(\text{MgCl}_2) = 24 + 2 \times 35.5 = 95$ (1) $\text{Mol MgCl}_2 = (\text{mol Mg}) = 0.0166666$ (or 0.0167) (1) $\text{Mass MgCl}_2 = 95 \times 0.0166666 = 1.58$ (g) 3 sf (1) Or $95 \times 0.0167 = 1.59$ (g) 3sf Or $95.3 \times 0.0166666 = 1.59$ Or $95 \times 0.0165 = 1.58$ Or $95.3 \times 0.0165 = 1.57$ Correct answer with no working scores (3) TE on 17(a)		3

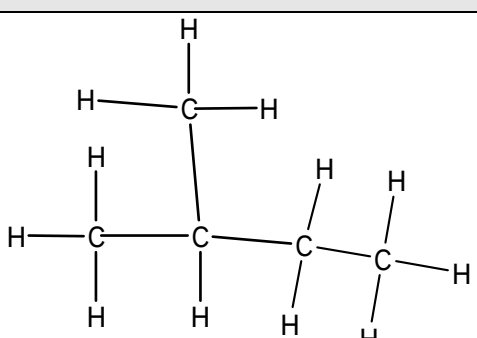
Question Number	Acceptable Answers	Reject	Mark
18 (a) (i)	Product in box: CuSO_4(aq) (1) Either Mark the arrows and then the labels: Two downward arrows (1) labelled with symbols or values with or without units (1) OR Mark each arrow and label separately Downward arrow & ΔH_1 or value (1) Downward arrow & ΔH_2 or value (1) Allow reversed arrows with reversed signs on ΔH Ignore any other labels on the arrows. Ignore $5\text{H}_2\text{O}$ in bottom product $ \begin{array}{ccc} \text{CuSO}_4 \cdot 5\text{H}_2\text{O}(\text{s}) & \xrightarrow{\Delta H_{\text{reaction}}} & \text{CuSO}_4(\text{s}) + 5\text{H}_2\text{O}(\text{l}) \\ & \searrow \Delta H_1 / +11.5 & \swarrow \Delta H_2 / -66.1 \\ & \text{CuSO}_4(\text{aq}) & \end{array} $		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 $\Delta H_{\text{reaction}} = \Delta H_1 - \Delta H_2$ stated or implied $= +11.5 - (-66.1)$ (1) $= (+) 77.6 \text{ (kJ mol}^{-1}\text{)}$ (1) Correct answer alone scores (2) $-77.6 \text{ (kJ mol}^{-1}\text{)}$ 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 $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ 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
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

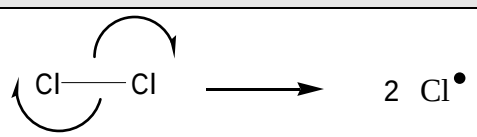
Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	$CH_4 + 1\frac{1}{2}O_2 \rightarrow CO + 2H_2O$ Formulae (1) balance (1) Or multiples Ignore state symbols No TE on any other species		2

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) CO₂ in the atmosphere / CO₂ 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 H₂O 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 <i>incomplete</i> 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)	$\text{CH}_4 + \text{Cl}^\bullet \rightarrow \text{CH}_3^\bullet + \text{HCl}$ (1) $\text{CH}_3^\bullet + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}^\bullet$ (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)	$\text{CH}_3^\bullet + \text{CH}_3^\bullet \rightarrow \text{C}_2\text{H}_6$ / $2\text{CH}_3^\bullet \rightarrow \text{C}_2\text{H}_6$ 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

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/



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 cm³ of a hydrocarbon vapour gave 350 cm³ of carbon dioxide, both gas volumes being measured at the same temperature and pressure. The formula of the hydrocarbon could be

- ☐ A C₈H₁₈
☐ B C₇H₁₆
☐ C C₆H₁₄
☐ D C₅H₁₂

(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)



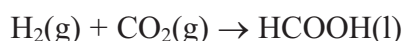
- 4 In an experiment to determine the enthalpy change of combustion of an alcohol, a spirit burner containing the alcohol was weighed, lit and placed under a copper can containing a known volume of water. The temperature rise of the water was measured and the burner re-weighed. The enthalpy change calculated 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



- ☐ A -803 kJ mol^{-1}
- ☐ B -15 kJ mol^{-1}
- ☐ C $+803 \text{ kJ mol}^{-1}$
- ☐ D $+15 \text{ kJ mol}^{-1}$

(Total for Question 5 = 1 mark)

- 6 For which of the following changes is the value of ΔH negative?

- ☐ A $\text{K}(\text{g}) \rightarrow \text{K}^+(\text{g}) + \text{e}^-$
- ☐ B $\text{K}^+\text{Cl}^-(\text{s}) \rightarrow \text{K}^+(\text{g}) + \text{Cl}^-(\text{g})$
- ☐ C $\text{Cl}(\text{g}) + \text{e}^- \rightarrow \text{Cl}^-(\text{g})$
- ☐ D $\text{Cl}_2(\text{g}) \rightarrow 2\text{Cl}(\text{g})$

(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, $-2526 \text{ kJ mol}^{-1}$; the second is the theoretical value, $-2326 \text{ kJ mol}^{-1}$. 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?

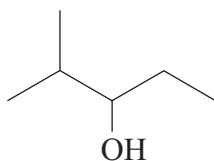
- ☐ A $\frac{1}{2}\text{Br}_2(\text{l}) \rightarrow \text{Br}(\text{g})$
- ☐ B $\frac{1}{2}\text{Br}_2(\text{g}) \rightarrow \text{Br}(\text{g})$
- ☐ C $\text{Br}_2(\text{l}) \rightarrow \text{Br}^+(\text{g}) + \text{Br}^-(\text{g})$
- ☐ D $\text{Br}_2(\text{g}) \rightarrow \text{Br}^+(\text{g}) + \text{Br}^-(\text{g})$

(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 $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$
- ☐ B $(\text{CH}_3)_2\text{CHC}(\text{OH})(\text{CH}_3)_2$
- ☐ C $(\text{CH}_3)_2\text{CHCH}_2\text{CH}(\text{OH})\text{CH}_3$
- ☐ D $(\text{CH}_3)_2\text{CHCH}(\text{OH})\text{CH}_2\text{CH}_3$

(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)

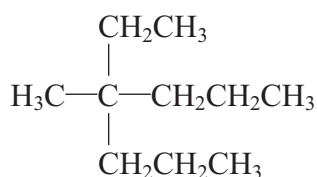
12 When methane reacts with chlorine, a mixture of products forms. Which product provides the strongest evidence for a free radical mechanism?

- ☐ 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 $\text{C}_2\text{H}_2\text{O}_4$
- ☐ C CHO
- ☐ D $\text{C}_2\text{H}_2\text{O}_2$

(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

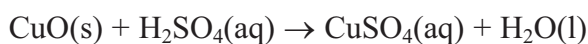
(Total for Question 16 = 1 mark)

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, YX_2 .
- ☐ B ionic, 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



The **ionic** equation for the reaction is

- ☐ A $\text{Cu}^{2+}\text{(s)} + \text{SO}_4^{2-}\text{(aq)} \rightarrow \text{CuSO}_4\text{(aq)}$
- ☐ B $\text{O}^{2-}\text{(s)} + \text{H}_2\text{SO}_4\text{(aq)} \rightarrow \text{H}_2\text{O(l)} + \text{SO}_4^{2-}\text{(aq)}$
- ☐ C $\text{CuO(s)} + 2\text{H}^+\text{(aq)} \rightarrow \text{Cu}^{2+}\text{(aq)} + \text{H}_2\text{O(l)}$
- ☐ D $\text{CuO(s)} + \text{H}_2\text{SO}_4\text{(aq)} \rightarrow \text{Cu}^{2+}\text{SO}_4^{2-}\text{(aq)} + \text{H}_2\text{O(l)}$

(Total for Question 18 = 1 mark)



19 Which of the following represents the electronic structure of a nitrogen atom?

	1s	2s	2p		
☐ A	↑↓	↑	↑↓	↑	↑
☐ B	↑↓	↑	↑↓	↑↓	
☐ C	↑↓	↑↓	↑	↑	↑
☐ D	↑↓	↑↓	↑↓	↑	

(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?

	1s	2s	2p		
☐ A	↑↓	↑↓	↑	↑	
☐ B	↑↓	↑↓	↑	↑	↑
☐ C	↑↓	↑↓	↑↓	↑↓	↑
☐ D	↑↓	↑↓	↑↓	↑↓	↑↓

(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)

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(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)

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* (ii) Explain how these ionization energies give evidence for the electronic structure of sodium. You may use a sketch graph if you wish.

(2)

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(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)

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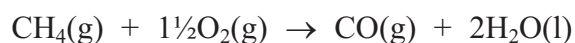
(Total for Question 22 = 9 marks)



23 (a) State Hess's Law.

(1)

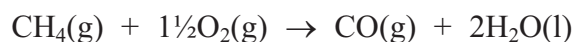
(b) Methane burns in a limited supply of oxygen to give carbon monoxide and water.



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.



(2)

- (ii) Calculate the enthalpy change for this reaction, in kJ mol^{-1} .

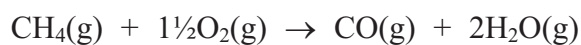
(2)



(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.



(2)

(Total for Question 23 = 8 marks)



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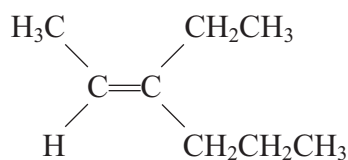
24 (a) Give the general formula for the homologous series of **alkenes**.

(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, $\text{CH}_2=\text{CH}_2$, with

(i) hydrogen.

(1)

(ii) chlorine.

(1)

(iii) acidified aqueous potassium manganate(VII).

(1)

(iv) bromine **water**.

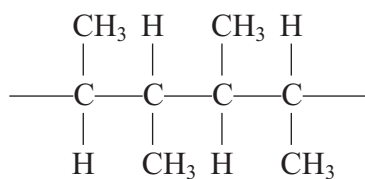
(1)

(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 $24 \text{ dm}^3 \text{ mol}^{-1}$.)

(2)

(v) Calculate the number of oxygen **molecules** that react with 1.73 g of sodium. (The Avogadro constant = $6.02 \times 10^{23} \text{ mol}^{-1}$.)

(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)



P 3 9 3 0 6 A 0 1 9 2 4

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, $\text{CH}_2=\text{CH}_2$

(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)

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- (ii) Explain the high melting temperature of silicon in terms of the bonding.

(2)

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(Total for Question 26 = 9 marks)

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



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4

P 3 9 3 0 6 A 0 2 4 2 4

Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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Summer 2012

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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 ¹²C atom (1) NOTE: The second mark is awarded for any mention of ¹²C 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) isotopes<u>s</u> /atoms<u>s</u> 'Mass of an element'	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	$\{(35 \times 75.53) + (37 \times 24.47)\} \div 100$ (1) = 35.4894 (1) = 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

[illegible]

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	72 (1) $^{35}\text{Cl} - ^{37}\text{Cl}^{(+)}$ (1) ALLOW $(^{35}\text{Cl} + ^{37}\text{Cl})^{(+)}$ and/or $(^{37}\text{Cl} + ^{35}\text{Cl})^{(+)}$ OR $(^{37}\text{Cl}^{35}\text{Cl})^{(+)}$ and/or $(^{35}\text{Cl}^{37}\text{Cl})^{(+)}$ OR $(^{35}\text{Cl} \text{ and } ^{37}\text{Cl})^{(+)}$ and/or $(^{37}\text{Cl} \text{ and } ^{35}\text{Cl})^{(+)}$ NOTE: The + charge is not needed on this ion IGNORE extra + charges, so ALLOW $^{35}\text{Cl}^+ ^{37}\text{Cl}^+$ and/or $^{37}\text{Cl}^+ ^{35}\text{Cl}^+$		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 1s²2s²2p⁶3s¹ 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)	$\text{CH}_4 + 1\frac{1}{2}\text{O}_2 \longrightarrow \text{CO} + 2\text{H}_2\text{O}$ $\swarrow (+\frac{1}{2}\text{O}_2) \quad \searrow (+\frac{1}{2}\text{O}_2)$ $\text{CO}_2 + 2\text{H}_2\text{O}$ $\text{CO}_2 + 2\text{H}_2\text{O}$ (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)	$\Delta H = -890 - (-283)$ (1) $= -607 \text{ (kJ mol}^{-1}\text{)}$ (1) Correct answer with no working scores (2) NOTE: $+607 \text{ (kJ mol}^{-1}\text{)}$ 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 H₂O 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)	<i>E</i> -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

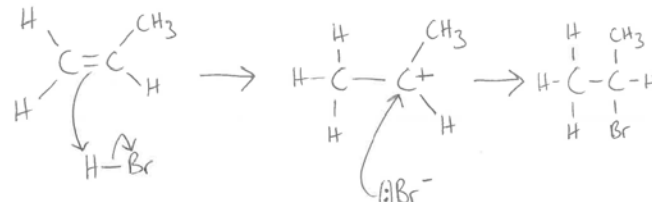
ALLOW displayed or skeletal formulae throughout 24(d)

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	CH ₃ CH ₃ ALLOW displayed or skeletal formulae throughout 24(d)	C ₂ H ₆	1

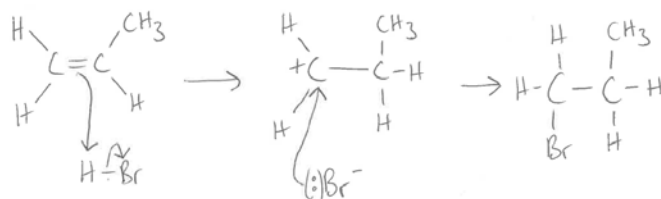
Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	ClCH ₂ CH ₂ Cl / CH ₂ ClCH ₂ Cl	C ₂ H ₄ Cl ₂	1

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	HOCH ₂ CH ₂ OH / CH ₂ OHCH ₂ OH	C ₂ H ₆ O ₂	1

Question Number	Acceptable Answers	Reject	Mark
24(d)(iv)	HOCH ₂ CH ₂ Br / CH ₂ OHCH ₂ Br	BrCH ₂ CH ₂ Br; C ₂ H ₅ OBr; C ₂ H ₄ Br 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)**

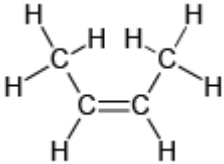
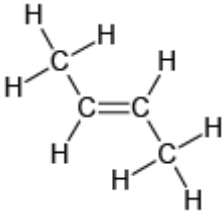


If the minor product route is shown, the last mark is lost, but the first three marks can be scored consequentially as follows:-

- 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: CH₃ group does not have to be displayed. IGNORE if any connectivity is shown from the H₃ in a CH₃ 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 = $1.73 \text{ (g)} \div 23 \text{ (g mol}^{-1}\text{)}$ = 0.075(22) (mol) Amount O = $1.20 \text{ (g)} \div 16 \text{ (g mol}^{-1}\text{)}$ = 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 = $23 \div 1.73 = 13.3$ Amount O = $16 \div 1.20 = 13.3$ 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 Na₂O. This scores (1) overall (i.e. the 2nd mark). NOTE: Use of O = 32 gives Na₂O and scores second mark	Na ₂ O ₂	2

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	(NaO = 39 hence molar mass twice that of NaO ∴) so Na₂O₂	'2NaO'	1

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	$2\text{Na(s)} + \text{O}_2\text{(g)} \rightarrow \text{Na}_2\text{O}_2\text{(s)}$ All species correct (1) State symbols and balancing (1) NOTE: 2 nd mark is conditional on correct species. NOTE: $2\text{Na(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{NaO(s)}$ scores (1) $\text{Na(s)} + \text{O}_2\text{(g)} \rightarrow \text{NaO}_2\text{(s)}$ scores (1) $4\text{Na(s)} + \text{O}_2\text{(g)} \rightarrow 2\text{Na}_2\text{O(s)}$ scores (2)		2

Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	Moles of O₂ = $0.075 \div 2 = 0.0375$ OR $1.2 \div 32 = 0.0375$ (mol) (1) $0.0375 \text{ mol} \times 24 \text{ dm}^3 \text{ mol}^{-1}$ = $0.9(0)$ (dm³) (1) ALLOW 900 cm³ (units must be present here) Correct answer no working (2) OR Moles of Na = $1.73 \div 23 = 0.075217$ = moles of O Moles of O₂ = $0.075217 \div 2 = 0.0376085$ $0.0376085 \times 24 = 0.903$ (dm³) or 903 cm³ IGNORE s.f., including ONE s.f. NOTE: If number of moles $\times 24$ (dm³ mol⁻¹) is clearly evident and correctly calculated in stated units, award second mark		2

Question Number	Acceptable Answers	Reject	Mark
25(a)(v)	$0.0375 \times 6.02 \times 10^{23}$ (= 2.2575×10^{22} (molecules)) = 2.26×10^{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)	$ \begin{array}{c} \text{H} \\ \bullet \times \\ \text{H} \times \text{C} \times \text{H} \\ \times \bullet \\ \text{H} \end{array} $		1

Question Number	Acceptable Answers	Reject	Mark
26(b)(ii)	$ \begin{array}{c} \text{H}^+ \quad \bullet \times \quad \text{H} \\ \bullet \times \quad \text{C} \times \quad \bullet \times \quad \text{C}^+ \\ \text{H}^+ \quad \times \quad \bullet \times \quad \text{H} \end{array} $		1

Question Number	Acceptable Answers	Reject	Mark
26(b)(iii)	$ \begin{array}{c} \times \\ \times \text{N} \times \text{N} \times \\ \times \\ \times \end{array} $ 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)	$ \left[\begin{array}{c} \text{H} \\ \bullet \times \\ \text{H} \times \text{N} \times \text{H} \\ \times \bullet \\ \text{H} \end{array} \right]^+ $ 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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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/



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 $\text{K}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{KCl}(\text{s})$
- ☐ B $\text{K}^{2+}(\text{aq}) + 2\text{Cl}^-(\text{aq}) \rightarrow \text{KCl}_2(\text{s})$
- ☐ C $\text{Ba}^+(\text{aq}) + \text{SO}_4^-(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$
- ☐ D $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$

(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, $\text{C}_{20}\text{H}_{42}$.
- ☐ 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, $\text{O}_2(\text{g})$?

[Avogadro constant = $6 \times 10^{23} \text{ mol}^{-1}$]

- ☐ 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.



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 $\text{Cu}(\text{s}) + \text{Ag}^{2+}(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{Ag}(\text{s})$
- ☐ B $\text{Cu}(\text{s}) + \text{Ag}^+(\text{aq}) \rightarrow \text{Cu}^+(\text{aq}) + \text{Ag}(\text{s})$
- ☐ C $2\text{Cu}(\text{s}) + \text{Ag}^{2+}(\text{aq}) \rightarrow 2\text{Cu}^+(\text{aq}) + \text{Ag}(\text{s})$
- ☐ D $\text{Cu}(\text{s}) + 2\text{Ag}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + 2\text{Ag}(\text{s})$

(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)



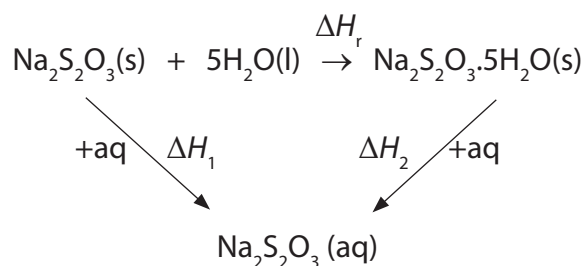
7 In an endothermic reaction in aqueous solution, which of the following is correct?

	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

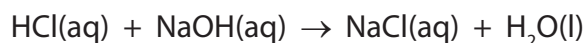
- ☐ A $\Delta H_1 + \Delta H_2$
- ☐ B $\Delta H_1 - \Delta H_2$
- ☐ C $-\Delta H_1 - \Delta H_2$
- ☐ D $-\Delta H_1 + \Delta H_2$

(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 cm³ of 2 mol dm⁻³ hydrochloric acid is reacted with 10 cm³ of 2 mol dm⁻³ sodium hydroxide solution, the temperature change is ΔT .



When the reaction is repeated with 50 cm³ 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 Al⁴⁺ 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.

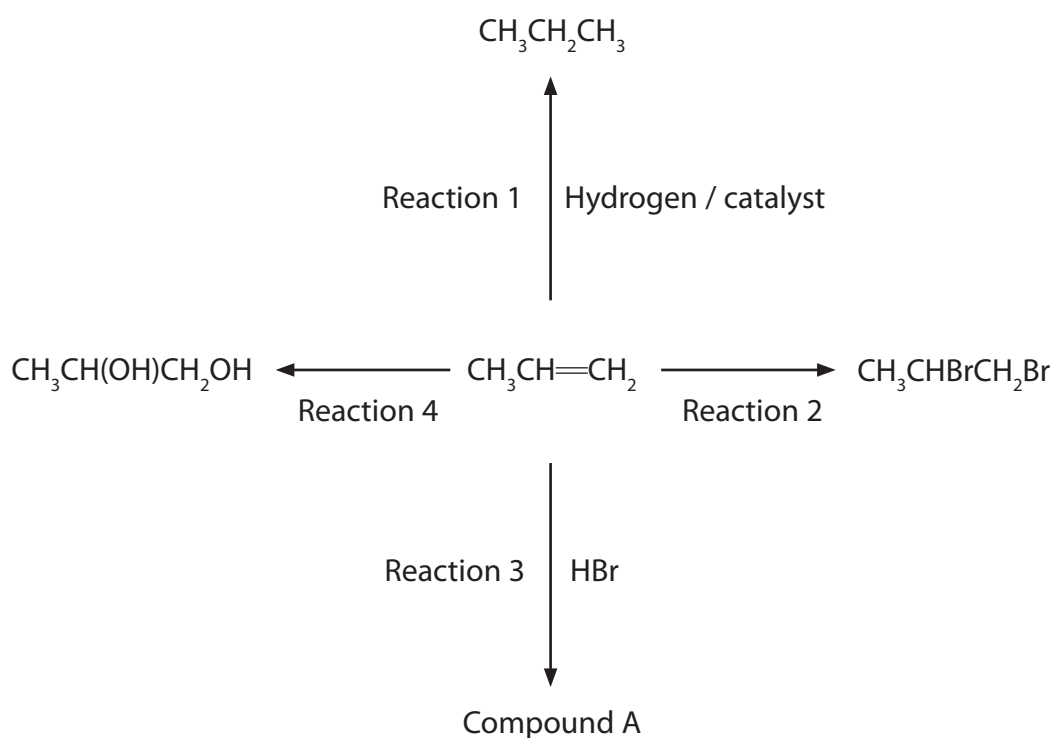
(Total for Question 15 = 1 mark)



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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



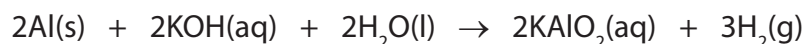
SECTION B

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

17 This question is about the preparation of the alum, potassium aluminium sulfate, $\text{KAl}(\text{SO}_4)_2 \cdot 12\text{H}_2\text{O}$. 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



- (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

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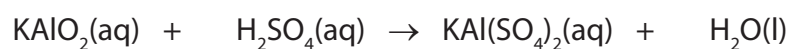
Hazard 2

.....

(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)



(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)

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*(iv) State and explain the steps necessary to obtain pure, dry crystals from the mixture.

(4)

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(v) Suggest the colour of the crystals.

(1)

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(vi) Suggest the formula of another metal ion which could form an alum, in combination with potassium and sulfate ions.

(1)

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(Total for Question 17 = 17 marks)

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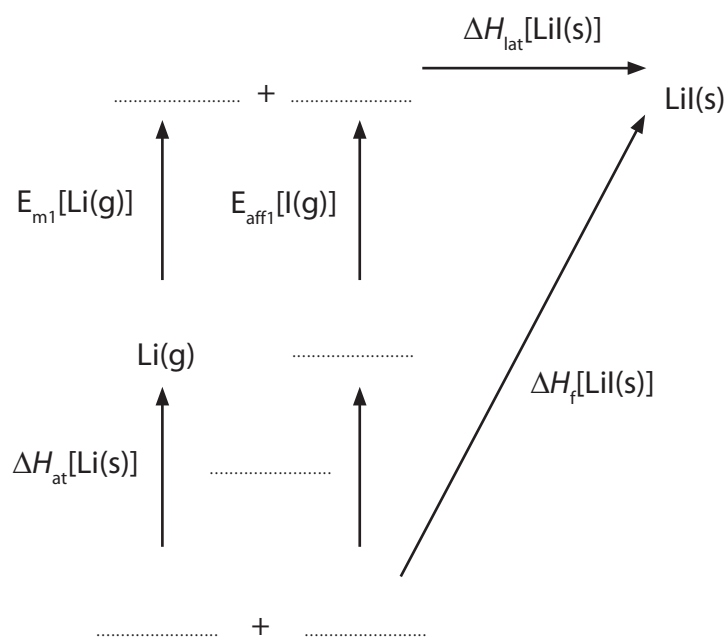
18 This question is about lithium iodide, an ionic salt.

- (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, $E_{\text{aff1}}[\text{I}(\text{g})]$, using the data below.

	$\Delta H/\text{kJ mol}^{-1}$
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)

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(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, ^1H , known as protium, ^2H , deuterium, and ^3H , tritium.

- (a) In terms of sub-atomic particles, give the similarities and differences between atoms of these three isotopes of hydrogen.

(3)

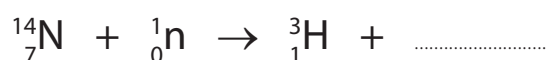
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- (b) When a nitrogen atom collides with a high energy neutron, one atom of tritium and one atom of another element are formed. Complete the equation below.

(1)



- (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 = $24\,000\text{ cm}^3\text{ mol}^{-1}$]

(1)



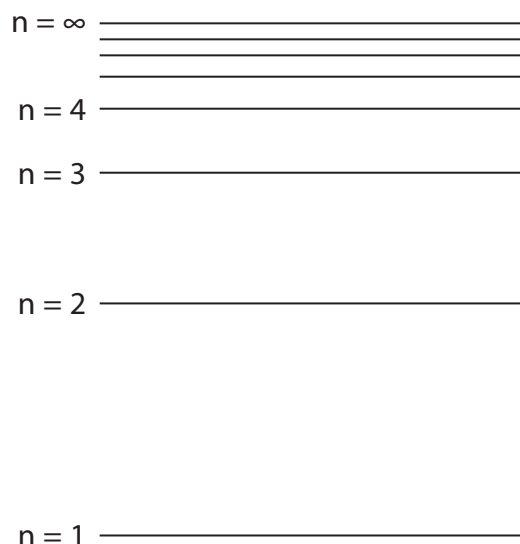
- (d) Tritium is not usually included in calculations of the relative atomic mass of hydrogen, because it is radioactive and has a relatively short half-life.

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
^1H	1.0078	99.9850
^2H	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)

.....

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(Total for Question 19 = 15 marks)

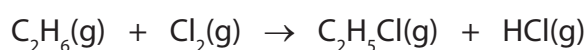


20 This question is about the gas ethane, C_2H_6 , and its reactions.

- (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.



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.



(i) State the type of reaction occurring in step 1 and the conditions needed for this step.

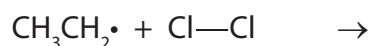
(2)

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)



(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)
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	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	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	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	Elements with atomic numbers 112-116 have been reported but not fully authenticated					
		[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[271] Ds darmstadtium 110	[272] Rg roentgenium 111
		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	173 Yb ytterbium 70
		175 Lu lutetium 71	179 Hf hafnium 72	181 Ta tantalum 73	183 W tungsten 74	186 Re rhenium 75	187 Os osmium 76
		190 Ir iridium 77	192 Pt platinum 78	195 Au gold 79	197 Hg mercury 80	200 Tl thallium 81	204 Pb lead 82
		207 Bi bismuth 83	209 Po polonium 84	210 At astatine 85	211 Rn radon 86	212 Ac actinium 87	213 Th thorium 88
		214 Pa protactinium 89	215 U uranium 90	216 Np neptunium 91	217 Pu plutonium 92	218 Am americium 93	219 Cm curium 94
		220 Bk berkelium 95	221 Cf californium 96	222 Es einsteinium 97	223 Fm fermium 98	224 Md mendelevium 99	225 No nobelium 100
		226 Lr lawrencium 101	227 Rf rutherfordium 102	228 Db dubnium 103	229 Sg seaborgium 104	230 Bh bohrium 105	231 Hs hassium 106
		232 Th thorium 90	233 Pa protactinium 91	234 U uranium 92	235 Np neptunium 93	236 Pu plutonium 94	237 Am americium 95
		238 Cm curium 96	239 Bk berkelium 97	240 Cf californium 98	241 Es einsteinium 99	242 Fm fermium 100	243 Md mendelevium 101
		244 No nobelium 102	245 Lr lawrencium 103	246 Rf rutherfordium 104	247 Db dubnium 105	248 Sg seaborgium 106	249 Bh bohrium 107
		250 Hs hassium 108	251 Mc moscovium 109	252 Lv livermorium 110	253 Ts tennessine 111	254 Og oganesson 112	255 Un unbinilium 113

* Lanthanide series

* Actinide series



Mark Scheme (Results)

January 2013

GCE Chemistry (6CH01) Paper 01
The Core Principles of Chemistry

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January 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	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)	$2\text{Al(s)} + 2\text{OH}^{\text{-}}(\text{aq}) + 2\text{H}_2\text{O(l)} \rightarrow 2\text{AlO}_2^{\text{-}}(\text{aq}) + 3\text{H}_2(\text{g})$	$2\text{O}_2^{2-}(\text{aq})$	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)	$0.02 / 2 \times 10^{-2}$ <u>Accept TE answer to (ii)</u>		1

Question Number	Acceptable Answers	Reject	Mark
17 (a) (iv)	$0.02 \times 27.0 = 0.54 / 5.4 \times 10^{-1} \text{ (g)}$ TE answer to (iii) OR (ii) $\times 27.0$ Ignore sf except 1	Other unit	1

Question Number	Acceptable Answers	Reject	Mark
17 (a) (v)	$(1.1 \times 0.54) = 0.59(4) / 5.9(4) \times 10^{-1}(\text{g})$ TE answer to (iv) $\times 1.1$ 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 / H₂ 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)	$\text{KAlO}_2(\text{aq}) + 2\text{H}_2\text{SO}_4(\text{aq}) \rightarrow \text{KAl}(\text{SO}_4)_2(\text{aq}) + 2\text{H}_2\text{O}(\text{l})$ Allow multiples		1

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	$\frac{2 \times 1000 \times 0.02}{1} = 40 \text{ (cm}^3\text{)}$ Allow 0.04(0) dm³ 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)	$\text{Cr}^{3+} / \text{Fe}^{3+} / \text{Sc}^{3+} / \text{Ga}^{3+}$ 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 $\text{KGa}(\text{SO}_4)_2 / \text{KGaO}_2$	Al^{3+} and anything else Group 3 element with incorrect charge	1

Question Number	Acceptable Answers	Reject	Mark
18 (a)	$[:\text{Li}]^+ (1) \quad \left(\begin{array}{c} \text{xx} \\ \text{xx} \text{xx} \\ \text{xx} \end{array} \right)^- (1)$ 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) $\frac{1}{2}\text{I}_2(\text{s})$ and I(g) (1) $(\Delta H_{\text{at}})[\frac{1}{2}\text{I}_2(\text{s})]$ (1) Notice the square brackets are essential for this mark If wrong state for iodine element ie if $\frac{1}{2}\text{I}_2(\text{g/l})$ and consistent $(\Delta H_{\text{at}})[\frac{1}{2}\text{I}_2(\text{g/l})]$ allow third mark If I(s) given for element and $(\Delta H_{\text{at}})[\text{I}(\text{s})]$ 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 =) $-297 \text{ (kJ mol}^{-1}\text{)}$ (1) $-297 \text{ (kJ mol}^{-1}\text{)}$ 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 (+) $297 \text{ (kJ mol}^{-1}\text{)}$ 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 iodide / negative ions (by the lithium ion). Can be shown by diagram (1) Iodine/ I / I₂ ion is not acceptable but iodine / I anion is allowed Note I₂ 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)	$({}^{14}_7\text{N} + {}^1_0\text{n} \rightarrow {}^3_1\text{H} + {}^{12}_6\text{C})$ 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) 0.8 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)	$24\,000 \times 0.8 = 19\,200 \text{ (cm}^3\text{)}$ 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

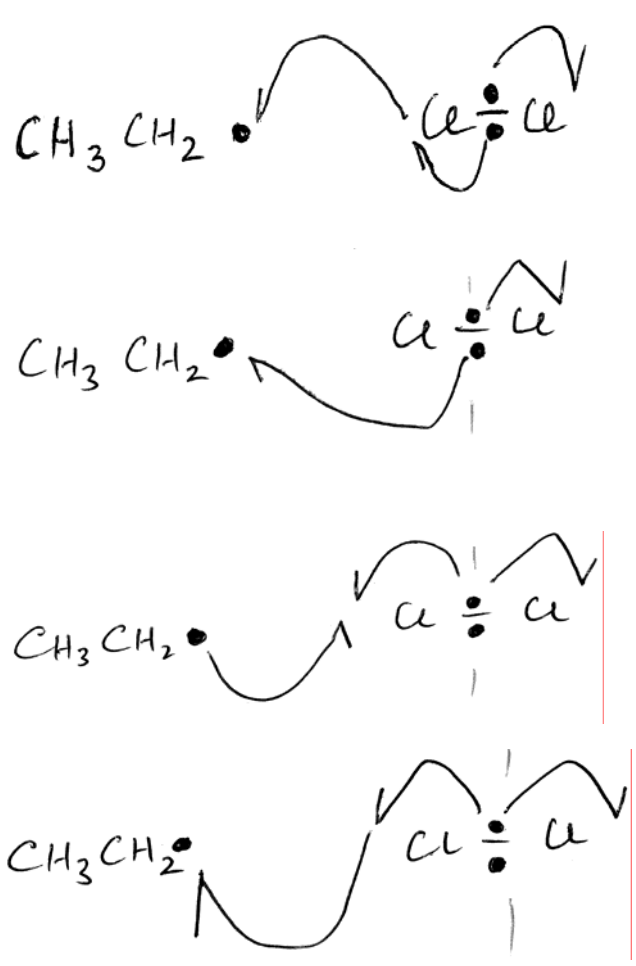
Question Number	Acceptable Answers	Reject	Mark
19 (e)(ii)	Hydrogen $1s^1$ and Sodium $1s^2 2s^2 2p^6 3s^1$ (1) Electron numbers may be on lines or subscript. Both have one (s) electron in the outer shell / orbital / sub shell OR same number of electrons / same electron(ic) configuration in outer shell / 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)	$\text{C}_2\text{H}_6(\text{g}) + 3\frac{1}{2}\text{O}_2(\text{g}) \rightarrow 2\text{CO}_2(\text{g}) + 3\text{H}_2\text{O}(\text{l})$ 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 $ \begin{array}{ccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C}-\text{C}-\text{H} & + & \text{Cl}-\text{Cl} & \rightarrow & \text{H}-\text{C}-\text{C}-\text{Cl} & + & \text{H}-\text{Cl} \\ & & & \\ \text{H} & \text{H} & \text{H} & \text{H} \end{array} $ (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)	$\text{CH}_3\text{CH}_2\cdot + \text{Cl}-\text{Cl} \rightarrow \text{CH}_3\text{CH}_2\text{Cl} + \text{Cl}\cdot$ OR $\text{CH}_3\text{CH}_2\cdot + \text{Cl}-\text{Cl} \rightarrow \text{C}_2\text{H}_5\text{Cl} + \text{Cl}\cdot$ 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)	$\text{Cl}\bullet + \text{Cl}\bullet \rightarrow \text{Cl}_2$ (1) $\bullet\text{CH}_2\text{CH}_3 + \bullet\text{CH}_2\text{CH}_3 \rightarrow \text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_3 / \text{C}_4\text{H}_{10}$ (1) $\bullet\text{CH}_2\text{CH}_3 + \text{Cl}\bullet \rightarrow \text{CH}_3\text{CH}_2\text{Cl}$ (1) Penalise missing dots once Allow $\bullet\text{C}_2\text{H}_5$ for $\bullet\text{CH}_2\text{CH}_3$ Di and tri substitution steps	C_4H_{12} $\text{CH}_3\text{CH}_2\text{CH}_3\text{CH}_2$	2

Question Number	Acceptable Answers	Reject	Mark
20 (d)	$\text{C}_2\text{H}_6 \rightarrow \text{C}_2\text{H}_4 + \text{H}_2$ Allow $2\text{C}_2\text{H}_6 \rightarrow \text{C}_2\text{H}_4 + 2\text{CH}_4$		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 alkane / alkene / ethane / ethene 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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Write your name here	
Surname	Other names
Centre Number	Candidate Number
Edexcel GCE Chemistry Advanced Subsidiary Unit 2: Application of Core Principles of Chemistry	Thurs day 21 Jan 2010 – Afternoon Time: 1 hour 30 minutes
Thurs day 21 Jan 2010 – Afternoon Time: 1 hour 30 minutes Paper Reference 6CH02/01	
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.

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N 3 5 6 9 2 A 0 1 2 4

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 Which of the following bond angles occur in a molecule of ethanol, $\text{C}_2\text{H}_5\text{OH}$?

- ☐ A 90° and 180°
- ☐ B 104.5° and 180°
- ☐ C 104.5° and 109.5°
- ☐ D 109.5° and 120°

(Total for Question 1 = 1 mark)

2 Which of the following molecules is linear?

- ☐ A Carbon dioxide, CO_2
- ☐ B Sulfur dioxide, SO_2
- ☐ C Water, H_2O
- ☐ D Methanal, HCHO

(Total for Question 2 = 1 mark)

3 Which of the following molecules contains polar bonds but is **not** a polar molecule?

- ☐ A Chlorine, Cl_2
- ☐ B Hydrogen chloride, HCl
- ☐ C Trichloromethane, CHCl_3
- ☐ D Tetrachloromethane, CCl_4

(Total for Question 3 = 1 mark)

4 Which of the following has dipole-dipole interactions between its molecules, but no hydrogen bonding?

- ☐ A Methane, CH_4
- ☐ B Methanol, CH_3OH
- ☐ C Ammonia, NH_3
- ☐ D Hydrogen iodide, HI

(Total for Question 4 = 1 mark)



5 Which list below shows the compounds in order of **increasing** boiling temperature?

- ☐ A CH₄, HCl, HF
- ☐ B HF, CH₄, HCl
- ☐ C HCl, HF, CH₄
- ☐ D HF, HCl, CH₄

(Total for Question 5 = 1 mark)

6 Which of the following has the highest boiling temperature?

- ☐ A Pentane, CH₃CH₂CH₂CH₂CH₃
- ☐ B Hexane, CH₃CH₂CH₂CH₂CH₂CH₃
- ☐ C 2-methylbutane, CH₃CH(CH₃)CH₂CH₃
- ☐ D 2-methylpentane, CH₃CH(CH₃)CH₂CH₂CH₃

(Total for Question 6 = 1 mark)

7 Which of the following could **not** be an element in Group 2?

- ☐ A An element with an oxide which forms a solution of pH 10.
- ☐ B An element with an insoluble sulfate.
- ☐ C An element with a chloride which is liquid at room temperature.
- ☐ D An element with a carbonate which decomposes on heating.

(Total for Question 7 = 1 mark)

8 Chlorides of Group 1 elements produce coloured flames when

- ☐ A electrons become excited to a higher energy level.
- ☐ B excited electrons move from a higher to a lower energy level.
- ☐ C an outer electron leaves the atom.
- ☐ D electrons move between the negative and positive ions.

(Total for Question 8 = 1 mark)



N 3 5 6 9 2 A 0 3 2 4

9 This question is about the following compounds.

A Barium carbonate

B Lithium nitrate

C Potassium bromide

D Potassium nitrate

(a) Which compound gives a green colour in a flame test?

(1)

☐ A

☐ B

☐ C

☐ D

(b) Which compound gives a lilac colour in a flame test and does **not** decompose on heating?

(1)

☐ A

☐ B

☐ C

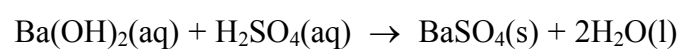
☐ D

(Total for Question 9 = 2 marks)

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



- 10 20 cm³ of sulfuric acid, concentration 0.25 mol dm⁻³, was neutralized in a titration with barium hydroxide, concentration 0.50 mol dm⁻³. The equation for the reaction is



- (a) The volume of barium hydroxide required was

(1)

- ☐ A 10 cm³
- ☐ B 20 cm³
- ☐ C 25 cm³
- ☐ D 40 cm³

- (b) During the titration, the barium hydroxide was added until it was present in excess. The electrical conductivity of the titration mixture

(1)

- ☐ A increased steadily.
- ☐ B decreased steadily.
- ☐ C increased and then decreased.
- ☐ D decreased and then increased.

(Total for Question 10 = 2 marks)

- 11 Which of the following trends occurs going down the elements in Group 2?

- ☐ A The solubility of the hydroxides increases.
- ☐ B The first ionization energy increases.
- ☐ C The solubility of the sulfates increases.
- ☐ D The stability of the carbonates to heat decreases.

(Total for Question 11 = 1 mark)

- 12 Which of the following is **not** a true statement about hydrogen iodide?

- ☐ A It forms steamy fumes in moist air.
- ☐ B It dissolves in water to form an acidic solution.
- ☐ C It forms a cream precipitate with silver nitrate solution.
- ☐ D It forms dense white smoke with ammonia.

(Total for Question 12 = 1 mark)

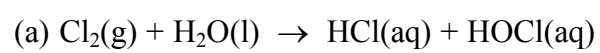


N 3 5 6 9 2 A 0 5 2 4

13 Chemical reactions may involve

- A oxidation
- B reduction
- C no change in oxidation number
- D disproportionation

Which of the terms above best describes what happens to the **chlorine** in the following reactions?



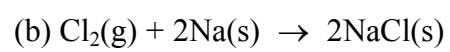
(1)

☐ A

☐ B

☐ C

☐ D



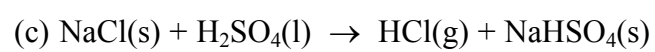
(1)

☐ A

☐ B

☐ C

☐ D



(1)

☐ A

☐ B

☐ C

☐ D

(Total for Question 13 = 3 marks)



14 When chloroethane is heated with a concentrated solution of potassium hydroxide in **ethanol**, the reaction which occurs is

- ☐ **A** substitution.
- ☐ **B** elimination.
- ☐ **C** hydrolysis.
- ☐ **D** redox.

(Total for Question 14 = 1 mark)

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



N 3 5 6 9 2 A 0 7 2 4

15 Chloroethane reacts with **aqueous** potassium hydroxide solution, producing ethanol as the organic product.

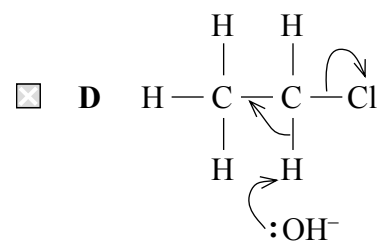
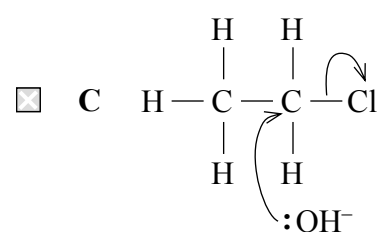
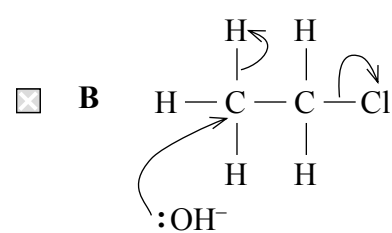
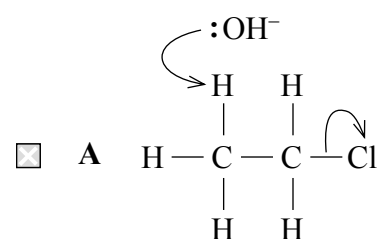
(a) The hydroxide ion is acting as

(1)

- ☐ A an electrophile.
- ☐ B a nucleophile.
- ☐ C an oxidizing agent.
- ☐ D a reducing agent.

(b) Which of the following shows the correct electron-pair movements in this reaction?

(1)



(Total for Question 15 = 2 marks)

TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

16 Magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, decomposes when it is heated. One product is the brown gas, nitrogen dioxide.

(a) (i) Write an equation for this reaction. State symbols are **not** required.

(2)

(ii) Calcium nitrate decomposes in a similar way to magnesium nitrate, but at a higher temperature.

Explain why the two nitrates have different stability to heat.

(2)

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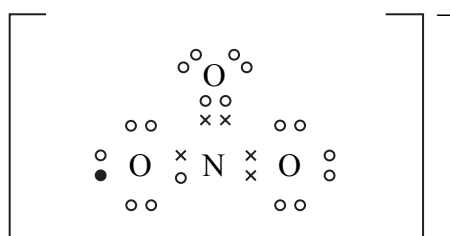
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(b) Sodium nitrate decomposes to give different products to magnesium nitrate. Write an equation for the decomposition of sodium nitrate. State symbols are **not** required.

(1)



(c) A student suggested that the structure of the nitrate ion, NO_3^- , is



Scientists have found that the bonds between nitrogen and oxygen in the nitrate ion are all the same length. Is the student's suggestion supported by this evidence? Explain your answer.

(1)

.....

.....

.....

(d) Nitrogen dioxide gas can dimerize to dinitrogen tetroxide, N_2O_4 , a very pale yellow gas, as shown in the equation below.



(i) What would you see when an equilibrium mixture of these gases is warmed gently? Explain your answer.

(2)

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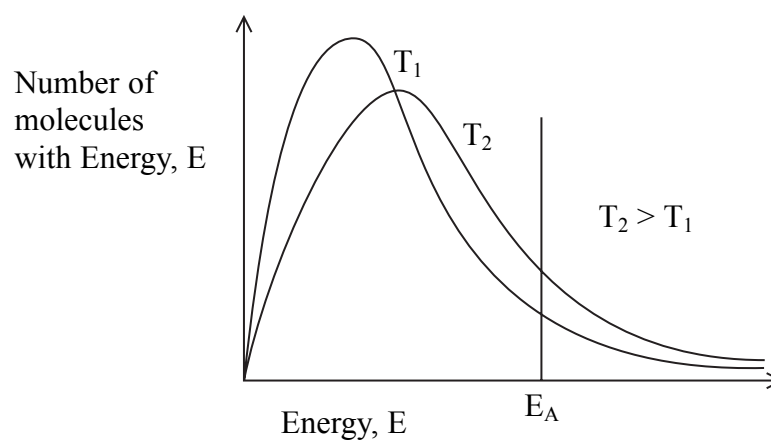
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- (ii) Explain why an equilibrium mixture of these gases eventually becomes paler in colour when the pressure on it is increased.

(2)

- (e) Two Maxwell-Boltzmann distributions showing the energy of particles in a gas at different temperatures, T_1 and T_2 , are shown below. The activation energy for the reaction is labelled E_A .



Use the distributions to explain why gases react faster when the temperature is increased.

(2)

(Total for Question 16 = 12 marks)



N 3 5 6 9 2 A 0 1 1 2 4

17 This question is about some reactions of halogens and halide ions.

- (a) (i) When chlorine is added to a solution containing bromide or iodide ions, a colour change occurs. What solvent would you add to the mixture to confirm the identity of the halogen produced?

(1)

- (ii) Give the result for the test with this solvent in a reaction in which bromine is produced.

(1)

- (b) (i) Solid potassium bromide and potassium iodide can be distinguished by their reactions with concentrated sulfuric acid.

Potassium bromide reacts with concentrated sulfuric acid initially to produce hydrogen bromide. This reacts further, as shown below, to produce a sharp smelling gas and a brown fuming liquid.



Show, by use of oxidation numbers for sulfur, that the sulfuric acid has been reduced.

(2)

- (ii) State TWO observations, which would differ from those with potassium bromide, when potassium iodide reacts with concentrated sulfuric acid.

(2)



(1)

(1)

N 3 5 6 9 2 A 0 1 3 2 4

18 Butan-1-ol and three other alcohols, **X**, **Y** and **Z**, are isomers.

- (a) (i) Give TWO observations you would make when any one of the alcohols reacts with sodium.

(2)

.....

.....

.....

- (ii) Give the molecular formula of the organic product of the reaction.

(1)

.....

- (b) Isomer **X** does **not** react with a mixture of potassium dichromate(VI) and sulfuric acid.

Draw the displayed formula of **X** and name it.

(2)

Name

- (c) When isomer **Y** is heated under reflux with a mixture of potassium dichromate(VI) and sulfuric acid, it forms 2-methylpropanoic acid.

Deduce the structural formula of the alcohol **Y**.

(1)



- (d) (i) Isomer **Z** reacts with a mixture of potassium dichromate(VI) and sulfuric acid to form a compound **Q**, which does **not** react with Fehling's or Benedict's solution.

Deduce the structural formula of the alcohol **Z**.

(1)

- (ii) What would be the principal difference between the infrared spectrum of **Q** and the infrared spectrum of 2-methylpropanoic acid?

You are **not** expected to quote absorption values.

(1)

- (e) One of the isomers, **X**, **Y** or **Z** can be converted to 2-chlorobutane.

What reagent would you use to carry out this conversion?

(1)

- (f) (i) 2-chlorobutane reacts with silver nitrate in a mixture of ethanol and water as a solvent. What would you see when the reaction occurred?

(1)

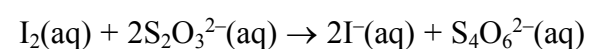
- *(ii) Both ethanol and water contain hydrogen bonds. By considering the hydrogen bonding on these two solvents, suggest why 2-chlorobutane is more soluble in ethanol than in water.

(2)

(Total for Question 18 = 12 marks)



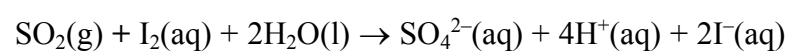
- 19 The concentration of iodine in solution can be measured by titration with sodium thiosulfate solution.



- (a) Name a suitable indicator which could be used for this titration.

(1)

- (b) The amount of sulfur dioxide in the atmosphere can be measured by passing a known volume of air through iodine solution. Sulfur dioxide converts iodine to iodide ions.



In an experiment, 100 m³ of air were passed through 100 cm³ of iodine, concentration 0.0100 mol dm⁻³. The remaining iodine was titrated with sodium thiosulfate solution and reacted with 12.60 cm³ of sodium thiosulfate, concentration 0.100 mol dm⁻³.

- (i) How many moles of iodine were present in the solution of the iodine at the start of the experiment?

(1)

- (ii) How many moles of iodine remained in the solution at the end of the experiment?

(2)

- (iii) Calculate the number of moles of iodine which **reacted** with the sulfur dioxide, and hence the number of moles of sulfur dioxide in 100 m³ of air.

(2)



- (iv) The European Commission recommend exposure to sulfur dioxide in air should be less than 350 micrograms (350×10^{-6} g) per cubic metre.

Calculate whether the sulfur dioxide in this sample of air was within this limit.
One mole of sulfur dioxide has mass 64.1 g.

(2)

- (c) Explain whether the changes below would or would not improve the experimental procedure for measuring the concentration of sulfur dioxide in air used in (b).

- (i) The 100 cm^3 of iodine was divided into 25 cm^3 samples before titration.

(1)

- (ii) The concentration of sodium thiosulfate used to titrate the iodine was changed from $0.100 \text{ mol dm}^{-3}$ to $0.050 \text{ mol dm}^{-3}$.

(2)

- (iii) 150 m^3 of air was passed through the iodine. The solutions used were of the same concentrations as in the original experiment.

(2)

(Total for Question 19 = 13 marks)

TOTAL FOR SECTION B = 45 MARKS



N 3 5 6 9 2 A 0 1 7 2 4

SECTION C

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

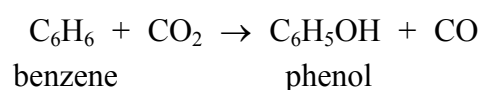
20

Fuel from the air?

A new catalyst that can break down carbon dioxide gas could allow us to use carbon from the atmosphere as a fuel source in a similar way to plants.

Plants break the stable bonds in carbon dioxide during photosynthesis. In the natural process, the carbon dioxide molecule is initially bonded to nitrogen atoms, making reactive compounds called carbamates. Carbamates are derivatives of carbamic acid, $\text{NH}_2\text{CO}_2\text{H}$. These compounds can then be broken down, allowing the carbon to be used in the synthesis of other plant products such as sugars and proteins.

A new catalyst produced by scientists is a graphite-like compound made from flat layers of carbon and nitrogen atoms arranged in hexagons. Carbon dioxide binds to the catalyst and takes part in the following reaction, which occurs at 150°C and at about three times atmospheric pressure.



Carbon monoxide can then be used to make liquid fuels such as methanol.

The energy required for photosynthesis comes from light, and experiments are now going on to develop a light activated catalyst which could break down carbon dioxide in a new process.

(Source: adapted from an article from the *NewScientist.com* by Tom Simonite, March 2007)

- *(a) Why are the bonds **within** a layer of carbon atoms in graphite stronger than the bonds **between** the layers of carbon atoms?

(2)

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(b) The data below gives the relative electrical conductivity of a pure graphite crystal.

Relative conductivity in plane of carbon hexagons	Relative conductivity perpendicular to plane of carbon hexagons
3.7	0.0017

Explain why the relative electrical conductivity of graphite differs with direction.

(2)

(c) Suggest why the strength of the bond between the layers in graphite would increase if some carbon atoms were replaced with nitrogen atoms.

(2)

(d) Suggest ONE benefit of using a light activated catalyst for the new process.

(1)



(e) The liquid fuel, methanol, is made by reacting carbon monoxide with hydrogen.

Write an equation for this reaction. State symbols are **not** required.

(1)

*(f) Benzene, which is needed for the new process of breaking down carbon dioxide, can be made from coal. It is now usually made by catalytic treatment of one fraction of crude oil at temperatures of around 500 °C and 20 atmospheres pressure.

Suggest the benefits and disadvantages of breaking down carbon dioxide using benzene and the catalyst as described in the passage. You should consider

- the energy and resources needed
- the effects on the atmosphere
- whether it is a beneficial method for producing energy compared to direct use of fossil fuels.

(6)

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(g) Carbon exists in forms other than graphite. Nanotubes are rolls of graphite layers, and fullerenes are cages of carbon atoms. Both nanotubes and fullerenes can trap other substances in their structures, and fullerenes can be coated with other substances.

Give ONE application of carbon nanotubes or fullerenes which exploits this behaviour.

(1)

(Total for Question 20 = 15 marks)

TOTAL FOR SECTION C = 15 MARKS
TOTAL FOR PAPER = 80 MARKS



N 3 5 6 9 2 A 0 2 1 2 4

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1.0	H	hydrogen	1
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Mark Scheme (Results) January 2010

GCE

GCE Chemistry (6CH02/01)

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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.

6CH02/01

Section A

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	D		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	C		1

Question Number	Correct Answer	Reject	Mark
8	B		1

Question Number	Correct Answer	Reject	Mark
9(a)	A		1

Question Number	Correct Answer	Reject	Mark
9(b)	C		1

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

Question Number	Correct Answer	Reject	Mark
10(b)	D		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)	D		1

Question Number	Correct Answer	Reject	Mark
13(b)	B		1

Question Number	Correct Answer	Reject	Mark
13(c)	C		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)	C		1

Section B

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	$2\text{Mg}(\text{NO}_3)_2 \rightarrow 2\text{MgO} + 4\text{NO}_2 + \text{O}_2$ Correct formulae (1) Balancing (1) ALLOW multiples or equation divided by 2 Second mark on correct species only Ignore state symbols even if incorrect ALLOW N_2O_4 Extra oxygen molecules on both sides in a balanced equation		2

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	Stand alone marks Mg^{2+} / Magnesium ion smaller or fewer electron shells / greater charge density (1) OR Magnesium ion has same charge (as calcium ion) but is smaller (1) Causes more polarisation / distortion of nitrate / anion (electron clouds) / N–O (bond)(1) OR MgO produced has stronger lattice (1) OR production of MgO is more exothermic (1) OR reverse argument based on Ca^{2+}	Magnesium / calcium / atoms / molecules	2

Question Number	Acceptable Answers	Reject	Mark
16(b)	$2\text{NaNO}_3 \rightarrow 2\text{NaNO}_2 + \text{O}_2$ ALLOW multiples or equation divided by 2 Ignore state symbols even if incorrect ALLOW Extra oxygen molecules on both sides in a balanced equation		1

Question Number	Acceptable Answers	Reject	Mark
16(c)	No as.... double bond would be shorter (than single bond) / shorter than dative (covalent) bond. ALLOW Structure has double and single bonds (between N and O) Double and single bonds have different lengths	Implication that the single covalent and dative covalent bonds have different lengths	1

Question Number	Acceptable Answers	Reject	Mark
16(d)(i)	Mark independently Goes darker (brown) (1) ALLOW Goes browner Ignore comments on mixture first becoming paler if volume increases Equilibrium moves in the endothermic direction (1) OR Equilibrium moves left as forward reaction is exothermic (1) For second mark ALLOW Equilibrium moves left to counteract addition of heat / increase in temperature(1) OR Reaction removes added heat by moving left (1)	Brown (gas evolved)	2

Question Number	Acceptable Answers	Reject	Mark
16(d)(ii)	Equilibrium moves right (ALLOW forwards) (so NO₂ concentration decreases) (1) OR Reaction reduces pressure (1) As fewer moles / molecules(ALLOW particles) (of gas) on RHS (1) Stand alone marks		2

Question Number	Acceptable Answers	Reject	Mark
16(e)	At T₂ more molecules/collisions have energy greater than (or equal to) E_A (1) This can be shown on the diagram by indicating areas to right of vertical line Energy must be at least E_A for successful collision / for reaction (1) OR So more collisions have sufficient energy to react(1) Ignore references to the average energy and speed of the molecules		2

Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	A hydrocarbon (solvent) / volasil / named hydrocarbon solvent / tetrachloromethane Formulae	Ethanol Alkenes	1

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	Red / brown / orange / amber / yellow Or any combination No TE on incorrect / no reagent		1

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	Oxidation number of S in H_2SO_4 = (+)6 Oxidation number of S in SO_2 = (+)4 (1) Oxidation number had decreased (1) ALLOW S has gained electrons for second mark Second mark stands alone provided oxidation numbers have decreased, even if calculated wrongly	Just 'S has gained electrons' without calculating oxidation numbers	2

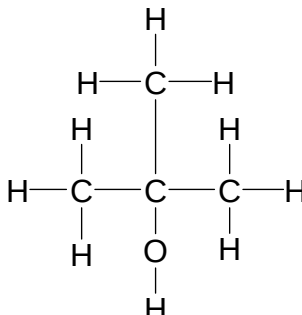
Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	Black / (shiny) grey solid (1) Purple / violet / pink vapour / fumes (1) Smell of (bad) eggs (1) Yellow solid (1) ALLOW Brown liquid (1) Any two	Purple solid	2

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	Oxidation number of S has reduced more / to -2 (in H_2S) (1) OR Oxidation number of S is lower in H_2S (than in SO_2) If ON of S in H_2S is calculated it must be correct		1

Question Number	Acceptable Answers	Reject	Mark
17(c)	People can choose whether to take extra fluoride ALLOW Fluoride is not released into the environment	Fluoride can be monitored	1

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	Effervescence / fizzing / bubbles (of colourless gas) (1) Mixture gets hot (1) White solid (ALLOW ppt) produced / sodium dissolves or disappears (1) Any two Ignore inferences unless incorrect		2

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	C_4H_9ONa / $C_4H_9O^-Na^+$ / structural or displayed formulae of any of the isomers: $CH_3CH_2CH_2CH_2ONa$ $(CH_3)_2CHCH_2ONa$ $(CH_3)_3CONa$ $CH_3CH(ONa)CH_2CH_3$	Structures showing a covalent bond between O and Na C_4H_9NaO / $C_4H_9Na^+O^-$	1

Question Number	Acceptable Answers	Reject	Mark
18(b)	 Do not penalise undisplayed CH_3 or $O-H$ (1) (2-)methylpropan-2-ol(1) Marks are stand alone	Missing hydrogen atoms Skeletal formula	2

Question Number	Acceptable Answers	Reject	Mark
18(c)	$(CH_3)_2CHCH_2OH$ OR correct displayed formula OR semi-displayed formula ALLOW $CH_3CH(CH_3)CH_2OH$ ALLOW missing bracket round CH_3 in this version Ignore names	Missing hydrogen atoms Skeletal formula	1

Question Number	Acceptable Answers	Reject	Mark
18(d)(i)	$\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ (1) OR correct displayed formula OR semi-displayed formula Do not penalise missing bracket round OH Ignore names	Missing hydrogen atoms Skeletal formula	1

Question Number	Acceptable Answers	Reject	Mark
18(d)(ii)	O—H absorption / peak in 2-methylpropanoic acid / No O—H absorption / peak in Q ALLOW C—O absorption / peak in 2-methylpropanoic acid / No C—O absorption / peak in Q Ignore references to broad or sharp peaks and to the fingerprint region		1

Question Number	Acceptable Answers	Reject	Mark
18(e)	PCl_5 / PCl_3 / conc HCl / SOCl_2 / mixture of $\text{NaCl} + \text{H}_2\text{SO}_4$ / mixture of $\text{KCl} + \text{H}_2\text{SO}_4$ Ignore reference to concentration of H_2SO_4 OR Names	Hydrogen chloride Conc hydrogen chloride HCl $\text{PCl}_5(\text{aq})$, $\text{PCl}_3(\text{aq})$, $\text{SOCl}_2(\text{aq})$	1

Question Number	Correct Answer	Reject	Mark
18(f)(i)	White precipitate/ white solid		1

Question Number	Acceptable Answers	Reject	Mark
18(f)(ii) QWC	Water has 2 hydrogen bonds per molecule (on average) whereas ethanol only has 1 (1) ALLOW Water has more hydrogen bonds (per molecule) than ethanol Needs more energy to break H bonds in water (so less soluble) / H bonding (ALLOW intermolecular forces) stronger in water (1) Second mark dependent on first. Ignore references to London, dispersion and van der Waals forces		2

Question Number	Acceptable Answers	Reject	Mark
19(a)	Starch (solution)		1

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	I_2 at start = $1 \times 10^{-3} / 0.001$ (mol)		1

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	1.26×10^{-3} (mol) thiosulfate (1) $6.3(0) \times 10^{-4} / 0.00063$ (mol) I_2 (1) Correct answer with no working (2) Ignore SF except 1 SF		2

Question Number	Acceptable Answers	Reject	Mark
19(b)(iii)	I_2 used = $(1 \times 10^{-3} - 6.30 \times 10^{-4}) = 3.70 \times 10^{-4}$ (mol) (1) Mol SO_2 = mol $I_2 = 3.70 \times 10^{-4} / 0.00037$ (mol) (1) Correct answer with no working (1) ALLOW TE from (i) and (ii) Ignore SF except 1 SF		2

Question Number	Acceptable Answers	Reject	Mark
19(b)(iv)	Mass SO_2 in $100 \text{ m}^3 = (64.1 \times 3.70 \times 10^{-4})$ (1) Mass SO_2 in $1 \text{ m}^3 = 64.1 \times 3.70 \times 10^{-4} / 100$ $= 237(.2) \times 10^{-6} \text{ g} = 2.37 \times 10^{-4} \text{ g}$ (1) $(= 237.2 / 237 / 240 \text{ } \mu\text{g})$ units required $(\therefore \text{ within limit})$ Allow TE from (iii) Ignore SF except 1 SF		2

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	Improved because titration may be repeated / averages could be taken ALLOW Smaller titration reading so greater (%) error		1

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Larger titration reading (1) So smaller (%)error in titration reading (1) OR Smaller mass of sodium thiosulfate used to make solution (1) So greater %) error in the mass measurement (1) Second mark dependent on correct first or near miss		2
Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	Smaller titration reading as more I_2 reacts/ less I_2 left (1) So greater (%) error in titration reading (1) Second mark dependent on correct first or near miss) OR Smaller (%) error in measuring volume of air (1)		2

Section C

Question Number	Acceptable Answers	Reject	Mark
20(a) QWC	(Strong) covalent bonds between atoms within the layers / good overlap of electron orbitals in layers (1) (Weak) London / dispersion / induced dipole-induced dipole (ALLOW van der Waals) forces between layers (1)	Intermolecular forces alone	2

Question Number	Acceptable Answers	Reject	Mark
20(b)	Within a layer, one electron per carbon is (ALLOW electrons are) delocalized (so electrons can move easily along layers) (1) Energy gap (ALLOW distance) between layers is too large for (easy) electron transfer (1)	Electrons between layers not delocalized	2

Question Number	Acceptable Answers	Reject	Mark
20(c)	N has one more (outer shell) electron than C(1) Would increase number of (delocalised) electrons ... contributing to the London / dispersion (ALLOW van der Waals) forces (1) OR holding layers together (1)	Just London / dispersion / van der Waals) forces stronger	2

Question Number	Acceptable Answers	Reject	Mark
20(d)	No heat energy required / low energy requirement / high temperatures not needed / sunlight (which is renewable) could be used Ignore generalisations such as 'greener', 'environmentally friendly' 'smaller carbon footprint' cheaper or fossil fuels not used.		1

Question Number	Acceptable Answers	Reject	Mark
20 (e)	$\text{CO} + 2\text{H}_2 \rightarrow \text{CH}_3\text{OH}$ OR Structural and displayed formulae ALLOW CH_4O for CH_3OH		1

Question Number	Acceptable Answers	Reject	Mark
20 (f) QWC	Score 1 mark for each clearly made point 1. Need energy to make benzene / catalyst / hydrogen 2. High energy / temperature / pressure needed for the reaction (ALLOW stated T or P) 3. Fossil fuel (oil or coal) used as source of energy, benzene or hydrogen 4. Hydrogen has to be manufactured 5. Hydrogen has to be stored 6. Fossil fuels non-renewable 7. Reduces CO₂ in atmosphere / recycles CO₂ 8. CO₂ is a greenhouse gas / causes global warming 9. CO toxic 10. Benzene toxic / carcinogenic 11. 100% atom economy in making methanol 12. Beneficial if phenol useful / not beneficial if phenol a waste product Ignore generalisations such as 'greener', 'smaller carbon footprint' or 'environmentally friendly'.	References to the ozone layer	6

Question Number	Acceptable Answers	Reject	Mark
20 (g)	Delivering drugs to cells ALLOW Delivering drugs to specific / targeted parts of the body Catalyst with big surface area	Just drug delivery	1

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Centre Number	Candidate Number
Edexcel GCE Chemistry Advanced Subsidiary Unit 2: Application of Core Principles of Chemistry	Monday 7 June 2010 – Morning Time: 1 hour 30 minutes Paper Reference 6CH02/01
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.

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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 This question is about bond angles.

- A 90°
- B 104°
- C 107°
- D 109.5°

Select, from A to D above, the most likely value for the bond angle of

(a) HCH in methane, CH₄.

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(b) FSF in sulfur hexafluoride, SF₆.

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(c) FOF in oxygen difluoride, OF₂.

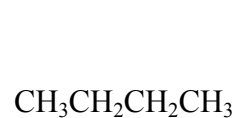
(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

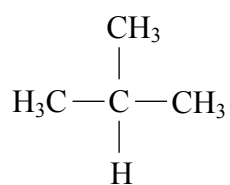
(Total for Question 1 = 3 marks)



2 Consider the following compounds, **P**, **Q**, **R** and **S**.



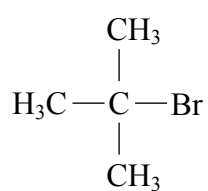
Compound P



Compound Q



Compound R



Compound S

The boiling temperatures of compounds P, Q, R and S **increase** in the order

- ☐ **A** P Q R S
- ☐ **B** R S P Q
- ☐ **C** Q S P R
- ☐ **D** Q P S R

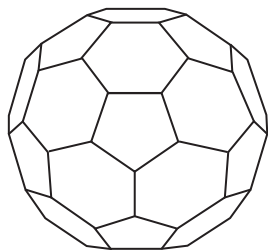
(Total for Question 2 = 1 mark)

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



N 3 6 3 9 0 A 0 3 2 4

- 3 Buckminsterfullerene has the formula C_{60} . Its structure is shown below.



The bonding in buckminsterfullerene is similar to the bonding in graphite.

Which of the following is true?

- ☐ A All the bond angles in buckminsterfullerene are 120° .
- ☐ B The melting temperature of buckminsterfullerene is higher than that of graphite.
- ☐ C There are delocalized electrons in buckminsterfullerene.
- ☐ D On complete combustion, buckminsterfullerene forms carbon dioxide and water.

(Total for Question 3 = 1 mark)

- 4 When concentrated sulfuric acid is added to solid sodium bromide, bromine is produced.

When concentrated sulfuric acid is added to solid sodium chloride, **no** chlorine is produced.

The reason for this difference is

- ☐ A sulfuric acid is a strong acid.
- ☐ B hydrogen chloride is a weak acid.
- ☐ C the chloride ion is a weaker reducing agent than the bromide ion.
- ☐ D bromine is less volatile than chlorine.

(Total for Question 4 = 1 mark)

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



- 5 Compound **X** is a white solid. On heating this compound, a colourless, acidic gas is the only gaseous product. A flame test is carried out on the solid residue and a reddish flame is observed.

Compound **X** is

- ☐ A calcium nitrate.
- ☐ B calcium carbonate.
- ☐ C magnesium carbonate.
- ☐ D strontium nitrate.

(Total for Question 5 = 1 mark)

- 6 Which of the following does **not** apply to the elements Mg, Ca, Sr and Ba in Group 2 of the Periodic Table?

- ☐ A Their oxides, MO, are all basic.
- ☐ B Their metal hydroxides, M(OH)₂, become more soluble down the group.
- ☐ C Their oxides, MO, react with water to form the metal hydroxide, M(OH)₂.
- ☐ D Their carbonates, MCO₃, all decompose on gentle heating.

(Total for Question 6 = 1 mark)

- 7 Which of the following compounds shows hydrogen bonding in the liquid state?

- ☐ A Hydrogen bromide, HBr
- ☐ B Hydrogen sulfide, H₂S
- ☐ C Silane, SiH₄
- ☐ D Ammonia, NH₃

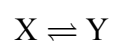
(Total for Question 7 = 1 mark)

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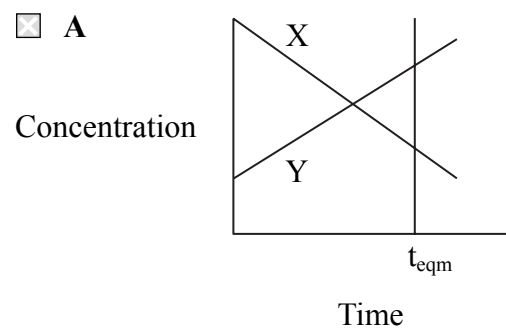
N 3 6 3 9 0 A 0 5 2 4

8 For the reversible reaction

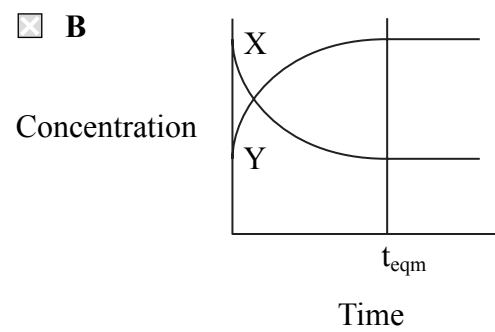


which of the following could represent the change in the concentrations of X and Y with time, starting with a mixture of both X and Y? Equilibrium is reached at time t_{eqm} .

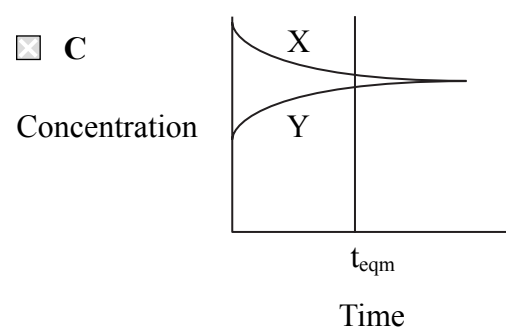
☒ A



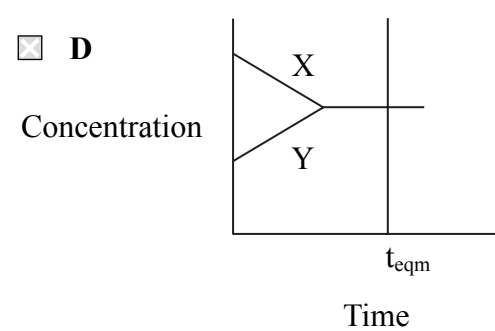
☒ B



☒ C



☒ D



(Total for Question 8 = 1 mark)

9 Which of the following molecules is polar?

☒ A Carbon dioxide, CO_2

☒ B Beryllium chloride, BeCl_2

☒ C Ammonia, NH_3

☒ D Boron trifluoride, BF_3

(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 electronegativities of four pairs of elements are given below. Which pair would form the compound with the greatest ionic character?

- ☐ A 0.7 and 4.0
- ☐ B 0.7 and 3.5
- ☐ C 1.0 and 4.0
- ☐ D 0.8 and 2.8

(Total for Question 10 = 1 mark)

11 Which of the following statements about the elements in Group 7 is **incorrect**?

- ☐ A They all show variable oxidation states in their compounds.
- ☐ B They all form acidic hydrides.
- ☐ C Electronegativity decreases as the group is descended.
- ☐ D They all exist as diatomic molecules.

(Total for Question 11 = 1 mark)

12 What are the products, other than water, when chlorine is passed through cold, dilute aqueous sodium hydroxide solution?

- ☐ A NaCl and NaClO
- ☐ B NaClO and NaClO₃
- ☐ C NaCl and NaClO₃
- ☐ D NaClO and NaClO₄

(Total for Question 12 = 1 mark)

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



N 3 6 3 9 0 A 0 7 2 4

13 When solutions of iodine are titrated with aqueous sodium thiosulfate solution, $\text{Na}_2\text{S}_2\text{O}_3(\text{aq})$, the thiosulfate ions are oxidized to

- ☐ A $\text{S}_2\text{O}_4^{2-}$
- ☐ B $\text{S}_2\text{O}_6^{2-}$
- ☐ C $\text{S}_2\text{O}_8^{2-}$
- ☐ D $\text{S}_4\text{O}_6^{2-}$

(Total for Question 13 = 1 mark)

14 The best method of converting ethanol, $\text{C}_2\text{H}_5\text{OH}$, into iodoethane, $\text{C}_2\text{H}_5\text{I}$, is to

- ☐ A heat iodine and ethanol under reflux.
- ☐ B react ethanol and potassium iodide in the presence of dilute acid.
- ☐ C heat potassium iodide and ethanol with concentrated sulfuric acid.
- ☐ D heat red phosphorus, ethanol and iodine under reflux.

(Total for Question 14 = 1 mark)

15 The use of poly(ethene) packaging has been criticised mainly because

- ☐ A the complete combustion of poly(ethene) produces dangerous fumes.
- ☐ B large amounts of oil are consumed in producing the monomer, ethene.
- ☐ C poly(ethene) degrades to form toxic products.
- ☐ D the catalyst used in the polymerization of ethene is expensive.

(Total for Question 15 = 1 mark)

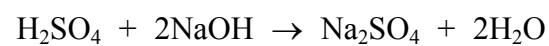
16 Which of the following is essential if a species is to act as a nucleophile?

- ☐ A A lone pair of electrons.
- ☐ B A negative charge.
- ☐ C An unpaired electron.
- ☐ D A strongly polar bond.

(Total for Question 16 = 1 mark)



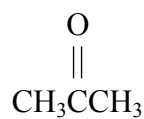
- 17 Calculate the volume of dilute sulfuric acid, concentration $0.500 \text{ mol dm}^{-3}$, required to neutralize 20.0 cm^3 aqueous sodium hydroxide, concentration $0.100 \text{ mol dm}^{-3}$.



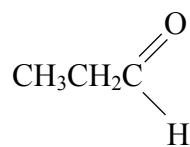
- ☐ A 2.0 cm^3
☐ B 4.0 cm^3
☐ C 8.0 cm^3
☐ D 20.0 cm^3

(Total for Question 17 = 1 mark)

- 18 Which of the following features is shown by the mass spectra of propanone and propanal?



propanone



propanal

		m/e of the molecular ion	Fragmentation pattern
☐	A	same	same
☐	B	same	different
☐	C	different	same
☐	D	different	different

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

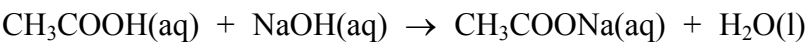


N 3 6 3 9 0 A 0 9 2 4

SECTION B

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

- 19 A student carried out an experiment to determine the concentration of ethanoic acid in a solution of vinegar.
- The student used a measuring cylinder to measure out 25.0 cm³ of the vinegar solution.
 - This solution was then transferred to a 250 cm³ volumetric flask and the liquid level was carefully made up to the mark with distilled water.
 - A pipette was used to transfer 25.0 cm³ portions of the acidic solution to conical flasks.
 - The solution was then titrated with sodium hydroxide solution, concentration 0.100 mol dm⁻³, using phenolphthalein as the indicator.



Results

Titration number	1	2	3	4
Burette reading (final) / cm ³	28.55	28.00	40.35	28.05
Burette reading (initial) / cm ³	0.00	0.05	12.30	0.05
Volume of NaOH used / cm ³	28.55	27.95	28.05	28.00

- (a) In this titration, what is the colour change of the phenolphthalein indicator? (2)

From to

- (b) Explain why the mean titre should be based only on titrations 2, 3 and 4. (1)

.....

.....

.....



(c) Calculate the mean titre in cm^3 .

(1)

(d) (i) Using your answer to (c), calculate the number of moles of sodium hydroxide in the mean titre.

(1)

(ii) Hence state the number of moles of ethanoic acid, CH_3COOH , in 25.0 cm^3 of the **diluted** solution used in the titration.

(1)

(iii) Calculate the concentration of the **diluted** acid solution in mol dm^{-3} .

(1)



N 3 6 3 9 0 A 0 1 1 2 4

(iv) Hence calculate the concentration of the ethanoic acid in the **original** vinegar solution in mol dm^{-3} .

(1)

(v) Use your answer from (d)(iv) to state the concentration of the ethanoic acid in the **original** vinegar solution in units of g dm^{-3} .

[The molar mass of the ethanoic acid is 60 g mol^{-1} .]

(1)

(e) Suggest, with a reason, how the student's method of preparing the diluted solution could be improved.

(2)

Improvement

.....

.....

Reason

.....

.....



(f) The burette used in the titration had an uncertainty for each reading of $\pm 0.05 \text{ cm}^3$.

(i) Identify, by letter, which ONE of the following should be regarded as the true value of the titre in titration number 2?

X Between 27.90 and 28.00 cm^3

Y Between 27.925 and 27.975 cm^3

Z Between 27.85 and 28.05 cm^3

(1)

(ii) Suggest ONE reason why a student may obtain volumes outside the uncertainty of the burette when performing a titration.

(1)

(Total for Question 19 = 13 marks)



N 3 6 3 9 0 A 0 1 3 2 4

20 (a) Propene, C_3H_6 , reacts with hydrogen bromide, HBr , in an electrophilic addition reaction.

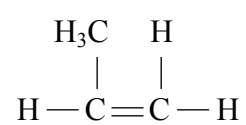
2-bromopropane is formed as the major product.



- (i) Complete the mechanism for the reaction, using 'curly arrows' where appropriate. Show clearly the structure of the intermediate carbocation formed.

(3)

Mechanism



(ii) Draw the structure of the alternative carbocation that can be formed in the reaction between propene and hydrogen bromide.

(1)

(b) Four isomers, each with the molecular formula $C_4H_{10}O$, are shown below.

Isomer **A**: $CH_3CH_2CH_2CH_2OH$

Isomer **B**: $CH_3CH_2CH(OH)CH_3$

Isomer **C**: $(CH_3)_3COH$

Isomer **D**: $CH_3CH(CH_3)CH_2OH$

(i) Which isomer is a secondary alcohol? Justify your answer.

(2)

.....

.....

.....

.....

(ii) Which isomer is resistant to oxidation when heated with acidified potassium dichromate(VI)? Justify your answer in terms of the structure of the isomer.

(2)

.....

.....

.....

.....



(iii) Which isomer can be oxidized to a ketone? Draw the displayed formula of the ketone produced.

(1)

(iv) Which isomers can be oxidized to an aldehyde?

(1)

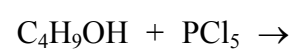
(v) Phosphorus(V) chloride (phosphorus pentachloride), PCl_5 , is used to test for the presence of an $-\text{OH}$ group.

What would you expect to see when any of the above four isomers, A, B, C or D, are reacted with phosphorus(V) chloride?

(1)

(vi) Complete the equation for the reaction shown below. State symbols are **not** required.

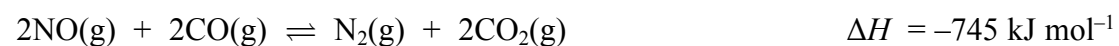
(2)



(Total for Question 20 = 13 marks)



21 (a) In the catalytic converter of a car engine's exhaust system, the following reaction occurs.



The temperature in a catalytic converter is high.

- (i) State the effect, if any, on the position of equilibrium if the temperature is lowered. Give a reason for your answer.

(2)

Effect.....

Reason.....

- (ii) The gases from the engine are **not** cooled before entering the converter. Explain why this is so.

(2)

- (iii) State the effect, if any, on the position of equilibrium if the pressure on the reacting gases is increased. Give a reason for your answer.

(2)

Effect.....

Reason.....



N 3 6 3 9 0 A 0 1 7 2 4

(b) Nitrogen monoxide, NO, is formed when nitrate ions, NO₃⁻, in acidic solution are reduced by silver metal.

(i) Calculate the oxidation number of nitrogen in NO and in NO₃⁻.

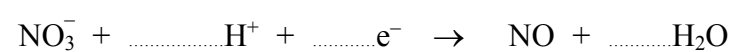
(2)

In NO

In NO₃⁻

(ii) Balance the half-equation for the reduction of nitrate ions, NO₃⁻, in acidic solution.

(1)



(iii) Write the half-equation for the oxidation of silver metal, Ag, to silver ions, Ag⁺.

(1)

(iv) Hence deduce the full ionic equation for the reaction between silver metal and nitrate ions in acidic solution. State symbols are **not** required.

(2)

(Total for Question 21 = 12 marks)

TOTAL FOR SECTION B = 38 MARKS



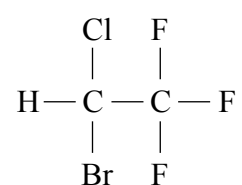
SECTION C

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

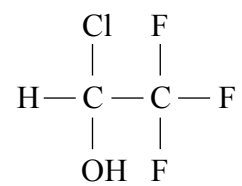
22 This question is about the chemistry of some halogenoalkanes.

Halothane is a colourless and sweet-smelling liquid. It has a boiling temperature of 50°C. Halothane vapour was used as a general anaesthetic in hospitals during the mid to late 20th Century. Patients inhaled the halothane vapour under medical supervision. However, halothane was found to have some adverse side-effects and was therefore replaced by other halogenoalkane anaesthetics.

Halothane has the structure



In an experiment, halothane was heated in a test tube with aqueous silver nitrate and ethanol, using a water bath. Compound X and bromide ions were formed. The structure of compound X is shown below.



Compound X

(a) (i) Give the systematic name of halothane.

(1)

(ii) Suggest the types of intermolecular force present between molecules of liquid halothane.

(2)

.....

.....

.....

.....



(iii) In the above experiment, suggest ONE reason why a water bath was used rather than heating the test tube containing the reaction mixture directly over a Bunsen flame.

(1)

(iv) Suggest why ethanol was used in this experiment.

(1)

(v) What would be seen in the test tube as the reaction progressed?

(1)

(vi) Write an ionic equation to show the reaction between aqueous silver ions and aqueous bromide ions. Include state symbols in your equation.

(1)

(b) Chloroethane, $\text{C}_2\text{H}_5\text{Cl}$, can also be used as an anaesthetic. In an experiment, chloroethane was hydrolysed by aqueous sodium hydroxide, NaOH .

(i) Name, and give the structural formula of, the organic product of the hydrolysis of chloroethane.

(2)

Name.....

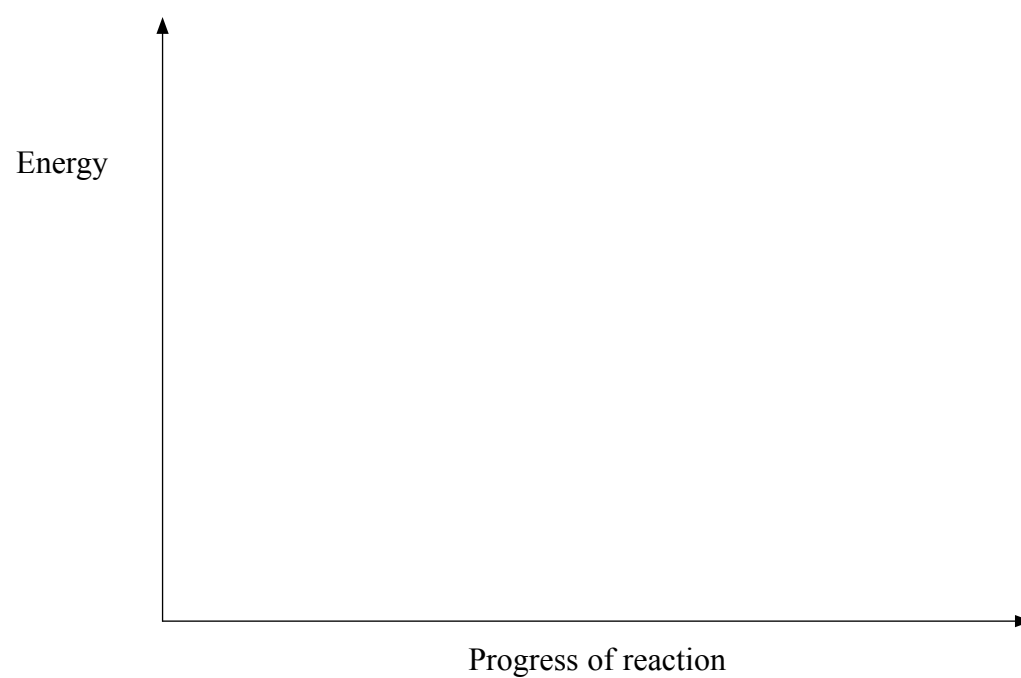
Structural formula.....



- (ii) The hydrolysis of chloroethane is an exothermic reaction which takes place in a single step.

On the diagram below, draw the energy profile for the reaction. Label clearly the activation energy for the reaction.

(3)



- (c) In the early 1900s, the CFC with formula CCl_2F_2 , was identified as a refrigerant which was both non-flammable and non-toxic.

- (i) What does the term **CFC** stand for?

(1)

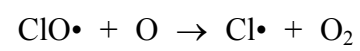
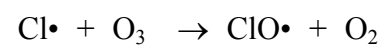
- (ii) Suggest ONE use for CFCs other than as a refrigerant.

(1)



*(iii) In the stratosphere, CFCs are broken down by absorption of UV radiation to form chlorine free radicals.

The following two reactions occur.



Combine these two equations to give the overall equation for the reaction of ozone in the stratosphere. State the role played by the chlorine free radical in the overall reaction. Hence explain why many scientists consider the effect of CFCs on ozone to be harmful.

(5)

.....

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(d) The compound of formula CH_2F_2 has replaced several CFCs for commercial use. If molecules of CH_2F_2 reach the stratosphere, they do not break down to produce fluorine free radicals.

(i) Suggest why C–F bonds are **not** broken in the stratosphere.

(1)

.....

.....

.....

*(ii) The compound CH_2F_2 acts as a greenhouse gas when it absorbs a particular type of radiation.

Name the type of radiation and explain why a molecule of CH_2F_2 is able to absorb this radiation.

(2)

.....

.....

.....

.....

(Total for Question 22 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS



1.0	H	hydrogen	1
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Elements with atomic numbers 112-116 have been reported but not fully authenticated

Mark Scheme (Results)

June 2010

GCE

GCE Chemistry (6CH02/01)

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Summer 2010

Publications Code US023632

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1(a)	D	1

Question Number	Correct Answer	Mark
1(b)	A	1

Question Number	Correct Answer	Mark
1(c)	B	1

Question Number	Correct Answer	Mark
2	D	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	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	A	1

Question Number	Correct Answer	Mark
12	A	1

Question Number	Correct Answer	Mark
13	D	1

Question Number	Correct Answer	Mark
14	D	1

Question Number	Correct Answer	Mark
15	B	1

Question Number	Correct Answer	Mark
16	A	1

Question Number	Correct Answer	Mark
17	A	1

Question Number	Correct Answer	Mark
18	B	1

Section B

Question Number	Acceptable Answers	Reject	Mark
19 (a)	Mark independently From: colourless (1) To: pink / (pale) red (1) If colour change wrong way round max (1)	From: clear To: magenta / purple / cerise	2

Question Number	Acceptable Answers	Reject	Mark
19 (b)	(Titres 2, 3 and 4) are concordant / within 0.2 (cm ³) / within 0.1 (cm ³) / consistent OR Titre 1 is rough / trial / a rangefinder / too far out / overshoot ALLOW Titre 1 is an outlier / is anomalous	Just “very similar” / within 0.05 / within 0.5 Titre 1 “very different” Just “not accurate” “Titration 1 is a control experiment”	1

Question Number	Acceptable Answers	Reject	Mark
19 (c)	28.00 (cm ³) / 28.0 (cm ³) / 28 (cm ³)	28.14 (cm ³) / 28.1 (cm ³) / 28.13 (cm ³)	1

IN (d)(i) to (d)(v), IGNORE UNITS EVEN IF INCORRECT AND
ALLOW ANSWER IN EACH CASE WHETHER BY TE OR MARK SCHEME ANSWER, REGARDLESS OF ANY WORKING SHOWN

Question Number	Acceptable Answers	Reject	Mark
19 (d)(i)	$\frac{0.100 \times 28.00}{1000} = \mathbf{0.0028} / \mathbf{2.8 \times 10^{-3}} \text{ (mol)}$ ALLOW TE from (c) IGNORE sf except one sf		1

Question Number	Acceptable Answers	Reject	Mark
19 (d)(ii)	$\mathbf{0.0028} / \mathbf{2.8 \times 10^{-3}} \text{ (mol)}$ OR Same answer to (d)(i) if TE applied IGNORE sf except one sf		1

Question Number	Acceptable Answers	Reject	Mark
19 (d)(iii)	$\frac{0.0028}{0.025} = \mathbf{0.112} \text{ (mol dm}^{-3}\text{)}$ OR Answer to (d)(ii) if TE applied from (d)(ii) 0.025 IGNORE sf except one sf		1

Question Number	Acceptable Answers	Reject	Mark
19 (d)(iv)	$10 \times 0.112 = \mathbf{1.12} \text{ (mol dm}^{-3}\text{)}$ OR Answer to (d)(iii) x 10 if TE applied from (d)(iii) IGNORE sf except one sf		1

Question Number	Acceptable Answers	Reject	Mark
19 (d)(v)	$1.12 \times 60 = \mathbf{67.2} \text{ (g dm}^{-3}\text{)}$ OR Answer to (d)(iv) $\times 60$ if TE applied from (d)(iv) <i>IGNORE</i> sf except one sf	67.1	1

Question Number	Acceptable Answers	Reject	Mark
19 (e)	<i>NOTE:</i> answer must refer to making up the diluted solution and not the titration <i>NOTE:</i> the Reason mark must be correctly linked to the Improvement Improvement: Use a pipette / burette to measure acid (solution) (1) Reason: Pipette / burette more accurate (than a measuring cylinder) (1) <i>ALLOW</i> “more precise” OR Improvement: Shake / invert the volumetric flask (thoroughly) (1) Reason: To ensure a uniform concentration (1) OR Improvement: Rinse out measuring cylinder (and transfer washings to the volumetric flask) (1) Reason: To ensure all the acid is transferred (to the volumetric flask) (1) OR Improvement: Use a (teat) pipette to make up to the mark (in volumetric flask) (1) Reason: To ensure volume of solution accurately measured (1)	Use of volumetric flask for initial measurement of volume of vinegar solution “more reliable” swirl (the flask) to ensure “fully dissolved” just “rinse out apparatus” Any suggested improvements relating to the titration part of this experiment	2

Question Number	Acceptable Answers	Reject	Mark
19 (f)(i)	Z / between 27.85 and 28.05 (cm³) <i>ALLOW</i> 27.95 ±0.10 (cm³)		1

Question Number	Acceptable Answers	Reject	Mark
19 (f)(ii)	Any one of the following / a statement equivalent to: - overshoots/misses end-point - water left in burette / pipette - air lock below tap in burette / air in pipette - burette not vertical - alkali not at stated concentration - leaking tap - not reading meniscus at eye-level - funnel left in top of burette - not reading level against a white background - not reading meniscus correctly - washing pipette between titres - washing the flask with the solution that will go in it - not swirling flask / mixture <i>IGNORE</i> “errors in calculation”	“water left in conical flask” just “measurements may be inaccurate” “there could be uncertainty with other equipment” “contamination of the vinegar”	1

Question Number	Acceptable Answers	Mark
20 (a)(i)	(1) for both arrows (1) for carbocation (1) for arrow 1st mark: - top arrow must start from the double bond / close to the double bond and not from either of the C atoms of the C=C bond - top arrow can end on, or close to, the H in HBr - lower arrow must start from the bond and not the H atom in HBr REJECT full charges on the HBr 2nd mark: the carbocation must have a full + and not δ+ 3rd mark: - the bromide ion must have a full ⁻ and not δ⁻ - the lone pair need not be shown on the Br⁻ - arrow from bromide ion can start anywhere on the Br⁻ or from the minus sign or the lone pair (if shown) on Br⁻ and can go to the C or the + sign on the intermediate 3rd mark available even if an incorrect intermediate has been drawn	3

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	OR CH₃CH₂CH₂⁺		1

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	B / $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ / butan-2-ol (1) Because the C atom bearing the OH is attached to two other C atoms / C with OH group attached to one H (atom) (1) ALLOW Because the C atom bearing the OH is attached to two alkyl groups These marks are stand alone	Just "OH is on the second C atom" / "OH is in the chain, not on the end" OR "OH attached to two methyl / two CH₃ groups" OH⁻ (instead of -OH)	2

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	C / $(\text{CH}_3)_3\text{COH}$ / (2-)methylpropan-2-ol (1) Because it is a tertiary (alcohol)/no C-H bonds to break (1) ACCEPT a description of a tertiary alcohol These marks are stand alone	"tertiary structure" / "tertiary carbon" / "tertiary carbocation"	2

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	BOTH B / $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ / butan-2-ol AND $ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{O} & & \text{H} \\ & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{H} \\ & & & & & & & \\ & \text{H} & & \text{H} & & & & \text{H} \end{array} $ BOTH required for the one mark	Structural / skeletal formula	1

Question Number	Acceptable Answers	Reject	Mark
20(b)(iv)	A / $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ / butan-1-ol and D / $\text{CH}_3\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ / (2-)methylpropan-1-ol BOTH needed for one mark		1

Question Number	Acceptable Answers	Reject	Mark
20(b)(v)	Steamy fumes / misty fumes / white mist	White smoke	1

Question Number	Acceptable Answers	Reject	Mark
20(b)(vi)	$(\text{C}_4\text{H}_9\text{OH} + \text{PCl}_5 \rightarrow) \text{C}_4\text{H}_9\text{Cl} + \text{POCl}_3 + \text{HCl}$ (1) for HCl (1) for rest of the equation correct <i>NOTE:</i> Equation must be completely correct for the second mark. <i>ACCEPT</i> "PCl ₃ O" instead of POCl ₃		2

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	Mark the two points independently, subject to the constraint in Reject column Effect: (Equilibrium) shifts to the right (1) <i>ALLOW:</i> “favours forward reaction” / “increase the amount of product” / “increase the yield (of product)” Reason: Exothermic (in forward direction) (1) <i>NOTE: Just</i> “(equilibrium) shifts in the exothermic direction” scores (1)	“Equilibrium shifts to left” will score (0) for (a)(i)	2

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	First mark: Activation energy for the reaction is too high / (if cooled) molecules would not have enough energy to react / few(er) molecules have the required E_a/more molecules have energy $\geq E_a$ at higher temperatures OR not (technologically) feasible to cool the gases before they enter the converter/costly to cool the gases (1) Second mark: (cooling the gases would make) the rate (too) slow /rate is faster if the temperature is high (so the gases are not cooled) (1)	Cooling the gases decreases the yield (of products) /an incorrect Le Chatelier argument	2

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	Mark the two points independently, subject to the constraint in Reject column Effect: (Equilibrium) shifts to the right <i>ALLOW:</i> “favours forward reaction” / “increase the amount of product” / “increase the yield of product” (1) Reason: Shifts / moves in the direction of fewer (moles of gas) molecules <i>ALLOW</i> “shifts in direction of fewer moles (of gas molecules)” (1) <i>IGNORE</i> effect on the rate	“Equilibrium shifts to left” will score (0) for (a)(iii) “.... fewer atoms”	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	(In NO): +2 / 2+ (1) (In NO₃⁻): +5 / 5+ (1) <i>NOTE:</i> (In NO): Just “2” AND (In NO₃⁻): Just “5” scores (1)		2

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$\text{NO}_3^- + 4\text{H}^+ + 3\text{e}^- \rightarrow \text{NO} + 2\text{H}_2\text{O}$ <i>ACCEPT</i> multiples		1

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	$\text{Ag} \rightarrow \text{Ag}^+ + \text{e}^{(-)} / \text{Ag} - \text{e}^{(-)} \rightarrow \text{Ag}^+$ ACCEPT multiples IGNORE state symbols, even if incorrect	$\text{Ag} + \text{e}^- \rightarrow \text{Ag}^+$	1

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	$3\text{Ag} + \text{NO}_3^- + 4\text{H}^+ \rightarrow 3\text{Ag}^+ + \text{NO} + 2\text{H}_2\text{O}$ (2) (1) for multiplication of the silver half-equation by three or eq multiple from (b)(ii) (1) for rest of equation correct NOTE: Equation must be completely correct for the second mark. IGNORE state symbols, even if incorrect	if any e^- are left in the final equation, second mark cannot be scored	2

SECTION C

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	2-bromo-2-chloro-1,1,1-trifluoroethane <i>ALLOW</i> 1-bromo-1-chloro-2,2,2-trifluoroethane <i>IGNORE</i> incorrect punctuation and incorrect order of the halogen atoms	“1-bromo-1-chloro-2-trifluoroethane”	1

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	London (forces) / instantaneous dipole / induced dipole / dispersion / van der Waals' (forces) (1) permanent dipole (-permanent dipole) (forces) / dipole-dipole (forces) / dipole (forces) (1) <i>IGNORE any</i> references to hydrogen bonding		2

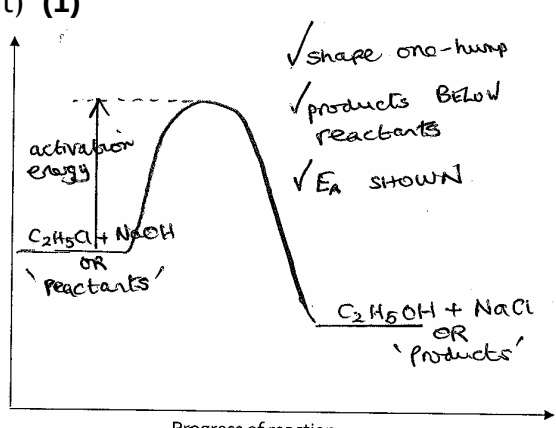
Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Any one of the following / a statement equivalent to: Ethanol is flammable [Note: if any reference to only the halogenoalkane being flammable scores (0)] OR reference to greater control of heating (e.g. “to control the rate of reaction” / “to prevent the reaction being too vigorous” / “to prevent the reaction getting out of control”) <i>ALLOW</i> “so that the reaction takes place slowly” OR “(reaction) mixture is flammable/it is flammable” OR “Bunsen flame too hot / too vigorous” OR “(Bunsen flame) would cause too much evaporation to occur” OR “(allows) constant heating” / “even heating”	Compound X is flammable Just “to prevent an explosion” Just “to minimise the risk”	1

Question Number	Acceptable Answers	Reject	Mark
22(a)(iv)	Solvent (for both reactants) OR To dissolve (the reactants) OR To mix the reactants ALLOW "To enable the mixture to dissolve"	Just "mixing" "to acidify the silver nitrate"	1

Question Number	Acceptable Answers	Reject	Mark
22(a)(v)	Cream / off-white / pale-yellow precipitate ALLOW Cream / off-white / pale-yellow solid IGNORE incorrect identification of this precipitate NOTE: both colour and state (of the AgBr) needed	Just "Yellow" (precipitate/ solid) OR " white precipitate" OR "white-yellow precipitate" (0) if contradictory observation given, eg "cream precipitate and fizzing"	1

Question Number	Acceptable Answers	Reject	Mark
22(a)(vi)	$\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \rightarrow \text{AgBr}(\text{s})$ Must include state symbols ACCEPT multiples	If NO_3^- left on either side	1

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	Mark independently Name: ethanol (1) ALLOW "ethan-1-ol" Structural formula: CH₃CH₂OH or C₂H₅OH (1) Allow displayed formula ALLOW brackets around the OH	C ₂ H ₆ O	2

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	Mark independently 1st mark: Energy of products, labelled, below that of reactants, labelled (1) <i>Note if the words 'reactants' and 'products' are written, ignore any formulae</i> <i>Note if the words 'reactants' and 'products' are not written, both formulae of the reactants and both formulae of the products must be given. (Na⁺ ions can be omitted.)</i> 2nd mark: Shape of profile with one 'hump' (1) 3rd mark: Activation energy / "E_a" correctly shown with a single-headed arrow to the peak (or close to it) (1) 	Maxwell-Boltzmann curve scores (0) for (b)(ii) Double-headed arrow showing E_a	3

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	Chlorofluorocarbon Accept ..f <u>l</u> ou <u>r</u> o... spelling		1

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	Any one of the following / a statement equivalent to: aerosol / propellant / spray cans OR (degreasing) solvent OR fire retardant <i>ALLOW</i> fire extinguishers / putting out fires <i>ALLOW</i> making expanded polystyrene / making plastics / making polymers	pesticides / anaesthetics just “retardant” anti-freeze air-conditioning frying pans detergents	1

Question Number	Acceptable Answers	Reject	Mark
22(c)(iii) QWC	Mark independently 1st mark: $O + O_3 \rightarrow 2O_2$ <i>IGNORE</i> any state symbols (1) 2nd mark: (chlorine free radical acts as a) catalyst (1) Last 3 marks: any three from: (the chlorine free radical) persists in the atmosphere / continues to attack / is regenerated / (starts) a chain reaction (1) <i>NOTE</i> ‘chain reaction’ may be described in terms of a chlorine radical breaking down many / a large number of / a specified number of, eg 10,000, O_3 (molecules). <i>NOTE:</i> As written, this response also earns the scoring point relating to ozone depletion. - less ozone / ozone decreases / causes hole(s) in ozone layer / breakdown of ozone (layer) / damages ozone layer / depletes ozone layer (1) UV (reaching Earth’s surface) increases / less UV absorbed / (more) UV reaches Earth’s surface (1) - causes (skin) cancer/mutation / DNA damage occurs (1) <i>IGNORE</i> any references to “global warming” / “Greenhouse Effect”	If $Cl\bullet$ and / or $ClO\bullet$ left in equation OR $2O_3 \rightarrow 3O_2$ Just (UV) “harmful”	5

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	The C-F bond is (very) strong OR C-F bond is (much) harder to break than the C-Cl bond OR UV/radiation does not have enough energy /does not have (high) enough frequency	Any mention of electronegativity OR mention of bond polarity scores (0)	1

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii) QWC	(long wavelength) IR /infrared radiation (1) The molecule is polar OR (the molecule) changes its polarity OR “polar bonds” OR vibrational energy/vibrations of the bonds / stretching or bending increases OR (IR causes) bonds to vibrate (1) Marks are stand alone	UV / ultraviolet Just “molecule vibrates” (0)	2

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Write your name here	
Surname	Other names
Centre Number	Candidate Number
Edexcel GCE Chemistry Advanced Subsidiary Unit 2: Application of Core Principles of Chemistry	
Thursday 20 January 2011 – Afternoon Time: 1 hour 30 minutes	Paper Reference 6CH02/01
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 ►

N37963A

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7/7/5/2/



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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 The equation for the reaction between limewater and hydrochloric acid, including state symbols, is

- ☐ A $\text{CaOH(s)} + \text{HCl(aq)} \rightarrow \text{CaCl(aq)} + \text{H}_2\text{O(l)}$
- ☐ B $\text{Ca(OH)}_2\text{(s)} + 2\text{HCl(aq)} \rightarrow \text{CaCl}_2\text{(aq)} + 2\text{H}_2\text{O(aq)}$
- ☐ C $\text{CaOH(aq)} + \text{HCl(aq)} \rightarrow \text{CaCl(aq)} + \text{H}_2\text{O(aq)}$
- ☐ D $\text{Ca(OH)}_2\text{(aq)} + 2\text{HCl(aq)} \rightarrow \text{CaCl}_2\text{(aq)} + 2\text{H}_2\text{O(l)}$

(Total for Question 1 = 1 mark)

- 2 As you go down Group 2 of the Periodic Table, which of the following decreases?

- ☐ A The reactivity of the elements.
- ☐ B The solubility of the hydroxides of the elements.
- ☐ C The solubility of the sulfates of the elements.
- ☐ D The thermal stability of the carbonates of the elements.

(Total for Question 2 = 1 mark)

- 3 Which concentrated acid would be best for mixing with a salt to carry out a flame test?

- ☐ A Hydrochloric acid
- ☐ B Nitric acid
- ☐ C Phosphoric(V) acid
- ☐ D Sulfuric acid

(Total for Question 3 = 1 mark)

- 4 The flame produced by a compound containing barium in a flame test is

- ☐ A colourless.
- ☐ B green.
- ☐ C red.
- ☐ D yellow.

(Total for Question 4 = 1 mark)



5 Which of the following is a greenhouse gas?

- ☐ A Argon
- ☐ B Nitrogen
- ☐ C Oxygen
- ☐ D Water vapour

(Total for Question 5 = 1 mark)

6 For parts (a) and (b), use your knowledge of intermolecular forces to predict the compound with the highest boiling temperature.

(a) ☐ A HF

☐ B H₂O

☐ C NH₃

☐ D CH₄

(1)

(b) ☐ A 1-iodobutane

☐ B 1-chlorobutane

☐ C 2-methyl-2-iodopropane

☐ D 2-methyl-2-chloropropane

(1)

(Total for Question 6 = 2 marks)

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



7 Consider the following organic liquids:

- A ethanal
- B ethanol
- C tetrachloromethane
- D trichloromethane

(a) Each liquid is run from a burette. Which liquid would **not** be deflected significantly by a charged rod?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(b) Which liquid would react with phosphorus(V) chloride to give a gas which fumes in moist air?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(c) Which liquid would you expect to have the peak at the greatest mass/charge ratio in its mass spectrum?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(d) Which liquid has an infrared spectrum with a broad absorption due to hydrogen bonding?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 7 = 4 marks)



8 Which of the following best defines the meaning of the term **anthropogenic** change?

It is a change caused by

- ☐ A nature.
- ☐ B plants.
- ☐ C animals.
- ☐ D humans.

(Total for Question 8 = 1 mark)

9 Which of the following equations represents the change when concentrated sulfuric acid is added to solid potassium chloride at room temperature?

- ☐ A $8\text{KCl} + 5\text{H}_2\text{SO}_4 \rightarrow 4\text{K}_2\text{SO}_4 + \text{H}_2\text{S} + 4\text{Cl}_2 + 4\text{H}_2\text{O}$
- ☐ B $2\text{KCl} + 3\text{H}_2\text{SO}_4 \rightarrow 2\text{KHSO}_4 + \text{SO}_2 + \text{Cl}_2 + 2\text{H}_2\text{O}$
- ☐ C $6\text{KCl} + 4\text{H}_2\text{SO}_4 \rightarrow 3\text{K}_2\text{SO}_4 + \text{S} + 3\text{Cl}_2 + 4\text{H}_2\text{O}$
- ☐ D $\text{KCl} + \text{H}_2\text{SO}_4 \rightarrow \text{KHSO}_4 + \text{HCl}$

(Total for Question 9 = 1 mark)

10 The Maxwell-Boltzmann distribution of molecular energies is useful for explaining why increasing temperature affects the rate of a chemical reaction.

(a) Which of the following statements describes how the shape of the Maxwell-Boltzmann distribution curve changes as temperature increases?

(1)

- ☐ A The peak decreases in height and moves to the left.
- ☐ B The peak increases in height and moves to the left.
- ☐ C The peak decreases in height and moves to the right.
- ☐ D The peak increases in height and moves to the right.

(b) The **main** reason that reaction rates increase with temperature is that

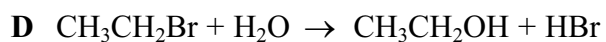
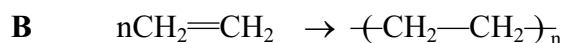
(1)

- ☐ A all the molecules move faster.
- ☐ B all the molecules collide more frequently.
- ☐ C more molecules collide with the correct orientation.
- ☐ D a larger proportion of molecules have high energies.

(Total for Question 10 = 2 marks)



11 Four organic reactions are given below:



(a) Which reaction is a substitution reaction?

(1)

☐ A

☐ B

☐ C

☐ D

(b) Which reaction is an electrophilic addition reaction?

(1)

☐ A

☐ B

☐ C

☐ D

(c) Which reaction involves initial attack by a nucleophile?

(1)

☐ A

☐ B

☐ C

☐ D

(d) Which reaction requires an initiator?

(1)

☐ A

☐ B

☐ C

☐ D

(Total for Question 11 = 4 marks)



12 Which of the following statements is true?

- ☐ **A** CFCs and nitrogen monoxide, NO, are involved in the depletion of the ozone layer.
- ☐ **B** CFCs act as catalysts for the depletion of the ozone layer, while nitrogen monoxide, NO, does not.
- ☐ **C** CFCs and ozone are free radicals.
- ☐ **D** CFCs and nitrogen monoxide, NO, are decomposed by UV radiation.

(Total for Question 12 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



N 3 7 9 6 3 A 0 7 2 4

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SECTION B

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

13 This question is about iodine and its compounds.

- (a) (i) The element iodine can be obtained from seaweed. One step in the procedure is to extract the iodine from aqueous solution by shaking with a hydrocarbon solvent in a separating funnel.

Draw a diagram of a separating funnel containing the separated layers. Label the hydrocarbon layer, and state its colour.

[Density of hydrocarbon layer 0.660 g cm^{-3}]

(3)

Diagram

Colour of hydrocarbon layer

- (ii) Iodine is also formed when an aqueous solution containing iodide ions reacts with an aqueous solution of iron(III) ions.

Write the ionic equation for this reaction. State symbols are **not** required.

(1)



(b) Hydrogen iodide gas is usually prepared by adding phosphoric(V) acid to solid potassium iodide.

- (i) Suggest why phosphoric(V) acid is used in this preparation rather than concentrated sulfuric acid.

(1)

- (ii) Describe what you would see if a test tube of hydrogen iodide gas was inverted in a beaker of water.

(1)

- (iii) When hydrogen iodide gas reacts with ammonia, dense white fumes form. Write the equation for this reaction, including state symbols.

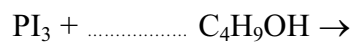
(2)



(c) 1-iodobutane can be made by reacting butan-1-ol with phosphorus(III) iodide, PI_3 , formed by reacting moist red phosphorus with iodine.

(i) Complete the following equation for the formation of 1-iodobutane.

(1)



(ii) Identify the intermolecular forces present between molecules of 1-iodobutane.

(1)

.....

.....

.....

(iii) 1-iodobutane reacts with hot aqueous silver nitrate solution. Describe what you would see when this reaction takes place.

(1)

.....

(iv) Give the structural formula for the organic product of the reaction between 1-iodobutane and ammonia.

(1)

(Total for Question 13 = 12 marks)



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14 This question is about methanol, CH_3OH , and ethanol, $\text{CH}_3\text{CH}_2\text{OH}$.

(a) (i) Draw a dot and cross diagram for **methanol**, showing outer electrons only.

(1)

(ii) Give the approximate values for the HCH and COH bond angles in methanol. Justify your answers.

(4)

HCH angle

Justification

.....

.....

COH angle

Justification

.....

.....

(iii) Using displayed formulae, draw a diagram to show a hydrogen bond between two methanol molecules. On your diagram, show the bond angle around the hydrogen atom of the hydrogen bond and give its value.

(2)



(b) Methanol reacts with sodium.

(i) State what you would observe in this reaction.

(2)

(ii) Write the equation for this reaction. State symbols are **not** required.

(1)

(c) **Ethanol** can be used to make ethanal.

(i) Identify, by name or formula, the two chemicals you would use to make ethanal from ethanol in the laboratory.

(2)



- (ii) Draw a diagram of the apparatus you would use to prepare ethanal from ethanol in the laboratory and collect the product.

(2)

- (iii) Both ethanal and propane have a molar mass of 44 g mol^{-1} , but their boiling temperatures are different.

Suggest which substance has the higher boiling temperature. Justify your answer by comparing the intermolecular forces in each compound.

(2)

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(Total for Question 14 = 16 marks)



N 3 7 9 6 3 A 0 1 5 2 4

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- 15 The ingredients list on the label of a commercial indigestion remedy states that each tablet contains 680 mg of calcium carbonate.

To check this, the following experiment was carried out.

One tablet was crushed. 50.0 cm³ of 1.00 mol dm⁻³ hydrochloric acid, an excess, was then added and the mixture was transferred to a volumetric flask. The volume was made up to exactly 100 cm³ with distilled water. 10.0 cm³ of this solution was titrated with 0.300 mol dm⁻³ sodium hydroxide solution. The following results were obtained.

Run	Rough	1	2
Final burette reading / cm ³	21.80	33.20	44.40
Initial burette reading / cm ³	10.00	21.80	33.20
Volume added / cm ³	11.80	11.40	11.20

- (a) (i) What should be used to crush the tablet?

(1)

- (ii) Name a suitable indicator for the titration. State the colour change you would expect to see.

(2)

Indicator

Colour change from to



(b) (i) Select appropriate readings and calculate the mean titre. (1)

(ii) Calculate the number of moles of sodium hydroxide used. (1)

(iii) Use your answer to (ii) to write down the number of moles of hydrochloric acid left in 10.0 cm^3 of the solution used in the titration. (1)

(iv) Calculate the number of moles of hydrochloric acid left in 100 cm^3 of solution. (1)



- (v) 50.0 cm³ of 1.00 mol dm⁻³ hydrochloric acid contains 0.0500 mol of hydrochloric acid.

Use this and your answer to (iv) to calculate the number of moles of hydrochloric acid that reacted with the indigestion tablet.

(1)

- (vi) The equation for the reaction between hydrochloric acid and calcium carbonate is:



Use this, and your answer to (v), to calculate the number of moles of calcium carbonate in one tablet.

(1)

- (vii) Calculate the mass of calcium carbonate in one tablet.

[Assume that the molar mass of CaCO₃ is 100 g mol⁻¹]

(1)

- (viii) Suggest a reason, other than experimental error, why your value differs from the value given on the label.

(1)

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.....

(Total for Question 15 = 11 marks)

TOTAL FOR SECTION B = 39 MARKS



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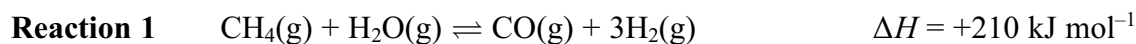


SECTION C

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

16 This question is about some reactions which can be used in the manufacture of hydrogen.

Reaction 1 uses two naturally occurring chemicals, water and natural gas. Steam is reacted with methane to form carbon monoxide and hydrogen in an equilibrium reaction.



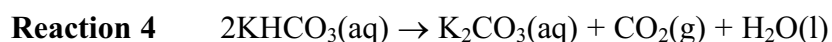
In reaction 2, carbon monoxide and steam are passed over copper at high temperature. This forms carbon dioxide and hydrogen.



The carbon dioxide formed is removed by passing it through potassium carbonate solution in reaction 3.



The potassium carbonate is regenerated by heating the potassium hydrogencarbonate solution in reaction 4. The carbon dioxide gas produced is released into the atmosphere.



(a) For each of the first three reactions, state the initial and final oxidation numbers of any elements that change their oxidation numbers. Hence decide which are redox reactions.

(5)

Reaction 1

.....

.....

Reaction 2

.....

.....

Reaction 3

.....

.....



- * (b) (i) Discuss, with reasons, the conditions of temperature and pressure that would favour the production of hydrogen in **reaction 1**. You should consider the effect of the conditions on both yield and rate.

(7)

- (ii) Excess steam is used in **reaction 1**. State why an excess of a reagent is used and suggest why steam, rather than methane, is chosen.

(2)



(c) Copper is a catalyst in **reaction 2**. Explain how a catalyst increases the rate of a reaction.

(2)

(d) (i) State **one** economic advantage of **reaction 4**.

(1)

*(ii) **Reaction 4** contributes to global warming. Identify the substance formed in this reaction which is likely to be responsible and explain the processes that lead to an increase in global temperatures.

Suggest **two** effects an increase in global temperatures might have on the environment.

(4)

(Total for Question 16 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS

TOTAL FOR PAPER = 80 MARKS



1

N 3 7 9 6 3 A 0 2 4 2 4

Mark Scheme (Results) January 2011

GCE

GCE Chemistry (6CH02/01)

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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	A	1

Question Number	Correct Answer	Mark
4	B	1

Question Number	Correct Answer	Mark
5	D	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)	C	1

Question Number	Correct Answer	Mark
7 (b)	B	1

Question Number	Correct Answer	Mark
7 (c)	C	1

Question Number	Correct Answer	Mark
7 (d)	B	1

Question Number	Correct Answer	Mark
8	D	1

Question Number	Correct Answer	Mark
9	D	1

Question Number	Correct Answer	Mark
10 (a)	C	1

Question Number	Correct Answer	Mark
10 (b)	D	1

Question Number	Correct Answer	Mark
11 (a)	D	1

Question Number	Correct Answer	Mark
11 (b)	C	1

Question Number	Correct Answer	Mark
11 (c)	D	1

Question Number	Correct Answer	Mark
11 (d)	B	1

Question Number	Correct Answer	Mark
12	A	1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
13 (a) (i)	Each mark is independent Diagram of separating funnel with tap. Sides can be straight or bulbous. Top can be stoppered or unstoppered, but not sealed (eg inverted test-tube with tap at bottom). (1) Allow straight sides with an open top Two layers. Upper layer is hydrocarbon layer (1) Colour – pink/purple/mauve. Allow violet (1)	Filter funnel with tap Three layers Mention of any other colours on their own (e.g. grey, brown, red) or in combination with those accepted.	3

Question Number	Acceptable Answers	Reject	Mark
13 (a) (ii)	$2\text{Fe}^{3+} + 2\text{I}^{-} \rightarrow 2\text{Fe}^{2+} + \text{I}_2$ Ignore state symbols Allow multiples/half amounts shown Accept answers involving I_3^{-}	Formation of Fe^{+}	1

Question Number	Acceptable Answers	Reject	Mark
13 (b)(i)	Answers must refer to oxidation/reduction Sulfuric acid oxidizes (hydrogen/potassium) iodide (to iodine) OR (hydrogen) iodide reduces sulfuric acid OR Phosphoric(V) acid does not oxidize (hydrogen) iodide (to iodine) (as well as sulfuric acid does) Allow sulfuric acid is a strong(er)/good oxidizing agent/phosphoric(V) acid is a weaker oxidizing agent	Sulfuric acid oxidizes iodine/oxidizes iodide to iodide Phosphoric acid is a better reducing agent Comments about hazards or strength of sulfuric acid alone Stability of phosphoric(V) acid alone	1

Question Number	Acceptable Answers	Reject	Mark
13 (b) (ii)	Water rises in the test tube Allow the gas /HI is soluble / dissolves	Steamy fumes Any coloured solutions forming even if with the acceptable/allowed answer Water would displace the gas	1

Question Number	Acceptable Answers	Reject	Mark
13 (b) (iii)	$\text{NH}_3(\text{g})/(\text{aq}) + \text{HI}(\text{g}) \rightarrow \text{NH}_4\text{I}(\text{s})$ Species and balanced equation (1) Allow $\text{NH}_4^+ + \text{I}^-$ for product All state symbols present (dependent on the entities above) (1)	NH_3I NH_3HI NIH_4	2

Question Number	Acceptable Answers	Reject	Mark
13 (c) (i)	$\text{PI}_3 + 3\text{C}_4\text{H}_9\text{OH} \rightarrow 3\text{C}_4\text{H}_9\text{I} + \text{H}_3\text{PO}_3$ Accept multiples Allow $\text{P}(\text{OH})_3$, PH_3O_3 , $\text{H}_2\text{O} + \text{HPO}_2$, as product/s		1

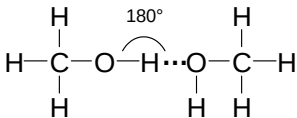
Question Number	Acceptable Answers	Reject	Mark
13 (c) (ii)	Both points required Van der Waals' / London / dispersion / induced dipole / temporary dipole (forces) in 1-iodobutane Allow recognisable spelling of van der Waals' and (permanent) dipole dipole/permanent dipole (forces) Allow dipolar-dipolar	Any mention of hydrogen bonding (0)	1

Question Number	Acceptable Answers	Reject	Mark
13 (c) (iii)	Yellow precipitate /ppt /ppte / solid The answer may appear with additional words and phrases: e.g. two clear colourless solutions form a yellow precipitate which is insoluble in concentrated ammonia solution Allow bright yellow, sunshine yellow Allow recognisable spelling eg yello percipitate	Off-white Cream Any other colours and combinations of yellow with any other colours Any other qualifications of yellow eg pale/light Any answers which include bubbles, fizzing, effervescence	1

Question Number	Acceptable Answers	Reject	Mark
13 (c) (iv)	CH₃CH₂CH₂CH₂NH₂ /CH₃(CH₂)₃NH₂ /CH₂(NH₂)CH₂CH₂CH₃ / NH₂CH₂CH₂CH₂CH₃ / H₂NCH₂CH₂CH₂CH₃ /(CH₃CH₂CH₂CH₂)₂NH /(CH₃CH₂CH₂CH₂)₃N Allow displayed and skeletal formulae, C₄H₉NH₂ Salts of amines which must include a positively charged ion and I⁻	NH₄I NH₃ instead of NH₂ Three carbon chains Missing hydrogens C₄H₁₁N	1

Question Number	Acceptable Answers	Reject	Mark
14 (a) (i)	$\begin{array}{c} \text{H} \\ \cdot \text{x} \quad \text{xx} \\ \text{H} \cdot \text{x} \text{C} \cdot \text{x} \text{O} \cdot \text{xH} \\ \cdot \text{x} \quad \text{xx} \\ \text{H} \end{array}$ Allow all dots / crosses, combinations of dots, crosses and other symbols like triangles Allow extra inner electrons around carbon and / or oxygen	Missing symbols Missing non-bonding electrons	1

Question Number	Acceptable Answers	Reject	Mark
14 (a) (ii)	Each mark is independent of the next unless the bond angle is greater than 119° 109° / 109.5° (1) Minimum repulsion / maximum separation (between four bond pairs of electrons / bonds) (1) $104^\circ - 105^\circ$ (1) (Two) lone pairs / non-bonding pairs (of electrons) repel more (than bonding pairs)/repel a lot (1)	Four bond pairs give tetrahedral shape	4

Question Number	Acceptable Answers	Reject	Mark
14 (a) (iii)	 Correct atoms in the hydrogen bond (O—H...O) (1) Allow CH₃ groups not displayed, correct ethanol formulae. Hydrogen bond can be shown as dots horizontal or vertical dashes. If it is a bond-like line it must be labelled. Second mark dependent on correct atoms involved. O—H...O in straight line (within small tolerance) and 180° bond angle given in the correct place (1)	Hydrogen bond between methanol and water does not score	2

Question Number	Acceptable Answers	Reject	Mark
14 (b) (i)	Any two from: Bubbles/ fizzing / effervescence (of gas) forming (1) Sodium /solid disappearing /dissolving (to form a clear colourless solution) (1) White solid /precipitate forming (1)	Vigorous reaction White solution/fumes form Clear colourless solution forms alone	2

Question Number	Acceptable Answers	Reject	Mark
14 (b) (ii)	$\text{CH}_3\text{OH} + \text{Na} \rightarrow \text{CH}_3\text{O}^{(-)}\text{Na}^{(+)} + \frac{1}{2}\text{H}_2$ Allow multiples, NaOCH ₃ as product, ethanol as CH ₃ CH ₂ OH/C ₂ H ₅ OH with sodium ethoxide as product, Ignore state symbols and charges	Na ⁺ as reactant CH ₃ O—Na CH ₃ NaO or NaCH ₃ O	1

Question Number	Acceptable Answers	Reject	Mark
14 (c) (i)	Na ₂ Cr ₂ O ₇ / K ₂ Cr ₂ O ₇ / Sodium / potassium dichromate(VI) (1) Allow recognisable spelling of potassium and dichromate If name and formula given, both must be correct. H ₂ SO ₄ / (Dilute / concentrated) sulfuric acid (1) Second mark dependent on recognisably correct oxidizing agent Allow acidified / H ⁺ and dichromate(VI) / Cr ₂ O ₇ ²⁻ for 1 mark Allow potassium manganate(VII) and dilute sulfuric acid for 1 mark	Other oxidation numbers Potassium/sodium dichromate(VI) ions Other acids e.g. hydrochloric, nitric, phosphoric Other oxidation numbers	2

Question Number	Acceptable Answers	Reject	Mark
14 (c) (ii)	Round-bottomed/pear shaped flask with heat Still head (1) Delivery tube and exit above/in (cooled) collection vessel (1) A condenser may be included Sealed apparatus (max. 1)	Reflux apparatus or reflux followed by distillation scores 0 Conical flask Open still head	2

Question Number	Acceptable Answers	Reject	Mark
14 (c) (iii)	Mark independently (Permanent) dipole dipole/permanent dipole (forces) in ethanal (1) Ethanal higher because both compounds have (similar) London /van der Waals' /etc forces OR no (permanent) dipole dipole /permanent dipole (forces) in propane OR propane (only) has London /van der Waals' /etc forces (1)	Ethanal has hydrogen bonds loses first mark only	2

Question Number	Acceptable Answers	Reject	Mark
15 (a) (i)	Pestle (and mortar) / mortar and pestle Allow any recognisable spelling eg pessl, morta	Anything else, including hammer, mallet, heavy metal object, spatula, glass rod, crusher, grinder	1

Question Number	Acceptable Answers	Reject	Mark
15 (a) (ii)	Methyl / methly orange (1) Red to orange / peach (allow yellow) (1) Accept other acid-base indicators eg phenolphthalein (1) Accept recognisable spelling for all acid-base indicators Correct colour change, the correct way round, to end point or beyond (1)	Litmus, Universal Indicator score 0/2	2

Question Number	Acceptable Answers	Reject	Mark
15 (b) (i)	(11.20 and 11.40 give) 11.3(0) (cm ³)		1

Question Number	Acceptable Answers	Reject	Mark
15 (b) (ii)	$\frac{11.3 \times 0.300}{1000} = 3.39 \times 10^{-3} / 0.00339$ (mol) If mean titre value is 11.47 then 3.44×10^{-3}	Ignore SF unless only one, in which case penalise this only once.	1

Question Number	Acceptable Answers	Reject	Mark
15 (b) (iii)	3.39×10^{-3} (mol) Or answer to (ii)		1

Question Number	Acceptable Answers	Reject	Mark
15 (b) (iv)	3.39×10^{-2} (mol) answer (iii) x 10		1

Question Number	Acceptable Answers	Reject	Mark
15 (b) (v)	$0.05 - 0.0339 = 0.0161$ (mol) Or $0.05 -$ (answer to (iv)) If mean titre value is 11.47 then 0.0156		1

Question Number	Acceptable Answers	Reject	Mark
15 (b) (vi)	0.00805 (mol) Or answer to (v) divided by 2 If mean titre value is 11.47 then 0.0078		1

Question Number	Acceptable Answers	Reject	Mark
15 (b) (vii)	0.00805×100 $= 0.805 \text{ (g) / } 805 \text{ mg}$ Or answer to (vi) $\times 100$ If mean titre value is 11.47 then 0.780		1

Question Number	Acceptable Answers	Reject	Mark
15 (b) (viii)	Reason – there must be some other ant acid present / substance/chemical which reacts with acid	Experimental / calculation error	1

TOTAL FOR SECTION B = 39 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
16 (a)	1 Reaction 1: C goes from -4 to $+2$, (1) 2 H from $+1$ to 0 (redox reaction) (1) 3 Reaction 2: C goes from $+2$ to $+4$ (1) 4 H from $+1$ to 0 (redox reaction) (1) Allow from $2(+1)$ to 0 For each mark both correct oxidation states are needed Additional incorrect oxidation numbers of oxygen lose 1 mark per reaction Allow number followed by charge Penalise missing plus signs only once Penalise wrong use of the terms reduced and oxidized only once Penalise correct oxidation states and not a redox reaction only once 5 Reaction 3 no (elements) change (oxidation number)/details for carbon / hydrogen calculated AND so this is not a redox reaction OR Redox mentioned in reactions 1 and 2 but 'not redox' omitted in reaction 3 (1)	H from $+2$ to 0 H from $+2$ to 0	5

Question Number	Acceptable Answers	Reject	Mark
*16 (b) (i)	Any seven from: 1 A higher temperature would increase the yield /favour the forward reaction /produce more hydrogen... (1) 2 ...(as) the reaction is endothermic (1) 3 Increased temperature would increase the rate/speed of reaction /make the reaction go faster... (1) 4 ...(as) a greater proportion of /more molecules have sufficient /higher/activation energy (to react) (1) 5 Decreased pressure increases the yield /favour the forward reaction /produce more hydrogen... (1) 6...(as) the forward reaction is favoured with more (gaseous) molecules /mole (1) 7 Decreased pressure would decrease the rate of reaction... (1) 8 ...(as) collision frequency decreases/less collisions (1) Points may muddle into one another Reverse statements allowed e.g. 'lower temperature decreases yield because reaction is endothermic'. Contradictory statements in each pair lose both marks e.g. 'lower temperature increases yield because reaction is endothermic'.	'More (successful) collisions' alone	7

Question Number	Acceptable Answers	Reject	Mark
16 (b) (ii)	An excess is used to drive the equilibrium to the right / to ensure all the methane reacts (as the reaction responds to remove steam by Le Chatelier's principle) (1) Methane is more expensive (so it is better to increase the amount of steam) / steam is cheaper / readily available / renewable OR Methane is not renewable (1)	...to get a better yield of hydrogen / to allow reaction to happen fully / so all the reactants react / to make the reaction go to completion Methane is a greenhouse gas / dangers associated with methane e.g. flammable	2

Question Number	Acceptable Answers	Reject	Mark
16 (c)	The catalyst provides an alternative route for the reaction (1) (with) a lower activation energy (1) Allow 'catalyst lowers activation energy' alone for one mark		2

Question Number	Acceptable Answers	Reject	Mark
16 (d) (i)	It regenerates / reforms potassium carbonate / reactant(s) (which reduces the cost of the process) OR potassium carbonate can be re-used Allow recycles potassium carbonate	Regenerates some of the other reactants. Chemicals are regenerated	1

Question Number	Acceptable Answers	Reject	Mark
*16 (d) (ii)	1 Carbon dioxide / CO₂ Allow both water and carbon dioxide (1) 2 Traps longer wavelength radiation / traps radiation / IR emitted (from the earth) OR Absorbs/traps heat / IR OR Prevents loss of IR / heat (1) 3,4 Any two from: Rising sea levels / flooding Polar ice / ice caps / glacier(s) / glacial / habitat ice melting Changing (sea /air) currents Changing weather patterns /more extreme weather / climate change (2) Other acceptable alternatives only if well justified e.g. more malaria because more breeding areas for mosquitoes But more malaria /desertification /forest fires alone is insufficient Three or more correct answers get 2 marks Three or more answers, where some are wrong, are marked 1 mark for each correct answer and -1 mark for each incorrect answer e.g. Two correct and one wrong award 1 mark Three correct and two wrong award 1 mark etc One on list and one wrong award 1. Ignore neutral statements	Water alone Mark is lost if any mention of UV / ozone layer depletion Absorbs IR / heat from the sun Increased UV Increased skin cancer /melanoma	4

TOTAL FOR SECTION C = 21 MARKS

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Centre Number

Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Friday 27 May 2011 – Afternoon

Time: 1 hour 30 minutes

Paper Reference

6CH02/01

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 ►

P38479A

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7/7/5/5/3/



P 3 8 4 7 9 A 0 1 2 0

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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 correct balanced equation for the reaction between heated magnesium and steam, including state symbols, is

- ☐ A $\text{Mg(s)} + \text{H}_2\text{O(l)} \rightarrow \text{MgO(s)} + \text{H}_2\text{(g)}$
- ☐ B $\text{Mg(s)} + 2\text{H}_2\text{O(g)} \rightarrow \text{Mg(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$
- ☐ C $\text{Mg(s)} + \text{H}_2\text{O(g)} \rightarrow \text{MgO(s)} + \text{H}_2\text{(g)}$
- ☐ D $\text{Mg(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Mg(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$

(Total for Question 1 = 1 mark)

- 2 This question concerns the trends in properties on descending Group 2 of the Periodic Table.

(a) What are the trends in solubility of sulfates and hydroxides down Group 2?

(1)

- ☐ A Sulfates increase, hydroxides decrease.
- ☐ B Sulfates decrease, hydroxides increase.
- ☐ C Sulfates increase, hydroxides increase.
- ☐ D Sulfates decrease, hydroxides decrease.

(b) What are the trends in thermal stability of carbonates and nitrates down Group 2?

(1)

- ☐ A Carbonates increase, nitrates decrease.
- ☐ B Carbonates decrease, nitrates increase.
- ☐ C Carbonates increase, nitrates increase.
- ☐ D Carbonates decrease, nitrates decrease.

(c) What are the trends in first ionization energy and electronegativity of the elements down Group 2?

(1)

- ☐ A Ionization energy increases, electronegativity decreases.
- ☐ B Ionization energy decreases, electronegativity increases.
- ☐ C Ionization energy increases, electronegativity increases.
- ☐ D Ionization energy decreases, electronegativity decreases.

(Total for Question 2 = 3 marks)



3 Which silver halide is a cream coloured solid which darkens in sunlight and dissolves in concentrated ammonia solution?

- ☐ A AgF
- ☐ B AgCl
- ☐ C AgBr
- ☐ D AgI

(Total for Question 3 = 1 mark)

4 What is the FBF bond angle in boron trifluoride, BF₃?

- ☐ A 180°
- ☐ B 120°
- ☐ C 109.5°
- ☐ D 90°

(Total for Question 4 = 1 mark)

5 What is the total number of electrons in the covalent bonds in a beryllium chloride molecule, BeCl₂?

- ☐ A 2
- ☐ B 4
- ☐ C 6
- ☐ D 8

(Total for Question 5 = 1 mark)

6 Which of the following molecules is linear?

- ☐ A CO₂
- ☐ B C₂H₄
- ☐ C H₂O
- ☐ D NH₃

(Total for Question 6 = 1 mark)



7 Which of the following molecules is **non-polar**?

- ☐ A CH_3Cl
- ☐ B CH_2Cl_2
- ☐ C CHCl_3
- ☐ D CCl_4

(Total for Question 7 = 1 mark)

8 Methanol dissolves in water mainly due to the formation of new

- ☐ A hydrogen bonds.
- ☐ B dipole-dipole forces.
- ☐ C London forces.
- ☐ D covalent bonds.

(Total for Question 8 = 1 mark)

9 Which of the following molecules does **not** absorb infrared radiation?

- ☐ A N_2
- ☐ B NO_2
- ☐ C CO
- ☐ D CO_2

(Total for Question 9 = 1 mark)

10 There would be a major peak in the mass spectrum for butan-1-ol, $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$, but **not** for butan-2-ol, $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$, at m/e value

- ☐ A 15
- ☐ B 17
- ☐ C 29
- ☐ D 43

(Total for Question 10 = 1 mark)

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



11 How many molecular ion peaks (parent ion peaks) occur in the mass spectrum of 1,2-dibromoethane, $\text{CH}_2\text{BrCH}_2\text{Br}$?

Assume the only isotopes present are ^1H , ^{12}C , ^{79}Br and ^{81}Br .

- ☐ A 1
- ☐ B 2
- ☐ C 3
- ☐ D 4

(Total for Question 11 = 1 mark)

12 The following reactions have been used in the chemical industry to make liquid and solid products, allowing any gaseous products to escape into the atmosphere:

- A $\text{CH}_3\text{OH}(\text{g}) + \text{CO}(\text{g}) \rightarrow \text{CH}_3\text{COOH}(\text{l})$
- B $\text{CaCO}_3(\text{s}) \rightarrow \text{CaO}(\text{s}) + \text{CO}_2(\text{g})$
- C $\text{CH}_4(\text{g}) + 3\text{Cl}_2(\text{g}) \rightarrow \text{CHCl}_3(\text{l}) + 3\text{HCl}(\text{g})$
- D $\text{CH}_2\text{CH}_2(\text{g}) + \text{Cl}_2(\text{g}) \rightarrow \text{CH}_2\text{ClCH}_2\text{Cl}(\text{l})$

(a) Which reaction has an atom economy by mass of 56%?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(b) Which reaction causes the most immediate damage to the environment?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(c) Which reaction is an electrophilic addition?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 12 = 3 marks)



- 13 Propan-1-ol and propan-2-ol are separately oxidized under mild conditions by acidified sodium dichromate(VI) and the product immediately distilled off. What is the oxidation product in each case?

		Propan-1-ol	Propan-2-ol
☐	A	propanal	propanone
☐	B	propanoic acid	propanone
☐	C	propanal	propanoic acid
☐	D	propanone	propanal

(Total for Question 13 = 1 mark)

- 14 Unsaturated vegetable oils are hardened to make margarine by reaction with hydrogen and a nickel catalyst. Which terms could both be used to describe this type of reaction?

- ☐ A Substitution and oxidation
- ☐ B Substitution and reduction
- ☐ C Addition and oxidation
- ☐ D Addition and reduction

(Total for Question 14 = 1 mark)

- 15 When iodomethane, CH_3I , is heated in a sealed tube with an excess of alcoholic ammonia, which of the following **cannot** be formed?

- ☐ A Methylamine, CH_3NH_2
- ☐ B Ethylamine, $\text{CH}_3\text{CH}_2\text{NH}_2$
- ☐ C Dimethylamine, $(\text{CH}_3)_2\text{NH}$
- ☐ D Ammonium iodide, NH_4I

(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 enthalpy change of neutralization of an acid by an alkali is measured by adding 10.0 cm^3 of hydrochloric acid to 10.0 cm^3 of sodium hydroxide. 10.0 cm^3 pipettes with an accuracy of $\pm 0.04 \text{ cm}^3$ are used to measure out both solutions.

The overall percentage error in measuring the total volume of the reaction mixture is

- ☐ A $\pm 0.04\%$
- ☐ B $\pm 0.08\%$
- ☐ C $\pm 0.4\%$
- ☐ D $\pm 4.0\%$

(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 the element chlorine and its compounds.

- (a) When chlorine is bubbled through water, a solution of chlorine water forms. What is the colour of chlorine water?

(1)

- (b) Chlorine water is added to potassium iodide solution.

- (i) State the colour of the solution produced.

(1)

- (ii) Write the **ionic** equation for the reaction, including state symbols.

(2)

- (c) The concentration of chlorine water was found by taking 10.0 cm^3 of solution, adding an excess of potassium iodide solution, and titrating with $0.0100 \text{ mol dm}^{-3}$ of sodium thiosulfate solution. The experiment was repeated.

The following results were obtained.

Titration number	1	2
Final burette reading / cm^3	38.60	47.60
Initial burette reading / cm^3	29.50	38.60
Volume added / cm^3	9.10	9.00



- (i) Name a suitable indicator for the titration. State the colour change you would expect to see at the end point.

(2)

Indicator

Colour change from to

- (ii) Calculate the mean titre and use this value to calculate the number of moles of sodium thiosulfate used in the titration.

(1)

Mean titre = cm^3

Moles of sodium thiosulfate

- (iii) Complete the ionic equation for the reaction between iodine and thiosulfate ions.

(2)



- (iv) Calculate the number of moles of iodine which reacted with the sodium thiosulfate solution.

(1)

- (v) Hence state the number of moles of chlorine present in 10.0 cm^3 of the chlorine water.

(1)

- (vi) Calculate the concentration of the chlorine water, in mol dm^{-3} .

(1)



(d) Potassium burns in chlorine to form potassium chloride.

(i) Give the colour of the flame when potassium burns in chlorine.

(1)

(ii) Write the equation for the reaction between potassium and chlorine. State symbols are **not** required.

(1)

(e) Concentrated sulfuric acid is added to potassium chloride in a test tube. Steamy fumes are given off which react with ammonia to give dense white smoke.

(i) Name the gas given off in this reaction.

(1)

(ii) Steamy fumes are observed at the mouth of the test tube. Explain how these fumes are formed.

(1)

(iii) The steamy fumes react with ammonia to give a dense white smoke. Identify the white smoke by name or formula.

(1)

(f) 2-chlorobutane can be made from butan-2-ol.

(i) Name the chemical you would add to butan-2-ol in the laboratory to make 2-chlorobutane.

(1)



- (ii) 2-chlorobutane reacts with alcoholic potassium hydroxide at a high temperature to form a mixture of gaseous alkenes.

Draw a fully labelled diagram of the apparatus you would use to prepare and collect this mixture.

(3)

(Total for Question 17 = 21 marks)



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18 This question is about ethanethiol, $\text{CH}_3\text{CH}_2\text{SH}$. Thiols are like alcohols, but the oxygen atom has been replaced by a sulfur atom. They react in a similar way to alcohols.

(a) (i) Draw a dot and cross diagram for ethanethiol, showing outer electrons only.

(2)

(ii) Give the value for the CSH bond angle in ethanethiol. Justify your answer.

(3)

CSH angle

Justification

.....
.....
.....

(b) There are hydrogen bonds between ethanol molecules but not between ethanethiol molecules.

(i) Explain why the bond angle around the hydrogen atom involved in a hydrogen bond is 180° .

(2)

.....
.....
.....
.....

(ii) Explain why there are no hydrogen bonds between ethanethiol molecules.

(1)

.....
.....



(c) (i) Describe the formation of London forces.

(2)

.....

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.....

.....

(ii) Explain why the London forces in ethanethiol are stronger than those in ethanol.

(1)

.....

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.....

(d) The reaction of sodium with ethanethiol, $\text{CH}_3\text{CH}_2\text{SH}$, is similar to its reaction with ethanol.

(i) Suggest one observation you would make when sodium is added to ethanethiol.

(1)

.....

.....

.....

(ii) Suggest a balanced equation for this reaction. State symbols are **not** required.

(1)



(e) Ethanol can be made from bromoethane by reaction with aqueous potassium hydroxide, KOH(aq), under suitable conditions.

(i) Write the equation for this reaction. State symbols are **not** required.

(1)

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

(2)

Type

Mechanism

(iii) Suggest the formula of a suitable chemical to make ethanethiol from bromoethane.

(1)

(f) When ethanethiol undergoes complete combustion in air, a gas is produced which is not formed on the complete combustion of ethanol. Identify the gas and suggest why it is damaging to the environment.

(2)

(Total for Question 18 = 19 marks)

TOTAL FOR SECTION B = 40 MARKS



SECTION C

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

- 19 This question is about nitrogen monoxide, NO, which can be described both as a friend and a foe.

Chemists have discovered that nitrogen monoxide plays an important role in the body by dilating blood vessels. If someone is suffering from blood circulatory or heart problems, a chemical may be given which will quickly break down to give nitrogen monoxide. Years ago, nitroglycerine was used for this purpose. Interestingly, the same chemical Nobel had used to make dynamite was used to treat him in old age.

In the laboratory, nitrogen monoxide can be prepared by adding concentrated nitric acid to powdered silver. Nitrogen monoxide is a colourless gas which is partially soluble in water. It is difficult to detect its smell, because it reacts with oxygen in the air to form pungent-smelling nitrogen dioxide.

Nitrogen monoxide is formed when a mixture of air and oxygen is heated to a high temperature. This reaction occurs in the engines of cars and aeroplanes. Nitrogen monoxide has a disastrous effect on the ozone layer because it is a free radical. Nitrogen monoxide is also a greenhouse gas.

- (a) (i) What is meant by the term **free radical**?

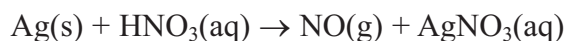
(1)

- (ii) Suggest a dot and cross diagram for nitrogen monoxide, showing outer shell electrons only, remembering that it is a free radical.

(2)



- (b) (i) **Part** of the **unbalanced** equation for the preparation of nitrogen monoxide from nitric acid is shown below.



Identify the elements which are oxidized and reduced and give their oxidation numbers.

(3)

Element oxidized

Oxidation number initial final

Element reduced

Oxidation number initial final

- (ii) Complete and balance the equation for the reaction between silver and nitric acid.

(2)



- (c) The reaction between nitrogen and oxygen to form nitrogen monoxide reaches equilibrium.



- (i) Explain why the yield of nitrogen monoxide is increased when the temperature is increased.

(1)

.....

- *(ii) State and explain the effect, if any, on the yield of nitrogen monoxide when the pressure is increased.

(2)

.....



(iii) State and explain how the rate of the reaction is affected by an increase in pressure.

(2)

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*(d) (i) Explain why a jet aeroplane in flight causes much more damage to the ozone layer than cars carrying the same number of passengers at sea level. You should assume that the nitrogen monoxide outputs for both methods of conveying the passengers are the same.

(2)

.....

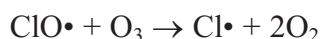
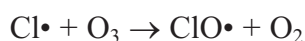
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- (ii) The reactions of chlorine free radicals with ozone may be represented by the following equations.



Write corresponding equations for the reactions of the free radical nitrogen monoxide with ozone. Combine your two equations to show the overall reaction.

Use these equations to explain why a small quantity of nitrogen monoxide can have a continuing effect on the ozone layer.

(5)

Equations

Explanation

.....

.....

.....

.....

.....

.....

(Total for Question 19 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 80 MARKS



The Periodic Table of Elements

1	2	Key										3	4	5	6	7	0 (8)		
		relative atomic mass atomic symbol name atomic (proton) number																1.0 H hydrogen 1	4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	(18)		
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	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				

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1.0
H
hydrogen
1



Mark Scheme (Results)

June 2011

GCE Chemistry (6CH02) Paper 01 Application of Core Principles of Chemistry

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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.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	C	1

Question Number	Correct Answer	Mark
2 (a)	B	1

Question Number	Correct Answer	Mark
2 (b)	C	1

Question Number	Correct Answer	Mark
2 (c)	D	1

Question Number	Correct Answer	Mark
3	C	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	A	1

Question Number	Correct Answer	Mark
9	A	1

Question Number	Correct Answer	Mark
10	D	1

Question Number	Correct Answer	Mark
11	C	1

Question Number	Correct Answer	Mark
12 (a)	B	1

Question Number	Correct Answer	Mark
12 (b)	C	1

Question Number	Correct Answer	Mark
12 (c)	D	1

Question Number	Correct Answer	Mark
13	A	1

Question Number	Correct Answer	Mark
14	D	1

Question Number	Correct Answer	Mark
15	B	1

Question Number	Correct Answer	Mark
16	C	1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a)	Pale / light and green / yellow Allow (virtually) colourless	clear yellow green any other colour	1

Question Number	Acceptable Answers	Reject	Mark
17 (b)(i)	Red/brown (solution) Allow yellow Ignore (From....) to....	Purple (or in combination with red or brown) Pale yellow Orange (or in combination with red or brown) Reject any other colours alone or in combination Grey/black (or any other colour alone or in combination) solid	1

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	$\text{Cl}_2(\text{aq}) + 2\text{I}^-(\text{aq}) \rightarrow 2\text{Cl}^-(\text{aq}) + \text{I}_2(\text{aq})/(\text{s})$ Entities (1) Balancing and all four state symbols Dependent on correct entities (1) $\text{Cl}_2(\text{aq}) + 2\text{KI}(\text{aq}) \rightarrow 2\text{KCl}(\text{aq}) + \text{I}_2(\text{aq})/(\text{s})$ 1 max $\text{K}^+(\text{aq})$ on both sides of otherwise correct equation 1 max		2

Question Number	Acceptable Answers	Reject	Mark
17 (c)(i)	Starch (1) Blue/black to colourless Dependent on starch indicator (1) Accept: no indicator needed (1) Yellow to colourless (1) Blank for indicator and yellow to colourless 1max	Any other indicator e.g. methyl orange/ phenolphthalein = 0/2 Colourless to blue/black Blue/black to clear Any mention of purple	2

Question Number	Acceptable Answers	Reject	Mark
17 (c)(ii)	(ii) – (vi) General comments: Allow correct answers with no working in all parts N.B. Mark each part to mark scheme answer first then allow TE from earlier parts. Minimum correct to 2SF. Penalise SF for 1SF once only. But incorrect rounding e.g. 4.525 to 4.52 is penalised once separately as well. Penalise wrong units once only as well. (Mean titre = 9.05) $\frac{9.05 \times 0.01}{1000}$ $= 9.05 \times 10^{-5} / 0.0000905(\text{mol})$ Allow $9.1 \times 10^{-5} / 0.000091(\text{mol})$	$9.(0) \times 10^{-5} / 0.00009(0)$	1

Question Number	Acceptable Answers	Reject	Mark
17 (c)(iii)	$\text{I}_2(\text{aq}) + 2\text{S}_2\text{O}_3^{2-}(\text{aq}) \rightarrow$ $\text{2I}^{-}(\text{aq}) + \text{S}_4\text{O}_6^{2-}(\text{aq})$ (1) (1) Marks stand alone for entities with balancing Either of these on their own scores 1 mark regardless of anything else that is written Multiples/fractions of equation allowed Ignore state symbols even if incorrect		2

Question Number	Acceptable Answers	Reject	Mark
17 (c)(iv)	$\frac{9.05 \times 10^{-5}}{2}$ $= 4.525 \times 10^{-5} / 0.00004525(\text{mol})$ Allow $4.53 \times 10^{-5} / 0.0000453$ etc Allow TE <u>ans (ii)</u> $\frac{2}{2}$ Accept TE from (iii) if you see it		1

Question Number	Acceptable Answers	Reject	Mark
17 (c)(v)	$4.525 \times 10^{-5} / 0.00004525$ (mol) Allow TE = ans (iv) [Allow 'ans (iv)' with no numbers for this part only]		1

Question Number	Acceptable Answers	Reject	Mark
17 (c)(vi)	$4.525 \times 10^{-5} \times \frac{1000}{10} =$ $4.525 / 4.53 \times 10^{-3} / 0.004525 / 0.00453$ (mol dm ⁻³) Accept TE ans (v) x 100 [a calculated number must be given]		1

Question Number	Acceptable Answers	Reject	Mark
17 (d)(i)	Lilac Allow (light) purple or mauve	Violet Reject any other colours alone or in combination	1

Question Number	Acceptable Answers	Reject	Mark
17 (d)(ii)	$2K + Cl_2 \rightarrow 2KCl$ Accept multiples/fractions Ignore state symbols even if incorrect Ignore correct charges on ions in KCl	K_2 and/or KCl_2 Charges on reactants K and/or Cl_2	1

Question Number	Acceptable Answers	Reject	Mark
17 (e)(i)	Hydrogen chloride This may be accompanied by HCl	Hydrochloric acid HCl /HCl(g)/HCl (gas) alone SO ₂ H ₂ S Anything else	1

Question Number	Acceptable Answers	Reject	Mark
17 (e)(ii)	Dissolves in moisture/water/water vapour (in the air) Or reacts with moisture/water/water vapour (in the air)	HCl condenses	1

Question Number	Acceptable Answers	Reject	Mark
17 (e)(iii)	NH_4Cl / Ammonium chloride/ ClNH_4 NH_4^+Cl^- / $\text{H}_4\text{N}^+\text{Cl}^-$ / Cl^-NH_4^+ Ignore any states even if incorrect	Ammonia chloride / NH_3Cl	1

Question Number	Acceptable Answers	Reject	Mark
17 (f)(i)	Any one of: Phosphorus(V) chloride/pentachloride Phosphorus(III) chloride/trichloride Allow (III/V) anywhere Concentrated hydrochloric acid Hydrogen chloride (gas) Sodium/potassium chloride and concentrated sulfuric acid Thionyl chloride Allow correct formula(e) for all above But note: conc HCl / conc H_2SO_4	Phosphorus chloride Hydrochloric acid/HCl/ HCl(aq) Chlorine	1

Question Number	Acceptable Answers	Reject	Mark
17 (f)(ii)	Be generous here Horizontal test tube with ceramic fibre/ any sort of wool except iron (1) soaked in 2-chlorobutane and (alcoholic) potassium hydroxide/reactants/ reagents/ chemicals/reaction mixture... ...with heat (or any diagram of a heat source or the word heat) (1) OR Round bottom/pear shaped flask/sloping test/boiling tube and heat (or any diagram of a heat source or the word heat) (1) containing 2-chlorobutane and (alcoholic) potassium hydroxide/reactants/ reagents/ chemicals/reaction mixture (1) Ignore: any use of aluminium oxide/pumice reflux/distillation set up Gas collection over water (1) Ignore Bunsen valves Allow: Collection in a gas syringe Note: This does not constitute a sealed apparatus	Sealed apparatus but ignore inadvertent closures owing to poor cross-sectional drawings (-1) Poor diagram e.g. clear air gaps at intermediate joints in the apparatus(-1) Solution/substances alone An arrow on its own Conical/flat bottomed flask N.B. contradiction between drawing and any label Solution/substances alone A poor diagram mark (which can be the second) should be deducted for the delivery tube through the side of trough and/or the delivery tube missing the collection tube.	3

Question Number	Acceptable Answers	Reject	Mark
18 (a)(i)	<pre> H H .x .x xx H.xC.xC.xSx.H .x .x xx H H </pre> All Bonding electrons (1) Ignore any circles/bonds with electrons Two lone pairs on sulfur Dependent on eight electrons around sulfur (1) Accept all dots/crosses Fully correct methanethiol 1max	missing Hs/Cs (-1)	2

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	104.5 (°) (accept 91 to 105)(1) (Four pairs/two bonding pairs and two non-bonding pairs of electrons in) minimum repulsion / maximum separation / as far apart as possible (tetrahedral arrangement) Ignore the number of pairs of electrons (1) And lone / non bonding pair(s) of electrons repel more (than bond pairs/CH bonds) (1) Mark independently	atoms... Linear shape (-1) ...repel any sort of atoms	3

Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	Two pairs of electrons/ two bonds (around the H atom) OR Can be shown on a diagram either with electrons or bonds (in approximate straight line) around the hydrogen (1) (Repel to) maximum separation/minimum repulsion/as far apart as possible (1) Dependent on first mark except: Allow: It has a linear shape due to maximum separation/minimum repulsion 1 max	Linear shape on its own	2

Question Number	Acceptable Answers	Reject	Mark
18 (b)(ii)	Sulfur is less electronegative (than oxygen)/not electronegative enough OR oxygen is more electronegative (than sulfur) / electronegative enough OR Hydrogen bonds can only occur between H and either N, O, or F due to the large difference in electronegativity	Bigger/higher rmm/atom/molecule alone Hydrogen not bonded to N, O, or F alone	1

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	Temporary asymmetrical distribution/random arrangement of electrons/ charge (density) Ignore references to atoms/molecules OR instantaneous/temporary dipole (1) (these produce) induced dipoles OR description of induction (1) Mark independently Ignore references to atoms/molecules	Any mention of permanent dipoles = 0/2 d+ and d- /δ+ and δ- unless clearly temporary	2

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Ethanethiol/sulfur has more electrons (so forces are stronger) Allow sulfur has an extra shell of electrons OR ethanol/oxygen has fewer/less electrons (so forces are weaker) Allow oxygen has one fewer shell of electrons	Larger charge cloud/larger electron cloud/more outer electrons on their own Any reference to size/radius/rmm unless with correct answer	1

Question Number	Acceptable Answers	Reject	Mark
18 (d)(i)	Any one from: Bubbles (of gas) /fizzing /effervescence Sodium disappears/dissolves/gets smaller White solid forms Multiple answers: number correct minus number wrong to give a maximum of 1 and a minimum of 0 Ignore: sodium floats or sinks and/or heat given out and/or hydrogen produced	Sodium rushes about (i.e. any confusion with reaction of sodium with water) Flames Steam	1

Question Number	Acceptable Answers	Reject	Mark
18 (d)(ii)	$\text{Na} + \text{CH}_3\text{CH}_2\text{SH} \rightarrow \text{CH}_3\text{CH}_2\text{SNa} + \frac{1}{2}\text{H}_2$ Accept multiples Ignore charges on sodium salt/state symbols even if incorrect	H for hydrogen $\text{CH}_3\text{CH}_2\text{NaS}$	1

Question Number	Acceptable Answers	Reject	Mark
18 (e)(i)	$\text{C}_2\text{H}_5\text{Br} + \text{KOH} \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{KBr} / \text{K}^+ + \text{Br}^-$ Accept ionic equation $\text{C}_2\text{H}_5\text{Br} + \text{OH}^- \rightarrow \text{C}_2\text{H}_5\text{OH} + \text{Br}^-$ Allow molecular formula of alcohol, $\text{C}_2\text{H}_6\text{O}$		1

Question Number	Acceptable Answers	Reject	Mark
18 (e)(ii)	Type – substitution (1) Mechanism – Nucleophilic (1) Accept words in either order. Both words may be given on either line. <u>N.B. This is the only way to score 2 marks!</u>		2

Question Number	Acceptable Answers	Reject	Mark
18 (e)(iii)	KSH /NaSH Allow KHS/NaHS or H_2S Ignore state symbols		1

Question Number	Acceptable Answers	Reject	Mark
18 (f)	Sulfur dioxide/SO₂ (1) Causes acid rain (1) Allow effects of acid rain e.g. acid lakes/lake pollution/ crop or forest damage/limestone building damage/named metal which corrodes. [It is quite possible candidates will give details of oxidation of sulfur dioxide to sulfur trioxide and formation of sulfuric acid. Ignore any of this additional information.] Allow triggers asthma Ignore any reference to greenhouse gas/ global warming/any reference to sea pollution or sea creatures Second mark dependent on first mark except allow: If SO₂ not mentioned then, SO₃/H₂SO₄ causes acid rain for 1 mark	SO₃ CO₂ Attacks ozone layer CO₂ causes acid rain	2

TOTAL FOR SECTION B = 40 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	An atom/ molecule (or ion)/species/entity with an unpaired electron Ignore any references to homolytic bond fission but penalise a reference to heterolytic bond fission	Lone/single/free electron with unpaired electrons A free radical is an unpaired electron	1

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	$\begin{array}{c} \times \times \quad \cdot \cdot \\ \times \text{N}_{\times}^{\times} : \text{O} : \end{array}$ Double bond (1) Other electrons correct Dependent on double bond (1) Allow: all dots or all crosses or any combination	N single bond O Reject unpaired electron on oxygen	2

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	<u>Wherever</u> it appears in the answer: Ag/silver (oxidized) 0 to +1/1+ (1) <u>Wherever</u> it appears in the answer: N/Nitrogen = +5/5+ (1) (Element reduced) N/nitrogen ... to +2/2+ (1) N.B. Some candidates give ...+2/2+ and +5/5+ which is correct for both nitrogen products Only penalise no positive charges once		3

Question Number	Acceptable Answers	Reject	Mark
*19 (b)(ii)	$3\text{Ag(s)} + 4\text{HNO}_3\text{(aq)} \rightarrow \text{NO(g)} + 3\text{AgNO}_3\text{(aq)} + 2\text{H}_2\text{O(l)}$ 3Ag reacting to form NO and 3AgNO₃ (1) 4HNO₃ and 2H₂O (1) mark independently of (b)(i) No TE from (b)(i)		2

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	The reaction is endothermic (so goes to remove heat/lower the temperature) Allow ΔH is positive (so goes to remove heat/lower the temperature)	Reaction/equilibrium moves to the right/to oppose change without any other statement	1

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	The yield is not changed OR No change OR no effect on the equilibrium (1) as there is no change in the number of (moles of) (gaseous) molecules OR as there is no change in the number of (gaseous) moles/particles (1) Allow: cylinder surface acts as catalyst (1) And all sites are filled so pressure has no affect (1) Second mark dependent on first in both cases Ignore any comment on rate whether correct or not	Reference to atoms or ions instead of molecules	2

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iii)	Rate increases because (increase in pressure) means more particles per unit volume/less space for molecules/molecules closer together/greater or increased concentration (1) Comment: A correct statement of why the rate increases is needed with rate increases (somewhere in the answer) for the first mark which increases the frequency / increases the number of collisions/more chance of (successful) collisions (between molecules) (1) Ignore any references to (activation/kinetic) energy Mark independently	more particles per unit area Reference to atoms or ions instead of molecules	2

Question Number	Acceptable Answers	Reject	Mark
*19 (d)(i)	Jet aeroplanes fly (much) close(r)/near(er) to the ozone (layer)/stratosphere (so more NO to deplete ozone layer) (1) ALLOW: Jet aeroplanes fly in the ozone (layer)/stratosphere Some NO from cars reacts (e.g. with O₂ to give NO₂) OR NO from planes does not react before it can react with the ozone (1) Mark independently	Anything else e.g. aeroplanes fly in the ionosphere NO absorbed by plants NO from cars dissociates/decomposes/break down NO from planes does not dissociate/decompose/break down NO from cars takes a long time to reach the ozone layer NO dissolves	2

Question Number	Acceptable Answers	Reject	Mark
19 (d)(ii)	Comment: Please underline Key Points with highlighter, or annotate with tick at Key Point, or annotate with Key Point number from mark scheme wherever mark awarded. This ensures that it is easy to count up marks for this part. KP1 $\text{NO}(\bullet) + \text{O}_3 \rightarrow (\bullet)\text{NO}_2 + \text{O}_2$ (1) Comment: Dots are not required for KP1 KP2 $\bullet\text{NO}_2 + \text{O}_3 \rightarrow \text{NO}\bullet + 2\text{O}_2$ (1) Comment: Dots can be on either side of both free radicals ALLOW for KP2: $\text{O}_3 \rightarrow \text{O}\bullet + \text{O}_2$ $\bullet\text{NO}_2 + \text{O}\bullet \rightarrow \text{NO}\bullet + \text{O}_2$ N.B. Both equations required here The overall equation is: KP3 $2\text{O}_3 \rightarrow 3\text{O}_2$ (1) ALLOW: equilibrium arrow This mark is independent of KP1 and KP2 KP4 NO/the free radical (Allow $\text{Cl}\bullet$) is regenerated/a catalyst or wtte (1) KP5 and one molecule can break down large numbers of ozone molecules OR NO (Allow $\text{Cl}\bullet$) continues to react (with ozone)/reaction is continuous OR Mention of chain reaction (1) Ignore any reference to global warming as an additional problem KP4 and 5 marks are independent	Overall equation with nothing cancelled If $\text{Cl}^\cdot$ is referred to as the radical then neither KP4 nor KP5 can be gained If the candidate makes clear that any of these processes lead to global warming loses KP4 or 5 but not both.	5

TOTAL FOR SECTION C = 20 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Thursday 19 January 2012 – Afternoon

Time: 1 hour 30 minutes

Paper Reference

6CH02/01

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 ►

P39303A

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7/7/5/3/



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 This question concerns the shapes of molecules and ions:

- A linear
- B trigonal planar
- C pyramidal
- D tetrahedral

Select from A to D the shape of

(a) boron trichloride, BCl_3

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(b) the ammonium ion, NH_4^+

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(c) carbon dioxide, CO_2

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 1 = 3 marks)



2 Tetrachloromethane, CCl_4 , is a

- ☐ A polar molecule with polar bonds.
- ☐ B polar molecule with non-polar bonds.
- ☐ C non-polar molecule with polar bonds.
- ☐ D non-polar molecule with non-polar bonds.

(Total for Question 2 = 1 mark)

3 The difference in boiling temperature between methane ($T_b = 109 \text{ K}$) and ethane ($T_b = 185 \text{ K}$) is best explained by the different numbers of

- ☐ A protons.
- ☐ B electrons.
- ☐ C covalent bonds.
- ☐ D hydrogen bonds.

(Total for Question 3 = 1 mark)

4 What is the oxidation number of oxygen in OF_2 ?

- ☐ A -2
- ☐ B -1
- ☐ C +1
- ☐ D +2

(Total for Question 4 = 1 mark)

5 In which of the following reactions is sulfuric(IV) acid, H_2SO_3 , acting as an oxidizing agent?

- ☐ A $2\text{NaOH} + \text{H}_2\text{SO}_3 \rightarrow \text{Na}_2\text{SO}_3 + 2\text{H}_2\text{O}$
- ☐ B $2\text{FeCl}_3 + \text{H}_2\text{SO}_3 + \text{H}_2\text{O} \rightarrow 2\text{FeCl}_2 + \text{H}_2\text{SO}_4 + 2\text{HCl}$
- ☐ C $2\text{H}_2\text{S} + \text{H}_2\text{SO}_3 \rightarrow 3\text{H}_2\text{O} + 3\text{S}$
- ☐ D $\text{H}_2\text{SO}_3 \rightarrow \text{H}_2\text{O} + \text{SO}_2$

(Total for Question 5 = 1 mark)



6 Ethanol is soluble in water. The **best** explanation for this is

- ☐ A ethanol molecules form hydrogen bonds with water molecules.
- ☐ B ethanol molecules form London (dispersion) forces with water molecules.
- ☐ C ethanol molecules form permanent dipole interactions with water molecules.
- ☐ D ethanol and water are miscible liquids.

(Total for Question 6 = 1 mark)

7 During a titration, when the solution in a pipette is transferred to a conical flask, a small amount of liquid remains in the tip of the pipette. This situation should be dealt with by

- ☐ A leaving the liquid in the pipette which is calibrated to allow for it.
- ☐ B slightly over-filling the pipette to compensate for the additional volume.
- ☐ C carefully blowing the liquid out of the pipette to ensure that it is empty.
- ☐ D repeating the titration.

(Total for Question 7 = 1 mark)

8 The tolerance of a 25 cm^3 pipette is $\pm 0.06\text{ cm}^3$. The percentage error in the measurement of 25 cm^3 using this pipette is

- ☐ A $\pm 0.06\%$
- ☐ B $\pm 0.12\%$
- ☐ C $\pm 0.24\%$
- ☐ D $\pm 0.48\%$

(Total for Question 8 = 1 mark)

9 A series of titrations is carried out using the same conical flask. Before carrying out each titration, the conical flask **must** be

- ☐ A rinsed with ethanol.
- ☐ B rinsed with distilled or deionised water.
- ☐ C rinsed with the solution that it will contain.
- ☐ D dried to remove all traces of liquid.

(Total for Question 9 = 1 mark)



10 When excess calcium is added to water, effervescence occurs and

- ☐ A a clear colourless solution is formed.
- ☐ B a cloudy suspension is formed.
- ☐ C an orange-red flame is seen.
- ☐ D a yellow flame is seen.

(Total for Question 10 = 1 mark)

11 When samples of magnesium nitrate, $\text{Mg}(\text{NO}_3)_2$, and calcium nitrate, $\text{Ca}(\text{NO}_3)_2$, are heated

- ☐ A both compounds decompose to form the corresponding nitrite and oxygen.
- ☐ B both compounds decompose to form the corresponding oxide, nitrogen dioxide and oxygen.
- ☐ C magnesium nitrate decomposes to form magnesium nitrite and oxygen whereas calcium nitrate decomposes to form calcium oxide, nitrogen dioxide and oxygen.
- ☐ D magnesium nitrate decomposes to form magnesium oxide, nitrogen dioxide and oxygen whereas calcium nitrate decomposes to form calcium nitrite and oxygen.

(Total for Question 11 = 1 mark)

12 Which of the following properties of the elements chlorine, bromine and iodine **increases** with increasing atomic number?

- ☐ A Boiling temperature
- ☐ B Bond enthalpy
- ☐ C Electronegativity
- ☐ D First ionization energy

(Total for Question 12 = 1 mark)

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

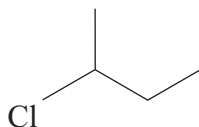


13 Which of the following is a secondary alcohol?

- ☐ A butan-1-ol
- ☐ B butan-2-ol
- ☐ C 2-methylpropan-1-ol
- ☐ D 2-methylpropan-2-ol

(Total for Question 13 = 1 mark)

14 The compound



has the systematic name

- ☐ A 2-chlorobutane
- ☐ B 3-chlorobutane
- ☐ C 1-chloro-1-methylpropane
- ☐ D 1-chloro-2-methylbutane

(Total for Question 14 = 1 mark)

15 When a chloroalkane is heated with aqueous sodium hydroxide

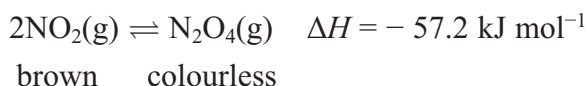
- ☐ A no reaction occurs with primary, secondary or tertiary chloroalkanes.
- ☐ B a reaction occurs with primary and secondary chloroalkanes but not with tertiary chloroalkanes.
- ☐ C a reaction occurs with tertiary chloroalkanes but not with primary and secondary chloroalkanes.
- ☐ D a reaction occurs with primary, secondary and tertiary chloroalkanes.

(Total for Question 15 = 1 mark)

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



- 16 Brown nitrogen dioxide, NO_2 , exists in equilibrium with colourless dinitrogen tetroxide, N_2O_4 .



- (a) The **pressure** is increased. When equilibrium is restored, the appearance of the mixture of gases will be

(1)

- ☐ A colourless.
- ☐ B unchanged.
- ☐ C paler brown.
- ☐ D darker brown.

- (b) The **temperature** is increased. When equilibrium is restored, the appearance of the mixture of gases will be

(1)

- ☐ A colourless.
- ☐ B unchanged.
- ☐ C paler brown.
- ☐ D darker brown.

(Total for Question 16 = 2 marks)

- 17 When propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, and propanone, CH_3COCH_3 , are compared using physical methods of analysis, which of the following is **not** correct?

- ☐ A The carbonyl groups absorb at very similar frequencies of the IR spectrum.
- ☐ B The compounds will have different patterns in the fingerprint region of the IR spectrum.
- ☐ C The compounds will form different fragmentation patterns in a mass spectrum.
- ☐ D The compounds will have molecular ion peaks at different mass to charge ratios in a mass spectrum.

(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 boiling temperatures of some hydrides are given below.

Compound	Boiling temperature / K
HF	293
HCl	188
HBr	206
HI	238
H ₂ O	373

*(a) Explain, by comparing the forces involved, why HI has a higher boiling temperature than HBr.

(3)

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*(b) Explain, by comparing the types of forces involved, why HF has a higher boiling temperature than HCl.

(3)

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(c) Suggest why H_2O has a higher boiling temperature than HF.

(1)

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(Total for Question 18 = 7 marks)

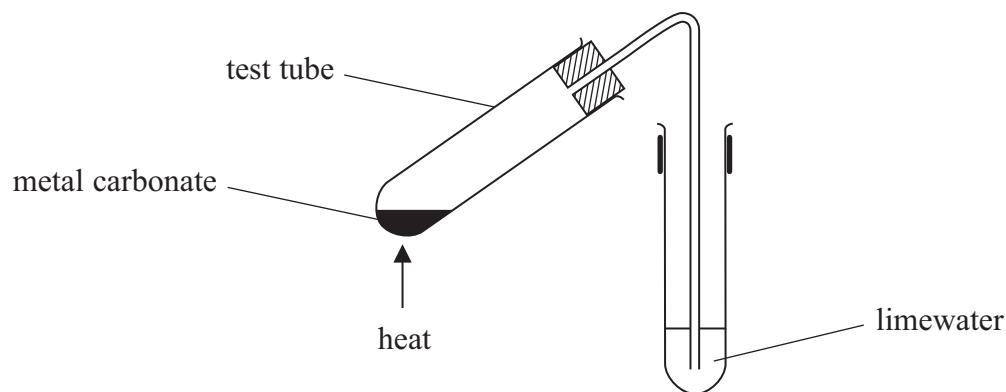


P 3 9 3 0 3 A 0 9 2 4

- 19 The carbonates of Group 2 in the Periodic Table decompose on heating to form the corresponding metal oxide and carbon dioxide. A general equation for the reaction is



The thermal stability of these carbonates can be compared in the laboratory using the apparatus in the diagram below. The test tube on the left contains a sample of a metal carbonate and the tube on the right contains limewater.



- (a) (i) State the measurement that you would make in this experiment.

(1)

- (ii) Suggest **three** ways to make sure that, when carrying out this experiment, the thermal stabilities of the different carbonates are compared fairly.

(3)

1

2

3



(b) (i) State the trend in the thermal stability of the metal carbonates as the group is descended.

(1)

* (ii) Explain this trend in stability.

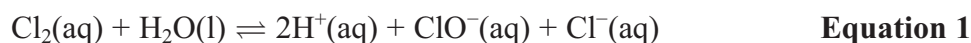
(3)

(Total for Question 19 = 8 marks)



P 3 9 3 0 3 A 0 1 1 2 4

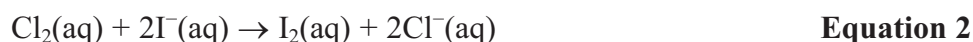
- 20** Chlorine disinfectants are essentially solutions containing chlorine molecules and chlorate(I) ions in an equilibrium summarised by the equation



The chlorine content of a disinfectant was determined using the following procedure.

1. 10.0 cm^3 of the disinfectant was transferred to a 250 cm^3 volumetric flask.
2. Approximately 20 cm^3 of nitric acid and 20 cm^3 potassium iodide solution (both in excess) were added to the volumetric flask.
3. The solution in the volumetric flask was made up to the mark with distilled water and then mixed thoroughly.
4. 10.0 cm^3 portions of the solution in the volumetric flask were titrated against a solution of sodium thiosulfate, concentration $0.109 \text{ mol dm}^{-3}$. Starch solution was added near the end-point of the titration and the mean (average) titre was 27.35 cm^3 .

The equations for the reactions involved in this procedure are



- (a) (i) Calculate the number of moles of sodium thiosulfate used in the titration. (2)
- (ii) Calculate the number of moles of iodine, I_2 , that reacted in the titration (step 4). (1)
- (iii) Hence state the number of moles of chlorine, Cl_2 , in 10.0 cm^3 of the solution in the volumetric flask. (1)



(iv) Calculate the concentration of chlorine, in mol dm^{-3} , in the **original** disinfectant.

(2)

(b) **Equation 1** is an example of a disproportionation reaction. Define the term 'disproportionation' and explain, by considering the relevant oxidation numbers, why this reaction is a disproportionation.

(3)

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(c) State the colours of the titration solution just before the starch solution is added, after the starch solution is added and the colour change at the end-point of the reaction.

(2)

Colour just before adding the starch

Colour after adding the starch

Colour at the end-point

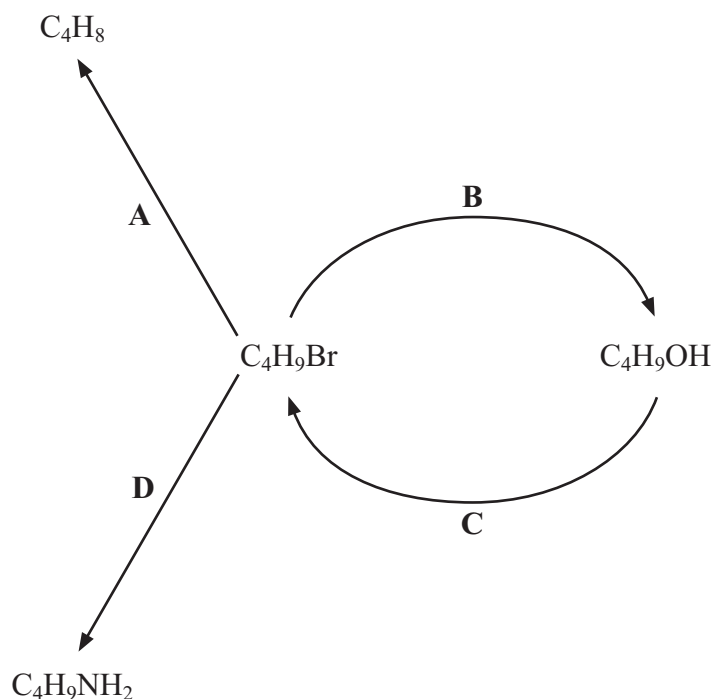
(Total for Question 20 = 11 marks)



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21 Halogenoalkanes are important intermediates in organic chemistry. The scheme below summarises some important reactions of a halogenoalkane.



(a) Identify the reagents and any specific conditions required for the reactions in the diagram. (You may assume that a suitable temperature is maintained in each reaction.)

(4)

A

B

C

D

(b) (i) Classify the type of reaction in each of **A** and **D**.

(2)

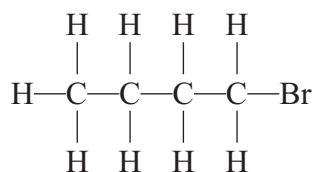
A

D



- *(ii) Reaction **B** can proceed via two possible reaction mechanisms, depending on the structure of the original compound. For each of the two isomers of C_4H_9Br shown below, draw the structure of the intermediate or transition state which is formed during the reaction. Explain in each case why the specified structure is more favourable.

(4)



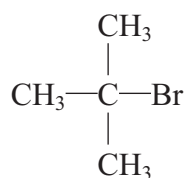
Intermediate or transition state

Explanation

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Intermediate or transition state

Explanation

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(iii) If $\text{C}_4\text{H}_9\text{I}$ is used instead of $\text{C}_4\text{H}_9\text{Br}$ in reaction **D**, the rate of formation of $\text{C}_4\text{H}_9\text{NH}_2$ increases. Explain why the rate of reaction increases.

(1)

(c) Halogenoalkanes are widely used as refrigerants and belong to the class of refrigerants that cool by change of state (typically by boiling).

(i) Suggest how halogenoalkanes cool by change of state.

(1)

(ii) Suggest **two** characteristics or properties desirable in a refrigerant.

(2)

- 1
- 2

(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 40 MARKS



SECTION C

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

22

Nitrogen monoxide is an unusual molecule both in its chemical structure (shown below) and in its impact on our lives.

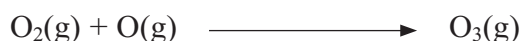
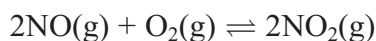


Nitrogen monoxide is an important chemical messenger in all mammals and, at appropriate concentrations, it is vital to life; however, at high concentrations in the body, it is extremely toxic.

Nitrogen monoxide is considered a dangerous atmospheric pollutant; it is involved in the formation of a range of toxic substances, including ozone, at low altitudes, and in the depletion of the ozone layer at high altitudes.

Nitrogen monoxide is formed by the direct combination of nitrogen and oxygen at high temperatures, a reaction that occurs naturally in lightning discharges, and as a by-product of the reactions in internal combustion and jet engines. Catalytic converters reduce nitrogen monoxide emissions from car engines by catalysing the reaction between nitrogen monoxide and carbon monoxide to form nitrogen and carbon dioxide.

The reactions of nitrogen monoxide which involve ozone in the atmosphere are summarised below.



When the ratio of nitrogen dioxide to nitrogen monoxide is high (> 3), the rate of formation of ozone is faster than its rate of removal. When the ratio is low (< 0.3), the reverse is true.

Ozone causes breathing difficulties, headaches, fatigue and can aggravate respiratory problems. The reaction of nitrogen monoxide with hydrocarbons can also produce other toxic compounds, such as aldehydes.

- (a) Write the equation for the formation of nitrogen monoxide from nitrogen and oxygen. State symbols are **not** required.

(1)



(b) The electronic structure of nitrogen monoxide is unusual in that it has an unpaired electron.

- (i) What name is given to a chemical species such as nitrogen monoxide that has an unpaired electron?

(1)

- (ii) Chemical species with unpaired electrons occur as intermediates in some chemical reactions. What type of bond breaking produces these species?

(1)

- (c) (i) Suggest the most likely source of the hydrocarbons that react with nitrogen monoxide to form toxic compounds.

(1)

- (ii) Suggest the type of reaction that is involved when a hydrocarbon is converted into an aldehyde.

(1)

- (iii) Draw the **skeletal** formula of the aldehyde with three carbon atoms.

(1)

- (iv) By considering the equation



explain the effect of the reaction of hydrocarbons with nitrogen monoxide on the breakdown of ozone.

(1)



(d) Suggest why the proportion of nitrogen dioxide might be reduced at high altitudes.

(2)

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(e) Explain why it is important to maintain the concentration of ozone in the upper atmosphere.

(2)

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(f) (i) Write an equation for the reaction on a catalytic converter described in the passage. State symbols are **not** required.

(1)



- (ii) Draw an energy profile for the exothermic reaction in (f)(i). Label the axes, the reactants and products, the enthalpy change and the activation energy.

(3)

- *(iii) By referring to your energy profile, explain how a catalyst speeds up a chemical reaction.

(3)

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- (g) Jet aircraft are considered a greater threat to the ozone layer than road vehicles. Suggest an explanation for this.

(2)

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(Total for Question 22 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS

TOTAL FOR PAPER = 80 MARKS



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The Periodic Table of Elements

1	2	Key										3	4	5	6	7	0 (8)		
		relative atomic mass atomic symbol name atomic (proton) number																1.0 H hydrogen 1	4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	(18)		
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	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				

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1.0
H
hydrogen
1



Mark Scheme (Results)
January 2012

GCE Chemistry (6CH02) Paper 01
Application of Core Principles of Chemistry

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January 2012

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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 (a)	B		1
(b)	D		1
(c)	A		1

Question Number	Correct Answer	Reject	Mark
2	C		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	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	C		1

Question Number	Correct Answer	Reject	Mark
9	B		1

Question Number	Correct Answer	Reject	Mark
10	B		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	B		1

Question Number	Correct Answer	Reject	Mark
14	A		1

Question Number	Correct Answer	Reject	Mark
15	D		1

Question Number	Correct Answer	Reject	Mark
16 (a)	C		1
(b)	D		1

Question Number	Correct Answer	Reject	Mark
17	D		1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
18(a)	London/dispersion forces greater (ALLOW 'more') (in HI) ALLOW van der Waals forces/ temporary dipole (forces)/induced dipole (forces) Just 'Intermolecular (forces)' does not score this mark Stand alone mark (1) Any two from Because (Iodine/HI) has more electrons/iodine has more electron shells ALLOW bigger surface area (1) (So) more energy needed (ALLOW 'harder') to separate molecules / break the (London) forces ALLOW more energy needed to boil compound ALLOW intermolecular (forces) here (1) Permanent dipole in HI is weaker than the permanent dipole in HBr (1) The increase in London forces (from HCl to HI) outweighs the decrease in permanent dipole (1)	Iodide/bromide More electrons in the bond HI has more electron shells Just 'easier to boil compound'	3

Question Number	Acceptable Answers	Reject	Mark
18(b)	HF has hydrogen bonding (and HCl does not) Stand alone mark (1) Any two from Fluorine very electronegative/more electronegative than chlorine (1) Hydrogen bonding is (much) stronger (than other/named intermolecular forces) ALLOW Hydrogen bonding is (very) strong (1) So more energy needed (ALLOW 'harder') to separate molecules/ break the hydrogen bonds ALLOW more energy needed to boil compound (1) HCl has London/dispersion (and (weak) dipole-dipole) forces ALLOW (weak) dipole-dipole forces ALLOW 'Only London/dispersion forces' (1) ALLOW van der Waals forces/ temporary or induced dipole forces for London/dispersion	Just 'HF has stronger intermolecular forces (than HCl)' HF/F⁻ for fluorine Just 'easier to boil compound'	3

Question Number	Acceptable Answers	Reject	Mark
18(c)	Water forms (up to) two hydrogen bonds (per molecule but HF only one). IGNORE references to numbers of lone pairs.	More/stronger/ greater than two	1

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	Time for the first (permanent) cloudiness to appear in the limewater ALLOW Time for the limewater to turn milky/cloudy ALLOW Time for the limewater to turn milky/cloudy and (ppt) to dissolve ALLOW how long for time IGNORE references to volume of CO₂	How fast/how quickly	1

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	Any three from Constant Bunsen flame/electrical heater setting Fixed height of test tube above the flame Fixed moles/(ALLOW mass/amount) of carbonate Fixed volume/amount/mass of limewater Penalise use of quantity once only Same surface area/particle size (of solid) Standardise cloudiness of limewater using the disappearance of a cross (or similar) IGNORE repeats & use same measuring instruments /same person	Constant temp/heat Water bath Fixed angle Volume/quantity Concentration / quantity	3

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	More stable/(thermal stability) increases (as the group is descended)		1

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	Ignore an incorrect answer to 19b(i) and mark statements given independently Cation/positive (ALLOW metal) ion becomes larger (charge unchanged) OR cation charge density reduced (1) IGNORE references to shielding Polarisation/distortion reduced (1) (ALLOW polarising power reduced) of carbonate electron cloud/ carbonate ion/C-O bonds /anion (1) OR reverse argument for stability <i>decreasing as group ascended</i>	Atomic/metal radius/charge density of atom /molecule	3

Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	Throughout 20 (a): IGNORE sf except 1 sf (penalise once) correct answer with no working scores full marks mark consequentially IGNORE units unless incorrect $0.109 \times 27.35 \times 10^{-3}$ (1) $= 2.98115 \times 10^{-3} \text{ (mol)}$ $= 2.98 \times 10^{-3} / 0.00298 \text{ (mol)}$ (1) cq only on some concentration x some volume	0.003	2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	Moles $\text{I}_2 = 0.5 \times$ moles thiosulfate = 0.5 x answer to (a)(i) $= 1.490575 \times 10^{-3} = 1.49 \times 10^{-3} / 0.00149 \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iii)	Moles of $\text{Cl}_2 =$ moles of $\text{I}_2 =$ answer to (a)(ii) $= 1.49 \times 10^{-3} / 0.00149 \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iv)	Mark consequentially on answer in (a)(iii) Amount in volumetric flask = $25 \times \text{answer to (a)(iii)} (= 25 \times 1.490575 \times 10^{-3} = 3.72644 \times 10^{-2})$ OR $(25 \times 1.49 \times 10^{-3} = 3.725 \times 10^{-2})$ (1) (= amount in 10 cm^3 of disinfectant) Concentration = $100 \times \text{previous value}$ $(= 1000 \times 3.73 \times 10^{-2} / 10 = 3.73 \text{ (mol dm}^{-3}\text{)})$ (1) Concentration = $100 \times \text{answer to (a)(iii) scores}$ (1)		2

Question Number	Acceptable Answers	Reject	Mark
20(b)	(Atoms of) the same element (in the same species) are oxidized and reduced (1) ALLOW chlorine for 'element' Chlorine ON 0 oxidized to (+)1 in ClO^- (1) and reduced to -1 in Cl^- (1) Only penalise once if oxidized and reduced omitted Just 'Chlorine ON 0 oxidized to (+)1 and reduced to -1' or 'Chlorine oxidized to chlorate(I) and reduced to chloride'(1 mark only) Only penalise once if oxidized and reduced reversed	Molecule/substance/reactant /species Just Cl oxidized & reduced	3

Question Number	Acceptable Answers	Reject	Mark
20(c)	Colour just before adding the starch: (very) pale yellow/straw coloured (1) Colour after adding the starch: Blue-black (ALLOW black or (dark) blue) Colour at the end point: colourless (1) Both colours required IGNORE 'Clear'	Just 'yellow', brown, gold purple	2

Question Number	Acceptable Answers	Reject	Mark
21(a)	Names OR Formulae A = NaOH/KOH in ethanol /alcohol (1) B = NaOH/KOH in water/ aqueous (1) IGNORE any reference to ethanol /alcohol /dilute C = NaBr/KBr & (50% or moderately conc) H₂SO₄ / P & Br₂ / PBr₃ /PBr₅ /NaBr /KBr & H₃PO₄ /HBr ALLOW phosphorus bromide (1) IGNORE red/white (phosphorus) D = NH₃ (in alcohol /in a sealed tube /at high pressure) (1) IGNORE aqueous	Water + ethanol /water + alcohol For A and B OH⁻/alkali (penalise once) Dilute H₂SO₄ any mention of alkali any mention of acid	4

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	A = elimination (1) IGNORE 'nucleophilic' D = (nucleophilic) substitution (1)	mention of dehydration in A mention of electrophilic in A or D	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	Mark the diagrams; then mark the explanation sections together Score (1) for intermediate/ transition state wrong way round IGNORE geometry and missing minus sign and $\delta+$/ $\delta-$ (1) (1) Any two from Tertiary carbocation more stable (than primary carbocation) ALLOW Tertiary carbocation very stable/fairly stable/stable (1) This mark can be awarded even if structures and other explanations are incorrect or missing Methyl groups stabilise charge (of carbocation) (through positive inductive effect) Steric hindrance (by methyl groups) inhibits formation of (trigonal bipyramid) transition state/attack by nucleophile with tertiary compound Steric hindrance is less with the primary halogenoalkane/more with tertiary halogenoalkane ALLOW a description of steric hindrance e.g. blocking/less space	Full O—C—Br bonds OH—C + sign $\delta+$ Just 'primary carbocation unstable'	4

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	C–I bond weaker ALLOW C–I bond easier to break ALLOW iodine forms weaker bonds than bromine without mention of carbon ALLOW reverse arguments with C–Br bond stronger IGNORE Explanations in terms of electronegativity or bond polarity or activation energy or shielding even if incorrect	Just C–I bond longer	1

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	(Boiling) absorbs heat (allow energy)/latent heat (of vaporization)/enthalpy of vaporization from the surroundings/endothermic. If bonds are mentioned they must be intermolecular		1

Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	Any two from Not flammable Not toxic Unreactive/inert/non-corrosive (only one of these can score) (easily) compressible does not harm the ozone layer Boiling temperature below target temperature ALLOW low boiling temperature high heat of vaporization high gas density high critical temperature IGNORE Non-polluting/ environmentally friendly/ cheap/easily manufactured/ easy to store/easy to contain /take up little space/low melting point/endothermic/ harmful	Does not produce CFCs Gas/solid stable	2

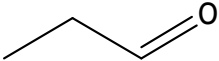
Question Number	Acceptable Answers	Reject	Mark
22 (a)	$\text{N}_2 + \text{O}_2 \rightarrow 2\text{NO}$ or $\frac{1}{2}\text{N}_2 + \frac{1}{2}\text{O}_2 \rightarrow \text{NO}$ Or multiples ALLOW extra oxygen or nitrogen molecules provided equation is balanced IGNORE state symbols even if incorrect ALLOW $\rightleftharpoons$ and $2\text{NO}^\bullet$		1

Question Number	Acceptable Answers	Reject	Mark
22(b)(i)	Free radical(s) ALLOW recognisable spellings e.g. radicle		1

Question Number	Acceptable Answers	Reject	Mark
22(b)(ii)	Homolytic (fission) ALLOW recognisable spellings e.g. homolitic		1

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	(unburnt) fuel/petrol/diesel/kerosene (aviation fuel) ALLOW Car exhaust fumes/fossil fuels/oil IGNORE burning/combustion except if stated as complete	Engines/factories/cattle/methane/ethane/crude oil/natural gas/coal/pollution	1

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	Oxidation ALLOW partial oxidation	Redox Addition oxidation	1

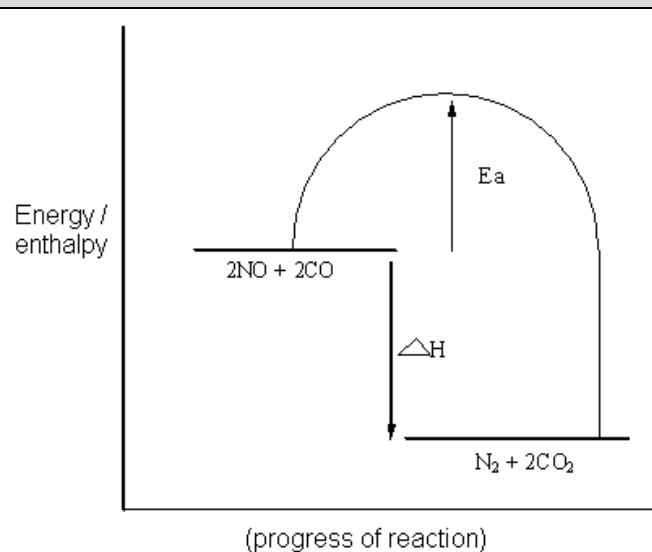
Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	 IGNORE angles provided clearly 3 carbons	displayed or structural or molecular formulae or skeletal showing any H atoms	1

Question Number	Acceptable Answers	Reject	Mark
22(c)(iv)	NO removed so less O ₃ broken down/NO reacts with hydrocarbon rather than O ₃ so less O ₃ broken down IGNORE build up of ozone	Just 'less O ₃ broken down'	1

Question Number	Acceptable Answers	Reject	Mark
22(d)	(At high altitudes) intensity of UV (radiation/light) is greater (1) ALLOW more UV So conversion of NO ₂ to NO will increase (1) ALLOW (At high altitudes) pressure is lower (1) So equilibrium $2\text{NO(g)} + \text{O}_2\text{(g)} \rightleftharpoons 2\text{NO}_2\text{(g)}$ shifts to the left (1)	NO ₂ removed before it gets to high altitudes more sunlight less oxygen	2

Question Number	Acceptable Answers	Reject	Mark
22(e)	Ozone absorbs/blocks/filters/protects against ALLOW removes (all) UV radiation (1) UV/sunlight is biologically harmful/causes genetic damage/causes (skin) cancer/causes eye cataracts (1) Reference to global warming max (1)	Sunlight; Infrared; reflects Just 'harmful' Effect of radiation without any mention of UV or sunlight	2

Question Number	Acceptable Answers	Reject	Mark
22(f)(i)	$2\text{NO} + 2\text{CO} \rightarrow \text{N}_2 + 2\text{CO}_2$ OR $\text{NO} + \text{CO} \rightarrow \frac{1}{2}\text{N}_2 + \text{CO}_2$ Or multiples IGNORE state symbols even if incorrect ALLOW $\rightleftharpoons$		1

Question Number	Acceptable Answers	Reject	Mark
22(f)(ii)	 (progress of reaction) ALLOW names or symbols in diagram ALLOW double headed arrows or headless arrows IGNORE Maxwell Boltzmann distributions First mark Labelled y axis and reactants and products ALLOW potential energy (1) IGNORE units IGNORE formula errors and x axis labels even if incorrect ALLOW 'reactants' and 'products' as labels Second mark Exothermic reaction and ΔH label (1) IGNORE negative sign on ΔH Third mark Activation energy line and label OR a double hump with higher first (smooth curve is not needed) (1)	Reversed arrows Energy change or enthalpy change or ΔH Any other humped diagram	3

Question Number	Acceptable Answers	Reject	Mark
22(f)(iii)	Catalyst provides an alternative route/mechanism (1) with lower activation energy ALLOW low activation energy (1) So a higher proportion (ALLOW more) molecules / collisions (ALLOW reactants) have energy equal to or greater than E_a ALLOW 'so more molecules react' (1)		3

Question Number	Acceptable Answers	Reject	Mark
22(g)	Aircraft (release NO) closer to the ozone layer/(atmosphere) at high altitude/in the stratosphere (1) IGNORE greenhouse gases at this point So less NO is lost through competing / other reactions (1) ALLOW broken down ALLOW NO (released at ground level) dissipated (e.g. by reaction with oxygen or hydrocarbons or by reaction to form ozone (as in the passage))	Just 'atmosphere'	2

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 2: Application of Core Principles of Chemistry

Wednesday 23 May 2012 – Afternoon

Time: 1 hour 30 minutes

Paper Reference

6CH02/01

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 ►

P39307A

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7/7/5/5/

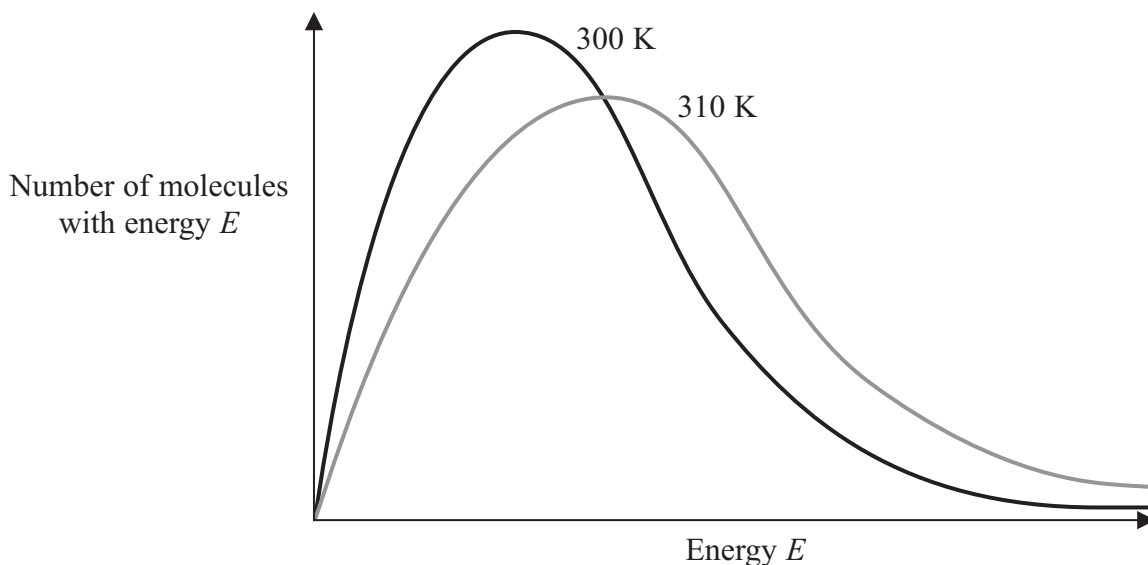


PEARSON

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 diagram below shows the Maxwell-Boltzmann distribution of molecular energies for a gaseous system at two temperatures.



- (a) The energy plotted on the horizontal axis is **mainly**

(1)

- ☐ A activation.
- ☐ B kinetic.
- ☐ C rotation.
- ☐ D vibration.

- (b) The rate of a chemical reaction increases with temperature **mainly** because

(1)

- ☐ A the activation energy increases.
- ☐ B the activation energy decreases.
- ☐ C more collisions occur with energy greater than the activation energy.
- ☐ D the molecules collide more frequently.



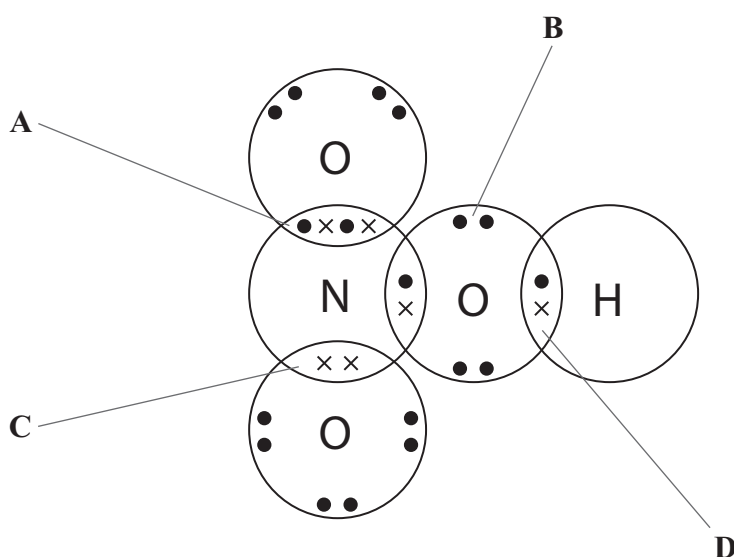
(c) The total area under each curve

(1)

- ☐ A decreases with increasing temperature.
- ☐ B increases with increasing temperature.
- ☐ C increases or decreases with increasing temperature, depending on the size of the molecules.
- ☐ D does not change with temperature.

(Total for Question 1 = 3 marks)

2 The diagram below shows a dot and cross diagram of nitric acid.



(a) Identify which of the labelled sets of electrons represents a dative covalent bond.

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(b) In terms of orbital overlap, the double bond is

(1)

- ☐ A a π bond.
- ☐ B two σ bonds.
- ☐ C two π bonds.
- ☐ D a σ bond and a π bond.

(Total for Question 2 = 2 marks)



P 3 9 3 0 7 A 0 3 2 0

3 The colour observed in a flame test is due to

- ☐ A electrons jumping to a higher energy level, absorbing energy.
- ☐ B electrons jumping to a higher energy level, emitting energy.
- ☐ C electrons dropping from a higher energy level, absorbing energy.
- ☐ D electrons dropping from a higher energy level, emitting energy.

(Total for Question 3 = 1 mark)

4 The best way to confirm the presence of **iodine** in an aqueous solution is

- ☐ A adding hexane to form a purple layer.
- ☐ B adding hexane to form an orange layer.
- ☐ C adding acidified silver nitrate solution to form a yellow precipitate which is soluble in concentrated ammonia.
- ☐ D adding acidified silver nitrate solution to form a yellow precipitate which is insoluble in concentrated ammonia.

(Total for Question 4 = 1 mark)

5 The oxidation number of sulfur in sodium hydrosulfide, NaHS, is

- ☐ A -2
- ☐ B -1
- ☐ C +1
- ☐ D +2

(Total for Question 5 = 1 mark)

6 Which of the following is **not** a disproportionation reaction?

- ☐ A $\text{Cl}_2 + 2\text{OH}^- \rightarrow \text{Cl}^- + \text{ClO}^- + \text{H}_2\text{O}$
- ☐ B $\text{Cu}_2\text{O} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{Cu} + \text{H}_2\text{O}$
- ☐ C $3\text{IO}^- \rightarrow 2\text{I}^- + \text{IO}_3^-$
- ☐ D $\text{Cu} + 4\text{HNO}_3 \rightarrow \text{Cu}(\text{NO}_3)_2 + 2\text{H}_2\text{O} + 2\text{NO}_2$

(Total for Question 6 = 1 mark)

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



7 Hydrogen iodide has a higher boiling temperature than hydrogen bromide. This is because

- ☐ A the H—I bond is stronger than the H—Br bond.
- ☐ B hydrogen iodide has stronger London forces than hydrogen bromide.
- ☐ C hydrogen iodide has a larger permanent dipole than hydrogen bromide.
- ☐ D hydrogen iodide forms hydrogen bonds but hydrogen bromide does not.

(Total for Question 7 = 1 mark)

8 Butane has a higher boiling temperature than 2-methylpropane. This is because butane has

- ☐ A stronger C—H bonds.
- ☐ B more electrons.
- ☐ C a larger surface area.
- ☐ D hydrogen bonds.

(Total for Question 8 = 1 mark)

9 The oxygen atom in a molecule of water has two bonding pairs and two lone pairs of electrons. Based on the electron-pair repulsion theory, the H—O—H bond angle is most likely to be

- ☐ A 180°
- ☐ B 109.5°
- ☐ C 107°
- ☐ D 104.5°

(Total for Question 9 = 1 mark)

10 The shape of a molecule of boron trifluoride, BF_3 , is

- ☐ A trigonal planar.
- ☐ B pyramidal.
- ☐ C tetrahedral.
- ☐ D T-shaped.

(Total for Question 10 = 1 mark)



11 When solid samples of sodium carbonate and magnesium carbonate are strongly heated

- ☐ A both compounds decompose.
- ☐ B sodium carbonate decomposes but magnesium carbonate does not.
- ☐ C magnesium carbonate decomposes but sodium carbonate does not.
- ☐ D neither compound decomposes.

(Total for Question 11 = 1 mark)

12 As Group 2 is descended

- ☐ A the solubility of hydroxides and of sulfates increases.
- ☐ B the solubility of hydroxides increases and of sulfates decreases.
- ☐ C the solubility of hydroxides decreases and of sulfates increases.
- ☐ D the solubility of hydroxides and of sulfates decreases.

(Total for Question 12 = 1 mark)

13 These questions concern the use of infrared (IR) spectra to identify organic compounds. The IR absorption ranges associated with some organic functional groups are given below.

- A O—H stretching in alcohols at $3750 - 3200 \text{ cm}^{-1}$
- B C=O stretching in aldehydes at $1740 - 1720 \text{ cm}^{-1}$
- C C=O stretching in ketones at $1700 - 1680 \text{ cm}^{-1}$
- D C=O stretching in carboxylic acids at $1725 - 1700 \text{ cm}^{-1}$

(a) When propan-2-ol is refluxed with potassium dichromate(VI) and sulfuric acid, the **product** will show a peak due to

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(b) When propan-1-ol is heated with potassium dichromate(VI) and sulfuric acid, the **product**, that is distilled off as it is formed, will show a peak due to

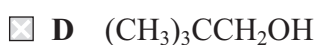
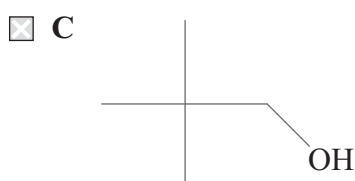
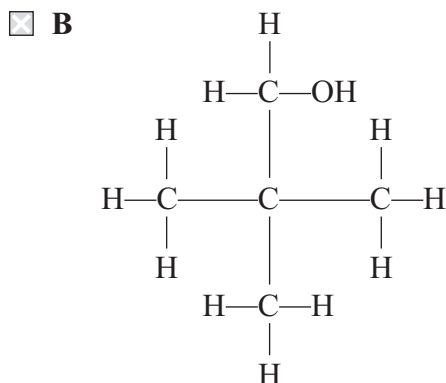
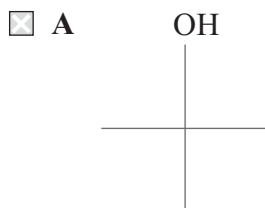
(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 13 = 2 marks)



14 Which of the following formulae does **not** represent 2,2-dimethylpropan-1-ol?



(Total for Question 14 = 1 mark)

15 Nucleophiles are

- ☐ A electron pair donors that attack regions of high electron density.
- ☐ B electron pair donors that attack regions of low electron density.
- ☐ C electron pair acceptors that attack regions of high electron density.
- ☐ D electron pair acceptors that attack regions of low electron density.

(Total for Question 15 = 1 mark)

16 Which of the following is **not** true? Chlorofluorocarbons, CFCs,

- ☐ A are flammable.
- ☐ B are greenhouse gases.
- ☐ C damage the ozone layer.
- ☐ D are excellent refrigerants.

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



P 3 9 3 0 7 A 0 7 2 0

SECTION B

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

- 17 (a) Ozone, O_3 , is formed when oxygen is exposed to ultraviolet (UV) radiation or to an electric discharge. Ozone is a blue gas whereas oxygen is colourless. When the two gases are mixed, an equilibrium is established as shown in the following equation.



- (i) When the temperature of the pale blue equilibrium mixture is increased at constant volume, the colour darkens. Explain this observation in terms of the changes to the equilibrium.

(2)

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- (ii) State and explain what you would see if the pressure of the system at equilibrium were increased.

(2)

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- (iii) A small amount of oxygen gas containing the isotope ^{18}O is added to the equilibrium mixture. After a few hours, ozone containing ^{18}O is detected. Given that the equilibrium position is **not** affected, explain this observation.

(1)

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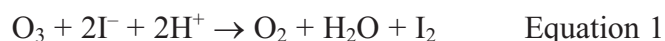
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- (b) The concentration of ozone in the atmosphere may be determined by bubbling air through a solution of acidified potassium iodide. Iodine is formed in solution, the concentration of which may be determined by titration with a solution of sodium thiosulfate of known concentration. The equations for the reactions are



In an experiment to determine the concentration of ozone in a sample of air, 100 m³ of air was bubbled through 100 cm³ of a solution containing an excess of acidified potassium iodide.

The resulting solution was titrated against a solution of sodium thiosulfate of concentration 0.0155 mol dm⁻³. The volume of sodium thiosulfate solution required for complete reaction was 25.50 cm³.

- (i) Calculate the number of moles of sodium thiosulfate that react.

(1)

- (ii) Calculate the number of moles of iodine that reacted with the sodium thiosulfate.

(2)

- (iii) Use equation 1 to deduce the number of moles of ozone that reacted with the acidified potassium iodide.

(1)



(iv) Calculate the volume of ozone, measured in m^3 , present in the original sample of air. Assume that all gas volumes were measured at room temperature and pressure and that the molar volume of any gas under these conditions is $0.024 \text{ m}^3 \text{ mol}^{-1}$.

(1)

(v) Calculate the concentration of ozone in the sample of air in units of parts per million (ppm) by volume.

(1)

(vi) A student suggested that the 100 cm^3 of acidified potassium iodide should be divided into four portions before the titration. Explain how this change increases the reliability and decreases the accuracy of the experiment.

(3)

Increases reliability.....

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Decreases accuracy.....

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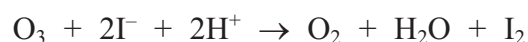
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(c) Give the oxidation numbers of oxygen in equation 1, shown below. Hence state the role of ozone in this reaction.

(3)



Oxidation number of O

Role of ozone.....

(d) Ozone is used as an alternative to chlorine to disinfect flood damaged buildings, to remove residual smoke odours from fires and in the treatment of drinking water. Suggest one advantage of using ozone rather than chlorine, given that chlorine and ozone are both toxic.

(1)

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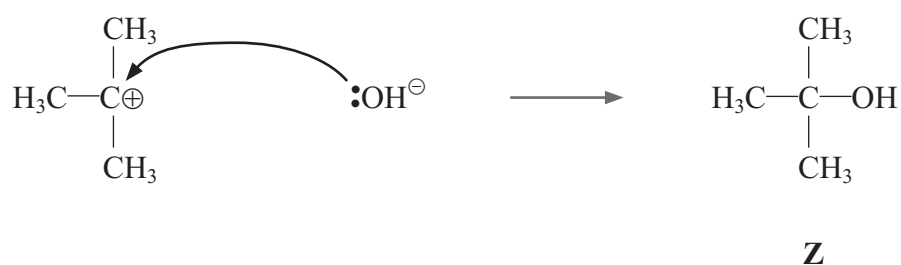
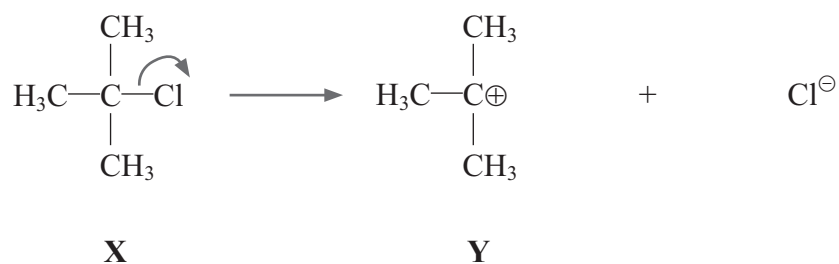
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(Total for Question 17 = 18 marks)



18 The steps below show the reaction mechanism for the reaction of a halogenoalkane with sodium hydroxide in aqueous solution to form an alcohol.



(a) (i) Name **X** and **Z**.

(2)

X

Z

(ii) Draw the **skeletal** formula of **X**.

(1)

(iii) What type of alcohol is **Z**?

(1)

.....



(b) (i) Name the mechanism and type of reaction shown above.

(2)

(ii) Explain what the curly arrows shown in the mechanism represent.

(1)

*(iii) Suggest the shape of the intermediate Y. Explain your answer.

(3)

(iv) If the reaction is carried out in alcoholic (ethanolic) rather than aqueous solution, a different type of reaction occurs and a different product is formed. Name the type of reaction that occurs in alcoholic (ethanolic) solution and identify the product by name or formula.

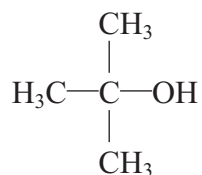
(2)

Type of reaction.....

Product



- (c) The alcohol **Z** (shown below) resists oxidation. However, **Z** has three structural isomers which are readily oxidized. On complete oxidation, one isomer forms a ketone and the other two isomers form carboxylic acids.



Z

- (i) Draw the structural formula of the isomer of **Z** that forms a ketone.

(1)

- (ii) Draw the structural formulae of the isomers of **Z** that form carboxylic acids.

(2)

(Total for Question 18 = 15 marks)



19 Metal nitrates decompose on heating. Potassium nitrate, KNO_3 , decomposes to form potassium nitrite and oxygen, whereas calcium nitrate, $\text{Ca}(\text{NO}_3)_2$, decomposes to form calcium oxide, nitrogen dioxide and oxygen.

(a) Write equations for the decomposition of each of these metal nitrates. State symbols are **not** required.

(2)

(i) Potassium nitrate

(ii) Calcium nitrate

(b) State **two** things that you would **see** when anhydrous calcium nitrate is heated.

(2)

*(c) Explain why potassium nitrate and calcium nitrate decompose to form different products.

(3)

(Total for Question 19 = 7 marks)

TOTAL FOR SECTION B = 40 MARKS



SECTION C

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

20

Fuels of the Future

Concerns about the future availability of fossil fuels, and the fact that their combustion produces greenhouse gases, have led to a search for alternative sources of energy. A great deal of attention has been directed at developing the use of hydrogen as a fuel. Since the only product of its combustion is water, hydrogen is considered to be a clean fuel.

However, the use of hydrogen has major drawbacks. The small size of the hydrogen molecule means that it is difficult to prevent leaks and, to store enough to provide a reasonable amount of fuel for a car, hydrogen must be compressed to around 700 atmospheres. Furthermore, the main source of hydrogen is currently fossil fuels such as methane, which is combined with steam in a series of reactions to form carbon dioxide and hydrogen.

One suggested alternative to hydrogen is ammonia. Ammonia, which is obtained by combining nitrogen and hydrogen at temperatures around 450°C and pressures of about 150 atmospheres, also has serious disadvantages: it is a toxic, corrosive and pungent gas which is difficult to ignite.

However, burning ammonia produces only nitrogen and water and it is relatively easy to liquefy, having a boiling temperature of just -33°C . Furthermore, the technology works: ammonia was used as a fuel for Belgian buses in the Second World War and, in 2007, the 'NH₃ Car' project based in Ann Arbor, Michigan, used a mixture of ammonia and petrol to fuel a 2500 mile journey, from Detroit to San Francisco, in a modified pickup truck.

(a) (i) Explain the term **greenhouse gas**.

(2)

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*(ii) State and explain whether or not water (in the gaseous state) is a greenhouse gas. (2)

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(iii) Write the equation for the formation of hydrogen from methane and steam. State symbols are **not** required. (2)

(iv) Suggest why using methane to form hydrogen in this way is preferable to burning methane directly. (1)

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(v) Storing hydrogen at a pressure of 700 atmospheres is a disadvantage to its use as a fuel because of the costs involved. Suggest why using such high pressures is so expensive. (1)

.....

.....

.....

(b) (i) Draw a dot and cross diagram for ammonia, showing the outer electrons only. (1)



- * (ii) By considering the intermolecular forces involved, explain why methane has a boiling temperature of 109 K while ammonia has a boiling temperature of 240 K, although these two compounds have very similar molar masses.

(4)

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- (c) (i) Write the equation for the combustion of ammonia. State symbols are **not** required.

(2)

- (ii) The enthalpy change of combustion of methane is $-890.3 \text{ kJ mol}^{-1}$ and that of ammonia is $-510.1 \text{ kJ mol}^{-1}$. Suggest **two** additional items of information, **not** connected with environmental factors or the fact that methane is non-renewable, which would be useful in comparing methane and ammonia as fuels.

(2)

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- (iii) The fact that ammonia has a pungent smell is listed as a disadvantage of its use as a fuel. Suggest why this might also be an advantage.

(1)

.....

.....



(iv) Suggest why ammonia was mixed with petrol in the 'NH₃ Car' project.

(1)

(v) State, with a reason, whether hydrogen or ammonia can currently be considered to be long term replacements for fossil fuels.

(1)

(Total for Question 20 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS

TOTAL FOR PAPER = 80 MARKS



The Periodic Table of Elements

1	2	Key										3	4	5	6	7	0 (8)		
		relative atomic mass atomic symbol name atomic (proton) number																1.0 H hydrogen 1	
(1)	(2)											(13)	(14)	(15)	(16)	(17)	(18)		
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	4.0 He helium 2		
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	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				

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1.0
H
hydrogen
1



P 3 9 3 0 7 A 0 2 0 2 0

Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH02) Paper 01
Application of Core Principles of
Chemistry

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Summer 2012

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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 (a)	B		1
(b)	C		1
(c)	D		1

Question Number	Correct Answer	Reject	Mark
2 (a)	C		1
(b)	D		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		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	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)	C		1
(b)	B		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	A		1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a)(i)	More O₃ is formed/equilibrium shifts to the right (1) Because (increase in temperature) favours endothermic reaction ALLOW (Forward) reaction is endothermic ALLOW ΔH is positive for endothermic (1) IGNORE references to rate and pressure change	equilibrium shifts to the left (scores zero overall)	2

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	The mixture becomes darker ALLOW: more blue/bluer (1) (Increase in pressure) favours side with fewer moles/molecules (of gas) (so equilibrium shifts to the right) (1) IGNORE references to rate Marks are stand alone	Just 'more ozone' Blue gas formed Mixture becomes blue Atoms/particles	2

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iii)	The equilibrium is dynamic OR Forward & reverse reactions still occurring OR O₃ continues to be formed from O₂ at the same rate as O₃ decomposes OR O₃ continues to be formed from O₂ with no nett change in composition		1

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	In (b) Any units given must be correct. Penalise once IGNORE SF except 1 SF. Penalise once TE at each step through calculation Amount of thiosulfate $= 0.0155 \times 25.50 \times 10^{-3}$ $= 3.9525 \times 10^{-4} \text{ (mol)}$ Or correct answer with no working		1

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	1 mol I_2 reacts with 2 mol $\text{S}_2\text{O}_3^{2-}$ ALLOW 'using equation 2' $\therefore$ Amount of iodine = answer in (b)(i) / 2 (1) $= 3.9525 \times 10^{-4} / 2 = 1.97625 \times 10^{-4} \text{ (mol)}$ (1) Correct answer with no working (2) If ratio reversed, TE only if ratio is stated		2

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	Amount of iodine = Amount of ozone = answer in (b)(ii) $= 1.97625 \times 10^{-4} \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
17(b)(iv)	Volume of ozone = answer in (b)(iii) $\times 0.024$ $= 1.97625 \times 10^{-4} \times 0.024$ $= 4.743 \times 10^{-6} \text{ (m}^3 \text{ in } 100 \text{ m}^3\text{)}$		1

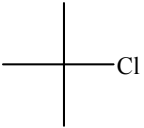
Question Number	Acceptable Answers	Reject	Mark
17(b)(v)	Volume of ozone in ppm = answer in (b)(iv) $\times 10^6 \div 100$ $= 4.743 \times 10^{-6} \times 10^4$ $= 4.743 \times 10^{-2} = 0.04743 \text{ (ppm)}$		1

Question Number	Acceptable Answers	Reject	Mark
17 (b)(vi)	(<u>Increase reliability</u>) because a mean (average) value can be used/ anomalous results (ALLOW outliers) may be identified ALLOW the titration can be repeated (1) (<u>Decrease accuracy</u>) because smaller titration volume/volume of thiosulfate ALLOW volume of (acidified) KI ALLOW 'amount' for 'volume' (1) so percentage error/uncertainty will increase (1) The % error mark is NOT stand alone but 'smaller volume increases percentage error' scores final mark	Experiment can be repeated More results	3

Question Number	Acceptable Answers	Reject	Mark
17(c)	Oxygen in $O_3 = 0$ and $O_2 = 0$ (1) in $H_2O = -2 / 2-$ (1) Ozone acts as an oxidizing agent. ALLOW 'is reduced' / oxidizes I^- (1) Third mark is stand alone; No TE on incorrect oxidation numbers		3

Question Number	Acceptable Answers	Reject	Mark
17(d)	(Residual) ozone is (quickly) converted into (odourless) oxygen OR chlorine has a persistent/unpleasant odour or taste OR Chlorine forms HCl/ hydrochloric acid (in drinking water)	(Oxygen) and water Ozone is odourless/cheap /more available Chlorine forms free radicals/ hazardous compounds/ reacts with hydrogen/ damages ozone layer	1

Question Number	Acceptable Answers	Reject	Mark
18 (a)(i)	X = 2-chloro-2-methylpropane ALLOW X = 2,2-chloromethylpropane X = 2-methyl-2-chloropropane X = 2,2-methylchloropropane X = 2-chloromethylpropane (1) Z = 2-methylpropan-2-ol (1) ALLOW methylpropan-2-ol ALLOW propane for propan IGNORE omission of (or extra) commas and hyphens IGNORE spaces	2-methylchloropropane Hydroxy for -ol	2

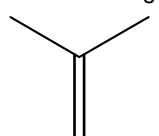
Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	 ALLOW any angles	Any other type of structure	1

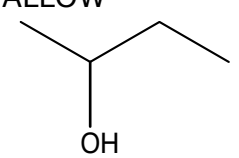
Question Number	Acceptable Answers	Reject	Mark
18 (a)(iii)	Tertiary ALLOW recognisable abbreviations: 3 ^y /3 ^o		1

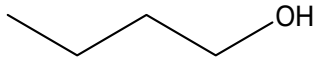
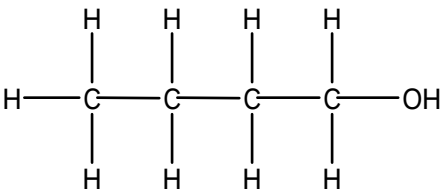
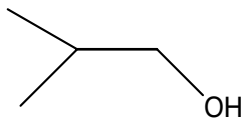
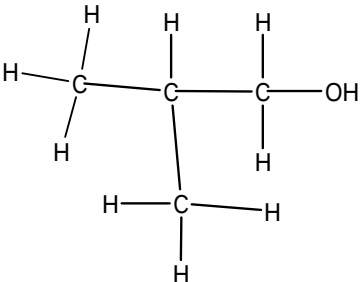
Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	Nucleophilic (1) Substitution (1) S_N1 scores 1/2	S_N2	2

Question Number	Acceptable Answers	Reject	Mark
18 (b)(ii)	Movement (ALLOW Transfer/donation)/ start and finish positions of an electron pair ALLOW two electrons for pair IGNORE bonded/unbonded for electrons IGNORE heterolytic bond breaking and bond formation	electrons	1

Question Number	Acceptable Answers	Reject	Mark
18 (b)(iii)	These marks are stand alone Trigonal (ALLOW triangular) planar/ planar with bond angles of 120° (1) 3 bond pairs (no lone pairs) of electrons (1) ALLOW 3 pairs of electrons around the central atom /carbon Arranged at minimum repulsion (1) ALLOW maximum separation / distance apart IGNORE references to the positive charge	Bonds or 'areas of electron density' for pairs Just '3 pairs of electrons' Just 'repel' Repel as much as possible	3

Question Number	Acceptable Answers	Reject	Mark
18 (b)(iv)	(Type of reaction:) elimination ALLOW dehydrohalogenation (1) IGNORE nucleophilic Product: 2-methylpropene ALLOW methylpropene 2-methylprop-1-ene Methylprop-1-ene any correct formula e.g. $(\text{CH}_3)_2\text{CCH}_2$ ALLOW $\text{CH}_3\text{C}(\text{CH}_3)\text{CH}_2$ $\begin{array}{c} \text{H}_3\text{C} \quad \text{CH}_2 \\ \quad \diagdown \quad \diagup \\ \quad \text{C} = \\ \quad \\ \quad \text{CH}_3 \end{array}$ $\begin{array}{c} \text{H} \\ \\ \text{H}-\text{C}-\text{C}=\text{CH}_2 \\ \quad \diagdown \\ \text{H} \quad \text{CH}_3 \end{array}$  (1) If a displayed formula or part displayed formula is used, all the atoms must be shown.	2-methylprop-2-ene methylprop-2-ene	2

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	If a displayed formula or part displayed formula is used, all the atoms must be shown. If a carbon is <i>clearly</i> shown bonded to the H in OH, penalise once in (c) $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3$ ALLOW  OR $\begin{array}{cccc} \text{H} & \text{H} & \text{H} & \text{H} \\ & & & \\ \text{H}-\text{C} & -\text{C} & -\text{C} & -\text{C}-\text{H} \\ & & & \\ \text{H} & \text{H} & \text{OH} & \text{H} \end{array}$		1

Question Number	Acceptable Answers	Reject	Mark
18 (c) (ii)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ (1) ALLOW  or  $(\text{CH}_3)_2\text{CHCH}_2\text{OH}$ (1) ALLOW  OR  If 2 correct carboxylic acids are shown, 1 out of 2	Aldehydes	2

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	$2\text{KNO}_3 \rightarrow 2\text{KNO}_2 + \text{O}_2$ Or multiples or equation divided by 2 ALLOW O_2 on LHS if balanced by additional O_2 on RHS IGNORE state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	$2\text{Ca}(\text{NO}_3)_2 \rightarrow 2\text{CaO} + 4\text{NO}_2 + \text{O}_2$ Or multiples or equation divided by 2 ALLOW O_2 on LHS if balanced by additional O_2 on RHS IGNORE state symbols even if incorrect		1

Question Number	Acceptable Answers	Reject	Mark
19 (b)	Brown gas (ALLOW fumes or vapour) evolved (1) IGNORE Effervescence/bubbles EITHER (White) solid melts (and then solidifies/freezes) OR (Colourless) liquid forms (1) IGNORE white solid formed		2

Question Number	Acceptable Answers	Reject	Mark
19 (c)	Penalise any omission of reference to ion in MP 1 only but calcium ions or Ca^{2+} and potassium ions or K^+ are equivalent <u>Marking Point 1</u> Calcium ions have greater positive charge (than potassium ions) OR Calcium ions 2+ but potassium ions 1+ OR Ca^{2+} but K^+ OR calcium ions are smaller (than potassium ions) OR calcium ions have greater charge density (1) <u>Marking Point 2</u> $\therefore$ Calcium (ions) more polarising or cause greater distortion (1) <u>Marking Point 3</u> Of... nitrate (ion) OR anion OR $\text{N}-\text{O}$ / $\text{N}=\text{O}$(bond) OR nitrate electron cloud (1) Reverse argument for K^+ gains full marks		3

TOTAL FOR SECTION B = 40 MARKS

Section C

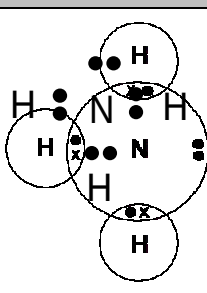
Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	(A greenhouse gas) traps/absorbs/ reflects IR (radiation) / heat (1) (re-radiating) from the earth (1) ALLOW Back to the earth	Absorbs UV (heat) from the sun From the earth's atmosphere	2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	(water is a greenhouse gas) because it absorbs infrared (IR) radiation (1) The polarity of the water molecule changes when its bonds vibrate ALLOW Water is a polar molecule/has polar bonds (1)	Reflects (for absorbs) Heat (for IR) Traps IR/heat from the earth	2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iii)	$\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow \text{CO}_2 + 4\text{H}_2$ ALLOW $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO} + 3\text{H}_2$ Species (1) balance (1) No TE on incorrect species	$\text{CH}_4 + 2\text{H}_2\text{O} \rightarrow$ $\text{CO}_2 + 8\text{H}$ $\text{CH}_4 + \text{H}_2\text{O} \rightarrow \text{CO}$ $+ 6\text{H}$	2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iv)	Hydrogen is obtained from the water (as well as from the methane) OR Easier to capture the CO_2 in a chemical plant than in a moving vehicle ALLOW Higher yield of/more hydrogen		1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(v)	(High cost of) energy needed (to generate the pressure) OR (High cost of) construction / maintenance of the equipment OR (High cost of) the equipment required to withstand / contain the high pressure	High pressure is expensive	1

Question Number	Acceptable Answers	Reject	Mark
20 (b)(i)	ALLOW  Accept dots and/or crosses for electrons, provided there are 3 bond pairs plus 2 electrons with or without lines for the bonds With or without circles		1

Question Number	Acceptable Answers	Reject	Mark
20 (b)(ii)	Comment Any incorrect statement cancels a correct one. The order of the marking points is not important. Marking Point 1 Ammonia has hydrogen bonds (as well as London forces) (1) IGNORE permanent dipole-dipole forces here Marking Point 2 Methane (only) has London / dispersion forces (1) ALLOW van der Waals forces Marking Point 3 (So) Intermolecular forces (stated or implied) in ammonia are (much) stronger than those in methane (1) Marking Point 4 (Ammonia has hydrogen bonds) because nitrogen is very electronegative (1) (and has a lone pair) OR London forces are similar in both methane and ammonia (because they have the same number of electrons) (1) OR So more energy is needed to separate ammonia molecules (than methane molecules)		4

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	$4\text{NH}_3 + 3\text{O}_2 \rightarrow 2\text{N}_2 + 6\text{H}_2\text{O}$ Species (1) balance (1) ALLOW Equation forming nitrogen monoxide $4\text{NH}_3 + 5\text{O}_2 \rightarrow 4\text{NO} + 6\text{H}_2\text{O}$ Species (1) balance (1)	$4\text{NH}_3 + 3\text{O}_2 \rightarrow 4\text{N} + 6\text{H}_2\text{O}$	2

	No TE on incorrect species		
--	----------------------------	--	--

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	Any two Energy density / energy per unit volume of the fuels ALLOW miles per gallon or equivalent (1) Cost / Ease of Production (1) Storage (1) Transport (1) Liquefaction (1) Ease of ignition (1) Corrosiveness (1) IGNORE references to Environment Renewability Safety Boiling temperatures Atom economy		2

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iii)	Leaks would be easy to detect IGNORE reference to spillage		1

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iv)	Ammonia is difficult to ignite/does not burn/combust easily	Ammonia is unreactive	1

Question Number	Acceptable Answers	Reject	Mark
20 (c)(v)	No because hydrogen is obtained from fossil fuels (and ammonia from hydrogen) OR Yes because hydrogen can be obtained by electrolysis of water using renewable energy sources		1

TOTAL FOR SECTION C = 20 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Wednesday 16 January 2013 – Morning

Time: 1 hour 30 minutes

Paper Reference

6CH02/01

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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7/6/5/4/5/



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 these bond angles is the **largest**?

- ☐ A Cl—B—Cl in BCl_3
- ☐ B H—N—H in NH_3
- ☐ C Cl—Be—Cl in BeCl_2
- ☐ D H—O—H in H_2O

(Total for Question 1 = 1 mark)

2 In propene, $\text{CH}_2=\text{CH}-\text{CH}_3$,

- ☐ A the C=C double bond is longer and stronger than the C—C single bond.
- ☐ B the C=C double bond is shorter and stronger than the C—C single bond.
- ☐ C the C=C double bond is shorter and weaker than the C—C single bond.
- ☐ D the C=C double bond is longer and weaker than the C—C single bond.

(Total for Question 2 = 1 mark)

3 Which of the following molecules is **not** polar?

- ☐ A HCl
- ☐ B CH_3Cl
- ☐ C CHCl_3
- ☐ D CCl_4

(Total for Question 3 = 1 mark)

4 The O—H bond in water is polar because, compared with the hydrogen atom, the oxygen atom has

- ☐ A more electrons.
- ☐ B more neutrons.
- ☐ C greater electronegativity.
- ☐ D a larger atomic radius.

(Total for Question 4 = 1 mark)



5 Which of the following compounds has the highest boiling temperature?

- ☐ A CH_4
- ☐ B CH_3Cl
- ☐ C HCHO
- ☐ D CH_3OH

(Total for Question 5 = 1 mark)

6 The oxidation number of sulfur in thiosulfate ions, $\text{S}_2\text{O}_3^{2-}$, is

- ☐ A +2
- ☐ B +3
- ☐ C +4
- ☐ D +6

(Total for Question 6 = 1 mark)

7 Which of the following is a redox reaction?

- ☐ A $\text{Ca} + 2\text{H}_2\text{O} \rightarrow \text{Ca}(\text{OH})_2 + \text{H}_2$
- ☐ B $\text{MgO} + \text{H}_2\text{O} \rightarrow \text{Mg}(\text{OH})_2$
- ☐ C $\text{NaCl} + \text{AgNO}_3 \rightarrow \text{AgCl} + \text{NaNO}_3$
- ☐ D $\text{Na}_2\text{CO}_3 + 2\text{HCl} \rightarrow 2\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O}$

(Total for Question 7 = 1 mark)

8 A solid gives a red colour in a flame test and reacts with concentrated sulfuric acid to produce steamy fumes, but no other gases. The solid could be

- ☐ A lithium bromide.
- ☐ B strontium chloride.
- ☐ C calcium bromide.
- ☐ D sodium chloride.

(Total for Question 8 = 1 mark)



9 Which of the following statements is correct?

- ☐ A Barium sulfate is less soluble in water than calcium sulfate.
- ☐ B Barium hydroxide is less soluble in water than calcium hydroxide.
- ☐ C Barium nitrate undergoes thermal decomposition more readily than calcium nitrate.
- ☐ D Barium shows more than one oxidation state in its compounds.

(Total for Question 9 = 1 mark)

10 Going down Group 7 from chlorine to iodine

- ☐ A the boiling temperature of the hydrogen halide decreases.
- ☐ B the polarity of the hydrogen halide bond increases.
- ☐ C the reducing power of the halide ion increases.
- ☐ D the oxidizing power of the halogen element increases.

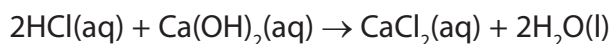
(Total for Question 10 = 1 mark)

11 What colour is the vapour which forms when concentrated sulfuric acid is added to solid potassium iodide?

- ☐ A Green
- ☐ B Orange
- ☐ C Brown
- ☐ D Purple

(Total for Question 11 = 1 mark)

12 Calculate the volume of dilute hydrochloric acid, concentration $0.200 \text{ mol dm}^{-3}$, needed to neutralize 20 cm^3 of aqueous calcium hydroxide, concentration $0.100 \text{ mol dm}^{-3}$.



- ☐ A 10 cm^3
- ☐ B 20 cm^3
- ☐ C 40 cm^3
- ☐ D 80 cm^3

(Total for Question 12 = 1 mark)



13 The reaction of heated magnesium with steam is faster than the reaction of magnesium with cold water. This is mainly because

- ☐ **A** in cold water, the water molecules do not collide as frequently with magnesium.
- ☐ **B** the coating of oxide on magnesium decomposes when it is heated.
- ☐ **C** the fraction of particles with energy greater than the activation energy is higher in the reaction with steam.
- ☐ **D** the reaction with steam goes by an alternative route with lower activation energy.

(Total for Question 13 = 1 mark)

14 Which of these compounds would **not** react when heated with a mixture of potassium dichromate(VI) and sulfuric acid?

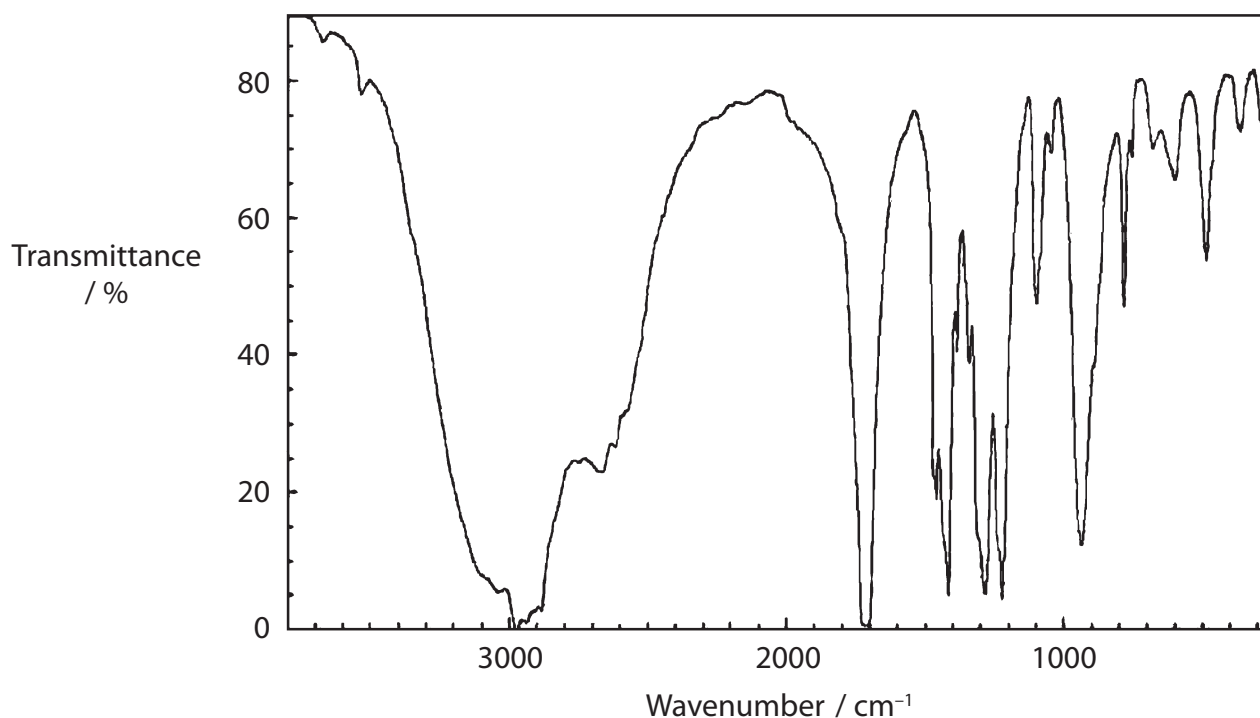
- ☐ **A** CH_3OH
- ☐ **B** $\text{CH}_3(\text{CH}_2)_2\text{OH}$
- ☐ **C** $(\text{CH}_3)_2\text{CHOH}$
- ☐ **D** $(\text{CH}_3)_3\text{COH}$

(Total for Question 14 = 1 mark)

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



- 15 Under certain conditions, butan-1-ol can be oxidized to the compound with infrared spectrum shown below.



O—H stretching vibrations alcohols	3750 – 3200 cm ⁻¹
O—H stretching vibrations carboxylic acids	3300 – 2500 cm ⁻¹
C=O stretching vibrations aldehydes and ketones	1740 – 1680 cm ⁻¹
C=O stretching vibrations carboxylic acids	1725 – 1700 cm ⁻¹

The compound is most likely to be

- ☐ A butan-2-ol.
- ☐ B butanal.
- ☐ C butanone.
- ☐ D butanoic acid.

(Total for Question 15 = 1 mark)

- 16 Which of the following is a **secondary** alcohol?

- ☐ A 2-methylpentan-3-ol
- ☐ B 2-methylpropan-2-ol
- ☐ C 2,2-dimethylpropan-1-ol
- ☐ D ethane-1,2-diol

(Total for Question 16 = 1 mark)



17 Propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, and propanone, CH_3COCH_3 , are isomers, but only propanal has a significant peak in its mass spectrum at mass/charge ratio

- ☐ A 15
- ☐ B 29
- ☐ C 43
- ☐ D 58

(Total for Question 17 = 1 mark)

18 The reaction of the halogenoalkane, $\text{C}_2\text{H}_5\text{Cl}$, with alcoholic ammonia is

- ☐ A nucleophilic substitution.
- ☐ B electrophilic substitution.
- ☐ C reduction.
- ☐ D elimination.

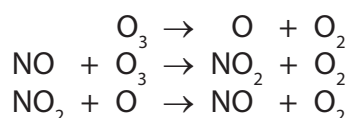
(Total for Question 18 = 1 mark)

19 The formation of a carbocation from a halogenoalkane is an example of

- ☐ A homolytic fission.
- ☐ B heterolytic fission.
- ☐ C an initiation reaction.
- ☐ D a propagation reaction.

(Total for Question 19 = 1 mark)

20 The equations below show some reactions which occur in the upper atmosphere.



Which of the following statements is **not** correct?

- ☐ A Oxygen free radicals are formed by the action of ultraviolet light.
- ☐ B NO acts as a catalyst.
- ☐ C NO acts as an oxidizing agent.
- ☐ D NO is released by aircraft engines.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

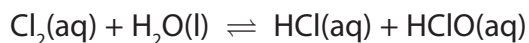


P 4 1 2 1 3 A 0 7 2 4

SECTION B

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

- 21** Chlorine is used to prevent the growth of bacteria in swimming pool water. It reacts as shown below.



- (a) (i) By giving appropriate oxidation numbers, explain why this is a disproportionation reaction.

(3)

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- (ii) State and explain the effect on the position of equilibrium if concentrated hydrochloric acid is added to a sample of chlorinated swimming pool water.

(2)

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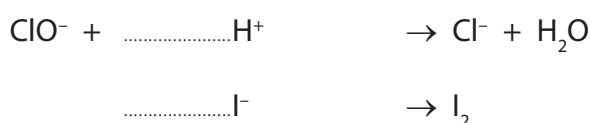
- (b) In a similar reaction, chlorine reacts with sodium hydroxide to make household bleach.



The concentration of NaClO in diluted bleach was measured by titration. A 25.0 cm³ sample of bleach was pipetted into a conical flask. Approximately 1.5 g of solid potassium iodide and 10 cm³ of hydrochloric acid with concentration 2.00 mol dm⁻³ were added. Each mole of ClO⁻, from the NaClO in the solution of bleach, produced one mole of iodine, I₂, which was titrated with sodium thiosulfate solution.

- (i) Complete the ionic half-equations below for the reaction of ClO⁻ with acidified potassium iodide by balancing them and **adding electrons** where required.

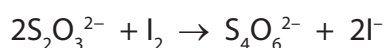
(2)



- (ii) Use your answer to (a)(i) to write the overall ionic equation for the reaction between ClO⁻ and I⁻ ions in acidic conditions.

(1)

- (iii) The iodine in the sample required a mean (average) titre of 24.20 cm³ of 0.0500 mol dm⁻³ sodium thiosulfate solution. Thiosulfate ions react with iodine as shown below.



Calculate the number of moles of iodine in the solution.

(2)

- (iv) What is the number of moles of ClO⁻ ions in the sample of diluted bleach?

(1)



(v) Hence calculate the concentration, in mol dm^{-3} , of ClO^- in the diluted bleach.

(1)

(vi) 1.5 g of potassium iodide, KI, contains 9.04×10^{-3} mol of I^- . Use your answers to (b)(ii) and (b)(iv) to show by calculation why this amount was suitable.

(2)

(vii) A student carrying out this titration measured the mean (average) titre as 24.50 cm^3 .

What is the percentage difference in this student's titre, compared with the accurate value of 24.20 cm^3 ?

(1)



(viii) The difference between the student's mean titre and the accurate value was **not** due to the limitations in the accuracy of the measuring instruments.

Suggest one possible reason for this difference.

(1)

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(c) Suggest **one** damaging effect to the upper atmosphere which could be caused by the presence of chlorine compounds.

(1)

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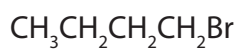
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(Total for Question 21 = 17 marks)

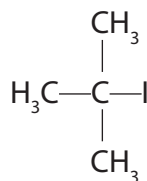
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22 This question is about two halogenoalkanes, **X** and **Y**, which have the structures shown below.



X



Y

(a) (i) Draw the skeletal formula of **X**.

(1)

(ii) Name **Y**.

(1)

(iii) Write an equation for the reaction of **X** with an alcoholic solution of ammonia, and name the organic product.

(2)

Name of product.....

(iv) When **Y** is heated with an **aqueous** solution of potassium hydroxide, an alcohol is formed in a two-step reaction. Write the mechanism for this reaction using 'curly arrows' where appropriate and clearly showing the structure of the intermediate.

(3)



(v) When **Y** is heated with an **alcoholic** solution of potassium hydroxide, the alkene C_4H_8 is formed. What type of reaction occurs to produce the alkene?

(1)

(b) Separate ethanolic solutions of **X** and **Y** were warmed with water containing dissolved silver nitrate. Describe what would be seen in each case, ignoring any differences in the rates of reaction.

(2)

Observation with **X**

Observation with **Y**

(c) The rates of hydrolysis of primary halogenoalkanes are affected by the strength of the bond between the carbon and the halogen atom.

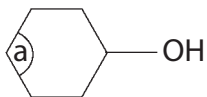
Is the C—Br bond weaker or stronger than the C—I bond? Explain why the bond strength differs.

(2)

(Total for Question 22 = 12 marks)



23 The skeletal formula of cyclohexanol is shown below.



- (a) (i) The actual bond angles differ from the angles in the two dimensional diagram shown.

What is the angle of the C—C—C bond labelled **a**?

(1)

Angle

- *(ii) What is the angle of the C—O—H bond? Justify your answer, explaining why the size of the angle is different from the angle in (i).

(3)

Angle

Explanation

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- (b) (i) Suggest what you would expect to **see** when cyclohexanol reacts with sodium.

(2)

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(ii) Phosphorus(V) chloride (phosphorus pentachloride) is used to test for the presence of an —OH group. Write the equation for the reaction of cyclohexanol with phosphorus(V) chloride.

(2)

(iii) Give the chemical test you could use to identify the gas produced, and the observation you would make.

(1)

(iv) Cyclohexanol reacts with hot acidified potassium dichromate(VI) solution.

Give the skeletal formula of the organic product of this reaction.

(1)

(v) What colour change would you observe as this reaction takes place?

(1)

From to

(c) The mass spectrum of cyclohexanol has a prominent peak at mass / charge ratio 82. Suggest the molecular formula of the fragment which causes this peak.

(1)

(Total for Question 23 = 12 marks)

TOTAL FOR SECTION B = 41 MARKS



SECTION C

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

24

Carbon capture is the name given to some processes used to prevent carbon dioxide entering the atmosphere. Carbon capture is carried out because carbon dioxide is a greenhouse gas.

Flue gases in chimneys contain carbon dioxide produced from burning fossil fuels. Various different compounds can be used to react with the carbon dioxide to capture it. Alternatively, carbon dioxide can be separated from other gases by a physical process.

Many sources of natural gas contain carbon dioxide, which can be removed by freezing.

Captured carbon dioxide must then be stored to prevent it entering the atmosphere. It can be injected into depleted oil and gas formations, or into porous rocks full of salt water. These are usually over 1 km below the Earth's surface and have non-porous rocks above them. Eventually the carbon dioxide dissolves, forming carbonate ions and then new minerals.

- (a) Greenhouse gases can absorb infrared radiation. Explain why carbon dioxide absorbs infrared radiation but oxygen cannot.

(2)

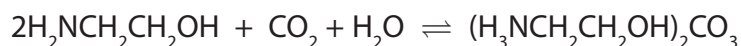
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- (b) A solution of the compound aminoethanol, $\text{H}_2\text{NCH}_2\text{CH}_2\text{OH}$, can be used to absorb carbon dioxide.



- (i) Explain why aminoethanol is soluble in water.

(1)

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- (ii) The position of this equilibrium moves to the left on heating. This frees the captured carbon dioxide for storage. Use this information to decide whether the forward reaction is exothermic or endothermic. Explain your answer.

(2)

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- (c) The composition of a sample of natural gas and the melting temperatures of four of its components are shown below.

	Percentage	Melting temperature / K
Methane	95.2	91.1
2-methylpropane	0.8	113.7
Butane	0.9	134.7
Other hydrocarbons	2.4	
Carbon dioxide	0.7	216.5

- (i) Draw a dot and cross diagram for carbon dioxide.

(2)

- (ii) The London forces between molecules of carbon dioxide are stronger than the London forces between molecules of methane. Suggest a reason for this.

(1)

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(iii) Use your knowledge of intermolecular forces to suggest why butane has a higher melting temperature than 2-methylpropane.

(2)

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(d) When carbon dioxide dissolves, it may eventually form minerals such as magnesium carbonate and calcium carbonate.

(i) State the results of flame tests carried out on these two minerals.

(2)

Magnesium carbonate

Calcium carbonate



- *(ii) Magnesium carbonate and calcium carbonate both undergo thermal decomposition, but they have different stability to heat. The difference in stability to heat can be compared in an experiment.

Suggest how this experiment could be carried out. You should indicate

- how to detect when the thermal decomposition occurs
- the measurement you would make to compare the stability to heat
- how to make the comparison fair.

You may include a diagram if you wish but it is not essential.

(4)

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*(iii) State and explain which of the two carbonates is more stable to heat.

(3)

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(Total for Question 24 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS
TOTAL FOR PAPER = 80 MARKS



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4

P 4 1 2 1 3 A 0 2 4 2 4

Mark Scheme (Results)

January 2013

GCE Chemistry (6CH02) Paper 01
Application of Core Principles of
Chemistry

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January 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	B		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	D		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	B		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	D		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	D		1

Question Number	Correct Answer	Reject	Mark
15	D		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	A		1

Question Number	Correct Answer	Reject	Mark
19	B		1

Question Number	Correct Answer	Reject	Mark
20	C		1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	First two marks Cl in Cl₂ is 0 Goes to +1 in HClO Goes to -1 in HCl (2) All three correct for two marks Any two correct for one mark Ignore correct oxidation numbers for other elements If three correct numbers given without saying what species they are in max 1 for these two marks Third mark Cl/Cl₂/the same element is both oxidized and reduced Allow same molecule/species/ type of atom is both oxidized and reduced if answer elsewhere has been in terms of chlorine OR Cl/Cl₂/the same element both increases and decreases in oxidation number OR Chlorine both loses and gains electrons (1)	Only 'Cl⁺' for oxidation number +1 Only 'Cl⁻' for oxidation number -1 (treat each separately) For each incorrect oxidation number change for O and H, lose one mark. 0 to +1 described as reduction and/or 0 to -1 described as oxidation (for third mark)	3

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	Equilibrium moves to the left / moves in reverse direction / moves to increase concentration of reactants (1) To use up (some of) added HCl/ to react with added HCl/ to stop formation of HCl/ restores equilibrium by producing more chlorine and water (1) Second mark depends on first Allow 'moves to decrease concentration of products/HCl' for both marks	Just "reverse reaction is favoured" Just "to counteract the change in the system" To minimise effect of HCl	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	$\text{ClO}^- + 2\text{H}^+ + 2\text{e}^{(-)} \rightarrow \text{Cl}^- + \text{H}_2\text{O}$ ALLOW $\text{ClO}^- + 2\text{H}^+ \rightarrow \text{Cl}^- + \text{H}_2\text{O} - 2\text{e}^{(-)} \quad (1)$ $2\text{I}^- \rightarrow \text{I}_2 + 2\text{e}^{(-)}$ ALLOW $2\text{I}^- - 2\text{e}^{(-)} \rightarrow \text{I}_2 \quad (1)$ Allow multiples Ignore state symbols even if incorrect	Equations without electrons	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$\text{ClO}^- + 2\text{H}^+ + 2\text{I}^- \rightarrow \text{Cl}^- + \text{H}_2\text{O} + \text{I}_2$ Mark independently. No TE on 21(b)(i)	Equations including electrons	1

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	Moles thiosulfate = $(24.20 \times 0.0500 / 1000) = 1.21 \times 10^{-3} / 1.2 \times 10^{-3} / 0.00121 / 0.0012$ (mol) (1) Moles iodine = half moles of thiosulfate = $6.05 \times 10^{-4} / 6.1 \times 10^{-4} / 0.000605 / 0.00061$ (mol) (1) Correct answer without working (2)	1.20×10^{-3} (mol) $1 \times 10^{-3} / 0.001$ 6.0×10^{-4} (mol) 6×10^{-4} (mol)	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(iv)	Moles $\text{ClO}^- = 6.05 \times 10^{-4}$ (mol) TE on (b)(ii) and (b)(iii): If ratio $\text{ClO}^- : \text{I}_2 = 2:1$ answer is 2 x answer to (b)(iii) If ratio $\text{ClO}^- : \text{I}_2 = 1:2$ answer is half of answer to (b)(iii)		1

Question Number	Acceptable Answers	Reject	Mark
21(b)(v)	Concentration = $(6.05 \times 10^{-4} \times 1000/25)$ $= 2.42 \times 10^{-2} / 0.0242/ 0.024/ 2.4 \times 10^{-2}$ (mol dm ⁻³) TE. Answer to (b)(iv) $\times 1000 \div 25$	Answers to 1 significant figure	1

Question Number	Acceptable Answers	Reject	Mark
21(b)(vi)	(Minimum) amount of I ⁻ to react with OCl ⁻ $= 2 \times \text{answer to (b)(iv)}$ $= 2 \times 6.05 \times 10^{-4}$ $= 1.21 \times 10^{-3} \text{ (mol)}$ (1) Allow TE for $2 \times \text{answer to (b)(iv)}$ Ignore s.f. Moles of I ⁻ (9.04×10^{-3}) is more than this number of moles of ClO ⁻ / I ⁻ is in excess / KI is in excess / so that all the ClO ⁻ can react (1) OR $9.04 \times 10^{-3} \text{ mol I}^{-}$ can react with $4.52 \times 10^{-3} \text{ mol OCl}^{-}$ (1) Ignore s.f. TE from incorrect equation in (b)(ii) Moles OCl ⁻ (6.05×10^{-4}) is less than this/ I ⁻ is in excess / KI is in excess / so that all the ClO ⁻ can react (1)	"KI is in excess" if no calculation has been done.	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(vii)	$0.30 \times 100 / 24.2$ $(=1.2396694)$ $= 1.24/ 1.2 \%$		1

Question Number	Acceptable Answers	Reject	Mark
21(b)(viii)	Judgement (of colour change) at end point / adding starch too early in the titration / jet of burette not filled Errors must cause an increase in titre. Ignore Just "Human error" Just 'overshot endpoint' Transfer errors / spillage Errors due to misreading burette / pipette	Some potassium iodide did not dissolve Leaving funnel in burette Errors which affect both the students titre and an accurate titre using the same solutions e.g. impure solutions	1

Question Number	Acceptable Answers	Reject	Mark
21(c)	(Cl radicals) break down ozone (layer)/ ozone depletion / ozone (layer) thinning Allow damage ozone (layer)/ react with ozone	Global warming Causes acid rain	1

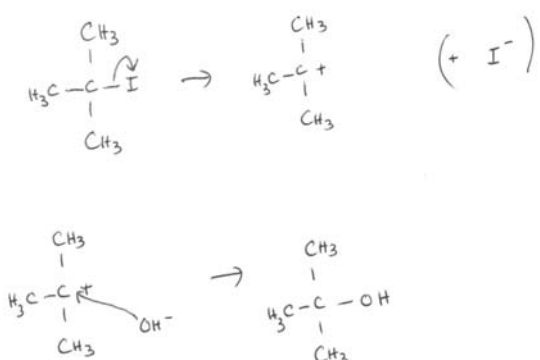
Total for Q21 = 17 marks

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	  Allow the bond to Br to be before or after the zig-zag line representing the 4C atoms, and to be at any angle Ignore bonds of unequal length		1

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	2-iodo-(2-)methylpropane Accept (2-)methyl-2-iodopropane Ignore punctuation (brackets, hyphens, commas)	2,2-iodomethylpropane 2-iodobutane	1

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	$\text{C}_4\text{H}_9\text{Br} + 2\text{NH}_3 \rightarrow \text{C}_4\text{H}_9\text{NH}_2 + \text{NH}_4\text{Br}$ OR $\text{C}_4\text{H}_9\text{Br} + \text{NH}_3 \rightarrow \text{C}_4\text{H}_9\text{NH}_2 + \text{HBr}$ OR $\text{C}_4\text{H}_9\text{Br} + \text{NH}_3 \rightarrow \text{C}_4\text{H}_9\text{NH}_3^{(+)}\text{Br}^{(-)} \quad \textbf{(1)}$ Accept structural / skeletal formula for X and product Allow inorganic product as ions Butylamine / 1-aminobutane / 1-butylamine/ 1-butanamine/ butan-1-amine (1) Ignore incorrect spacing and punctuation OR (N) butyl ammonium bromide if third equation given (1) OR Answers with multiple substitutions giving $(\text{C}_4\text{H}_9)_2\text{NH}$ (1) dibutylamine (1) $(\text{C}_4\text{H}_9)_3\text{N}$ (1) tributylamine (1) $(\text{C}_4\text{H}_9)_4\text{N}^{(+)}\text{Br}^{(-)}$ (1) tetrabutyl ammonium bromide (1) No TE on naming a product in an incorrect equation except if C_4H_8 is shown in a correct or incorrect elimination equation then 1 mark for naming it but-1-ene	Just word equations Molecular formula for organic product i.e. $\text{C}_4\text{H}_{11}\text{N}$ Equation for elimination reaction Aminobutane Butamine Any amide	2

	If correct equation and name (e.g. 2-amino-2-methylpropane) are given using Y max 1		
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Question Number	Acceptable Answers	Reject	Mark
22 (a)(iv)	 Arrow to I from within C-I bond (1) Formula of carbocation (1) Arrow from OH⁻ to C⁺ (1) If both arrows are shown before formation of intermediate max 2 Charge on OH⁻ essential for third mark. Lone pair need not be shown. Ignore partial charges on C and I in Y Ignore arrows showing hydroxide ion formation in KOH / covalent KOH Ignore K⁺ ions combining with I⁻ / inorganic products Mechanism for X instead of Y Max 2 Correct SN2 mechanism can score first mark and third mark for arrow from OH⁻ to C^(δ+)	Half arrows, but don't penalise twice δ ⁺ charge on intermediate	3

Question Number	Acceptable Answers	Reject	Mark
22(a)(v)	(Nucleophilic) elimination (reaction) (of HI)	Electrophilic elimination Nucleophilic substitution Dehydration	1

Question Number	Acceptable Answers	Reject	Mark
22(b)	X Cream precipitate Allow off white / creamy white / white-cream / (very) pale yellow (1) Y yellow precipitate (1) One mark for two correct colours but not precipitates Mention of precipitate without colours doesn't score Ignore identity of precipitates even if incorrect	Yellow/ creamy yellow precipitate for X Pale yellow precipitate for Y	2

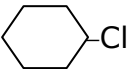
Question Number	Acceptable Answers	Reject	Mark
22(c)	C-Br stronger / C-I weaker with an attempt at an explanation (correct or incorrect) (1) as bond is shorter/ Br (atom) is smaller / as nuclei are closer OR reverse argument (1) Allow Br is more electronegative/ there is a bigger electronegativity difference / bond is more polar / $C^{\delta+}$ and $Br^{\delta-}$ attract more strongly / Br is less shielded Second mark depends on first	Br_2 is smaller References to Br^- implying bond is ionic. Br is more reactive	2

Total for Q22 = 12 marks

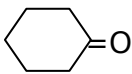
Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	109 (°) / 109.5 (°) / 109° 28'		1

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	104 – 106 (°) (1) O atom has two lone pairs (and 2 bonding pairs) (1) This mark can be given independently of the first and third mark Lone pairs repel each other more than bonding pairs / angle is reduced to minimise repulsion (by lone pairs) / to maximise separation (of lone pairs) (1) Ignore 'bonds repel each other' Angle in (ii) must be smaller than in (i) for third mark to be given	Lone pairs repel H atoms	3

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	Any two from Fizzing / effervescence / bubbles (of gas) (1) Sodium dissolves / disappears / reduces in size (1) White solid /precipitate forms (1) Ignore identification of products even if incorrect. Ignore sodium melting / moving around / sinking / floating Ignore colourless solution forms Ignore temperature changes / sodium going on fire	Just "Hydrogen forms"/"gas forms" Fumes	2

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	$\text{C}_6\text{H}_{11}\text{OH} + \text{PCl}_5 \rightarrow \text{HCl} + \text{C}_6\text{H}_{11}\text{Cl} + \text{POCl}_3$ (1) (1) (1) for HCl (1) for rest of the equation correct Cyclohexanol can be skeletal, $\text{C}_6\text{H}_{11}\text{OH}/\text{C}_6\text{H}_{12}\text{O}$ Accept 'PCl₃O' instead of POCl₃ Accept skeletal formula for $\text{C}_6\text{H}_{11}\text{Cl}$  Ignore state symbols	$\text{C}_5\text{H}_{11}\text{COH}$ $\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{CHOH}$ Unless a bond is shown connecting C1 and C6	2

Question Number	Acceptable Answers	Reject	Mark
23(b)(iii)	White smoke / solid with ammonia Allow white fumes / dense white fumes / steamy white fumes OR White precipitate with silver nitrate Ignore reference to ammonia solution unless HCl is specifically bubbled into solution Ignore using an indicator to show gas is acidic with one of the above tests Ignore description of appearance of HCl before testing	Just steamy / misty fumes Just testing with an indicator Bleaches litmus	1

Question Number	Acceptable Answers	Reject	Mark
23(b)(iv)			1

Question Number	Acceptable Answers	Reject	Mark
23(b)(v)	(Colour change from) Orange to green / blue / brown	blue- green green-blue yellow to green	1

Question Number	Acceptable Answers	Reject	Mark
23(c)	$\text{C}_6\text{H}_{10}^{(+)}$	$\text{C}_6\text{H}_{10}^-$ $(\text{CH}_2)_5\text{C}$ $\text{C}_5\text{H}_{10}\text{C}$ C_6H_{11} $(\text{CH})_5\text{OH}$ $\text{C}_2(\text{CH}_2)_3\text{O}$	1

Total for Q23 = 12 marks

Question Number	Acceptable Answers	Reject	Mark
24(a)	CO₂ has polar bonds / oxygen does not have polar bonds (1) Ignore O₂ is a non polar molecule (As it vibrates) polarity of CO₂ changes / dipole moment changes / shifts (1) Allow "Oxygen has no difference in electronegativity so polarity does not change" for 2 marks	CO ₂ is a polar molecule	2

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Hydrogen bonds can form with water Allow full description of hydrogen bonds in absence of name. Ignore incorrect naming of functional groups in aminoethanol.	Just "it is polar"	1

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	Exothermic, with attempt at a reason OR reverse reaction is endothermic, with attempt at a reason (1) Reaction will go in the endothermic direction on heating / equilibrium moves to left to use up heat supplied (1) Second mark depends on the reaction being exothermic in first mark	Just "exothermic"	2

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	 Electrons in double bond (1) Other electrons (1) Second mark dependent on first Only bonding electrons need be shown If inner shell electrons are included they must be correct. Electrons may be on circles, within circles or no circles may be shown.		2

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	Number of electrons (per molecule) is greater in CO₂ (than methane). If numbers are given must be correct. CO₂ has 22e⁻, methane has 10e⁻. Ignore CO₂ has larger surface area than methane	double bonds in CO ₂ as the cause	1

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	Butane has a greater surface area / butane is less branched (1) so more contact between (neighbouring) molecules / (neighbouring) molecules pack better (1) OR Reverse argument for 2-methylpropane		2

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	Mg – no colour in flame (1) Allow 'no flame visible' Ca brick red / red / yellow-red / red-orange (1)	Mg: white flame Bright / white light Clear flame Just orange	2

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	First mark: Detect thermal decomposition by Passing gas into / reacting gas with lime water OR By collecting the gas evolved (in syringe or by displacement) OR By measuring change of mass (1) Second mark: Measure time for (same volume) of lime water to go milky OR Measure volume of gas produced in a measured time OR Measure time for a specified / same volume of gas to form OR Find loss of mass after heating samples for equal time (1) The mark for measurement should only be given if it matches the suggested method of detection. Third and fourth marks: For fair comparison Any two from: Keep strength of flame constant (1) Distance of flame from containing tube constant (1) Use carbonates with similar particle size (1) Same volume of lime water (1) Heat equal moles / same amount of each carbonate (1) Judge equal milkiness of lime water using a piece of paper marked with a cross (1) The marks for fair comparison should only be given if they match the suggested method of detection. Ignore 'heat same mass' and 'known mass' Ignore using water bath as source of heat	First mark: Combustion Heating carbonate solution Second mark: Just "measure volume of gas produced" Measure time for a specified change in mass to occur	4

	Ignore 'heat to same temperature' Ignore 'use same heat source' Ignore 'constant heat' These points could be shown on a diagram but marks are for the principles, not the detail of drawing a sketch diagram.		
--	---	--	--

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	CaCO₃ more stable / MgCO₃ less stable (1) Mg²⁺ is smaller than Ca²⁺ / magnesium ions are smaller than calcium ions / charge density of Mg²⁺ is greater than Ca²⁺ / Ca²⁺ has more shells (1) EITHER Mg²⁺ causes more distortion of carbonate ion / more weakening of C-O / more polarisation of carbonate / more polarisation of anion / has more polarising power OR More energy is given out when MgO forms as the MgO lattice is stronger than CaO / as the 2+ ions can get closer to the 2⁻ ions on decomposition (1) Second and third marks can be scored if conclusion given in first mark is wrong	Mg is smaller "It" (unspecified) is smaller MgCO₃ is smaller More disruption of ion Polarisation of carbonate molecules CaO is less stable than MgO	3

Total for Q24 = 19 marks

TOTAL FOR SECTION B = 60 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Tuesday 4 June 2013 – Afternoon

Time: 1 hour 30 minutes

Paper Reference

6CH02/01

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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10/5/6/7/



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 molecules has the smallest bond angle?

- ☒ A H_2O
- ☐ B NH_3
- ☐ C CH_4
- ☐ D SF_6

(Total for Question 1 = 1 mark)

2 A charged rod is held beside a stream of liquid coming from a burette. Which of the following liquids would NOT be significantly deflected?

- ☒ A H_2O
- ☐ B CCl_4
- ☐ C $\text{C}_2\text{H}_5\text{OH}$
- ☐ D $\text{C}_2\text{H}_5\text{Br}$

(Total for Question 2 = 1 mark)

3 Which of the following statements about electronegativity is true?

- ☒ A Non-metals have lower electronegativity than metals.
- ☐ B Electronegativity decreases across a period in the Periodic Table.
- ☐ C Electronegativity decreases going down a group in the Periodic Table.
- ☐ D The bonds between atoms with equal electronegativity are always weak.

(Total for Question 3 = 1 mark)



4 In which series of compounds does the covalent character increase, going from left to right?

- ☒ A NaCl , MgCl_2 , AlCl_3 , SiCl_4
- ☒ B SiO_2 , Al_2O_3 , MgO , Na_2O
- ☒ C LiI , NaI , KI , RbI
- ☒ D KI , KBr , KCl , KF

(Total for Question 4 = 1 mark)

5 Going down Group 2 from calcium to barium

- ☒ A the first ionization energy of the element increases.
- ☒ B the strength of the metallic bonding increases.
- ☒ C the polarizing power of the $2+$ ion decreases.
- ☒ D the stability of the nitrate to heat decreases.

(Total for Question 5 = 1 mark)

6 Fullerenes, graphite and diamond are all forms of carbon. Fullerenes dissolve in petrol, but diamond and graphite do not. This is because

- ☒ A the bonds between the carbon atoms in fullerenes are weaker than in diamond and graphite.
- ☒ B diamond and graphite are giant structures but fullerenes are molecular.
- ☒ C there are delocalized electrons in diamond and graphite but not in fullerenes.
- ☒ D there are covalent bonds in diamond and graphite, but not in fullerenes.

(Total for Question 6 = 1 mark)

7 Sodium chloride is more soluble in water than in hexane because

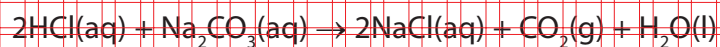
- ☒ A the intermolecular forces between water molecules are stronger than those between hexane molecules.
- ☒ B hexane molecules cannot fit between the ions in the sodium chloride lattice.
- ☒ C energy is released when the ions in sodium chloride are hydrated.
- ☒ D sodium ions and chloride ions form hydrogen bonds with water.

(Total for Question 7 = 1 mark)



P 4 1 6 5 0 A 0 3 2 4

8 Hydrochloric acid and sodium carbonate solution react as shown below.



Which sample of sodium carbonate solution will be neutralized by 20 cm³ of 0.05 mol dm⁻³ hydrochloric acid?

	Volume of sodium carbonate/ cm ³	Concentration of sodium carbonate/ mol dm ⁻³
☒ A	10	0.05
☒ B	40	0.05
☒ C	40	0.10
☒ D	10	0.10

(Total for Question 8 = 1 mark)

9 A white solid produces oxygen when it is heated but no other gases. The solid could be

- ☒ A lithium nitrate.
- ☒ B potassium nitrate.
- ☒ C strontium nitrate.
- ☒ D calcium oxide.

(Total for Question 9 = 1 mark)

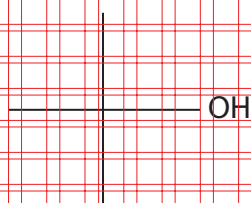
10 A solid is soluble in water and produces steamy acidic fumes with concentrated sulfuric acid. The solid could be

- ☒ A potassium carbonate.
- ☒ B magnesium sulfate.
- ☒ C silver chloride.
- ☒ D sodium chloride.

(Total for Question 10 = 1 mark)



11



The systematic name of the compound with skeletal formula shown above is

- ☒ A 1,1-dimethylethanol.
- ☒ B 2,2-dimethylethanol.
- ☒ C 2-methylpropan-1-ol.
- ☒ D 2-methylpropan-2-ol.

(Total for Question 11 = 1 mark)

12 Samples of 1-chloropropane and 1-bromopropane are warmed with water containing dissolved silver nitrate in the presence of ethanol. The 1-chloropropane reacts more slowly because

- ☒ A the C—Cl bond is more polar than the C—Br bond.
- ☒ B the C—Cl bond is stronger than the C—Br bond.
- ☒ C 1-chloropropane is less soluble than 1-bromopropane.
- ☒ D 1-chloropropane is a weaker oxidising agent than 1-bromopropane.

(Total for Question 12 = 1 mark)

13 The reaction of 1-chloropropane with water containing dissolved silver nitrate in the presence of ethanol is

- ☒ A a redox reaction.
- ☒ B a nucleophilic substitution.
- ☒ C an electrophilic substitution.
- ☒ D a free radical substitution.

(Total for Question 13 = 1 mark)



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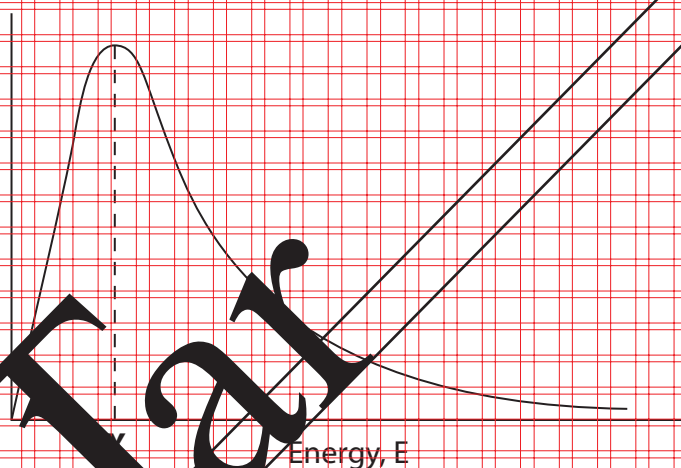
14 The compound with formula $\text{CH}_3\text{CH}(\text{NH}_2)\text{CH}_3$ can be made by reacting alcoholic ammonia with

- ☐ A propane.
- ☐ B propene.
- ☐ C 2-chloropropane.
- ☐ D propan-2-ol.

(Total for Question 14 = 1 mark)

15

Fraction of molecules with energy, E



The energy marked A on the Maxwell-Boltzmann distribution shows

- ☐ A the most common energy of the molecules.
- ☐ B the activation energy of the reaction.
- ☐ C the activation energy of a catalysed reaction.
- ☐ D the number of molecules with energy greater than the activation energy.

(Total for Question 15 = 1 mark)

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



16 In the industrial process involving gas phase reactions to produce ammonia, many collisions between molecules are unsuccessful because

- ☒ A gas phase reactions are reversible.
- ☒ B the collisions are not energetic enough to break the bonds in the molecules.
- ☒ C gas phase reactions can only occur when a catalyst is present.
- ☒ D gas phase reactions can only occur when UV light is present.

(Total for Question 16 = 1 mark)

17 The molecular (parent) ion in the mass spectrum of a hydrocarbon containing ^{12}C and ^1H only

- ☒ A is the peak with highest relative abundance.
- ☒ B is the peak with highest charge.
- ☒ C is the peak produced by the most stable fragment.
- ☒ D is the peak with highest mass to charge ratio.

(Total for Question 17 = 1 mark)

18 A compound which has major peaks with mass/charge ratio at 29, 57 and 58 in the mass spectrum could be

- ☒ A propanal, $\text{CH}_3\text{CH}_2\text{CHO}$
- ☒ B propanone, CH_3COCH_3
- ☒ C propan-1-ol, $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
- ☒ D propan-2-ol, $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$

(Total for Question 18 = 1 mark)

19 Which of the following would **not** be used to assess whether the use of a biofuel produced from a crop of sugar cane is carbon neutral?

The amount of

- ☒ A fuel used to operate farm machinery.
- ☒ B pesticides and fertilisers used.
- ☒ C energy released per tonne of biofuel.
- ☒ D fuel used to process the crop.

(Total for Question 19 = 1 mark)



P 4 1 6 5 0 A 0 7 2 4

20 The principal reason why scientists have recommended that chlorofluorocarbons (CFCs) are not used in aerosols is that they cause

- ☐ A global warming.
- ☐ B acid rain.
- ☐ C ozone depletion.
- ☐ D water pollution.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



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P 4 1 6 5 0 A 0 9 2 4

SECTION B

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

- 21 (a) (i) An alkaline solution is produced when barium reacts with cold water. Write the equation for this reaction, including all state symbols.

(2)

- (ii) The reaction in (a)(i) is a redox reaction. State the initial and final oxidation number of any element that changes its oxidation number.

(2)

- (b) Dilute hydrochloric acid is added to the solution produced in (a)(i). Write the equation for the reaction which occurs. State symbols are **not** required.

(1)

- (c) Dilute sulfuric acid is added to another sample of the solution produced in (a)(i). How would the appearance of the resulting mixture differ from the mixture produced in (b)? Explain this difference.

(2)

Appearance

Explanation



- (d) (i) Two white powders are known to be barium carbonate and magnesium carbonate.

How could you distinguish between the two powders by heating them?
[No practical details are required.]

Include the equation for the action of heat on one of these carbonates. State symbols are not required.

(2)

Equation:

- (ii) Suggest another test, other than heating, the use of an acid, which could be used to distinguish between magnesium carbonate and barium carbonate. State the results for both compounds.

(2)

Test

Result with magnesium carbonate

Result with barium carbonate

(Total for Question 21 = 11 marks)



DRAFT

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22 (a) The products of the reaction when 2-chlorobutane is heated with sodium hydroxide depend on the conditions.

(i) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce a mixture of but-1-ene and but-2-ene?

(1)

(ii) What type of reaction occurs in (a)(i)?

(1)

(iii) What condition, other than a suitable temperature and sodium hydroxide concentration, would produce butan-2-ol in the reaction of 2-chlorobutane with sodium hydroxide?

(1)

(iv) Suggest the mechanism for the reaction of 2-chlorobutane with hydroxide ions to form butan-2-ol. Use curly arrows to show the movement of electron pairs.

(2)

Example



P 4 1 6 5 0 A 0 1 3 2 4

(b) Phosphorus(V) chloride, PCl_5 , can be used to test for the $-\text{OH}$ group.

Describe what would be seen when phosphorus(V) chloride is added to butan-2-ol. Give the equation for the reaction. State symbols are not required.

(2)

Observation

Equation

(c) A tertiary alcohol, **A**, is an isomer of butan-2-ol.

(i) Butan-2-ol and **A** can be distinguished by warming separate samples with a mixture of potassium dichromate(VI) and sulfuric acid. State the observations which would be made with each alcohol.

(2)

Observation with butan-2-ol

Observation with **A**

(ii) Give the structural formula of the organic product which forms when butan-2-ol is oxidised.

(1)



(iii) Explain how infrared spectroscopy could be used to detect whether butan-2-ol has been oxidized.

(1)

(Total for Question 22 = 11 marks)

Example



P 4 1 6 5 0 A 0 1 5 2 4

23 The boiling temperatures of fluorine and two of its compounds are given below.

Substance	F_2	CH_3F	HF
T_b/K	85	195	293

(a) A molecule of F_2 has 18 electrons.

Which intermolecular force depends to a large extent on the number of electrons in the molecule?

(1)

(b) Calculate the number of electrons in a molecule of CH_3F .

(1)

(c) Explain why the boiling temperature of CH_3F is greater than that of F_2 , referring to the intermolecular forces present.

(1)

Explain why the boiling temperature of HF is the highest in the series.

(2)



- (e) Explain why the values of the boiling temperatures for Cl_2 , CH_3Cl and HCl do not follow the same trend as F_2 , CH_3F and HF .

(1)

(Total for Question 23 = 6 marks)

Dr Example



P 4 1 6 5 0 A 0 1 7 2 4

24 The percentage by mass of tin in a piece of rock containing tin(IV) oxide, SnO_2 , was determined as described in the procedure below.

Step 1 A sample of rock, with mass 10.25 g, was crushed and dissolved in sulfuric acid.

Step 2 The solution was treated with a reducing agent to convert the Sn^{4+} to Sn^{2+} ions.

Step 3 50 cm^3 of aqueous iodine solution with concentration $0.250 \text{ mol dm}^{-3}$ was added to the solution of Sn^{2+} ions. The following reaction occurred:



Step 4 The **excess** iodine was titrated with sodium thiosulfate solution with concentration $0.100 \text{ mol dm}^{-3}$. The volume of sodium thiosulfate solution required was 11.60 cm^3 .

(a) Thiosulfate ions react with iodine as shown below.



(i) Calculate the number of moles of sodium thiosulfate which were used in **Step 4**.

(1)

(ii) Calculate the number of moles of iodine which reacted with this amount of sodium thiosulfate.

(1)

(iii) Calculate the number of moles of iodine added to the solution of Sn^{2+} ions in **Step 3**.

(1)

(iv) Use your results from (ii) and (iii) to calculate the number of moles of iodine which reacted with the Sn^{2+} ions from the rock.

(1)



(v) Hence calculate the percentage by mass of tin in the rock.

(2)

(b) (i) What change could be made in **Step 4** to improve the reliability of the result?

(1)

(ii) The error each time the burette was read was $\pm 0.05 \text{ cm}^3$. Calculate the percentage error in the titre value of 11.4 cm^3 .

(1)

(iii) How could the percentage error in the titre value be reduced without using a different buret?

(1)

(c) The titration can be carried out with or without an indicator. What colour **change** is observed at the end-point if an indicator was **not** used? The tin ions are colourless.

(1)

(Total for Question 24 = 10 marks)

TOTAL FOR SECTION B = 38 MARKS



P 4 1 6 5 0 A 0 1 9 2 4

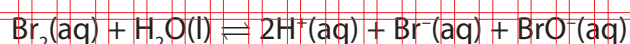
SECTION C

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

- 25 (a) Sea water is a source of chemicals. The most abundant chemical dissolved in sea water is sodium chloride. Compounds of magnesium and bromine are also present. Magnesium occurs at 1300 parts per million (ppm) and bromine at 60 ppm by mass.

The solution left after crystallizing sodium chloride from sea water is even richer in bromine, and contains around 2.2 g dm^{-3} of bromine.

Bromine is extracted from this solution by passing in chlorine gas. The mixture is acidified to prevent hydrolysis of bromine by the reaction



The bromine can be separated by heating the solution to collect bromine vapour which is then condensed, or by blowing air through the solution.

- (i) Show by calculation that a solution containing 2.2 g dm^{-3} of bromine is richer in bromine than one containing 60 ppm.

[Assume that the mass of 1 dm^3 of the bromine solution is 1000 g]

(1)

- (ii) Write an ionic equation, including state symbols, for the reaction in which chlorine gas reacts with bromide ions in solution to produce bromine.

(2)

- (iii) What would be observed when the reaction in (ii) occurs?

(1)



(iv) Explain why the addition of an acid, such as hydrochloric acid, prevents hydrolysis of bromine.

(2)

(v) Assuming the hydrolysis of bromine is endothermic, explain how an increase in temperature would affect the equilibrium position for the hydrolysis of bromine.

(2)

(vi) Use your knowledge of activation energy to explain why an increase in temperature increases the rate of hydrolysis of bromine.

(1)

(vii) Use the equation for the hydrolysis of bromine to show that it is a disproportionation reaction.



(2)



- (b) At the surface of the sea, there is a dynamic equilibrium between carbon dioxide gas in air and dissolved carbon dioxide in the surface sea water.



- (i) State **two** features of a system which has reached dynamic equilibrium.

(2)

1.

2.

- *(ii) Carbon dioxide dissolves more easily in seawater than in pure water because seawater contains carbonate ions, $\text{CO}_3^{2-}(\text{aq})$ and the following reaction occurs.



Explain how an increase in concentration of carbonate ions in sea water affects the amount of carbon dioxide gas in the atmosphere.

(2)

Carbon dioxide and water vapour both contain polar bonds.

What effect does infrared radiation have on the bonds in these molecules?

(1)



* (iv) Outline the mechanism by which molecules such as carbon dioxide and water cause global warming.

(2)

* (v) Without water vapour in the atmosphere, the earth would be many degrees colder than it is at present. Why are many climate change scientists more concerned about warming due to carbon dioxide in the atmosphere, than warming due to the presence of water vapour? Refer to the difference between anthropogenic climate change and natural climate change in your answer.

(4)

(Total for Question 25 = 22 marks)

TOTAL FOR SECTION C = 22 MARKS
TOTAL FOR PAPER = 80 MARKS



P 4 1 6 5 0 A 0 2 3 2 4

1 2 3 4 5 6 7 0(8) 0(8) 0(8)

- * Lanthanide series
- * Actinide series

Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH02/01
Application of Core Principles of
Chemistry

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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	D		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	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		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	D		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	C		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	A		1

Question Number	Correct Answer	Reject	Mark
19	C		1

Question Number	Correct Answer	Reject	Mark
20	C		1

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	$\text{Ba(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Ba(OH)}_2\text{(aq)} + \text{H}_2\text{(g)}$ OR $\text{Ba(s)} + 2\text{H}_2\text{O(l)} \rightarrow \text{Ba}^{2+}\text{(aq)} + 2\text{OH}^-\text{(aq)} + \text{H}_2\text{(g)}$ Correct products (1) State symbols and balancing (1)	Ba_2 $\text{H}_2\text{O(aq)}$ BaO_2	2

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	Ba(increases in ON) from 0 to +2 (1) H (decreases in ON) from +1 to 0 (1) TE from (a)(i) Stand-alone marks	Inclusion of oxygen changes will lose 1 mark	2

Question Number	Acceptable Answers	Reject	Mark
21(b)	$\text{Ba(OH)}_2 + 2\text{HCl} \rightarrow \text{BaCl}_2 + 2\text{H}_2\text{O}$ IGNORE state symbols even if incorrect ALLOW $\text{H}^+ + \text{OH}^- \rightarrow \text{H}_2\text{O}$ TE from (a)(i): $\text{BaO} + 2\text{HCl} \rightarrow \text{BaCl}_2 + \text{H}_2\text{O}$		1

Question Number	Acceptable Answers	Reject	Mark
21(c)	White precipitate / white solid / white crystals (rather than colourless solution) (1) Barium sulfate is insoluble (whereas barium chloride is soluble) (1) Stand-alone marks	'Cloudy' alone	2

Question Number	Acceptable Answers	Reject	Mark
21(d)(i)	If flame test is described in (d)(i) then award appropriate marks for (d)(ii). A correct decomposition equation given in (d)(i) would score 1 mark. Allow valid discussion of thermal stability appearing in (d)(ii) for mark in (d)(i) Barium carbonate is more thermally stable (than magnesium carbonate) / requires more heating / needs a higher temperature / decomposes more slowly / produces carbon dioxide more slowly OR Reverse argument (MgCO_3 decomposes faster) ALLOW BaCO_3 doesn't decompose on heating but MgCO_3 does (1) $\text{MCO}_3 \rightarrow \text{MO} + \text{CO}_2$ Where M stands for Mg or Ba (1) IGNORE state symbols even if incorrect	Just 'barium' Just 'produces more carbon dioxide' Just 'magnesium'	2

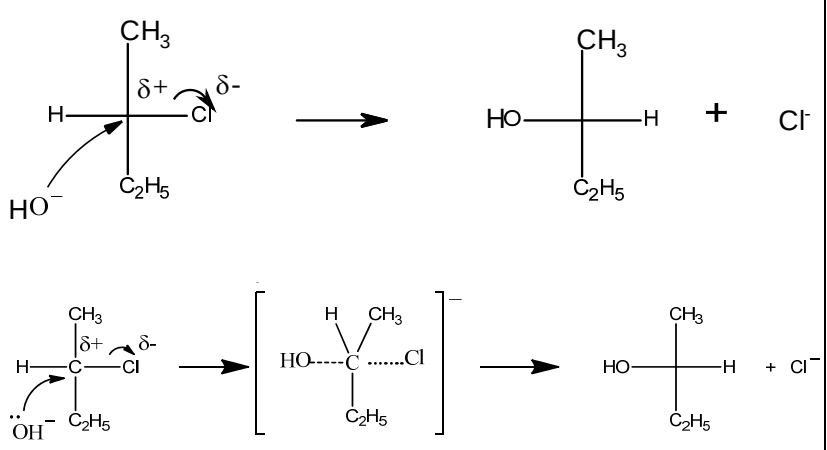
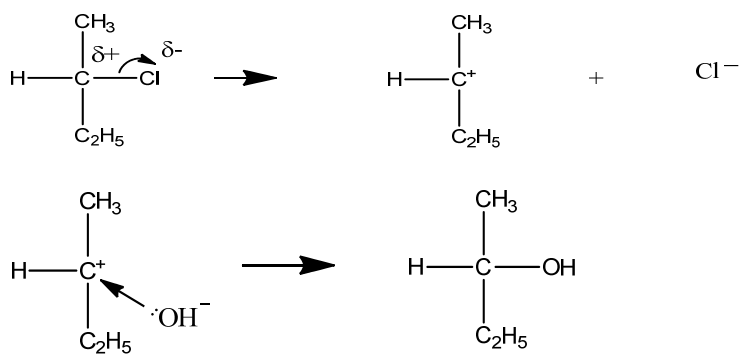
Question Number	Acceptable Answers	Reject	Mark
21(d)(ii)	Flame test or description of: Mg does not colour flame (1) ALLOW colourless / clear Ba: (pale / apple) green flame (1) Stand-alone marks	Magnesium gives white / bright flame 'blue-green' Instrument analysis	2

Total for Question 21 = 11 Marks

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	Alcohol /ethanol (as solvent for NaOH) IGNORE heat / pressure	Any other reagents	1

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Elimination		1

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Water (as solvent for NaOH) / aqueous (NaOH) / aqueous (ethanol)	Aqueous silver nitrate	1

Question Number	Acceptable Answers	Reject	Mark
22 (a)(iv)	 ALLOW  Arrow from OH⁻ to appropriate C (connected / previously connected) to Cl (1) Arrow from C-Cl bond to Cl producing Cl⁻ (1) Accept three dimensional diagrams ; displayed formulae; CH₃CH₂ for C₂H₅ Use of C₄H₉Cl as formula can score 1 for arrow from C-Cl bond to Cl Lone pair on hydroxide ion need not be shown ALLOW solid lines instead of dotted lines in the transition state	OH without charge Cl[•] (chlorine radical)	2

Question Number	Acceptable Answers	Reject	Mark
22(b)	Steamy / misty / white and fumes / gas (1) IGNORE fizzing $\text{CH}_3\text{CH}_2\text{CH}(\text{OH})\text{CH}_3 + \text{PCl}_5 \rightarrow \text{CH}_3\text{CH}_2\text{CHClCH}_3 + \text{HCl} + \text{POCl}_3$ (1) ALLOW $\text{C}_4\text{H}_9\text{OH}$ and $\text{C}_4\text{H}_9\text{Cl}$ ALLOW PCl_3O Accept displayed formulae ALLOW missing bracket in alcohol Stand alone marks	White smoke Solid $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ $\text{C}_4\text{H}_{10}\text{O}$	2

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	With butan-2-ol: (change from orange) to green / blue (1) With A : remains orange / no change (1) ALLOW 'no reaction' Any reference to 'yellow': max 1	Reference to gas given off or formation of precipitate Green-blue Just 'nothing'	2

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	$\text{CH}_3\text{CH}_2\text{COCH}_3$ ALLOW displayed or skeletal		1

Question Number	Acceptable Answers	Reject	Mark
22(c)(iii)	Absorption / peak / trough for O-H / C-O / OH bond / alcohol CO bond would disappear OR Absorption / peak / trough for C=O / CO ketone bond would appear	Just - OH / CO Just 'alcohol peak' Just 'ketone peak'	1

Total for Question 22 = 11 Marks

Question Number	Acceptable Answers	Reject	Mark
23(a)	London (forces) / van der Waals (forces) / temporary dipole-induced dipole (attractions) / dispersion forces / instantaneous dipole-dipole	Dipole-dipole Permanent dipole-dipole Just abbreviations, eg ID-ID, VdW	1

Question Number	Acceptable Answers	Reject	Mark
23(b)	18 /eighteen		1

Question Number	Acceptable Answers	Reject	Mark
23(c)	(Permanent) dipole-dipole attractions (also) present	Hydrogen bonds Reference to CH ₃ F having more electrons than F ₂	1

Question Number	Acceptable Answers	Reject	Mark
23(d)	Hydrogen bonds (also) present (1) Which are stronger / which require more energy to break than dipole-dipole / London forces / van der Waals' forces / Or strongest intermolecular force (1)		2

Question Number	Acceptable Answers	Reject	Mark
23(e)	HCl does not have hydrogen bonds (between molecules) IGNORE references to electronegativity	Just 'chlorine does not have hydrogen bonds'	US035563

Total for Question 23 = 6 Marks

Question Number	Acceptable Answers	Reject	Mark
24(a)(i)	In (a) any units given must be correct. Penalise once only. IGNORE SF except 1SF. Penalise once only. TE throughout $((0.1 \times 11.6)/(1000) = 1.16 \times 10^{-3} / 0.00116 / 0.0012 / 1.2 \times 10^{-3}(\text{mol})$		1

Question Number	Acceptable Answers	Reject	Mark
24(a)(ii)	$(1.16 \times 10^{-3} / 2) = 5.8 \times 10^{-4} / 0.00058 (\text{mol I}_2 \text{ react with thiosulfate})$ 6.0×10^{-4} if 1.2×10^{-3} used	6×10^{-4}	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(iii)	$((50 \times 0.25)/1000) = 1.25 \times 10^{-2} / 12.5 \times 10^{-3} / 0.0125 (\text{mol})$	0.012	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(iv)	= Answer to (a)(iii)- answer to a(ii) $(1.25 \times 10^{-2} - 5.8 \times 10^{-4}) = 1.192 \times 10^{-2} / 0.01192 (\text{mol reacted with tin})$ $1.19 \times 10^{-2} / 0.0119 (\text{mol})$ if 6.0×10^{-4} used ALLOW $1.2 \times 10^{-2} / 0.012 (\text{mol})$	1.20×10^{-2}	1

Question Number	Acceptable Answers	Reject	Mark
24(a)(v)	Mass of tin = answer to (a)(iv) $\times 118.7 /$ $= 1.414904 / 1.415 \text{ g} \quad \quad \quad \mathbf{(1)}$ $\% \text{ tin} = \frac{(1.415 \times 100)}{10.25} = 13.803941$ $= 13.8 \% \quad \quad \quad \mathbf{(1)}$ TE from mass if only 1 error in its calculation 13.83/ 13.8% if 1.194×10^{-2} used If answer to (a)(iv) = $5.8 \times 10^{-4} \text{ mol I}_2$ this gives 0.068846 g Sn and 0.67167 % Sn scores (2) Correct answer without working scores (2) ALLOW (1) for 17.5% of SnO_2		2

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Divide solution into separate portions for titration	Just 'repeat the titration' Use starch	1

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	$\frac{(0.05 \times 2 \times 100)}{11.6} = (\pm) 0.86\%$ ALLOW 0.9%	0.90%	1

Question Number	Acceptable Answers	Reject	Mark
24(b)(iii)	Use more dilute thiosulfate (to make titration reading bigger) / Use a larger volume or moles of excess iodine	Use more rock	1

Question Number	Acceptable Answers	Reject	Mark
24(c)	(Pale) yellow / straw-coloured to colourless	Clear for colourless Blue / black to colourless Orange / grey / brown	1

Total for Question 24 = 10 Marks

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	2.2 g in 1000 g = 2200 g per 1 000 000 g / 2200 (ppm) (greater than 60) OR 60ppm = 0.060 (g dm⁻³) (less than 2.2) OR 2.2g dm⁻³ = 0.22% which is more than 60ppm = 0.006% (Both values needed as neither is given in question) OR $2.2 \div 1000 = 2.2 \times 10^{-3}$ and $60 \div 1000000 = 6 \times 10^{-5}$		1

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	$\text{Cl}_2 (\text{g/aq}) + 2\text{Br}^- (\text{aq}) \rightarrow 2\text{Cl}^- (\text{aq}) + \text{Br}_2 (\text{aq})$ Correct species (1) Balancing and state symbols (1)		2

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	(Colourless to) yellow / orange / brown / red-brown colour (or any combination of these colours) appears	'Effervescence'	1

Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	Addition of hydrochloric acid increases the concentration of H⁺ (1) Equilibrium shifts to the left/ favours the backwards reaction / H⁺ combines with Br⁻ and BrO⁻ to make H₂O and Br₂ (1) OR The equilibrium will not produce H⁺ (1) So forward reaction will not occur (1) Standalone marks		2

Question Number	Acceptable Answers	Reject	Mark
25(a)(v)	The equilibrium shifts to the right / favours the forward reaction (1) To absorb added heat (energy) / in the endothermic / positive ΔH direction (1)		2

Question Number	Acceptable Answers	Reject	Mark
25(a)(vi)	Greater proportion of / more molecules with energy more than (or equal to) activation energy / sufficient energy to react (at higher temperature) ALLOW particles. ALLOW 'overcome' for 'more than'.	Atoms Lowers activation energy Just 'more successful collisions'	1

Question Number	Acceptable Answers	Reject	Mark
25(a)(vii)	Bromine (atoms) are (simultaneously) oxidized from 0 to +1 in BrO^- (1) And reduced to -1 in Br^- (1)		2

Question Number	Acceptable Answers	Reject	Mark
25(b)(i)	The forward and backward reactions occur at the same rate (1) The concentrations or amounts or moles of reactants and products remain constant / intensive or macroscopic properties (e.g. colour) are constant (1) IGNORE reference to 'closed system'	Concentrations of products and reactants are the same	2

Question Number	Acceptable Answers	Reject	Mark
25(b)(ii)	Equilibrium shifts to the right so more $\text{CO}_2(\text{g})$ dissolves / equilibrium shifts to the right so reducing the concentration of $\text{CO}_2(\text{aq})$ (1) So amount of CO_2 in atmosphere / gaseous decreases (1) Second mark depends on first unless qualified by a near miss		2

Question Number	Acceptable Answers	Reject	Mark
25(b)(iii)	(Bonds) bend / stretch / vibrate (more)/ bonds change polarity or dipole (moment)	Molecules vibrate Bonds break.	1

Question Number	Acceptable Answers	Reject	Mark
25(b)(iv)	Infrared radiation / heat is absorbed by greenhouse gases / by carbon dioxide and water (1) And one of the following: When energy from the sun is (re-)emitted from the earth's surface (allow 'reflected') OR IR / heat cannot escape from earth's atmosphere OR IR / heat is (re-)emitted back to the earth (1)	IR absorbed from the sun UV radiation	2

Question Number	Acceptable Answers	Reject	Mark
25(b)(v)	• Anthropogenic climate change is caused by human activity (1) • Natural climate change is caused by volcanic eruptions etc (1) Up to any three of the following to a max of (4) • Water vapour levels always relatively constant / water levels fluctuate normally / water levels vary only to a small extent • CO₂ levels increasing due to (fossil) fuel combustion/deforestation / industrial revolution • CO₂ molecules absorb more IR radiation than H₂O molecules OR CO₂ molecules have a greater 'greenhouse effect' than H₂O molecules • Increase in CO₂ levels has accompanied rise in global temperatures • Concern due to melting of ice packs / rising sea levels / flooding / change in sea pH etc	Reference to UV Reference to ozone depletion negates this mark	4

Total for Question 25 = 22 Marks

Total for Paper = 80 Marks

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Centre Number

Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary

Unit 2: Application of Core Principles of Chemistry

Tuesday 4 June 2013 – Afternoon

Time: 1 hour 30 minutes

Paper Reference

6CH02/01R

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 ►

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7/6/7/1/1/



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 could be used to oxidize ethanol to ethanoic acid?

- ☐ A Concentrated H_2SO_4
- ☐ B $\text{H}^+/\text{Cr}_2\text{O}_7^{2-}$
- ☐ C $\text{H}^+/\text{Cr}^{3+}$
- ☐ D Concentrated NaOH solution

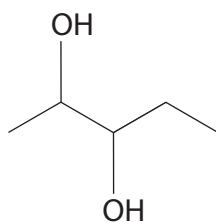
(Total for Question 1 = 1 mark)

2 The term "reflux" is best described as

- ☐ A continuous evaporation and condensation.
- ☐ B heating to evaporation and separation.
- ☐ C heating under reduced pressure and separation.
- ☐ D constant boiling.

(Total for Question 2 = 1 mark)

3 The alcohol shown below can be classified as

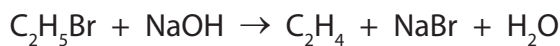


- ☐ A just primary.
- ☐ B primary and secondary.
- ☐ C just secondary.
- ☐ D secondary and tertiary.

(Total for Question 3 = 1 mark)



4



This reaction is an example of

- ☐ A addition.
- ☐ B elimination.
- ☐ C hydrolysis.
- ☐ D oxidation.

(Total for Question 4 = 1 mark)

5 Which of the following is **not** a greenhouse gas?

- ☐ A H_2O
- ☐ B NO
- ☐ C CH_4
- ☐ D O_2

(Total for Question 5 = 1 mark)

6 Which type of radiation is absorbed by molecules and results in the greenhouse effect?

- ☐ A Infrared
- ☐ B Microwave
- ☐ C Ultraviolet
- ☐ D X-ray

(Total for Question 6 = 1 mark)

7 It is important to lower the level of carbon dioxide in the atmosphere because of concerns over which environmental problem?

- ☐ A Acid rain
- ☐ B Global warming
- ☐ C Non-biodegradability
- ☐ D Ozone depletion

(Total for Question 7 = 1 mark)



P 4 2 9 8 3 A 0 3 2 0

8 The meaning of homolytic fission is

- ☐ A bond-breaking to form two free radicals.
- ☐ B bond-making to form two free radicals.
- ☐ C bond-breaking to form a cation and an anion.
- ☐ D bond-making to form a cation and an anion.

(Total for Question 8 = 1 mark)

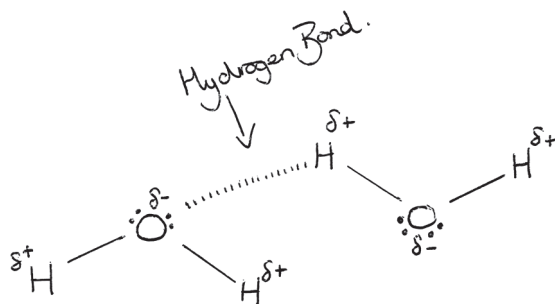
9 What are the strongest forces between molecules of hydrogen fluoride, HF?

- ☐ A Dipole-dipole forces.
- ☐ B Hydrogen bonds.
- ☐ C Ionic interactions.
- ☐ D London forces.

(Total for Question 9 = 1 mark)

10 The diagram below is taken from a student's examination paper. It shows the hydrogen bonding between two water molecules.

Identify the error in the diagram.



- ☐ A The H—O—H bond angle within each water molecule should be 90°.
- ☐ B There should only be one lone pair of electrons on each oxygen atom.
- ☐ C The O—H—O bond angle between the water molecules should be 180°.
- ☐ D The hydrogen atoms should be δ^- and the oxygen atoms should be δ^+ .

(Total for Question 10 = 1 mark)



11 The boiling temperatures from methane to propane increase because

- ☐ A the number of ions increases, so there are stronger electrostatic attractions.
- ☐ B the covalent bonds are getting stronger, so require more energy to break.
- ☐ C there are more covalent bonds, so more energy is needed to break them.
- ☐ D the number of electrons increases, so there are stronger London forces.

(Total for Question 11 = 1 mark)

12 In a chemical reaction, which of the following factors increases the proportion of particles that have sufficient energy to react?

- ☐ A A decrease in concentration
- ☐ B An increase in concentration
- ☐ C A decrease in temperature
- ☐ D An increase in temperature

(Total for Question 12 = 1 mark)

13 A 'greener' chemical process will be one that

- ☐ A uses energy less efficiently.
- ☐ B forms a non-polluting waste product.
- ☐ C produces significant amounts of waste.
- ☐ D makes use of non-renewable resources.

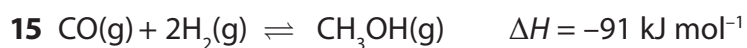
(Total for Question 13 = 1 mark)

14 Which of the following **cannot** alter the position of a chemical equilibrium?

- ☐ A Increasing the amount of catalyst
- ☐ B Increasing the reactant concentration
- ☐ C Increasing the temperature
- ☐ D Increasing the total pressure

(Total for Question 14 = 1 mark)





The conditions which would produce the greatest yield of methanol are

- ☐ **A** high pressure and high temperature.
- ☐ **B** high pressure and low temperature.
- ☐ **C** low pressure and low temperature.
- ☐ **D** low pressure and high temperature.

(Total for Question 15 = 1 mark)

16 What is the oxidation number of chlorine in Cl_2O_7 ?

- ☐ **A** -1
- ☐ **B** +1
- ☐ **C** -7
- ☐ **D** +7

(Total for Question 16 = 1 mark)

17 The concentration of a solution of potassium iodate(V) can be determined by the liberation of iodine, followed by titration with sodium thiosulfate.

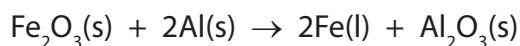
A suitable indicator is

- ☐ **A** methyl orange.
- ☐ **B** phenolphthalein.
- ☐ **C** starch.
- ☐ **D** universal indicator.

(Total for Question 17 = 1 mark)



18 The thermite reaction, shown below, is a useful industrial process.



The iron in this reaction undergoes

- ☐ **A** disproportionation.
- ☐ **B** oxidation.
- ☐ **C** redox.
- ☐ **D** reduction.

(Total for Question 18 = 1 mark)

19 Which of the following molecules has a linear shape and bond angles of 180° ?

- ☐ **A** CH_4
- ☐ **B** H_2O
- ☐ **C** CO_2
- ☐ **D** SF_6

(Total for Question 19 = 1 mark)

20 What would be the experimental observations if chlorine gas was bubbled through potassium iodide solution, followed by the addition of cyclohexane?

- ☐ **A** The solution turns brown, then two layers are produced and the top layer is purple.
- ☐ **B** A white precipitate is formed, which then dissolves to leave a colourless solution.
- ☐ **C** Bubbles of gas are seen and then a brown precipitate is formed.
- ☐ **D** The solution remains colourless, and then two layers are seen with the bottom layer being brown.

(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 This is a question about Group 2 compounds.

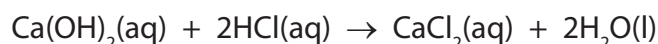
Limewater is a solution of calcium hydroxide, commonly used in the identification of carbon dioxide gas. Since calcium hydroxide is only sparingly soluble in water, technicians often make the solution by adding an excess of the solid calcium hydroxide to the required volume of deionised water, shaking the container and then leaving the mixture to settle. In this way, a saturated solution is produced but it can be of variable concentration.

Two students were each given a sample of limewater, from the same batch, in order to determine its concentration. Using 50.0 cm^3 portions of the limewater, they carried out titrations using $0.100 \text{ mol dm}^{-3}$ hydrochloric acid. One of the students obtained the following results:

Titration	Trial	1	2
Final Volume / cm^3	14.50	28.60	42.70
Initial Volume / cm^3	0.00	14.50	28.60
Volume Added / cm^3	14.50	14.10	14.10

The student decided that the mean titre was 14.10 cm^3

The equation for the reaction is:



(a) (i) Calculate the number of moles of hydrochloric acid that reacted.

(1)

(ii) Calculate the number of moles of calcium hydroxide, Ca(OH)_2 , that reacted with the acid.

(1)



(iii) Calculate the concentration of Ca(OH)_2 , in mol dm^{-3} , in this sample of limewater.

(1)

(iv) Calculate the concentration of Ca(OH)_2 , in g dm^{-3} , in this sample of limewater. Use the Periodic Table as a source of data.

(2)

(v) This student did not include the trial value when calculating the mean titre. Explain why.

(1)

.....

.....

.....

.....

(vi) The second student obtained a different mean titre value for the experiment and thought that this difference may be due to the use of a faulty pipette.

Suggest a simple method, involving distilled water and a balance, by which the accuracy of the pipette in measuring out exactly 50.0 cm^3 could be checked.

(2)

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.....

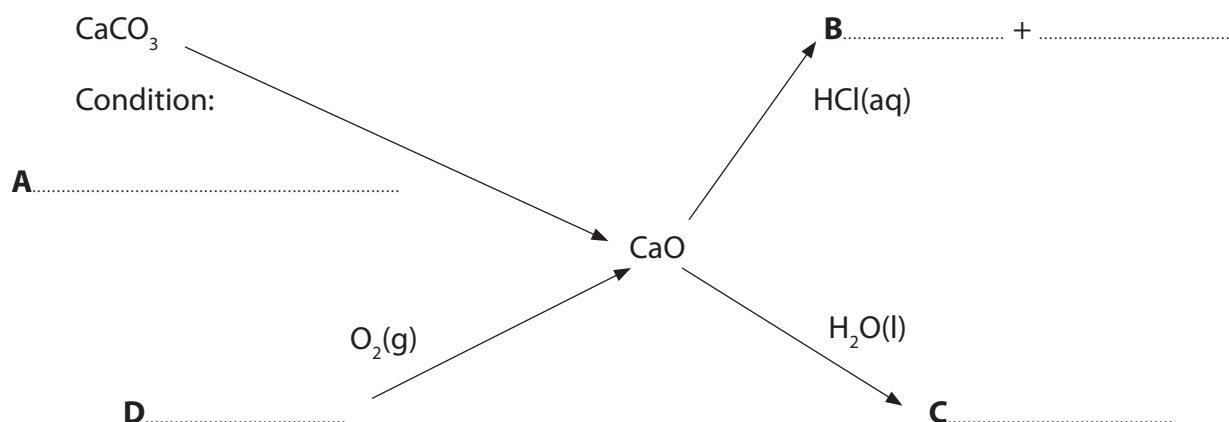
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- (b) Complete the missing details from the reaction flowchart shown below, giving the condition for **A** and using chemical formulae for answers **B**, **C** and **D**. State symbols are not required.

(4)



- (c) In certain areas of the UK, calcium and magnesium carbonates tend to be deposited as an off-white solid on the inside surface of pipes and the surface of heating elements in kettles. These deposits can be removed by treatment with a weak acid. An equation for this is shown below.



State **one** observation, other than the solid disappearing, that would be made when the above reaction is carried out.

(1)

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.....

- (d) The thermal stability of these carbonates depends on a combination of factors, including the size of their lattice energies.

Explain why the lattice energy of calcium carbonate is less exothermic than that of magnesium carbonate.

(2)

.....

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.....



- (e) Calcium and magnesium ions can be distinguished by the use of a flame test. State the difference in the flame colour and explain how colours in a flame are produced in terms of electronic transitions.

(3)

Calcium.....

Magnesium.....

Colour produced by

.....

.....

.....

.....

.....

.....

(Total for Question 21 = 18 marks)



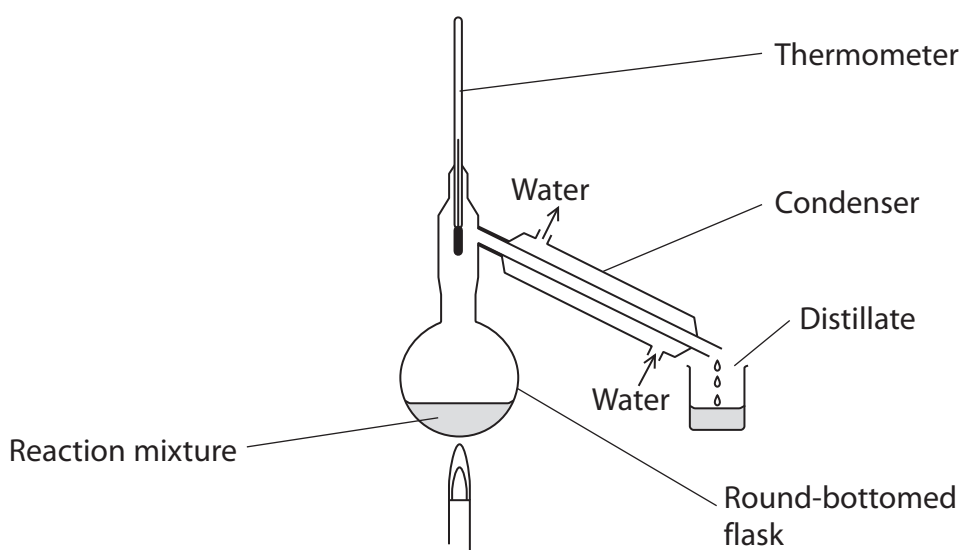
P 4 2 9 8 3 A 0 1 1 2 0

22 Ethane-1,2-diol, $\text{CH}_2\text{OHCH}_2\text{OH}$, is commonly used in antifreeze for cars to lower the freezing temperature of the water in the car radiator. It reacts in a similar way to ethanol but both of the alcohol groups can react.

- (a) Write an equation for the **complete** reaction between sodium and ethane-1,2-diol. State symbols are **not** required.

(2)

- (b) Ethane-1,2-diol is very quickly oxidized to ethanedioic acid, $(\text{COOH})_2$, even under the conditions shown below.



However, ethanol requires stronger oxidizing conditions to be converted into ethanoic acid.

Explain how you would change the above apparatus to achieve this oxidation of ethanol.

(2)

.....

.....

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.....



(c) Draw the **skeletal** formula of ethanedioic acid.

(1)

(d) Explain why phosphorus(V) chloride, PCl_5 , would not be a suitable reagent to be used to distinguish between ethane-1,2-diol and ethanedioic acid.

(1)

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P 4 2 9 8 3 A 0 1 3 2 0

- (e) (i) Depending on the reaction conditions, ethanol can be oxidized to either an aldehyde or to carboxylic acid. Infrared spectroscopy is a suitable technique for determining whether the oxidation product obtained is an aldehyde or a carboxylic acid.

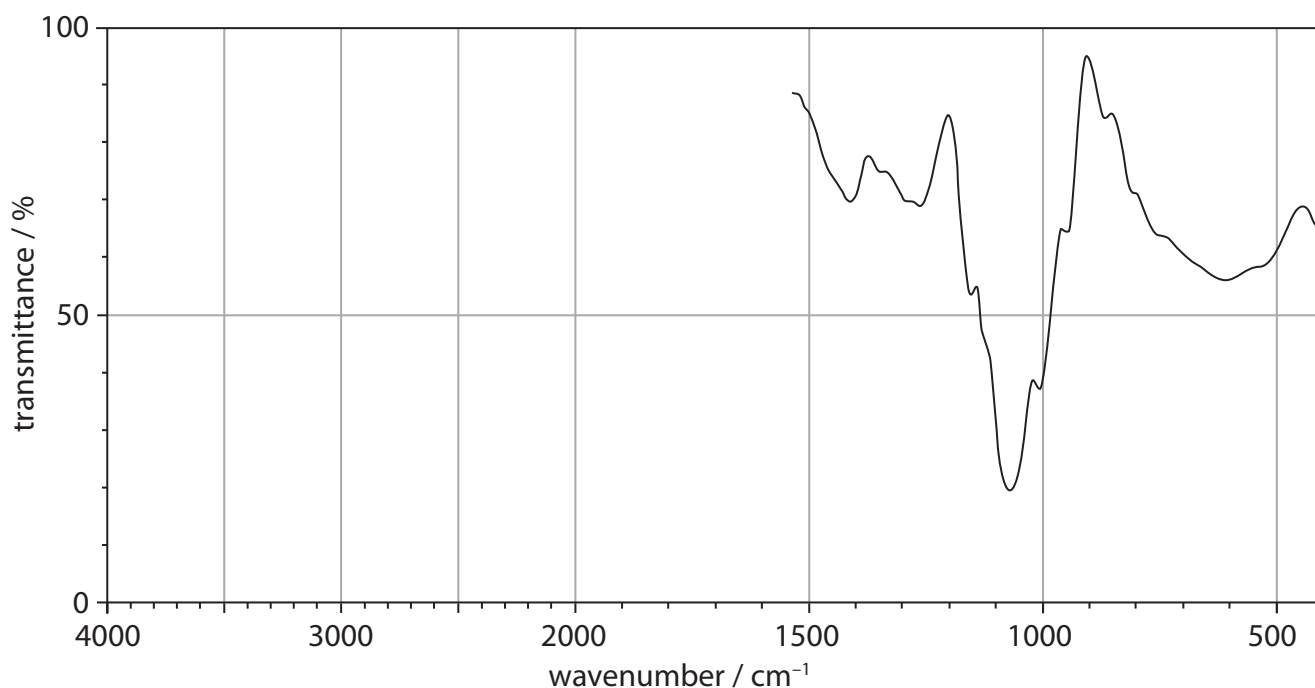
Draw, on the spectrum below, any peak(s) that you would expect to see between 4000 and 1500 cm^{-1} if the product was an aldehyde and **not** a carboxylic acid.

(2)

DATA

The IR absorption ranges associated with some organic functional groups are given below:

O—H stretching in alcohols (variable, broad) at	$3750 - 3200\text{ cm}^{-1}$
O—H stretching in carboxylic acids (weak) at	$3300 - 2500\text{ cm}^{-1}$
C=O stretching in aldehydes (strong) at	$1740 - 1720\text{ cm}^{-1}$
C=O stretching in ketones (strong) at	$1700 - 1680\text{ cm}^{-1}$
C=O stretching in carboxylic acids, alkyl (strong) at	$1725 - 1700\text{ cm}^{-1}$
C—H stretching in aldehydes (weak) at	$2900 - 2820\text{ cm}^{-1}$
and (weak) at	$2775 - 2700\text{ cm}^{-1}$



- (ii) The infrared spectrum of the distillate from the reaction in (e)(i) included a peak at $3750\text{--}3200\text{ cm}^{-1}$.

What substance is likely to have caused this?

(1)



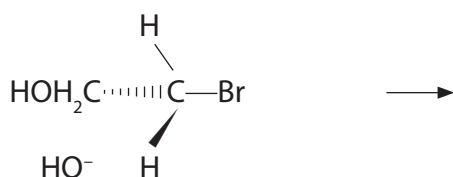
- (iii) Mass spectrometry can be used to identify the products of the oxidation of ethanol. Suggest the formula of a fragment that would show when **ethanoic acid** is produced and would not be present in either ethanol or ethanal.

(1)

- (f) Treatment of 2-bromoethanol, $\text{CH}_2\text{BrCH}_2\text{OH}$, with aqueous sodium hydroxide would be one way to produce ethane-1,2-diol.

- (i) Complete a possible mechanism for this reaction in the space below.

(3)



- (ii) Classify the mechanism and type of reaction in (f)(i):

(2)

Mechanism.....

Type.....

- (g) Aqueous silver nitrate can be used to test for the presence of bromide ions. Write an ionic equation for the reaction. Include **state symbols** in your answer.

(2)

Ionic Equation

- *(h) It can be difficult to distinguish between the colours of the silver halides. The use of solutions of ammonia can be very helpful.

A silver halide dissolved in concentrated ammonia to form a colourless solution.

Explain why this result does not prove conclusively that the silver halide was silver bromide and give a further test to confirm that the silver halide is silver bromide.

(2)

(Total for Question 22 = 19 marks)

TOTAL FOR SECTION B = 37 MARKS



SECTION C

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

- 23** Nanorockets have generated a lot of excitement due to their potential uses in the medicinal field, such as in the delivery of drugs around the body.

Some bacteria have the ability to move at speeds of 100 times their body length per second. Scientists in one study made nanorockets that reached speeds of up to 200 times their length per second. These scientists made their rockets on a nano scale (10^{-9}) from nanotubes with platinum coated on the inside as a catalyst. The fuel used to power these tiny rockets was hydrogen peroxide, H_2O_2 , which forms water and oxygen gas when undergoing decomposition.

Other forms of nanotechnology are already being used. For example, some sun creams use nanoparticles of titanium(IV) oxide which form an invisible protective layer against UV radiation.

- (a) Write an equation for the catalytic decomposition of hydrogen peroxide.
State symbols are **not** required.

(1)

- (b) Draw a dot and cross diagram to show the electronic configuration of the oxygen gas produced in the breakdown of the hydrogen peroxide (only outer electrons should be shown).

(1)

- (c) Suggest a dot and cross diagram for the hydrogen peroxide molecule in which each oxygen atom is covalently bonded to one hydrogen atom (only outer electrons should be shown).

(2)



*(d) The bond angles in hydrogen peroxide are similar to those in a water molecule. Suggest a bond angle for hydrogen peroxide and reasons for your value.

(3)

Bond Angle.....

Reasons.....

.....

.....

.....

(e) In the future, the aim is to develop a nanorocket that can use a fuel such as glucose rather than hydrogen peroxide. Suggest an advantage of using glucose and a disadvantage of using hydrogen peroxide.

(2)

Glucose advantage.....

.....

Hydrogen peroxide disadvantage.....

.....

(f) The boiling temperature of hydrogen peroxide is relatively high, about 150 °C, for such a small molecule. Explain fully why this is the case.

(2)

.....

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.....

.....



*(g) It is suggested that hydrogen peroxide is a polar liquid.

Describe how you might carry out an experiment to test whether a liquid is polar.

(3)

*(h) The speed of the nanorockets is controlled by the rate of decomposition of hydrogen peroxide. The speed at the body temperature of 37°C is faster than under normal laboratory conditions. Draw Maxwell-Boltzmann distribution curves on the axes below. Label your diagram and use it to explain why the increase in the speed of the rockets occurred.

(4)





- (i) The scientists used platinum in their nanorockets. Explain the catalytic role of the platinum in the reaction.

(2)

- (j) Nanotubes can be made from carbon. These carbon nanotubes can be good electrical conductors in a similar way to graphite.

Explain why they are able to conduct electricity.

(2)

- (k) Some scientists are concerned that the use of nanoparticles in cosmetic products, such as sun cream, could pose a health hazard. Suggest why this might be the case.

(1)

(Total for Question 23 = 23 marks)

TOTAL FOR SECTION C = 23 MARKS
TOTAL FOR PAPER = 80 MARKS



The Periodic Table of Elements

1	2	3	4	5	6	7	0 (8)
							(18)
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	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	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	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	[227] Rg roentgenium 111	[271] Ds darmstadtium 110	[268] Mt meitnerium 109	[277] Hs hassium 108	[264] Bh bohrium 107
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[277] Hs hassium 108	[264] Bh bohrium 107
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	175 Lu lutetium 71	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	257 Lr lawrencium 103	257 Lr lawrencium 103

* Lanthanide series

* Actinide series

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

P 4 2 9 8 3 A 0 2 0 2 0

Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH02/01R
Application of Core Principles of
Chemistry

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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	B		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	D		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	A		1

Question Number	Correct Answer	Reject	Mark
9	B		1

Question Number	Correct Answer	Reject	Mark
10	C		1

Question Number	Correct Answer	Reject	Mark
11	D		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		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	C		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	A		1

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a) (i)	In (a) any units given must be correct. Penalise once only IGNORE SF except 1SF. Penalise once only If rounding is done then must be correct, penalise once only TE throughout $n = (0.100 \times 0.0141) = 1.41 \times 10^{-3} / 0.00141 \text{ (mol)}$	1×10^{-3}	1

Question Number	Acceptable Answers	Reject	Mark
21 (a) (ii)	$7.05 \times 10^{-4} / 0.000705 \text{ (mol)}$ ALLOW TE = ans to (i) $\div 2$ 1.4×10^{-3} gives 7.0×10^{-4} 0.0014 gives 0.00070	$7.10 \times 10^{-4} / 0.000710$	1

Question Number	Acceptable Answers	Reject	Mark
21 (a) (iii)	$c = (7.05 \times 10^{-4} \div 0.05)$ $= 1.41 \times 10^{-2} / 0.0141 \text{ (mol dm}^{-3}\text{)}$ ALLOW TE = ans to (ii) $\div 0.05$ OR ALLOW TE = ans to (ii) $\times 20$		1

Question Number	Acceptable Answers	Reject	Mark
21 (a) (iv)	$\text{Ca(OH)}_2 \text{ M}_r = 74.1$ (1) ALLOW 74 $m = (1.41 \times 10^{-2} \times 74.1) = 1.04481$ $= 1.045 = 1.04 \text{ (g dm}^{-3}\text{)}$ (1) If $\text{M}_r = 74$ then $m = 1.0434 = 1.04 \text{ (g dm}^{-3}\text{)}$ ALLOW TE = ans to (iii) $\times 74.1$ ALLOW TE for second mark if ans to (iii) $\times$ incorrect M_r value OR $7.05 \times 10^{-4} \times 74.1 = 0.0522405 = 0.0522$ (g) (1) $(0.0522 \div 0.05) = 1.044 \text{ (g dm}^{-3}\text{)}$ (1)	1.05	2

Question Number	Acceptable Answers	Reject	Mark
21 (a) (v)	It's only a rangefinder / It's a rough OR approximate titration / It's an estimation / More than 0.2 cm^3 from other titres / Overshot on first titration / Not concordant ALLOW It is anomalous / It is out of range It differs / is not consistent with titrations 1 and 2 Titrations 1 and 2 are more consistent If a list of suggestions is given, a wrong cancels a right	Not titrated accurately It is not precise Control Just 'it's a trial'	1

Question Number	Acceptable Answers	Reject	Mark
21 (a) (vi)	Pipette 50.0 cm³ (of distilled water) into weighed beaker and find the mass ALLOW “fill the pipette” (with water) and transfer into weighed beaker and find the mass / measure the mass of the pipetted distilled water (1) ALLOW alternative containers to beaker. Use the density of water to determine the exact volume / density of water is 1(.00)g cm⁻³ /check it weighs 50(.0) g (1) Stand-alone marks	“Transfer 50cm³ water into a beaker” without reference to pipette. Approx. 50g Use of lime water Use of solution	2

Question Number	Acceptable Answers	Reject	Mark
21 (b)	A – (Strong) heat / high temperature (1) B – CaCl₂ + H₂O (Both needed) (1) C – Ca(OH)₂ (1) D – Ca (1) IGNORE state symbols even if wrong IGNORE any number in front of species, e.g. ½O₂ or 2Ca given in D	Warm / Gentle heat Reflux Combustion / burnt Answers suggesting reaction with air or oxygen CaCl CaOH Ca₂	4

Question Number	Acceptable Answers	Reject	Mark
21 (c)	Bubble(s) / Fizz(ing) / Effervescence IGNORE references to colourless solution, solid disappearing and energy / temperature changes and further tests eg effect on limewater	Coloured or colourless fumes Cloudy solution Just 'CO₂ forming' Just '(colourless) gas forming' Bubbles of any gas except CO₂	1

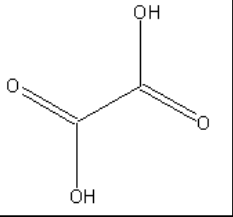
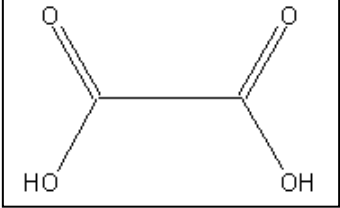
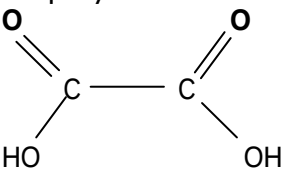
Question Number	Acceptable Answers	Reject	Mark
21 (d)	Method 1: Calcium is larger ion / calcium has a bigger ionic radius / or reverse argument for magnesium ion Use of the reverse argument applies throughout (1) (Distance between centres of ions increases so) weaker attraction/weaker bond between (calcium and carbonate) ions OR Shielding is greater in the calcium ion so weaker attraction (of calcium nucleus for carbonate ion) (1) Method 2: Calcium ion has a lower charge density (1) weaker attraction (between ions) (1) IGNORE references to polarization and the breaking of the covalent bonds in the carbonate ion	Calcium is bigger Any reference to atoms/molecules scores 0 Reference to ionization energy/weaker attraction for own electrons	2

Question Number	Acceptable Answers	Reject	Mark
21 (e)	Calcium's flame is yellow-red /orange-red / red / brick red Magnesium has no colour (Both needed for first mark) (1) Electrons excited / promoted (by heat energy) (1) (Colour produced from) energy / light emitted as electron returns (to ground state) (1)	Crimson Magnesium is white / bright Just "Mg / Ca decomposes" Electrons escape the orbitals	3

Total for Question 21 = 18 Marks

Question Number	Acceptable Answers	Reject	Mark
22 (a)	$2\text{Na} + \text{CH}_2\text{OHCH}_2\text{OH} \rightarrow \text{CH}_2\text{O}^{(-)}\text{Na}^{(+)}\text{CH}_2\text{O}^{(-)}\text{Na}^{(+)} + \text{H}_2$ This equation scores (2) marks Accept multiples and $(\text{CH}_2\text{OH})_2$ and $(\text{CH}_2\text{O}^{(-)}\text{Na}^{(+)})_2$ Organic product (Charges not needed) (1) Balancing and the rest (1) ALLOW for one mark: $\text{Na} + \text{CH}_2\text{OHCH}_2\text{OH} \rightarrow \text{CH}_2\text{OHCH}_2\text{O}^{(-)}\text{Na}^{(+)} + \frac{1}{2}\text{H}_2$ Accept multiples	$2 \text{CH}_2\text{O}^{(-)}\text{Na}^{(+)}$ $\text{CH}_2\text{Na}^{(+)}\text{O}^{(-)}\text{CH}_2\text{Na}^{(+)}\text{O}^{(-)}$ Reject bond from C to Na	2

Question Number	Acceptable Answers	Reject	Mark
22 (b)	Remove thermometer / still-head / leave the top of condenser open (1) Place condenser directly on top of flask/in vertical position (1) ALLOW correct diagram for 2 marks IGNORE comments on use of electric heaters, changing concentration of reagents	Sealed apparatus, e.g. with thermometer in the top	2

Question Number	Acceptable Answers	Reject	Mark
22 (c)	 OR  ALLOW the OH bond to be displayed ALLOW displayed formula as 'working out' ALLOW any orientation IGNORE bonds of different lengths or incorrect bond angles	Displayed formula  Just 'Structural formula' Bond from carbon clearly to the H of the OH	1

Question Number	Acceptable Answers	Reject	Mark
22 (d)	Both have OH / hydroxyl groups OR Both would produce steamy / misty / white and fumes /gas (of HCl)	Hydroxide ions White smoke Just 'both produce HCl' Both give the same products'	1

Question Number	Acceptable Answers	Reject	Mark
22 (e)(i)	(Strong) Peak at 1750-1700 (cm^{-1}) (1) Peak(s) (either or both) at 2900-2700(cm^{-1}) (1) ALLOW these if merged	peak at 3300-2500 (cm^{-1}) peak at 3750-3200 (cm^{-1})	2

Question Number	Acceptable Answers	Reject	Mark
22 (e)(ii)	(Unreacted) ethanol $\text{C}_2\text{H}_5\text{OH}$ /displayed /skeletal IGNORE references to O-H bonding	Molecular formula Just "O-H in alcohol" Ethane-1,2-diol	1

Question Number	Acceptable Answers	Reject	Mark
22 (e) (iii)	COOH^+ ALLOW CO_2H^+ ALLOW CH_3COO^+ ALLOW CH_2COOH^+ ALLOW the + sign wherever it is seen Also allow correct displayed, semi-displayed or structural formulae	COOH^- or any other formula with – charge $\text{CH}_3\text{CO}_2\text{H}^+$ CH_3COOH^+ $\text{C}_2\text{H}_3\text{O}_2^+$	1

Question Number	Acceptable Answers	Reject	Mark
22 (f) (i)	One mark for curly arrow from hydroxide ion; (This arrow can be drawn from anywhere on the hydroxide ion) (1) One mark for curly arrow from C-Br bond (1) Correct products; (1) If SN1 is shown, then intermediate with positive charge must be shown after loss of Br, followed by attack by hydroxide. This mechanism can score all 3 marks	Carbon with δ^- Bond to H of OH	3

Question Number	Acceptable Answers	Reject	Mark
22 (f) (ii)	Mechanism: Nucleophilic (1) Type: Substitution (1) ALLOW either way round Just S_N scores (1) ALLOW nucleophile and phonetic spelling IGNORE Heterolytic fission	Elimination S_N with elimination or other type of reaction Homolytic fission	2

Question Number	Acceptable Answers	Reject	Mark
22 (g)	$\text{Ag}^+(\text{aq}) + \text{Br}^-(\text{aq}) \longrightarrow \text{AgBr}(\text{s})$ Species (1) State symbols (1) ALLOW one mark for chemical equation with state symbols rather than ionic equation, e.g. $\text{AgNO}_3(\text{aq}) + \text{NaBr}(\text{aq}) \longrightarrow \text{AgBr}(\text{s}) + \text{NaNO}_3(\text{aq})$	Spectator ions included	2

Question Number	Acceptable Answers	Reject	Mark
22 (h)	Both silver chloride and silver bromide dissolve /give colourless solution in conc. ammonia (1) If the solid doesn't dissolve in dilute ammonia then it is silver bromide OR Add conc. sulfuric acid to the (solid) silver bromide and get red-orange bromine gas (1)	Alternative tests which don't work eg displacement of bromine, use of organic solvent, leave in sunlight to see if bromine forms, add conc. sulfuric acid to halide solution.	2

Total for Question 22 = 19 Marks

Total for Section B = 37 Marks

Section C

Question Number	Acceptable Answers	Reject	Mark
23 (a)	$\text{H}_2\text{O}_2 \longrightarrow \text{H}_2\text{O} + \frac{1}{2}\text{O}_2$ IGNORE state symbols even if wrong ALLOW multiples		1

Question Number	Acceptable Answers	Reject	Mark
23 (b)	Correct shared pairs of electrons between the two oxygens and two lone pairs of electrons on each of the oxygens ALLOW either all dots or all crosses IGNORE any 'circles' given If inner electrons given then must be correct		1

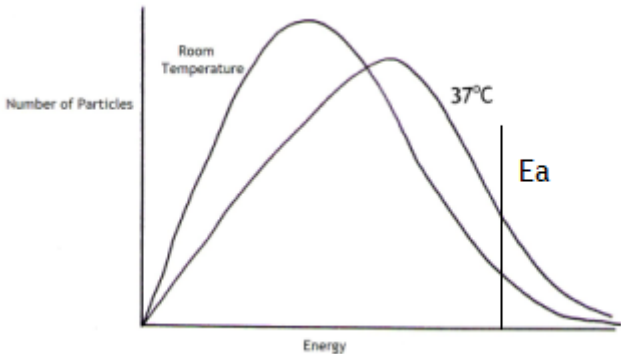
Question Number	Acceptable Answers	Reject	Mark
23 (c)	One shared electron pair between each hydrogen and an oxygen (1) Rest of molecule correct (1) (IGNORE positions of hydrogen around molecule) Second mark consequential on first ALLOW either all dots or all crosses, even triangles IGNORE any 'circles' given	Both hydrogens bonded to the same oxygen (0)	2

Question Number	Acceptable Answers	Reject	Mark
23 (d)	Bond Angle = 104.5° – 95.0° (1) ALLOW 105° Electron pairs repel to the maximum extent / minimal repulsion (1) Lone pairs repel more than bonded pairs (1) Stand-alone marks	Atoms repel	3

Question Number	Acceptable Answers	Reject	Mark
23 (e)	Glucose is a renewable / sustainable resource OR Glucose is readily available (in the body or from plants) (1) H_2O_2 is toxic/produces free radicals / more dangerous/poisonous (than glucose) / corrosive / introduces gas bubbles / (powerful) oxidizing agent (1)	Just 'safe' Just 'cheaper' Just 'harmful' Produces water which is a greenhouse gas	2

Question Number	Acceptable Answers	Reject	Mark
23 (f)	H_2O_2 has hydrogen bonds (1) IGNORE any references to London forces and dipole-dipole interactions provided hydrogen bonds have the major effect Extra energy / More energy (than expected to break) (1) IGNORE the number of hydrogen bonds quoted for each molecule or between each Second mark consequential on first mark	Hydrogen bonds within the molecule High energy	2

Question Number	Acceptable Answers	Reject	Mark
23 (g)	Method 1 Stream of H₂O₂ liquid (1) (Idea of) charging a comb / rod /balloon / other suitable (1) Put near 'stream' and stream is diverted /attracted /deflected if polar (1) ALLOW marks for suitable diagram Method 2 Add to a non-polar solvent (1) Named non-polar solvent (1) (formation / observation of) two layers (1) OR Add to a polar solvent (1) Named polar solvent (1) Dissolves / no layers / miscible (1) IGNORE references to IR	Stream of H₂O Use of metal rod Movement away from 'charged instrument'	3

Question Number	Acceptable Answers	Reject	Mark
23 (h)	Three marks for the diagram: One mark for a correct Maxwell-Boltzmann diagram with labelled axes and any one curve Allow fraction /proportion / percentage of particles / molecules on y axis (1) One mark for the peak at 37°C to be lower and clearly to the right of the peak for lab temperature; (1) E_a / A_e / Activation energy shown in suitable place (right of both peaks) (1)  Explanation: A greater proportion of /more particles / nanorockets have or exceed E_a / have sufficient energy to react (1)	Atoms Curve not starting from the origin Curve touching the x axis Curve going up or making a plateau over ½ way up on the right hand side	4

Question Number	Acceptable Answers	Reject	Mark
23 (i)	Lowers activation energy (1) (by) providing alternative reaction pathway (1) ALLOW 'catalytic pathway' OR ALTERNATIVE ANSWER Adsorbed onto the (catalytic) surface (1) Weakened bonds / desorbed from surface (1)		2

Question Number	Acceptable Answers	Reject	Mark
23 (j)	Delocalised electrons/ Sea of electrons (1) (Electrons) can move (and carry charge) (1)	Just 'free electrons' Just 'carry charge'	2

Question Number	Acceptable Answers	Reject	Mark
23 (k)	In the long term OR Due to absorption And they could be dangerous / toxic / carcinogenic / have side-effects	Just 'skin reaction/allergy' without reference to long term effect Block pores Just 'harmful'	1

Total for Section C = 23 Marks

Total for paper = 80 Marks

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Write your name here	
Surname	Other names
Centre Number	Candidate Number
Edexcel GCE Chemistry Advanced Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry (including synoptic assessment)	
Wednesday 27 January 2010 – Morning Time: 1 hour 40 minutes	Paper Reference 6CH04/01
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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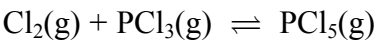


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SECTION A

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 Consider the equilibrium



Which of the following is true when the total pressure of the system is increased at constant temperature?

		Value of K_p	Mole fraction of $\text{PCl}_5(\text{g})$
☐	A	decreases	decreases
☐	B	unaltered	increases
☐	C	decreases	increases
☐	D	unaltered	unaltered

(Total for Question 1 = 1 mark)

2 In which of the following reactions is nitric acid acting as a base?

- ☐ A $\text{HNO}_3 + \text{NaOH} \rightarrow \text{NaNO}_3 + \text{H}_2\text{O}$
- ☐ B $\text{HNO}_3 + \text{H}_2\text{O} \rightarrow \text{H}_3\text{O}^+ + \text{NO}_3^-$
- ☐ C $\text{HNO}_3 + \text{H}_2\text{SO}_4 \rightarrow \text{H}_2\text{NO}_3^+ + \text{HSO}_4^-$
- ☐ D $\text{HNO}_3 + \text{NaHCO}_3 \rightarrow \text{NaNO}_3 + \text{H}_2\text{O} + \text{CO}_2$

(Total for Question 2 = 1 mark)

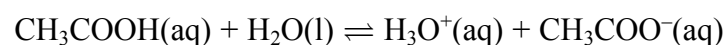
3 Why does phenolphthalein, which is colourless in acidic solutions, turn pink in alkaline solutions?

- ☐ A It is oxidized to a pink compound by hydroxide ions.
- ☐ B It forms a pink anion by loss of H^+ ions.
- ☐ C It forms a pink anion by gain of H^+ ions.
- ☐ D It forms a pink cation by gain of H^+ ions.

(Total for Question 3 = 1 mark)



4 The dissociation of ethanoic acid in aqueous solution is represented by



Which of the following statements is true for this equilibrium?

- ☐ A CH_3COOH is an acid and its conjugate base is CH_3COO^- .
- ☐ B H_2O is an acid and its conjugate base is OH^- .
- ☐ C At equilibrium, the concentrations of each substance are the same.
- ☐ D At equilibrium, the reaction from left to right and the reaction from right to left have stopped.

(Total for Question 4 = 1 mark)

5 Why are aqueous solutions of sodium ethanoate slightly alkaline?

- ☐ A The sodium ions react with water to give an alkali.
- ☐ B The ethanoate ions react with water to give hydroxide ions.
- ☐ C All sodium salts give alkaline solutions.
- ☐ D The sodium ethanoate is fully ionized in solution.

(Total for Question 5 = 1 mark)

6 When ammonium nitrate crystals dissolve in water, the entropy of the system

- ☐ A remains the same.
- ☐ B falls, because the hydrated ions are more ordered than the solid.
- ☐ C rises, because the ions in the crystal become hydrated in the solution.
- ☐ D rises, because the ions are arranged more randomly in the solution than in the crystal.

(Total for Question 6 = 1 mark)

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



N 3 6 2 8 9 A 0 3 2 8

7 Which of the following molecules is a methyl ester?

- ☐ A $\text{CH}_3\text{COOCH}_2\text{CH}_3$
- ☐ B HCOOCH_3
- ☐ C $\text{CH}_3\text{COCH}_2\text{CH}_3$
- ☐ D CH_3COCl

(Total for Question 7 = 1 mark)

8 During the preparation of a liquid compound, samples were taken of the product at various stages in the purification procedure. Which of the following techniques would be most suitable for showing the change in composition of these samples during the purification procedure?

- ☐ A Gas-liquid chromatography
- ☐ B Fractional distillation
- ☐ C Filtration
- ☐ D Distillation

(Total for Question 8 = 1 mark)

9 Which of the following compounds would react with lithium tetrahydridoaluminate (lithium aluminium hydride) **and** also with phosphorus(V) chloride (phosphorus pentachloride)?

- ☐ A $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$
- ☐ B $\text{CH}_3\text{CH}_2\text{COCH}_3$
- ☐ C $\text{CH}_3\text{CH}=\text{CHCH}_3$
- ☐ D $\text{CH}_2=\text{CHCH}_2\text{CH}_2\text{OH}$

(Total for Question 9 = 1 mark)

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



10 In the synthesis of an ester, the use of an acyl chloride and an alcohol gives a better yield than the use of a carboxylic acid and an alcohol.

This is because the reaction between

- ☐ A an acyl chloride and an alcohol is an equilibrium.
- ☐ B an acid and an alcohol goes to completion.
- ☐ C an acid and an alcohol requires a catalyst.
- ☐ D an acyl chloride and an alcohol goes to completion.

(Total for Question 10 = 1 mark)

11 Not all molecules will absorb infrared radiation. Those that do

- ☐ A change their dipole moment when their bonds stretch or bend.
- ☐ B undergo homolytic fission.
- ☐ C must be polar.
- ☐ D are always organic substances.

(Total for Question 11 = 1 mark)

12 Which of the following methods may be used **in a single step** to make carboxylic acids?

- ☐ A Hydrolysis of an ester with an alkali.
- ☐ B Reaction of acidified potassium manganate(VII) with an alkene.
- ☐ C Hydrolysis of a nitrile with hydrochloric acid.
- ☐ D Reaction of an acyl chloride with ammonia.

(Total for Question 12 = 1 mark)

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



N 3 6 2 8 9 A 0 5 2 8

13 A solution of a weak acid cannot be titrated with a weak base using an indicator to find the end-point because

- ☐ **A** the pH change is too gradual close to the equivalence point.
- ☐ **B** there are too few H^+ ions to affect the indicator.
- ☐ **C** there are too few OH^- ions to affect the indicator.
- ☐ **D** the pH change occurs outside the range of any indicator.

(Total for Question 13 = 1 mark)

14 Which of the following reagents could be used to produce propanamide, $\text{CH}_3\text{CH}_2\text{CONH}_2$?

- ☐ **A** Ammonia and 1-chloropropane
- ☐ **B** Ammonia and propanoyl chloride
- ☐ **C** Methylamine and 1-chloropropane
- ☐ **D** Methylamine and propanoyl chloride

(Total for Question 14 = 1 mark)

15 The radio waves used in proton nmr

- ☐ **A** must not be absorbed by the sample.
- ☐ **B** cause electron transitions in the hydrogen atom.
- ☐ **C** can only be used with organic substances.
- ☐ **D** cause the hydrogen nucleus to change its spin state.

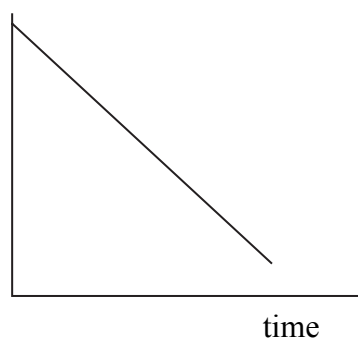
(Total for Question 15 = 1 mark)

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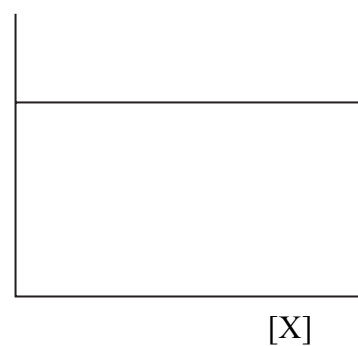


16 Which of the following graphs shows that a reaction is first order with respect to reactant **X**?

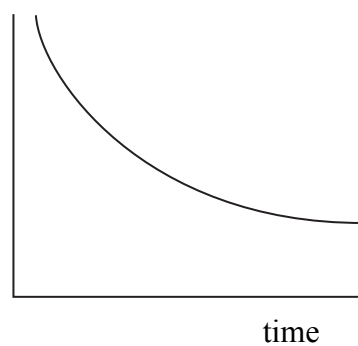
☐ **A** [X]



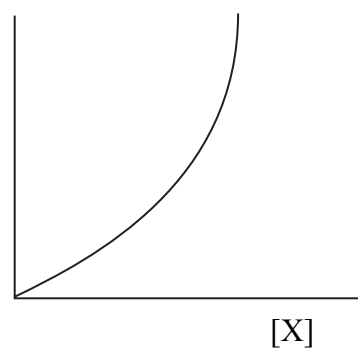
☐ **B** rate



☐ **C** [X]



☐ **D** rate

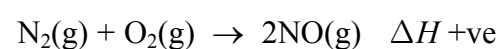


(Total for Question 16 = 1 mark)



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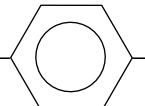
17 Which of the following changes will lead to the greatest increase in the **rate** of the following endothermic reaction?

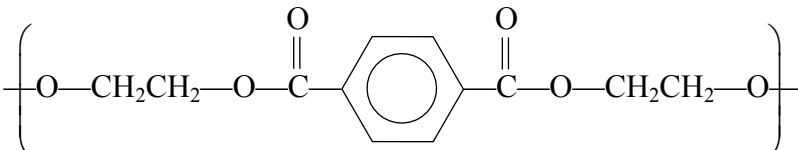
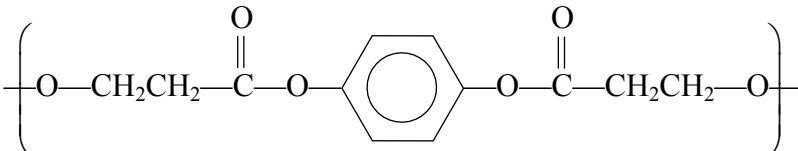
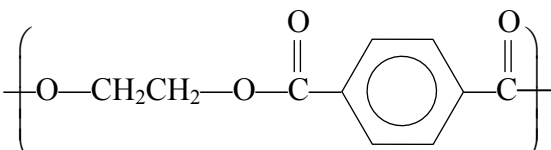
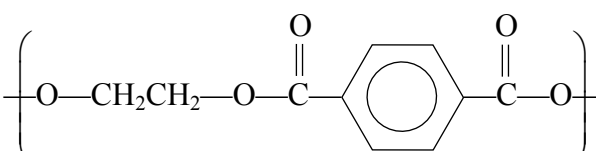


		Temperature	Initial concentration of N ₂ and O ₂
☐	A	decrease by 15%	decrease by 15%
☐	B	increase by 15%	stay the same
☐	C	decrease by 15%	increase by 15%
☐	D	increase by 15%	increase by 15%

(Total for Question 17 = 1 mark)

18 The repeat unit of the polyester formed from ethane-1,2-diol, HOCH₂CH₂OH, and

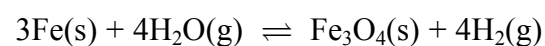
benzene-1,4-dicarboxylic acid, HOOC--COOH, is

- ☐ A 
- ☐ B 
- ☐ C 
- ☐ D 

(Total for Question 18 = 1 mark)



- 19 Iron and steam at high temperature react in a closed vessel to give an equilibrium mixture



Which of the following is the correct expression for K_p ?

- ☐ A $K_p = \frac{P_{\text{H}_2}}{P_{\text{H}_2\text{O}}}$
- ☐ B $K_p = \frac{P_{\text{Fe}_3\text{O}_4} P_{\text{H}_2}^4}{P_{\text{Fe}}^3 P_{\text{H}_2\text{O}}^4}$
- ☐ C $K_p = \frac{P_{\text{H}_2}^4}{P_{\text{H}_2\text{O}}^4}$
- ☐ D $K_p = P_{\text{H}_2}^4$

(Total for Question 19 = 1 mark)

- 20 At 100 °C, pure water has a pH of 6, whereas at 25 °C it has a pH of 7. This is because

- ☐ A the dissociation of water is endothermic, so the concentration of hydrogen ions is lower at 100 °C than it is at 25 °C.
- ☐ B the dissociation of water is exothermic, so the concentration of hydrogen ions is lower at 100 °C than it is at 25 °C.
- ☐ C the dissociation of water is endothermic, so the concentration of hydrogen ions is higher at 100 °C than it is at 25 °C.
- ☐ D at 100 °C, water has a higher concentration of hydrogen ions than of hydroxide ions.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



N 3 6 2 8 9 A 0 9 2 8

SECTION B

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

21 (a) (i) Define pH.

(1)

(ii) Calculate the pH of $0.0100 \text{ mol dm}^{-3}$ hydrochloric acid, which is a strong acid.

(1)

(b) Ethanoic acid is a weak acid with an acid dissociation constant, K_a , of value $1.75 \times 10^{-5} \text{ mol dm}^{-3}$ at 25°C .

(i) Calculate the pH of $0.0100 \text{ mol dm}^{-3}$ ethanoic acid at 25°C , stating any ONE assumption that you have made.

(4)

Assumption

.....

.....



- (ii) The pH of hydrochloric and of ethanoic acid at two different concentrations is given in the table.

	pH of 0.00100 mol dm ⁻³ solution	pH of 0.000100 mol dm ⁻³ solution
Hydrochloric acid	3.0	4.0
Ethanoic acid	3.9	4.4

In the case of hydrochloric acid, dilution by a factor of 10 increases the pH by one unit. Suggest why ethanoic acid behaves differently.

(2)

- (c) Orange marmalade usually contains sodium citrate as a preservative. Together with the fruit in the marmalade, it forms a buffer solution which, at a suitable pH, inhibits mould growth.

- (i) Define the term **buffer solution**.

(2)

- (ii) What is the substance in the fruit that produces a buffer with sodium citrate?

(1)



(iii) Explain how a buffer solution works using this system or any other of your choice. Support your explanation with equations.

(4)

(Total for Question 21 = 15 marks)



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22 *(a) Ethanol can be oxidized successively to ethanal and to ethanoic acid.

The boiling temperatures of these substances are:
ethanol 78 °C, ethanal 21 °C, ethanoic acid 118 °C.

Explain in terms of the intermolecular forces in the liquids why the order of the boiling temperature is

ethanal < ethanol < ethanoic acid

(3)

(b) State what tests you would perform in each case, and the result you would expect, to show that

(i) ethanal contains a carbonyl group.

(2)

(ii) ethanal is an aldehyde.

(2)



(c) Ethanal reacts with HCN, in the presence of a catalyst of cyanide ions from KCN, to give a cyanohydrin, $\text{CH}_3\text{CH}(\text{OH})\text{CN}$.

(i) Give the mechanism for this reaction.

(3)

(ii) Explain why it is necessary to use HCN and KCN in this reaction, rather than HCN on its own.

(1)

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*(iii) Explain why the product mixture from this reaction is **not** optically active.

(2)

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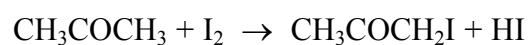
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(Total for Question 22 = 13 marks)



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

23 Iodine and propanone react in the presence of an aqueous acid catalyst as follows



To determine the rate equation for the reaction, propanone is reacted with iodine in the presence of aqueous hydrochloric acid at constant temperature. Samples are withdrawn at known times, quenched with sodium hydrogencarbonate solution, and the iodine remaining titrated with a standard solution of sodium thiosulfate.

The rate equation for the reaction is

$$\text{rate} = k[\text{CH}_3\text{COCH}_3]^1 [\text{H}^+]^1 [\text{I}_2]^0$$

(a) The graph of $[\text{I}_2]$ against time is a straight line, showing that the order of reaction with respect to iodine is zero.

(i) Explain why the propanone and the hydrogen ions must be in large excess in this experiment in order to give this straight line.

(2)

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(ii) What further experiment could be done to show that the order of reaction with respect to propanone is one? State the effect of this change on the graph.

(2)

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(iii) Explain why the minimum number of steps in the mechanism for this reaction is two.

(2)

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(b) Sodium hydrogencarbonate stops the reaction by neutralizing the acid catalyst.

(i) Give the ionic equation for the reaction between sodium hydrogencarbonate and acid.

(1)

(ii) Sodium hydroxide cannot be used for neutralization because under very alkaline conditions a reaction occurs between propanone and iodine.

Write the equation for this reaction. State symbols are **not** required.

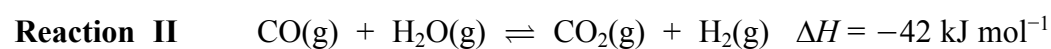
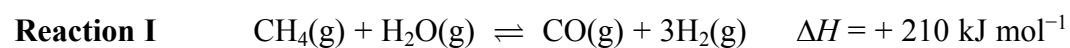
(3)

(Total for Question 23 = 10 marks)



N 3 6 2 8 9 A 0 1 7 2 8

24 Hydrogen is used in very large quantities as a fuel, as a reducing agent, and in the production of ammonia. Hydrogen is manufactured by steam reforming of methane from natural gas. Two reactions are involved, both being in equilibrium in closed systems.



(a) Write the expression for the equilibrium constant, K_p , for reaction I.

(1)

(b) Reaction I occurs at a temperature of 1000 K and a pressure of 30 atm over a nickel catalyst.

(i) State and explain the effect, if any, **on the value of K_p** of increasing the pressure on the reaction.

(1)

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(ii) Explain, in terms of your answers to (a) and (b)(i), why an increase in the pressure leads to a decrease in yield in reaction I.

(2)

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(iii) Increasing the pressure on this heterogeneously-catalysed reaction **I** has very little effect on the rate of the reaction. Suggest why this is so.

(2)

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(c) The expression for K_p for reaction **II** is

$$K_p = \frac{P_{\text{CO}_2} P_{\text{H}_2}}{P_{\text{CO}} P_{\text{H}_2\text{O}}}$$

At a particular temperature and 30 atm pressure, a mixture of equal amounts of carbon monoxide and steam react to give an equilibrium mixture where 75 % of the CO has reacted.

Calculate the value of K_p showing your working.

(3)



(d) Carbon dioxide and hydrogen are separated by washing the gas with potassium carbonate solution to give potassium hydrogencarbonate solution, leaving hydrogen in the gas stream. Potassium carbonate is expensive and is regenerated by heating the potassium hydrogencarbonate and liberating the carbon dioxide.

- (i) Hydrogen is often claimed to be a non-polluting fuel as it only produces water on burning.

Explain why its manufacture using reactions **I** and **II** does **not** support this claim.

(1)

- (ii) Write the equation for the thermal decomposition of potassium hydrogencarbonate.

State symbols are **not** required.

(1)

- (e) Although industrial processes are often discussed in terms of equilibria, they are rarely allowed to reach equilibrium.

Suggest why, apart from insufficient reaction time, this is so.

(1)

(Total for Question 24 = 12 marks)

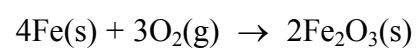
TOTAL FOR SECTION B = 50 MARKS



SECTION C

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

25 The oxidation of iron metal in the presence of oxygen is spontaneous.



(a) Explain the meaning of **spontaneous** in a thermodynamic context.

(1)

(b) (i) Find the values of the standard molar entropies of iron and of iron(III) oxide from your data booklet.

(1)

(ii) The standard molar entropy at 298 K for oxygen molecules O_2 is $+205 \text{ J mol}^{-1} \text{ K}^{-1}$.

Calculate the standard entropy change of the system for the reaction between iron and oxygen. Include a sign and units in your answer.

(2)

(iii) The standard enthalpy change for the reaction at 25°C is $-1648 \text{ kJ mol}^{-1}$.

Calculate $\Delta S_{\text{surroundings}}$.

(1)



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

(iv) Use your answers to (b)(ii) and (iii) to calculate the total standard entropy change for the reaction. Include a sign and units in your answer.

(2)

*(v) The reaction is thermodynamically spontaneous.

Use your answers to (b)(ii), (iii) and (iv) to explain, in terms of the physical states of the substances in the reaction and the movement of the molecules in the surroundings, why this is so.

(3)

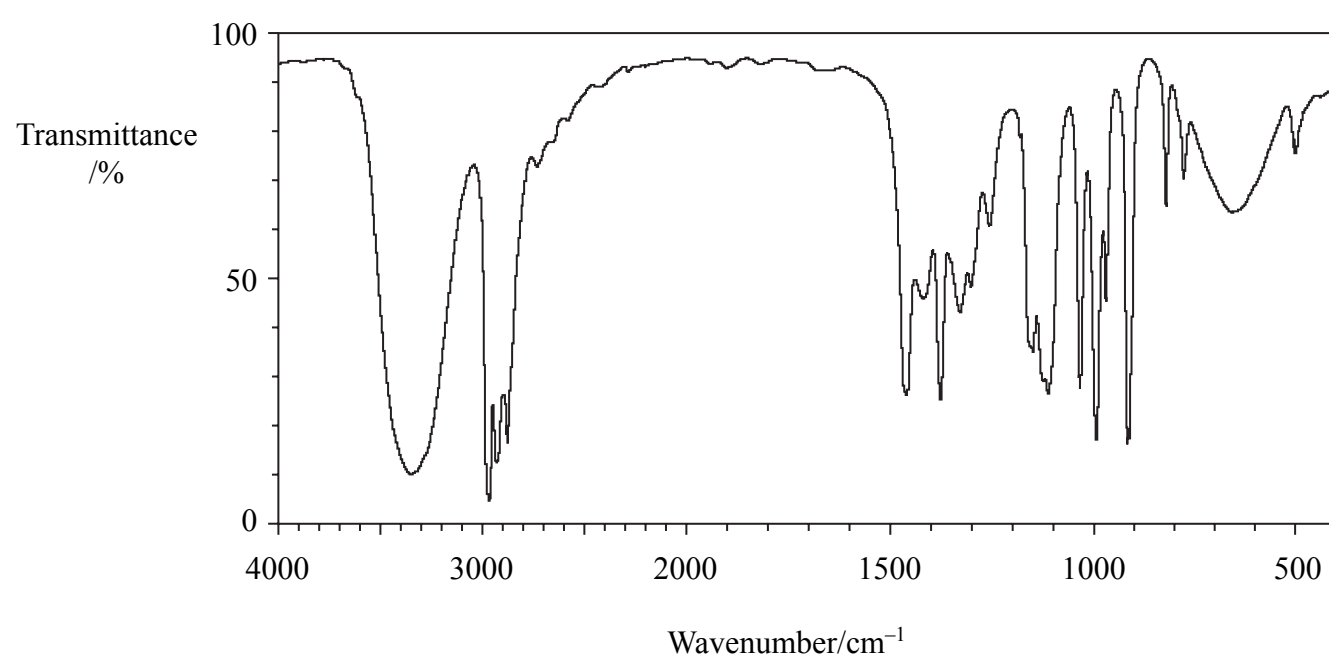
(Total for Question 25 = 10 marks)



26 This question is about compounds **X**, $\text{C}_4\text{H}_{10}\text{O}$, and **Y**, $\text{C}_4\text{H}_8\text{O}$.

- (a) Compound **X**, $\text{C}_4\text{H}_{10}\text{O}$, can be oxidized to compound **Y**, $\text{C}_4\text{H}_8\text{O}$. The infrared spectrum of **X** is given below.

Infrared Spectrum of X



What can be deduced about the structures of **X** and **Y** using all this information and the data booklet? Justify your answer.

(4)

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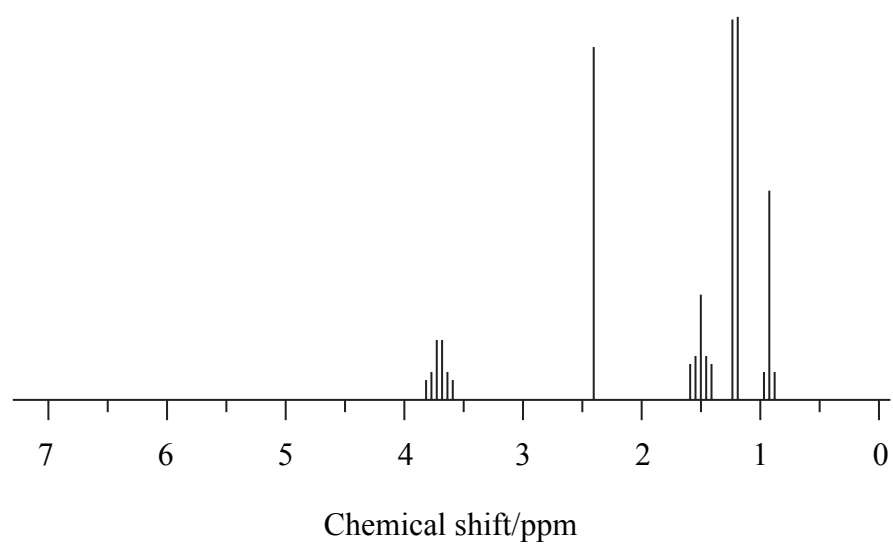
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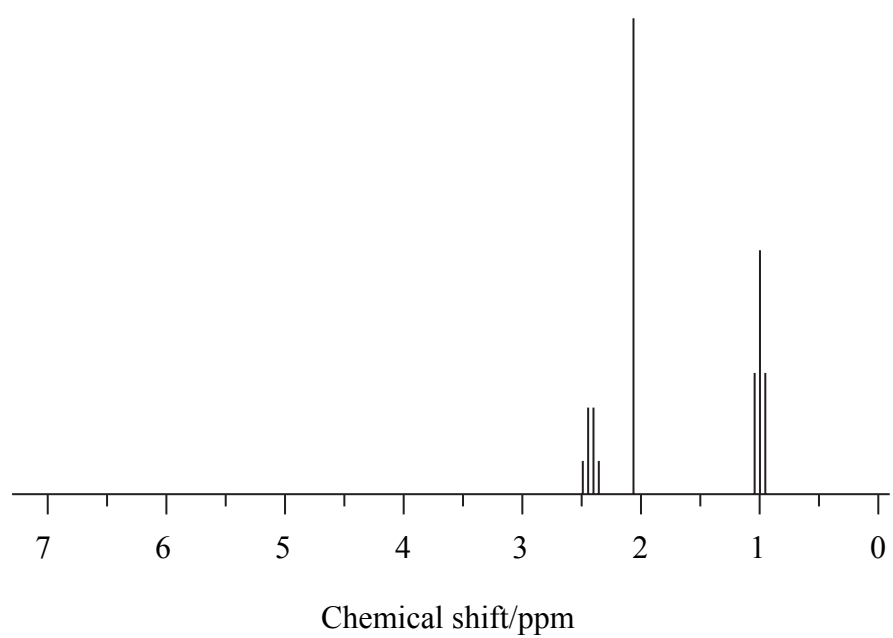


(b) Below are the nmr spectra of **X** and **Y**.

nmr spectrum of X



nmr spectrum of Y



*Use these nmr spectra and your answer to (a) to deduce the structural formulae of **X** and **Y**. Justify your answer and explain why **both** nmr spectra are consistent with these structures.

(6)

(Total for Question 26 = 10 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS



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

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1.0	H	hydrogen	1
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- * Lanthanide series
- * Actinide series

Mark Scheme (Results) January 2010

GCE

GCE Chemistry (6CH04/01)

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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.

Section A

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	B		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	D		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	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	B		1

Question Number	Correct Answer	Reject	Mark
15	D		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	C		1

Question Number	Correct Answer	Reject	Mark
19	C		1

Question Number	Correct Answer	Reject	Mark
20	C		1

Section B

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	$(\text{pH} =) -\log [\text{H}^+]$ OR $(\text{pH} =) -\log [\text{H}_3\text{O}^+]$ OR Accept Definition in words (For example: “It is minus / negative log(arithm) of the hydrogen ion concentration”) Base 10 does not have to be there, but reject “ln”	Just “concentration of hydrogen ions” { } curly brackets $-\log \text{H}^+$	1

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	$(\text{pH} = -\log 0.0100) = 2(.00)$	If any units given	1

Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	$[H_3O^+] = \frac{K_a[CH_3COOH]}{[CH_3COO^-]}$ OR $[H_3O^+]^2 = K_a[CH_3COOH] \quad (1)$ <i>ALLOW</i> [HA] for [CH₃COOH] and [A⁻] for [CH₃COO⁻] in rearranged expression Accept [H⁺] for [H₃O⁺] $\therefore [H_3O^+] = \sqrt{1.75 \times 10^{-7}}$ OR $\therefore [H_3O^+] = 4.18(3) \times 10^{-4} \text{ (mol dm}^{-3}\text{)} \quad (1)$ pH = 3.38 / 3.4 (1) ignore sf except one sf Third mark TE from [H⁺] only if pH less than 7 <i>N.B. CORRECT ANSWER, WITH OR WITHOUT WORKING, SCORES (3)</i> Assumption assumes that degree of ionisation of the acid is very small/negligible OR $[CH_3COOH]_{eqm} = [CH_3COOH]_{initial}$ OR $[H^+] = [CH_3COO^-]$ OR all of the hydrogen ions come from the acid / ignore hydrogen ions from the water (1) IGNORE any references to temperature	3.37 / 3 / 3.39 / a correct pH value with units just “weak acid” / just “partially dissociates” / acid does not dissociate / [CH₃COOH] constant $[H^+] = [OH^-]$ / $[H^+] = [\text{salt}]$	4

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)	First mark: (Dilution/addition of water) shifts the equilibrium $\text{CH}_3\text{COOH} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}^+ /$ $\text{CH}_3\text{COOH} + \text{H}_2\text{O} \rightleftharpoons \text{CH}_3\text{COO}^- + \text{H}_3\text{O}^+$ to the right OR the above stated in words such as: degree of dissociation increases/ proportion of dissociation increases/ more dissociation (as the ethanoic acid is diluted) (1) Second mark: so the $[\text{H}^+]$ is greater than expected/ so the decrease in $[\text{H}^+]$ is less than expected / so that the decrease in $[\text{H}^+]$ is less than that for hydrochloric acid (1) Each mark is a stand alone mark. <i>ALTERNATIVE ROUTE:</i> First mark: $[\text{H}^+] = \sqrt{K_a \times [\text{HA}]} \text{ OR } (K_a \times [\text{HA}])^{1/2}$ OR $\text{pH} = \frac{1}{2}\text{p}K_a - \frac{1}{2}\log[\text{HA}]$ (1) Second mark: use of mathematical expression given (e.g. $[\text{H}^+]$ affected by factor of $1/\sqrt{10}$ on dilution OR substitution of numerical values into the equation) (1) <i>IGNORE:</i> any comments or calculations relating to HCl(aq)	Reject just a reference to a 0.5 increase in pH for $\text{CH}_3\text{COOH}(\text{aq})$ compared with a 1.0 increase in pH for $\text{HCl}(\text{aq})$	2

Question Number	Acceptable Answers	Reject	Mark
21 (c)(i)	These marks are stand alone. Maintains an almost constant pH / resists change(s) in pH (1) for small addition of H^+ or OH^- ions (N.B. both ions needed) / for small additions of acid or alkali / for small additions of acid or base (1) <i>IGNORE</i> any references to named buffer mixtures	“resists small change(s) in pH” OR “pH does not change”	2

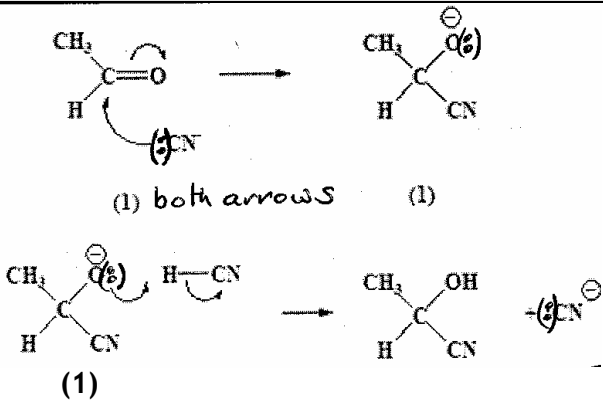
Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii)	citric acid		1

Question Number	Acceptable Answers	Reject	Mark
21 (c)(iii)	First mark: (buffer contains) reservoir of HA and A⁻ OR (buffer contains) large concentrations of [HA] and [A⁻] OR both equations: HA $\rightleftharpoons$ A⁻ + H⁺ and NaA $\rightarrow$ Na⁺ + A⁻ (1) Second mark: (Addition of alkali/base) HA + OH⁻ $\rightarrow$ A⁻ + H₂O OR description/equations to show that H⁺ reacts with OH⁻ (to form H₂O) and more acid dissociates (to replace H⁺) (1) Third mark: (Addition of acid) A⁻ + H⁺ $\rightarrow$ HA OR A⁻ reacting with H⁺ in any context described in words (e.g. by reference to weak acid equilibrium) (1) Fourth mark: the ratio of [A⁻]:[HA] hardly changes / the ratio of [HA]:[A⁻] hardly changes OR [A⁻] nor [HA] changes significantly (1)	<u>JUST</u> NaA $\rightleftharpoons$ Na⁺ + A⁻ and HA $\rightarrow$ H⁺ + A⁻ without correct description Just [H⁺] remains constant	4

Question Number	Acceptable Answers	Reject	Mark
22 (a) QWC	Each mark is a stand alone mark. First mark: hydrogen bonds in both ethanoic acid and ethanol OR no hydrogen bonds in ethanal (1) Second mark: hydrogen bonds are stronger than van der Waals' / dipole-dipole/London/dispersion/ induced dipole / permanent dipole /intermolecular forces (in ethanal) OR hydrogen bonds are the strongest/strong intermolecular forces (1) Third mark: ethanoic acid has more electrons/ethanoic acid has the most electrons OR ethanoic acid is dimeric OR ethanoic acid forms dimers OR description of ethanoic acid dimers (N.B. In the context of dimerisation, ignore statement that "ethanoic acid forms two hydrogen bonds per molecule") OR ethanoic acid is more polar because of having more oxygen atoms (1)	any reference to hydrogen bonding in ethanal just references to ethanol and ethanoic acid forming H bonds with water references to breaking covalent bonds Just "ethanoic acid has more hydrogen bonds than ethanol"	3

Question Number	Acceptable Answers	Reject	Mark
22 (b)(i)	(Test): 2,4-dinitrophenylhydrazine /Brady's reagent/2,4-dnp/ 2,4-DNP/2,4-DNPH (1) (Result):yellow precipitate /orange precipitate /red precipitate ALLOW: 'solid' or 'crystals' in lieu of precipitate (1) Result mark for result CQ on correct reagent (or a near miss reagent (e.g. 2,4-DHPN))	1,2-DNP etc/ hydrazine / /2,4-dinitrophenolhydrazine /2,4-dinitrophenylhydrazone	2

Question Number	Acceptable Answers	Reject	Mark
22 (b)(ii)	(Warm with) Fehling's (solution) / Benedict's (solution) (1) red precipitate/brown precipitate/brick-red precipitate (1) ALLOW "solid" ALLOW "red Cu₂O" ALLOW yellow/orange solid for Benedict's test <i>Penalise omission of "solid" once only in parts (b)(i) and (b)(ii)</i> OR (Warm with) Tollens' (reagent) (1) silver (mirror)/black(solid) (1) (N.B. here, solid not required) OR (Warm with) ammoniacal silver nitrate (solution) (1) silver (mirror)/ black / dark-grey (solid) (1) (N.B. here, solid not required) 2nd mark CQ on correct reagent or a near miss <i>Penalise omission of "solid" once only in (b)(i) and (b)(ii)</i>	acidified potassium dichromate(VI) / manganate(VII) (0) iodoform reaction (0) just "red due to Cu⁺" / "red solid due to Cu³⁺," (0)	2

Question Number	Acceptable Answers	Reject	Mark
22 (c)(i)	 (1) both arrows (1) (1) <i>IGNORE</i> any dipoles shown Check curly arrows are all double-headed in mechanism. (If all arrows are single-headed, can only score intermediate mark.) Accept: arrow to an H^+ instead of an H-CN for third mark. [It is not necessary to show the lone pairs.] <i>IGNORE</i> any equations which generate CN^- ions	 arrow from N in CN^-	3

Question Number	Acceptable Answers	Reject	Mark
22 (c)(ii)	With HCN alone, insufficient CN^- OR KCN provides (sufficient) CN^- OR KCN increases the concentration of CN^- <i>ALLOW</i> "nucleophile" instead of CN^- <i>IGNORE</i> any subsequent comments about the role of the CN^- ion	Just "HCN is a weak acid" OR HCN "is too weak a nucleophile"	1

Question Number	Acceptable Answers	Reject	Mark
22 (c)(iii) QWC	These are stand alone marks First mark: attack from both sides OR attack from above and below (1) Second mark: (gives) racemic mixture / (gives) equal amounts of each isomer / (gives) equal amounts of each enantiomer (1)	attack on a (planar) carbocation OR attack on a (planar) intermediate OR S_N1 OR S_N2 “planar product”	2

Question Number	Acceptable Answers	Reject	Mark
23 (a)(i)	These are stand alone marks First mark: (ensures that) $[H^+]$ and [propanone] (virtually) constant OR so that the $[H^+]$ and [propanone] do not affect the rate (1) Second mark: the $[I_2]$ / iodine concentration changes OR so that the overall order (of reaction) is not determined OR otherwise a curve (graph) is obtained (1) NOTE:- “only the $[I_2]$ changes scores (2) OR “only the I_2 concentration changes” scores (2) BUT “only the iodine changes” scores (1)		2

Question Number	Acceptable Answers	Reject	Mark
23 (a)(ii)	First mark: double the concentration of propanone OR change/increase/decrease the concentration of propanone (1) Second mark (mark consequentially): slope/gradient of line doubles ALLOW “rate doubles” OR slope or gradient changes/increases/decreases by same factor ALLOW “rate changes/increases/decreases by same factor” (1) NOTE: may suggest a different procedure:- First mark: monitor/measure [propanone] over time (1) Second mark (mark consequentially): plot [propanone] v. time graph and state that $t_{1/2}$ constant (1)		2

Question Number	Acceptable Answers	Reject	Mark
23 (a)(iii)	I₂ not involved in rate-determining step/ I₂ not involved in slow(est) step / H⁺ and propanone involved in rate-determining step/ H⁺ and propanone involved in slow(est)step (1) so there must be another step where I₂ is involved/ so there must be a fast step where I₂ is involved (1) BUT:- I₂ not involved until after the rate-determining step/ I₂ not involved until after the slow(est) step (2) ALLOW H⁺ involved in rate-determining step (1) and is regenerated as it is a catalyst (in another step) (1)	I₂ involved before rate-determining/slowest step (0)	2

Question Number	Acceptable Answers	Reject	Mark
23 (b)(i)	$\text{HCO}_3^- + \text{H}^+ \rightarrow \text{H}_2\text{O} + \text{CO}_2$ OR $\text{HCO}_3^- + \text{H}^+ \rightarrow \text{H}_2\text{CO}_3$ OR $\text{HCO}_3^- + \text{H}_3\text{O}^+ \rightarrow 2\text{H}_2\text{O} + \text{CO}_2$ OR $\text{HCO}_3^- + \text{H}_3\text{O}^+ \rightarrow \text{H}_2\text{CO}_3 + \text{H}_2\text{O}$ ALLOW: $\text{NaHCO}_3 + \text{H}^+ \rightarrow \text{Na}^+ + \text{H}_2\text{O} + \text{CO}_2$ OR $\text{Na}^+ + \text{HCO}_3^- + \text{H}^+ \rightarrow \text{Na}^+ + \text{H}_2\text{O} + \text{CO}_2$ IGNORE any correct or any incorrect state symbols	$\text{NaHCO}_3 + \text{HCl} \rightarrow \text{NaCl} + \text{H}_2\text{O} + \text{CO}_2$ OR any equations with HA	1

Question Number	Acceptable Answers	Reject	Mark
23 (b)(ii)	$\text{CH}_3\text{COCH}_3 + 3\text{I}_2 + 4\text{NaOH}$ $\rightarrow \text{CHI}_3 + \text{CH}_3\text{COONa} + 3\text{NaI} + 3\text{H}_2\text{O}$ IGNORE any correct or any incorrect state symbols CHI₃ on RHS of equation (1) remaining species correct (1) balanced equation (1) NOTE: balancing mark is CQ on all species correct Accept correct ionic equation (i.e. Na^+ omitted) NOTE: If CH_3I , can only access second mark above		3

Question Number	Acceptable Answers	Reject	Mark
24 (a)	$K_p = \frac{p(\text{H}_2)^3 p(\text{CO})}{p(\text{CH}_4)p(\text{H}_2\text{O})}$ (1) Brackets not required	[] $K_p = \frac{p(\text{H}_2)^3 + p(\text{CO})}{p(\text{CH}_4) + p(\text{H}_2\text{O})}$	1

Question Number	Acceptable Answers	Reject	Mark
24 (b)(i)	No effect (as K_p dependent only on temperature) (1)		1

Question Number	Acceptable Answers	Reject	Mark
24 (b)(ii)	(Since $K_p = \frac{x(\text{H}_2)^3 x(\text{CO})}{x(\text{CH}_4)x(\text{H}_2\text{O})} \times \frac{P_T^4}{P_T^2}$ to maintain K_p constant, mole fractions of numerator must decrease OR mole fractions of denominator must increase as $\times P_T^2$ overall) First mark: <i>EITHER</i> mole fractions/partial pressures of numerator decrease <i>OR</i> mole fractions/partial pressures of denominator increase (1) Second mark: any mention of $\times P_T^2$ OR $\times \frac{P_T^4}{P_T^2}$ (1) <i>ALLOW P for P_T</i> NOTE: If Le Chatelier quoted, statements such as: “Equilibrium shifts to side of fewer moles (of gas molecules)/fewer (gas) molecules” max (1)		2

Question Number	Acceptable Answers	Reject	Mark
24 (b)(iii)	Reaction takes place on surface of the catalyst (1) Active sites/(catalyst) surface is saturated with reactant molecules/reactants (at the pressure of the reaction) (1) <i>NOTE:</i> an answer such as “... depends on the availability of active sites on catalyst surface” scores (2)		2

Question Number	Acceptable Answers	Reject	Mark																				
24 (c)	$\text{CO} + \text{H}_2\text{O} \rightleftharpoons \text{CO}_2 + \text{H}_2$<table border="1"><tr><td>initial</td><td>1</td><td>1</td><td>0</td><td>0</td></tr><tr><td>eq'm</td><td>0.25</td><td>0.25</td><td>0.75</td><td>0.75</td></tr><tr><td>mol frac</td><td>0.125</td><td>0.125</td><td>0.375</td><td>0.375</td></tr><tr><td>pp</td><td>3.75</td><td>3.75</td><td>11.25</td><td>11.25</td></tr></table> - eq'm moles all correct (1) - mole fractions all correct (1) - partial pressures and answer = 9 with no units (1) NOTE: 3rd mark not awarded if any units shown NOTE: $\frac{11.25^2}{3.75^2}$ = 9 scores (3) NOTE: Mark each step CQ. CHECK ALL WORKING	initial	1	1	0	0	eq'm	0.25	0.25	0.75	0.75	mol frac	0.125	0.125	0.375	0.375	pp	3.75	3.75	11.25	11.25		3
initial	1	1	0	0																			
eq'm	0.25	0.25	0.75	0.75																			
mol frac	0.125	0.125	0.375	0.375																			
pp	3.75	3.75	11.25	11.25																			

Question Number	Acceptable Answers	Reject	Mark
24 (d)(i)	production (of hydrogen) forms CO ₂ OR production (of hydrogen) forms a Greenhouse gas OR production (of hydrogen) forms CO OR CO ₂ is a Greenhouse gas OR CO is a Greenhouse gas ALLOW production (of hydrogen) uses/requires energy ALLOW CO is toxic/poisonous	methane produced (0)	1

Question Number	Acceptable Answers	Reject	Mark
24 (d)(ii)	$2\text{KHCO}_3 \rightarrow \text{K}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$ ALLOW multiples		1

Question Number	Acceptable Answers	Reject	Mark
24 (e)	products removed OR not a closed system OR balance between rate and yield OR balance between time and yield OR recycling of reactants OR more product in unit time (so process more economically viable) IGNORE any comments relating to cost	references to atom economy dangers of maintaining high pressures	1

Section C

Question Number	Acceptable Answers	Reject	Mark
25 (a)	$\Delta S^{\circ}_{\text{total}}$ is positive / $\Delta S^{\circ}_{\text{total}} > 0$ with or without superscript NOTE: This mark may be awarded from answer to Q25(b)(v) Accept ΔG° is negative	Just “the entropy is positive”	1

Question Number	Acceptable Answers	Reject	Mark
25 (b)(i)	(+)27.3 and (+)87.4 (J mol ⁻¹ K ⁻¹) <i>IGNORE</i> incorrect units		1

Question Number	Acceptable Answers	Reject	Mark
25 (b)(ii)	$\Delta S^{\circ}_{\text{sys}} = (2 \times 87.4) - \{(4 \times 27.3 + (3 \times 205.0))\}$ (1) $= -549.4 / -549(\text{J mol}^{-1} \text{K}^{-1})$ (1) Correct answer with or without correct units (2) <i>IGNORE any wrong units</i> Accept TE from (b)(i) NOTE: +549/+549.4 scores (1) Check working NOTE: 1 st mark: for x2, x4 and x3 2 nd mark: for (products - reactants), with correct arithmetic		2

Question Number	Acceptable Answers	Reject	Mark
25 (b)(iii)	$\Delta S_{\text{surr}} = -\frac{\Delta H}{T}$ $= -(-1648 \times 10^3) \div 298(.15) \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ $= (+) 5530 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ OR $= (+) 5.53 \text{ kJ mol}^{-1} \text{ K}^{-1} \quad (1)$ NOTES: - Correct answer, with or without working, scores (1) - If 5530 (J mol⁻¹ K⁻¹) given, IGNORE any subsequent incorrect attempts to convert it to a value in kJ mol⁻¹ K⁻¹ IGNORE s.f. except one s.f.	Just (+)5.53 with no units OR (+)5.53 kJ mol⁻¹	1

Question Number	Acceptable Answers	Reject	Mark
25 (b)(iv)	$\Delta S_{\text{total}} = (-549.4) + (+5530)$ $= +4980.6 / + 4981 \text{ J mol}^{-1} \text{ K}^{-1}$ OR $+4.981 \text{ kJ mol}^{-1} \text{ K}^{-1}$ (1) for value (1) for correct sign and units IGNORE s.f. except one s.f. Accept TE from (b)(ii) and (b)(iii)	Just the formula: $\Delta S_{\text{total}} = \Delta S_{\text{sys}}^{\circ} + \Delta S_{\text{surr}}$	2

Question Number	Acceptable Answers	Reject	Mark
25 (b)(v)	(ΔS_{system} is negative): as loss of disorder as gas $\rightarrow$ solid OR more order as gas $\rightarrow$ solid OR as decrease in entropy as gas $\rightarrow$ solid (1) (ΔS_{surr} is positive): (heat) energy released (increases kinetic energy and hence movement of the surrounding molecules) (1) ΔS_{total} is positive because ΔS_{surr} is (numerically) greater than ΔS_{sys} OR ΔS_{surr} “outweighs” ΔS_{sys} OR ΔS_{surr} sufficiently large so that ΔS_{total} is positive (1)	Just “reaction is exothermic” ΔS_{total} is negative (0) for third scoring point	3

Question Number	Acceptable Answers	Reject	Mark
26 (a)	(IR spectrum of X) peak at 3400 (cm⁻¹) (1) <i>MAY BE ANNOTATED ON SPECTRUM</i> <i>ALLOW</i> anything in the Data Booklet range which is 3200 to 3750 (cm⁻¹) X has an O-H (group) OR X is an alcohol (1) (From the chemical information) X is primary or secondary (alcohol) OR X is not tertiary (alcohol) OR X is any two from: butan-1-ol, butan-2-ol, (2)-methylpropan-1-ol (1) Y is an aldehyde or a ketone <i>ALLOW</i> “ Y is a carbonyl” (1) <i>NOTE RE THIRD/FOURTH SCORING POINTS:</i> If just state that X is butan-1-ol with no justification (0) but then go on to state Y is butanal, give (1) CQ mark OR If just state that X is butan-2-ol with no justification (0) but then go on to state Y is butanone, give (1) CQ mark OR If just state that X is (2)-methylpropan-1-ol with no justification (0) but then go on to state Y is (2)-methylpropanal, give CQ mark (1) NOTE: These Part (a) marks may be awarded from answers to either Part (a) or Part (b)	X is a phenol (0)	4

26 (b)
QWC

First two marks:

X is $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{CH}_3$ (1)

Y is $\text{CH}_3\text{COCH}_2\text{CH}_3$ (1)

These marks are stand alone

NOTE: Two correct names, but no structural formulae for both scores (1) out of (2)

If X identified as $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$
and
and Y identified as $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$

award (1) unless previously credited in (a)

(NMR spectrum of X)

Third mark:-
hydrogen OR H in five (different) environments

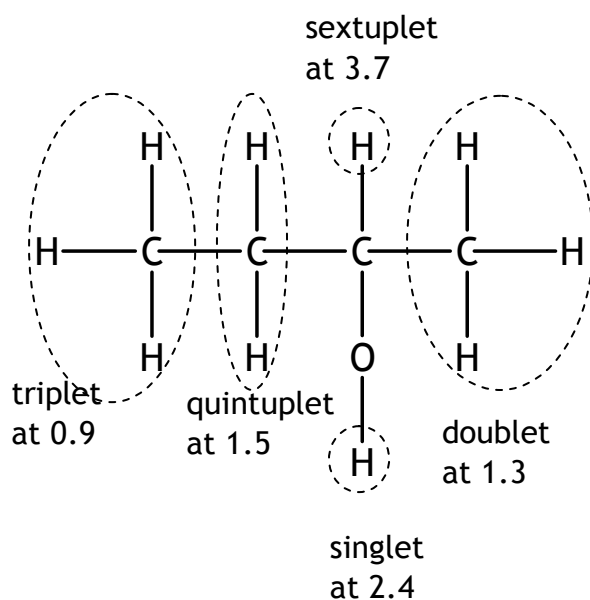
(IGNORE reference to butan-1-ol here)

OR

(so must be butan-1-ol or butan-2-ol and) not
2-methylpropan-1-ol which has four
peaks/hydrogen environments

(1)

NOTE: Candidates may annotate a structural or displayed formula to show that there are five environments. (For this mark, no details of splitting or chemical shifts are needed.)



splitting pattern (2,6,1,5,3) consistent with
butan-2-ol

OR

splitting pattern inconsistent with butan-1-ol
(which is 3,6,5,3,1) (1)

6

Fourth mark:-

splitting pattern (2,6,1,5,3) consistent with butan-2-ol

OR

splitting pattern inconsistent with butan-1-ol (which is 3,6,5,3,1)

OR

assign peaks correctly quoting chemical shifts from the spectrum

(1)

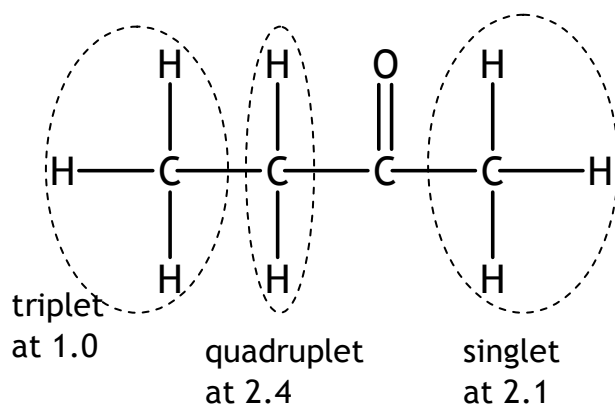
(NMR spectrum of Y)

Fifth mark:-

hydrogen OR H in three (different) environments

(1)

NOTE: Candidates may annotate a structural or displayed formula to show that there are three environments. (For this mark, no details of splitting or chemical shifts are needed.)



Sixth mark:-

splitting pattern (1,4,3) is consistent with butanone

OR

splitting pattern is inconsistent with butanal (which is 3,6,4,3)

OR

splitting pattern inconsistent with 2-methylpropanal (which is 2,8,2)

OR

assign peaks correctly quoting chemical shifts from the spectrum

(1)

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Write your name here			
Surname		Other names	
Centre Number		Candidate Number	
Edexcel GCE			
Chemistry Advanced Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry (including synoptic assessment)			
Thursday 17 June 2010 – Afternoon Time: 1 hour 40 minutes		Paper Reference 6CH04/01	
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.

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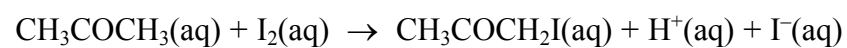
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SECTION A

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 Propanone reacts with iodine in acidic solution as shown in the equation below.



The rate equation for the reaction is

$$\text{Rate} = k[\text{CH}_3\text{COCH}_3(\text{aq})][\text{H}^+(\text{aq})]$$

- (a) The most appropriate technique to investigate the rate of this reaction is

(1)

- ☐ A titrating samples of reaction mixture with acid.
☐ B measurement of optical activity.
☐ C measurement of the volume of gas given off.
☐ D colorimetry.

- (b) Which statement about the reaction is **not** correct?

(1)

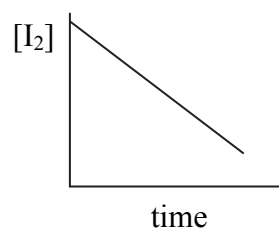
- ☐ A The overall order of reaction is second order.
☐ B The units of the rate constant are $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$.
☐ C The rate constant increases with temperature.
☐ D The rate increases four times when the concentration of propanone and iodine are both doubled.



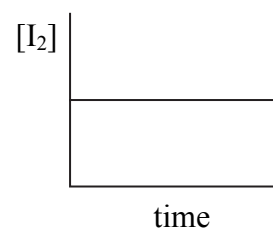
(c) The reaction is carried out using a large excess of both propanone and acid.
Which of the graphs below shows the change of iodine concentration with time?

(1)

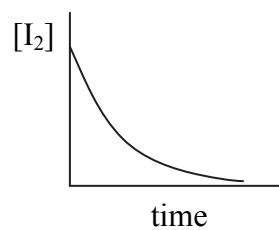
☐ A



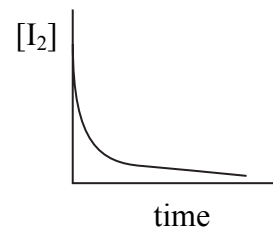
☐ B



☐ C

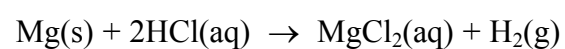


☐ D



(Total for Question 1 = 3 marks)

2 Which of the following is true for the exothermic reaction shown below?



- ☐ A ΔH positive
- ☐ B $\Delta S_{\text{surroundings}}$ positive
- ☐ C ΔS_{system} negative
- ☐ D ΔS_{total} negative

(Total for Question 2 = 1 mark)

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



N 3 6 5 0 6 A 0 3 2 4

3 In which reaction is water acting as a Brønsted-Lowry acid?

- ☐ A $\text{H}_2\text{O} + \text{HCl} \rightarrow \text{H}_3\text{O}^+ + \text{Cl}^-$
- ☐ B $\text{H}_2\text{O} + \text{SO}_3 \rightarrow \text{H}_2\text{SO}_4$
- ☐ C $\text{H}_2\text{O} + \text{NH}_3 \rightarrow \text{NH}_4^+ + \text{OH}^-$
- ☐ D $\text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3$

(Total for Question 3 = 1 mark)

4 Which of the following compounds has both optical and *E-Z* isomers?

- ☐ A $\text{CH}_3\text{CH}=\text{CHCH}_2\text{CH}_3$
- ☐ B $\text{CH}_3\text{CHClCH}=\text{C}(\text{CH}_3)_2$
- ☐ C $\text{CH}_3\text{CCl}=\text{CClCH}_3$
- ☐ D $\text{CH}_3\text{CHBrCH}=\text{CHCl}$

(Total for Question 4 = 1 mark)

5 Which of the following reacts with hydrogen cyanide, HCN, to make a racemic mixture?

- ☐ A Methanal, HCHO
- ☐ B Ethanal, CH_3CHO
- ☐ C Propanone, CH_3COCH_3
- ☐ D Pentan-3-one, $\text{C}_2\text{H}_5\text{COC}_2\text{H}_5$

(Total for Question 5 = 1 mark)

6 Which of the following is a redox reaction?

- ☐ A Ethanal reacting with Tollens' reagent.
- ☐ B Ethanoyl chloride reacting with ammonia.
- ☐ C Ethanoic acid reacting with ethanol.
- ☐ D Ethanoic acid reacting with sodium hydroxide.

(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 following methods can be used to distinguish between pairs of organic compounds without further tests.

- A Warm each compound with Fehling's or Benedict's solution.
- B Add solid sodium carbonate to each compound.
- C Add 2,4-dinitrophenylhydrazine (Brady's reagent) to each compound.
- D Add water, drop by drop, to each compound.

(a) Which test would distinguish propanone from propan-1-ol?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(b) Which test would distinguish between aqueous solutions of ethanoic acid and ethanol?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(c) Which test would distinguish ethanoyl chloride from ethanol?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 7 = 3 marks)

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



N 3 6 5 0 6 A 0 5 2 4

8 When propanone reacts with iodine in the presence of sodium hydroxide, the crystalline solid product has the formula

- ☐ A CH_3I
- ☐ B CHI_3
- ☐ C $\text{CH}_3\text{COCH}_2\text{I}$
- ☐ D CH_3COCl_3

(Total for Question 8 = 1 mark)

9 When the following reaction mixtures are warmed, which will contain ethanoic acid as one of the products?

- ☐ A Ethyl methanoate and sodium hydroxide solution.
- ☐ B Ethyl methanoate and dilute sulfuric acid.
- ☐ C Methyl ethanoate and sodium hydroxide solution.
- ☐ D Methyl ethanoate and dilute sulfuric acid.

(Total for Question 9 = 1 mark)

10 The spectra of the compounds with the formulae $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ and $\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$ can be distinguished by

- ☐ A the value of m/e of the molecular ion in the mass spectrum.
- ☐ B the presence of a fragment with $m/e = 15$ in the mass spectrum.
- ☐ C the presence of an absorption peak due to O–H in the infrared spectrum.
- ☐ D the number of peaks in the nmr spectrum.

(Total for Question 10 = 1 mark)

11 Which of the following has two singlet peaks in its nmr spectrum?

- ☐ A Methanal, HCHO
- ☐ B Methanol, CH_3OH
- ☐ C Chloromethane, CH_3Cl
- ☐ D Dichloromethane, CH_2Cl_2

(Total for Question 11 = 1 mark)



12 The nmr spectrum of 2,2-dimethylpropane, $\text{H}_3\text{C}-\overset{\text{CH}_3}{\underset{\text{CH}_3}{\text{C}}}-\text{CH}_3$, contains

- ☐ A one singlet peak.
- ☐ B four singlet peaks.
- ☐ C one quartet peak.
- ☐ D four quartet peaks.

(Total for Question 12 = 1 mark)

13 Which of the following solutions has the lowest pH?

- ☐ A 0.010 mol dm⁻³ hydrochloric acid.
- ☐ B 0.100 mol dm⁻³ hydrochloric acid.
- ☐ C 0.010 mol dm⁻³ ethanoic acid.
- ☐ D 0.100 mol dm⁻³ ethanoic acid.

(Total for Question 13 = 1 mark)

14 Which of the following solutions, when mixed, would make a buffer with pH more than 7?

- ☐ A Methanoic acid and sodium methanoate.
- ☐ B Sodium hydroxide and sodium chloride.
- ☐ C Ammonia and ammonium chloride.
- ☐ D Ammonium chloride and ammonium ethanoate.

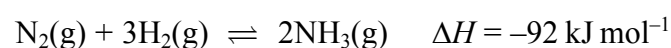
(Total for Question 14 = 1 mark)

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



N 3 6 5 0 6 A 0 7 2 4

15 This question is about the equilibrium reaction

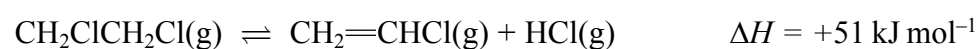


Which statement is **not** correct?

- ☐ A The units of K_p are atm^{-2} .
- ☐ B K_p increases as temperature is decreased.
- ☐ C K_p increases when the pressure increases.
- ☐ D K_p increases when the total entropy change, ΔS_{total} , increases.

(Total for Question 15 = 1 mark)

16 1,2-dichloroethane decomposes in the presence of a catalyst.



Which of the following would result in an increase in the equilibrium yield of chloroethene?

- ☐ A Increasing the temperature.
- ☐ B Increasing the pressure.
- ☐ C Increasing the surface area of the catalyst.
- ☐ D Changing the catalyst to a more efficient one.

(Total for Question 16 = 1 mark)

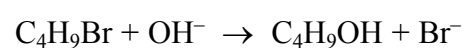
TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

- 17** A bromoalkane has the molecular formula $\text{C}_4\text{H}_9\text{Br}$. The ionic equation for the hydrolysis of this compound with aqueous sodium hydroxide is shown below.



- (a) The rate of hydrolysis was investigated by mixing a large excess of the bromoalkane with aqueous sodium hydroxide, and measuring the time taken for **all** the hydroxide ions to be used up. This was carried out with different initial concentrations of the bromoalkane and the hydroxide ions. The results are shown in the table below.

Experiment	$[\text{C}_4\text{H}_9\text{Br}]$ /mol dm ⁻³	$[\text{OH}^-]$ /mol dm ⁻³	Time for OH^- to be used up/s	Initial rate /mol dm ⁻³ s ⁻¹
1	0.017	0.0012	42	2.9×10^{-5}
2	0.034	0.0012	21	5.7×10^{-5}
3	0.034	0.0020	35	

- (i) Complete the missing value of the initial rate in the table. (1)
- (ii) State the order of the reaction with respect to $\text{C}_4\text{H}_9\text{Br}$ and to OH^- . Justify each answer by reference to the concentrations of both reactants. (3)

Order with respect to $\text{C}_4\text{H}_9\text{Br}$

Reason

Order with respect to OH^-

Reason

- (iii) Deduce the rate equation for the reaction. (1)

Rate =



N 3 6 5 0 6 A 0 9 2 4

(iv) Use the results for the first experiment in the table to calculate the rate constant and give its units.

(2)

Units

(b) What evidence supports the theory that there is more than one step in the reaction mechanism?

(1)

.....

.....

.....

(c) Write the mechanism for the hydrolysis of $\text{C}_4\text{H}_9\text{Br}$ which is consistent with your rate equation. Show the structure of $\text{C}_4\text{H}_9\text{Br}$ clearly in your mechanism.

(3)



*(d) Explain why primary and tertiary bromoalkanes are hydrolysed by different mechanisms.

(2)

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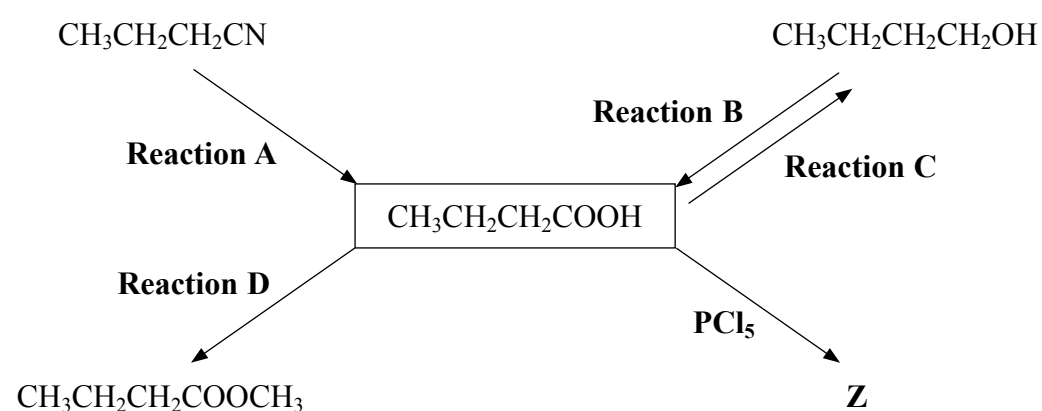
(Total for Question 17 = 13 marks)



N 3 6 5 0 6 A 0 1 1 2 4

18 This question is about butanoic acid, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$.

(a) Some reactions involving butanoic acid are shown below.



(i) What type of reaction is **Reaction A**?

(1)

(ii) Identify, by name or formula, the reagent which is used with sulfuric acid to carry out **Reaction B**.

(1)

(iii) What reagent is used in **Reaction C**?

(1)

(iv) Name the organic product of **Reaction D** and write a balanced equation for its formation.

(2)

Name

Equation

(v) Write the **displayed** formula for **Z**, the organic product of the reaction of butanoic acid with phosphorus(V) chloride, PCl_5 .

(1)



(b) Butanoic acid and propane-1,2,3-triol are formed when fats in milk are hydrolysed. The presence of milk fat in low fat spreads is detected by hydrolysing the spread, and then analysing the products using gas chromatography (also called gas-liquid chromatography, GLC).

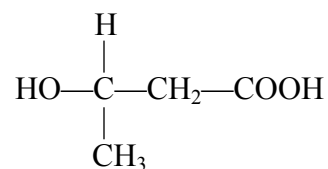
(i) Explain why nitrogen, rather than oxygen, is used as the carrier gas in GLC.

(1)

(ii) What property determines whether butanoic acid or propane-1,2,3-triol would move faster through the chromatography column?

(1)

(c) The formula of 3-hydroxybutanoic acid is shown below.



(i) 3-hydroxybutanoic acid can form a polymer which is used to make “green” packaging as it is biodegradable.

Draw a section of this polymer, showing TWO monomer units. Clearly show any double bonds.

(2)

(ii) The polymer cannot be used in acidic conditions. What reaction would occur when the polymer is in prolonged contact with an acid?

(1)

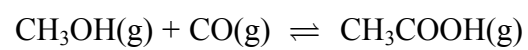
(Total for Question 18 = 11 marks)



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- 19 Ethanoic acid can be manufactured by the following reaction, which is carried out between 150 °C and 200 °C.



- (a) A mixture of 50.0 mol of methanol and 50.0 mol of carbon monoxide reaches equilibrium at a pressure of 32.0 atm. At 175 °C, the equilibrium partial pressure of ethanoic acid is 22.2 atm.

- (i) Write the expression for the equilibrium constant in terms of pressure, K_p , for this reaction.

(1)

- (ii) Calculate the partial pressures of methanol and carbon monoxide at equilibrium.

(2)

Methanol

Carbon monoxide

- (iii) Calculate the value of K_p for this reaction at 175 °C. Include a unit in your answer and give your answer to **three** significant figures.

(2)



N 3 6 5 0 6 A 0 1 5 2 4

- (b) Another sample of 50.0 mol of methanol and 50.0 mol of carbon monoxide was allowed to reach equilibrium at the same pressure of 32.0 atm, but at a lower temperature. 93.6 % of the methanol was converted at equilibrium.
- (i) Complete the table below to show the number of moles of each species in the equilibrium mixture.

(2)

	CH ₃ OH	CO	CH ₃ COOH
Number of moles at start	50.0	50.0	0
Number of moles at equilibrium			

- (ii) Calculate the partial pressure of ethanoic acid in the equilibrium mixture.

(1)

- (iii) Is the reaction exothermic or endothermic? Explain your answer.

(1)

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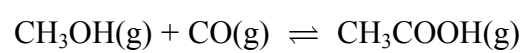
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(c) How, if at all, does the addition of methanol to the equilibrium mixture affect the following? Justify your answers.



(i) The equilibrium constant for the formation of ethanoic acid.

(1)

(ii) The equilibrium yield of ethanoic acid.

(1)

(d) In industry, catalysts are used even though they are often expensive.

State and explain ONE benefit to the **environment** resulting from the use of catalysts in industrial processes.

(2)

(Total for Question 19 = 13 marks)



20 Vinegar is used as a food preservative. It is an acidic solution containing ethanoic acid, CH_3COOH .

(a) A titration was carried out to measure the concentration of ethanoic acid in a sample of vinegar. 25.0 cm^3 of a vinegar solution was titrated with a solution of sodium hydroxide, concentration $0.250 \text{ mol dm}^{-3}$. The concentration of the ethanoic acid in the vinegar solution was found to be $0.125 \text{ mol dm}^{-3}$.

(i) Calculate the pH of $0.250 \text{ mol dm}^{-3}$ sodium hydroxide at 298 K.

$[K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6} \text{ at } 298 \text{ K.}]$

(2)

(ii) Write the expression for the acid dissociation constant, K_a , for ethanoic acid.

(1)

(iii) Calculate the pH of $0.125 \text{ mol dm}^{-3}$ ethanoic acid at 298 K.

$[K_a \text{ for ethanoic acid is } 1.7 \times 10^{-5} \text{ mol dm}^{-3} \text{ at } 298 \text{ K.}]$

(2)

(iv) When half the ethanoic acid is neutralized, the concentration of the remaining ethanoic acid equals the concentration of the sodium ethanoate which has formed. What is the pH of the mixture at this point? Justify your answer.

(2)

pH

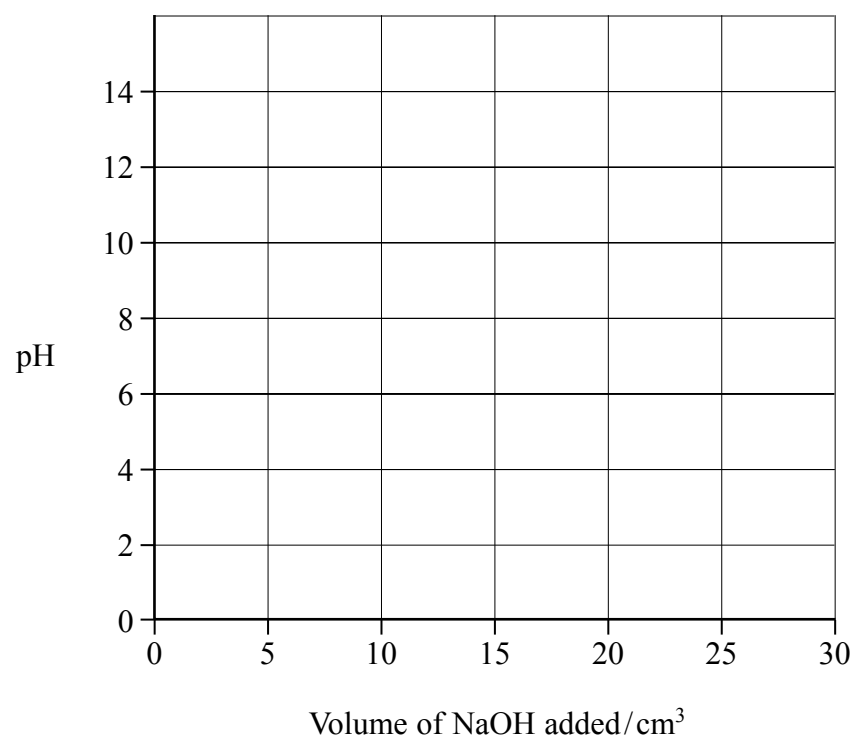
Justification

.....



- (v) On the axes below, sketch the titration curve for this reaction when 30 cm³ of the sodium hydroxide is added to 25.0 cm³ of the vinegar solution.

(3)



- *(vi) The only indicators which were available for this titration were methyl yellow (in ethanol) and thymolphthalein. Explain which indicator is more suitable for this titration and why the other is unsuitable. You will need to refer to your data booklet.

(2)

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- (b) In the food industry, ethanoic acid is described as an acidity regulator, additive number E260.

Ethanoic acid can neutralize alkalis. What substance could be mixed with ethanoic acid so that it regulates pH as a buffer in foodstuffs?

(1)

.....

(Total for Question 20 = 13 marks)

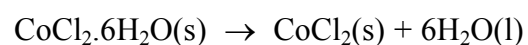
TOTAL FOR SECTION B = 50 MARKS



SECTION C

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

- 21 (a) Crystals of hydrated cobalt(II) chloride, $\text{CoCl}_2 \cdot 6\text{H}_2\text{O}$, lose water when they are heated, forming anhydrous cobalt(II) chloride, CoCl_2 .



- (i) Calculate the entropy change of the system, $\Delta S_{\text{system}}^\ominus$, at 298 K. Include a sign and units in your answer. You will need to refer to your data booklet.

(2)

- (ii) Explain whether the sign of your answer to (a)(i) is as expected from the equation for the reaction.

(1)

.....

.....

.....

- (iii) The standard enthalpy change for the reaction, $\Delta H^\ominus$, is $+88.1 \text{ kJ mol}^{-1}$. Calculate the entropy change in the surroundings, $\Delta S_{\text{surroundings}}^\ominus$, at 298 K for this reaction. Include a sign and units in your answer.

(2)

- (iv) Calculate the total entropy change, $\Delta S_{\text{total}}^\ominus$, at 298 K for the reaction.

(1)



- (v) Does your answer to (a)(iv) indicate whether hydrated cobalt(II) chloride can be stored at 298 K without decomposition? Explain your answer.

(1)

.....

.....

.....

- (b) A student attempted to measure the enthalpy change of solution of anhydrous cobalt(II) chloride by adding 2.00 g of cobalt(II) chloride to 50.0 cm³ of water in a well-insulated container. A temperature rise of 1.5 °C was recorded.

The student used a balance which reads to 0.01 g, a 50.0 cm³ pipette, and a thermometer which can be read to 0.25 °C.

- (i) Which measuring instrument should be changed to give a result which is closer to the accepted value? Justify your answer.

(2)

.....

.....

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- (ii) Suggest ONE **other** change the student could make to give a result which is closer to the accepted value. Justify your suggestion.

(2)

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*(c) The lattice energies of magnesium chloride, MgCl_2 , calcium chloride, CaCl_2 , and strontium chloride, SrCl_2 are shown in the table below.

Chloride	Lattice energy/ kJ mol^{-1}
MgCl_2	-2526
CaCl_2	-2258
SrCl_2	-2156

- (i) Use data on ionic radii, from your data booklet, to explain the trend in these values. Estimate a value for the lattice energy of cobalt(II) chloride, giving ONE piece of data to justify your estimate.

(4)

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(ii) Explain how lattice energy values, together with other data, can be used to predict the solubility of ionic compounds.

(3)

*(d) Cobalt forms another chloride, CoCl_3 , but scientists predict that MgCl_3 cannot be made. Suggest a reason for this.

You should consider the enthalpy changes in the Born-Haber cycle, which provide evidence about why cobalt(III) chloride is known but magnesium(III) chloride is not.

(2)

(Total for Question 21 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS



N 3 6 5 0 6 A 0 2 3 2 4

1.0	H	hydrogen	1
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[illegible]

Mark Scheme (Results)

June 2010

GCE

GCE Chemistry (6CH04/01)

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Summer 2010

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Section A (multiple choice)

Question Number	Correct Answer	Mark
1 (a)	D	1

Question Number	Correct Answer	Mark
1 (b)	D	1

Question Number	Correct Answer	Mark
1 (c)	A	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	B	1

Question Number	Correct Answer	Mark
6	A	1

Question Number	Correct Answer	Mark
7 (a)	C	1

Question Number	Correct Answer	Mark
7 (b)	B	1

Question Number	Correct Answer	Mark
7 (c)	D	1

Question Number	Correct Answer	Mark
8	B	1

Question Number	Correct Answer	Mark
9	D	1

Question Number	Correct Answer	Mark
10	D	1

Question Number	Correct Answer	Mark
11	B	1

Question Number	Correct Answer	Mark
12	A	1

Question Number	Correct Answer	Mark
13	B	1

Question Number	Correct Answer	Mark
14	C	1

Question Number	Correct Answer	Mark
15	C	1

Question Number	Correct Answer	Mark
16	A	1

Section B

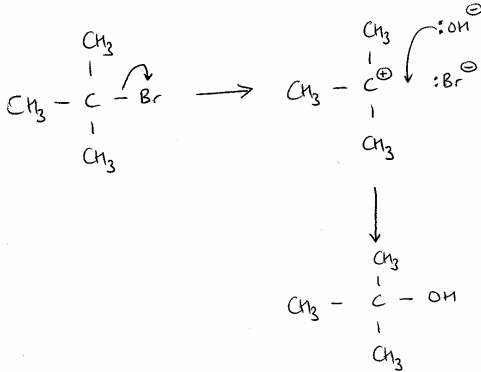
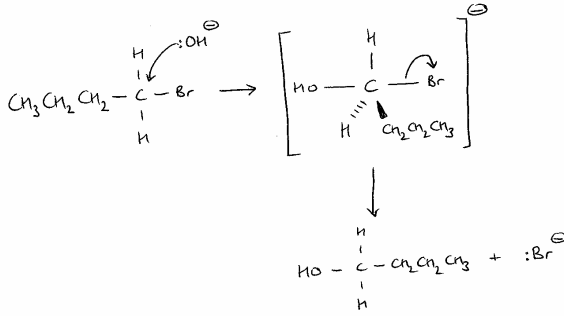
Question Number	Acceptable Answers	Reject	Mark
17 (a)(i)	5.7×10^{-5} / 5.71×10^{-5} / 5.714×10^{-5} / 0.000057 IGNORE SF except 1 (ie don't accept 6×10^{-5})		1

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	C₄H₉Br: first order / 1 (1) (going from first to second experiment) rate doubles when concentration / number of moles doubles (and [OH⁻] constant) / rate and concentration increase in proportion (1) ALLOW 'time halves' instead of 'rate doubles' OH⁻ : zero order / 0 and (going from second to third expt) as increase in concentration does not affect rate (and [C₄H₉Br] constant) (1) ALLOW 'doubling in concentration of OH⁻ instead of 'increase in concentration' ALLOW time increases by the same factor as increase in hydroxide concentration (5/3) May refer to experiment number rather than concentrations		3

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iii)	Rate = $k[\text{C}_4\text{H}_9\text{Br}]$ OR Rate = $k[\text{C}_4\text{H}_9\text{Br}]^1[\text{OH}^-]^0$ ALLOW k in lower or upper case Rate equation must be consistent with orders in (a)(ii) If no order is given for hydroxide in (ii) mark cannot be given		1

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iv)	$k = \frac{2.9 \times 10^{-5}}{0.017}$ $= 1.7 \times 10^{-3} / 1.71 \times 10^{-3} / 1.706 \times 10^{-3} \text{ s}^{-1}$ ALLOW $k = 1.68 \times 10^{-3}$ (value obtained from experiment 2 or 3) value of k (1) units (1) stand alone mark ALLOW TE from (a)(iii) IGNORE SF except 1 Rate = $k[\text{C}_4\text{H}_9\text{Br}]^2$ gives $k = 0.10036 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ Rate = $k[\text{C}_4\text{H}_9\text{Br}][\text{OH}^-]$ gives $k = 1.42 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ ALLOW $k = 1.39 \text{ dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ (value obtained from experiment 2 or 3) Rate = $k[\text{C}_4\text{H}_9\text{Br}][\text{OH}^-]^2$ gives $k = 1184.6 \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$ Rate = $k[\text{C}_4\text{H}_9\text{Br}]^2[\text{OH}^-]$ gives $k = 83.62 \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$		2

Question Number	Acceptable Answers	Reject	Mark
17(b)	$[\text{OH}^-]$ is (in chemical equation but) not in rate equation / not in rate determining step (so is in a step other than rate determining step) OR Only $\text{C}_4\text{H}_9\text{Br}$ is in rate equation / rate determining step (so OH^- is in a step other than rate determining step)		1

Question Number	Acceptable Answers	Mark
17 (c)	First mark Choice of bromoalkane must be consistent with rate equation in (a)(iii). If $[\text{OH}^-]$ is not in rate equation, secondary/tertiary bromoalkane. If $[\text{OH}^-]$ is in rate equation, primary/secondary bromoalkane. (1) Second and third marks Either SN1 or SN2 mechanism can score 2 marks regardless of choice of bromoalkane.  Lone pairs not required Curly arrow from C-Br bond to Br (making Br^-) (1) Curly arrow from anywhere on OH^- / HO^- to C^+ in correct intermediate (making alcohol) (1) OR  Both curly arrows from OH^- and from C-Br bond to Br (may both be shown at start) (1) Transition state including minus charge (and product) (1) Do not penalise if C_2H_5 shown instead of C_3H_7. Bonds in transition state can be dotted. Do not penalise the missing H atoms in alkyl groups in mechanism.	3

Question Number	Acceptable Answers	Reject	Mark
17 (d) QWC	(Primary and tertiary) carbocation intermediates have different stabilities (1) as (inductive effects of) alkyl groups stabilise tertiary carbocation (1) OR Steric hindrance differs for attack on primary and tertiary carbon (in the molecule) / less space available for attack by OH⁻ on tertiary carbon / more space for attack by OH⁻ on primary carbon (1) as bulky / three alkyl groups obstruct attack (1)	“Tertiary bromoalkanes react by SN1” without further explanation carbocation intermediates have different reactivity steric hindrance in carbocation	2

Question Number	Acceptable Answers	Reject	Mark
18 (a)(i)	(Acid) hydrolysis	substitution	1

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	$K_2Cr_2O_7$ / $Na_2Cr_2O_7$ / $Cr_2O_7^{2-}$ Potassium dichromate(VI) / sodium dichromate(VI) / dichromate(VI) ions ALLOW manganate(VII) ions, etc	Just "dichromate" chromates Correct formula with wrong name and vice versa Incorrect oxidation number	1

Question Number	Acceptable Answers	Reject	Mark
18 (a)(iii)	Lithium tetrahydridoaluminate/ lithium aluminium hydride/ $LiAlH_4$ (in dry ether)	Just $[H^-]$	1

Question Number	Acceptable Answers	Reject	Mark
18 (a)(iv)	Methyl butanoate (1) $CH_3CH_2CH_2COOH + CH_3OH \rightarrow CH_3CH_2CH_2COOCH_3 + H_2O$ (1) ALLOW $\rightleftharpoons$ IGNORE state symbols even if wrong	Methyl butoate	2

Question Number	Acceptable Answers	Reject	Mark
18 (a)(v)	$\text{CH}_3-\text{CH}_2-\text{CH}_2-\text{C} \begin{array}{l} \text{O} \\ \parallel \\ \text{Cl} \end{array}$ Don't penalise undisplayed methyl groups as here. COCl must be displayed as above.	C ₃ H ₇ for CH ₃ CH ₂ CH ₂	1

Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	Nitrogen inert / unreactive / less reactive (than oxygen) OR Oxygen might react with chemicals going through column / sample might oxidise		1

Question Number	Acceptable Answers	Reject	Mark
18 (b)(ii)	Solubility (in liquid / stationary phase) OR Interaction with liquid / stationary phase OR Interaction between mobile and stationary phase OR Attraction for liquid / stationary phase OR Strength of (named) intermolecular forces OR Adsorption on liquid / stationary phase OR Absorption on liquid / stationary phase	Size of molecule / molar mass Polarity, unless with explanation Boiling point / volatility Viscosity Attraction for carrier gas Just a named intermolecular force Just 'retention time' Density	1

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	$\left[\begin{array}{c} \text{H} \quad \quad \text{O} \quad \quad \text{H} \quad \quad \text{O} \\ \quad \quad // \quad \quad \quad \quad // \\ -\text{O}-\text{C}-\text{CH}_2-\text{C}-\text{O}-\text{C}-\text{CH}_2-\text{C}- \\ \quad \quad \quad \\ \text{CH}_3 \quad \quad \text{CH}_3 \end{array} \right]$ OR $\left[\begin{array}{c} \text{H} \quad \quad \text{O} \quad \quad \text{H} \quad \quad \text{O} \\ \quad \quad // \quad \quad \quad \quad // \\ -\text{C}-\text{CH}_2-\text{C}-\text{O}-\text{C}-\text{CH}_2-\text{C}-\text{O}- \\ \quad \quad \quad \\ \text{CH}_3 \quad \quad \text{CH}_3 \end{array} \right]$ Ester link including C=O (1) Rest of polymer with oxygens at end correct (1) All H atoms must be shown. <i>PENALISE</i> lack of displayed C=O once only <i>ACCEPT</i> Without brackets around formula but bonds at end should be shown More than two correct units <i>IGNORE</i> n after brackets		2

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Hydrolysis OR Splits / breaks ester link OR polymer breaks down to monomers OR equation showing hydrolysis	Just 'breaks polymer down'	1

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	$(K_p =) \frac{p_{\text{CH}_3\text{CO}_2\text{H}}}{p_{\text{CH}_3\text{OH}} (x) p_{\text{CO}}}$ Partial pressure symbol can be shown in various ways, eg pp, p_{CO} , (CO)p, etc ALLOW p in upper or lower case, round brackets IGNORE units	[] State symbols given as (l) + in bottom line	1

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	$P_{\text{CH}_3\text{OH}} = 4.9 \text{ (atm)}$ (1) $P_{\text{CO}} = 4.9 \text{ (atm)}$ (1) 1 mark for recognition that pressures are equal IGNORE units		2

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	$K_p = ((22.2)/(4.9)^2)$ $= 0.925$ (1) atm^{-1} (1) stand alone mark but must match expression used in (a)(iii) OR $9.25 \times 10^4 \text{ Pa}^{-1} / 92.5 \text{ kPa}^{-1}$ (2) ALLOW TE from (a)(i) if inverted and/or (a)(ii)	Answers to other than 3 significant figures	2

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	CH₃OH: 3.2 CO : 3.2 (1) for both values CH₃CO₂H: 46.8 (1) ALLOW TE for moles of ethanoic acid based on numbers of methanol and carbon monoxide used, as long as moles of methanol and carbon monoxide are equal and moles ethanoic acid + moles methanol = 50		2

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	$\left(\frac{46.8 \times 32}{53.2} \right) = 28.2 / 28.1504 \text{ (atm)}$ IGNORE sf except 1 Value = 28.16 if mol fraction rounded ALLOW TE from (b)(i)	28.1 $\frac{46.8 \times 32}{50} = 29.95 \text{ (atm)}$	1

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	exothermic as yield / pp of ethanoic acid / conversion of reactants/ K_p is higher at lower temperature / as equilibrium moves (right) at lower temperature ALLOW if partial pressure of ethanoic acid < 22.2 atm in (b)(ii), endothermic as yield / pp of ethanoic acid / conversion of reactants/ K_p is lower at lower temperature		1

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	No effect and other concentrations change to keep K_p constant / K_p is only affected by temperature / as equilibrium moves (right) to keep K_p constant / change in pressure does not change K_p	As K_p is a constant	1

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	Yield increased to restore fraction / quotient / partial pressure ratio back to K_p <i>ALLOW</i> (equilibrium moves) to use up the methanol / answers based on entropy or Le Chatelier Correct prediction in (c)(i) and (c)(ii) with inadequate explanations scores 1 mark in (c)(ii)	Just 'equilibrium moves to the right'	1

Question Number	Acceptable Answers	Reject	Mark
19 (d)	Mark independently Reaction can occur at lower temperature / has lower activation energy / requires less energy (1) less fuel needed / fewer emissions (from fuels) / fewer raw materials needed / less natural resources used (1) OR Enables use of an alternative process with higher atom economy (1) fewer raw materials needed / less natural resources used (1)	Answer based on car exhaust emissions	2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	Correct answer with or without working scores 2 marks $[H^+] = (1.00 \times 10^{-14} / 0.250) = 4 \times 10^{-14}$ (1) pH = (13.39794 $\Rightarrow$) 13.4 (1) OR pOH = -log 0.250 = 0.602 (1) pH = (13.39794 $\Rightarrow$) 13.4 (1) <i>ALLOW</i> TE in second mark if error in $[H^+]$ calculation gives pH more than 7 3 or more sf <i>IGNORE</i> rounding errors e.g. accept 13.39		2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	$(K_a =) \frac{[CH_3COO^-][H^+]}{[CH_3COOH]}$ (1) <i>ALLOW</i> H_3O^+ instead of H^+ $\frac{[A^-][H^+]}{[HA]}$ if key to symbols given <i>IGNORE</i> state symbols	$\frac{[H^+]^2}{[CH_3COOH]}$	1

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iii)	Correct answer with or without working scores 2 marks $1.7 \times 10^{-5} = \frac{[H^+]^2}{0.125}$ (1) $[H^+] = 1.46 \times 10^{-3}$ pH = 2.84/2.8 (1) no TE from an incorrect $[H^+]$		2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(iv)	pH = 4.8 / 4.77 (1) pH = pK_a / [H⁺] = K_a (when acid is half neutralized) (1)	H ⁺ = K _a	2

Question Number	Acceptable Answers	Reject	Mark
20 (a)(v)	Sigmoid curve starting between pH 2 and 4 (2.8), ending between pH 12 and 14 inclusive (1) with steep rise (may be vertical or gently sloping) of between 3 – 7 units between pH 6 and 12. Sloping section should not extend over more than 5cm³. (1) When 12.5 cm³, NaOH added. (1) ALLOW tolerance for grid Reverse curves lose first mark		3

Question Number	Acceptable Answers	Reject	Mark
20 (a)(vi)	First mark Thymolphthalein more suitable as it changes (from colourless to blue) in steep region of titration (pH 8.3 to 10.6)/ at the equivalence point / at the end point OR thymolphthalein has pH range in steep region of titration (1) Second mark Methyl yellow changes (from red to yellow at pH 2.9 to 4) before equivalence point / before the end point / doesn't change in steep section OR Methyl yellow has pH range before / outside steep region of titration (1) <i>ALLOW</i> 'Thymolphthalein more suitable as it changes at the equivalence point but methyl yellow does not.' This scores 2 marks OR First mark $pK_{in} \pm 1$ must lie within vertical region on titration curve (1) Second mark hence thymolphthalein is suitable and methyl yellow is not (1)		2

Question Number	Acceptable Answers	Reject	Mark
20 (b)	Sodium ethanoate / CH_3COONa Potassium ethanoate / CH_3COOK <i>ALLOW</i> other cations as alternatives to sodium	Use of sodium hydroxide (because it's in food)	1

Question Number	Acceptable Answers	Reject	Mark
21 (a)(i)	$\Delta S^\circ_{\text{system}} = 109.2 + (6 \times 69.9) - 343$ (1) $= (+)185.6 (\text{J mol}^{-1} \text{K}^{-1})$ / $(+)186 (\text{J mol}^{-1} \text{K}^{-1})$ (1) OR $(+)0.186 (\text{kJ mol}^{-1} \text{K}^{-1})$ (2) IGNORE units even if incorrect correct answer with no working scores 2 Value using 1 for $\text{H}_2\text{O} = -163.9$ scores 1 Use of value for $\text{H}_2\text{O(g)}$ (188.7) gives $898.4 (\text{J mol}^{-1} \text{K}^{-1})$ (1) correct value with incorrect sign scores 1	185	2

Question Number	Acceptable Answers	Reject	Mark
21 (a)(ii)	Yes as (solid and) liquid forms (from solid) / number of moles increases OR If $\Delta S^\circ_{\text{system}}$ in (i) is negative the sign is not as expected as liquid forms from solid / number of moles increases	Disorder increases, with no ref to liquid or number of moles	1

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iii)	First mark $\Delta S^{\ominus}_{\text{surroundings}} = \frac{-88.1 \times (1000)}{298} \quad (1)$ Second mark $= -295.6375$ $= -295.6 \text{ J mol}^{-1} \text{ K}^{-1} \quad (1)$ correct units must be shown but order not important OR $-0.2956 \text{ kJ mol}^{-1} \text{ K}^{-1} \quad (1)$ correct units must be shown but order not important correct answer with or without working and correct units scores (2) ignore sf except 1 correct value with positive sign scores 1		2

Question Number	Acceptable Answers	Reject	Mark
21 (a)(iv)	$(185.6 - 295.6)$ $= -110 \text{ (J mol}^{-1} \text{ K}^{-1} \text{)}$ OR -0.110 (kJ mol⁻¹ K⁻¹) could use 186 or 296 etc TE from (a)(i) and (iii) (+)602.8 (J mol⁻¹ K⁻¹) if value for 6H₂O(g) was used in (a) (i) -459.5 (J mol⁻¹ K⁻¹) if value for one H₂O was used in (a) (i)	Answers where values in J are added to kJ	1

Question Number	Acceptable Answers	Reject	Mark
21 (a)(v)	Decomposition (at 298 K) will not occur as $\Delta S^{\circ}_{\text{total}}$ is negative / Reactions are only spontaneous if total entropy change is positive / decomposition not thermodynamically feasible / (hydrated cobalt chloride) is thermodynamically stable TE if answer to (a)(iv) is positive showing decomposition (at 298 K) may occur OR Positive total entropy change doesn't indicate rate of reaction		1

Question Number	Acceptable Answers	Reject	Mark
21 (b)(i)	First mark Thermometer (1) Second mark (dependent on first) depends on choosing thermometer as temperature change is small / (%) error in balance smaller than for temperature reading (%) error in pipette smaller than for temperature reading (can be shown by calculation) / as scale with greater degree of precision needed / scale with more graduations needed (1) /IGNORE any references to 'accurate thermometer'		2

Question Number	Acceptable Answers	Reject	Mark
21 (b)(ii)	Use more cobalt chloride / less water (1) To increase temperature rise (1) Mark independently	Just 'use more reactants' Use more cobalt chloride and more water repeat expt add a lid or extra insulation to beaker use distilled water	2

Question Number	Acceptable Answers	Reject	Mark
21 (c)(i) QWC	Radius (of cation) increases (down group) OR any two values of radius: $\text{Mg}^{2+} = 0.072$, $\text{Ca}^{2+} = 0.100$ / $\text{Sr}^{2+} = 0.113$ (nm) data may be shown beside the table (1) Radius $\text{Co}^{2+} = 0.065$ nm OR Co^{2+} radius smaller than other ions (1) Data on EITHER Co^{2+} OR data showing increase in radius down Group II required for BOTH of first two marks Force of attraction between ions decreases (as radius of ions increases) / charge density of ions decreases / negative ion can come closer to nucleus of positive ion (1) <i>ALLOW</i> "weaker ionic bonds" Predict lattice energy -2550 to -2900 (kJ mol^{-1}) (1) IGNORE sign	Atomic radii unless ionic radii also given Radius of cobalt chloride Polarising power decreases	4

Question Number	Acceptable Answers	Reject	Mark
21 (c)(ii) QWC	First mark Reference to enthalpy of hydration (may be in equation $\Delta H_{\text{solution}} = -LE + \Delta H_{\text{hydration}}$) (1) Second mark Solubility depends on relative size of lattice energy and enthalpy of hydration (1) Third mark EITHER Solubility more likely if $\Delta H_{\text{solution}}$ is negative OR (If $\Delta H_{\text{solution}}$ is positive,) may / will dissolve if ΔS_{total} is positive <i>ACCEPT</i> solvation instead of hydration		3

Question Number	Acceptable Answers	Reject	Mark
21 (d) QWC	First mark Third ionization energy high(er) for Mg / Mg = 7733 kJ mol^{-1}, (third ionization energy for Co = 3232 kJ mol^{-1}) (1) Second mark (Third ionization energy for Mg is high) because the electron is being removed from an inner shell / full shell / 2p level / 2p orbital (1) OR Not compensated by higher lattice energy for Mg^{3+} (and so $\Delta H_{\text{formation}}$ of MgCl_3 would be highly endothermic) (1)		2

Write your name here	
Surname	Other names
Centre Number	Candidate Number
Edexcel GCE	
Chemistry Advanced Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry (including synoptic assessment)	
Wednesday 26 January 2011 – Morning Time: 1 hour 40 minutes	Paper Reference 6CH04/01
You must have: Data Booklet	Total Marks
Candidates may use a calculator.	

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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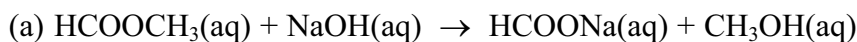
SECTION A

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 Methods for investigating reaction rates include

- A colorimetry.
- B measurement of change in volume.
- C measurement of change of mass.
- D quenching followed by titrating with acid.

Which method would be most suitable to investigate the rate of the following reactions?



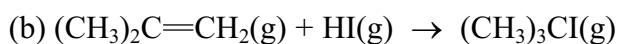
(1)

☐ A

☐ B

☐ C

☐ D



(1)

☐ A

☐ B

☐ C

☐ D



(1)

☐ A

☐ B

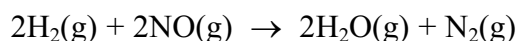
☐ C

☐ D

(Total for Question 1 = 3 marks)



2



This reaction is first order with respect to hydrogen and second order with respect to nitrogen(II) oxide.

By what factor will the initial rate increase if the concentration of hydrogen and nitrogen(II) oxide are both tripled?

- ☐ A 3
- ☐ B 9
- ☐ C 12
- ☐ D 27

(Total for Question 2 = 1 mark)

3 Which reaction has the most positive entropy change for the system, ΔS_{system} ?

- ☐ A $\text{NaOH}(\text{aq}) + \text{HCl}(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- ☐ B $\text{AgNO}_3(\text{aq}) + \text{NaCl}(\text{aq}) \rightarrow \text{AgCl}(\text{s}) + \text{NaNO}_3(\text{aq})$
- ☐ C $\text{C}_2\text{H}_4(\text{g}) + \text{HCl}(\text{g}) \rightarrow \text{C}_2\text{H}_5\text{Cl}(\text{l})$
- ☐ D $\text{C}_4\text{H}_{10}(\text{g}) \rightarrow \text{C}_2\text{H}_4(\text{g}) + \text{C}_2\text{H}_6(\text{g})$

(Total for Question 3 = 1 mark)

4 Barium carbonate decomposes in an endothermic reaction when heated to 1500 K.



What are the signs of the entropy changes at 1500 K?

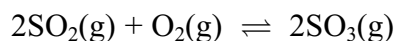
		ΔS_{system}	$\Delta S_{\text{surroundings}}$
☐	A	+	+
☐	B	+	–
☐	C	–	+
☐	D	–	–

(Total for Question 4 = 1 mark)

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



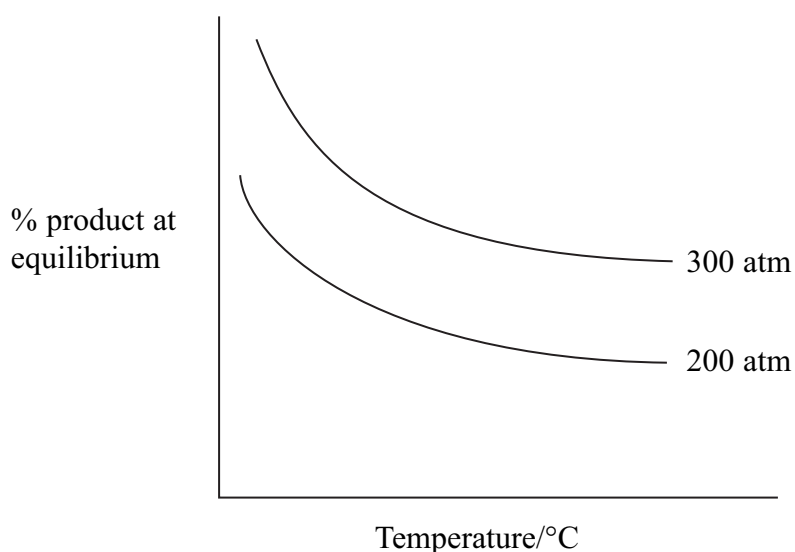
5 What are the units of K_c for the following equilibrium?



- ☐ A atm
- ☐ B atm^{-1}
- ☐ C $\text{dm}^3 \text{mol}^{-1}$
- ☐ D mol dm^{-3}

(Total for Question 5 = 1 mark)

6 The graph below shows the yield of product in a gaseous equilibrium at different temperatures and pressures.



The forward reaction in the equilibrium is

- ☐ A exothermic, and the number of moles of gas is increasing.
- ☐ B endothermic, and the number of moles of gas is increasing.
- ☐ C exothermic, and the number of moles of gas is decreasing.
- ☐ D endothermic, and the number of moles of gas is decreasing.

(Total for Question 6 = 1 mark)

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



7 Hydrogen cyanide, HCN, reacts with propanal, $\text{CH}_3\text{CH}_2\text{CHO}$, in the presence of potassium cyanide, KCN.

(a) The mechanism for this reaction is

(1)

- ☐ A nucleophilic addition.
- ☐ B nucleophilic substitution.
- ☐ C electrophilic addition.
- ☐ D electrophilic substitution.

(b) The first stage of the mechanism of this reaction is

(1)

- ☐ A the lone pair of electrons on carbon in CN^- attacking $\text{C}^{\delta+}$ of propanal.
- ☐ B the lone pair of electrons on nitrogen in CN^- attacking $\text{C}^{\delta+}$ of propanal.
- ☐ C the lone pair of electrons on oxygen in propanal attacking $\text{C}^{\delta+}$ of HCN.
- ☐ D the lone pair of electrons on oxygen in propanal attacking $\text{H}^{\delta+}$ in HCN.

(c) The product of the reaction is

(1)

- ☐ A 1-hydroxypropanenitrile.
- ☐ B 2-hydroxypropanenitrile.
- ☐ C 1-hydroxybutanenitrile.
- ☐ D 2-hydroxybutanenitrile.

(Total for Question 7 = 3 marks)

8 Which of the following does not have hydrogen bonding in a pure sample, but forms hydrogen bonds with water when it dissolves?

- ☐ A Propane
- ☐ B Propanal
- ☐ C Propanol
- ☐ D Propanoic acid

(Total for Question 8 = 1 mark)

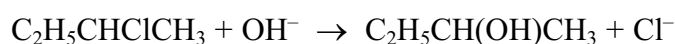


9 Which of the following has both optical and E-Z isomers?

- ☐ A $\text{ClCH}_2\text{CHClCH}=\text{CH}_2$
- ☐ B $\text{CH}_2=\text{CClCH}_2\text{CH}_2\text{Cl}$
- ☐ C $\text{ClCH}_2\text{CH}=\text{CHCH}_2\text{Cl}$
- ☐ D $\text{CHCl}=\text{CHCHClCH}_3$

(Total for Question 9 = 1 mark)

10 One optically active isomer of 2-chlorobutane reacts with hydroxide ions to form butan-2-ol.



The organic product is a **mixture** of enantiomers because

- ☐ A butan-2-ol contains a chiral carbon atom.
- ☐ B the reaction is a nucleophilic substitution.
- ☐ C 2-chlorobutane forms a carbocation intermediate.
- ☐ D 2-chlorobutane forms a five-bonded transition state.

(Total for Question 10 = 1 mark)

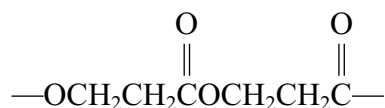
11 The organic product of the reaction between ethanoyl chloride and methylamine has the formula

- ☐ A $\text{CH}_3\text{NHCH}_2\text{C}\begin{array}{l} \text{O} \\ \parallel \\ \text{Cl} \end{array}$
- ☐ B $\text{CH}_3\text{CH(NH}_2\text{)C}\begin{array}{l} \text{O} \\ \parallel \\ \text{Cl} \end{array}$
- ☐ C $\text{CH}_3\text{C}\begin{array}{l} \text{O} \\ \parallel \\ \text{NH}_2 \end{array}$
- ☐ D $\text{CH}_3\text{C}\begin{array}{l} \text{O} \\ \parallel \\ \text{NHCH}_3 \end{array}$

(Total for Question 11 = 1 mark)



- 12 A section of a polymer is shown below. Which of the following monomers would form this polymer?



- ☐ A $\text{HOCH}_2\text{CH}_2\text{OH}$ and $\text{ClCOCH}_2\text{CH}_2\text{COCl}$
☐ B $\text{HOCH}_2\text{CH}_2\text{OH}$ and $\text{HOOCCH}_2\text{CH}_2\text{COOH}$
☐ C $\text{ClCH}_2\text{CH}_2\text{COCl}$ alone
☐ D $\text{HOCH}_2\text{CH}_2\text{COOH}$ alone

(Total for Question 12 = 1 mark)

- 13 Which of the following is **not** a reaction of a Brønsted-Lowry acid and base?

- ☐ A $\text{CH}_3\text{Cl} + \text{OH}^- \rightarrow \text{CH}_3\text{OH} + \text{Cl}^-$
☐ B $\text{NH}_3 + \text{HCl} \rightarrow \text{NH}_4^+ + \text{Cl}^-$
☐ C $\text{H}_2\text{O} + \text{HSO}_4^- \rightarrow \text{H}_2\text{SO}_4 + \text{OH}^-$
☐ D $\text{HCO}_3^- + \text{H}_2\text{O} \rightarrow \text{CO}_3^{2-} + \text{H}_3\text{O}^+$

(Total for Question 13 = 1 mark)

- 14 A buffer solution is made from ammonia and ammonium chloride. When a small amount of acid is added to this buffer

- ☐ A hydrogen ions in the acid combine with chloride ions to make HCl .
☐ B hydrogen ions in the acid combine with NH_3 to make NH_4^+ .
☐ C NH_4^+ ions dissociate to make more NH_3 .
☐ D the hydrogen ions in the acid prevent dissociation of the NH_4Cl .

(Total for Question 14 = 1 mark)

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



15 Information about four samples of acid is shown below.

Sample 1: $1.0 \text{ mol dm}^{-3} \text{ HCl}$

Sample 2: $1.0 \text{ mol dm}^{-3} \text{ H}_2\text{SO}_4$

Sample 3: $0.1 \text{ mol dm}^{-3} \text{ HCl}$

Sample 4: $0.1 \text{ mol dm}^{-3} \text{ CH}_3\text{COOH}$

Which of the following lists shows the samples in order of increasing pH?

- ☐ **A** 1, 2, 3, 4
- ☐ **B** 4, 3, 2, 1
- ☐ **C** 2, 1, 3, 4
- ☐ **D** 4, 3, 1, 2

(Total for Question 15 = 1 mark)

16 Which reaction has an enthalpy change equal to the enthalpy of hydration of the sodium ion?

- ☐ **A** $\text{Na}^+(\text{g}) + \text{excess H}_2\text{O}(\text{l}) \rightarrow \text{Na}^+(\text{aq})$
- ☐ **B** $\text{Na}^+(\text{g}) + 1 \text{ mol of H}_2\text{O}(\text{l}) \rightarrow \text{Na}^+(\text{aq})$
- ☐ **C** $\text{Na}^+(\text{s}) + \text{excess H}_2\text{O}(\text{l}) \rightarrow \text{Na}^+(\text{aq})$
- ☐ **D** $\text{Na}^+(\text{s}) + 1 \text{ mol of H}_2\text{O}(\text{l}) \rightarrow \text{Na}^+(\text{aq})$

(Total for Question 16 = 1 mark)

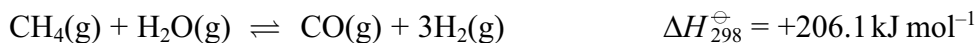
TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

- 17 Hydrogen can be manufactured by reacting methane with steam, as shown in the equation below.



Use these values:

the standard entropy of 1 mol of $\text{H}_2(\text{g})$ is $(2 \times 65.3) = 130.6 \text{ J mol}^{-1} \text{ K}^{-1}$

the standard entropy of 1 mol of $\text{H}_2\text{O}(\text{g})$ is $188.7 \text{ J mol}^{-1} \text{ K}^{-1}$

You will also need to refer to the data booklet in the calculations which follow.

- (a) Calculate the standard entropy change of the system, $\Delta S_{\text{system}}^{\ominus}$, for this reaction at 298 K.

(2)

- (b) Calculate the standard entropy change of the surroundings, $\Delta S_{\text{surroundings}}^{\ominus}$, for this reaction at 298 K. Include a sign and units in your answer.

(2)

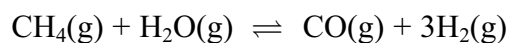
- (c) Calculate the total entropy change, $\Delta S_{\text{total}}^{\ominus}$, for this reaction at 298 K.

Explain why this value shows that the reaction is not spontaneous at this temperature.

(2)



- (d) The composition of an equilibrium mixture produced at 2.0 atmospheres pressure and at a much higher temperature is shown below.



Amount in equilibrium mixture / mol	0.80	0.80	1.20	3.60
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- *(i) Write the expression for the equilibrium constant, K_p , of the reaction and calculate its value. Include units in your answer.

(6)

- (ii) The total entropy change in $\text{J mol}^{-1} \text{K}^{-1}$ is related to the equilibrium constant by the equation

$$\Delta S_{\text{total}}^{\ominus} = R \ln K_p \quad \text{or} \quad \Delta S_{\text{total}}^{\ominus} = 2.3R \log K_p$$

Calculate the total entropy change at the temperature of the reaction.

$[R = 8.31 \text{ J mol}^{-1} \text{K}^{-1}]$

(1)



- (iii) Calculate the temperature at which this equilibrium is reached using your answer to (ii) for $\Delta S_{\text{total}}^{\ominus}$. Assume that ΔH is still $+206.1 \text{ kJ mol}^{-1}$ and that $\Delta S_{\text{system}}^{\ominus} = +225 \text{ J K}^{-1} \text{ mol}^{-1}$. (This is not the same as the value for $\Delta S_{\text{system}}^{\ominus}$ calculated in (a) which is at 298 K.)

(2)

- *(e) Use the magnitude and signs of the entropy changes to explain the effect of a temperature increase on the equilibrium constant of this endothermic reaction.

(2)

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(Total for Question 17 = 17 marks)



18 (a) Calculate the pH of 0.25 mol dm^{-3} hydrochloric acid.

(1)

(b) Propanoic acid, $\text{CH}_3\text{CH}_2\text{COOH}$, is a weak acid with $K_a = 1.3 \times 10^{-5} \text{ mol dm}^{-3}$ at 25°C .

(i) Write the expression for K_a for propanoic acid.

(1)

(ii) Calculate the pH of 0.25 mol dm^{-3} propanoic acid at 25°C .

(2)

(c) During a titration, 10 cm^3 0.10 mol dm^{-3} sodium hydroxide was added to 10 cm^3 of 0.25 mol dm^{-3} propanoic acid.

(i) Write an equation for the reaction which occurs. State symbols are **not** required.

(1)

(ii) At this point the titration mixture contains 1.5×10^{-3} moles of propanoic acid and 1.0×10^{-3} moles of propanoate ion.

Use your expression for K_a for propanoic acid to calculate the pH of the mixture.

(2)

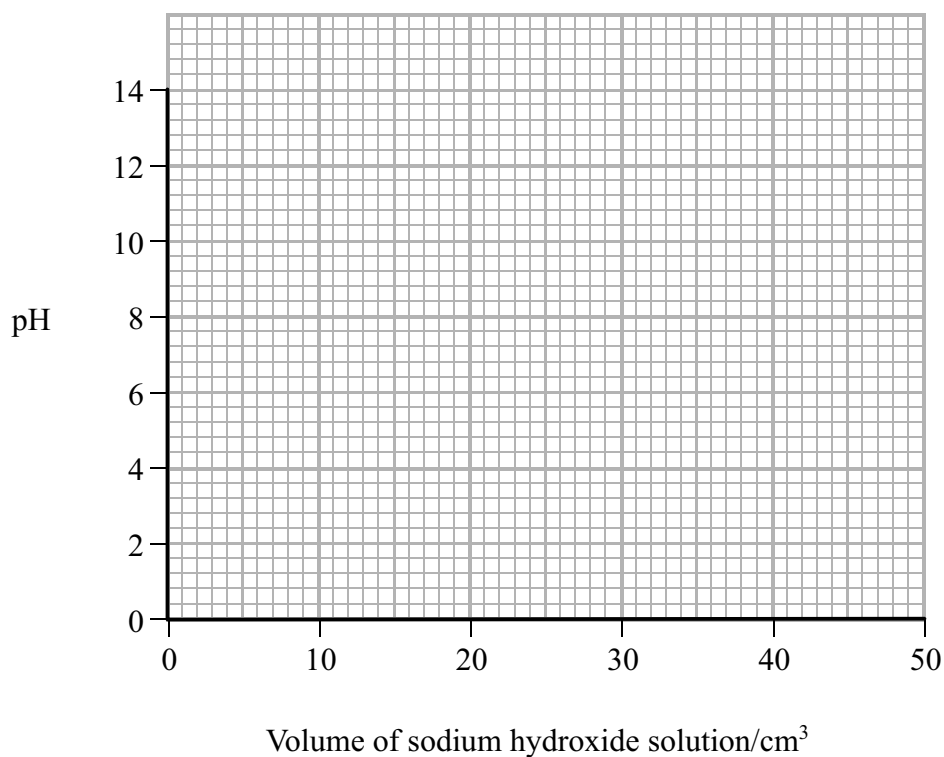


- *(iii) When a further small amount of 0.10 mol dm^{-3} sodium hydroxide is added in the titration, the pH changes very little. Explain why the pH change is small.

(3)

- (iv) Draw the titration curve showing the change in pH when 0.10 mol dm^{-3} sodium hydroxide is added to 10 cm^3 of 0.25 mol dm^{-3} propanoic acid until present in excess. The equivalence point is 25 cm^3 .

(3)



- (v) Explain, referring to your data booklet, whether bromocresol green would be a suitable indicator for this titration.

(2)

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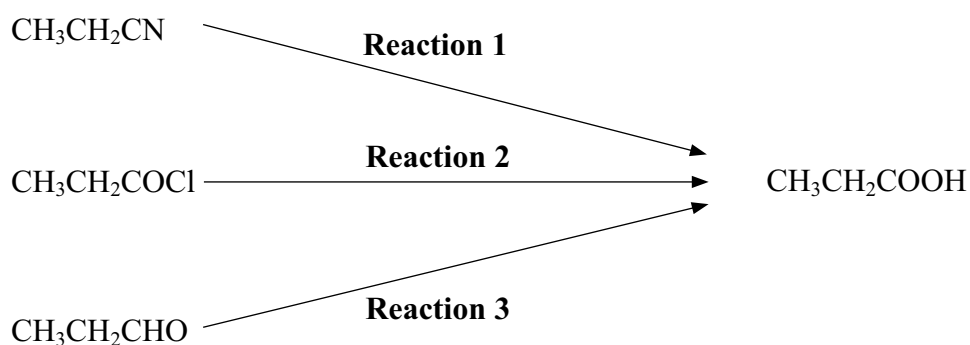
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- (d) Propanoic acid is produced in the reactions shown below.



- (i) Suggest a reagent which could be used to carry out **reaction 1**.

(1)

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- (ii) Write an equation for **reaction 2**. State symbols are **not** required.

(1)

- (iii) What would be observed if **reaction 3** was carried out using potassium dichromate(VI) and sulfuric acid?

(1)

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(e) What type of reagent would be used to convert propanoic acid to propan-1-ol?
Identify a suitable reagent for this reaction.

(2)

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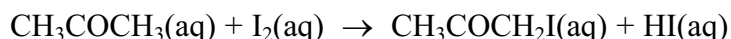
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(Total for Question 18 = 20 marks)



N 3 7 9 4 9 A 0 1 5 2 4

19 A student investigated the reaction between iodine and propanone in acidic conditions.



- 50 cm³ of 0.020 mol dm⁻³ iodine solution was measured into a flask.
- 25 cm³ of propanone and 25 cm³ of 1.0 mol dm⁻³ sulfuric acid were measured into a second flask.
- Several 10 cm³ samples of 0.5 mol dm⁻³ sodium hydrogencarbonate solution were placed in separate conical flasks.
- The mixture of propanone and sulfuric acid was added to the iodine, and a clock started.
- At two minute intervals, 10 cm³ of the reaction mixture was removed and added to one of the flasks containing sodium hydrogencarbonate solution.
- The contents of this flask were then titrated with 0.01 mol dm⁻³ sodium thiosulfate.

(a) Explain the purpose of adding the reaction mixture to the sodium hydrogencarbonate.

(2)

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(b) What indicator should be used in the titration?

(1)

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*(c) In this experiment the concentration of the iodine was 0.020 mol dm⁻³ and the concentrations of propanone and sulfuric acid were both 1.00 mol dm⁻³. Why was the iodine solution used much less concentrated than the propanone and sulfuric acid?

(2)

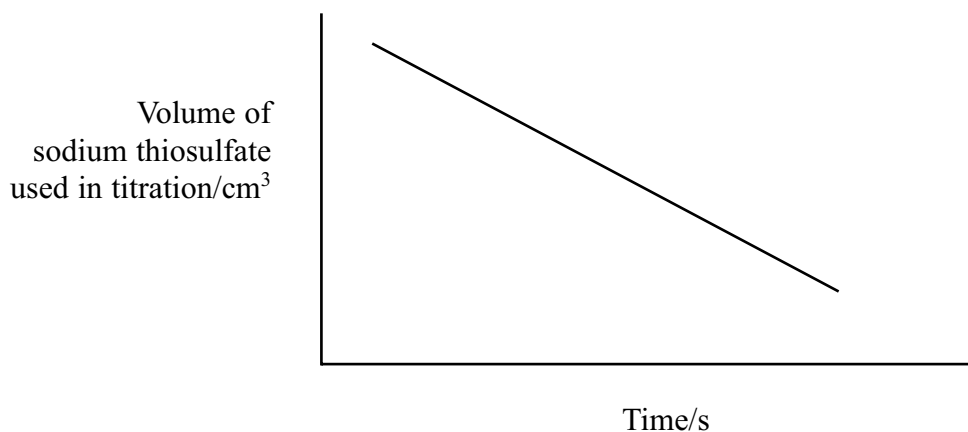
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(d) The shape of the graph obtained from the results of the experiment is shown below.



Use the graph to deduce the order of reaction with respect to iodine, explaining your reasoning.

(2)

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(e) The solutions used in this experiment could be measured using either measuring cylinders or pipettes.

Give **one** advantage of using a measuring cylinder and **one** advantage of using a pipette.

(2)

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- (f) In a further investigation, different volumes of sulfuric acid, propanone, iodine and water were mixed. The time taken for the mixture to go colourless was measured.

The experiments were repeated and the results below show average values for the rate of the reaction.

Expt	2 mol dm ⁻³ H ₂ SO ₄ /cm ³	2 mol dm ⁻³ propanone /cm ³	Water /cm ³	0.01 mol dm ⁻³ iodine /cm ³	Rate /mol dm ⁻³ s ⁻¹
1	20.0	8.0	0	4.0	8×10^{-5}
2	10.0	8.0	10.0	4.0	4×10^{-5}
3	20.0	4.0	4.0	4.0	4×10^{-5}

- (i) Explain why water is added in experiments 2 and 3.

(1)

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- (ii) Show how you would use the data in the table to deduce the order of reaction with respect to propanone and hydrogen ions. Write the rate equation for the reaction.

(3)

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(Total for Question 19 = 13 marks)

TOTAL FOR SECTION B = 50 MARKS



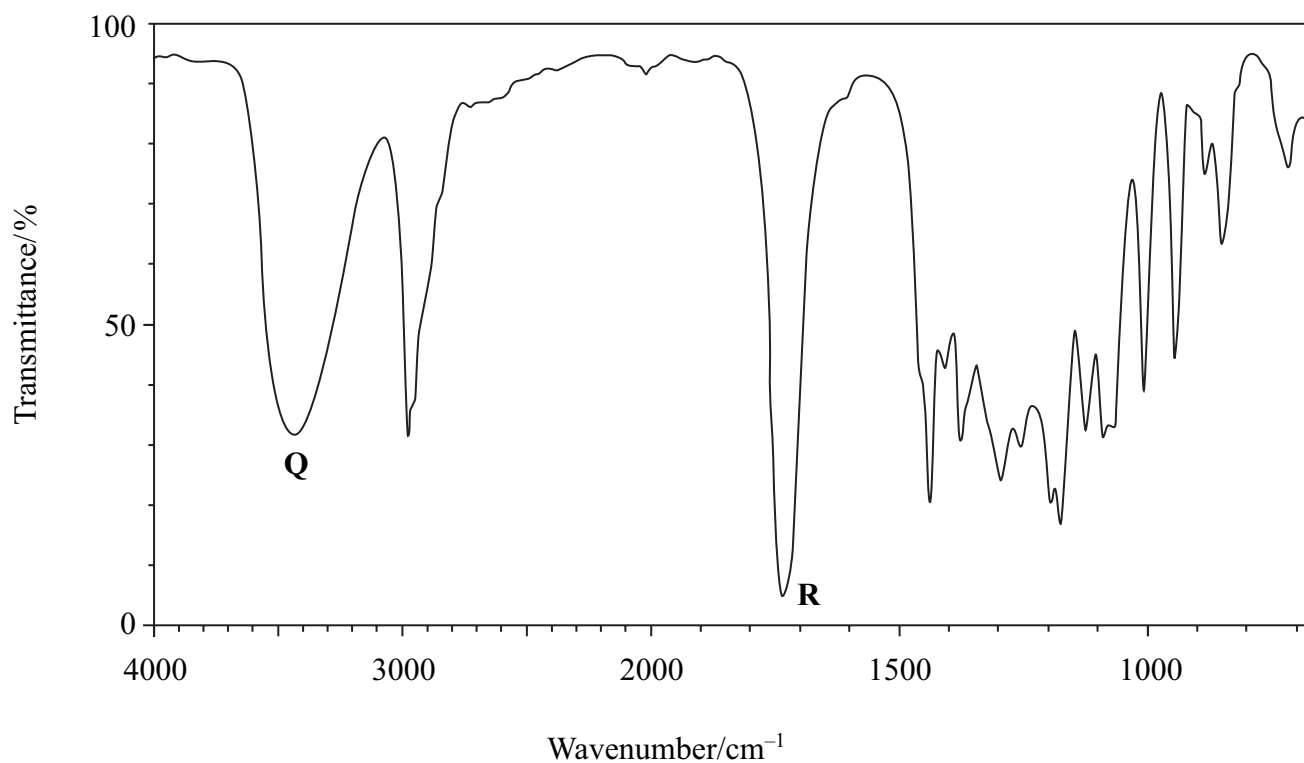
SECTION C

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

20 An organic compound **X** is an ester found in orange peel and has the molecular formula $C_5H_{10}O_3$.

(a) Identify the bonds responsible for the peaks labelled **Q** and **R** in the infrared spectrum of **X** shown below, referring to your data booklet.

(2)

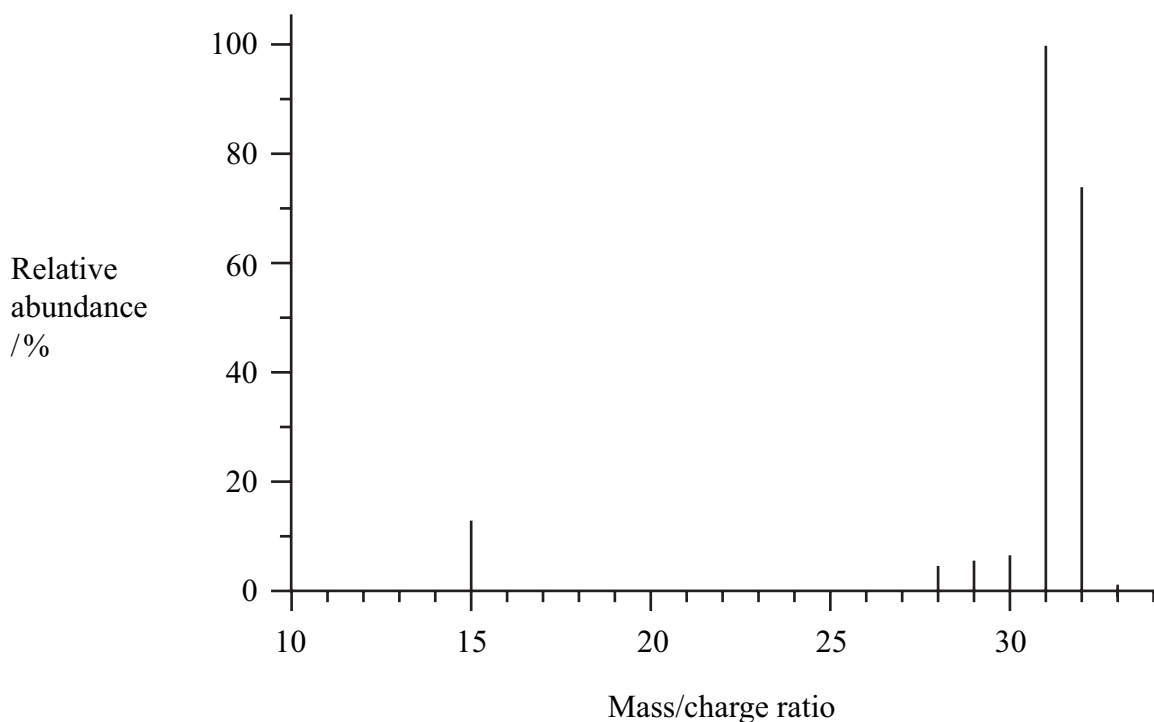


Q

R



- (b) **X** was heated under reflux with dilute sulfuric acid. The resulting mixture was distilled and a liquid **Y** was collected. The mass spectrum of **Y** is shown below.



- (i) Identify **Y**, by name or formula, using the information available. Use **two** pieces of data from the mass spectrum to support your answer.

(2)

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- (ii) The identity of **Y** could be confirmed using nmr spectroscopy. Predict the number of peaks in the low resolution proton nmr spectrum of **Y**. Give the chemical shift range for each peak, referring to your data booklet.

(2)

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- (c) A second product from the reaction of **X** with hydrochloric acid is **Z**, which has the molecular formula $C_4H_8O_3$.

What can you deduce about **Z** from the results of the following tests?

- (i) One mole of **Z** reacts with two moles of phosphorus(V) chloride, PCl_5 .

(1)

- (ii) When sodium carbonate solution is added to **Z**, effervescence is seen.

(1)

- (iii) **Z** is warmed gently with potassium dichromate(VI) and sulfuric acid. The organic product of the reaction gives a yellow precipitate with 2,4-dinitrophenylhydrazine (Brady's reagent) but does not react with Tollens' reagent.

(1)

- (iv) **Z** reacts with a solution of iodine in sodium hydroxide to produce a yellow precipitate with an antiseptic smell.

(1)

- (d) Use the results of these tests to deduce the structural formula of **Z** and hence the structural formula of **X**.

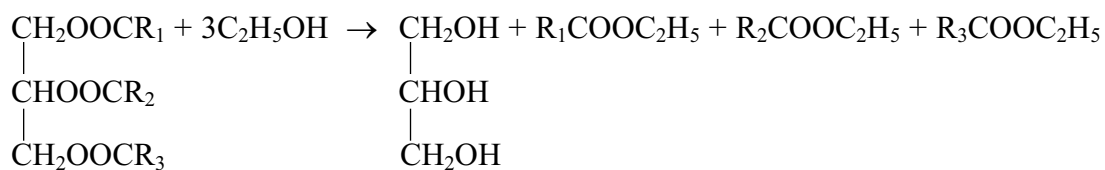
(2)

(Total for Question 20 = 12 marks)



N 3 7 9 4 9 A 0 2 1 2 4

- 21 The equation below shows the type of reaction which can be used in the production of biodiesel from vegetable oils.



- (a) (i) Name this type of reaction.

(1)

- (ii) Suggest why water must not be present when this reaction with ethanol is carried out.

(1)

- (b) Give **one** reason why biodiesel is considered a “greener” fuel than diesel produced from crude oil.

(1)



In chromatography, compounds are separated because of the difference in distribution between a mobile phase and a stationary phase.

Explain why this difference in distribution occurs, and contrast the phases used in gas chromatography (GC) and high performance liquid chromatography (HPLC).

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS



The Periodic Table of Elements

1	2	3	4	5	6	7	0 (18)										
1.0 H hydrogen 1																	4.0 He helium (18) 2
Key																	
relative atomic mass atomic symbol name atomic (proton) number																	
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)
6.9 Li lithium 3	9.0 Be beryllium 4	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	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	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	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	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	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																	

* Lanthanide series

* Actinide series

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



Mark Scheme (Results)

January 2011

GCE

GCE Chemistry (6CH04/01)

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January 2011

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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	D	1

Question Number	Correct Answer	Mark
3	D	1

Question Number	Correct Answer	Mark
4	B	1

Question Number	Correct Answer	Mark
5	C	1

Question Number	Correct Answer	Mark
6	C	1

Question Number	Correct Answer	Mark
7 (a)	A	1

Question Number	Correct Answer	Mark
7 (b)	A	1

Question Number	Correct Answer	Mark
7 (c)	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	D	1

Question Number	Correct Answer	Mark
12	D	1

Question Number	Correct Answer	Mark
13	A	1

Question Number	Correct Answer	Mark
14	B	1

Question Number	Correct Answer	Mark
15	C	1

Question Number	Correct Answer	Mark
16	A	1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a)	$\Delta S_{\text{system}} = (3 \times 2 \times 65.3 + 197.6) - (186.2 + 188.7)$ Correct data for CH ₄ and CO (186.2 and 197.6) (1) $= (+) 214.5 / 215 \text{ (J mol}^{-1} \text{ K}^{-1})$ $/ (+) 0.2145 / 0.215 \text{ kJ (mol}^{-1} \text{ K}^{-1})$ (1) Units must be shown if data has been converted to kJ Full marks (2) for correct answer without working Ignore sf except 1 Answer of -214.5 scores (1) Answer of +18.6 if entropy of H not doubled scores (1) Answer of -46.7 if entropy of H ₂ not tripled scores (1) ALLOW TE in second mark for minor error in data e.g. writing 63.5 instead of 65.3. No TE if data used is not entropy of compounds.	214 0.214	2
Question Number	Acceptable Answers	Reject	Mark
17 (b)	$(\Delta S_{\text{surroundings}}) = \frac{-\Delta H}{T}$ Expression or use of expression, $\frac{-206.1 \times (1000)}{298}$ (1) $= -691.6 \text{ J (mol}^{-1} \text{ K}^{-1}) / -0.6916 \text{ kJ (mol}^{-1} \text{ K}^{-1})$ (1) Ignore sf except 1		2

Question Number	Acceptable Answers	Reject	Mark
17 (c)	$\Delta S_{\text{total}} = (214.5 + (-691.6)) = -477.1 \text{ (J mol}^{-1} \text{ K}^{-1}) / -0.4771 \text{ (kJ mol}^{-1} \text{ K}^{-1}) \text{ (1)}$ ALLOW TE for answer to (a) plus answer to (b). If 214.5 is added to -0.69 no TE unless -0.69 is specified to be in joules. Ignore sf except 1 Negative / less than zero (so not spontaneous) / would be positive if spontaneous. (1) ALLOW “feasible” for spontaneous. If answer to calculation is positive, accept comment that it would be expected to be negative if not spontaneous	Addition of value in J to specified value in kJ Comments on kinetic stability	2

Question Number	Acceptable Answers	Reject	Mark										
*17 (d) (i)	$K_p = \frac{(p_{H_2})^3 \times (p_{CO})}{(p_{CH_4})(p_{H_2O})} \quad (1)$ 4 Correct partial pressures (3) <table border="1"><tr><td></td><td>CH₄</td><td>H₂O</td><td>CO</td><td>H₂</td></tr><tr><td>pp</td><td>0.25</td><td>0.25</td><td>0.375</td><td>1.125</td></tr></table> ALLOW partial pressures as fractions $K_p = \frac{(1.125)^3 \times (0.375)}{(0.25)(0.25)} = 8.54 \text{ atm}^2$ value of K_p (1) unit (1) (Stand alone mark) Correct calculation without working scores the 5 calculation marks. TE from K_p expression if inverted Ignore sf except 1 If any partial pressures are incorrect: Calculating total number of moles (6.4) (1) Calculating mole fractions (0.125, 0.125, 0.1875, 0.5625 if total number of moles is correct) (1) Multiplying mole fractions by total pressure (x 2 atm) (1) value of K_p (1) unit (1) (stand alone mark) ALLOW TE in value of K_p only from incorrect partial pressures, not using values in question as not using equilibrium moles If treated as a K_c calculation following K_p expression : K_p expression (1) units atm² (1) Max. mark (2)		CH ₄	H ₂ O	CO	H ₂	pp	0.25	0.25	0.375	1.125	Square brackets	6
	CH ₄	H ₂ O	CO	H ₂									
pp	0.25	0.25	0.375	1.125									

Question Number	Acceptable Answers	Reject	Mark
17 (d) (ii)	$\Delta S_{\text{total}} = (8.31 \ln 8.54) = (+)17.8 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ Accept any value that rounds to 17.8 TE from value in (i) K_p value of 87.48 (obtained by treating calculation in (i) as K_c) gives $\Delta S_{\text{total}} = 37.16 / 37.12$		1

Question Number	Acceptable Answers	Reject	Mark
17 (d) (iii)	$17.8 = 225 - \frac{206.1 \times 1000}{T} \quad (1)$ $T = \frac{(206.1 \times 1000)}{207.2} = 995 / 990 \text{ (K)} \quad (1)$ Correct answer with no working shown scores 2 Correct method with wrong answer or missing 10^3 scores 1 TE from (ii) K_p value of 87.48 gives $T = 1097$ OR If ΔS_{total} is taken as zero $0 = 225 - \frac{206.1 \times 1000}{T} \quad (1)$ $T = 916 \text{K} \quad (1)$ K_p value of 87.48 gives $T = 916$ Ignore sf except 1		2

Question Number	Acceptable Answers	Reject	Mark
*17 (e)	$\Delta S_{\text{surroundings}} / \frac{-\Delta H}{T}$ becomes less negative making ΔS_{total} more positive (as T increases) OR $\Delta S_{\text{surroundings}} / \frac{-\Delta H}{T}$ becomes less negative making ΔS_{total} greater (as T increases) OR (magnitude of) $\Delta S_{\text{surroundings}}$ becomes less / lower making ΔS_{total} more positive / greater (as T increases) (1) Because ΔS_{total} increases equilibrium constant increases (1) OR value of ΔS_{total} at new temperature is more than at 298K (1) (must be clear that the two ΔS_{total} values at the different temperatures have been considered) Because ΔS_{total} increases equilibrium constant increases (1)	Le Chatelier statements without reference to entropy changes Just 'as temperature increases ΔS_{total} increases'	2

Question Number	Acceptable Answers	Reject	Mark
18 (a)	$\text{pH} = (-\log 0.25) = 0.602 / 0.60 / 0.6$ Ignore significant figures		1

Question Number	Acceptable Answers	Reject	Mark
18 (b) (i)	$(K_a =) \frac{[\text{H}^+][\text{CH}_3\text{CH}_2\text{COO}^-]}{[\text{CH}_3\text{CH}_2\text{COOH}]}$ ALLOW $[\text{H}_3\text{O}^+]$ for $[\text{H}^+]$ ALLOW C_2H_5 for CH_3CH_2 ALLOW $\frac{[\text{H}^+][\text{A}^-]}{[\text{HA}]}$ if HA and A^- identified	Wrong / missing charge on $\text{CH}_3\text{CH}_2\text{COO}^-$ $K_a = \frac{[\text{H}^+]^2}{[\text{CH}_3\text{CH}_2\text{COOH}]}$ unless full expression also given	1

Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	$1.3 \times 10^{-5} = \frac{[\text{H}^+]^2}{0.25}$ / rearrangement of this expression (1) $([\text{H}^+] = 1.8 \times 10^{-3})$ $\text{pH} = 2.74$ (1) Correct answer with no working scores (2) No TE for incorrect $[\text{H}^+]$ Ignore significant figures except 1 Minimum of 1 decimal place needed		2

Question Number	Acceptable Answers	Reject	Mark
18 (c) (i)	$\text{CH}_3\text{CH}_2\text{COOH} + \text{NaOH} \rightarrow \text{CH}_3\text{CH}_2\text{COO}^{(-)}\text{Na}^{(+)} + \text{H}_2\text{O}$ OR $\text{CH}_3\text{CH}_2\text{COOH} + \text{OH}^- \rightarrow \text{CH}_3\text{CH}_2\text{COO}^- + \text{H}_2\text{O}$ Accept $\text{CH}_3\text{CH}_2\text{CO}_2\text{H}$, $\text{C}_2\text{H}_5\text{COOH}$, $\text{C}_2\text{H}_5\text{CO}_2\text{H}$	Equations for ethanoic acid	1

Question Number	Acceptable Answers	Reject	Mark
18 (c) (ii)	$1.3 \times 10^{-5} = \frac{[\text{H}^+][5 \times 10^{-2}]}{[7.5 \times 10^{-2}]} \quad (\text{concentration ratio})$ OR $1.3 \times 10^{-5} = \frac{[\text{H}^+](1 \times 10^{-3})}{(1.5 \times 10^{-3})} \quad (\text{ratio by moles})$ (ratio by moles allowed as volumes acid and salt equal) (1) ($[\text{H}^+] = 1.95 \times 10^{-5}$) pH = 4.7 / 4.7099654 (1) Second mark dependent on first Correct answer with or without working (2) OR $\text{pH} = \text{pK}_a - \log \frac{(1.5 \times 10^{-3})}{1 \times 10^{-3}}$ OR $\text{pH} = \text{pK}_a - \log \frac{(7.5 \times 10^{-2})}{5 \times 10^{-2}} \quad (1)$ pH = 4.7 (1) Correct answer with or without working (2) Accept any value which rounds to 4.7		2

Question Number	Acceptable Answers	Reject	Mark
*18 (c) (iii)	Mixture is a buffer (1) EITHER OH⁻ combines with H⁺ in solution (1) Propanoic acid dissociates to replace H⁺ (1) <i>Correct equations could gain these marks</i> OR OH⁻ reacts with propanoic acid (1) <i>Correct equation could gain this mark</i> Significant quantities of weak acid and salt are both present /ratio of acid and salt does not change (1) ALLOW a reservoir of weak acid and salt are present: Allow conjugate base for salt	NaOH combines	3

Question Number	Acceptable Answers	Reject	Mark
18 (c) (iv)	S-shaped curve, vertical at 25 cm³ (with kink at start) (1) Starting at pH 2-3 (TE from (b)(ii), finishing at pH 12 -13 (1) Vertical section between 3 and 6 units high centred round a pH of between 8 and 9 (1) Vertical section should not extend over more than $\pm 2.5\text{cm}^3$ This section should start between 5.5 and 7.5 and finish between 9.5 and 11.5 but do not penalise for very small differences. Reverse curve maximum 2		3

Question Number	Acceptable Answers	Reject	Mark
18 (c) (v)	Either Need indicator changing in vertical region of curve / need indicator changing where pH changes sharply / bromocresol green changes before the vertical region (1) Not bromocresol green which changes at 3.8 - 5.4 (1) OR $pK_{in} \pm 1$ must be in vertical section / sharply changing section (1) Not bromocresol green because pK_{in} is 4.7 (1) TE from curve with vertical section including pH 3.7 - 5.7	Just “the equivalence point is outside the bromocresol green range”	2

Question Number	Acceptable Answers	Reject	Mark
18 (d) (i)	Dilute acid / dilute strong named acid or formula / NaOH(aq) followed by dilute acid / water plus dilute acid / water plus H^+	NaOH alone water any weak acid concentrated sulfuric acid HCN acid hydrolysis alone	1

Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	$CH_3CH_2COCl + H_2O \rightarrow CH_3CH_2COOH + HCl$ / $C_2H_5COCl + H_2O \rightarrow C_2H_5COOH + HCl$ Accept displayed formula	Equations with NaOH or OH^-	1

Question Number	Acceptable Answers	Reject	Mark
18 (d) (iii)	Colour change orange to green / blue		1

Question Number	Acceptable Answers	Reject	Mark
18 (e)	Reducing agent /Reduction (of the acid) occurs (1) Li Al H₄ / lithium tetrahydridoaluminate / lithium aluminium hydride (1) Allow minor error in name if correct formula is given Ignore solvent ALLOW nucleophile AND H⁻ for 1 mark	Lithal without correct name or formula	2

Question Number	Acceptable Answers	Reject	Mark
19 (a)	Quenches reaction / stops reaction / slows reaction / freezes reaction (1) EITHER by neutralizing the acid / removing the acid / neutralizing the catalyst / removing the catalyst OR So that the acid does not react with the thiosulfate (1)	By neutralizing HI Just “by diluting the reaction mixture” just “by neutralizing the reaction mixture”	2

Question Number	Acceptable Answers	Reject	Mark
19 (b)	Starch (solution)		1

Question Number	Acceptable Answers	Reject	Mark
19 (c)	First mark So that [propanone] and [acid] are (virtually) constant OR so that the [propanone] and $[H^+]$ do not affect the rate OR Propanone and acid are in excess so changes in concentration don't affect rate (1) Second mark And therefore rate changes would only depend on [iodine] OR so that the overall order is not determined ALLOW [Iodine] is the limiting factor (1) NOTE "so that only the $[I_2]$ changes" scores (2) "so that only the I_2 concentration changes" scores (2) "so that only the I_2 changes" scores (1)	Propanone and acid are in excess, without reference to further comments	2

Question Number	Acceptable Answers	Reject	Mark
19 (d)	Zero order (1) (Gradient =) rate is constant / I_2 (concentration) doesn't affect rate / rate of change of I_2 (concentration) doesn't change with time (1) Mark independently	Just 'straight line' Or just 'gradient is constant' [Thiosulfate] or volume of Thiosulfate is proportional to time without reference to iodine Reference to half life $[I_2]$ is proportional to rate	2

Question Number	Acceptable Answers	Reject	Mark
19 (e)	Measuring cylinder quicker / Measuring cylinder can measure a variety of volumes (1) ALLOW Measuring cylinder can be plastic so unbreakable Comment on lower cost of measuring cylinder if qualified with a reason Pipette more accurate / (graduated) pipette more precise / pipette can be used to extract samples from a reaction mixture (for titration) (1)	Just “Measuring cylinder easier to use” Easier to clean Measuring cylinder can be used for large volumes Pipette more reliable Ignore references to easier	2

Question Number	Acceptable Answers	Reject	Mark
19 (f) (i)	To keep (total) volume constant / to make the (total) volume 32 cm ³ / to make concentrations proportional to volume of reactant	To keep concentrations constant	1

Question Number	Acceptable Answers	Reject	Mark
19 (f) (ii)	First order wrt propanone with explanation (1) First order wrt hydrogen ions/ sulfuric acid, with explanation (1) Explanation can be in terms of experiments 1 and 3 (propanone) or 1 and 2 (acid) and can be in terms of concentration or volume $\text{Rate} = k[\text{CH}_3\text{COCH}_3][\text{H}^+][\text{I}_2]^0$ / $\text{Rate} = k[\text{CH}_3\text{COCH}_3][\text{H}_2\text{SO}_4][\text{I}_2]^0$ (1) ALLOW names of propanone and sulfuric acid in place of formulae Ignore case of k in rate equation Ignore order wrt iodine even if wrong Third mark is consequential if incorrect orders of propanone and acid given.	Expressions without rate or k Expressions with K_c R / r for rate	3

TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
20 (a)	Q: O-H ALLOW OH — O — H (1) R: C=O ALLOW — C = O — C = O (1) IGNORE names ACCEPT answers written on spectrum	Just 'alcohol' — OH Just 'carbonyl' - C O C-O	2

Question Number	Acceptable Answers	Reject	Mark
20 (b) (i)	Y = methanol / CH₃OH (1) Any two of the following: Molecular ion / M⁺ / M_r / CH₃OH⁺ / methanol = 32 CH₃⁺ = 15 CH₃O⁺ / CH₂OH⁺ = 31 CHOH⁺ / CH₂O⁺ = 30 COH⁺ = 29 CO⁺ = 28 (1) Charges not required TE in second mark for two correct possible peaks from an incorrect compound.		2

Question Number	Acceptable Answers	Reject	Mark
20 (b) (ii)	Two (1) This mark may be scored if two shifts are given. Any two shifts correctly identified: -OH at 2.0-4.0 / any value in this range H-C-O at 3.0- 4.2 / any value in this range H in CH₃ OH at 3.39 (ppm) (1) Allow TE for ethanol with three peaks (1) and three correct shift values: -OH at 2.0-4.0 / any value in this range H-C-O at 3.0- 4.2 / any value in this range CH in an alkane at 0.1-1.9 (1)	CH in an alkane at 0.1-1.9 Just CH₃ OH at 3.39	2

Question Number	Acceptable Answers	Reject	Mark
20 (c) (i)	Z contains two -OH/ one alcohol + one acid ALLOW two alcohol groups / is a diol		1

Question Number	Acceptable Answers	Reject	Mark
20 (c) (ii)	Z is an acid / contains -COOH / contains -CO₂H/ contains a carboxylic acid group / contains H⁺		1

Question Number	Acceptable Answers	Reject	Mark
20 (c) (iii)	Z is a secondary alcohol/ a ketone is formed from Z / Z contains $\begin{array}{c} \\ -\text{C}-\text{OH} \\ \\ \text{H} \end{array}$ (1)	Z is a ketone	1

Question Number	Acceptable Answers	Reject	Mark
20 (c) (iv)	(Iodoform produced) so Z contains CH₃ CH(OH)- TE if Z is identified as a ketone in (iii): Z contains CH₃ C=O / Z is a methyl ketone		1

Question Number	Acceptable Answers	Reject	Mark
20 (d)	Answers will be based on several pieces of information (molecular formula, products of ester hydrolysis, answers to (c)) which may be contradictory if errors have been made. ALLOW TE marks for formulae which are chemically possible (ie no 5 bonded carbons etc) and based on most of the deductions but not necessarily all. Z is $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{COOH}$ (1) Stand alone mark ALLOW TE for an acid with OH in wrong position in Z if oxidation product identified as aldehyde TE for Z = $\text{CH}_3\text{COCH}_2\text{COOH}$ if identified as ketone in (iii) X is $\text{CH}_3\text{CH}(\text{OH})\text{CH}_2\text{COOCH}_3$ (1) Stand alone mark TE for a methyl ester of Z		2

Question Number	Acceptable Answers	Reject	Mark
21 (a) (i)	Transesterification Ethanol transesterification	Substituted esterification	1

Question Number	Acceptable Answers	Reject	Mark
21 (a) (ii)	To prevent hydrolysis/ to stop fatty acids forming / to stop breakdown of esters / water reacts with esters/ water is a better nucleophile than ethanol	To dilute ethanol Ethanol would react with water A reaction would occur (unspecified)	1

Question Number	Acceptable Answers	Reject	Mark
21 (b)	(Vegetable) Fats/ oils are renewable (crude oil is not) / biodiesel comes from a renewable source / doesn't use up fossil fuel resources/ carbon footprint is less / (closer to) carbon neutral / growing vegetables absorb CO₂ If more than one answer is given, and one is incorrect, no mark Ignore comments on biodegradability	Just "made from plants" Just "crude oil is not sustainable" Less polluting produces less greenhouse gases / less CO₂ Burns more cleanly Requires less energy for production	1

Question Number	Acceptable Answers	Reject	Mark
21 (c)	Substances to be separated have different (forces of) attraction to / affinity for / solubilities in / adsorption to one or both of the mobile and stationary phases OWTTE (1) ALLOW absorption GC: mobile phase a (inert / unreactive) gas OR GC: mobile phase nitrogen / helium / argon / other named inert gas (1) GC: Stationary phase a liquid (on an (inert) solid) / a solid (1) HPLC: stationary phase a solid / silica (1) HPLC: mobile phase a liquid (1)	Different retention times without a reason why Different volatilities Different masses Different reactivity Different reactions Different interactions	5

TOTAL FOR SECTION C = 20 MARKS

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Write your name here	
Surname	Other names
Centre Number	Candidate Number
Edexcel GCE Chemistry Advanced Unit 4: General Principles of Chemistry I – Rates, Equilibria and Further Organic Chemistry (including synoptic assessment)	
Wednesday 15 June 2011 – Afternoon Time: 1 hour 40 minutes	Paper Reference 6CH04/01
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 ►

P38482A

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7/7/5/5/3/



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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 ☐.

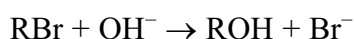
- 1 Which of the following methods would **not** be suitable for measuring the rate of the reaction between methanoic acid and bromine?



- ☐ A Colorimetry
- ☐ B Measuring change in electrical conductivity
- ☐ C Quenching samples and titrating with acid
- ☐ D Measuring change in pressure

(Total for Question 1 = 1 mark)

- 2 The equation below shows the hydrolysis of a bromoalkane.



For a particular bromoalkane, the rate equation is

$$\text{rate} = k[\text{RBr}]$$

The bromoalkane, RBr, is most likely to be

- ☐ A CH_3Br
- ☐ B $\text{CH}_3\text{CH}_2\text{Br}$
- ☐ C $(\text{CH}_3)_3\text{CCH}_2\text{Br}$
- ☐ D $(\text{CH}_3)_3\text{CBr}$

(Total for Question 2 = 1 mark)

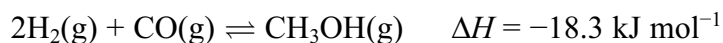
- 3 A decrease in the entropy of the system, ΔS_{system} , occurs when

- ☐ A water freezes.
- ☐ B water boils.
- ☐ C water reacts with sodium.
- ☐ D water reacts with ethanoyl chloride.

(Total for Question 3 = 1 mark)



- 4 Methanol is produced in the equilibrium reaction



Addition of more hydrogen to the equilibrium mixture at constant temperature

- ☐ A increases the equilibrium yield of methanol.
- ☐ B decreases the equilibrium yield of methanol.
- ☐ C increases the value of K_p .
- ☐ D decreases the value of K_p .

(Total for Question 4 = 1 mark)

- 5 The equation for the equilibrium between $\text{NO}_2(\text{g})$ and $\text{N}_2\text{O}_4(\text{g})$ can be written in two ways.



or

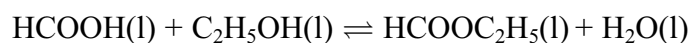


Which expression is correct?

- ☐ A $K_c = K'_c$
- ☐ B $K_c = (K'_c)^2$
- ☐ C $K_c = 2(K'_c)$
- ☐ D $K_c = \frac{1}{2}K'_c$

(Total for Question 5 = 1 mark)

- 6 4.0 mol of methanoic acid are reacted with 6.0 mol of ethanol.



The equilibrium mixture contains 3.0 mol of HCOOC_2H_5 .

The equilibrium constant, K_c , for the reaction is

- ☐ A 0.33
- ☐ B 1.0
- ☐ C 3.0
- ☐ D 4.0

(Total for Question 6 = 1 mark)



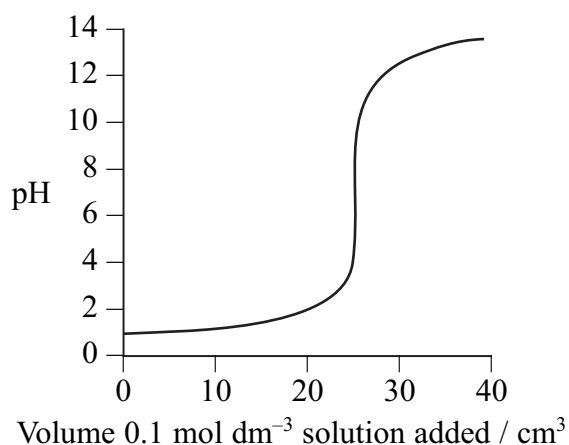
- 7 A solution of hydrochloric acid has pH 3.0. When it is made 10 times more dilute, the pH is

- ☐ A 0.3
☐ B 2.0
☐ C 4.0
☐ D 13.0

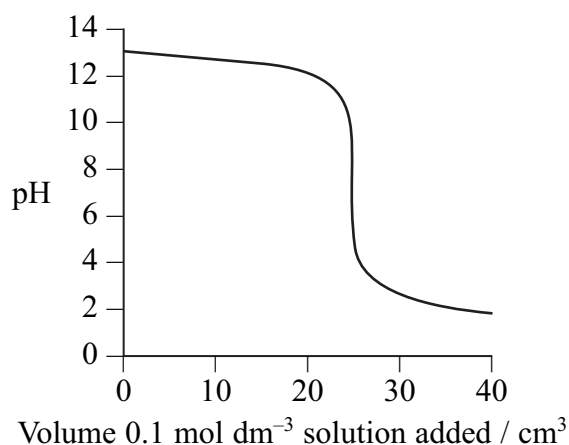
(Total for Question 7 = 1 mark)

- 8 The titration curves below were obtained using different acids and bases, each with concentration 0.1 mol dm^{-3} .

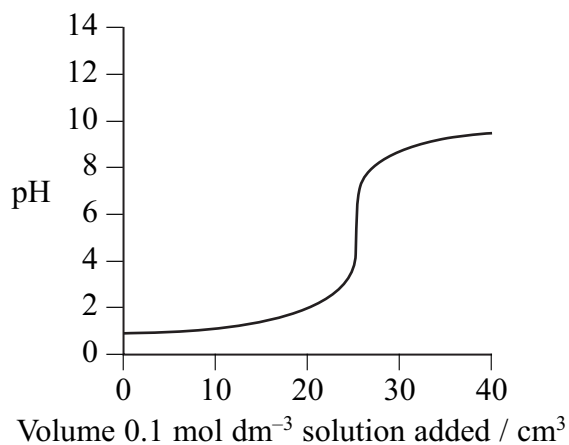
A



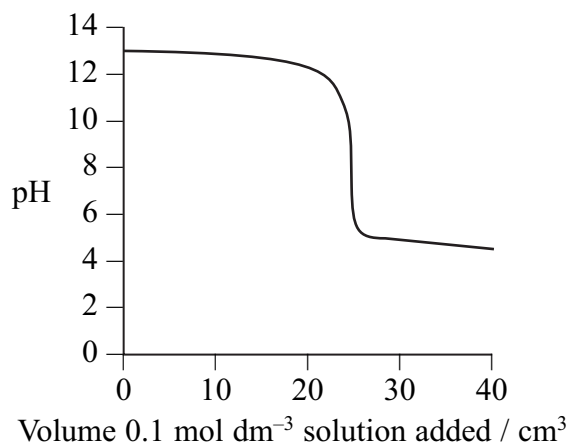
B



C



D



(a) Which curve is produced by adding ammonia to 25 cm³ of hydrochloric acid?

(1)

☐ A

☐ B

☐ C

☐ D

(b) Which curve is produced by adding ethanoic acid to 25 cm³ of sodium hydroxide?

(1)

☐ A

☐ B

☐ C

☐ D

(c) An indicator with pK_{In} 8.5 is suitable for the following titrations.

(1)

☐ A Titrations A and B only.

☐ B Titrations A, B and D only.

☐ C Titration C only.

☐ D Titrations A, B, C and D.

(Total for Question 8 = 3 marks)

9 Ethanoic acid is **not** a product in the reaction of

☐ A ethanal with lithium tetrahydridoaluminate.

☐ B ethanoyl chloride with water.

☐ C ethyl ethanoate with dilute sulfuric acid.

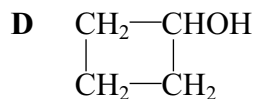
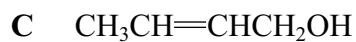
☐ D ethanol refluxed with potassium dichromate(VI) and sulfuric acid.

(Total for Question 9 = 1 mark)

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



10 This question is about four compounds with molecular formula C_4H_8O .



(a) The compounds which react when heated with a mixture of potassium dichromate(VI) and sulfuric acid are

(1)

☐ A compounds A, B and C.

☐ B compounds A, B and D.

☐ C compounds A, C and D.

☐ D compounds B, C and D.

(b) The compound which produces a yellow precipitate when heated with a mixture of iodine and sodium hydroxide is

(1)

☐ A compound A.

☐ B compound B.

☐ C compound C.

☐ D compound D.

(c) There would **not** be a significant peak at mass/charge ratio of 15 in the mass spectrum of

(1)

☐ A compound A.

☐ B compound B.

☐ C compound C.

☐ D compound D.

(Total for Question 10 = 3 marks)



11 The following tests can be carried out on organic compounds.

- A Warm with 2,4-dinitrophenylhydrazine.
- B Warm with Fehling's or Benedict's solution.
- C Add solid sodium carbonate.
- D Add phosphorus(V) chloride, PCl_5 .

(a) Which test would give a positive result with propanoic acid but not with propan-1-ol?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(b) Which test would give a positive result with propanoic acid **and** with propan-1-ol?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(c) Which test would give a positive result with propanal but not with propanone?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

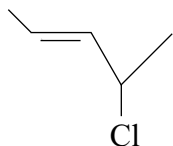
(Total for Question 11 = 3 marks)

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

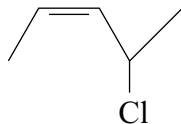


12 Which of the following compounds is a *Z* isomer **and** contains a chiral carbon atom?

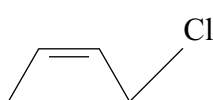
☐ A



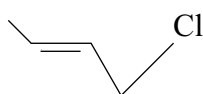
☐ B



☐ C



☐ D



(Total for Question 12 = 1 mark)

13 Which of the following statements about ethanoyl chloride is **not** correct?

☐ A It reacts with ammonia to make an amine.

☐ B It reacts with an amine to make an amide.

☐ C It reacts with an alcohol to make an ester.

☐ D It reacts with water to make an organic acid.

(Total for Question 13 = 1 mark)

14 In gas chromatography, mixtures are passed through a long tube containing a liquid as the stationary phase. The mixtures are separated into their components because the components differ in

☐ A relative molecular mass.

☐ B melting temperature.

☐ C volatility.

☐ D force of attraction to the liquid.

(Total for Question 14 = 1 mark)

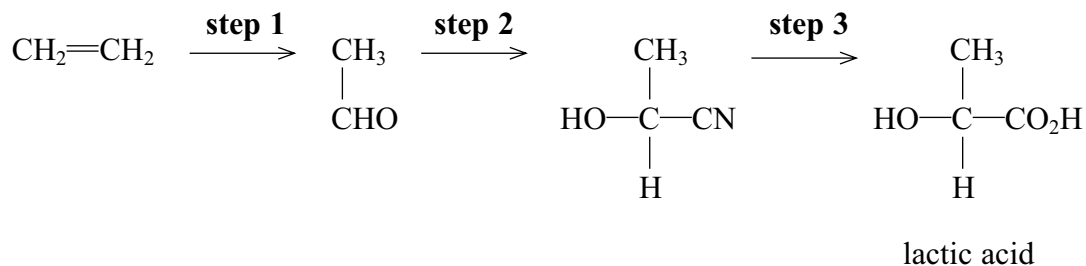
TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

15 A sequence of reactions for the production of lactic acid is shown below.



(a) (i) Name the type and mechanism of the reaction in **step 2**.

(2)

(ii) Which **two** substances need to be added to ethanal to carry out the reaction in **step 2**?

(2)

(iii) Give the mechanism for the reaction in **step 2**, using curly arrows to show movements of electron pairs.

(3)



*(iv) The product of **step 2** is not optically active even though it has a chiral carbon atom in its formula. Explain, by reference to the mechanism, the reason for the lack of optical activity.

(2)

(b) What reactant, or combination of reactants, is needed to carry out **step 3**?

(1)

(c) (i) What is the systematic name of lactic acid?

(1)

(ii) Lactic acid molecules can combine to form a biodegradable polymer, poly(lactic acid) or PLA. Draw a section of the polymer with **two** units of the polymer chain and showing all bonds.

(1)

(iii) Suggest why PLA is biodegradable.

(1)



- (iv) Lactic acid can be prepared from ethene as shown in the scheme. Lactic acid also forms when milk turns sour.

Suggest **one** reason why it would be advantageous to make lactic acid from milk rather than from ethene.

(1)

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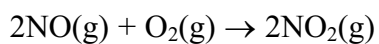
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(Total for Question 15 = 14 marks)



16 Nitrogen(IV) oxide, NO_2 , is a brown gas which is a pollutant in air. It is produced in the reaction below.



- (a) The table below shows the results of a series of experiments to measure the rate of this reaction at 298 K.

Experiment number	Initial concentration / mol dm^{-3}		Initial rate / $\text{mol dm}^{-3} \text{s}^{-1}$
	$[\text{O}_2(\text{g})]$	$[\text{NO}(\text{g})]$	
1	0.0050	0.0125	5.10×10^{-4}
2	0.0100	0.0125	10.2×10^{-4}
3	0.0100	0.0250	40.8×10^{-4}

- (i) State, with reasons, the order of reaction with respect to oxygen and the order of reaction with respect to nitrogen(II) oxide, NO.

(2)

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(ii) Write the rate equation for the reaction.

(1)

(iii) Calculate the value of the rate constant. Include units in your answer.

(2)

(b) Nitrogen(IV) oxide in air reacts with carbon monoxide in car exhausts. The following two-step reaction mechanism has been suggested.

Step 1: $2\text{NO}_2(\text{g}) \rightarrow \text{NO}(\text{g}) + \text{NO}_3(\text{g})$ Slow

Step 2: $\text{NO}_3(\text{g}) + 2\text{CO}(\text{g}) \rightarrow \text{NO}(\text{g}) + 2\text{CO}_2(\text{g})$ Fast

(i) Write the equation for the overall reaction which takes place.

(1)

(ii) The overall reaction is second order. Suggest a rate equation for this reaction, justifying your answer.

(2)

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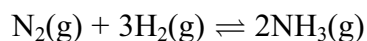
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(Total for Question 16 = 8 marks)



17 Ammonia is manufactured using the reaction



- (a) (i) Calculate $\Delta S_{\text{system}}^\ominus$ for this reaction at 298 K. Give your answer in $\text{J mol}^{-1} \text{K}^{-1}$ and include a sign. You will need to refer to your data booklet.

[Note that the standard molar entropy values for gaseous diatomic elements are given for half a mole of molecules, and not per mole of molecules
eg entropy for 1 mol of N_2 is $2 \times 95.8 \text{ J mol}^{-1} \text{K}^{-1}$.]

(2)

- (ii) Using ideas about disorder, explain whether the sign of your answer to (a)(i) is as expected.

(2)

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(b) At 700 K, the enthalpy change for this reaction, $\Delta H = -110.2 \text{ kJ mol}^{-1}$.

- (i) Calculate the entropy change of the surroundings, $\Delta S_{\text{surroundings}}$, at 700 K. Include a sign and units in your answer.

(2)



- (ii) Calculate ΔS_{system} for this reaction at 700 K. At this temperature the total entropy change, $\Delta S_{\text{total}} = -78.7 \text{ J K}^{-1} \text{ mol}^{-1}$. Include a sign and units in your answer.

(1)

- (iii) What does the value of ΔS_{total} , which is $-78.7 \text{ J K}^{-1} \text{ mol}^{-1}$ at 700 K, indicate about the relative proportions of nitrogen, hydrogen and ammonia at equilibrium?

(1)

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- (c) A mixture of nitrogen, hydrogen and ammonia is at equilibrium at 150 atm. The partial pressures of nitrogen and ammonia in the mixture are 21 atm and 36 atm respectively.

- (i) Write an expression for the equilibrium constant, K_p , for the formation of ammonia, in terms of partial pressures for this reaction, and calculate its value at 700 K. Include units in your answer.

(4)



- (ii) In the manufacture of ammonia, pressures of between 100 and 250 atm are used. State and explain **one** advantage, in terms of the yield of ammonia, of using a pressure above 100 atm.

(1)

- *(iii) In the manufacture of ammonia, a temperature of about 700 K is used.

For this exothermic reaction how does $\Delta S_{\text{surroundings}}$ change as temperature increases?

Explain how this change affects the value of ΔS_{total} and the equilibrium constant as temperature increases.

Hence explain the disadvantage of using a temperature higher than 700 K.

(4)

- (iv) Suggest **one** advantage of using a temperature higher than 700 K.

(1)

(Total for Question 17 = 18 marks)



18 Methanoic acid, ethanoic acid and iodic(I) acid, HIO_3 , are all weak acids.

- (a) The values of the acid dissociation constant, K_a , for methanoic and ethanoic acid at 298 K are given below. Iodic(I) acid has a $\text{p}K_a$ of 10.64. Complete the table by calculating the value of K_a for iodic(I) acid.

(1)

Acid	$K_a / \text{mol dm}^{-3}$
methanoic acid	1.6×10^{-4}
ethanoic acid	1.7×10^{-5}
iodic(I) acid	

- (b) (i) Write the expression for K_a for methanoic acid, HCOOH .

(1)

- (ii) Calculate the pH of a solution of methanoic acid with concentration 0.50 mol dm^{-3} at 298 K.

(3)

- (iii) State **one** of the assumptions you have made when calculating the pH in (ii).

(1)

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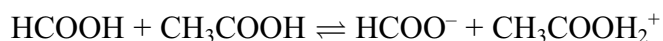
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(c) The following equilibrium occurs in a mixture of pure methanoic and ethanoic acids.

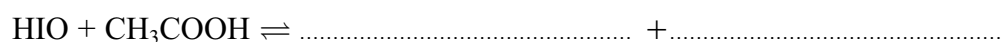


(i) Give the formulae of the two Brønsted-Lowry acids in this equilibrium.

(1)

(ii) Write an equation showing the products of the equilibrium which is set up when iodic(I) acid is mixed with ethanoic acid.

(1)



(d) A shampoo is buffered by the addition of a mixture of methanoic acid and sodium methanoate.

The pH of this shampoo is 4.9. Calculate the hydrogen ion concentration in the shampoo, and hence the ratio of methanoate ions to methanoic acid.

(2)

(Total for Question 18 = 10 marks)

TOTAL FOR SECTION B = 50 MARKS



SECTION C

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

- 19 The chemical **X** is an ester with formula $\text{CH}_3\text{COOC}(\text{CH}_3)_3$ which occurs in raspberries and pears. It can be prepared in the laboratory by refluxing ethanoic acid with an alcohol in the presence of a catalyst.

(a) Name the alcohol and catalyst which would be used to make **X**.

(2)

Alcohol

Catalyst

- (b) After refluxing, the resulting mixture is distilled to give an impure product containing **X**. The impure product is washed several times with sodium carbonate solution and then dried.

(i) Name the piece of equipment in which the impure product would be washed.

(1)

(ii) What is the purpose of washing the impure product with sodium carbonate solution?

(1)

(iii) Name a suitable drying agent.

(1)

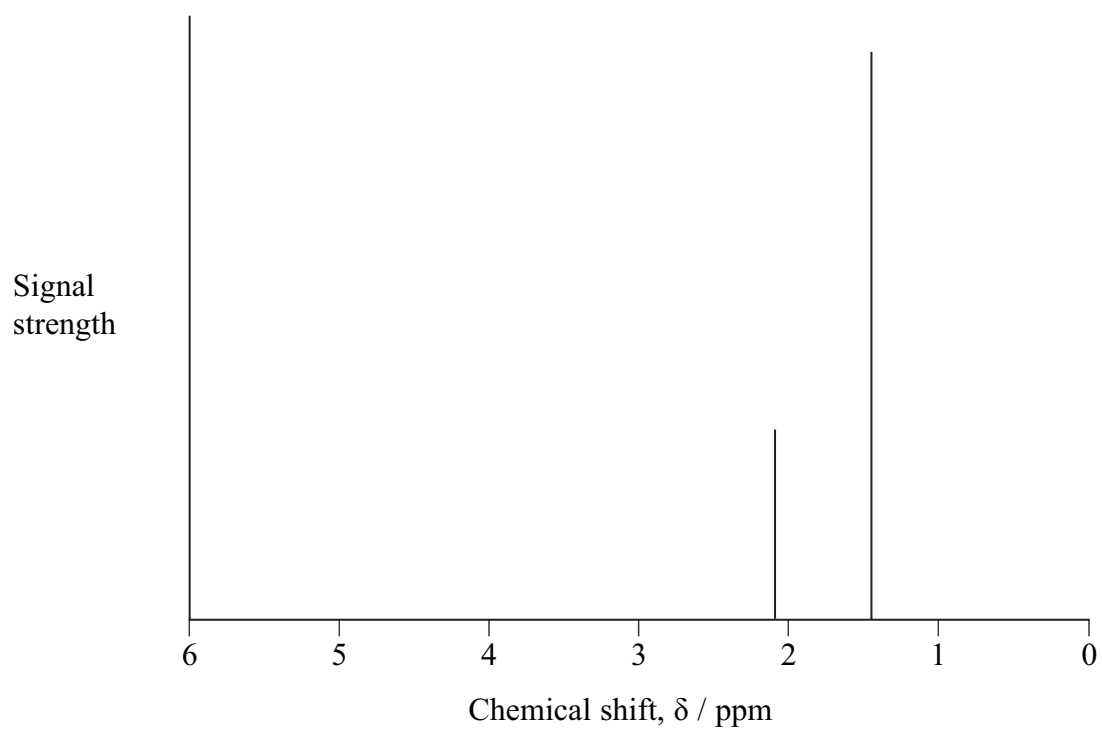


(iv) The impure product is then redistilled and **X**, which has a boiling temperature of 97°C, is collected. Draw a labelled diagram of the apparatus you would use.

(3)

*(c) **Spectrum 1** is the high resolution proton nmr spectrum of **X**, $\text{CH}_3\text{COOC}(\text{CH}_3)_3$.

Spectrum 1



Explain how **spectrum 1** is consistent with the structure of **X**. You should refer to the number and height of the peaks, the atoms which produce them and their splitting patterns.

(4)

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P 3 8 4 8 2 A 0 2 1 2 4

(d) **X** has an isomer, **Y**. **Y** is an ester which can be made from ethanoic acid and 2-methylpropan-1-ol.

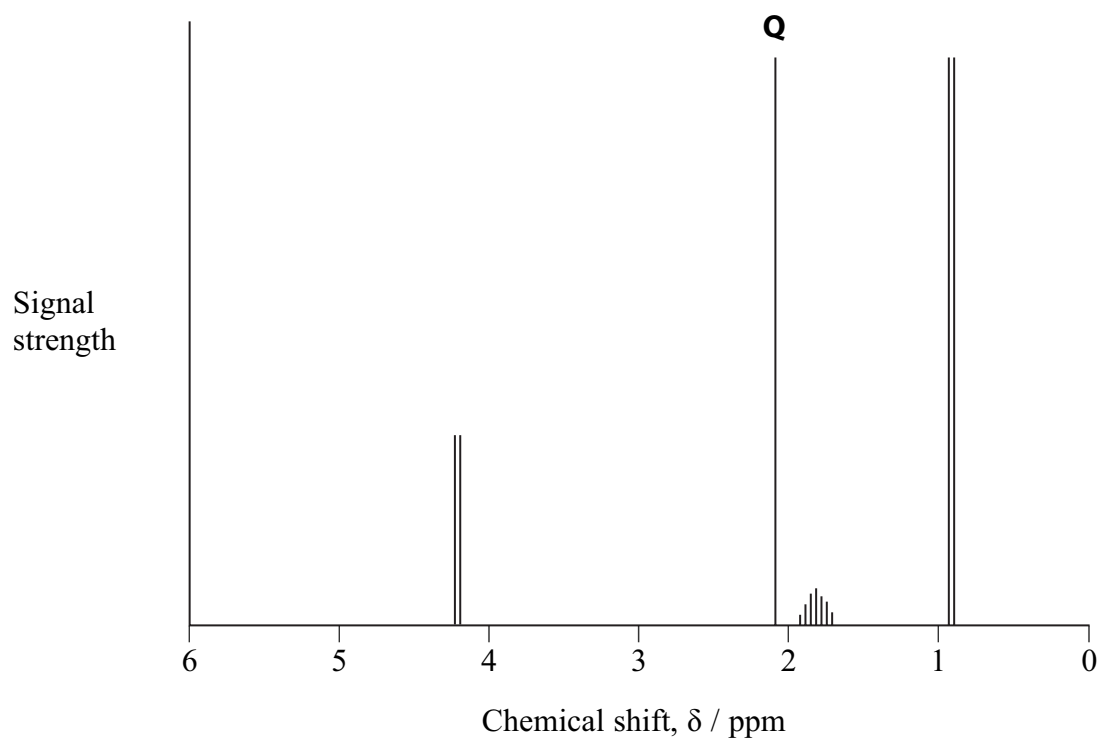
(i) Draw the structural formula of **Y**.

(1)

(ii) **Spectrum 2** is the high resolution proton nmr spectrum of **Y**. On your structural formula in (i), circle the atom or atoms causing the peak labelled **Q** on **spectrum 2**.

(1)

Spectrum 2



(e) **X** has several other structural isomers which have a broad peak at approximately 2960 cm^{-1} in their infrared spectra. Some of the isomers have a chiral carbon atom and all have a higher boiling temperature than **X**. None of them reacts with 2,4-dinitrophenylhydrazine.

*(i) Draw the structure of **one** of the isomers which is optically active, explaining how you use **all** the information in the question.

(5)

(ii) Could the compound you have drawn in (e)(i) be distinguished by infrared spectroscopy from its other isomers with the properties listed above? Explain your answer.

(1)

(Total for Question 19 = 20 marks)

TOTAL FOR SECTION C = 20 MARKS
TOTAL FOR PAPER = 90 MARKS



4

P 3 8 4 8 2 A 0 2 4 2 4

Mark Scheme (Results)

June 2011

GCE Chemistry (6CH04) Paper 01
General Principles of Chemistry

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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.

Section A (multiple choice)

Question Number	Correct Answer	Mark
1	C	1

Question Number	Correct Answer	Mark
2	D	1

Question Number	Correct Answer	Mark
3	A	1

Question Number	Correct Answer	Mark
4	A	1

Question Number	Correct Answer	Mark
5	B	1

Question Number	Correct Answer	Mark
6	C	1

Question Number	Correct Answer	Mark
7	C	1

Question Number	Correct Answer	Mark
8 (a)	C	1

Question Number	Correct Answer	Mark
8 (b)	D	1

Question Number	Correct Answer	Mark
8 (c)	B	1

Question Number	Correct Answer	Mark
9	A	1

Question Number	Correct Answer	Mark
10 (a)	D	1

Question Number	Correct Answer	Mark
10 (b)	A	1

Question Number	Correct Answer	Mark
10 (c)	D	1

Question Number	Correct Answer	Mark
11 (a)	C	1

Question Number	Correct Answer	Mark
11 (b)	D	1

Question Number	Correct Answer	Mark
11 (c)	B	1

Question Number	Correct Answer	Mark
12	B	1

Question Number	Correct Answer	Mark
13	A	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)	Addition (1) Nucleophilic (1) Either order	SN1 SN2	2

Question Number	Acceptable Answers	Reject	Mark
15 (a)(ii)	Hydrogen cyanide / HCN (1) Potassium cyanide / KCN/ sodium cyanide/ NaCN (1) OR Potassium cyanide / KCN (1) With hydrochloric acid / sulfuric acid (to generate HCN) (1) Ignore concentration of acids Mark for HCl etc is consequential on KCN OR Hydrogen cyanide / HCN (1) With sodium hydroxide / other base (to make cyanide ions) (1) Mark for NaOH etc is consequential on HCN	Just CN ⁻ Just CN ⁻ Just acid/ H ⁺ any weak acid Just OH ⁻	2

Question Number	Acceptable Answers	Reject	Mark
15 (a)(iii)	Both arrows in first step of mechanism above correctly drawn (1) Correct intermediate with charge (1) Both arrows in second step with correct organic product (CN⁻ is not required) (1) Use of HCN for first step max 2 marks Allow omission of lone pair on CN⁻ and O⁻ Allow curly arrow from negative charge or elsewhere on cyanide ion Allow arrow from O⁻ in 2nd step to H⁺ (no other product or only one product) or H₂O (with OH⁻ formed)	C=O breaking before attack by CN⁻ Arrows from atoms when they should be from bonds and vice versa	3

Question Number	Acceptable Answers	Reject	Mark
*15 (a)(iv)	Attack (by nucleophile on the C) is from both sides (equally)/ above and below (at the planar reaction site in the aldehyde group) (1) So a mixture of two enantiomers/(optical)isomers in equal proportions forms OR racemic mixture forms (1) First and second marks are independent	Attack on intermediate in reaction mechanism is from both sides Attack from both ends/two angles Just "both enantiomers form"	2

Question Number	Acceptable Answers	Reject	Mark
15 (b)	Any named (aqueous) strong acid or its formula. Allow (aqueous) sodium hydroxide followed by named acid or formula Ignore references to concentration	Water H⁺ Potassium dichromate + sulfuric acid Carboxylic acids	1

Question Number	Acceptable Answers	Reject	Mark
15 (c)(i)	2-hydroxypropanoic acid	2-hydroxylpropanoic acid 2-hydroxopropanoic acid 2-hydroxypropan-1-oic acid	1

Question Number	Acceptable Answers	Reject	Mark
15 (c)(ii)	$ \begin{array}{c} \text{CH}_3 \quad \quad \text{CH}_3 \\ \quad \quad \\ -\text{C}-\text{C}-\text{O}-\text{C}-\text{C}-\text{O}- \\ \quad \quad \quad \\ \text{H} \quad \text{O} \quad \text{H} \quad \text{O} \end{array} $ OR $ \begin{array}{c} \text{CH}_3 \quad \quad \text{CH}_3 \\ \quad \quad \\ -\text{O}-\text{C}-\text{C}-\text{O}-\text{C}-\text{C}- \\ \quad \quad \quad \\ \text{H} \quad \text{O} \quad \text{H} \quad \text{O} \end{array} $ All bonds in ester link must be shown More than 2 units may be shown but structure shown should be a repeat unit Ignore brackets/n	A dimer Missing H atoms Missing bonds at ends	1

Question Number	Acceptable Answers	Reject	Mark
15 (c)(iii)	Ester (link/bond) in PLA can be hydrolysed/broken down (by enzymes) OR Ester (link/bond) in PLA can be broken down	Just "it can be hydrolysed"	1

Question Number	Acceptable Answers	Reject	Mark
15 (c)(iv)	Ethene is (from crude oil so) non-renewable/ milk is from a renewable source/ energy required to make ethene is high/ high temperatures needed to make ethene/ energy requirements for process from sour milk less/ process from milk doesn't use toxic chemicals / process from milk doesn't use cyanide Allow process from ethene requires many steps so expensive/so loss of material occurs at each step /so more reagents needed Ignore references to cost, unless answer gives a reason for lower cost.	Milk is more readily available Greater atom economy No other chemicals needed in process from milk Just "process from ethene requires many steps" Just "cheaper"	1

Question Number	Acceptable Answers	Reject	Mark
16 (a)(i)	O₂ : first order as increasing [O₂] x 2 increases rate x 2 / as rate is (directly) proportional to oxygen concentration (1) (Experiments 1 and 2 or [NO] constant) NO: second order as increasing [NO] x 2 increases rate x 4/ by 2² (1) (Experiments 2 and 3 or [O₂] constant) Two correct orders with no explanation (1) only	Two correct orders based on stoichiometry	2

Question Number	Acceptable Answers	Reject	Mark
16 (a)(ii)	Rate = k [O₂][NO]² Rate equation must be consistent with answer in (a)(i)	Just k [O₂][NO]² i.e. no rate/R Non square brackets	1

Question Number	Acceptable Answers	Reject	Mark
16 (a)(iii)	Rate = k[O₂][NO]² TE from (i) k=((5.10 x 10⁻⁴)/(0.005)(0.0125)²) = 652.8 / 653/650 OR k=((10.2 x 10⁻⁴)/(0.0100)(0.0125)²) = 652.8 / 653/650 OR k=((40.8 x 10⁻⁴)/(0.0100)(0.025)²) = 652.8 / 653/650 (1) TE for value of k from rate equation given dm⁶ mol⁻² s⁻¹ (allow any order) (1)		2

Question Number	Acceptable Answers	Reject	Mark
16 (b)(i)	NO₂ + CO → NO + CO₂ Allow multiples	Equation not cancelled down eg NO ₃ on both sides.	1

Question Number	Acceptable Answers	Reject	Mark
16 (b)(ii)	Rate = $k[\text{NO}_2]^2$ OR Rate = $k[\text{NO}_2]^2[\text{CO}]^0$ OR Rate = $k[\text{NO}_2]^2[\text{CO}]^0[\text{NO}_3]^0$ (1) Only molecules/reactant in slow step are $(2)\text{NO}_2$ OR CO appears after the rate determining/slow step (and 2NO_2 molecules in slow step) OR CO is not involved in rate determining / slow step OR Only the molecules in the slow step are in the rate equation OR Step 1 is slowest so determines rate equation (1) Second mark: No TE on rate equation containing incorrect species. Only allow TE if k missing in correct rate equation	Equations involving CO to power other than zero	2

Question Number	Acceptable Answers	Reject	Mark
17 (a)(i)	$\Delta S_{\text{system}} = ((2 \times 192.3) - (2 \times 95.8) - (2 \times 3 \times 65.3))$ (1) $= -198.8 / -199$ (J mol ⁻¹ K ⁻¹) Allow – 200 (2 SF) If units are not those in which data is given, must be correct. (1) <i>Note check working</i> Correct answer without working (2) Correct choice of multiples and data but wrong answer scores first mark (1) Correct value with wrong sign based on entropy of reactants – entropy of products (giving +199) (1) TE for second mark if multiples for hydrogen, nitrogen and ammonia are missed/ incorrect, but correct data used. or multiples correct and one error in data.	198	2

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	If answer to (a)(i) is negative: Disorder decreases / order increases (as reaction goes forward) (1) Reference to order or disorder required for the mark. As number of (gas)molecules/moles/particles decreases (1) OR 4 moles of gas produces 2 moles Ignore comments on number of different types of molecule in equilibrium mixture If answer to (a)(i) is positive: Must say this is unexpected with correct reasons to score 2 marks No marks if the positive answer is expected	Just "entropy decreases"	2

Question Number	Acceptable Answers	Reject	Mark
17 (b)(i)	$\Delta S_{\text{surr}} = -(-110.2 \times 1000) / 700$ (1) $(+157.4285)$ $= (+) \mathbf{157.4 / 157}$ (J mol ⁻¹ K ⁻¹) OR $(+) 0.1574 / 0.157$ kJ mol⁻¹ K⁻¹ (1) Ignore sf except 1 Correct answer without working (2) Correct value with negative sign (1) Use of $\Delta S_{\text{surr}} = -\Delta H/T$ but wrong answer (1)		2

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	$(\Delta S_{\text{system}} = \Delta S_{\text{total}} - \Delta S_{\text{surr}})$ $= (-78.7 - 157.4)$ $= \mathbf{-236.1 / -236}$ (J mol ⁻¹ K ⁻¹) OR $-0.2361 / -0.236$ (kJ mol ⁻¹ K ⁻¹) Allow -235.7 if 157 used and -238.7 if 160 used Ignore units unless value in kJ given as J or vice versa TE from (b)(i)	values in kJ added to values in J	1

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iii)	Reactants predominate / more nitrogen and hydrogen (than ammonia)	Just "Equilibrium lies to the left" Just "no ammonia is present". The gases are present in ratio 1:3:2	1

Question Number	Acceptable Answers	Reject	Mark
17 (c)(i)	$K_p = (p\text{NH}_3)^2 / (p\text{N}_2)(p\text{H}_2)^3$ (1) Can be written in other formats eg $p^2\text{NH}_3$ etc $p\text{H}_2 = (150 - 21 - 36) = \mathbf{93}$ (atm) (1) $K_p = ((36)^2 / (21)(93)^3) = (7.6724994 \times 10^{-5})$ $= \mathbf{7.67 \times 10^{-5}}$ (1) Ignore sf except 1 TE on incorrect $p\text{H}_2$ atm^{-2} (1) TE for units on incorrect K_p expression Correct answer including units without quoting K_p expression scores 3	Square brackets in first mark No TE for value on incorrect K_p Expression Units other than atm	4

Question Number	Acceptable Answers	Reject	Mark
17 (c)(ii)	(Yield of ammonia is increased) because there are fewer moles / molecules (of gas) on the right OR System tries to reduce the pressure by going to the side with fewer moles/ molecules (of gas) Ignore comments about value of K_p changing Ignore comments about more collisions occurring/more molecules having energy greater than or equal to activation energy	Just 'equilibrium moves right'	1

Question Number	Acceptable Answers	Reject	Mark
*17 (c)(iii)	First mark At higher temperature ΔS_{surr} is less positive/ decrease/more negative (1) Second mark making ΔS_{total} more negative / less positive/decreases No TE for 2nd mark if ΔS_{surr} is said to increase. (1) Third mark (so) K_p decreases (1) Third mark depends on second mark being correct/neutral answer Fourth mark so equilibrium position further left /in endothermic direction/ in reverse direction OR lower yield of ammonia / reaction is less feasible (1) Fourth mark is a stand alone mark		4

Question Number	Acceptable Answers	Reject	Mark
17 (c)(iv)	Rate (of reaching equilibrium) is higher / faster Ignore comments about increasing numbers of successful collisions at higher temperature		1

Question Number	Acceptable Answers	Reject	Mark
18 (c)(i)	HCOOH CH ₃ COOH ₂ ⁺ both correct (1)		1

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	(HIO + CH ₃ COOH $\rightleftharpoons$) H ₂ IO ⁺ + CH ₃ COO ⁻ / (HIO + CH ₃ COOH $\rightleftharpoons$) HIOH ⁺ + CH ₃ COO ⁻ Ignore position of positive charges		1

Question Number	Acceptable Answers	Reject	Mark
18 (d)	(pH = 4.9) so $[H^+] = (1.2589254 \times 10^{-5})$ $= 1.259 \times 10^{-5}$ (1) ($K_a = \frac{[HCOO^-]}{[H^+][HCOOH]}$ $= \frac{1.6 \times 10^{-4}}{1.259 \times 10^{-5}}$) = 12.7 (:1) / 13(:1) (HCOO⁻ per HCOOH or base:acid) (12.709252 from unrounded $[H^+]$ 12.708499 from $[H^+]$ rounded to 1.259×10^{-5} 12.3 from $[H^+]$ rounded to 1.3×10^{-5}) TE from error in $[H^+]$ Allow 800:63 (1) Correct answer scores 2 Accept (0.0786828) = 0.079 HCOOH per HCOO⁻ for acid:base ratio (0.0786874) = 0.079 from rounded pH OR $pK_a = -\log K_a = 3.79$ $3.79 = 4.9 - \log \frac{[base]}{[acid]}$ (1) $\log \frac{[base]}{[acid]} = 1.11$ $\frac{[base]}{[acid]} = (12.882496) = \mathbf{12.9 (:1) (1)}$ Correct answer scores 2 Accept 0.0776/ 0.078 HCOOH per HCOO⁻ for acid:base ratio (0.0776247) TE from error in pK_a Ignore sf except 1		2

TOTAL FOR SECTION B = 50 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
19 (a)	Alcohol; (2)-methylpropan-2-ol (1) Catalyst: sulfuric acid OR any named strong acid Ignore concentration of acid (1) Accept formula for acid	Formula of alcohol Just acid/H ⁺ for catalyst	2

Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	Tap funnel / separating funnel	Buchner funnel Filter funnel	1

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	To neutralize / remove/ react with (excess) acid Allow To neutralize / remove / react with (excess) H ⁺ To remove acidic impurities To remove ethanoic acid To remove the acid (used as a) catalyst Ignore additional comments on quenching or reaction stopping	To purify it To remove excess acid and alcohol Just "to quench acid catalyst/stop reaction"	1

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	Add (anhydrous) calcium chloride/ sodium sulfate/ magnesium sulfate/ Allow silica gel Allow formulae of drying agents	Conc. sulfuric acid Anhydrous copper sulphate Just "silica"	1

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iv)	Round bottomed or pear-shaped flask + still head with stopper or thermometer + heat source (1) This mark cannot be given if apparatus is completely sealed /large gaps between components Downwards sloping condenser (with correct water flow) + collection vessel (1) Thermometer in correct position with bulb opposite condenser opening (1) Ignore fractionating column if included between flask and condenser	Conical flask Flat bottomed flask	3

Question Number	Acceptable Answers	Reject	Mark
*19 (c)	First mark (Two signals so) two hydrogen environments (1) This mark may be gained by a description of the only two environments, but reference to hydrogen must be made. Second mark (Numbers of hydrogen in each environment are/ are predicted to be) in ratio 3:9 or 1:3 OR Peak due to $(\text{CH}_3)_3$ is 3x higher than peak due to CH_3 (1) Third mark Environments are CH_3COO and $(\text{CH}_3)_3$ (H may have been specified in first marking point) These may be shown on a diagram of the formula of the molecule OR $\text{H}-\text{C}-\text{C}=\text{O}$ (peak at 2.1) and $\text{H}-\text{C}-\text{C}$ (peak at 1.3) (1) Fourth mark Singlets/ no splitting as no H on adjacent C OR Singlets as the hydrogen environments are not adjacent to other H environments Allow "only one peak" for no splitting (1)	Just "the peaks are due to $(\text{CH}_3)_3$ and CH_3	4

Question Number	Acceptable Answers	Reject	Mark
19 (d)(i)	$\text{CH}_3\text{COOCH}_2\text{CH}(\text{CH}_3)_2$ Or correctly displayed Allow $\text{CH}_3\text{COOCH}_2\text{CH}(\text{CH}_3) \text{CH}_3$		1

Question Number	Acceptable Answers	Reject	Mark
19 (e)(ii)	No because the isomers (which are carboxylic acids) contain same bonds / groups (C=O, C-O, C-H etc) (1) OR Yes because could be distinguished by infrared fingerprint (1)	Yes because spectrum is unique	1

TOTAL FOR SECTION C = 20 MARKS

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Edexcel GCE

Chemistry

Advanced

**Unit 4: General Principles of Chemistry I – Rates,
Equilibria and Further Organic Chemistry
(including synoptic assessment)**

Thursday 26 January 2012 – Afternoon

Time: 1 hour 40 minutes

Paper Reference

6CH04/01

You must have: Data Booklet

Total Marks

Candidates may use a calculator.

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 ►

P39304A

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7/7/5/3/3/3/

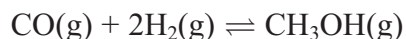


PEARSON

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 carbon monoxide and hydrogen reaches a dynamic equilibrium.



- (a) Which of these statements about a dynamic equilibrium is **not** true?

(1)

- ☐ A The forward rate of reaction is equal to the backward rate of reaction.
- ☐ B The concentrations of the products and reactants do not change.
- ☐ C The concentrations of the products and reactants are equal.
- ☐ D The equilibrium can be approached from either direction.

- (b) The K_c expression for the above reaction is

(1)

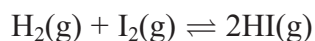
- ☐ A $K_c = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}] \times [\text{H}_2]^2}$
- ☐ B $K_c = \frac{[\text{CO}] \times 2[\text{H}_2]}{[\text{CH}_3\text{OH}]}$
- ☐ C $K_c = \frac{[\text{CO}] \times [\text{H}_2]^2}{[\text{CH}_3\text{OH}]}$
- ☐ D $K_c = \frac{[\text{CH}_3\text{OH}]}{[\text{CO}] \times 2[\text{H}_2]}$

(Total for Question 1 = 2 marks)

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



- 2 Hydrogen and iodine, both with an initial concentration of $0.010 \text{ mol dm}^{-3}$, were allowed to react. At equilibrium, the concentration of hydrogen iodide was $0.0030 \text{ mol dm}^{-3}$.

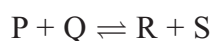


K_c is calculated using the values

		$\text{H}_2(\text{g}) / \text{mol dm}^{-3}$	$\text{I}_2(\text{g}) / \text{mol dm}^{-3}$	$\text{HI}(\text{g}) / \text{mol dm}^{-3}$
☐	A	0.0070	0.0070	0.0030
☐	B	0.0040	0.0040	0.0030
☐	C	0.0040	0.0040	0.0060
☐	D	0.0085	0.0085	0.0030

(Total for Question 2 = 1 mark)

- 3 The reaction below reached a dynamic equilibrium from an initial mixture of all four substances P, Q, R and S in aqueous solution.



The following data were obtained.

Substance	Concentration at equilibrium / mol dm^{-3}
P	0.050
Q	0.040
R	0.020
S	0.010

K_c for the equilibrium is

- ☐ A 0.10
☐ B 0.33
☐ C 3.00
☐ D 10.0

(Total for Question 3 = 1 mark)



- 4 The Haber process is used to make ammonia from nitrogen and hydrogen at 450 °C.



- (a) If the partial pressures of these gases were measured in atm, the units of the equilibrium constant K_p will be

(1)

- ☐ A atm
- ☐ B atm^2
- ☐ C atm^{-2}
- ☐ D atm^{-1}

- (b) When the temperature of the system is increased

(1)

- ☐ A K_p decreases.
- ☐ B K_p increases.
- ☐ C K_p stays the same.
- ☐ D K_p first decreases and then increases.

(Total for Question 4 = 2 marks)

- 5 In high performance liquid chromatography, HPLC, which of these factors does **not** affect the time taken for a component to pass through the column?

- ☐ A Type of detector
- ☐ B Material of stationary phase
- ☐ C Particle size of stationary phase
- ☐ D Temperature of column

(Total for Question 5 = 1 mark)

- 6 When equimolar amounts of the solutions below are mixed, which forms a buffer solution with a pH less than 7?

- ☐ A Hydrochloric acid and sodium chloride
- ☐ B Ethanoic acid and sodium ethanoate
- ☐ C Sodium hydroxide and sodium chloride
- ☐ D Ammonia and ammonium chloride

(Total for Question 6 = 1 mark)



7 The pH of a 1.5 mol dm^{-3} solution of hydrochloric acid, HCl(aq) , is

- ☐ A -1.50
- ☐ B -0.18
- ☐ C 0.18
- ☐ D 1.50

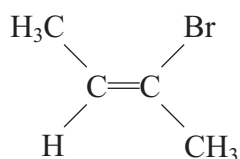
(Total for Question 7 = 1 mark)

8 Which of these solid substances is likely to have the greatest standard entropy? Use of the data booklet is not required.

- ☐ A SnO
- ☐ B SnO_2
- ☐ C SnBr_2
- ☐ D SnBr_4

(Total for Question 8 = 1 mark)

9 What is the correct name for the molecule shown below?



- ☐ A *Z*-2-bromobut-2-ene
- ☐ B *E*-2-bromobut-2-ene
- ☐ C *E*-3-bromobut-2-ene
- ☐ D *Z*-3-bromobut-2-ene

(Total for Question 9 = 1 mark)

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



10 Ketones react with hydrogen cyanide, HCN, in the presence of cyanide ions, CN^- .

(a) Which of these ketones does **not** form a racemic mixture in this reaction?

(1)

- ☐ A $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCH}_3$
- ☐ B $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$
- ☐ C $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{COCH}_3$
- ☐ D $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCH}_2\text{CH}_3$

(b) This type of reaction is classified as

(1)

- ☐ A nucleophilic substitution.
- ☐ B nucleophilic addition.
- ☐ C electrophilic addition.
- ☐ D electrophilic substitution.

(Total for Question 10 = 2 marks)

11 Which of these is **not** observed when ethanoyl chloride reacts with water?

- ☐ A Misty fumes given off.
- ☐ B The gas given off turns damp blue litmus paper red.
- ☐ C The mixture gets hot.
- ☐ D A white precipitate forms.

(Total for Question 11 = 1 mark)

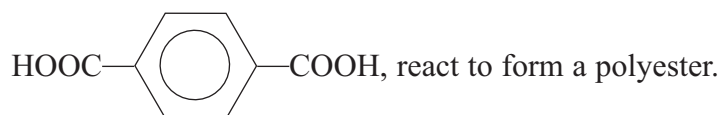
12 UV light is useful in initiating some reactions because it

- ☐ A lowers the activation energy of the reaction.
- ☐ B causes bonds in molecules to stretch and bend.
- ☐ C causes molecules to form ions.
- ☐ D causes molecules to form free radicals.

(Total for Question 12 = 1 mark)

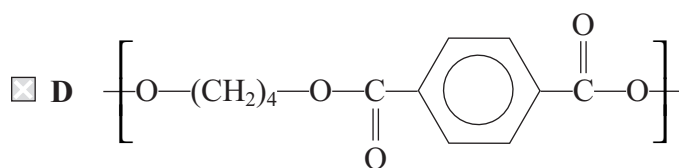
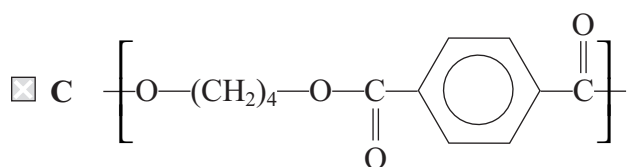
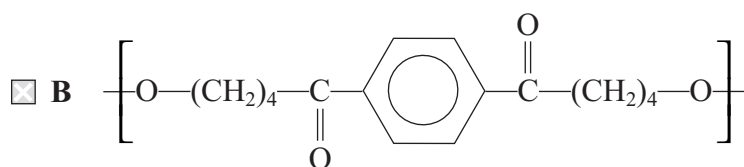
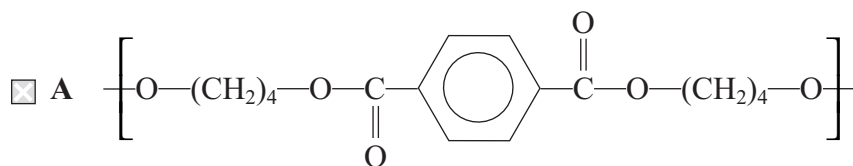


13 Butane-1,4-diol, $\text{HO}(\text{CH}_2)_4\text{OH}$, and benzene-1,4-dicarboxylic acid,



(a) The repeat unit of the polyester is

(1)



(b) The type of reaction is

(1)

- ☐ A hydrolysis.
☐ B addition.
☐ C substitution.
☐ D condensation.

(Total for Question 13 = 2 marks)

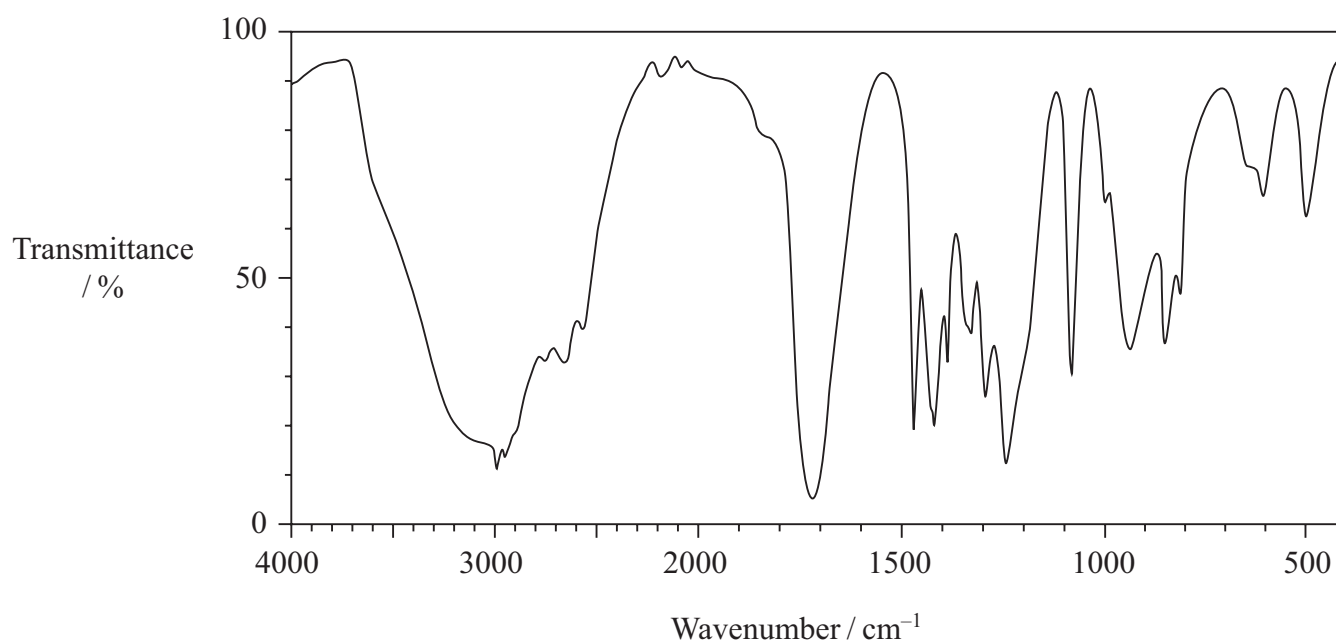


14 The equation for the enthalpy of hydration for a magnesium ion is

- ☐ A $\text{Mg}^{2+}(\text{s}) + \text{aq} \rightarrow \text{Mg}^{2+}(\text{aq})$
- ☐ B $\text{Mg}^{2+}(\text{g}) + \text{aq} \rightarrow \text{Mg}^{2+}(\text{aq})$
- ☐ C $\text{Mg}^{2+}(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{g}) + \text{aq}$
- ☐ D $\text{Mg}^{2+}(\text{aq}) \rightarrow \text{Mg}^{2+}(\text{s}) + \text{aq}$

(Total for Question 14 = 1 mark)

15 The IR spectrum of a substance is shown below.



Which of the following substances has this spectrum?

You may use the information on page 6 of the data booklet.

- ☐ A Propan-1-ol
- ☐ B Propanal
- ☐ C Propanone
- ☐ D Propanoic acid

(Total for Question 15 = 1 mark)

16 Two ketones, $\text{CH}_3\text{COCH}_2\text{CH}_2\text{CH}_3$ and $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$, both have $M_r = 86$. Which peak due to fragmentation into singly charged ions would you expect to be present in the mass spectrum of one but not the other?

- ☐ A 71
- ☐ B 57
- ☐ C 43
- ☐ D 29

(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 Two organic compounds, **X** and **Y**, both with the molecular formula C_4H_8O , contain a carbonyl group.

- (a) Describe what you would see when 2,4-dinitrophenylhydrazine is added to either of these compounds.

(1)

- (b) It is suspected that **X** is a ketone and **Y** is an aldehyde. Outline a chemical test you could carry out to confirm this, describing the results in each case.

(3)

- (c) (i) Give the structural formulae of the two possible isomers of **Y** which are aldehydes.

(1)

- (ii) Name the technique you would use to purify the product of the test with 2,4-dinitrophenylhydrazine.

(1)

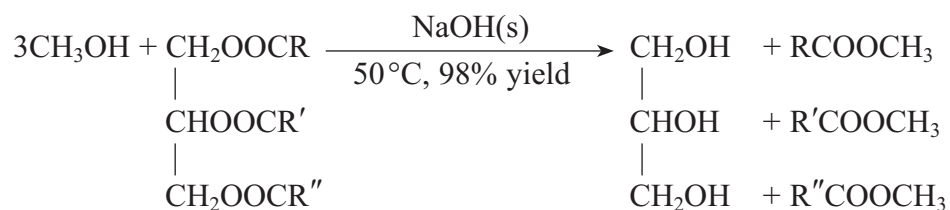
- (iii) Other than by spectroscopic techniques, how would you use the purified product to identify compound **Y**? [Practical details are not required.]

(2)

(Total for Question 17 = 8 marks)



18 Kits for manufacturing biodiesel from vegetable oils and methanol are sold for home use. The reaction which takes place may be represented by the following equation.



*(a) Describe any two of the main hazards when carrying out this reaction. What precaution would you take to minimise the risk in each case?

(4)

Hazard

Precaution

Hazard

Precaution

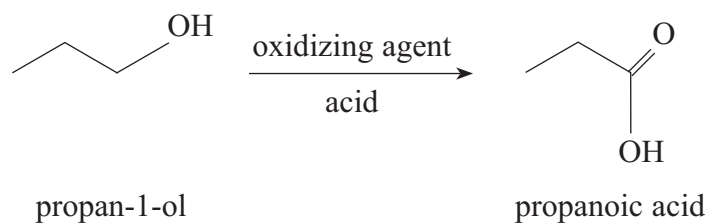
(b) Suggest **two** environmental benefits of using these kits, despite the associated risks.

(2)

(Total for Question 18 = 6 marks)



19 The carboxylic acid, propanoic acid, can be prepared by oxidation of the alcohol, propan-1-ol.



(a) (i) Identify a suitable oxidizing agent you could use in this reaction.

(1)

(ii) If you carried out this preparation in the laboratory, describe **two** measures you would take to ensure the maximum possible yield of propanoic acid is obtained.

(2)

(iii) Propanoic acid can be made by the hydrolysis of a nitrile. Give the structural formula of the nitrile and write an equation for this reaction.

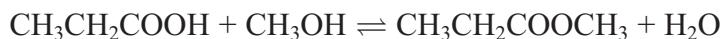
(3)

Structural formula

Equation



*(b) Propanoic acid reacts with methanol, CH₃OH, to form the ester, methyl propanoate.



Even with the use of a catalyst, this reaction is quite slow and incomplete. Suggest a reagent, to replace the propanoic acid, which would form the ester at a faster rate. Suggest **two** reasons why your chosen reagent reacts faster.

(3)

(c) The structure of methyl propanoate can be investigated by using high resolution ¹H nuclear magnetic resonance (nmr) spectroscopy.

(i) What type of radiation interacts with ¹H nuclei in nmr spectroscopy?

(1)

(ii) Describe what happens to ¹H nuclei when they absorb this radiation.

(2)

(iii) Complete the table to show values for the chemical shift of the different ¹H nuclei in methyl propanoate and their splitting pattern. Page 7 of the data booklet gives information about chemical shifts.

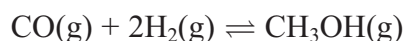
(2)

¹ H environment	Chemical shift, δ / ppm	Splitting pattern
CH ₃ O–	3.7	Singlet
–CH ₂ –	2.3	
–CH ₃		Triplet

(Total for Question 19 = 14 marks)



- 20 The exothermic reaction between carbon monoxide and hydrogen can be used industrially to make methanol. The process is carried out at 250 °C and between 50 and 100 atm.



- (a) Explain why increasing the pressure increases the yield of methanol. Give **one** disadvantage of increasing the pressure.

(2)

- (b) The reaction gives a greater equilibrium yield at 100 °C than at 250 °C.

- (i) Explain, in terms of the entropy change of the surroundings and the total entropy change of the reaction, why this is so.

A calculation is **not** required.

(2)

- (ii) Explain why the reaction is, nevertheless, carried out at 250 °C.

(1)

- (c) Given that the reaction is an equilibrium, suggest **two** ways in which the atom economy of this process could be maximised without changing the temperature or pressure.

(2)

(Total for Question 20 = 7 marks)



21 This question is about the kinetics of the reaction between bromoethane and aqueous hydroxide ions.

- (a) The results of an experiment to find the initial rate of the reaction are shown in the table below.

$[\text{CH}_3\text{CH}_2\text{Br}]$ / mol dm^{-3}	$[\text{OH}^-]$ / mol dm^{-3}	Initial rate / $\text{mol dm}^{-3} \text{ s}^{-1}$
0.100	0.150	1.54×10^{-6}

The rate equation for the reaction is

$$\text{rate} = k[\text{CH}_3\text{CH}_2\text{Br}][\text{OH}^-]$$

- (i) Calculate the value of k . Give your answer to three significant figures and include units.

(3)

- (ii) Calculate the initial rate if the concentrations of both reactants were changed to $0.020 \text{ mol dm}^{-3}$.

(1)

- (b) (i) State the order of the reaction.

(1)

-
- (ii) The mechanism for this reaction can be inferred from the rate equation. Draw the transition state formed in the reaction between bromoethane and hydroxide ions.

(2)



- (c) The rate constant for the reaction between bromoethane and hydroxide ions was determined at five different temperatures. The results are shown in the table below.

Temperature (T) / K	1/Temperature (1/T) / K ⁻¹	Rate constant, k	$\ln k$
293	3.41×10^{-3}	5.83×10^{-5}	-9.75
303	3.30×10^{-3}	1.67×10^{-4}	-8.70
313	3.19×10^{-3}	5.26×10^{-4}	-7.55
323	3.10×10^{-3}	1.36×10^{-3}	-6.60
333		3.77×10^{-3}	

- (i) Complete the missing values in the table.

(2)

- (ii) Plot a graph of $\ln k$ against $1/T$. Calculate the gradient of your graph and use this to calculate the activation energy, E_A . The Arrhenius equation can be expressed as

$$\ln k = \frac{-E_A}{R} \times \left(\frac{1}{T} \right) + \text{a constant}$$

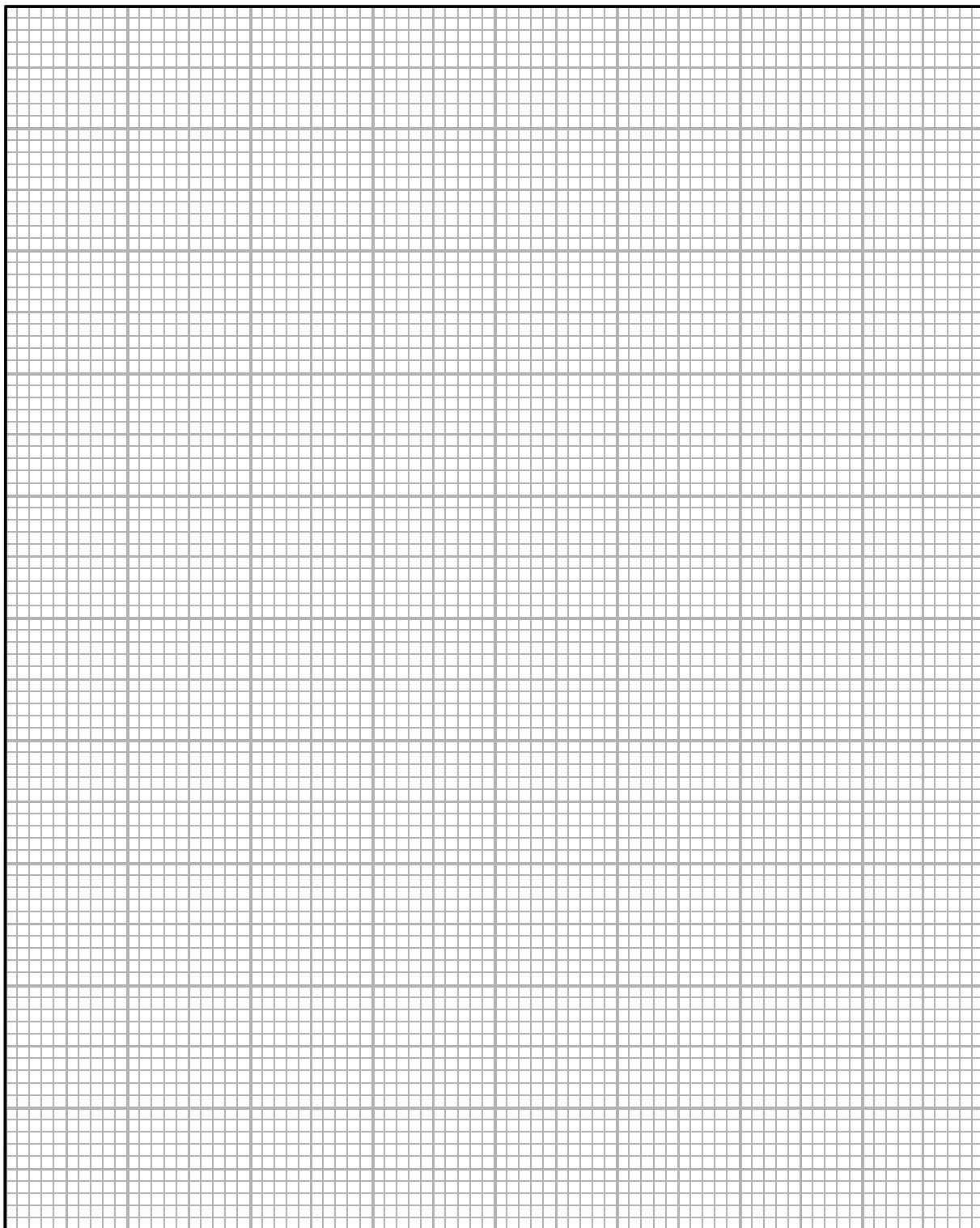
[Gas constant, $R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$]

(5)



$1/T/K^{-1}$

$\ln k$



(Total for Question 21 = 14 marks)

TOTAL FOR SECTION B = 49 MARKS

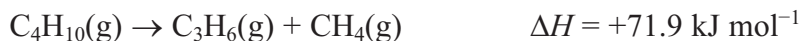


P 3 9 3 0 4 A 0 1 7 2 4

SECTION C

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

- 22** The hydrocarbon butane can be cracked to form propene and methane by passing it over a heated aluminium oxide catalyst at a temperature of 700 K. The equation for the reaction is



- (a) (i) Use page 20 of the data booklet to complete the table below.

(1)

Hydrocarbon	$S^\ominus / \text{J mol}^{-1} \text{K}^{-1}$
$\text{C}_4\text{H}_{10}(\text{g})$	+310.1
$\text{C}_3\text{H}_6(\text{g})$	+266.9
$\text{CH}_4(\text{g})$	

- (ii) Calculate the standard entropy change of the system, $\Delta S^\ominus_{\text{system}}$, for this reaction. Include a sign in your answer.

(2)

- (iii) Was the sign for your answer as you expected? Fully justify your answer.

(2)

.....

.....

.....

.....



(iv) Calculate the entropy change of the surroundings, $\Delta S_{\text{surroundings}}$, at 700 K.

Include a sign and units in your answer.

Use this value and your answer to (ii) to explain why butane cracks into propene and methane at this temperature.

(3)

.....

.....

.....

.....

(v) Calculate the minimum temperature needed for this reaction to be thermodynamically feasible.

(3)



(b) The aluminium oxide behaves as a heterogeneous catalyst. Explain both what is meant by the term **heterogeneous** and how, in terms of activation energy, the catalyst is able to speed up the reaction.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 22 = 14 marks)



23 The bubble bath ‘Colour Change Matey’ has amongst its ingredients the weak acid benzoic acid, as well as the indicator bromocresol green. When it is added to bath water, its colour changes from yellow to blue.

(a) (i) Write the K_a expression for the dissociation of benzoic acid, C_6H_5COOH .

(1)

(ii) Use the data on page 18 of the data booklet to calculate the pH of a solution of benzoic acid, C_6H_5COOH , of concentration $0.0025 \text{ mol dm}^{-3}$.

(2)

*(b) Use the data on page 19 of the data booklet, and your answer to (a)(ii), to suggest why the bubble bath changes colour when it is diluted by being added to the bath water.

(4)

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(Total for Question 23 = 7 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 90 MARKS



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4

P 3 9 3 0 4 A 0 2 4 2 4

Mark Scheme (Results)
January 2012

GCE Chemistry (6CH04) Paper 01

General Principles of Chemistry I
Rates Equilibria and Further Organic
Chemistry

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January 2012

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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(a)	C		1

Question Number	Correct Answer	Reject	Mark
1(b)	A		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(a)	C		1

Question Number	Correct Answer	Reject	Mark
4(b)	A		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	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)	B		1

Question Number	Correct Answer	Reject	Mark
10 (b)	B		1

Question Number	Correct Answer	Reject	Mark
11	D		1

Question Number	Correct Answer	Reject	Mark
12	D		1

Question Number	Correct Answer	Reject	Mark
13 (a)	C		1

Question Number	Correct Answer	Reject	Mark
13 (b)	D		1

Question Number	Correct Answer	Reject	Mark
14	B		1

Question Number	Correct Answer	Reject	Mark
15	D		1

Question Number	Correct Answer	Reject	Mark
16	C		1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17(a)	Orange/yellow and precipitate/ppt or solid or crystals ALLOW orange-red or red-orange for colour	Any other colour alone or in combination, e.g.red	1

Question Number	Acceptable Answers	Reject	Mark
17(b)	(Heat with) Benedict's/Fehling's (solution) (1) Ketone/X would remain blue/no change/no reaction (1) Aldehyde/Y would form red/brown and ppt/Cu_2O (1) ALLOW combinations of red or brown with orange OR (Heat with) Tollens' Reagent/ammoniacal silver nitrate (1) Ketone/X remains colourless/no change/no reaction (1) Aldehyde/Y forms a silver mirror or black/grey precipitate/Ag/silver (1) OR (Heat with) acidified dichromate((VI)) (ions) (1) Ketone/X remains orange/no change/no reaction (1) Aldehyde/Y goes green/blue (1) ALLOW <i>answer with acidified or alkaline KMnO_4</i> Ketone/X remains purple/pink/no change/no reaction (1) Aldehyde/Y goes colourless (with acid)/goes green (with alkali) (1) Near miss on reagent (e.g. silver nitrate not ammoniacal silver nitrate) observations can score 2 ALLOW iodoform test with ketone identified (since X can only be butanone) (Aqueous) sodium hydroxide and iodine (1) Ketone/X forms yellow precipitate/solid/crystals (1) Aldehyde/Y no change/no reaction (1)	Just orange Ppt Just clear	3

Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	Both $\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$ And $(\text{CH}_3)_2\text{CHCHO}$ ACCEPT displayed or skeletal formulae if structural formulae not given	COH unless shown correctly in a displayed or skeletal formula	1

Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	Recrystallization IGNORE solvent	Just crystallization	1

Question Number	Acceptable Answers	Reject	Mark
17(c)(iii)	Measure melting temperature / point (1) Compare with literature/database / known value (1) Second mark can only be awarded if first mark scored	Just boiling temperature	2

Question Number	Acceptable Answers	Reject	Mark
18(a)	Hazard – methanol/alcohol is flammable (1) IGNORE flammability of vegetable/diesel oils Precaution – use electrical heating source/water bath /avoid naked flames (1) OR Hazard – methanol/alcohol is toxic (1) Precaution – Use in well-ventilated area/fume cupboard/store away from children/wear gloves (1) OR Hazard – NaOH/reaction mixture is corrosive /burns (the skin)/damages the eyes (1) IGNORE references to (strong) alkali(ne) Precaution – wear gloves/goggles ALLOW any 2 hazards but the precaution must be associated with the appropriate hazard If the Hazard is not clearly identified but the precaution is appropriate then allow one mark, e.g. "Use of flammable substances so avoid naked flames" = (1) mark	Just volatile Just dangerous /harmful Just irritant	4

Question Number	Acceptable Answers	Reject	Mark
18(b)	Any two from: Reuses/reduces waste (vegetable) oil/ lessens need to dispose of (vegetable) oil (1) Could lessen use of (non-renewable/non-sustainable) crude oil/fossil fuels OR vegetable oil/biodiesel/reactants renewable/sustainable (1) Plants grown for vegetable oil could offset some CO₂ emissions (1) IGNORE references to transport/temperature/energy savings cost/profit/high yield/biodegradability/greenhouse gases	Just methanol is renewable Just carbon neutral/just reduces carbon footprint	2

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	Sodium/potassium dichromate((VI))/potassium manganate ((VII))/Na ₂ Cr ₂ O ₇ /K ₂ Cr ₂ O ₇ /KMnO ₄ IGNORE references to acid	Just Cr ₂ O ₇ ²⁻ /MnO ₄ ⁻	1

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	(Heat under) reflux (1) Use excess/sufficient oxidizing agent/reagent named in (a)(i), even if incorrect (1) IGNORE references to (excess) acid Stand alone marks		2

Question Number	Acceptable Answers	Reject	Mark
19(a)(iii)	CH₃CH₂CN/C₂H₅CN (1) ACCEPT displayed or skeletal formulae CH₃CH₂CN + H⁺ + 2H₂O → CH₃CH₂COOH + NH₄⁺ OR CH₃CH₂CN + HCl + 2H₂O → CH₃CH₂COOH + NH₄Cl (2) If equation is incorrect then presence of H⁺ or acid in equation/or above arrow and water on LHS scores (1) Mark cq on formula of nitrile ALLOW one mark for the following equation without H⁺. CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₃ ALLOW two marks for either of the following with H⁺ above the arrow CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₃ CH₃CH₂CN + 2H₂O → CH₃CH₂COOH + NH₄⁺ ALLOW answers for alkaline hydrolysis followed by acidification CH₃CH₂CN + OH⁻ + H₂O → CH₃CH₂COO⁻ + NH₃ (1) Then CH₃CH₂COO⁻ + H⁺ → CH₃CH₂COOH (1) If propanamide, CH₃CH₂CONH₂ is given initially then ALLOW the two equation marks for the hydrolysis CH₃CH₂CONH₂ + H⁺ + H₂O → CH₃CH₂COOH + NH₄⁺ If no acid is used then only one mark CH₃CH₂CONH₂ + H₂O → CH₃CH₂COOH + NH₃	Hydroxynitriles	3

Question Number	Acceptable Answers	Reject	Mark
19(b)	Reagent - Propanoyl chloride/$\text{CH}_3\text{CH}_2\text{COCl}$ (1) Any two from: C-Cl bond is weaker (than C- O) (1) Cl^-/chloride (ion) is a better leaving group (1) Carbonyl carbon is more positive/more δ^+/more attractive to nucleophiles (1) OR Reagent - Propanoic anhydride/$(\text{CH}_3\text{CH}_2\text{CO})_2\text{O}$ (1) CH_3COO^-/propanoate (ion) is a better leaving group (1) Carbonyl carbon is more positive/more δ^+/more attractive to nucleophiles (1) IGNORE references to reversible/equilibrium/catalysts IGNORE bond polarity	Propyl chloride Just Cl is more electronegative	3

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	Radio waves/radio frequency	Just radio	1

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Any two from: Protons/nuclei/they have a property called spin/ have a magnetic moment/ have a magnetic field/ are aligned with the external magnetic field (1) which flips/changes (1) align against the external magnetic field (when radiation is absorbed) (1)	starts to spin just dipole moment polarity flips any reference to electrons or molecules scores zero	2

Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	Quartet (1) ALLOW quadruplet/indication of four (peaks) Value from 0.1 to 1.9 (ppm) inclusive (1) ACCEPT any range within the above range		2

Question Number	Acceptable Answers	Reject	Mark
20(a)	(Greater yield) as fewer moles/molecules (of gas) on RHS OR 3 moles/molecules on left but only 1 on right (1) ALLOW arguments in terms of K_p remaining constant Disadvantage: Extra cost of (building) equipment (to withstand higher pressure)/ thicker pipes/compressor/maintaining equipment (1) OR Higher cost of energy needed for compression (1) IGNORE references to explosion	Just (higher) cost	2

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	(Reaction is exothermic) so the value of $\Delta S_{\text{surroundings}}$ becomes more positive/larger (at 100 °C) (1) Therefore ΔS_{total} becomes more positive/larger/less negative(at 100 °C) (1) Second mark consequential on first		2

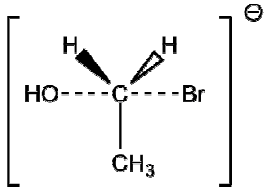
Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	(Higher temperature gives a) faster rate of reaction /more particles have $E \geq E_a$ (ALLOW more successful collisions (per second) IGNORE references to yield		1

Question Number	Acceptable Answers	Reject	Mark
20(c)	Remove methanol/the product (as it is formed) (1) Recycle/reuse unreacted reactants (1) IGNORE references to catalyst and increasing amounts of reactants		2

Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	$k = (1.54 \times 10^{-6}) \div (0.1 \times 0.15)$ (1) $(= 1.0267 \times 10^{-4})$ $= 1.03 \times 10^{-4}$ (1) must be to 3 SF $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$ (1) Unit mark is stand alone and units can be in any order Correct answer with units but no working (3) marks	1.02×10^{-4}	3

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	If correct unrounded answer to (a) (i) stored in calculator then $4.1067 \times 10^{-8} = 4.1 \times 10^{-8} (\text{mol dm}^{-3} \text{s}^{-1})$ OR If 1.0267×10^{-4} used then $4.1068 \times 10^{-8} = 4.1 \times 10^{-8} (\text{mol dm}^{-3} \text{s}^{-1})$ OR If 1.03×10^{-4} used then $4.12 \times 10^{-8} = 4.1 \times 10^{-8} (\text{mol dm}^{-3} \text{s}^{-1})$ IGNORE sf except 1sf IGNORE units even if incorrect TE from (a)(i)		1

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	$2^{(\text{nd})}/\text{second}/\text{two}/(1 + 1) = 2$ (order)		1

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	 Structure (1) ALLOW structure without wedged bonds Dotted bonds must be shown and OH and Br must be on opposite sides with a C-C or C-H bond between them Charge (1) Charge mark can be awarded for a near miss with a single error in the structure (e.g. one hydrogen atom missing) ALLOW -ve charge shown as δ^- on both OH and Br Brackets not essential ALLOW -ve charge to be anywhere on the structure IGNORE δ^+ on carbon atom		2

Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	3.00×10^{-3} (1) IGNORE sf for 1/T -5.58 (1) IGNORE sf except 1sf	-5.60	2

Question Number	Acceptable Answers	Reject	Mark
21(c)(ii)	Appropriate scale (1) Plotted points must cover at least half of the graph paper on each axis. Points plotted correctly and straight line drawn (1) through all points Gradient = -10230 ± 500 (1) Example $E_a = 10230 \times 8.31$ (1) allow TE from incorrect gradient $E_a = (+) 85.0 \text{ kJ}(\text{mol}^{-1}) / (+) 85\,000 \text{ J}(\text{mol}^{-1})$ (1) 3 sf E_a range from 80.9 to 89.2 kJ mol⁻¹ ALLOW TE from incorrect gradient IGNORE SF except 1	K ⁻¹	5

TOTAL FOR SECTION B = 49 MARKS

Section C

Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	(+)186.2 (J mol ⁻¹ K ⁻¹)		1

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	(266.9 + 186.2) – 310.1 (1) = + 143 (J mol⁻¹ K⁻¹) (1) – 143 scores (1) Correct answer with sign and no working scores (2) marks ALLOW TE from (i)		2

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Yes, as reaction produces 2 molecules/moles from one/more molecules/moles (1) (and) all products are gases (1) IGNORE references to volumes More moles/molecules of gas produced scores (2) OR Yes, (as the reaction is endothermic) $\Delta S_{\text{surroundings}}$ is negative (1) Since the reaction takes place/goes (spontaneously) ΔS_{total} is positive and therefore ΔS_{system} is positive (1) ALLOW TE from (a)(ii) i.e. 'No, as....'		2

Question Number	Acceptable Answers	Reject	Mark
22(a)(iv)	$\Delta S_{\text{surr}} = -\Delta H/T$ (1) $= -71900/700$ $= -102.7 \text{ J K}^{-1} \text{ mol}^{-1} / -0.1027 \text{ kJ K}^{-1} \text{ mol}^{-1}$ (1) Correct answer and sign with no working scores (2) $-0.103 \text{ J K}^{-1} \text{ mol}^{-1}$ scores (1) Third mark So ΔS_{total} is positive (so reaction is feasible) (1) OR $\Delta S_{\text{total}} = +40.3 \text{ J K}^{-1} \text{ mol}^{-1}$ (so reaction is feasible) (1) ALLOW TE from (a)(ii)	1 or 2 sf	3

Question Number	Acceptable Answers	Reject	Mark
22(a)(v)	$\Delta S_{\text{total}} = 0$ OR $\Delta S_{\text{surroundings}} = -143$ (1) $T = \Delta H \div \Delta S_{\text{surroundings}}$ OR $T = (-) 71900 \div (-) 143$ (1) $= 502.8 \text{ (K)}$ (1) IGNORE sf except 1sf Correct answer with no working scores (3) ALLOW 0.5028 (K) for (2) marks ALLOW -502.8 (K) for (2) marks ALLOW -0.5028 (K) for (1) mark ALLOW TE from (a)(ii) If the calculation is not based on $\Delta S_{\text{total}} = 0$ then a maximum of (2) marks can be awarded if done correctly		3

Question Number	Acceptable Answers	Reject	Mark
22(b)	The catalyst is in a different state/phase to the reactants (1) IGNORE references to products Any two from It provides an alternative (reaction) route/mechanism/gases adsorbed on catalyst surface (1) Of lower activation energy/weaken bonds in reactants (1) Greater proportion of molecules have $E \geq E_a$ (1)		3

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	$(K_a =) [H^+][C_6H_5COO^-]/[C_6H_5COOH]$ Penalise missing charges ALLOW $[H_3O^+]$ in place of $[H^+]$ IGNORE state symbols and units even if incorrect	$K_a = [H^+]^2/[C_6H_5COOH]$	1

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	$[H^+] = \sqrt{(6.3 \times 10^{-5} \times 0.0025)}$ (1) $pH = -\log \sqrt{(6.3 \times 10^{-5} \times 0.0025)}$ $= 3.4$ (1) Answer without working scores (2) marks 6.8 scores (1) IGNORE sf except 1	answer if units given	2

Question Number	Acceptable Answers	Reject	Mark
23(b)	(pH) range (of indicator) 3.8 to 5.4 OR $pK_{in} = 4.7$ (1) Bubble bath is (initially yellow since) pH less than 3.8 / is 3.4 (1) Adding of water/dilution (of acid) causes pH to rise/ means $[H^+]$ decreases (1) Hence pH rises to ≥ 5.4 so blue/changes colour (1) If a(ii) $pH > 3.8$ and < 5.4 then loses second marking point but can score other marking points. If a(ii) $pH > 5.4$ then can score first and third marking points only	Water neutralizes acid	4

TOTAL FOR SECTION C = 21 MARKS

TOTAL FOR PAPER = 90 MARKS

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Centre Number

Candidate Number

Edexcel GCE

Chemistry

Advanced

**Unit 4: General Principles of Chemistry I – Rates,
Equilibria and Further Organic Chemistry
(including synoptic assessment)**

Wednesday 13 June 2012 – Morning

Time: 1 hour 40 minutes

Paper Reference

6CH04/01

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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7/7/5/5/3/



P 3 9 3 0 8 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 interacts with the nuclei of hydrogen atoms in a nuclear magnetic resonance spectrometer?

- ☐ A Gamma rays
☐ B X-rays
☐ C Microwaves
☐ D Radio waves

(Total for Question 1 = 1 mark)

- 2 HPLC stands for

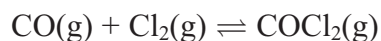
- ☐ A high pressure liquid column.
☐ B high performance liquid chromatography.
☐ C heterogeneous phase liquid chromatography.
☐ D homogenous phase liquid column.

(Total for Question 2 = 1 mark)

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



3 Consider the equilibrium below.



(a) An increase in pressure by a factor of 2 will

(1)

- ☐ A quadruple K_p .
- ☐ B double K_p .
- ☐ C have no effect on K_p .
- ☐ D halve K_p .

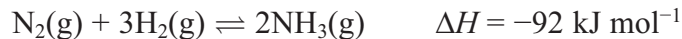
(b) The units of K_p are

(1)

- ☐ A atm^{-2}
- ☐ B atm^{-1}
- ☐ C atm
- ☐ D atm^2

(Total for Question 3 = 2 marks)

4 Which of these will **not** improve the **overall** yield of the Haber process?



- ☐ A Increasing the pressure.
- ☐ B Liquefying then removing the ammonia from the reaction.
- ☐ C Increasing the temperature.
- ☐ D Recycling unreacted nitrogen and hydrogen.

(Total for Question 4 = 1 mark)

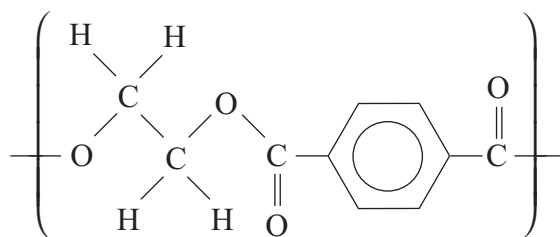
5 The equation for the reaction between ethanoic acid and phosphorus(V) chloride is

- ☐ A $\text{CH}_3\text{COOH} + \text{PCl}_5 \rightarrow \text{CH}_3\text{COCl} + \text{POCl}_3 + \text{HCl}$
- ☐ B $\text{CH}_3\text{COOH} + \text{PCl}_5 \rightarrow \text{CH}_3\text{COOCl} + \text{PCl}_3 + \text{HCl}$
- ☐ C $\text{CH}_3\text{COOH} + \text{PCl}_5 \rightarrow \text{CH}_3\text{COCl} + \text{PCl}_3 + \text{HOCl}$
- ☐ D $2\text{CH}_3\text{COOH} + \text{PCl}_5 \rightarrow (\text{CH}_3\text{CO})_2\text{O} + \text{PCl}_3 + \text{H}_2\text{O} + \text{Cl}_2$

(Total for Question 5 = 1 mark)



6 An example of a polyester is



(a) The two monomers needed to form this polymer are

(1)

	Monomer One	Monomer Two
☐ A		$\text{HO}(\text{CH}_2)_2\text{OH}$
☐ B		$\text{HO}(\text{CH}_2)_2\text{OH}$
☐ C		$\text{HOOC}(\text{CH}_2)_2\text{COOH}$
☐ D		$\text{HOOC}(\text{CH}_2)_2\text{COOH}$

(b) The type of reaction to form this polymer is

(1)

- ☐ A addition.
- ☐ B substitution.
- ☐ C condensation.
- ☐ D hydrolysis.

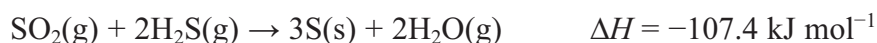
(Total for Question 6 = 2 marks)

7 In which of these reactions is the hydrogensulfate ion, HSO_4^- , behaving as a Brønsted-Lowry base?

- ☐ A $\text{HSO}_4^- + \text{H}_3\text{O}^+ \rightarrow \text{H}_2\text{SO}_4 + \text{H}_2\text{O}$
- ☐ B $\text{HSO}_4^- + \text{Ba}^{2+} \rightarrow \text{BaSO}_4 + \text{H}^+$
- ☐ C $\text{HSO}_4^- + \text{H}_2\text{O} \rightarrow \text{SO}_4^{2-} + \text{H}_3\text{O}^+$
- ☐ D $\text{HSO}_4^- + \text{CO}_3^{2-} \rightarrow \text{SO}_4^{2-} + \text{HCO}_3^-$

(Total for Question 7 = 1 mark)

8 The reaction below is carried out at 25 °C. Use the equation and the data to answer the questions that follow.



Substance	Standard molar entropy, $S^\ominus$ / $\text{J mol}^{-1} \text{K}^{-1}$
$\text{SO}_2(\text{g})$	248
$\text{H}_2\text{S}(\text{g})$	206
$\text{H}_2\text{O}(\text{g})$	189
$\text{S}(\text{s})$	32

(a) The standard entropy change of the system, in $\text{J mol}^{-1} \text{K}^{-1}$, is

(1)

- ☐ A -186
- ☐ B +186
- ☐ C -233
- ☐ D +233

(b) The standard entropy change of the surroundings, in $\text{J mol}^{-1} \text{K}^{-1}$, is

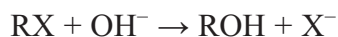
(1)

- ☐ A $107.4 \times 1000 / 25$
- ☐ B $-107.4 \times 1000 / 25$
- ☐ C $107.4 \times 1000 / 298$
- ☐ D $-107.4 \times 1000 / 298$

(Total for Question 8 = 2 marks)



- 9 A halogenoalkane, RX, reacts with hydroxide ions, OH⁻, to form an alcohol.



The rate equation for the reaction is $\text{rate} = k[\text{RX}]$. Which of these statements is **incorrect**?

- ☐ A Rate $\propto [\text{RX}]$.
- ☐ B RX is a primary halogenoalkane.
- ☐ C The reaction mechanism is S_N1.
- ☐ D A carbocation intermediate forms in the reaction.

(Total for Question 9 = 1 mark)

- 10 The rate equation for the reaction between hydrogen gas and nitrogen monoxide gas is

$$\text{rate} = k[\text{NO}]^2[\text{H}_2]$$

If the concentration of both reactants is doubled, the rate will increase by a factor of

- ☐ A 3
- ☐ B 4
- ☐ C 6
- ☐ D 8

(Total for Question 10 = 1 mark)

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



- 11 A reaction has the rate equation $\text{rate} = k[\text{X}][\text{Y}]^2[\text{Z}]$. The concentrations of each reactant are shown in the table below.

Reactant	Concentration / mol dm^{-3}
X	0.040
Y	0.20
Z	0.12

- (a) If the rate of reaction under these conditions has a value of $0.24 \text{ mol dm}^{-3} \text{ s}^{-1}$, then the numerical value of k is

(1)

- ☐ A 0.00080
☐ B 0.533
☐ C 1.875
☐ D 1250

- (b) The units for the rate constant, k , are

(1)

- ☐ A $\text{mol}^{-3} \text{ dm}^9 \text{ s}^{-1}$
☐ B $\text{mol}^3 \text{ dm}^9 \text{ s}^{-1}$
☐ C $\text{mol}^{-3} \text{ dm}^{-9} \text{ s}^{-1}$
☐ D $\text{mol}^3 \text{ dm}^{-9} \text{ s}^{-1}$

(Total for Question 11 = 2 marks)

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



12 This question is about the four organic substances shown below.



Which substance will

(a) give a positive result with both Brady's and Tollens' reagents?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(b) be formed by the oxidation of a secondary alcohol?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(c) form the most acidic solution when equal amounts are each mixed with 100 cm^3 of water?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(d) form steamy fumes in the reaction with PCl_5 ?

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 12 = 4 marks)



13 In order to make $\text{CH}_3\text{CH}_2\text{CONHCH}_3$, you could use

- ☐ A $\text{CH}_3\text{CH}_2\text{COOCH}_3 + \text{NH}_3$
- ☐ B $\text{CH}_3\text{CH}_2\text{COCl} + \text{CH}_3\text{NH}_2$
- ☐ C $\text{CH}_3\text{CH}_2\text{COO}^-\text{Na}^+ + \text{CH}_3\text{NH}_2$
- ☐ D $\text{CH}_3\text{CH}_2\text{CONH}_2 + \text{CH}_3\text{NH}_2$

(Total for Question 13 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

14 In a pH titration, 30 cm³ of sodium hydroxide solution was added, in 1 cm³ portions, to 20 cm³ of ethanoic acid solution, CH₃COOH(aq). The concentration of both solutions was 0.50 mol dm⁻³. After the addition of each 1 cm³, the pH was recorded using a pH meter.

(a) (i) Write the K_a expression for ethanoic acid.

(1)

(ii) Using your answer to (i), calculate the pH of the 0.50 mol dm⁻³ ethanoic acid solution before the titration starts. Refer to page 18 of the data booklet.

(2)

(iii) Deduce the volume of sodium hydroxide solution required to reach the end point.

(1)

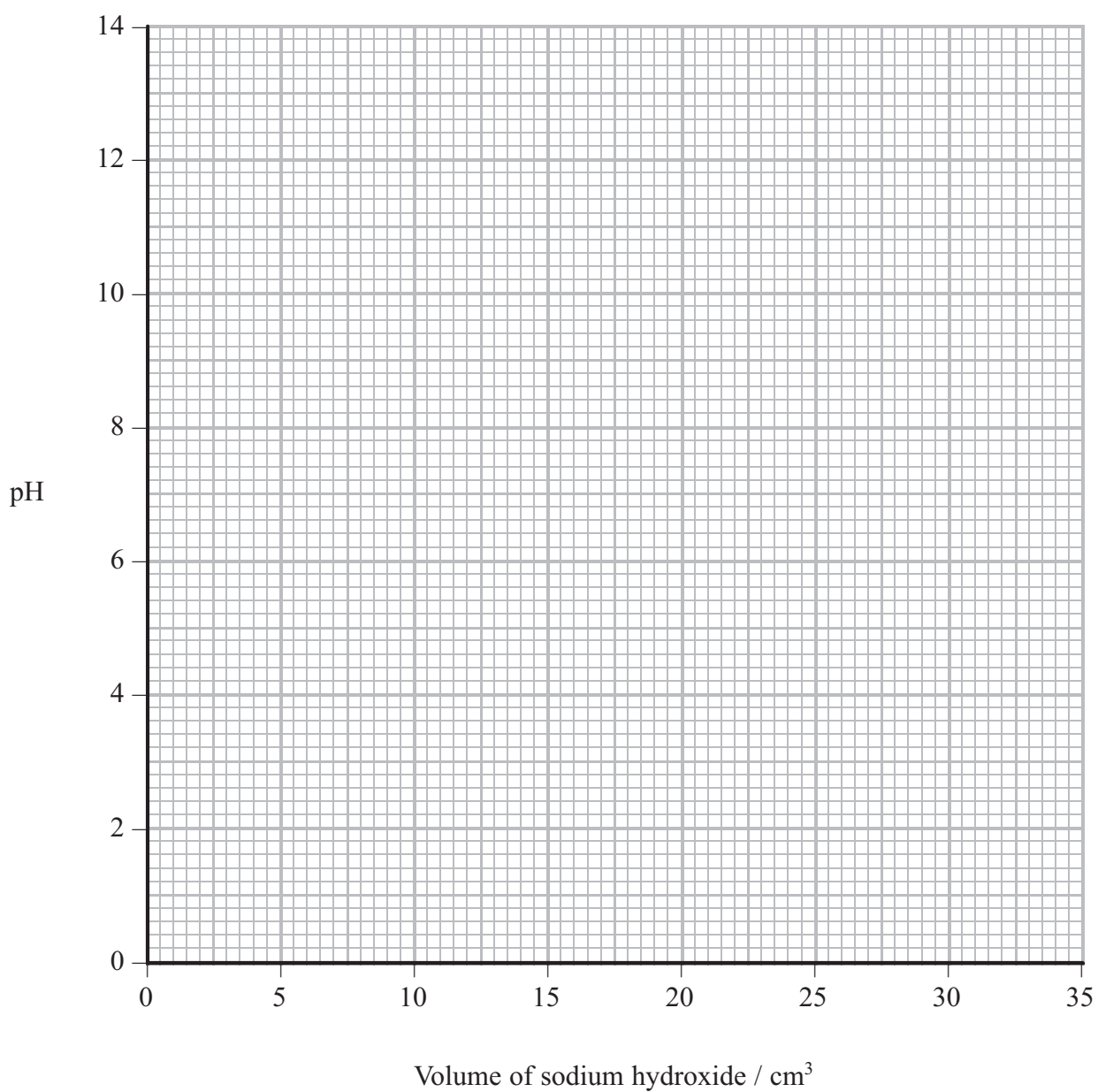
(iv) Calculate the pH of the solution after all of the sodium hydroxide is added.

(4)



- (v) On the axes below sketch a graph to show how the pH changes during the titration.

(3)



(b) An acidic buffer solution can be made by mixing together a solution of ethanoic acid and solid sodium ethanoate.

- (i) Calculate the mass of solid sodium ethanoate (molar mass = 82 g mol^{-1}) that would be added to 500 cm^3 of ethanoic acid, concentration 1.0 mol dm^{-3} , in order to make a buffer solution of $\text{pH} = 4.70$.

(4)

- *(ii) Explain how this buffer solution resists a change in pH when a few drops of sodium hydroxide are added.

(3)

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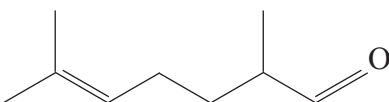
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(Total for Question 14 = 18 marks)



15 The molecule  is sometimes known as melonal as it smells similar to watermelon.

(a) Give the systematic name for melonal.

(2)

(b) (i) Melonal can be prepared by the oxidation of a compound, **X**. Suggest the formula of compound **X** and the names or formulae of the reagents needed to oxidize **X**.

(3)

Compound **X**

Reagents needed for oxidation

(ii) Briefly suggest a practical measure to maximise the yield of melonal in (b)(i). Justify your answer.

(2)

(c) Infrared spectra can be used to confirm the presence of functional groups in a molecule. Use page 5 of the data booklet to suggest the position of two absorptions and the identity of the bonds responsible which can confirm the presence of the two functional groups in melonal.

(2)

Wavenumber range / cm^{-1}	Bond	Functional group present in melonal



(d) The mass spectrum of melonal shows small peaks at $m/e = 57$ and $m/e = 83$.

Give the formula of each of the fragments most likely to have caused these peaks.

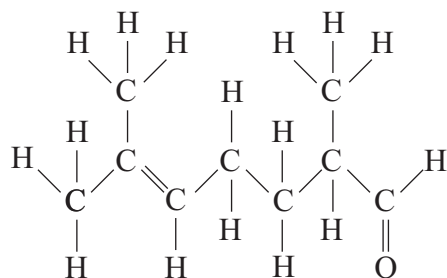
(2)

$m/e = 57$

$m/e = 83$

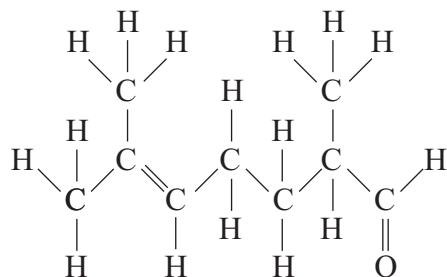
(e) (i) On the displayed formula below, circle the hydrogen atom that has a triplet peak in the proton nmr spectrum of melonal.

(1)



(ii) On the displayed formula below, circle the atom that gives rise to a peak at a chemical shift of $\delta = 9.65$ ppm in the proton nmr spectrum of melonal. Refer to page 7 of the data booklet.

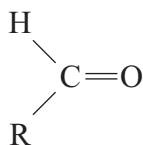
(1)



(f) Aldehydes react with HCN in the presence of CN^- ions.

- (i) Give the mechanism for this reaction, using the simplified displayed formula below.

(3)



- (ii) The product of this reaction has a chiral centre. Would you expect the reaction to produce a solution that rotates the plane of plane-polarized light? Explain your answer.

(3)

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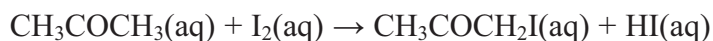
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(Total for Question 15 = 19 marks)



16 Iodine reacts with propanone in the presence of an acid catalyst.



An experiment was carried out to investigate the kinetics of this reaction by monitoring the concentration of iodine. The progress of the reaction was followed by mixing together the reagents, removing samples of the mixture every five minutes, quenching the reaction and then titrating to find the concentration of iodine at a given time.

(a) (i) Suggest a suitable reagent with which you could titrate the iodine.

(1)

(ii) State and explain how you would quench the reaction.

(2)

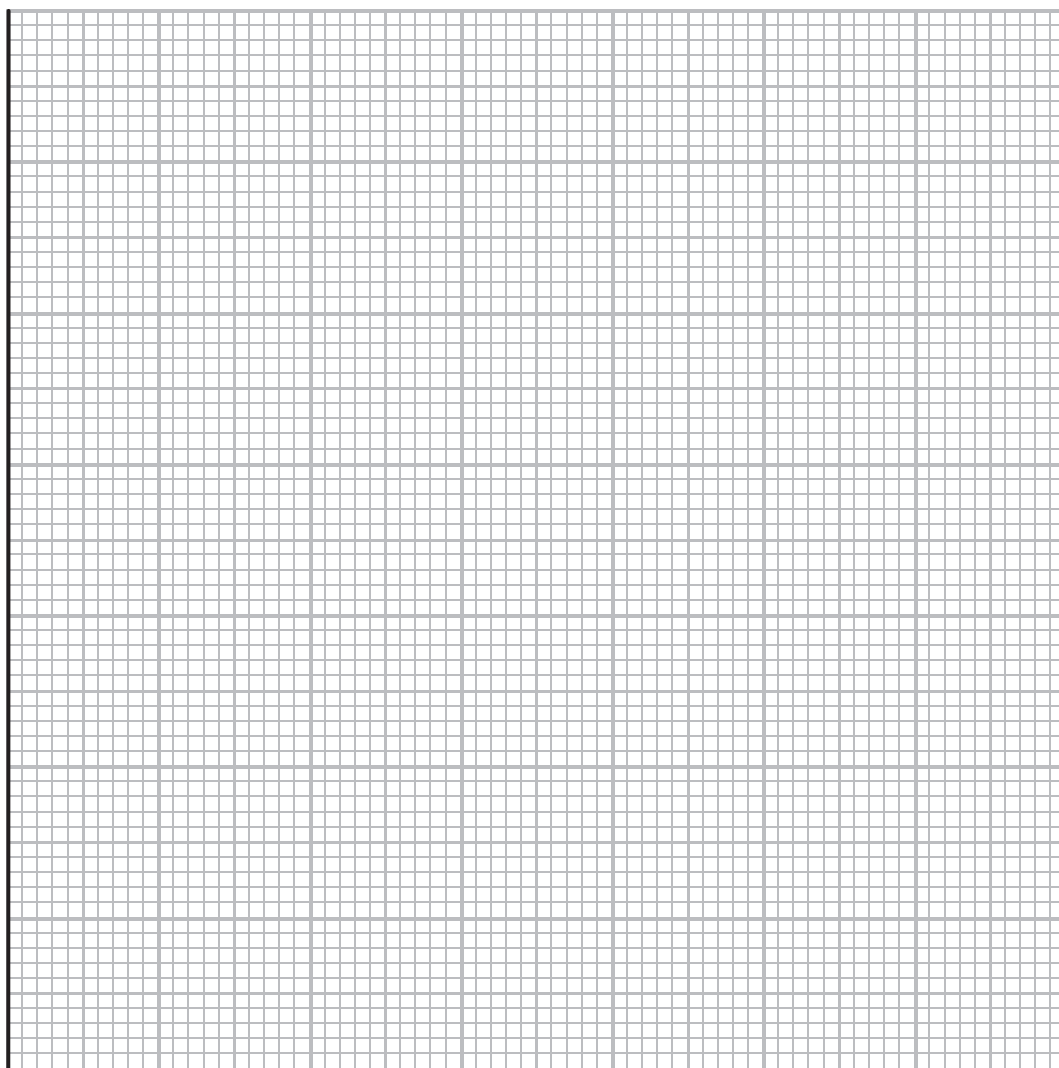
(b) (i) Data obtained from the experiment are shown in the table below. Use the data to plot a suitable graph to determine the order of the reaction with respect to iodine and state this order.

(3)

Time / mins	$[\text{I}_2(\text{aq})] / \text{mol dm}^{-3}$
5	9.74×10^{-4}
10	9.50×10^{-4}
15	9.25×10^{-4}
20	9.03×10^{-4}
25	8.80×10^{-4}
30	8.55×10^{-4}



$[\text{I}_2(\text{aq})] / \text{mol dm}^{-3}$



Time / minutes

Order with respect to iodine



P 3 9 3 0 8 A 0 1 7 2 4

(ii) Explain how you determined the order using your graph.

(2)

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(c) State an alternative practical procedure that could be used to monitor the concentration of iodine.

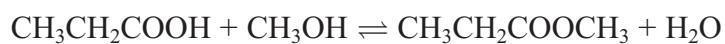
(1)

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(Total for Question 16 = 9 marks)



- 17 The ester $\text{CH}_3\text{CH}_2\text{COOCH}_3$ can be formed from the reaction between propanoic acid and methanol with an acid catalyst.



- (a) (i) Name the ester.

(1)

- (ii) The same product can be made using propanoyl chloride instead of propanoic acid. Suggest an additional hazard that could occur using this reagent and describe how you would minimise this risk.

(2)



(b) Complete the table below to show the amounts of each substance present at equilibrium. Use your values to calculate the equilibrium constant, K_c , for the reaction.

(3)

	$\text{CH}_3\text{CH}_2\text{COOH}$	CH_3OH	$\text{CH}_3\text{CH}_2\text{COOCH}_3$	H_2O
Initial amounts / mol	0.52	0.37	0	1.2
Equilibrium amounts / mol			0.21	

(Total for Question 17 = 6 marks)

TOTAL FOR SECTION B = 52 MARKS



SECTION C

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

18 This question is about the solubility of some Group 1 halides.

- (a) Potassium fluoride is a soluble, white, crystalline solid used in etching glass. A Hess cycle can be used to calculate its enthalpy of solution, using data including enthalpies of hydration of ions.

Define the term **enthalpy of hydration** of an ion.

(2)

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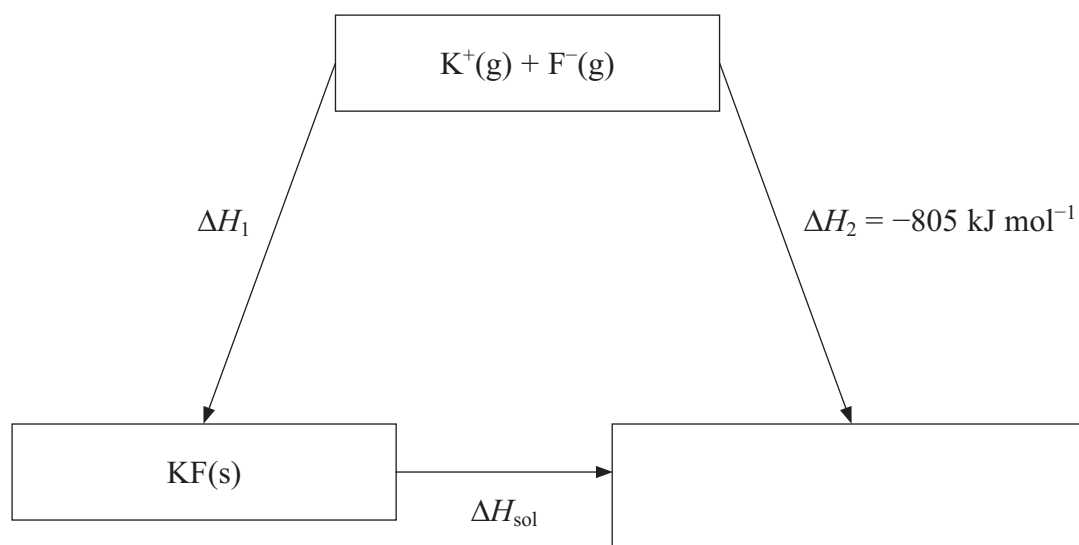
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- (b) Consider the Hess cycle below.



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

(1)



- (ii) Apply Hess's Law to obtain an expression for ΔH_{sol} in terms of ΔH_1 and ΔH_2 . (1)

$$\Delta H_{\text{sol}} =$$

- (iii) Give the name of the energy change ΔH_1 . (1)

-
- (iv) Referring to page 12 of the data booklet and your answer to (ii), calculate the standard enthalpy of solution of potassium fluoride. (2)

- (c) The standard enthalpy of solution of sodium chloride is $+3 \text{ kJ mol}^{-1}$.

- (i) 1 g of sodium chloride was added to 250 cm^3 of water in a beaker and stirred with a thermometer graduated in intervals of 1°C . Describe and explain what would happen to the reading on the thermometer as the sodium chloride dissolves. No calculation is required. (3)



*(ii) Explain, in terms of entropy changes, why sodium chloride dissolves in water under standard conditions. No calculation is required.

(4)

*(d) Lithium iodide is generally much more soluble in organic solvents than lithium chloride. Explain this observation using values of lattice energies from your data booklet and your knowledge of the trend in ionic radii down Group 7.

(4)

(Total for Question 18 = 18 marks)

TOTAL FOR SECTION C = 18 MARKS
TOTAL FOR PAPER = 90 MARKS



4

P 3 9 3 0 8 A 0 2 4 2 4

Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH04) Paper 01

General Principles of Chemistry I
Rates, Equilibria and Further Organic
Chemistry
(Including synoptic assessment)

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Summer 2012

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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	B		1
3 a	C		1
3 b	B		1
4	C		1
5	A		1
6 a	B		1
6 b	C		1
7	A		1
8 a	A		1
8 b	C		1
9	B		1
10	D		1
11 a	D		1
11 b	A		1
12 a	A		1
12 b	C		1
12 c	D		1
12 d	B		1
13	B		1
		Total for Section A	20 marks

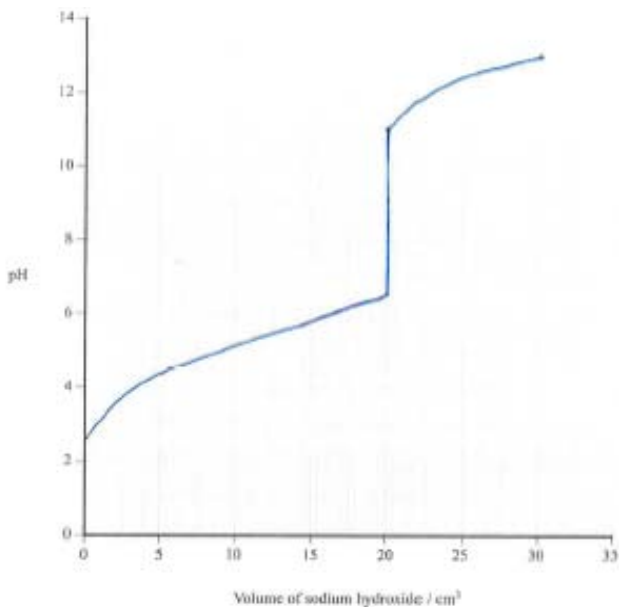
Section B

Question Number	Acceptable Answers	Reject	Mark
14 (a) (i)	$K_a = [\text{CH}_3\text{CO}_2^-] [\text{H}^+] / [\text{CH}_3\text{CO}_2\text{H}]$ OR $K_a = [\text{CH}_3\text{CO}_2^-] [\text{H}_3\text{O}^+] / [\text{CH}_3\text{CO}_2\text{H}]$ OR Use of $[\text{CH}_3\text{COO}^-]$ instead of $[\text{CH}_3\text{CO}_2^-]$ and $[\text{CH}_3\text{COOH}]$ instead of $[\text{CH}_3\text{CO}_2\text{H}]$ IGNORE state symbols even if wrong	Numerator as $[\text{H}^+]^2$ Expressions in terms of HA alone Round/curved brackets '()'' Any other carboxylic acid	1

Question Number	Acceptable Answers	Reject	Mark
14 (a) (ii)	$1.7 \times 10^{-5} = [\text{H}^+]^2 / 0.5$ $[\text{H}^+] = \sqrt{1.7 \times 10^{-5} \times 0.5} / 2.915(476) \times 10^{-3}$ (1) $\text{pH} = (-\log[\text{H}^+]) = 2.53529$ OR $= 2.54$ OR $= 2.5$ (1) ALLOW TE for second mark from any hydrogen ion concentration as long as pH less than 7 Correct answer alone scores (2) ALLOW $\text{pH} = 2.53$ if $[\text{H}^+]$ is rounded to 2.92×10^{-3} IGNORE sf except 1	4.77 or 4.8 from using $\text{pH} = -\log K_a$ loses both marks	2

Question Number	Acceptable Answers	Reject	Mark
14 (a) (iii)	20 (cm ³) IGNORE units OR 0.02 dm ³		1

Question Number	Acceptable Answers	Reject	Mark
14(a)(iv)	Moles of excess NaOH = $10/1000 \times 0.50$ $= 5 \times 10^{-3}$ (1) So $[\text{NaOH}/\text{OH}^-] = 5 \times 10^{-3} \times 1000/50 =$ 0.10 mol dm^{-3} (1) EITHER Kw route: $[\text{H}^+] \times 0.1 = 1 \times 10^{-14}$ (1) So $\text{pH} = -\log 1 \times 10^{-14} / 0.1 = 13$ (1) OR pOH route: $\text{pOH} = 1$ (1) So $\text{pH} = (14 - 1) = 13$ (1) ALLOW TE throughout Correct final answer scores (4)		4

Question Number	Acceptable Answers	Reject	Mark
14(a)(v)	Starting at pH 2-3 AND finishing at pH between 12 and 13.7 inclusive (1) Vertical section at 20 cm³ (1) S-shaped curve, with gradual rise and vertical section within the pH range 5.5 and 11.5 and of 3 to 5 units in length (1) These are stand alone marks 		3

Question Number	Acceptable Answers	Reject	Mark
14(b)(i)	EITHER $[\text{base}] = K_a [\text{acid}]/[\text{H}^+]$ Or $[\text{H}^+] = (10^{-\text{pH}4.70}) = 1.995 \times 10^{-5}$ (1) $[\text{base}] = 1.7 \times 10^{-5} \times 1/(1.995 \times 10^{-5}) = 0.852$ (1) moles base = $0.852 \times 0.5 = 0.426$ (mol) (1) mass base = $0.426 \times 82 = 34.9$ g (1) IGNORE sf except 1 Correct answer, with or without working (4) OR $\text{pH} = \text{p}K_a - \log[\text{acid}]/[\text{base}]$ $4.70 = 4.8 - \log [1/[\text{base}]]$ $\log[1/[\text{base}]] = 0.1$ (1) $[\text{base}] = 0.794(328)$ (mol dm⁻³) (1) So in 500 cm³ Moles = $0.794 \times 0.5 = 0.397$ mol (1) Mass = $0.397 \times 82 = 32.554/32.6$ g (1) (ALLOW using pKa = 4.77)		4

Question Number	Acceptable Answers	Reject	Mark
14(b)(ii)	First mark Buffer has large amount/ excess/ reservoir of CH_3COOH (and CH_3COO^-) (1) Second mark OH^- ions added react with CH_3COOH OR $\text{CH}_3\text{COOH} + \text{OH}^- \rightarrow \text{CH}_3\text{COO}^- + \text{H}_2\text{O}$ OR $\text{OH}^- + \text{H}^+ \rightarrow \text{H}_2\text{O}$ and $\text{CH}_3\text{COOH} \rightarrow \text{CH}_3\text{COO}^- + \text{H}^+$ OR Equations described in words (1) Third mark Ratio / values of $[\text{CH}_3\text{COOH}]$ to $[\text{CH}_3\text{COO}^-]$ remains (almost) unchanged (1) IGNORE concentration of hydrogen ions remains constant ALLOW answers in terms of HA and A^-		3

Question Number	Acceptable Answers	Reject	Mark
15(a)	2,6-dimethylhept-5-enal (2) Either part scores (1) e.g. 2,6-dimethyl (1) hept-5-enal (1) IGNORE missing/misplaced/misused hyphens or commas ALLOW ene for en ALLOW methy or methly for methyl		2

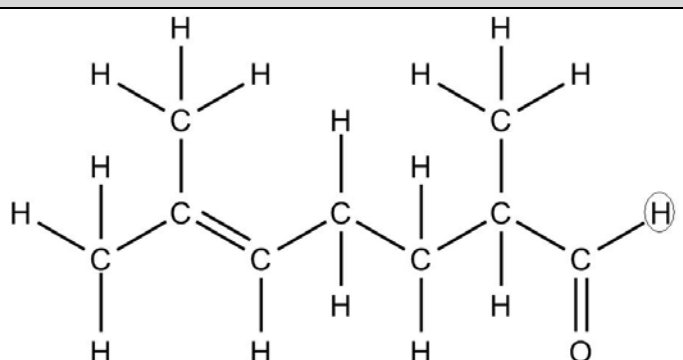
Question Number	Acceptable Answers	Reject	Mark
15(b)(i)	$\text{CH}_3\text{C}(\text{CH}_3)=\text{CHCH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ (1) OR $\text{CH}_3\text{C}(\text{CH}_3)\text{CHCH}_2\text{CH}_2\text{CH}(\text{CH}_3)\text{CH}_2\text{OH}$ OR $\text{CH}_3\text{C}(\text{CH}_3)=\text{CHCH}_2\text{CH}_2\text{C}(\text{CH}_3)\text{HCH}_2\text{OH}$ ALLOW displayed or skeletal formulae $\text{K}_2\text{Cr}_2\text{O}_7/\text{Na}_2\text{Cr}_2\text{O}_7/\text{name}$ (oxidation state must be correct if given (VI)) (1) This is a stand alone mark $\text{H}_2\text{SO}_4/\text{name}$ (ignore any references to concentration) (1) ALLOW H^+ and $\text{Cr}_2\text{O}_7^{2-}$ (2) 'Acidified dichromate' (1)	$\text{C}_9\text{H}_{18}\text{O}$ KMnO_4 (0) for last 2 marks HCl (0) for 3 rd mark	3

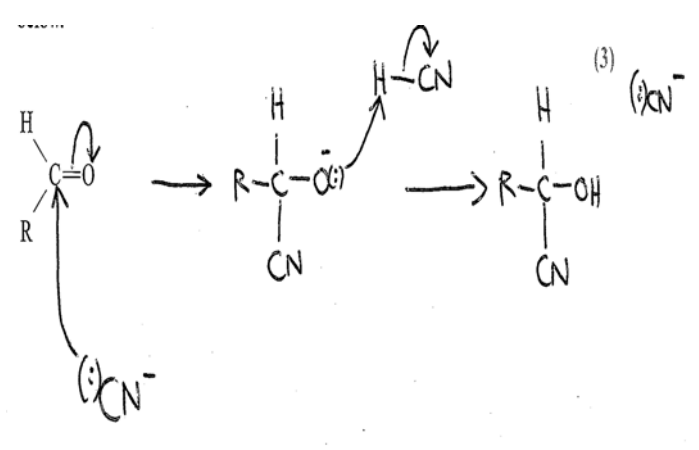
Question Number	Acceptable Answers	Reject	Mark
15(b)(ii)	(Steam) distil off melonal (as it forms) Allow add a limited amount of oxidizing agent/excess alcohol/excess X (1) To prevent further oxidation/To prevent carboxylic acid forming (1) Stand alone marks		2

Question Number	Acceptable Answers			Reject	Mark										
15(c)	<table><tr><th>Wavenumber range / cm⁻¹</th><th>Bond</th><th>Functional group present in melonal</th></tr><tr><td>1740 – 1720 OR 2900 – 2820 / 2775 – 2700</td><td>C=O</td><td>(saturated) Aldehyde/CHO</td></tr><tr><td>1669 – 1645 OR 3095 - 3010</td><td>C=C C-H</td><td>Alkene ALLOW 'carbon to carbon double bond'</td></tr></table>			Wavenumber range / cm ⁻¹	Bond	Functional group present in melonal	1740 – 1720 OR 2900 – 2820 / 2775 – 2700	C=O	(saturated) Aldehyde/CHO	1669 – 1645 OR 3095 - 3010	C=C C-H	Alkene ALLOW 'carbon to carbon double bond'	(1)	Just carbonyl	2
	Wavenumber range / cm ⁻¹	Bond	Functional group present in melonal												
	1740 – 1720 OR 2900 – 2820 / 2775 – 2700	C=O	(saturated) Aldehyde/CHO												
	1669 – 1645 OR 3095 - 3010	C=C C-H	Alkene ALLOW 'carbon to carbon double bond'												
				(1)	Just C=C in 3 rd column										
ALLOW any single value or range within the ranges above															
ALLOW one mark if both wavenumber ranges and bond columns are correct but neither bond identified															

Question Number	Acceptable Answers	Reject	Mark
15(d)	$\text{C}_3\text{H}_5\text{O}^+/\text{CH}_3\text{CHCHO}^+$ (1) $\text{C}_6\text{H}_{11}^+$ (1) [ALLOW Structural, skeletal or displayed formulae] Penalise omission of + charge once only ALLOW any order of atoms if correct totals.	C_4H_9^+ $\text{C}_5\text{H}_7\text{O}^+$	2

Question Number	Acceptable Answers	Reject	Mark
15(e)(i)		Circle around any other additional atoms	1

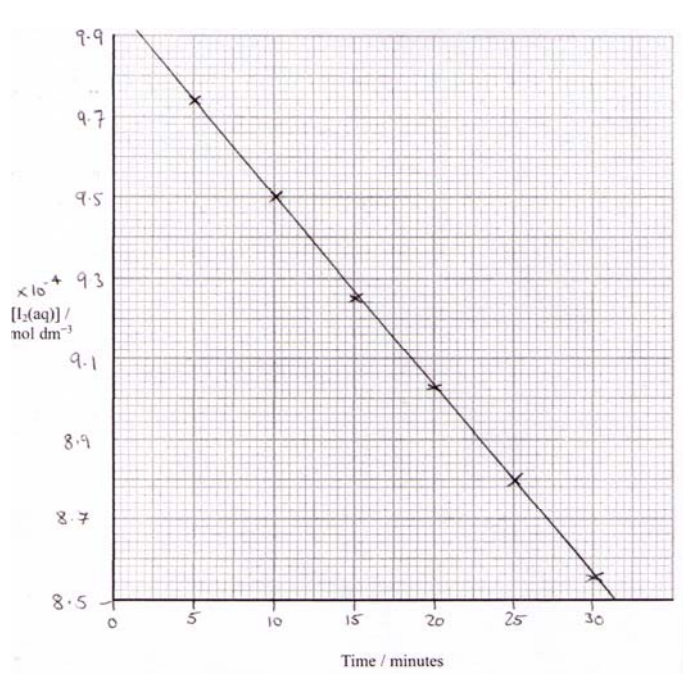
Question Number	Acceptable Answers	Reject	Mark
15(e)(ii)		Circle around any other additional atoms	1

Question Number	Acceptable Answers	Reject	Mark
15(f)(i)	 Arrow from anywhere on the cyanide ion to the carbon of the carbonyl. Arrow to the O must come from the carbonyl bond (1) Formula of intermediate (1) Arrow from oxygen to H and from H-CN bond to CN (1) ALLOW arrow from O⁻ to H⁺ or to H₂O	Starting from HCN/ CN^{δ-} Single headed arrows	3

Question Number	Acceptable Answers	Reject	Mark
15(f)(ii)	These marks are stand alone EITHER No First mark: Reaction site/carbonyl/aldehyde/molecule is planar (1) Second mark: Attack (equally likely) from both sides OR Attack (equally likely) from above and below (1) Third mark: (gives) racemic mixture/(gives) equal amounts of each isomer/(gives) equal amounts of each enantiomer (1) OR Yes Melonal has a chiral carbon atom (1) Correct identification of chiral centre (1) This chiral centre unaffected by reaction (1)	attack on a (planar) carbocation OR attack on a (planar) intermediate OR S_N1 OR S_N2 OR "planar product" Any/either direction or any/either angle	3

Question Number	Correct Answer	Reject	Mark
16 (a)(i)	Sodium thiosulfate/ $\text{Na}_2\text{S}_2\text{O}_3$ ALLOW $\text{S}_2\text{O}_3^{2-}$ or thiosulfate ions	Just thiosulfate	1

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	Add (excess) sodium hydrogencarbonate/ NaHCO_3 (1) To neutralize/remove/react with acid (catalyst) (1) Cool in ice (water) with no reference to neutralization – allow 1 mark but ignore if either of first two marks awarded	NaOH/ sodium hydroxide/ alkali just cold water	2

Question Number	Acceptable Answers	Reject	Mark
16(b)(i)	Suitable graph and scale (1) Points plotted and line of best fit (1) 0 order (with respect to iodine) (1) 		3

Question Number	Acceptable Answers	Reject	Mark
16(b)(ii)	Graph is a straight line/Gradient is constant (1) Rate stays constant (as iodine used up)/ Concentration has no effect on rate (1) Stand alone marks	Half life is constant	2

Question Number	Acceptable Answers	Reject	Mark
16(c)	Colorimetry/use of pH meter/conductivity/titrate with AgNO_3 /titrate with alkali (to monitor change in $[\text{H}^+]$)	Colorimetry Use of starch/ Iodine clock reaction	1

Question Number	Correct Answer	Reject	Mark
17 (a)(i)	Methyl propanoate ALLOW methy or methly for methyl		1

Question Number	Acceptable Answers	Reject	Mark
17(a)(ii)	Toxic (steamy/misty) fumes/ toxic HCl(gas)/corrosive HCl(gas)/toxic propanoyl chloride/lachrymatory propanoyl chloride (1) So use in a fume cupboard (1) OR Corrosive Propanoyl chloride is (1) So wear gloves when handling (1)	HCl(aq)/hydrochloric acid Just harmful/irritant Just harmful/irritant	2

Question Number	Acceptable Answers	Reject	Mark
17(b)	Table 0.31, 0.16, 1.41 all 3 scores 2, 2 out of 3 scores 1, 1 or 0 out of 3 scores 0 (2) $K_c = \frac{(0.21/V) \times (1.41/V)}{(0.16/V) \times (0.31/V)}$ $K_c = 5.969758$ $K_c = 5.97$ (1) IGNORE sf except 1 IGNORE any units ALLOW TE from incorrect values in table.		3

TOTAL FOR SECTION B = 52 MARKS

Question Number	Correct Answer	Reject	Mark
18(a)	First mark Enthalpy change when 1 mol of gaseous ions (1) ALLOW energy change/heat change/energy evolved/released/ given out/exothermic Second mark Is dissolved/hydrated/solvated such that further dilution causes no further heat change OR Is dissolved to produce an infinitely dilute solution/in excess water (1) ALLOW Is dissolved to produce a solution of 1.0 mol dm⁻³	Energy required or energy taken in Atoms or molecules (0) 1 mol of water	2

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)	K ⁺ (aq) (+) F ⁻ (aq)	K ⁺ F ⁻ (aq)	1

Question Number	Acceptable Answers	Reject	Mark
18(b)(ii)	$\Delta H_{\text{sol}} = -\Delta H_1 + \Delta H_2$ OR $\Delta H_{\text{sol}} = \Delta H_2 - \Delta H_1$		1

Question Number	Acceptable Answers	Reject	Mark
18(b)(iii)	(Standard) Lattice(enthalpy/energy/ ΔH)	LE/Lat - Lattice	1

Question Number	Acceptable Answers	Reject	Mark
18(b)(iv)	First mark Selection of (-)817 rather than (-)807 (1) Second mark $\Delta H_{\text{sol}} = 817 - 805 = (+)12 \text{ (kJ mol}^{-1}\text{)}$ (1) Just (+)12 (kJ mol⁻¹) (2) ALLOW TE for second mark e.g. for 807 gives (+) 2 (kJ mol⁻¹) ALLOW TE from incorrect b(ii)	-12 (max 1)	2

Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	EITHER No change/no measurable change in temperature OR (Very small) decrease in temperature (1) Thermometer not sensitive/precise enough/precision of thermometer is + or - 0.5 °C/graduations too large (1) Amount of energy taken in is small /ΔH_{sol} is small/mass of sodium chloride is small/slightly endothermic (1)	Any reference to temp increase /exothermic Just accuracy +/- 1 °C	3

Question Number	Acceptable Answers	Reject	Mark
*18(c)(ii)	(The reaction is endothermic so) Entropy(change) of surroundings decreases OR ΔS_{sur} is negative OR $-\Delta H/T$ is negative (1) But entropy (change)of system increases (as there is an increase in disorder) OR ΔS_{sys} is positive (1) Increase in entropy of system outweighs/greater than decrease in entropy of surroundings / value for entropy change of system is greater than entropy change of surroundings (1) Total entropy (change) is positive (1) All marks are stand alone	S_{sur} is negative S_{sys} is positive	4

Question Number	Acceptable Answers	Reject	Mark
*18(d)	Any four from: The difference between Born Haber and theoretical LE is greater for LiI than for LiCl (1) (845 and 848 =) 3 for LiCl whereas (738 and 759 =) 21 for LiI (1) Iodide ion is larger than chloride ion/lower charge density on iodide ion (1) The iodide ion is more likely (than the chloride ion) to be polarized (by lithium ion) (1) LiI likely to have more covalent character than LiCl (1)	Reject values with + Iodine/Chlorine atoms or molecules Iodine/Chlorine atoms or molecules	4

TOTAL FOR SECTION C = 18 MARKS

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Edexcel GCE

Chemistry

Advanced

**Unit 4: General Principles of Chemistry I – Rates,
Equilibria and Further Organic Chemistry
(including synoptic assessment)**

Monday 14 January 2013 – Afternoon

Time: 1 hour 40 minutes

Paper Reference

6CH04/01

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 ►

P41214A

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7/6/5/5/4/



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 Methods for investigating reaction rates include

- A colorimetry
- B collecting and measuring the volume of a gas
- C quenching, followed by titration with acid
- D quenching, followed by titration with iodine solution.

Which method would be most suitable to investigate the rate of the following reactions?



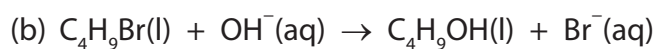
(1)

☐ A

☐ B

☐ C

☐ D



(1)

☐ A

☐ B

☐ C

☐ D

(Total for Question 1 = 2 marks)

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



- 2 For a given initial reactant pressure, the half-life for a first order gaseous reaction was found to be 30 minutes.

If the experiment were repeated at half the initial reactant pressure, the half-life would be

- ☐ A 15 minutes.
☐ B 30 minutes.
☐ C 45 minutes.
☐ D 60 minutes.

(Total for Question 2 = 1 mark)

- 3 To determine the activation energy (E_a) for a reaction, the variation of reaction rate with temperature is investigated.

The rate constant, k , for the reaction is related to the absolute temperature, T , by the expression

$$\ln k = -\frac{E_a}{R} \times \left(\frac{1}{T}\right) + \text{constant}$$

where R is the gas constant.

The activation energy for the reaction could be obtained by plotting a graph of

- | | vertical axis | horizontal axis |
|----------------------------|---------------|-----------------|
| ☐ A | k | T |
| ☐ B | k | $\frac{1}{T}$ |
| ☐ C | $\ln k$ | T |
| ☐ D | $\ln k$ | $\frac{1}{T}$ |

(Total for Question 3 = 1 mark)

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



- 4 Energy is evolved when one mole of gaseous calcium ions is hydrated.

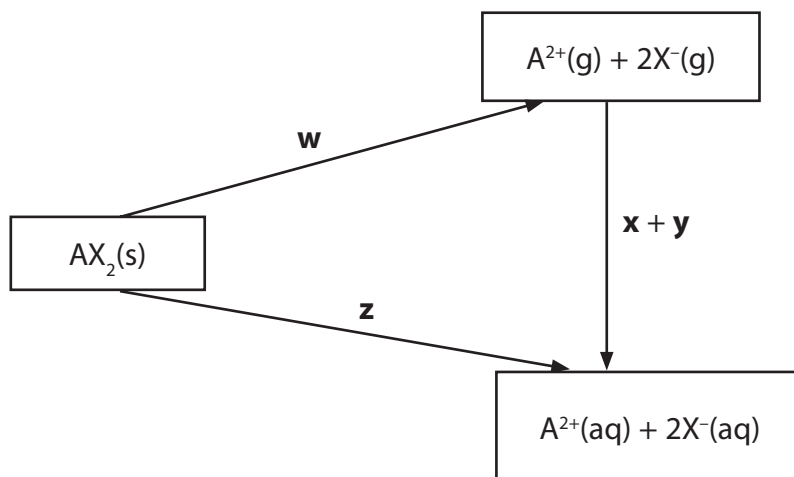


This reaction is more exothermic than the corresponding value for barium ions, Ba^{2+} , because the

- ☐ A ionization energy of calcium is greater than that of barium.
- ☐ B lattice energy of calcium oxide is more exothermic than that of barium oxide.
- ☐ C solubility of calcium hydroxide in water is less than that of barium hydroxide.
- ☐ D ionic radius of Ca^{2+} is less than that of Ba^{2+} .

(Total for Question 4 = 1 mark)

- 5 The following cycle represents the enthalpy changes **w**, **x**, **y** and **z**, occurring when an ionic solute, $\text{AX}_2(\text{s})$, dissolves in water.



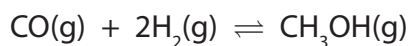
Which of the changes is the lattice energy of $\text{AX}_2(\text{s})$?

- ☐ A $\frac{1}{2} w$
- ☐ B $-w$
- ☐ C **z**
- ☐ D $z - x - y$

(Total for Question 5 = 1 mark)



6 The equation for the synthesis of methanol is



At equilibrium, when the temperature is 340 K, the total pressure is 20 atm. The moles of each component present at equilibrium are shown in the table below.

Formula	Equilibrium moles / mol	Mole fraction
CO	0.15	0.23
H ₂	0.32	
CH ₃ OH	0.18	0.28

(a) The mole fraction of hydrogen in the equilibrium mixture is

(1)

- ☐ A 0.23
- ☐ B 0.46
- ☐ C 0.49
- ☐ D 0.92

(b) The numerical value for the equilibrium partial pressure of the carbon monoxide, in atmospheres, is

(1)

- ☐ A 3.0
- ☐ B 4.6
- ☐ C 5.0
- ☐ D 9.2

(c) Units for the equilibrium constant, K_p , for this reaction are

(1)

- ☐ A no units
- ☐ B atm
- ☐ C atm⁻¹
- ☐ D atm⁻²

(Total for Question 6 = 3 marks)



7 An aqueous solution of ammonium chloride, NH_4Cl , has a pH of less than 7 because

- ☐ A the ammonium ions donate protons to water molecules giving rise to oxonium ions, $\text{H}_3\text{O}^+(\text{aq})$.
- ☐ B the chloride ions combine with hydrogen ions from water to form hydrochloric acid, $\text{HCl}(\text{aq})$.
- ☐ C an aqueous solution of ammonium chloride is unstable and evolves ammonia gas, $\text{NH}_3(\text{g})$, leaving dilute hydrochloric acid.
- ☐ D the ammonium chloride reacts with carbon dioxide from the atmosphere giving ammonium carbonate, $(\text{NH}_4)_2\text{CO}_3(\text{aq})$, and hydrochloric acid, $\text{HCl}(\text{aq})$.

(Total for Question 7 = 1 mark)

8 Which one of the following indicators is most suitable for titrating ethanoic acid with 0.1 mol dm^{-3} sodium hydroxide?

(Refer to page 19 of your data booklet.)

- ☐ A Thymol blue (acid)
- ☐ B Bromothymol blue
- ☐ C Thymol blue (base)
- ☐ D Alizarin yellow R

(Total for Question 8 = 1 mark)

9 What is the conjugate base of the acid, HCO_3^- ?

- ☐ A H_2CO_3
- ☐ B CO_3^{2-}
- ☐ C OH^-
- ☐ D CO_2

(Total for Question 9 = 1 mark)

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

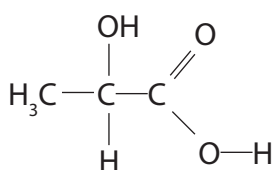


10 What is the approximate pH of a buffer solution containing 0.20 mol of a weak acid, HA, ($pK_a = 4.8$) and 0.20 mol of the sodium salt of the acid, NaA, in a total volume of 1 dm³ of solution?

- ☐ A 7.0
☐ B 5.8
☐ C 4.8
☐ D 3.8

(Total for Question 10 = 1 mark)

11 Ethanal, CH₃CHO, can be converted by a two-step synthesis into 2-hydroxypropanoic acid.



2-hydroxypropanoic acid

The reagents and conditions are

1st step

- ☐ A Na₂Cr₂O₇ and dilute H₂SO₄, heat under reflux
☐ B Cl₂, UV light
☐ C LiAlH₄ in dry ether
☐ D HCN, in presence of KCN(aq)

2nd step

- NaOH(aq), heat under reflux
NaOH(aq), heat under reflux
CO₂, room temperature
dilute HCl(aq), heat under reflux

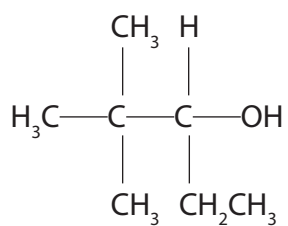
(Total for Question 11 = 1 mark)

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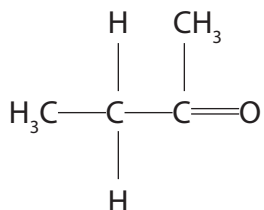


12 Questions (a) to (d) concern the following organic compounds.

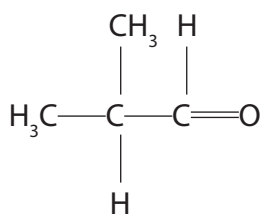
Compound A



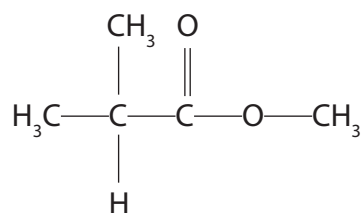
Compound B



Compound C



Compound D



Select from **A** to **D** the compound that

(a) forms iodoform with iodine in the presence of alkali.

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(b) is chiral.

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(c) reacts with Tollens' reagent.

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(d) can be oxidized to form a ketone.

(1)

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(Total for Question 12 = 4 marks)



P 4 1 2 1 4 A 0 9 2 8

13 Ethanoic acid, CH_3COOH , can be converted into ethanoyl chloride, CH_3COCl , by the action of

- ☐ **A** phosphorus(V) chloride.
- ☐ **B** chlorine.
- ☐ **C** dilute hydrochloric acid.
- ☐ **D** concentrated hydrochloric acid.

(Total for Question 13 = 1 mark)

14 A compound, **Q**, gives an orange precipitate with 2,4-dinitrophenylhydrazine. Compound **Q** is resistant to oxidation. On reduction, **Q** gives a product made up of a pair of optical isomers.

Which of the following compounds could be compound **Q**?

- ☐ **A** $\text{CH}_3\text{CH}_2\text{CH}_2\text{COCH}_3$
- ☐ **B** $\text{CH}_3\text{CH}=\text{CHCH}(\text{OH})\text{CH}_3$
- ☐ **C** $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CHO}$
- ☐ **D** $\text{CH}_3\text{CH}_2\text{COCH}_2\text{CH}_3$

(Total for Question 14 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

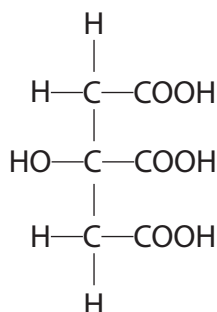


SECTION B

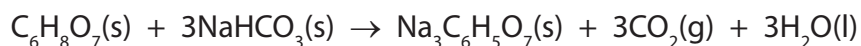
Answer ALL the questions. Write your answers in the spaces provided.

- 15 Citric acid is found in lemon juice.

The structure and formula of citric acid are shown below.



- (a) In the presence of a small amount of moisture, citric acid reacts with sodium hydrogencarbonate as shown in the equation below.



Use the structural formula of citric acid to explain why one mole of citric acid neutralizes three moles of sodium hydrogencarbonate.

(1)

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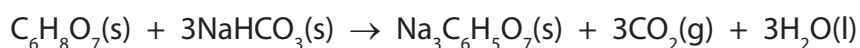
(b) You will need to refer to the data booklet in the calculations which follow.

You should also use the values given below.

compound	$S^{\ominus} / \text{J mol}^{-1} \text{K}^{-1}$
$\text{Na}_3\text{C}_6\text{H}_5\text{O}_7(\text{s})$	200.5
$\text{C}_6\text{H}_8\text{O}_7(\text{s})$	199.9

- (i) Calculate the standard entropy change of the system, $\Delta S_{\text{system}}^{\ominus}$, for the following reaction at 298 K. Include a sign and units in your answer.

(2)



- *(ii) Explain how the sign of your answer to (b)(i) could be predicted from the equation for the reaction between citric acid and sodium hydrogencarbonate.

(2)

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(iii) Given that $\Delta H_{298}^{\ominus}$ for the reaction shown in (b)(i) is $+70 \text{ kJ mol}^{-1}$, calculate the standard entropy change of the surroundings, $\Delta S_{\text{surroundings}}^{\ominus}$ for this reaction at 298 K. Include a sign and units in your answer.

(2)

(iv) Calculate the total entropy change, $\Delta S_{\text{total}}^{\ominus}$, for this reaction at 298 K.

(1)

(v) What does the sign of $\Delta S_{\text{total}}^{\ominus}$ suggest about this reaction at 298 K?

(1)

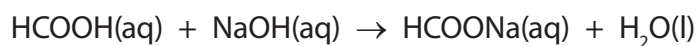
(Total for Question 15 = 9 marks)



16 Methanoic acid, HCOOH , is present in ant stings.

A scientist analyzed 25.0 cm^3 of an aqueous solution of methanoic acid, solution **Z**, by titrating it with dilute sodium hydroxide, NaOH(aq) .

- 20.0 cm^3 of sodium hydroxide was required to neutralize the methanoic acid
- The equation for the neutralization of methanoic acid is



- (a) (i) Give the expression for K_w , the ionic product of water.

(1)

- (ii) The concentration of the sodium hydroxide, NaOH(aq) , used in the titration was $0.00750 \text{ mol dm}^{-3}$.

Calculate the pH of the sodium hydroxide solution.

$$[K_w = 1.00 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}]$$

(2)

- (b) Use the equation for the reaction and the data from the titration to show that the concentration of the methanoic acid in solution **Z** was $6.00 \times 10^{-3} \text{ mol dm}^{-3}$.

(2)



(c) Methanoic acid is a weak acid.

(i) Explain the term **weak acid**.

(2)

Weak

.....

Acid

.....

(ii) The equation for the dissociation of methanoic acid in aqueous solution is shown below.



Write the expression for the acid dissociation constant, K_{a} , for methanoic acid.

(1)



*(iii) At 298 K, the acid in ant stings has a concentration of $6.00 \times 10^{-3} \text{ mol dm}^{-3}$ and a pH of 3.01.

Calculate the value of K_a for methanoic acid at 298 K.

State clearly any assumptions that you have made.

(4)

Calculation:

Assumption(s):

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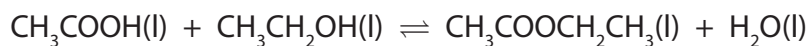
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(Total for Question 16 = 12 marks)



- 17 Ethanoic acid and ethanol react together to form the ester ethyl ethanoate, $\text{CH}_3\text{COOC}_2\text{H}_5$, and water.



- (a) (i) Give the expression for K_c .

(1)

- (ii) An equilibrium was reached when the amounts of substances shown in the table below were used.

Complete the table to show the amounts of each substance present at equilibrium.

(2)

Component	$\text{CH}_3\text{COOH(l)}$	$\text{CH}_3\text{CH}_2\text{OH(l)}$	$\text{CH}_3\text{COOCH}_2\text{CH}_3\text{(l)}$	$\text{H}_2\text{O(l)}$
Initial amount / mol	0.40	0.30	0.00	0.15
Equilibrium amount / mol	0.20			

- (iii) Explain why K_c for this reaction has no units.

(1)

- (iv) Calculate the numerical value of K_c .

(1)



- (b) The esterification reaction above was carried out in the presence of hydrochloric acid as the catalyst.

State the effect on the equilibrium position and the rate of attainment of equilibrium if the concentration of the acid catalyst were to be increased.

(2)

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- (c) (i) Identify which bonds are broken and which bonds are made in the esterification reaction.

(2)

Bonds broken:

Bonds made:

- (ii) Explain why ΔH for this reaction is not **exactly** zero.
(A calculation is not required.)

(1)

.....

.....

- (d) (i) State the relationship between ΔS_{total} and the equilibrium constant, K , of a reaction.

(1)



- *(ii) Use entropy considerations and your answer to (d)(i) to predict any effect of an increase in temperature on the value of the equilibrium constant of a reaction for which ΔH is zero. Assume that ΔS_{system} does not change with temperature.

(3)

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- (e) An alternative method for preparing ethyl ethanoate is to react ethanoyl chloride with ethanol.

- (i) Give the equation for the reaction.

(1)

- (ii) Draw the **skeletal** formula of ethyl ethanoate.

(1)

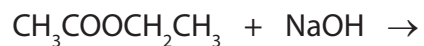
- (iii) Ethanoyl chloride also reacts with concentrated ammonia. Draw the **displayed** formula of the organic product of this reaction.

(1)



- (f) (i) Complete the equation below for the alkaline hydrolysis of ethyl ethanoate using sodium hydroxide. State symbols are **not** required.

(1)



- (ii) Explain why the reaction in (f)(i) gives a better yield of the alcohol compared with acid hydrolysis of the ethyl ethanoate.

(1)

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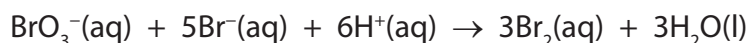
(Total for Question 17 = 19 marks)



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- 18** Bromate(V) ions, BrO_3^- , oxidize bromide ions, Br^- , in the presence of dilute acid, H^+ , as shown in the equation below.



Three experiments were carried out using different initial concentrations of the three reactants.

The initial rate of reaction was calculated for each experiment.

The results are shown in the table below.

Experiment number	$[\text{BrO}_3^-(\text{aq})] / \text{mol dm}^{-3}$	$[\text{Br}^-(\text{aq})] / \text{mol dm}^{-3}$	$[\text{H}^+(\text{aq})] / \text{mol dm}^{-3}$	Initial rate of reaction / $\text{mol dm}^{-3} \text{s}^{-1}$
1	0.050	0.25	0.30	1.68×10^{-5}
2	0.050	0.25	0.60	6.72×10^{-5}
3	0.15	0.50	0.30	1.01×10^{-4}

- *(a) (i) This reaction is first order with respect to $\text{BrO}_3^-(\text{aq})$. State, with reasons, including appropriate experiment numbers, the order of reaction with respect to

(5)

$\text{H}^+(\text{aq})$

.....

.....

.....

$\text{Br}^-(\text{aq})$

.....

.....

.....

.....

- (ii) Write the rate equation for the reaction.

(1)



(iii) Use the data from experiment 1 and your answer to (a)(ii) to calculate the value of the rate constant. Include units in your answer.

(3)

(b) What evidence suggests that this reaction proceeds by more than one step?

(1)

.....

.....

.....

(c) The initial rate of reaction was obtained from measurements of the concentration of bromine at regular time intervals. How is the **initial** rate of formation of bromine calculated from a concentration-time graph?

(2)

.....

.....

.....

.....

(Total for Question 18 = 12 marks)

TOTAL FOR SECTION B = 52 MARKS



SECTION C

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

19 An organic compound, **X**, was analyzed in a laboratory.

(a) Compound **X** was found to have the following percentage composition by mass:

carbon, C = 54.5%

hydrogen, H = 9.1%

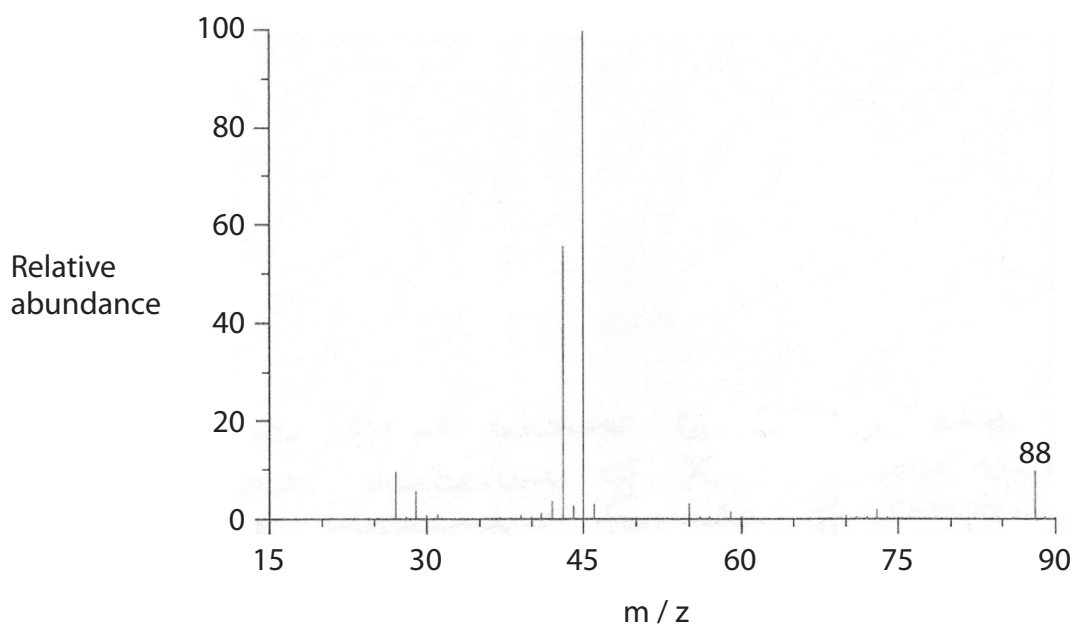
oxygen, O = 36.4%

(i) Use these data to calculate the empirical formula of compound **X**, showing your working.

(2)



(ii) The mass spectrum of **X** is shown below.



Use your answer to (a)(i), and the mass spectrum of **X**, to show that the molecular formula of compound **X** is $\text{C}_4\text{H}_8\text{O}_2$.

(2)

(b) The infrared spectrum of **X** has a broad peak at approximately 3500 cm^{-1} and a sharp peak at approximately 1700 cm^{-1} . Identify the **bond** responsible for the peak at

(2)

3500 cm^{-1}

1700 cm^{-1}



(c) (i) Some chemical information about compound **X** is given below.

- **X** is a neutral organic compound.
- **X** has no effect on Tollens' reagent.
- **X** turns hot acidified potassium dichromate(VI) solution from orange to green.

What does each of these three pieces of information suggest about the nature of **X**?

(4)

.....

.....

.....

.....

.....

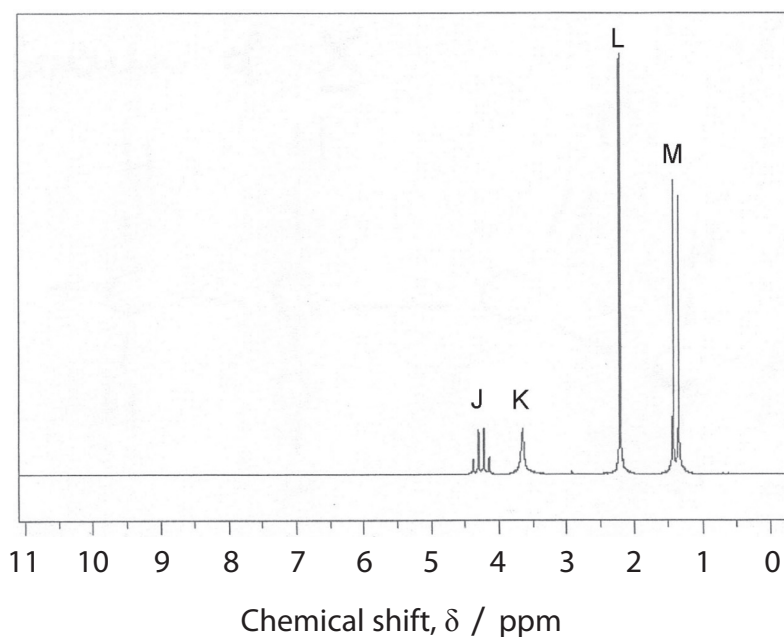
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(ii) Use your answers to parts (b) and (c)(i) to name the two functional groups present in **X**.

(1)

.....

*(d) The high resolution proton nmr spectrum of **X** is shown below.



Mark Scheme (Results)

January 2013

GCE Chemistry (6CH04) Paper 01

General Principles of Chemistry I Rates,
Equilibria and Further Organic Chemistry

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January 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

Question Number	Correct Answer	Mark
1(a)	A	1

Question Number	Correct Answer	Mark
1(b)	C	1

Question Number	Correct Answer	Mark
2	B	1

Question Number	Correct Answer	Mark
3	D	1

Question Number	Correct Answer	Mark
4	D	1

Question Number	Correct Answer	Mark
5	B	1

Question Number	Correct Answer	Mark
6(a)	C	1

Question Number	Correct Answer	Mark
6(b)	B	1

Question Number	Correct Answer	Mark
6(c)	D	1

Question Number	Correct Answer	Mark
7	A	1

Question Number	Correct Answer	Mark
8	C	1

Question Number	Correct Answer	Mark
9	B	1

Question Number	Correct Answer	Mark
10	C	1

Question Number	Correct Answer	Mark
11	D	1

Question Number	Correct Answer	Mark
12(a)	B	1

Question Number	Correct Answer	Mark
12(b)	A	1

Question Number	Correct Answer	Mark
12(c)	C	1

Question Number	Correct Answer	Mark
12(d)	A	1

Question Number	Correct Answer	Mark
13	A	1

Question Number	Correct Answer	Mark
14	A	1

Section B

Question Number	Acceptable Answers	Reject	Mark
15(a)	(It has) three (moles of) COOH groups / three (moles of) carboxylic acid groups / three (moles of) protons / three (moles of) H ⁺ / it is tribasic / three acid groups/ three (moles of) replaceable hydrogens/triprotic ALLOW Three acid groups	'carbonyl'/'carboxylate'	1

Question Number	Acceptable Answers	Reject	Mark
15(b)(i)	FIRST, CHECK THE FINAL ANSWER IF answer = +546 (J mol⁻¹ K⁻¹) award 2 marks "546" (J mol⁻¹ K⁻¹) scores (1) as sign omitted) $(\Delta S^{\circ}_{\text{system}} =) [200.5 + (3 \times 213.6) + (3 \times 69.9)]$ $- [199.9 + (3 \times 101.7)]$ (1) $= [+1051] - [+ 505]$ $= +546 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ (1) Allow + 0.546 kJ mol⁻¹ K⁻¹ 2nd mark is CQ on entropy values used for example EITHER Omission of factor of x3 for some or all substances in the equation OR The use of one incorrect entropy value(s) from the data book OR One missing value Note If two or more of the above three errors are made together, (0) awarded. IGNORE sf except 1 sf	Incorrect units (no 2nd mark)	2

Question Number	Acceptable Answers	Reject	Mark
15(b)(ii)	First mark Gas formed (from solid) OR Liquid formed (from solid) OR Gas and liquid formed (from solid) (1) Second mark EITHER More moles of product than reactants / more moles formed OR 4 mol (of reactants) to 7 mol (of products) OR 4 'molecules' to 7 'molecules' NOTE: If specific numbers are stated, these must be correct (ie 4→7) OR Increase in disorder / increase in ways of arranging particles (1) IGNORE 'entropy increases' NOTE: Both points may be made in the same sentence	Just 'more product' / 'more particles formed' 2 substances going to 3 substances	2

Question Number	Acceptable Answers	Reject	Mark
15(b)(iii)	$(\Delta S^{\circ}_{\text{surroundings}} =) \frac{-\Delta H}{T} \text{ OR } \frac{-70000}{298}$ (1) = -234.8993289 = -235 J mol⁻¹ K⁻¹ (1) OR $(\Delta S^{\circ}_{\text{surroundings}} =) \frac{-\Delta H}{T} \text{ OR } \frac{-70}{298}$ (1) = - 0.235 kJ mol⁻¹ K⁻¹ (1) IGNORE sf except 1 sf NOTE: Correct units are required for the award of the second mark +235 with units scores (1)	Incorrect rounding (e.g. -234 / -234.89) no 2nd mark +235 with no units (0) overall	2

Question Number	Acceptable Answers	Reject	Mark
15(b)(iv)	$(\Delta S^{\ominus}_{\text{total}} = \Delta S^{\ominus}_{\text{system}} + \Delta S^{\ominus}_{\text{surroundings}})$ $= (+546) + (-235)$ $= (+)311 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ OR $= (+)0.311 \text{ kJ mol}^{-1} \text{ K}^{-1}$ CQ on (i) and (iii) IGNORE sf except 1 sf	Incorrect units	1

Question Number	Acceptable Answers	Reject	Mark
15(b)(v)	Positive so feasible / spontaneous / will occur / reaction goes / reacts (at 298 K) NOTE: LOOK BACK at answer to (b)(iv) IF answer to (b)(iv) has a positive sign (the + sign can be stated or implied) THEN ALLOW JUST feasible / spontaneous / will occur / reaction goes / reacts (at 298 K) Mark CQ on sign of answer to (iv)		1

(Total 9 marks)

Question Number	Acceptable Answers	Reject	Mark
16(a)(i)	$K_w = [\text{H}^+] \times [\text{OH}^-]$ OR $K_w = [\text{H}_3\text{O}^+] \times [\text{OH}^-]$ State symbols are not required IGNORE any incorrect state symbols	Inclusion of $[\text{H}_2\text{O}]$	1

Question Number	Acceptable Answers	Reject	Mark
16(a)(ii)	FIRST, CHECK THE FINAL ANSWER IF answer pH = 11.875 / 11.88 / 11.9 / 12 award 2 marks IGNORE sf except 1 sf $ \begin{aligned} \frac{[\text{H}^+]}{[\text{OH}^-]} &= \frac{K_w}{0.00750} = \frac{1.00 \times 10^{-14}}{0.00750} \\ &= 1.3333 \times 10^{-12} \\ &= 1.33 \times 10^{-12} \quad \textbf{(1)} \\ &\quad (\text{mol dm}^{-3}) \end{aligned} $ ALLOW first mark for just $ \frac{[\text{H}^+]}{[\text{OH}^-]} = \frac{K_w}{[\text{OH}^-]} $ pH = $-\log_{10} [\text{H}^+]$ = 11.875 = 11.88 / 11.9 (1) OR pOH = $-\log_{10} [\text{OH}^-]$ = 2.12 (1) pH = $pK_w - \text{pOH}$ pH = 11.88 / 11.9 (1) Second mark only awarded CQ if pH between 8 and 14		2

Question Number	Acceptable Answers	Reject	Mark
16(b)	First mark $\text{Moles NaOH} = \frac{0.00750 \times 20.0}{1000}$ $= 1.50 \times 10^{-4} \text{ (mol)}$ (1) (Since HCOOH : NaOH ratio is 1:1) Second mark $[\text{HCOOH(aq)}] = \frac{1.50 \times 10^{-4}}{0.0250}$ OR $= 1.50 \times 10^{-4} \times \frac{1000}{25.0}$ (1) $(\text{= } 6.00 \times 10^{-3} \text{ mol dm}^{-3})$ ALTERNATIVE APPROACH: Use of an expression such as $0.00750 \times 20.0 = 25 \times y$ (1) $y = \frac{0.00750 \times 20.0}{25}$ (1)		2

Question Number	Acceptable Answers	Reject	Mark
16(c)(i)	(Weak) dissociates / ionizes to a small extent OR dissociate / ionizes partially OR dissociates / ionizes incompletely OR does not fully dissociate / ionize OR forms an equilibrium when reacted with water (1) (Acid) proton donor ALLOW 'proton donator' OR produces / releases H^+ ions OR produces / releases H_3O^+ ions (1) Ignore reference to typical acid reactions	'not easily dissociated'	2

Question Number	Acceptable Answers	Reject	Mark
16(c)(ii)	$(K_a =) \frac{[\text{HCOO}^-][\text{H}^+]}{[\text{HCOOH}]}$ State symbols are NOT required IGNORE any incorrect state symbols	$(K_a =) \frac{[\text{H}^+]^2}{[\text{HCOOH}]}$ Inclusion of $[\text{H}_2\text{O}]$	1

Question Number	Acceptable Answers	Reject	Mark
16(c)(iii)	IGNORE sf except 1 sf THROUGHOUT FIRST, CHECK THE FINAL ANSWER IF answer $K_a = 1.59 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ award the first two 2 marks $[\text{H}^+] (= 10^{-\text{pH}} = 10^{-3.01})$ $= 9.77 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ (1) $K_a = \frac{[\text{H}^+]^2}{[\text{HCOOH}]}$ $K_a = \frac{(9.77 \times 10^{-4})^2}{6.00 \times 10^{-3}}$ $= 1.59 \times 10^{-4} \text{ (mol dm}^{-3}\text{)}$ (1) Assumption 1 $[\text{H}^+] = [\text{HCOO}^-]$ OR no H^+ from the (ionization of) water OR H^+ only from the acid (1) Assumption 2 Ionization of the (weak) acid is negligible / very small / insignificant OR $[\text{HCOOH}]_{\text{initial}} - x = [\text{HCOOH}]_{\text{eqm}}$ OR $[\text{HCOOH}]_{\text{eqm}} = [\text{HCOOH}]_{\text{initial}}$ OR $[\text{HCOOH}]_{\text{eqm}} = 6.00 \times 10^{-3} \text{ (mol dm}^{-3}\text{)}$ OR $[\text{H}^+] \ll [\text{HA}]$ (1) Assumptions can be in either order	If incorrect units max 1 Just 'partial' / 'incomplete' Or 'no dissociation'	4

16(c)(iii) cont'd	OR $[\text{H}^+] (= 10^{-\text{pH}} = 10^{-3.01})$ $= 9.77 \times 10^{-4} \text{ (mol dm}^{-3}\text{)} \quad \textbf{(1)}$ $K_a = \frac{[\text{H}^+]^2}{[\text{HCOOH}]}$ $K_a = \frac{(9.77 \times 10^{-4})^2}{(6.00 \times 10^{-3} - 9.77 \times 10^{-4})} \quad \textbf{(1)}$ $= 1.90 \times 10^{-4} \text{ (mol dm}^{-3}\text{)} \quad \textbf{(1)}$ Assumption $[\text{H}^+] = [\text{HCOO}^-]$ OR no $[\text{H}^+]$ from the (ionization of) water OR H^+ only from the acid (1) Ignore references to constant temperature		
------------------------------------	--	--	--

(Total 12 marks)

Question Number	Acceptable Answers	Reject	Mark
17(a)(i)	$(K_c =) \frac{[\text{CH}_3\text{COOCH}_2\text{CH}_3] [\text{H}_2\text{O}]}{[\text{CH}_3\text{COOH}] [\text{CH}_3\text{CH}_2\text{OH}]}$ ALLOW C ₂ H ₅ for CH ₃ CH ₂ State symbols are not required IGNORE any incorrect state symbols		1

Question Number	Acceptable Answers		Reject		Mark	
17(a)(ii)					2	
	Component	CH ₃ COOH(l)	CH ₃ CH ₂ OH(l)	CH ₃ COOCH ₂ CH ₃ (l)		H ₂ O(l)
	Equilibrium amount / mol	(0.20)	0.10	0.20		0.35
	BOTH 0.10 AND 0.20 (1) 0.35 (1)					
	0.10 and 0.20 scores first mark					
	Allow 0.1 and 0.2					
	0.35 scores second mark					

Question Number	Acceptable Answers	Reject	Mark
17(a)(iii)	Units cancel OR same number of moles /same number of molecules on each side OR volume / V cancels Ignore statements such as 'concentrations cancel' 'products and reactants cancel' 'same number of products as reactants'	Concentrations are the same	1

Question Number	Acceptable Answers	Reject	Mark
17(a)(iv)	$K_c = \frac{(0.20) / V \times (0.35) / V}{(0.20) / V \times (0.10) / V}$ = 3.5 / 3.50 Correct answer with or without working scores 1 Ignore omission of V TE from values in (ii) table	$K_c = 4$	1

Question Number	Acceptable Answers	Reject	Mark
17(b)	- No effect on (position of) equilibrium (1) - Rate (of attainment of equilibrium) is faster / equilibrium reached sooner (1)		2

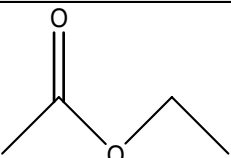
Question Number	Acceptable Answers	Reject	Mark
17(c)(i)	Bonds Broken C—O and O—H (1) Ignore where these bonds are broken in the acid and alcohol molecules. ALLOW C—OH for C—O CO—H for O—H Bonds Made C—O and O—H (1) Ignore where these bonds are made in the ester and water molecules. ALLOW C—OC for C—O H—OH for O—H Marks can be awarded by annotating displayed or structural formulae. Comment: Max 1 if any other bonds mentioned	Two O—H bonds formed in H₂O molecule ONLY C—O bond broken and made scores (0) overall	2

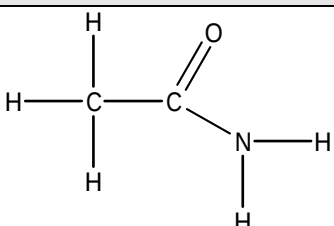
Question Number	Acceptable Answers	Reject	Mark
17(c)(ii)	(C—O and O—H) bond enthalpies differ in: different environments /different molecules /different compounds OR Bond enthalpies/bond energies are average values ALLOW Bonds being broken and made are attached to different atoms	'Heat loss'	1

Question Number	Acceptable Answers	Reject	Mark
17(d)(i)	$\Delta S_{\text{total}} = R \ln K$ Allow ΔS_{total} is proportional to <u>ln</u>K ALLOW K_c or K_p instead of K	log instead of ln ΔS_{total} is proportional to K / ΔS_{total} increases as K increases	1

Question Number	Acceptable Answers	Reject	Mark
*17(d)(ii)	First mark: $(\Delta H = 0 \text{ so})$ $\Delta S_{\text{surroundings}} = 0$ OR $-\frac{\Delta H}{T} = 0$ (1) IGNORE "$\Delta S_{\text{surroundings}}$ stays the same". Second mark: (so) ΔS_{total} does not change OR (so) $\Delta S_{\text{total}} = \Delta S_{\text{system}}$ (1) Third mark: (As $\Delta S_{\text{total}} = R \ln K$) K does not alter (1) ALLOW "it does not alter" to assume K does not alter. ALLOW use of K_c or K_p instead of K Each point is stand alone IGNORE justifications in terms of Le Chatelier's Principle NOTE: Can award max (1) (i.e. the third scoring point) if the effect on K stated follows on CQ from a change to ΔS_{total}	If only mentions 'no effect on position of equilibrium' rather than the equilibrium constant	3

Question Number	Acceptable Answers	Reject	Mark
17(e)(i)	$\text{CH}_3\text{COCl} + \text{CH}_3\text{CH}_2\text{OH} \rightarrow \text{CH}_3\text{COOCH}_2\text{CH}_3 + \text{HCl}$ Allow C_2H_5 for CH_3CH_2 Allow $\text{CH}_3\text{CO}_2\text{CH}_2\text{CH}_3$ for $\text{CH}_3\text{COOCH}_2\text{CH}_3$ IGNORE missing or incorrect state symbols	$\text{CH}_3\text{CClO} / \text{CH}_2\text{CH}_3\text{OH}$	1

Question Number	Acceptable Answers	Reject	Mark
17(e)(ii)	 IGNORE Bond angles and length of the lines.		1

Question Number	Acceptable Answers	Reject	Mark
17(e)(iii)	 IGNORE Other products of the reaction if the above structure has been correctly drawn.	NH_2 or CH_3	1

Question Number	Acceptable Answers	Reject	Mark
17(f)(i)	$(\text{CH}_3\text{COOCH}_2\text{CH}_3 + \text{NaOH} \rightarrow)$ $\text{CH}_3\text{COONa} + \text{CH}_3\text{CH}_2\text{OH} / \text{C}_2\text{H}_5\text{OH}$ Allow ionic representations of the sodium salt $\text{CH}_3\text{COO}^-\text{Na}^+$ IGNORE missing or incorrect state symbols	$\text{CH}_2\text{CH}_3\text{OH}$ for ethanol	1

Question Number	Acceptable Answers	Reject	Mark
17(f)(ii)	(Reaction with sodium hydroxide is) not an equilibrium / not reversible / goes to completion OR Reverse argument for acid hydrolysis		1

(Total 19 marks)

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	• In experiments 1 and 2, $[H^+]$ doubles (whilst keeping other concentrations constant) and the rate quadruples / rate increases x 4 (1) • Second order (with respect to H^+) (1) • In experiments 1 and 3, $[Br^-]$ doubles and $[BrO_3^-]$ triples (with $[H^+]$ constant) (1) • Rate increases by 3×2 / rate increases x 6 / rate increases to 5.04×10^{-5} (then to 1.01×10^{-4} stated or implied) (1) • First order with respect to Br^- (1) OR • In experiments 2 and 3, $[Br^-]$ doubles and $[BrO_3^-]$ triples and $[H^+]$ halves (1) • Rate increases by $3 \times 0.25 \times 2$ / rate increases x 1.5 (1) • First order with respect to Br^- (1) Penalise OMISSION of Experiment Numbers once only Mark each point independently		5

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	Rate = $k [BrO_3^-] [Br^-] [H^+]^2$ Mark CQ on (a)(i) Allow "r" or "R" for "rate" in the rate equation. IGNORE If k appears to be in upper case.		1

Question Number	Acceptable Answers	Reject	Mark
18(a)(iii)	IGNORE sf except 1 sf THROUGHOUT FIRST, CHECK THE FINAL ANSWER IF answer $k = 1.49 \times 10^{-2} \text{ dm}^9 \text{ mol}^{-3} \text{ s}^{-1}$ award (3) marks $k = \frac{\text{rate}}{[\text{BrO}_3^-] [\text{Br}^-] [\text{H}^+]^2}$ $= \frac{1.68 \times 10^{-5}}{0.05 \times 0.25 \times (0.30)^2} \quad \textbf{(1)}$ $= 0.014933333 \quad \textbf{(1)}$ $= 0.0149 \quad \textbf{(1)}$ $\text{dm}^9 \text{ mol}^{-3} \text{ s}^{-1} / \text{mol}^{-3} \text{ dm}^9 \text{ s}^{-1} \quad \textbf{(1)}$ IGNORE sf except 1 sf Mark CQ from (a)(ii) or, if no rate equation in (a)(ii), then any rate equation stated in (a)(iii) NOTE: IF the rate equation in (a)(ii) is given as Rate = $k [\text{BrO}_3^-] [\text{H}^+]^2$ CQ $k = 3.73 \times 10^{-3} \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$ scores (3) IF $[\text{H}^+]$ is not squared in the correct rate equation: $k = 4.48 \times 10^{-3} \text{ dm}^9 \text{ mol}^{-3} \text{ s}^{-1}$ OR $k = 4.48 \times 10^{-3} \text{ dm}^6 \text{ mol}^{-2} \text{ s}^{-1}$ scores (2) ALLOW Correct answers derived from the data in the table for Experiment 2 or Experiment 3		3

Question Number	Acceptable Answers	Reject	Mark
18(b)	The number(s) (of particles) in the rate equation / rate-determining step do not match those in the equation for the reaction OR The chance of (simultaneous) collision of 12 particles is unlikely OR The chance of (simultaneous) collision of 4 particles is unlikely OR The chance of (simultaneous) collision of 3 reactants is unlikely ALLOW 'molecules' / 'substances' for 'particles' <u>NOTE</u> ALLOW AS A CQ from (a)(ii) Br^- ions not in rate equation / Br^- ions not in rate-determining step / Zero order with respect to Br^- / (Only) two reactants in the rate-determining step / (only) two reactants in the rate-equation/ particles are in the equation (for the reaction) that are not in the rate equation		1

Question Number	Acceptable Answers	Reject	Mark
18(c)	REMEMBER TO SCROLL DOWN BELOW THE SPACE LEFT FOR A SKETCH-GRAPH TO SEE WHAT CANDIDATE HAS WRITTEN ON THE DOTTED LINES • (Calculate) gradient (of tangent) (1) ALLOW 'slope' for 'gradient' • At $t = 0$ / at the start / at the beginning / when reaction is at its fastest / at the origin (1) Each mark is stand-alone NOTE: Answer may be annotated on a suitable sketch-graph IGNORE any sketch-graph that shows an increase in concentration with time MAX (1) if sketch-graph shows a decrease in the concentration of a reactant / Br_2	Answers relating to half-life score (0) overall If sketch-graph or comments suggest that gradient is measured at other than $t = 0$ or at several values of t then max (1)	2

(Total 12 marks)

SECTION C

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	$\begin{array}{ccccccc} & \text{C} & : & \text{H} & : & \text{O} & \\ \text{Mole ratio / mol} & \underline{54.5} & : & \underline{9.1} & : & \underline{36.4} & \\ & 12 & & 1 & & 16 & \\ & & & & & & \textbf{(1)} \\ & = & 4.5417 & : & 9.1 & : & 2.275 \\ & = & 1.996 & : & 4 & : & 1 \\ & = & 2 & : & 4 & : & 1 \\ & & & & & & \text{C}_2\text{H}_4\text{O} \quad \textbf{(1)} \end{array}$ Correct empirical formula of C₂H₄O, with or without working, scores (2)		2

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	First mark: Any mention of 44 or of doubling C₂H₄O (1) Second mark: Any mention of 88 in the context of the mass spectrum eg mentions 'molecular ion' / M⁺ / heaviest peak / peak furthest to the right / annotation at 88 on the mass spectrum itself / highest $\frac{m}{z}$ value (1)	88 obtained just by adding up the relative atomic masses in C₄H₈O₂ scores (0) for 2nd scoring point	2

Question Number	Acceptable Answers	Reject	Mark
19(b)	(Peak at 3500 cm⁻¹) O—H (1) Allow OH (Peak at 1700 cm⁻¹) C=O (1) Penalise extra extension bond on an otherwise correct answer once only (eg —O—H and —C=O scores (1)) IGNORE any names for the bonds suggested even if incorrect	—O—H / —OH C—O / —C=O / CO	2

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	First mark: (X is neutral) so not a (carboxylic) acid (1) IGNORE "X doesn't have a charge as it is neutral" / "X is not an alkali" / "X is not a base" Second mark: (X does not react with Tollens') so is not an aldehyde / is a ketone (1) Third mark: (X reacts with H^+ / $Cr_2O_7^{2-}$ so) is an alcohol / contains an OH (group) / contains R—OH / contains hydroxyl (group) (1) IGNORE 'not an acid' if this is deduced solely from the H^+ / $Cr_2O_7^{2-}$ information Fourth mark: a primary or a secondary (alcohol) both needed OR (X is) not tertiary (alcohol) (1) Mark each point separately NOTE: 'X is a primary or a secondary alcohol' scores both the third and fourth marks ALLOW Correct formulae for the functional groups, instead of their names	X is an aldehyde scores (0) for this scoring point / X is not a ketone scores (0) for this scoring point	4

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	(primary or secondary) alcohol and ketone NOTE BOTH names are required here	Just 'hydroxyl for 'alcohol' and/or 'C=O /carbonyl' for ketone/	1

Question Number	Acceptable Answers	Reject	Mark
19(d)	MARKING ADVICE Check answer for the suggested structure of X. If the correct structure is shown Mark answer according to the following. However if no structure for X is shown or an incorrect structure for X is proposed, mark answer according to "COMMENTS" scheme below MARKS CAN BE AWARDED FROM SUITABLY ANNOTATED FORMULAE FOR X. First mark: Four different H / hydrogen / proton environments (1) Any five from following seven points: Either Application of the (n+1) rule to peak J (which is a quartet / splits into four) or application of the (n+1) rule peak M (which is a doublet / splits into two) (1) Any mention to explain no splitting for peak L as there is no H is attached to the adjacent carbon (1) Peak L (CH₃) next to C=O (1) Peak M (CH₃) next to CH (1) Peak K OH (1) Peak J (CH) next to CH₃ (1) Any one correct δ value quoted within ± 0.2 of the following chemical shifts: 1.4(M) or 2.2 (L) or 3.7(K) or 4.2 (J) (ppm) (1)	Just 'four different chemical environments' If any incorrect chemical shift OR A RANGE of chemical shifts is quoted, this scoring point is not available	7

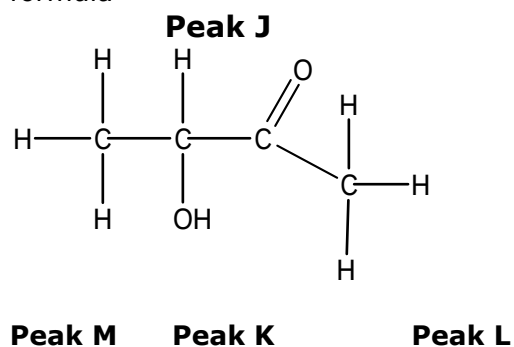
Final mark

(Compound **X** is) $\text{CH}_3\text{CH}(\text{OH})\text{COCH}_3$

NO other compound allowed.

ACCEPT

any unambiguous formula, e.g. displayed formula

**ACCEPT**

3-hydroxybutan-2-one

(1)

(Total 18 marks)
Total marks 90

COMMENT

Strategy for marking answers with an incorrect structure for X or where no structure is suggested for X.

The maximum mark in such cases is FOUR OUT OF SEVEN or TWO OUT OF SEVEN IF NO STRUCTURE DRAWN (as second and fourth marks are not available)

Scoring points:

First mark:

States four different H / hydrogen / proton environments

Second mark:

Structure drawn for **X** has exactly 4 hydrogen environments

Third mark:

Peak **K** is due to OH

Fourth Mark:

Providing the structure drawn for X would produce ONE of these splits.

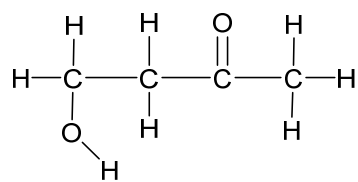
Any ONE of

Application of the (n+1) rule to peak to explain a peak which is a quartet splits into **four**
or

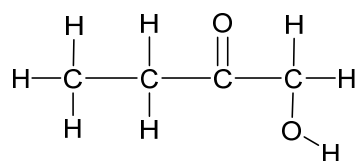
Application of the (n+1) rule to peak to explain a peak which is a doublet / splits into **two**
or

Application of the (n+1) rule to peak to explain a peak which is a singlet due to a CH₃ next to C=O

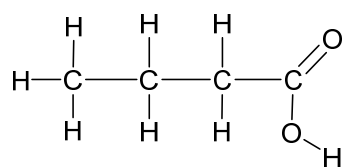
SEE NEXT PAGE FOR MAXIMUM MARKS AVAILABLE FOR SOME LIKELY INCORRECT STRUCTURES FOR **X**



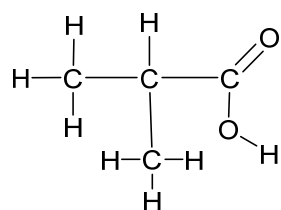
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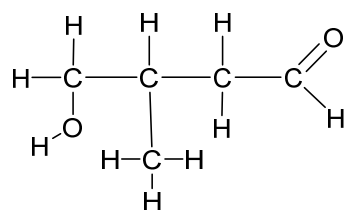
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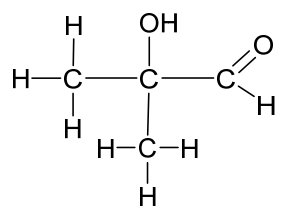
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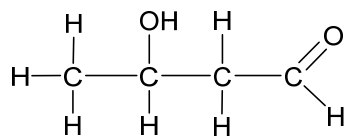
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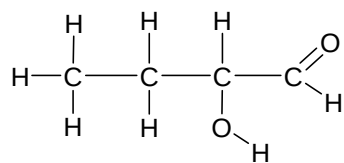
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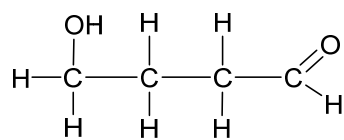
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Max 3



Max 2



Max 2

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Candidate Number

Edexcel GCE

Chemistry

Advanced

**Unit 4: General Principles of Chemistry I – Rates,
Equilibria and Further Organic Chemistry
(including synoptic assessment)**

Wednesday 12 June 2013 – Afternoon

Time: 1 hour 40 minutes

Paper Reference

6CH04/01

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 ►

P41572A

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6/5/7/7/7/



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 overall equation for a reaction between two chemicals, M and N, is

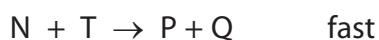


- (a) This reaction occurs spontaneously at room temperature. Which of the following **must** be true?

(1)

- ☐ A $\Delta H_{\text{reaction}}^{\ominus}$ is positive.
- ☐ B $\Delta H_{\text{reaction}}^{\ominus}$ is negative.
- ☐ C $\Delta S_{\text{total}}^{\ominus}$ is positive.
- ☐ D $\Delta S_{\text{total}}^{\ominus}$ is negative.

- (b) The reaction above occurs in two stages via an intermediate, T.



From this it can be deduced that the rate equation for the reaction between M and N is

(1)

- ☐ A rate = $k[M][N]$
- ☐ B rate = $k[M][N]^2$
- ☐ C rate = $k[M][T]$
- ☐ D rate = $k[N][T]$

(Total for Question 1 = 2 marks)

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



- 2 Calcium carbonate decomposes at high temperature to form calcium oxide and carbon dioxide:



Calcium carbonate is **thermodynamically** stable at room temperature because for this reaction

- ☐ A the activation energy is high.
- ☐ B the enthalpy change, ΔH , is positive.
- ☐ C entropy change of the system (ΔS_{system}) is positive.
- ☐ D entropy change of the system (ΔS_{system}) is negative.

(Total for Question 2 = 1 mark)

- 3 2-methylpropane has a smaller standard molar entropy at 298 K than butane. The best explanation for this is that 2-methylpropane has

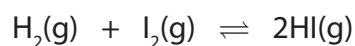
- ☐ A a lower boiling temperature.
- ☐ B a higher standard molar enthalpy change of formation.
- ☐ C fewer ways of distributing energy quanta.
- ☐ D more ways of distributing energy quanta.

(Total for Question 3 = 1 mark)

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



4 (a) For the equilibrium reaction between hydrogen and iodine

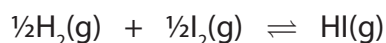


increasing the pressure of the system

(1)

- ☐ A has no effect on the rate or the position of equilibrium.
- ☐ B increases the rate but does not affect the position of equilibrium.
- ☐ C increases the rate and shifts the equilibrium to the right.
- ☐ D increases the rate and shifts the equilibrium to the left.

(b) The equation for the equilibrium reaction between hydrogen and iodine may also be written as



This change to the equation, compared to that in part (a),

(1)

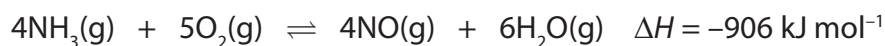
- ☐ A has no effect on the value of the equilibrium constant.
- ☐ B halves the value of the equilibrium constant.
- ☐ C doubles the value of the equilibrium constant.
- ☐ D square roots the value of the equilibrium constant.

(Total for Question 4 = 2 marks)

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



5 The first stage in the manufacture of nitric acid is the oxidation of ammonia:



(a) In modern industrial plants this reaction is carried out at a pressure of around 3 atm. Which of the following statements is **incorrect**? The raised pressure

(1)

- ☐ A helps push the reactants through the reactor.
- ☐ B shifts the position of equilibrium to the right.
- ☐ C increases the cost of the reactor.
- ☐ D increases the energy cost of this part of the process.

(b) A platinum-rhodium alloy catalyst is used in this reaction. Which of the following statements is **incorrect**? The catalyst

(1)

- ☐ A lowers the activation energy of the reaction.
- ☐ B has no effect on the equilibrium constant for the reaction.
- ☐ C alters the enthalpy change of the reaction.
- ☐ D reduces the energy cost of this part of the process.

(c) The operating temperature of this reaction is about 900 °C. The use of a high temperature

(1)

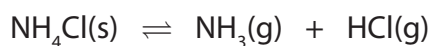
- ☐ A increases the rate of the reaction and the equilibrium yield.
- ☐ B increases the rate of the reaction and decreases the equilibrium yield.
- ☐ C decreases the rate of the reaction and the equilibrium yield.
- ☐ D decreases the rate of the reaction and increases the equilibrium yield.

(Total for Question 5 = 3 marks)

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



6 Ammonium chloride decomposes on heating:



The equilibrium constant, K_p , for this reaction equals

☐ A $p_{\text{NH}_3} \times p_{\text{HCl}}$

☐ B $\frac{1}{p_{\text{NH}_3} \times p_{\text{HCl}}}$

☐ C $\frac{p_{\text{NH}_3} \times p_{\text{HCl}}}{p_{\text{NH}_4\text{Cl}}}$

☐ D $\frac{p_{\text{NH}_4\text{Cl}}}{p_{\text{NH}_3} \times p_{\text{HCl}}}$

(Total for Question 6 = 1 mark)

7 The dissociation constant of water, K_w , increases with increasing temperature. When the temperature increases, water

☐ A remains neutral.

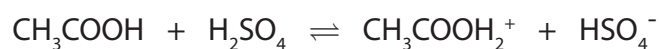
☐ B dissociates less.

☐ C becomes acidic.

☐ D becomes alkaline.

(Total for Question 7 = 1 mark)

8 The reaction between concentrated sulfuric acid and pure ethanoic acid is



The Brønsted-Lowry acids in this equilibrium are

☐ A CH_3COOH and H_2SO_4

☐ B $\text{CH}_3\text{COOH}_2^+$ and HSO_4^-

☐ C H_2SO_4 and $\text{CH}_3\text{COOH}_2^+$

☐ D CH_3COOH and HSO_4^-

(Total for Question 8 = 1 mark)



9 An aqueous solution of ethanoic acid is gradually diluted. Which of the following statements is **incorrect**?

- ☐ A The pH decreases.
- ☐ B The value of K_a is unchanged.
- ☐ C The concentration of ethanoic acid molecules decreases.
- ☐ D The proportion of ethanoic acid molecules which dissociates increases.

(Total for Question 9 = 1 mark)

10 Methyl orange and phenolphthalein are both acid-base indicators. In the titration of a strong acid against a weak alkali

- ☐ A methyl orange is a suitable indicator but phenolphthalein is not.
- ☐ B phenolphthalein is a suitable indicator but methyl orange is not.
- ☐ C both phenolphthalein and methyl orange are suitable indicators.
- ☐ D neither phenolphthalein nor methyl orange is a suitable indicator.

(Total for Question 10 = 1 mark)

11 Select the word that best describes the effect of a chiral molecule on the plane of plane-polarized light. The plane of polarization of light is

- ☐ A reflected.
- ☐ B refracted.
- ☐ C resolved.
- ☐ D rotated.

(Total for Question 11 = 1 mark)

12 An organic compound reacts with **both** acidified potassium dichromate(VI) **and** lithium tetrahydridoaluminate (lithium aluminium hydride). The organic compound could be

- ☐ A a primary alcohol.
- ☐ B an aldehyde.
- ☐ C a ketone.
- ☐ D a carboxylic acid.

(Total for Question 12 = 1 mark)



13 Ketones react with

- ☐ A both 2,4-dinitrophenylhydrazine solution and Tollens' reagent.
- ☐ B 2,4-dinitrophenylhydrazine solution but not with Tollens' reagent.
- ☐ C Tollens' reagent but not with 2,4-dinitrophenylhydrazine solution.
- ☐ D neither Tollens' reagent nor 2,4-dinitrophenylhydrazine solution.

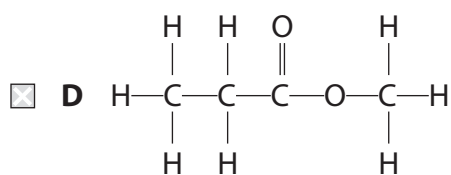
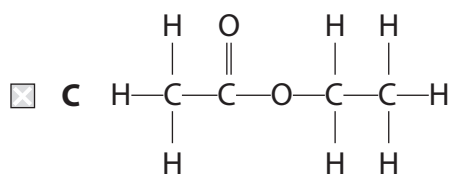
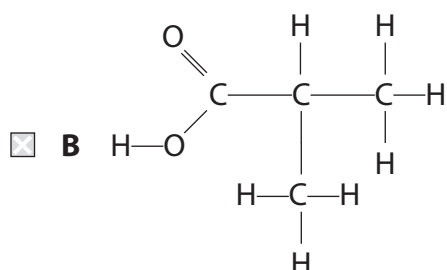
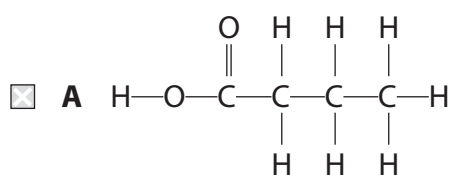
(Total for Question 13 = 1 mark)

14 Ethanoic acid, CH_3COOH , may be prepared from ethanenitrile, CH_3CN . This reaction is best described as

- ☐ A reduction.
- ☐ B oxidation.
- ☐ C hydrolysis.
- ☐ D condensation.

(Total for Question 14 = 1 mark)

15 Propanoic acid reacts with methanol to form an ester. The structure of the ester is



(Total for Question 15 = 1 mark)



16 The boiling temperature of ethanoic acid is very much higher than that of butane although these molecules have similar numbers of electrons. This is because ethanoic acid has

- ☐ **A** stronger covalent bonds.
- ☐ **B** stronger ionic bonds.
- ☐ **C** greater London forces.
- ☐ **D** hydrogen bonding.

(Total for Question 16 = 1 mark)

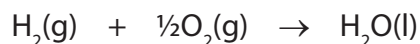
TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

17 The equation for the combustion of hydrogen is



- (a) Use the standard molar entropies on page 2 and page 25 of the data booklet to calculate the standard entropy change of the system ($\Delta S_{\text{system}}^{\ominus}$) for this reaction.

Note that the standard molar entropies of the elements are given **per atom** so that the standard molar entropy of oxygen, $S^{\ominus}[\frac{1}{2}\text{O}_2(\text{g})] = +102.5 \text{ J mol}^{-1} \text{ K}^{-1}$.

(3)

- (b) The standard enthalpy change for the combustion of hydrogen is $-285.8 \text{ kJ mol}^{-1}$. Use this value to calculate the entropy change of the surroundings for the combustion of hydrogen at 298 K. Give your answer to **3** significant figures and include a sign and units.

(3)



(c) Use your answers to (a) and (b) to calculate the total entropy change ($\Delta S_{\text{total}}^{\ominus}$) for the combustion of 1 mol of hydrogen. Include a sign and units in your answer.

(2)

*(d) By considering both the thermodynamic stability and the kinetic inertness of a mixture of hydrogen and oxygen, explain why hydrogen does not react with oxygen unless ignited.

(2)

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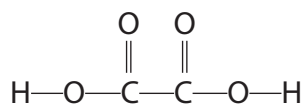
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(Total for Question 17 = 10 marks)



P 4 1 5 7 2 A 0 1 1 2 4

- 18** Ethanedioic acid, $\text{H}_2\text{C}_2\text{O}_4$, is a dicarboxylic acid which occurs in many plants, for example in rhubarb leaves, and is used as a rust remover and strong descaler. The structure of ethanedioic acid is shown below.



Ethanedioic acid is a much stronger acid than carboxylic acids such as ethanoic acid, having a $\text{p}K_{\text{a}}$ of 1.38. The hydrogenethanedioate ion, HC_2O_4^- , is a weaker acid than ethanedioic acid, having a $\text{p}K_{\text{a}}$ of 4.28, although slightly stronger than ethanoic acid.

- (a) (i) Write an equation for the reaction of the hydrogenethanedioate ion with water to form an acidic solution. Include state symbols in your equation.

(2)

- (ii) Write the expression for the acid dissociation constant, K_{a} , of the weak acid, HC_2O_4^- .

(1)



(iii) A solution containing hydrogenethanedioate ions behaves as a typical weak acid. Use your answer to (a)(ii) and the pK_a of the hydrogenethanedioate ion to calculate the pH of a $0.050 \text{ mol dm}^{-3}$ solution of sodium hydrogenethanedioate, NaHC_2O_4 .

(3)

(b) (i) State **two** approximations used in the calculation of pH in (a)(iii).

(2)

1.....

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2.....

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*(ii) Explain why the calculation of the pH of a solution of sodium hydrogenethanedioate gives a more accurate value than a similar calculation for ethanedioic acid.

(2)

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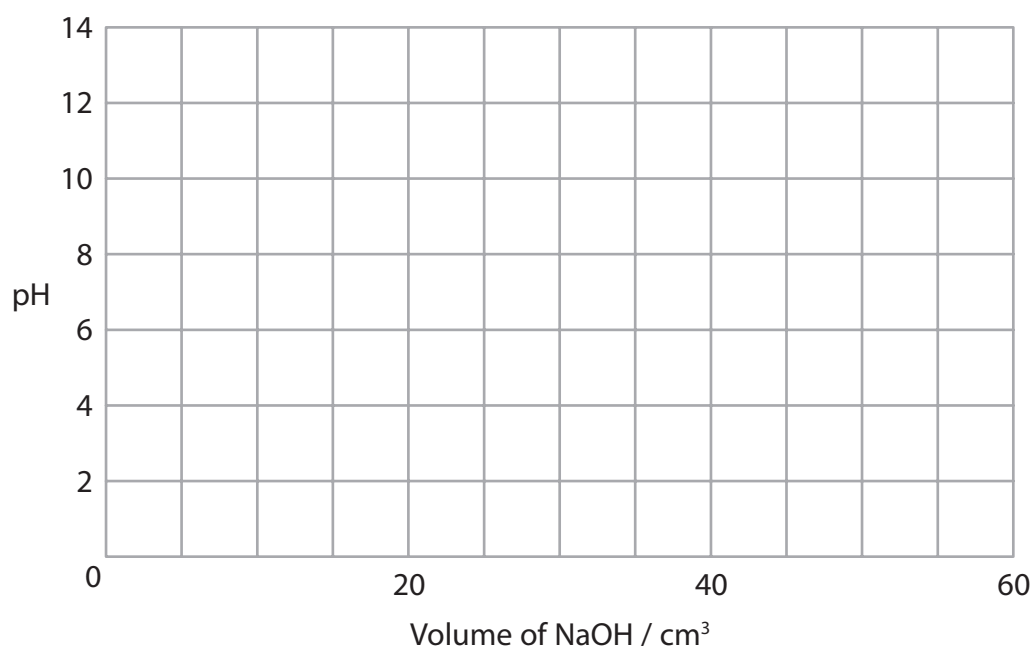
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(c) 25 cm³ of a 0.050 mol dm⁻³ solution of sodium hydrogenethanedioate was titrated with a sodium hydroxide solution of the same concentration.

(i) On the axis below, sketch the curve for this titration.

(3)



*(ii) When 25 cm³ of a 0.050 mol dm⁻³ solution of **ethanedioic acid** is titrated with sodium hydroxide solution of the same concentration using phenolphthalein as the indicator, the end point is 50 cm³.

When methyl yellow indicator is used, the colour changes at around 25 cm³.

Using the information given at the start of the question and quoting data from page 19 of your data booklet, suggest why these volumes are different.

(2)

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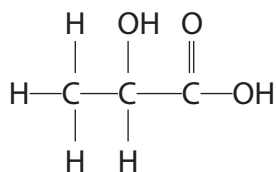
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(Total for Question 18 = 15 marks)



- 19 2-hydroxypropanoic acid, lactic acid, is a chiral molecule which is found in muscles and in sour milk. The 2-hydroxypropanoic acid formed in muscles is optically active but that in sour milk is not.



2-hydroxypropanoic acid

- (a) (i) Explain the term **chiral**, stating the feature of 2-hydroxypropanoic acid that makes it chiral. Label this feature on the formula above.

(3)

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- (ii) What is the difference between the 2-hydroxypropanoic acid formed in muscles and that found in sour milk which gives rise to the difference in optical activity?

(2)

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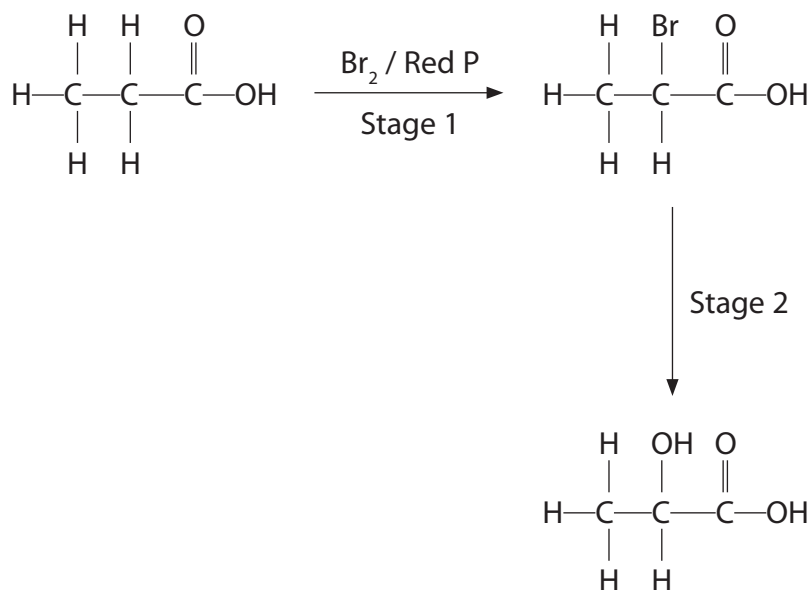
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- (b) 2-hydroxypropanoic acid may be prepared in the laboratory from propanoic acid in a two-stage sequence in which 2-bromopropanoic acid is formed as an intermediate:



- (i) Stage 2 of this sequence was carried out in two steps. Identify the reagent required for each step in Stage 2.

(2)

First step

Second step

- (ii) When an optically active isomer of 2-bromopropanoic acid is used in Stage 2, the resulting 2-hydroxypropanoic acid is also optically active. State and explain what this indicates about the mechanism of the first reaction in Stage 2.

(3)

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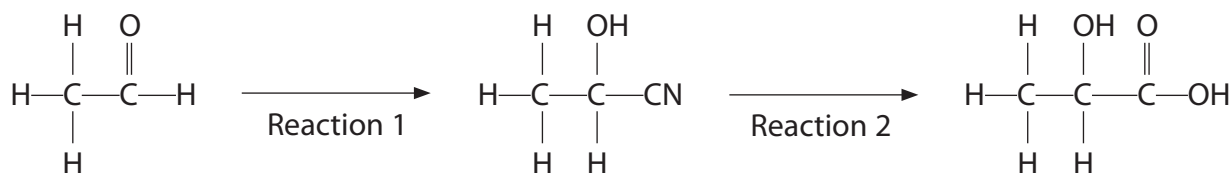
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(c) 2-hydroxypropanoic acid may also be prepared from ethanal in the following sequence:



(i) Name the mechanism and type of reaction occurring in Reaction 1.

(2)

(ii) Identify the attacking species in Reaction 1.

(1)

(iii) Give the first step of the mechanism of Reaction 1, showing the formation of the intermediate.

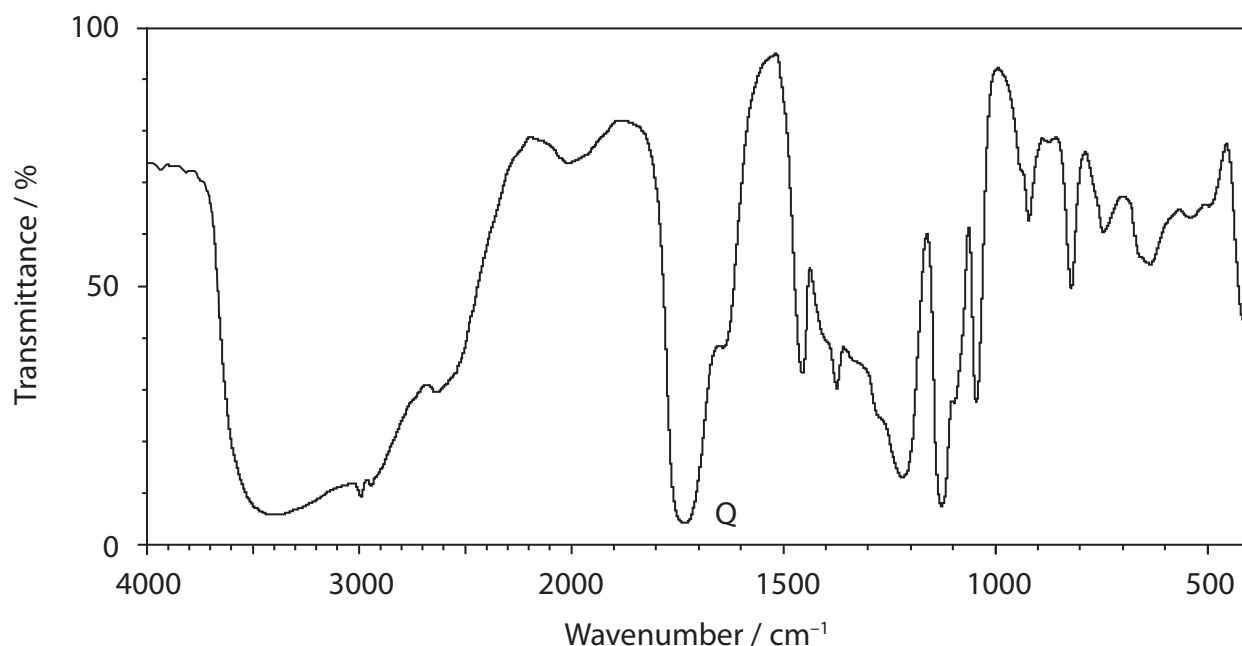
(2)

*(iv) Explain, by referring to the mechanism in (c)(iii), why the 2-hydroxypropanoic acid formed from ethanal shows no optical activity.

(3)



(d) The infrared spectrum of 2-hydroxypropanoic acid is shown below.



- (i) Give the wavenumber of the peak that is present in the infrared spectrum of 2-hydroxypropanoic acid but will not be present in the infrared spectrum of ethanal, identifying the group most likely to be responsible for this peak. Use the data on pages 5 and 6 of the data booklet.

(1)

- *(ii) Identify the bond responsible for absorption peak Q in the spectrum. By considering the wavenumber of this peak, and the data on pages 5 and 6 of the data booklet, explain whether this peak **alone** can be used to distinguish between ethanal and 2-hydroxypropanoic acid.

(3)



- (e) Ethanal and 2-hydroxypropanoic acid can be distinguished by the use of chemical tests. Give two suitable tests **not** involving indicators. For each test, state the observation associated with a positive result.

(4)

Test which is positive for ethanal but not for 2-hydroxypropanoic acid.

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Test which is positive for 2-hydroxypropanoic acid but not for ethanal.

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(Total for Question 19 = 26 marks)

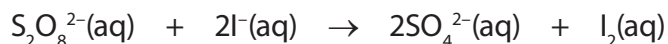
TOTAL FOR SECTION B = 51 MARKS



SECTION C

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

- 20** The ionic equation for the reaction of ammonium peroxodisulfate (persulfate), $(\text{NH}_4)_2\text{S}_2\text{O}_8$, with potassium iodide, KI, is



- (a) In a series of experiments to determine the rate equation for this reaction, 10 cm^3 of $0.0050\text{ mol dm}^{-3}$ sodium thiosulfate was mixed with 20 cm^3 of $(\text{NH}_4)_2\text{S}_2\text{O}_8$ solution and 5 drops of starch solution. 20 cm^3 of KI solution was added with mixing and the time taken for the solution to darken was noted. The initial concentrations of the $(\text{NH}_4)_2\text{S}_2\text{O}_8$ and KI solutions and the times for the mixture to darken are shown below.

Experiment Number	Initial concentration / mol dm^{-3}		Time for solution to darken / s
	$\text{S}_2\text{O}_8^{2-}$	I^-	
1	0.10	0.20	35
2	0.05	0.20	69
3	0.10	0.10	70

- (i) Explain the purpose of the sodium thiosulfate solution.

(2)

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- (ii) Use the data in the table to deduce the rate equation for the reaction between $\text{S}_2\text{O}_8^{2-}$ and I^- ions. Explain, by referring to the data, how you arrived at your answer.

(3)

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(b) A further experiment was carried out to confirm the order of the reaction with respect to iodide ions. $(\text{NH}_4)_2\text{S}_2\text{O}_8$ was mixed with KI to form a solution in which the initial concentration of $(\text{NH}_4)_2\text{S}_2\text{O}_8$ was 2.0 mol dm^{-3} and that of KI was $0.025 \text{ mol dm}^{-3}$. The concentration of iodine was measured at various times until the reaction was complete.

- (i) Outline a method, **not** involving sampling the mixture, which would be suitable for measuring the iodine concentrations in this experiment. Experimental details are not required but you should state how you would use your measurements to obtain iodine concentrations.

(3)

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- (ii) Explain why the initial concentration of $(\text{NH}_4)_2\text{S}_2\text{O}_8$ is much higher than that of KI.

(1)

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- (iii) State how the initial rate of reaction may be obtained from the results of this type of experiment.

(2)

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(iv) In such an experiment a student calculated the initial rate of reaction to be $8.75 \times 10^{-5} \text{ mol dm}^{-3} \text{ s}^{-1}$. Use this value, the initial concentrations in (b) and the rate equation that you obtained in (a)(ii), to calculate the rate constant for this reaction. Include units in your answer.

(2)

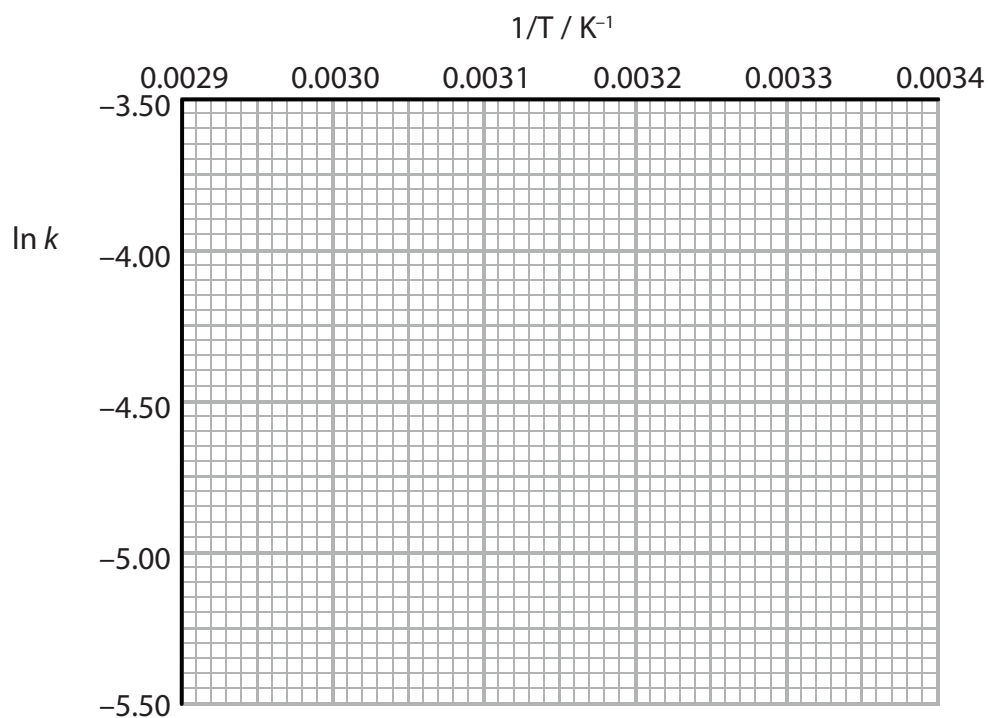
- (c) Using the method outlined in (b), the rate constant for this reaction was determined at various temperatures. The data from these experiments are shown in the table below. Note that none of the temperatures corresponds to that used in (b) and that the rate constant is given in appropriate units.

Temperature T / K	Rate constant <i>k</i>	ln <i>k</i>	1/T / K ⁻¹
300	0.00513	-5.27	0.00333
310	0.00833	-4.79	0.00323
320	0.0128	-4.36	0.00313
330	0.0201	-3.91	0.00303
340	0.0301	-3.50	0.00294



- (i) Use the data in the table to plot a graph of $\ln k$ (on the y axis) against $1/T$ (on the x axis) and draw a best fit line through the points.

(2)



- (ii) Determine the gradient of the best fit line in (c)(i) and use this value to calculate the activation energy, E_a , of the reaction, stating the units.

(4)

The rate constant of a reaction, k , is related to the temperature, T , by the expression

$$\ln k = -\frac{E_a}{R} \times \frac{1}{T} + \text{constant} \quad R = 8.31 \text{ J K}^{-1} \text{ mol}^{-1}$$

(Total for Question 20 = 19 marks)

TOTAL FOR SECTION C = 19 MARKS

TOTAL FOR PAPER = 90 MARKS



P 4 1 5 7 2 A 0 2 4 2 4

Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH04/01
General Principles of Chemistry I

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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(a)	C		1
(b)	A		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)	B		1
(b)	D		1

Question Number	Correct Answer	Reject	Mark
5(a)	B		1
(b)	C		1
(c)	B		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	C		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	D		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	C		1

Question Number	Correct Answer	Reject	Mark
15	D		1

Question Number	Correct Answer	Reject	Mark
16	D		1

Total for Section A = 20 Marks

Section B

Question Number	Acceptable Answers	Reject	Mark
17(a)	Units are not required in (a) or (c) but if used should be correct. Penalise incorrect units in (a), (b) & (c) once only IGNORE case of J and K order of units First mark: 65.3/ 130.6 and 69.9 (J mol⁻¹ K⁻¹) (1) Second mark: $\Delta S = 69.9 - (130.6 + 102.5)$ (1) Third mark: $\Delta S = -163.2 = -163$ (J mol⁻¹ K⁻¹) (1) Correct answer with no working scores 3 Ignore SF except 1 SF TE at each stage If 65.3 used instead of 130.6 penalize once (answer is then $\Delta S = -97.9$ (J mol⁻¹ K⁻¹))	+163 or any positive answer	3

Question Number	Acceptable Answers	Reject	Mark
17(b)	$\Delta S_{\text{surroundings}} = -\Delta H / T$ or just numbers (1) $= +285800/298$ $= +959.06 = +959$ J mol⁻¹ K⁻¹ / $+0.959$ kJ mol⁻¹ K⁻¹ Correct value to 3SF (1) Correct units and positive sign (1) Correct answer with no working scores 3	answer with no sign	3

Question Number	Acceptable Answers	Reject	Mark
17(c)	$\Delta S_{\text{total}} = \Delta S_{\text{system}} + \Delta S_{\text{surroundings}}$ (1) Allow $\Delta S_{\text{reaction}}$ for ΔS_{system} $\Delta S_{\text{total}} = \text{answer (a)} + \text{answer (b)}$ $= -163.2 + 959$ $= (+)795.8 = (+)796 \text{ (J mol}^{-1} \text{ K}^{-1})$ If $\Delta S_{\text{surroundings}} = +959.06$ then $\Delta S_{\text{total}} = +795.9$ (1) Correct answer with no working scores 2 Ignore SF except 1 SF TE on values in (a) & (b) no TE on incorrect equation If answer to (a) = $-97.9 \text{ (J mol}^{-1} \text{ K}^{-1})$ $\Delta S_{\text{total}} = (+)861.1 \text{ (J mol}^{-1} \text{ K}^{-1})$		2

Question Number	Acceptable Answers	Reject	Mark
17(d)	A mixture of hydrogen and oxygen is thermodynamically unstable because ΔS_{total} is positive OR Reaction between hydrogen and oxygen is thermodynamically feasible because ΔS_{total} is positive ALLOW ΔS for ΔS_{total} (1) No TE on negative ΔS_{total} from (c) The mixture is kinetically inert /stable or reaction is (very) slow because the activation energy is (very) high (1) Mixture / reaction is kinetically inert / stable but thermodynamically unstable / feasible scores 1 mark IGNORE References to spark / flame providing the (activation) energy for reaction	Reference to the stability of individual elements	2

Total for Question 17 = 10 Marks

Question Number	Acceptable Answers	Reject	Mark
18(a)(i)	$\text{HC}_2\text{O}_4^-(\text{aq}) + \text{H}_2\text{O}(\text{l}) \rightleftharpoons \text{C}_2\text{O}_4^{2-}(\text{aq}) + \text{H}_3\text{O}^+(\text{aq})$ (or $\rightarrow$) ALLOW $\text{H}_2\text{O}(\text{aq})$ Equation (1) states (1) ALLOW for 1 mark $\text{HC}_2\text{O}_4^-(\text{aq}) \rightleftharpoons \text{C}_2\text{O}_4^{2-}(\text{aq}) + \text{H}^+(\text{aq})$ States mark is not stand alone but can be awarded if the equation has a minor error e.g. an incorrect charge		2

Question Number	Acceptable Answers	Reject	Mark
18(a)(ii)	$K_a = [\text{C}_2\text{O}_4^{2-}] [\text{H}_3\text{O}^+] / [\text{HC}_2\text{O}_4^-]$ OR $K_a = [\text{C}_2\text{O}_4^{2-}] [\text{H}^+] / [\text{HC}_2\text{O}_4^-]$ No TE on incorrect equation in (a)(i) Penalise incorrect charges in (i) and (ii) once only	$K_a =$ $[\text{H}^+]^2 / [\text{HC}_2\text{O}_4^-]$ $[\text{H}^+][\text{A}^-] / [\text{HA}]$	1

Question Number	Acceptable Answers	Reject	Mark
18 (a) (iii)	No TE on (a)(ii) $K_a = 10^{-4.28}$ OR $5.24807 \times 10^{-5} (\text{mol dm}^{-3})$ (1) $K_a = [\text{H}^+]^2 / [\text{HC}_2\text{O}_4^-]$ $K_a = [\text{H}^+]^2 / 0.050$ $[\text{H}^+] = \sqrt{(0.05 \times 10^{-4.28})} = 1.61988 \times 10^{-3} (\text{mol dm}^{-3})$ (1) TE on incorrect K_a value $\text{pH} = -\log 1.61988 \times 10^{-3} = 2.7905 = 2.8$ (1) For final mark TE on algebraic / arithmetical errors providing $\text{pH} \geq 1.3$ Correct answer with no working scores 3 Ignore SF except 1 SF		3

Question Number	Acceptable Answers	Reject	Mark
18(b)(i)	IGNORE explanations First mark: HC_2O_4^-/hydrogenethanedioate ion ionization negligible ALLOW Acid for HC_2O_4^- Slight / partial / incomplete / does not dissociate for negligible OR $[\text{HC}_2\text{O}_4^-]_{\text{equilibrium}} = [\text{HC}_2\text{O}_4^-]_{\text{initial}} / 0.050 \text{ (mol dm}^{-3}\text{)}$ (1) Second mark: $[\text{H}^+]$ due to ionization of water negligible OR auto ionization of water negligible OR $[\text{H}^+]$ only due to ionization of HC_2O_4^-/acid OR $[\text{C}_2\text{O}_4^{2-}] = [\text{H}^+]$ (1) IGNORE references to temperature and to HA and A^- Penalize omission of [] in discussion once only	Use of NaHC_2O_4 for HC_2O_4^- OR sodium hydrogenethanedioate for hydrogenethanedioate ion throughout this item	2

Question Number	Acceptable Answers	Reject	Mark
18(b)(ii)	Ethanedioic acid is a (much) stronger acid (than hydrogenethanedioate ion / sodium hydrogenethanedioate) OR Ethanedioic acid has a (much) smaller pK_a (than hydrogenethanedioate) OR Ionization / dissociation of ethanedioic acid is (much) greater (than hydrogenethanedioate) OR Reverse arguments (1) IGNORE $NaHC_2O_4$ ionization negligible Approximation of negligible ionization invalid / incorrect OR $[H_2C_2O_4]_{equilibrium}$ not equal to $[H_2C_2O_4]_{initial}$ (1) No TE on 18(a)(iii) IGNORE Second ionization occurs	Ethanedioic acid is a strong acid / fully dissociated Just 'approximation invalid'	2

Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	Start pH at 2.8 ALLOW 2—4 (1) Vertical section at 25 cm^3 within pH range 6-11 and 2.5-4 units long (1) end pH (approaching) value in range 12-13 (asymptotically) (1)	deviation from vertical maximum before final pH	3

Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	First mark: Methyl yellow range = 2.9—4 and the phenolphthalein range = 8.2—10 ALLOW pK_{in} (methyl yellow) = 3.5 and pK_{in} (phenolphthalein) = 9.3 (1) Second mark: (The volumes are different) because ethanedioic acid is dibasic / diprotic / has two replaceable/acidic hydrogen atoms ALLOW dicarboxylic (acid) (therefore there are two stages to the neutralization) OR Methyl yellow range coincides with neutralization of first proton and phenolphthalein range coincides with neutralization of second proton (1)		2

Total for Question 18 = 15 Marks

Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	A chiral molecule is non-superimposable on its mirror image / 3D molecule with no plane of symmetry (1) 2-hydroxypropanoic acid has a carbon atom which is asymmetric / has four different groups attached (1) Middle carbon labelled in any clear way (1) e.g. $ \begin{array}{ccccccc} & & \text{H} & & \text{OH} & & \text{O} \\ & & & & & & \\ \text{H} & - & \text{C} & - & \text{C}^* & - & \text{C} & - & \text{OH} \\ & & & & & & \\ & & \text{H} & & \text{H} & & \end{array} $ ALLOW asymmetric C described but not labelled IGNORE references to rotation of plane polarized light	just 'non-superimposable' just 'no plane of symmetry' Molecules for groups	3

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	2-hydroxypropanoic acid formed in muscles is a single (allow pure) enantiomer /(optical) isomer ALLOW Unequal mixture of enantiomers /(optical) isomers (1) 2-hydroxypropanoic acid formed in milk is a racemic mixture / equimolar mixture of the two enantiomers / racemate (1) If milk and muscles are reversed but the rest is correct, one mark is awarded	Just "not a racemic mixture" Just 'a mixture of enantiomers'	2

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	First step NaOH(aq) / KOH(aq) or names (1) Second mark dependent on first being correct Second step HCl(aq) / hydrochloric acid / H₂SO₄(aq) / sulfuric acid ALLOW HNO₃ / nitric acid /dil HCl /(dil) H₂SO₄ /(dil) HNO₃ or any strong acid (name or formula) including HBr((aq)) and HI((aq)) (1) IGNORE Omission of (aq) and references to temperature Ethanolic /alcoholic solutions ALLOW One mark for correct two reagents in the wrong order One mark for 'alkali / OH⁻ followed by acid / H⁺ /H₃O⁺'	OH⁻ / alkali H⁺ / H₃O⁺ /acid	2

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	First mark (Stand alone) A racemic mixture is not formed OR More of one enantiomer /(optical) isomer is formed OR Only one enantiomer /(optical) isomer is formed (1) Second mark (Stand alone) (Some of the) reaction is S_N2 (1) Third mark (Stand alone) Nucleophile / OH⁻ only attacks from one side of the molecule / from the opposite side to leaving group (1) ALLOW Use of 'intermediate' for 'transition state' in description of S_N2 Reverse argument based on S_N1 forming a racemic mixture	Carbocation (for molecule)	3

Question Number	Acceptable Answers	Reject	Mark
19(c)(i)	Nucleophilic (1) Addition (1)	S_N1/S_N2	2

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	Cyanide (ion) / CN^- / $C\equiv N^-$ / $:C\equiv N^-$ / ^-CN	HCN/ $C\equiv N$	1

Question Number	Acceptable Answers	Reject	Mark
19(c)(iii)	Both curly arrows (1) Intermediate (1) ALLOW Omission of lone pair Curly arrow from anywhere on nucleophile including from charge or nitrogen Formation of charged canonical form followed by attack of cyanide ion IGNORE $\delta+/\delta-$ even if unbalanced	Omission of charges (penalise once only) Full charges on ethanal —C—NC in intermediate	2

Question Number	Acceptable Answers	Reject	Mark
19 (c) (iv)	Racemic mixture / equal amounts of the two enantiomers / racemate formed (1) Stand alone mark CHO / aldehyde group is (trigonal) planar (1) ALLOW ethanal / molecule is (trigonal) planar Cyanide (ion) / CN^- / nucleophile attacks (equally) from above or below / either side (of the molecule) (1) Penalise use of intermediate / ion for aldehyde group once only Third mark cannot be awarded if the reaction is described as a nucleophilic substitution	Intermediate / carbonyl group / $\text{C}_=\text{O}$ is planar two positions Intermediate	3

Question Number	Acceptable Answers	Reject	Mark
19(d)(i)	Any value /range within the range $3750\text{--}2500\text{ cm}^{-1}$ due to O--H / OH / --OH IGNORE COOH / CO_2H / carboxylic acid	Wavenumbers alone OH in alcohol	1

Question Number	Acceptable Answers	Reject	Mark
19(d)(ii)	These three marks are stand alone Q is due to $\text{C}=\text{O}$ (1) The ($\text{C}=\text{O}$) aldehyde range is $1740\text{--}1720\text{ cm}^{-1}$ and ($\text{C}=\text{O}$) carboxylic acid range is $1725\text{--}1700\text{ cm}^{-1}$ (1) So the peaks / absorptions cannot be used to distinguish these two compounds because they overlap. OR The (broad) absorption Q covers both the aldehyde and the carboxylic acid ranges (1) ALLOW 'too close'/'quite similar' for 'overlap'	Carboxylic acid / COOH group Just 'cannot be used to distinguish the compounds'	3

Question Number	Acceptable Answers	Reject	Mark																						
19(e)	If reagent incorrect, observation mark can only be awarded for a near miss Test positive for ethanal <table><tr><th>Reagent (1)</th><th>Observation (1)</th></tr><tr><td>Tollens'</td><td>Silver mirror / black / grey ppt</td></tr><tr><td>Fehling's / Benedict's</td><td>Red-brown ppt</td></tr><tr><td>2,4-DNP(H) / Brady's reagent</td><td>Orange / red / yellow ppt ALLOW brick-red ppt</td></tr></table> Test positive for 2-hydroxypropanoic acid <table><tr><th>Reagent (1)</th><th>Observation (1)</th></tr><tr><td>PCl₅ / Phosphorus (V)chloride / phosphorus pentachloride</td><td>Steamy fumes* ALLOW gas evolved turns (blue) litmus / UI red</td></tr><tr><td>Named metal carbonate (solution)</td><td>Effervescence ALLOW gas / CO₂ evolved turns lime water cloudy</td></tr><tr><td>Sodium hydrogencarbonate (solution)</td><td>Effervescence ALLOW gas / CO₂ evolved turns lime water cloudy</td></tr><tr><td>Magnesium (& water)</td><td>Effervescence</td></tr><tr><td>Ethanol & H₂SO₄/named strong acid</td><td>Sweet / fruity / pear drops / glue smell</td></tr><tr><td>Ethanoic acid & H₂SO₄/named strong acid</td><td>Sweet / fruity / pear drops / glue smell</td></tr></table> ALLOW Na and effervescence / gas evolved pops with a lighted splint for 2-hydroxypropanoic acid (2) ALLOW fizzing / bubbling for effervescence IGNORE names of product IF two tests given for one substance both must be correct for full marks *misty fumes / white fumes / gas for fumes	Reagent (1)	Observation (1)	Tollens'	Silver mirror / black / grey ppt	Fehling's / Benedict's	Red-brown ppt	2,4-DNP(H) / Brady's reagent	Orange / red / yellow ppt ALLOW brick-red ppt	Reagent (1)	Observation (1)	PCl ₅ / Phosphorus (V)chloride / phosphorus pentachloride	Steamy fumes* ALLOW gas evolved turns (blue) litmus / UI red	Named metal carbonate (solution)	Effervescence ALLOW gas / CO ₂ evolved turns lime water cloudy	Sodium hydrogencarbonate (solution)	Effervescence ALLOW gas / CO ₂ evolved turns lime water cloudy	Magnesium (& water)	Effervescence	Ethanol & H ₂ SO ₄ /named strong acid	Sweet / fruity / pear drops / glue smell	Ethanoic acid & H ₂ SO ₄ /named strong acid	Sweet / fruity / pear drops / glue smell	Iodine in alkali / iodoform test Acidified potassium dichromate Smoke Just 'fumes' Any indicator as sole test incorrect formulae of reagents	4
Reagent (1)	Observation (1)																								
Tollens'	Silver mirror / black / grey ppt																								
Fehling's / Benedict's	Red-brown ppt																								
2,4-DNP(H) / Brady's reagent	Orange / red / yellow ppt ALLOW brick-red ppt																								
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PCl ₅ / Phosphorus (V)chloride / phosphorus pentachloride	Steamy fumes* ALLOW gas evolved turns (blue) litmus / UI red																								
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Sodium hydrogencarbonate (solution)	Effervescence ALLOW gas / CO ₂ evolved turns lime water cloudy																								
Magnesium (& water)	Effervescence																								
Ethanol & H ₂ SO ₄ /named strong acid	Sweet / fruity / pear drops / glue smell																								
Ethanoic acid & H ₂ SO ₄ /named strong acid	Sweet / fruity / pear drops / glue smell																								

Total for Question 19 = 26 Marks

Total for Section B = 51 Marks

Section C

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	(Sodium thiosulfate) (rapidly) reacts with / reduces the iodine (as it is formed) (1) So prevents the starch-iodine colour appearing until a fixed amount of reaction has occurred ALLOW (for second mark) So prevents the starch-iodine colour appearing until all the thiosulfate has reacted OR Moles of iodine reacted / thiosulfate $\div$ time is (approximately) proportional to the (initial) rate of reaction (1) ALLOW Use of 'thio' for thiosulfate	iodide / I^-	2

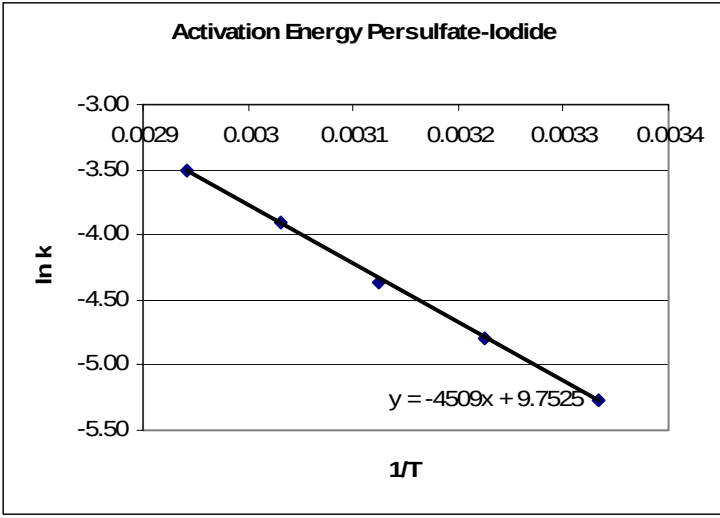
Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	(From 2 to 1) $[\text{S}_2\text{O}_8^{2-}]$ doubles ($[\text{I}^-]$ unchanged) and rate doubles / time halves so order wrt $\text{S}_2\text{O}_8^{2-} = 1$ (1) (From 3 to 1) $[\text{I}^-]$ doubles ($[\text{S}_2\text{O}_8^{2-}]$ unchanged) and rate doubles / time halves so order wrt $\text{I}^- = 1$ OR (if first mark awarded) (From 3 to 2) $[\text{I}^-]$ doubles ($[\text{S}_2\text{O}_8^{2-}]$ halved) and rate unchanged so order wrt $\text{I}^- = 1$ (1) Penalise omission of concentration/square brackets once only Rate = $k[\text{S}_2\text{O}_8^{2-}][\text{I}^-]$ (1) Third mark stand alone if no working & TE on incorrect orders IGNORE case of k	Rate equation =	3

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	First mark Colorimetry /Use a colorimeter (1) Second mark Measure transmittance / absorbance (at various times) (1) Third mark (Use a calibration curve to) convert transmittance / absorbance into concentration. OR transmittance / absorbance proportional to concentration ALLOW Colorimetry may be used because iodine (solution) is coloured (and other reagents are colourless) / to measure intensity of the iodine colour (1) ALLOW (for the same three marks) Electrical conductivity Measured at various times / (use a calibration curve to) convert conductivity into concentration. Conductivity reduces as reaction proceeds because 3 mol ions converted to 2 mol ions / fewer ions on right hand side	Sampling methods calorimeter pH meter Just conductivity changes	3

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	$[(\text{NH}_4)_2\text{S}_2\text{O}_8]$ / $[\text{S}_2\text{O}_8^{2-}]$ / [peroxodisulfate] / [persulfate] remains (approximately) unchanged during the reaction. OR $[\text{KI}]$ / $[\text{I}^-]$ is the only variable	$(\text{NH}_4)_2\text{S}_2\text{O}_8$ in excess. $[(\text{NH}_4)_2\text{S}_2\text{O}_8]$ etc does not affect the rate Only $[\text{KI}]$ / $[\text{I}^-]$ affects the rate	1

Question Number	Acceptable Answers	Reject	Mark
20(b)(iii)	Plot a graph of concentration (of iodine/I_2) (on the y axis) against time (1) Measure the initial gradient / gradient at $t=0$ (1) 'Plot a graph and measure the initial gradient / gradient at $t=0$' alone scores second mark		2

Question Number	Acceptable Answers	Reject	Mark
20(b)(iv)	TE on 20(a)(ii) on numerical answer and appropriate units $8.75 \times 10^{-5} = k \times 2.0 \times 0.025$ $k = 8.75 \times 10^{-5} / (2.0 \times 0.025)$ $= 1.75 \times 10^{-3}$ $\text{dm}^3 \text{ mol}^{-1} \text{ s}^{-1}$ (1) (1) ALLOW units in any order Correct answer including units with no working scores 2	1 SF	2

Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	Activation Energy Persulfate-Iodide  Use the overlay to mark the graph At least 4 points within the circles on the overlay (1) Best fit line on points given (1)		2

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	Gradient = $-(-3.50 - -5.27) / (0.00333 - 0.00294)$ $= (-)4538 = (-)4500$ ALLOW values from $(-)4300$ to $(-)4700$ (1) gradient value negative (1) $E_a = -\text{gradient} \times R = --4538 \times 8.31$ $= (+)37700 \text{ J mol}^{-1} (= (+)38 \text{ kJ mol}^{-1})$ (1) TE on value of gradient even if it is positive -4300 gives 35.7; -4700 gives 39.1 Correct units (1) Correct answer from the gradient calculation with units scores final 2 marks BUT correct answer with units but no gradient calculation scores units mark only		4

Total for Section C = 19 Marks

Total for Paper = 90 Marks

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Other names

Centre Number

Candidate Number

Edexcel GCE

Chemistry

Advanced

**Unit 4: General Principles of Chemistry I – Rates,
Equilibria and Further Organic Chemistry
(including synoptic assessment)**

Wednesday 12 June 2013 – Afternoon

Time: 1 hour 40 minutes

Paper Reference

6CH04/01R

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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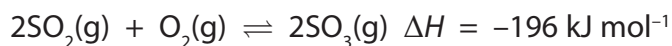
PEARSON

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 important step in the production of sulfuric acid is the oxidation of sulfur dioxide.



Which of the conditions below is best suited to produce a high yield of sulfur trioxide, SO_3 ?

- ☐ A 1 atm pressure and 800 °C.
☐ B 2 atm pressure and 800 °C.
☐ C 1 atm pressure and 400 °C.
☐ D 2 atm pressure and 400 °C.

(Total for Question 1 = 1 mark)

- 2 Which of the following statements is true about **all** substances that form acidic solutions in water?

- ☐ A They are corrosive.
☐ B They are liquids.
☐ C They contain hydrogen atoms.
☐ D They form $\text{H}^+(\text{aq})$ 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 Select the correct pH for each of the following solutions.

(a) Nitric acid, HNO_3 , of concentration 2 mol dm^{-3} , assuming it is fully dissociated.

(1)

- ☐ **A** -0.3
- ☐ **B** 0.0
- ☐ **C** 0.3
- ☐ **D** 2.0

(b) Sodium hydroxide, NaOH , of concentration 2 mol dm^{-3} ,
using $K_w = 1.0 \times 10^{-14} \text{ mol}^2 \text{ dm}^{-6}$

(1)

- ☐ **A** -13.7
- ☐ **B** 13.7
- ☐ **C** 14.0
- ☐ **D** 14.3

(c) Ethanoic acid, CH_3COOH , of concentration 2 mol dm^{-3} , making the usual assumptions.

$$K_a = \frac{[\text{H}^+][\text{CH}_3\text{COO}^-]}{[\text{CH}_3\text{COOH}]} = 1.7 \times 10^{-5} \text{ mol dm}^{-3}$$

(1)

- ☐ **A** 2.2
- ☐ **B** 2.4
- ☐ **C** 4.5
- ☐ **D** 4.8

(d) The mixture formed when 25 cm^3 of 2 mol dm^{-3} sodium hydroxide solution is added to 50 cm^3 of 2 mol dm^{-3} ethanoic acid, for which $K_a = 1.7 \times 10^{-5} \text{ mol dm}^{-3}$.

(1)

- ☐ **A** 2.2
- ☐ **B** 2.5
- ☐ **C** 4.5
- ☐ **D** 4.8

(Total for Question 3 = 4 marks)



4 A solution of 2,4-dinitrophenylhydrazine (Brady's reagent) is used as a test for organic functional groups.

(a) The positive result of the test is the formation of

(1)

- ☐ **A** a yellow solution.
- ☐ **B** an orange precipitate.
- ☐ **C** a red solution.
- ☐ **D** a green precipitate.

(b) Which of the following gives a positive result with a solution of 2,4-dinitrophenylhydrazine?

(1)

- ☐ **A** Only aldehydes
- ☐ **B** Only ketones
- ☐ **C** Only aldehydes and ketones
- ☐ **D** Any compound containing the $\text{C}=\text{O}$ group

(c) The initial attack by 2,4-dinitrophenylhydrazine, when it reacts, is by

(1)

- ☐ **A** a free radical.
- ☐ **B** an electrophile.
- ☐ **C** a nucleophile.
- ☐ **D** a negative ion.

(d) The product of a positive test, a 2,4-dinitrophenylhydrazone, contains which of the following bonds?

(1)

- ☐ **A** $\text{N}=\text{N}$
- ☐ **B** $\text{C}=\text{N}$
- ☐ **C** $\text{C}=\text{C}$
- ☐ **D** $\text{C}=\text{O}$

(Total for Question 4 = 4 marks)



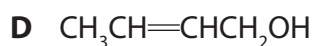
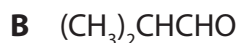
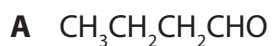
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Turn over for Question 5



P 4 2 9 8 4 A 0 5 2 4

5 This question is about the following isomeric compounds with the molecular formula C_4H_8O and molar mass 72 g mol^{-1} .



(a) Which compound would you expect to give a peak at $m/e = 41$ in its mass spectrum?

(1)

☐ A

☐ B

☐ C

☐ D

(b) Which compound would NOT react with an acidified solution of potassium dichromate(VI)?

(1)

☐ A

☐ B

☐ C

☐ D

(c) Which compound would give a pale yellow precipitate when reacted with iodine in alkaline solution?

(1)

☐ A

☐ B

☐ C

☐ D

(d) Which compound can be reduced to give a chiral product?

(1)

☐ A

☐ B

☐ C

☐ D



(e) Which compound would NOT react with hydrogen cyanide under suitable conditions to form a hydroxynitrile?

(1)

- ☐ A
- ☐ B
- ☐ C
- ☐ D

(Total for Question 5 = 5 marks)

6 Transesterification involves the conversion of

- ☐ A esters into different esters.
- ☐ B esters into carboxylic acids.
- ☐ C *cis* carbon-carbon double bonds to the *trans* arrangement.
- ☐ D *trans* carbon-carbon double bonds to the *cis* arrangement.

(Total for Question 6 = 1 mark)

7 Biodiesel is formed by transesterification. It is used as a fuel in preference to untreated vegetable oils because

- ☐ A on combustion, biodiesel produces less carbon dioxide than vegetable oils.
- ☐ B on combustion, biodiesel produces more energy than vegetable oils.
- ☐ C biodiesel vaporises more easily than vegetable oils.
- ☐ D biodiesel is less volatile than vegetable oils.

(Total for Question 7 = 1 mark)

8 The main reason for hardening vegetable oils when producing low-fat spreads is to

- ☐ A prevent oxidation.
- ☐ B make the oil less viscous.
- ☐ C increase the melting temperature.
- ☐ D decrease the cholesterol content.

(Total for Question 8 = 1 mark)



P 4 2 9 8 4 A 0 7 2 4

9 Which atoms are not detected by X-rays but are detected by nuclear magnetic resonance imaging which also shows their environments?

- ☐ A Carbon
- ☐ B Hydrogen
- ☐ C Nitrogen
- ☐ D Oxygen

(Total for Question 9 = 1 mark)

10 In one type of high-performance liquid chromatography (HPLC), the stationary phase is non-polar and a polar solvent is used as the eluent. Which of the following would travel through the chromatography column most quickly?

- ☐ A Tetrachloromethane
- ☐ B Chloromethane
- ☐ C Iodomethane
- ☐ D Hexane

(Total for Question 10 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



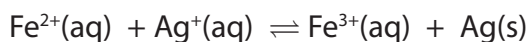
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SECTION B

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

11 This question is about the equilibrium reaction below.



The equilibrium is reached slowly.

- *(a) Describe the changes you would see if aqueous solutions of iron(II) sulfate and silver nitrate were mixed and allowed to stand for a few hours.

(2)

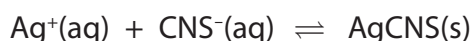
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- (b) The concentration of silver ions in the equilibrium mixture can be found by titration with potassium thiocyanate. Silver thiocyanate precipitates.



When all the silver ions have reacted, a deep red complex ion of iron(III) thiocyanate forms.

In an experiment, 25.0 cm³ of 0.100 mol dm⁻³ silver nitrate solution was added to 25.0 cm³ of 0.100 mol dm⁻³ of iron(II) sulfate solution, mixed thoroughly, and allowed to stand overnight in an air-tight container.

10.0 cm³ samples of the reaction mixture were then titrated with 0.0200 mol dm⁻³ potassium thiocyanate solution. The average titre was 5.60 cm³.

- (i) The initial concentrations of silver ions and iron(II) ions **in the reaction mixture** are the same.

Calculate this initial concentration in mol dm⁻³.

(1)



(ii) Calculate the number of moles of silver ions in the 10.0 cm³ sample at equilibrium and hence calculate the equilibrium concentration of silver ions in the mixture.

(2)

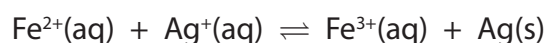
(iii) Deduce the equilibrium concentration of iron(II) ions.

(1)

(iv) Hence calculate the equilibrium concentration of iron(III) ions.

(1)

(v) Write the expression for the equilibrium constant, K_c , for the reaction



Calculate its value and give your answer, with appropriate units, to **three** significant figures.

(4)



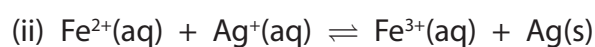
- (c) (i) The relationship between the total entropy change for a reaction and the equilibrium constant is

$$\Delta S_{\text{total}}^{\ominus} = R \ln K$$

Calculate the total entropy change for this reaction, giving a sign and appropriate units.

$$[R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}]$$

(2)



$\Delta S_{\text{system}}^{\ominus}$ for this reaction is $-208.3 \text{ J mol}^{-1} \text{ K}^{-1}$

Use ideas about entropy to explain why this value is negative.

(2)

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(iii) Calculate the entropy change of the surroundings, $\Delta S_{\text{surroundings}}^{\ominus}$.

(1)



(iv) Use your answer to (c)(iii) to calculate the standard enthalpy change, $\Delta H^\ominus$, for this reaction at 298 K.

Hence state and explain the effect of increasing temperature on the value of ΔS_{total} .

(3)

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*(d) After the samples from the original mixture for the titration are taken, the remainder was filtered and then allowed to stand overnight, in an air-tight container at the same temperature. Another 10.0 cm³ sample was taken and titrated. How, if at all, would you expect the titre to change?

Justify your answer. A calculation is not required.

(2)

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(Total for Question 11 = 21 marks)



12 This question is about the reactions of butanoic acid, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$. It has a foul smell and behaves like a typical carboxylic acid.

- (a) (i) The addition of sodium carbonate solution is often used as a chemical test to distinguish carboxylic acids, like butanoic acid, from other compounds, such as aldehydes.

Explain why old stocks of aldehydes often react with sodium carbonate solution.

(1)

- (ii) How would the result of this test distinguish between a carboxylic acid and an old stock of an aldehyde?

(1)

- (iii) Write the balanced chemical equation, including state symbols, for the reaction of sodium carbonate solution with butanoic acid.

(2)

- *(iv) Infrared spectroscopy is a good physical method to distinguish carboxylic acids from other organic compounds. Give the wavenumbers of **two** characteristic absorptions for a carboxylic acid. Indicate the bond responsible for each absorption. Suggest why one of the absorptions is broad.

(3)



- (v) High resolution nuclear magnetic resonance spectroscopy is a suitable physical method to use alongside infrared spectroscopy to identify butanoic acid. State the total number of peaks and suggest the splitting pattern for each peak that you would expect for butanoic acid, $\text{CH}_3\text{CH}_2\text{CH}_2\text{COOH}$.

(3)

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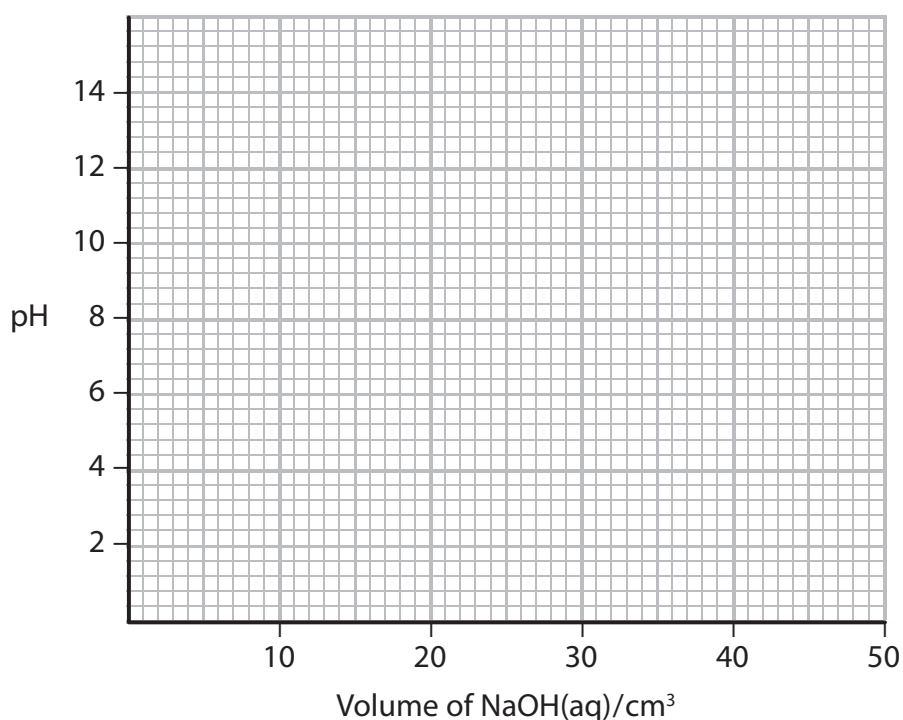
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- (b) Sketch the titration curve obtained when 50 cm^3 of 0.10 mol dm^{-3} sodium hydroxide solution is added to 25 cm^3 of 0.10 mol dm^{-3} butanoic acid.

(4)



(c) (i) What would you see when phosphorus pentachloride, PCl_5 , reacts with butanoic acid?

(1)

(ii) Give the structural formula and name of the organic product of this reaction.

(2)

Structural formula

Name

(d) (i) Give the name or formula of the organic product of the reaction between butanoic acid and lithium tetrahydridoaluminate (lithium aluminium hydride).

(1)

(ii) Water cannot be used as the solvent in this reaction because it reacts with lithium tetrahydridoaluminate. Suggest a suitable solvent.

(1)

(iii) State the type of reaction that takes place between butanoic acid and lithium tetrahydridoaluminate. Justify your classification.

(2)

Type

Justification



(e) (i) Butanoic acid can be reacted with methanol to make methyl butanoate. State **two** conditions that help to speed up this reaction.

(2)

(ii) Draw the **displayed** formula of methyl butanoate.

(1)

(iii) Identify another chemical, by name or formula, which could be added to methanol to make methyl butanoate.

(1)

*(iv) Give **two** advantages and **one** disadvantage of using the reaction occurring in (e)(iii), compared to the reaction in (e)(i), when making methyl butanoate.

(3)

Advantages

Disadvantage

(Total for Question 12 = 28 marks)

TOTAL FOR SECTION B = 49 MARKS)



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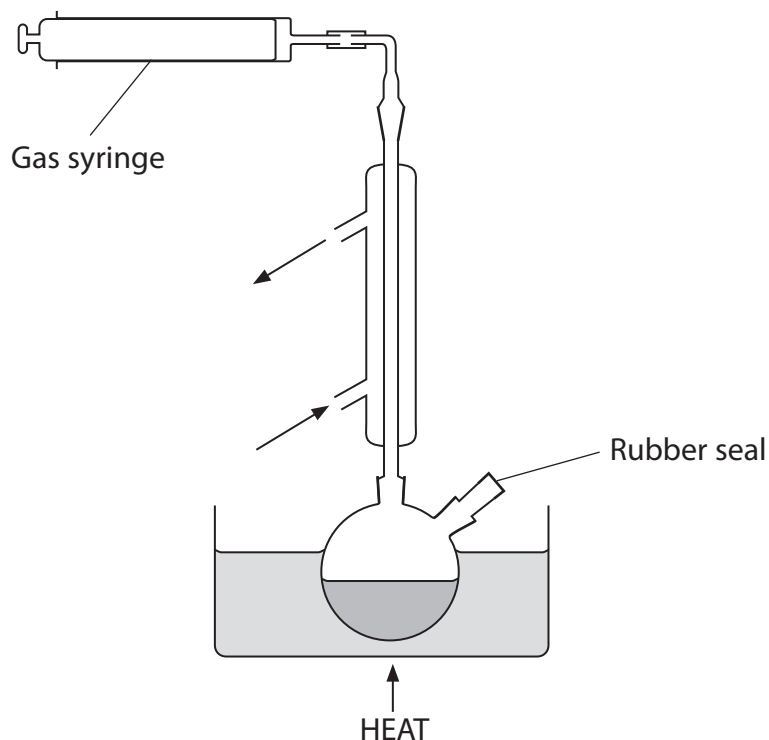
SECTION C

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

- 13 This question is about the elimination of hydrogen bromide from bromoalkanes by reaction with alcoholic potassium hydroxide.



To investigate the kinetics of this reaction the following apparatus was used:



A solution of concentrated potassium hydroxide in ethanol was refluxed and the gas syringe connected as shown.

0.6 cm³ of 1-bromobutane was added to the solution with a hypodermic syringe through a rubber seal.

A stop clock was started and the volume of gas, V_t , measured at 2 minute intervals, for 12 minutes. When there was no further evolution of gas the volume of gas, V_{final} , was 76.5 cm³.

- (a) (i) Calculate the number of moles of 1-bromobutane used. You will need the values of the density and molar mass of 1-bromobutane from your Data booklet.

(2)



(ii) Calculate the maximum volume of gaseous but-1-ene, in cm^3 , that could form.

[Molar volume of a gas $24\,000\text{ cm}^3$ under reaction conditions]

Suggest **two** reasons why this volume is unlikely to form.

(3)

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(b) The results obtained are shown in the table below.

Time t/min	Volume of but-1-ene V_t/cm^3	$(V_{\text{final}} - V_t)/\text{cm}^3$
0	0	76.5
2	31.5	45.0
4	51.0	25.5
6	62.5	14.0
8	68.5	8.0
10	72.0	4.5
12	74.0	2.5

(i) Explain why a large excess of potassium hydroxide is used in this experiment.

(1)

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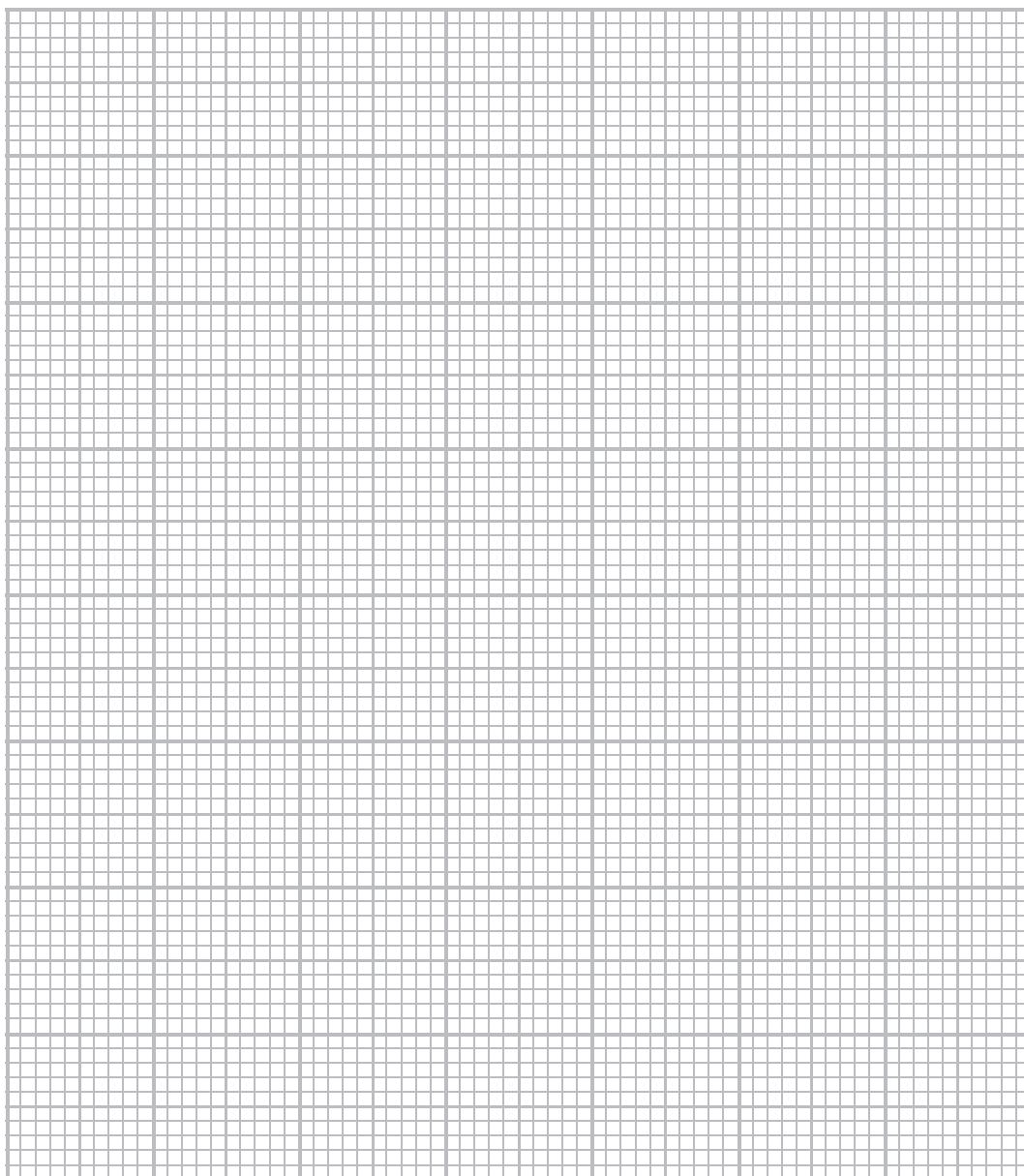
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(ii) Plot a graph of $(V_{\text{final}} - V_t)/\text{cm}^3$ against t/min .

(3)



(iii) Suggest why the value of $(V_{\text{final}} - V_t)$ was plotted on your graph.

(1)

.....

.....



(iv) Measure two successive half lives from your graph.

(2)

First half life min

Second half life min

(v) Deduce the order of reaction with respect to 1-bromobutane.

Justify your answer.

(2)

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.....

(c) In another experiment, an excess of 1-bromobutane is reacted with varying concentrations of hydroxide ions. The results for the initial rate of the reaction are shown in the table below.

Experiment Number	$[\text{C}_4\text{H}_9\text{Br}]$ $/10^{-2} \text{ mol dm}^{-3}$	$[\text{OH}^-]$ $/10^{-3} \text{ mol dm}^{-3}$	Initial rate $/10^{-5} \text{ mol dm}^{-3} \text{ min}^{-1}$
1	2.50	2.50	5.00
2	2.50	1.25	2.50
3	2.50	0.50	1.00

(i) Deduce the order of reaction with respect to hydroxide ions. Justify your answer using the data in the table.

(2)

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(ii) Write the rate equation for the reaction using your answers to parts (b)(v) and (c)(i).

(1)



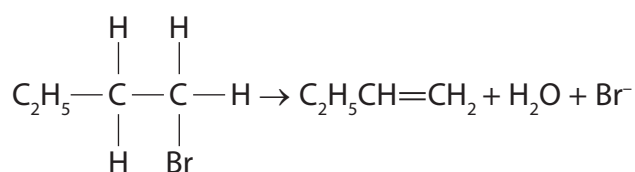
(iii) Give the units of the rate constant.

(1)

*(iv) It is suggested that the reaction begins with the slow attack by a hydroxide ion on a hydrogen atom in the 1-bromobutane, as shown below.

Complete the electron pair movement for this reaction using curly arrows and explain why this step is consistent with the rate equation for the reaction you have given in (c)(ii).

(3)



HO^- :

(Total for Question 13 = 21 marks)

TOTAL FOR SECTION C = 21 MARKS
TOTAL FOR PAPER = 90 MARKS



Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH04/01R
General Principles of Chemistry I

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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	D		1

Question Number	Correct Answer	Reject	Mark
2	D		1

Question Number	Correct Answer	Reject	Mark
3 (a)	A		1

Question Number	Correct Answer	Reject	Mark
(b)	D		1

Question Number	Correct Answer	Reject	Mark
(c)	A		1

Question Number	Correct Answer	Reject	Mark
(d)	D		1

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

Question Number	Correct Answer	Reject	Mark
(b)	C		1

Question Number	Correct Answer	Reject	Mark
(c)	C		1

Question Number	Correct Answer	Reject	Mark
(d)	B		1

Question Number	Correct Answer	Reject	Mark
5(a)	D		1

Question Number	Correct Answer	Reject	Mark
(b)	C		1

Question Number	Correct Answer	Reject	Mark
(c)	C		1

Question Number	Correct Answer	Reject	Mark
(d)	C		1

Question Number	Correct Answer	Reject	Mark
(e)	D		1

Question Number	Correct Answer	Reject	Mark
6	A		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	B		1

SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
*11(a)	(A green solution) forms a yellow / orange / brown (solution) ALLOW reddish-brown (1) A grey / black precipitate ALLOW silver ppt ALLOW solid / crystals for precipitate (1)	Red 'Green(ish)' with any other colour Silver mirror silver compound	2

Question Number	Acceptable Answers	Reject	Mark
11(b)(i)	0.05(00) (mol dm ⁻³)		1

Question Number	Acceptable Answers	Reject	Mark
11(b)(ii)	Amount of silver ion in 10 cm³ = amount of thiocyanate = $\frac{5.6 \times 0.0200}{1000} = 0.000112/1.12 \times 10^{-4}$ (mol) (1) So concentration of silver ion = $0.000112 \times \frac{1000}{10} = 0.0112/1.12 \times 10^{-2}$ (mol dm⁻³) (1)		2

Question Number	Acceptable Answers	Reject	Mark
11(b)(iii)	0.0112/1.12 x 10⁻² (mol dm⁻³) Accept TE = answer to (ii)		1

Question Number	Acceptable Answers	Reject	Mark
11(b)(iv)	0.0500 - 0.0112 = 0.0388/3.88 x 10⁻² (mol dm⁻³) Accept TE = 0.05 - answer to (iii) Accept answer to (i) - answer to (iii)		1

Question Number	Acceptable Answers	Reject	Mark
11(b)(v)	$K_c = \frac{[\text{Fe}^{3+}(\text{aq})]}{[\text{Fe}^{2+}(\text{aq})][\text{Ag}^+(\text{aq})]}$ ALLOW $K_c = \frac{[\text{Fe}^{3+}]}{[\text{Fe}^{2+}][\text{Ag}^+]} \quad (1)$ $= \frac{0.0388}{0.0112^2}$ $= 309.311 = 309 \text{ dm}^3 \text{ mol}^{-1}$ Value (1) Unit (any order) (1) Three SF (1) Accept TE from (iii) and (iv): (use of 0.1 from (i) gives $708 \text{ dm}^3 \text{ mol}^{-1}$) If [Ag] is included in the numerator and taken as $[\text{Fe}^{3+}(\text{aq})]$, then allow unit and SF marks ONLY, but must either state 'no units' or show working	[Ag] in numerator	4

Question Number	Acceptable Answers	Reject	Mark
11(c)(i)	$\Delta S^\ominus_{\text{total}} = 8.31 \times \ln 309$ $= +47.6(4) / +47.6(5) \text{ J mol}^{-1} \text{ K}^{-1}$ OR $= 8.31 \times \ln 309.311 = +47.6(5) \text{ J mol}^{-1} \text{ K}^{-1}$ Accept TE : $8.31 \times \ln(\text{answer from b(v)})$ Value (1) Sign and Unit (any order) (1) IGNORE sf except 1		2

Question Number	Acceptable Answers	Reject	Mark
11(c)(ii)	First Mark: One of the products is a solid OR Two moles going to two moles but one of them is a solid OR Two moles of solution react to form one mole of solution / liquid and one mole of solid (1) Second Mark (Hence) RHS more ordered / LHS less ordered (1)		2

Question Number	Acceptable Answers	Reject	Mark
11(c)(iii)	$\Delta S^\circ_{\text{surroundings}} = \Delta S^\circ_{\text{total}} - \Delta S^\circ_{\text{system}}$ $= +47.6 - (-208.3) = (+)255.9 \text{ (J mol}^{-1} \text{ K}^{-1}\text{)}$ Accept TE on c(i) IGNORE sf except 1		1

Question Number	Acceptable Answers	Reject	Mark
11(c)(iv)	Because $\Delta S^\circ_{\text{surroundings}} = \frac{-\Delta H^\circ}{T}$ (1) $\Delta H = -298 \times 255.9 = -76258 \text{ (J mol}^{-1}\text{)}$ $= -76.258 \text{ (kJ mol}^{-1}\text{)}$ (1) Units if given must be correct Correct answer with or without working scores 2 marks IGNORE SF except 1 As T increases $\Delta S^\circ_{\text{surroundings}}$ becomes less positive / decreases therefore ΔS_{total} becomes less positive / decreases ALLOW more negative for less positive (1)	$\Delta S^\circ_{\text{total}} = \frac{-\Delta H^\circ}{T}$	3

Question Number	Acceptable Answers	Reject	Mark
11 * (d)	No change in the titre ALLOW No significant change Stand alone mark (1) (though silver solid was removed the equilibrium constant remains the same so) the equilibrium concentration(s) would remain the same (1) Second mark dependent on first IGNORE references to temperature		2

Total for Question 11 = 21 Marks

Question Number	Acceptable Answers	Reject	Mark
12(a)(i)	Aldehydes often contain (carboxylic) acid formed by oxidation (by the oxygen in air)		1

Question Number	Acceptable Answers	Reject	Mark
12(a)(ii)	A larger volume of sodium carbonate solution is neutralized / a larger volume of carbon dioxide forms / faster reaction / more effervescence / more vigorous ALLOW reverse argument for impure aldehyde	(The old stock of) aldehyde does not react	1

Question Number	Acceptable Answers	Reject	Mark
12(a)(iii)	$\text{Na}_2\text{CO}_3(\text{aq}) + 2\text{C}_3\text{H}_7\text{COOH}(\text{aq}) \rightarrow$ $2\text{C}_3\text{H}_7\text{COO}^{(-)}\text{Na}^{(+)}(\text{aq}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ Correct balanced equation (1) Correct state symbols on correct species (1) ALLOW $\text{H}_2\text{O}(\text{aq})$ $\text{C}_3\text{H}_7\text{COO}^{(-)}\text{Na}^{(+)}(\text{s})$ $\text{C}_3\text{H}_7\text{COOH}(\text{l})$	NaCO_3	2

Question Number	Acceptable Answers	Reject	Mark
12(a)*(iv)	3300 -2500 (cm^{-1}) AND O-H (stretching) (1) 1725 – 1700 (cm^{-1}) AND C=O (stretching) (1) ALLOW single numbers or ranges within these ranges ALLOW 1300-1250 (cm^{-1}) AND C-O in COOH Very broad (O-H) due to hydrogen bonding (1)	COOH (group) COOH (group) Hydrogen Bonding in C=O	3

Question Number	Acceptable Answers	Reject	Mark
12(a)(v)	First mark (stand alone) 4 peaks OR 4 hydrogen environments ALLOW 4 chemical shifts (1) Second and Third Marks Splitting pattern: (CH₃CH₂CH₂COOH<u>H</u>) singlet / 1 line (CH₃CH₂C<u>H</u>₂COOH) triplet / three lines (CH₃C<u>H</u>₂CH₂COOH) sextuplet / sextet / six lines (C<u>H</u>₃CH₂CH₂COOH) triplet / three lines All four correct (2) any three (1) ALLOW No splits, 2 splits, five splits, 2 splits scores 2 1,3,6,3 'splits' scores 1 mark	1 split 3 splits 6 splits 3 splits	3

Question Number	Acceptable Answers	Reject	Mark
12(b)	Start pH at 2.9 ALLOW 2—4 (1) Initial sharp rise to buffer region then vertical section at 25 cm³ ALLOW Gradual rise to vertical section at 25 cm³ (1) Vertical within pH range 6-11 and 2.5-4 units long (1) End pH value in range 12-13 (1)	Horizontal from start deviation from vertical maximum before final pH Graph ending before 50cm³	4

Question Number	Acceptable Answers	Reject	Mark
12(c)(i)	White / steamy / misty fumes ALLOW 'gas' for fumes IGNORE correct indicator test on product	White smoke Effervescence Just 'fumes' Just 'gas'	1

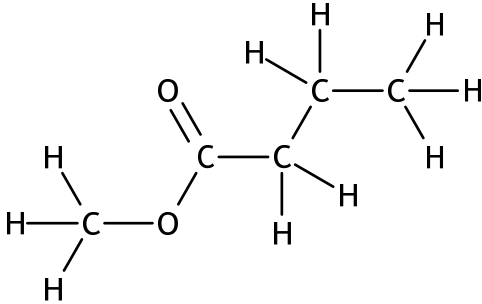
Question Number	Acceptable Answers	Reject	Mark
12(c)(ii)	$\text{CH}_3\text{CH}_2\text{CH}_2\text{COCl}$ (1) ALLOW displayed formula butanoyl chloride (1) ALLOW Butanoyl chloride No TE on incorrect structure	$\text{C}_3\text{H}_7\text{COCl}$ Butyl Chloride Buthyl Chloride	2

Question Number	Acceptable Answers	Reject	Mark
12(d)(i)	Butan-1-ol OR $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{OH}$ If 2 answers are given both must be correct	Butanol Butanal $\text{C}_4\text{H}_9\text{OH}$	1

Question Number	Acceptable Answers	Reject	Mark
12(d)(ii)	(Dry) Ethoxyethane / diethylether / Ether OR $\text{C}_2\text{H}_5\text{OC}_2\text{H}_5$ / $\text{CH}_3\text{CH}_2\text{OCH}_2\text{CH}_3$ If 2 answers are given they must both be correct		1

Question Number	Acceptable Answers	Reject	Mark
12(d)(iii)	The responses are in pairs: a type (1) and an associated justification (1) Reduction (of butanoic acid) (1) By addition of hydrogen / loss of oxygen (1) OR Oxidation of lithium tetrahydridoaluminate / aluminium hydride / LiAlH_4 (1) By addition of oxygen (1) OR (Nucleophilic) addition (1) of hydride / H^- (1) OR Redox (1) Because butanoic acid has been reduced AND LiAlH_4 has been oxidised (1)	Any substitution Electrophilic addition	2

Question Number	Acceptable Answers	Reject	Mark
12(e)(i)	(Concentrated / dilute) sulfuric / hydrochloric acid ALLOW any strong acid ALLOW 'acid (catalyst)' (1) (heat or boil under) reflux ALLOW Heat / warm (1) Elevated temp $\leq 65^\circ\text{C}$	Just 'catalyst' Just H^+ Just 'boil' Just 'distil' High temperature Increased concentration	2

Question Number	Acceptable Answers	Reject	Mark
12(e)(ii)	 All bonds must be shown except ALLOW CH₃ at either end of molecule.	Omitted Hydrogen / sticks	1

Question Number	Acceptable Answers	Reject	Mark
12(e)(iii)	Butanoyl chloride / CH₃CH₂CH₂COCl ALLOW Butanoyl chloride OR Butanoic anhydride / (CH₃CH₂CH₂CO)₂O OR Specified alkyl butanoate (not methyl butanoate) If name and structure are both given they must both be correct	Butyl Chloride Buthyl Chloride	1

Question Number	Acceptable Answers	Reject	Mark
12(e)(iv)	Advantage marks are dependent on correct reagent (or near miss e.g. propanoyl chloride) in (iii). No TE on random answer to (iii) eg H₂SO₄ Advantages – any two from: Higher yield / goes to completion/ not an equilibrium reaction / not reversible No heat / no refluxing / less energy needed No catalyst needed / faster By-product is a gas (so easier to separate) (2) Disadvantage (marked independently of (e)(iii)) any one of: (Acyl chloride is) more expensive / corrosive IGNORE Acyl chloride is toxic / hazardous / harmful / difficult to store OR toxic /corrosive and HCl /gas / fumes evolved IGNORE harmful/ hazardous/ dangerous OR has lower atom economy (1)	Good yield	3

Total for Question 12 = 28 Marks

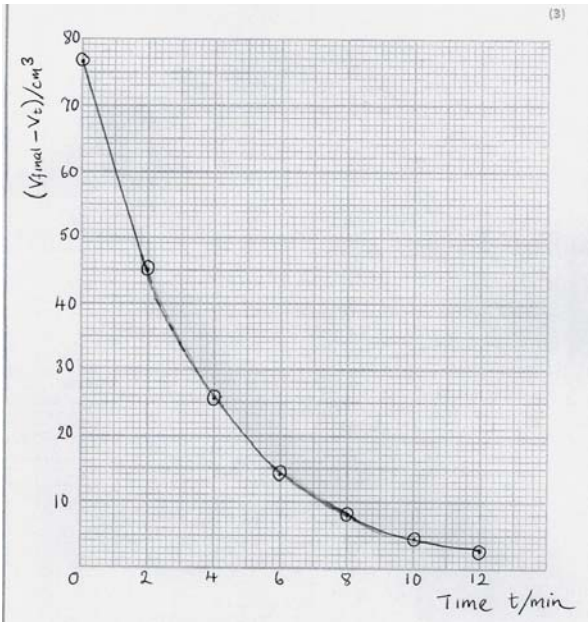
Total for Section B = 49 Marks

Section C

Question Number	Acceptable Answers	Reject	Mark
13(a)(i)	Mass of bromobutane = 0.6×1.276 $(=0.7656 \text{ (g)})$ (1) Amount of bromobutane = $\frac{0.6 \times 1.276}{137.0}$ $= 5.5883 \times 10^{-3}$ $= 5.59 \times 10^{-3} / 0.00559 \text{ (mol)}$ OR Amount of bromobutane = $\frac{0.6 \times 1.276}{136.9}$ $= 5.5924 \times 10^{-3}$ $= 5.59 \times 10^{-3} / 0.00559 \text{ (mol)}$ TE on incorrect mass ALLOW $6 \times 10^{-3} \text{ (mol)}$ (1) Correct answer with no working scores 2 marks		2

Question Number	Acceptable Answers	Reject	Mark
13(a)(ii)	$5.5883 \times 10^{-3} \times 24\,000$ $= 134.12 \text{ (134.22 from 136.9)} = 134 \text{ cm}^3$ (1) ALLOW answer from (i) $\times 24000$ IGNORE SF except 1 Any two from: Formation of butan-1-ol / other / side reactions Incomplete reaction Some but-1-ene may remain in solution (2) IGNORE Reaches equilibrium / reaction reversible But-1-ene reacts with ethanol/ solvent	Transfer losses Gas escapes Gas reacts with water But-1-ene condenses	3

Question Number	Acceptable Answers	Reject	Mark
13(b)(i)	So $[\text{OH}^-]$ remains (effectively) constant OR [1-bromobutane] is the only variable IGNORE So $[\text{OH}^-]$ is not the limiting factor	Ensure that all $\text{C}_4\text{H}_9\text{Br}$ reacts $[\text{OH}^-]$ is in excess $[\text{OH}^-]$ does not affect the rate Just 'Only [1-bromobutane] affects the rate'	1

Question Number	Acceptable Answer	Reject	Mark
13(b)(ii)	 Axes correct with sensible scales to use at least half of graph paper on both axes (1) Labels ($(V_{\text{final}} - V_t)$ and t) fully correct with units (1) All 7 points correctly plotted and smooth curve drawn (1)	Axes plotted wrong way round 'Volume'	3

Question Number	Acceptable Answers	Reject	Mark
13(b)(iii)	$(V_{\text{final}} - V_t)$ is proportional to the concentration of 1-bromobutane		1

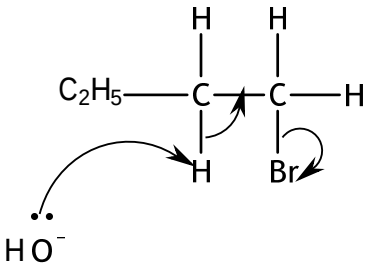
Question Number	Acceptable Answers	Reject	Mark
13(b)(iv)	Two values 2.5 ± 0.3 (min) (each scores one mark) (2)		2

Question Number	Acceptable Answers	Reject	Mark
13(b)(v)	Answer must be consistent with values in (iv) Because half lives are constant / similar (1) The reaction is first order... (1) If values in (iv) are 2.5 and 5, then: Reaction is 2nd order because half lives are increasing scores both marks. Reaction is 1st order because half lives are constant scores 1 mark		2

Question Number	Acceptable Answers	Reject	Mark
13(c)(i)	Order one (1) Any one of: (Exp 1 and 2) $[\text{OH}^-]$ halves and rate halves. (Exp 1 and 3) $[\text{OH}^-]$ 1/5 and rate 1/5 (Exp 2 and 3) $[\text{OH}^-]$ 2/5 and rate 2/5 ALLOW reverse logic (1)		2

Question Number	Acceptable Answers	Reject	Mark
13(c)(ii)	Rate = $k[\text{C}_4\text{H}_9\text{Br}][\text{OH}^-]$ IGNORE case of K/k TE on b(v) and c(i)		1

Question Number	Acceptable Answers	Reject	Mark
13(c)(iii)	$\text{dm}^3 \text{mol}^{-1} \text{min}^{-1}$ ALLOW $\text{dm}^3 \text{mol}^{-1} \text{s}^{-1}$ any sequence of units TE on (ii)		1

Question Number	Acceptable Answers	Reject	Mark
13(c) * (iv)	 Arrows from OH⁻ to H and from C-H bond to make additional bond between carbons (1) Third arrow from bond between carbon and bromine to bromine (1) (Because) both 1-bromobutane and hydroxide ion appear in the RDS ALLOW Attack of OH⁻ on H is slow, therefore this is the RDS (Because) both 1-bromobutane and hydroxide ion appear in the slow step (1) IGNORE mention of rate equation	Both are involved in the reaction Mechanism described as S_N2	3

Total for Section C = 21 Marks

Total for Paper = 90 Marks

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Surname	Other names
Centre Number	Candidate Number
Edexcel GCE 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.

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Turn over ►

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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	(1)
(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)

(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 cm³ conical flask to which 50 cm³ 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 cm³ volumetric flask. A further 50 cm³ 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 cm³ 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 cm³ 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.

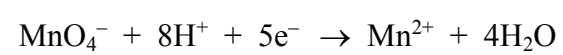
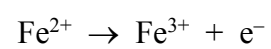
(2)
- (ii) Calculate the mean titre in cm³.

(1)



N 3 6 5 0 8 A 0 7 1 6

(iii) The ionic half-equations for the reactions of the iron(II) ions and the manganate(VII) ions are given below.



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 25.0cm³ solution containing iron(II) ions in step 5 and the 50cm³ sulfuric acid in steps 2 and 4.

Explain why different apparatus is used in each case.

(2)

To measure 25.0 cm³ of solution.....

To measure 50 cm³ 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)

.....
.....
.....
.....

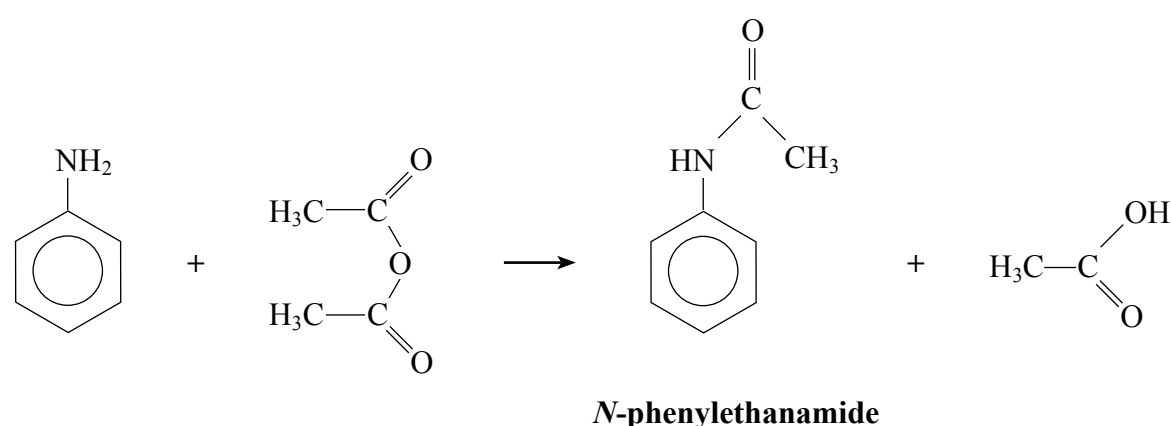
(Total for Question 3 = 15 marks)



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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.



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} : $\text{C}_6\text{H}_5\text{NH}_2 = 93.0$; $\text{CH}_3\text{COOCOCH}_3 = 102$]

(2)



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

(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 cm³ 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.

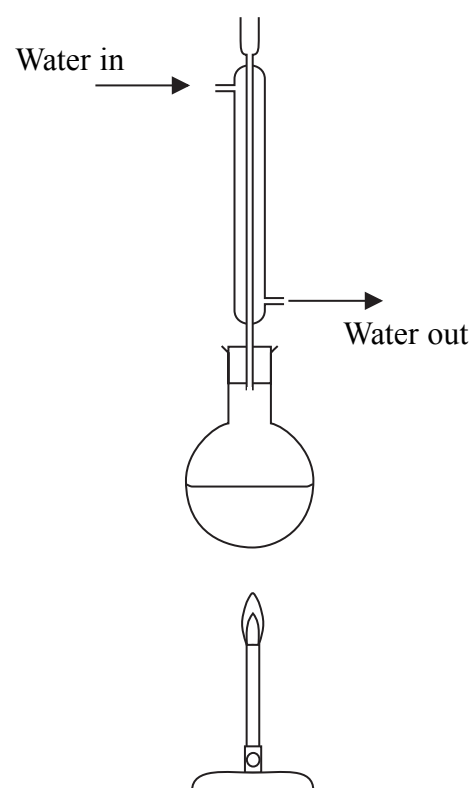
(1)

- (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)

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.....



(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} : $\text{C}_6\text{H}_5\text{NH}_2 = 93.0$; $\text{C}_6\text{H}_5\text{NHCOCH}_3 = 135$]

(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



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

[illegible]

1.0

H

hydrogen

1

(18)

(1)

(2)

(3)

(4)

(5)

(6)

(7)

(8)

(9)

(10)

(11)

(12)

(13)

(14)

(15)

(16)

(17)

(18)

relative atomic mass
atomic symbol
name
atomic (proton) number

6.9

Li

lithium

3

9.0

Be

beryllium

4

23.0

Na

sodium

11

24.3

Mg

magnesium

12

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

germanium

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

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

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

209.0

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

150

Sm

samarium

62

152

Eu

europtium

63

157

Gd

gadolinium

64

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

[242]

Pu

plutonium

94

[243]

Am

americium

95

[247]

Cm

curium

96

[251]

Cf

californium

98

[254]

Es

einsteinium

99

[253]

Fm

fermium

100

[256]

Md

mdendelevium

101

[254]

No

nobelium

102

[257]

Lr

lawrencium

103

Mark Scheme (Results)

June 2010

GCE

GCE Chemistry (6CH07/01)

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Summer 2010

Publications Code US023643

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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 platinum, 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, Li²⁺, Ca, Sr, Rb Ca²⁺, Sr²⁺, 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 CO₂/CaCO₃	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^- / $(\text{OH})_2$	$(\text{OH})_2^-$	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 $\text{Li}_2(\text{CO}_3)$ 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)	C₃H₇I (in any order) Accept additional information like additional formulae	Any answer which does not have C₃H₇I somewhere	1

Question Number	Acceptable Answers	Reject	Mark
2 (a)(iii)	<pre> H H H H - C - C - C - H H I H </pre> Accept structural formula CH₃CHICH₃	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 / $\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$ Accept displayed formula (allow slightly displaced bonds C) $\begin{array}{c} \\ \text{HO} \end{array}$ Accept skeletal formula Allow TE from (a)(iii) eg 1-iodopropane forms propan-1-ol	Propanol prop-1-ol $\text{C}_3\text{H}_7\text{OH}$	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 /phenolphthalein 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)	$\frac{13.73 \times 0.0200}{1000} = 2.746 \times 10^{-4} \text{ / } 0.0002746(\text{mol})$ 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)	$1.373 \times 10^{-4} \text{ / } 0.0001373(\text{mol})$ Also $1.35/1.37/1.375 \text{ / } 1.4 \times 10^{-4}$ Accept answer to $\frac{(b)(iii)}{2}$	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) $4.57667/4.577 \times 10^{-5}$ etc Also $4.583/4.57/4.6(0) \times 10^{-5}$ 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 $4.57/4.6 \times 10^{-4}$ 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)	$4.58 \times 10^{-4} \times 214$ $= 0.098 / 0.98012 \text{ g}$ 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

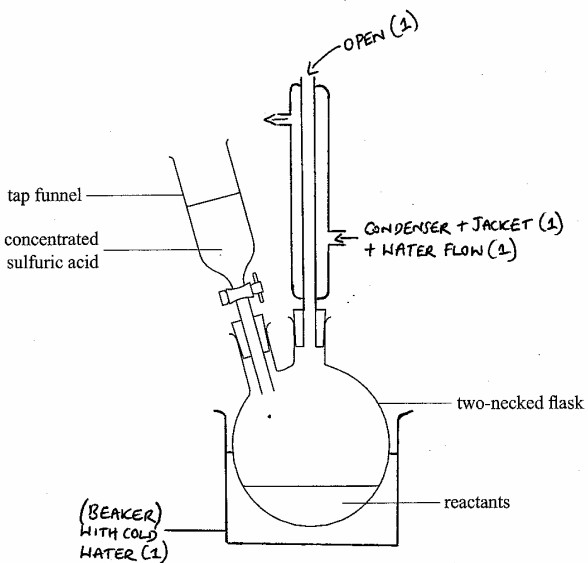
Question Number	Acceptable Answers	Reject	Mark
3 (e)(v)	$\frac{0.098}{0.10} \times 100$ $= 98 / 98.0/98.01/98.012 \%$ Also 97.941/97.94/97.9 % Accept answer to <u>(e)(iii)</u> x100 0.10 correct answer with no working scores (1) Ignore SF	1 sf (unless already penalised anywhere in this question)	1

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-bromobutane (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)	74×0.125 (1) = 9.25 (g) $\frac{9.25}{0.81} = 11.4$ / 11.42 / 11.420 / 11.419753 cm³ (1) ie ignore sf unless only one Accept 11.4 / 11.42 / 11.420 / 11.419753 cm³ (2) (with no working)	1sf	2

Question Number	Acceptable Answers	Reject	Mark
4 (a)(iii)	$0.125 \times 119 = 14.875$ /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 denser 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 ₂ SO 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 °C) (Pure if it agrees)} OR Boils at boiling temperature of liquid/ 101.7 °C / boils over a very small temperature range/ boils at one particular temperature OR Collect the product at 101.7 °C/ between 100 and 103 °C		1

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Write your name here	
Surname	Other names
Centre Number	Candidate Number
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/



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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	$\text{Cu}(\text{OH})_2$	(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**.

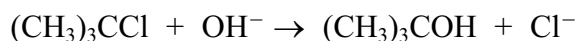
(1)

(Total for Question 1 = 12 marks)



P 3 8 4 8 1 A 0 3 1 2

- 2 The tertiary halogenoalkane 2-chloro-2-methylpropane reacts with hydroxide ions in solution as follows:



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 $0.100 \text{ mol dm}^{-3}$, was placed in a flask in a water bath at 25°C . 250 cm^3 of aqueous sodium hydroxide solution, also of concentration $0.100 \text{ mol dm}^{-3}$, 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 $0.0500 \text{ mol dm}^{-3}$, 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)

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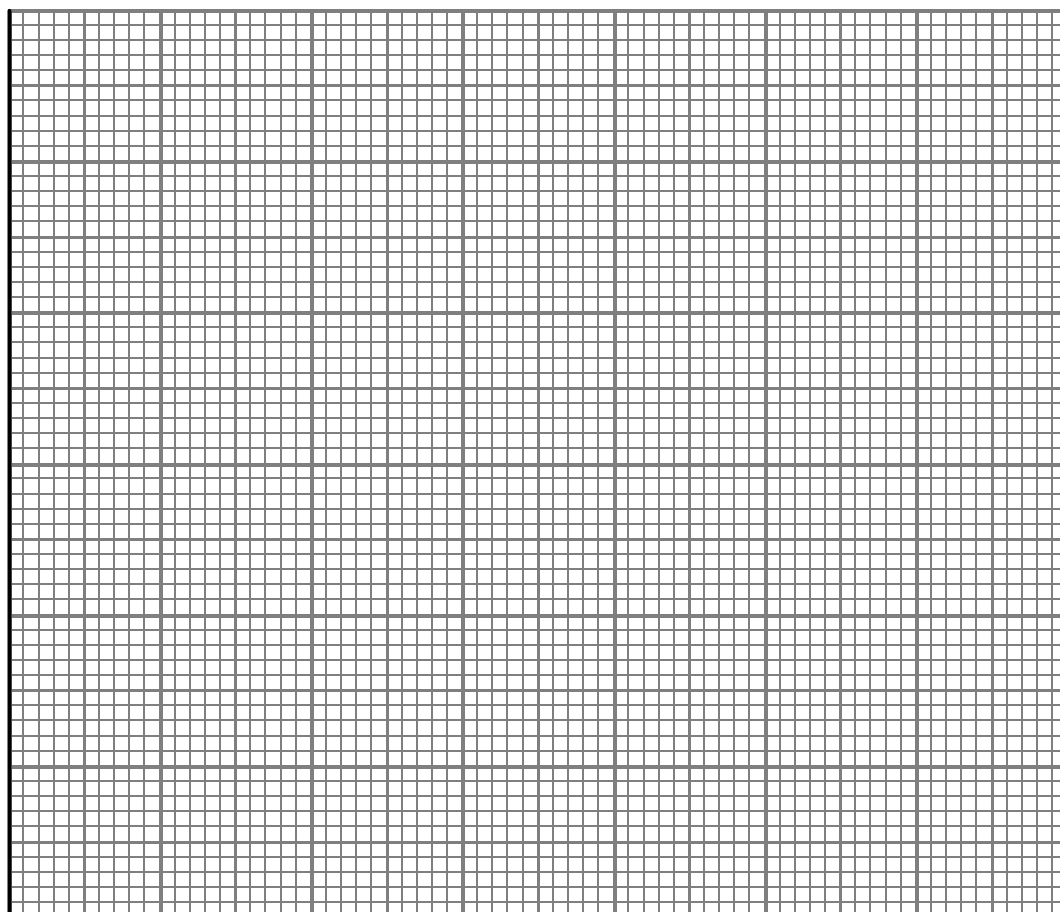
(c) In an experiment which was carried out as described above, the following data were obtained.

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/cm³



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

$$\text{rate} = k[(\text{CH}_3)_3\text{CCl}]$$

or of the form $\text{rate} = k[\text{OH}^-]$

Suggest a further experiment which could be carried out to show that it is in fact first order with respect to the halogenoalkane.

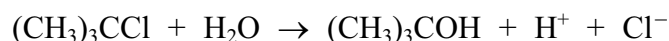
(2)

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- (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



- (i) Suggest what the initial pH of the mixture would be. Justify your answer.

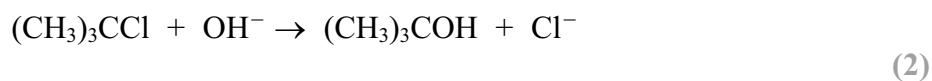
(1)

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- (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



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- (iii) Assuming that the reaction rate follows the rate equation

$$\text{rate} = k[(\text{CH}_3)_3\text{CCl}]$$

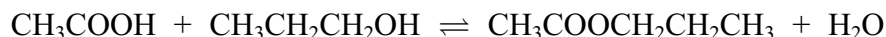
write the equation for the rate-determining step.

(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



Procedure

1. Propan-1-ol (50 cm³) and ethanoic acid (50 cm³) are mixed thoroughly in a 250 cm³ round-bottomed flask.
2. Concentrated sulfuric acid (10 cm³) 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 cm³) 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)

- (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



12

P 3 8 4 8 1 A 0 1 2 1 2

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
2	Bromine water From: red / brown / orange / yellow (or combinations of these colours) (1) To: colourless/decolourised (1) <i>NOTE:</i> 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) <i>NOTE:</i> 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(°C) (1) ALLOW a stated value within ± 0.1 (°C) of graph's max temp	If the two straight lines do not meet above 29.5 °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 (cm³) <i>ALLOW:</i> a stated volume within ± 0.5 cm³ of graph's volume of HCl(aq) <i>ALLOW:</i> 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. $0.05(00) \div \text{candidate's volume of HCl(aq) in dm}^3$ (1) Answer (1) e.g. for a volume of HCl(aq) = 26.0 cm³ [NOTE: <i>ALLOW</i> "26" for 26.0] $0.05(00) \div \text{candidate's volume of HCl(aq) in dm}^3$ = $\frac{0.05(00)}{0.026}$ = 1.92 (mol dm⁻³) Correct answer only using suitable volume of HCl(aq) scores both marks <i>IGNORE</i> 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 $\Delta T = (29.8 - 22.2) = 7.6$ $(^{\circ}\text{C})$ <i>IGNORE</i> s.f. <i>IGNORE</i> any signs <i>NOTE:</i> 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] $= 76 \times 4.2 \times 7.6$ $= 2426 \text{ (J) }$ Assume 2.426 (or similar) is the answer in kJ <i>NOTE:</i> 2nd mark can be awarded cq on a wrong mass and/or a wrong ΔT (e.g. use of $50(.00) \times 4.2 \times 7.6$ $= 1596 \text{ (J) }$ scores (1)) <i>IGNORE</i> sig figs (except one sig fig) <i>IGNORE</i> any signs <i>ALLOW</i> 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:- (–) $\frac{\text{answer to (b)(ii) in kJ or J}}{\text{answer to (a)(iv)}}$ (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. $- \frac{2.426}{0.05(00)}$ $= -49 \text{ (kJ mol}^{-1}\text{)}$ 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 ($\pm$)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) $\frac{0.100 \times 24.20}{1000}$ $= 0.00242 / 0.0024 / 2.42 \times 10^{-3} / 2.4 \times 10^{-3} \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
4 (a) (iv)	Answer to (a)(iii) $\div 2$ $= 0.00121 / 0.0012 / 1.21 \times 10^{-3} / 1.2 \times 10^{-3} \text{ (mol)}$		1

Question Number	Acceptable Answers	Reject	Mark
4 (a) (v)	Answer to (a)(iv) $\div 3$ $= 0.000403 / 0.0004(0) / 4.03 \times 10^{-4} / 4(.0) \times 10^{-4}$		1

Question Number	Acceptable Answers	Reject	Mark
4 (a) (vi)	EITHER Answer to (a)(v) $\div$ 0.025(0) $= 0.0161 / 0.016(0) / 1.61 \times 10^{-2} / 1.6(0) \times 10^{-2}$ (mol dm⁻³) (1) so concentration of KIO₃ in g dm⁻³ is $214 \text{ (g mol}^{-1}\text{)} \times 0.0161 \text{ (mol dm}^{-3}\text{)}$ $= 3.45 \text{ (g dm}^{-3}\text{)}$ OR $214 \text{ (g mol}^{-1}\text{)} \times 0.016(0) \text{ (mol dm}^{-3}\text{)}$ $= 3.42 \text{ (g dm}^{-3}\text{)}$ (1) OR Calculate mass KIO₃ using $0.000403 \times 214 = 0.086242$ (g) (1) <i>IGNORE</i> units even if incorrect (then) $\frac{0.086242 \text{ (g)}}{0.025 \text{ (dm}^3\text{)}}$ $= 3.45 \text{ (g dm}^{-3}\text{)}$ (1) ALLOW 2 s.f. but reject 1 s.f. <i>NOTE:</i> Check all calculations as final answer is dependent on accuracy in interim steps		2

Question Number	Acceptable Answers	Reject	Mark
4 (b) (i)	$\frac{0.06}{0.2\% \times 25.00} \times 100\% = (\pm) 0.24$ <i>NOTE: $\pm$ not required for the mark</i>		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 <i>ALLOW</i> • 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/I₂ 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 (°C) Any upper temperature: 73 to 75 (°C) <i>NOTE:</i> Award the mark if the correct numbers are written the other way round (e.g. from 74 (°C) to 70 (°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 $M_r(\text{CH}_3\text{CH}_2\text{I}) = 156$ (1) 0.2(00) mol of iodoethane (1) 2nd mark CQ on (c)(i) $0.2(00) \times 156 = 31.2 \text{ g}$ (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: $M_r(\text{CH}_3\text{CH}_2\text{I}) = 156$ (1) 0.4(00) mol of iodoethane (1) $0.4(00) \times 156 = 62.4 \text{ g}$ (1)		3

Question Number	Acceptable Answers	Reject	Mark
5 (c) (iii)	$\frac{23.4}{25.4} \times 100 \% = 75\%$ ans to (c)(ii) <i>IGNORE</i> 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: $\frac{23.4}{62.4} \times 100 \% = 37.5\%$	$\frac{23.4}{25.4} \times 100 \% = 92.1\%$	1

TOTAL FOR PAPER = 50 MARKS

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Centre Number

Candidate Number

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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7/7/5/5/



PEARSON

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 $[\text{Cr}(\text{OH})_6]^{3-}$ 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
(v)	Warm another sample of the chromium(III) chloride solution with alkaline hydrogen peroxide solution, which acts as an oxidizing agent.	A yellow solution forms.	The formula of the ion causing the yellow colour is
	Add sulfuric acid to the resulting mixture.	The solution goes orange when sulfuric acid is added.	The ion causing the orange colour is dichromate(VI), $\text{Cr}_2\text{O}_7^{2-}$.

(1)

(1)

(c) Tests (i) and (ii) above were repeated on an aqueous solution of nickel(II) chloride.

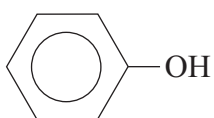
In what way, other than any difference in colour, does the reaction of dilute sodium hydroxide solution with nickel(II) chloride differ from its reactions with chromium(III) chloride?

(1)

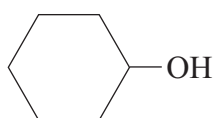
(Total for Question 1 = 8 marks)



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

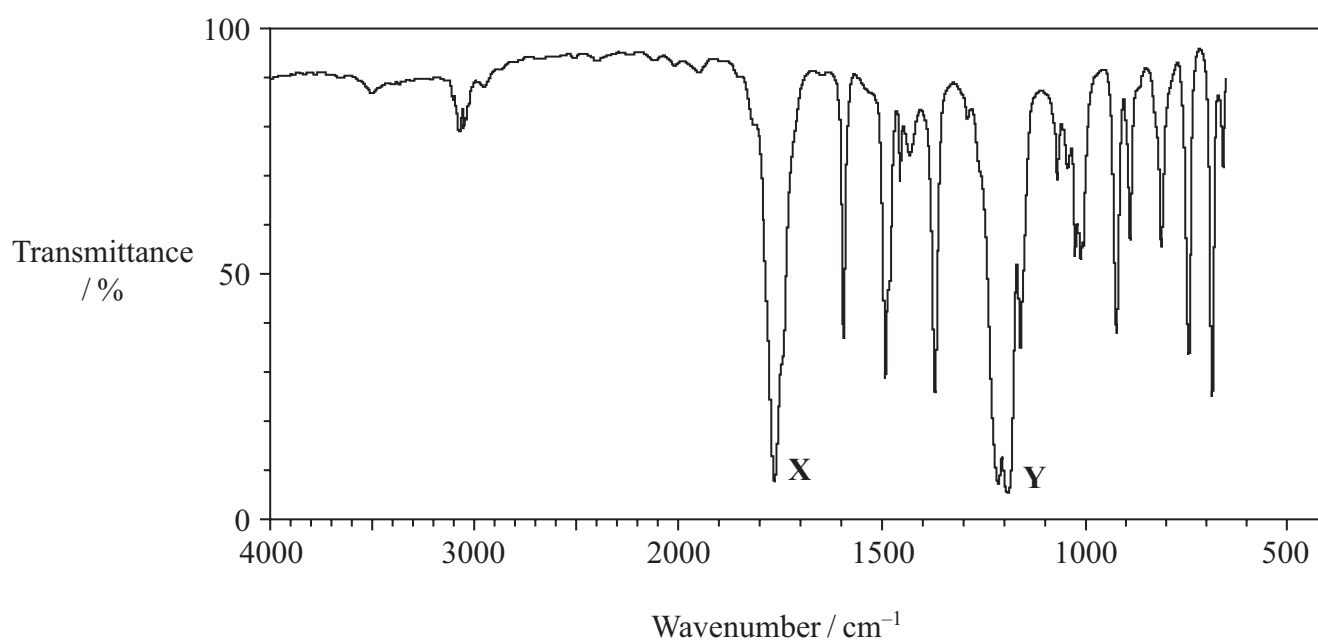
- (c) Both phenol and cyclohexanol react with ethanoyl chloride to produce steamy fumes and an ester. Phenol behaves like an alcohol in this reaction.

- (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)

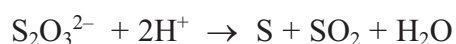
(Total for Question 2 = 11 marks)



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 cm³ with distilled water.
 4. 25 cm³ portions of this solution were transferred to separate conical flasks. Then 10 cm³ 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.



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?

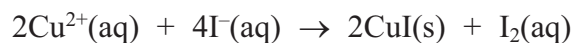
(1)

- (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.



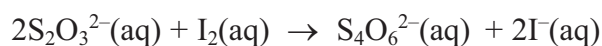
(i) Give the name of the precipitate formed in this reaction.

(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



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 Cu²⁺ in the 25 cm³ 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 $\pm 0.10 \text{ cm}^3$. 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?

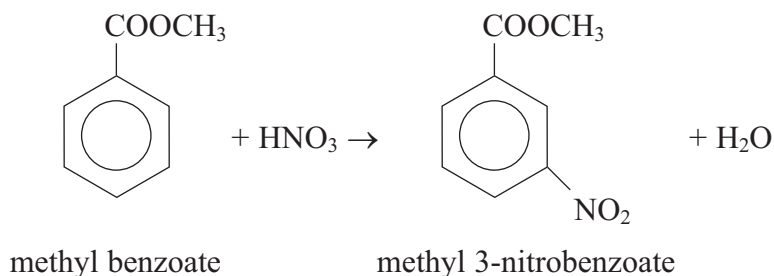
(1)

(Total for Question 3 = 14 marks)



P 3 9 3 1 1 A 0 9 1 6

- 4 A student attempted to make a sample of methyl 3-nitrobenzoate using the following reaction.



Procedure

1. Transfer 9 cm³ of concentrated sulfuric acid into a 100 cm³ 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 cm³ of concentrated nitric acid with 3 cm³ 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)

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- (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.

Temperature / °C	Solubility of methyl 3-nitrobenzoate / g per 100 g solvent	
	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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6

P 3 9 3 1 1 A 0 1 6 1 6

Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH07) Paper 01
Chemistry Laboratory Skills (WA)

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Summer 2012

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Question Number	Correct Answer	Reject	Mark
1(c)	$\text{Ag}^+(\text{aq}) + \text{I}^-(\text{aq}) \rightarrow \text{AgI}(\text{s})$ 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) $\text{Ag}^+(\text{aq}) + \text{Cl}^-(\text{aq}) \rightarrow \text{AgCl}(\text{s})$ (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)	$\text{Ba}(\text{NO}_3)_2$ ALLOW $\text{Ba}(\text{NO}_3)_2 \cdot x\text{H}_2\text{O}$ where x is a number between 1 and 10 e.g. $\text{Ba}(\text{NO}_3)_2 \cdot 2\text{H}_2\text{O}$		1

Question Number	Correct Answer	Reject	Mark
2(c)	$2\text{Ba}(\text{NO}_3)_2 \rightarrow 2\text{BaO} + 4\text{NO}_2 + \text{O}_2$ Fully correct equation (2) Formulae of all three products correct (1) ALLOW multiples ALLOW $4\text{BaNO}_3 \rightarrow 2\text{Ba}_2\text{O} + 4\text{NO}_2 + \text{O}_2$ (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 ₃ CH ₂ CH ₂ CH ₂ OH (1) CH ₃ CH(CH ₃)CH ₂ OH/ (CH ₃) ₂ CHCH ₂ OH (1) In either order Formulae may also be displayed or skeletal	C ₄ H ₉ OH Displayed formula with C-H-O OR C-HO	2

Question Number	Correct Answer	Reject	Mark
3(b)	(CH ₃) ₃ COH ALLOW CH ₃ COH(CH ₃)CH ₃ Formula may also be displayed or skeletal ALLOW CH ₃ CH ₂ CH ₂ OCH ₃ CH ₃ CH(CH ₃)OCH ₃ CH ₃ CH ₂ OCH ₂ CH 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)	$ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & & \text{H} & & \text{H} \\ & & & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{O} - \text{H} \\ & & & & & & & & & \\ & \text{Br} & & \text{OH} & & \text{H} & & \text{H} & & \text{H} \end{array} $ ALLOW Addition of -Br and -OH across the double bond, in either order OR $ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & & \text{H} & & \text{H} \\ & & & & & & & & & \\ \text{H} & - \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{O} - \text{H} \\ & & & & & & & & & \\ & \text{Br} & & \text{Br} & & \text{H} & & \text{H} & & \text{H} \end{array} $ 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)	$ \begin{array}{ccccccc} & \text{H} & & \text{H} & & \text{H} & & \text{H} & & \text{H} \\ & & & & & & & & & \\ \text{H} & - \text{C} & = & \text{C} & - & \text{C} & - & \text{C} & - & \text{C} & - \text{Cl} \\ & & & & & & & & & \\ & & & & & \text{H} & & \text{H} & & \text{H} \end{array} $ 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)	$(25.0 \times 4.18 \times 10.0 =)$ $1045/1050/1000 \text{ (J)}$ ALLOW 1.045/1.05/1.0 kJ IGNORE signs IGNORE sf except 1		1

Question Number	Correct Answer	Reject	Mark
4(a)(ii)	$\left(\frac{3.48}{100} \right) = 0.0348/0.035 \text{ (mol)}$ IGNORE sf except 1		1

Question Number	Correct Answer	Reject	Mark
4(a)(iii)	$\left(\frac{\text{Answer to (a)(i) in kJ}}{\text{Answer to (a)(ii)}} \right) = \frac{1.045}{0.0348}$ $= +30.03/30.0/30 \text{ (kJ mol}^{-1}\text{)}$ 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 g cm^{-3}	Thermometer is accurate	1

Question Number	Correct Answer	Reject	Mark
4(c)(i)	$(\Delta H_r =) 2 \times \Delta H_1 - \Delta H_2$		1

Question Number	Correct Answer	Reject	Mark
4(c)(ii)	$(\Delta H_r = (2 \times +30) - (-34) =)$ $+ 94 \text{ (kJ mol}^{-1}\text{)}$ value (1) sign (1) The sign mark is only available if the value is correct or almost correct. ALLOW $(\Delta H_r = (+30) - (-34) =)$ $= +64 \text{ (kJ mol}^{-1}\text{)}$ (1) IGNORE sf except 1		2

Question Number	Correct Answer	Reject	Mark		
5(a)(i)	<table><tr><td>(Mass of contents after heating / g)</td><td>2.49</td></tr></table>	(Mass of contents after heating / g)	2.49		1
(Mass of contents after heating / g)	2.49				

Question Number	Correct Answer	Reject	Mark		
5(a)(ii)	<table><tr><td>(Mass of water removed / g)</td><td>0.98</td></tr></table>	(Mass of water removed / g)	0.98		1
(Mass of water removed / g)	0.98				

Question Number	Correct Answer	Reject	Mark
5(b)(i)	$\left(\frac{0.98}{18.0} \right) = \frac{0.0544}{5.44 \times 10^{-2}} / \frac{0.054}{5.4 \times 10^{-2}} \text{ (mol)}$ IGNORE sig figs except ONE sf CQ on mass of water removed		1

Question Number	Correct Answer	Reject	Mark
5(b)(ii)	$\left(\frac{2.49}{102.9} \right) = \frac{0.0242}{2.42 \times 10^{-2}} / \frac{0.024}{2.4 \times 10^{-2}} \text{ (mol)}$ 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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Mark Scheme (Results)

Summer 2012

GCE Chemistry (6CH08) Paper 01
Chemistry Laboratory Skills (WA)

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1(a)	Green ACCEPT any green eg blue-green		1

Question Number	Correct Answer	Reject	Mark
1 (b)(i)	Chromium((III)) hydroxide/ $\text{Cr}(\text{OH})_3$ / $(\text{[Cr}(\text{OH})_3(\text{H}_2\text{O})_3])$ / $(\text{[Cr}(\text{H}_2\text{O})_3(\text{OH})_3])$ 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/ $\text{Cr}(\text{OH})_3$ / $(\text{[Cr}(\text{OH})_3(\text{H}_2\text{O})_3])$,/ $(\text{[Cr}(\text{H}_2\text{O})_3(\text{OH})_3])$ (1)		2

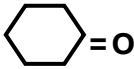
Question Number	Correct Answer	Reject	Mark
1(b)(iv)	$(\text{[Cr}(\text{NH}_3)_6]^{3+})$ Allow other numbers of NH_3 with H_2O provided correct charge and 6 ligands	Mixture of NH_3 and OH^- in ligands	1

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)	$\begin{array}{c} \text{CH}_3\text{-C=O} \\ \\ \text{O-C}_6\text{H}_5 \end{array}$ ALLOW skeletal, displayed, $\text{CH}_3\text{COOC}_6\text{H}_5$ and $\text{C}_6\text{H}_5\text{OCOCH}_3$ ALLOW C_6H_5 as benzene ring	$\text{C}_6\text{H}_5\text{COOCH}_3$ $\text{C}_6\text{H}_5\text{OOCCH}_3$ 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)	$((24.40 \times 0.125) / 1000)$ $= 3.05 \times 10^{-3} / 0.00305 \text{ (mol)}$ ALLOW $3.1 \times 10^{-3} \text{ (mol)}$	3.00×10^{-3} 3.10×10^{-3}	1

Question Number	Correct Answer	Reject	Mark
3(d)(ii)	Mol I_2 = half answer to (i) (1) $= 1.525 \times 10^{-3}$ Mol Cu^{2+} = $2 \times \text{mol } I_2$ (1) $= 3.05 \times 10^{-3}$ 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 cm³ = (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 cm³ 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)	$(5.0 / 136 = 0.0367647)$ $= 0.0368 / 0.037 \text{ (mol)}$ 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 = $(181 \times 0.0367647 = 6.6544118)$ $= 6.65 / 6.7\text{g}$ (1) % yield = $(3.4 / 6.6544118 \times 100 = 51.09392)$ $= 51.1 / 51$ (1) OR M_r for product = 181 (1) Moles product = $(3.40 / 181 = 0.0187845) = 0.0188 / 0.019$ (1) % yield = $(0.01878 / 0.036747 \times 100 = 51.111854)$ $= 51.1 / 51$ (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-nitrobenzoate) 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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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 ►

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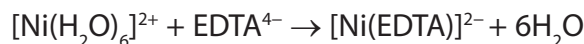
Answer ALL the questions. Write your answers in the spaces provided.

- 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 $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}(\text{aq})$
(ii)	Add concentrated hydrochloric acid to the solution containing $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ 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 $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ ions	Green precipitate forms	Formula of the precipitate formed is (1)
(iv)	Add excess dilute aqueous ammonia to the solution containing $[\text{Ni}(\text{H}_2\text{O})_6]^{2+}$ ions until no further change is observed	 (1)	Formula of the complex ion formed is $[\text{Ni}(\text{NH}_3)_6]^{2+}$



- (b) A 10.0 cm³ sample of a solution containing [Ni(H₂O)₆]²⁺ ions was titrated with a solution of concentration 0.010 mol dm⁻³ with respect to the ligand EDTA⁴⁻ ions. The equation for the reaction is



- (i) The mean titre of the solution containing EDTA⁴⁻ ions was 24.20 cm³. Use this information, and the equation above, to calculate the concentration in mol dm⁻³ of the solution containing [Ni(H₂O)₆]²⁺ ions.

(2)

- (ii) Assuming the total error in the measurement of the mean titre is ±0.10 cm³, calculate the percentage error in this titre.

(1)

- (iii) A similar solution, containing the same concentration of [Ni(H₂O)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)

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(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.

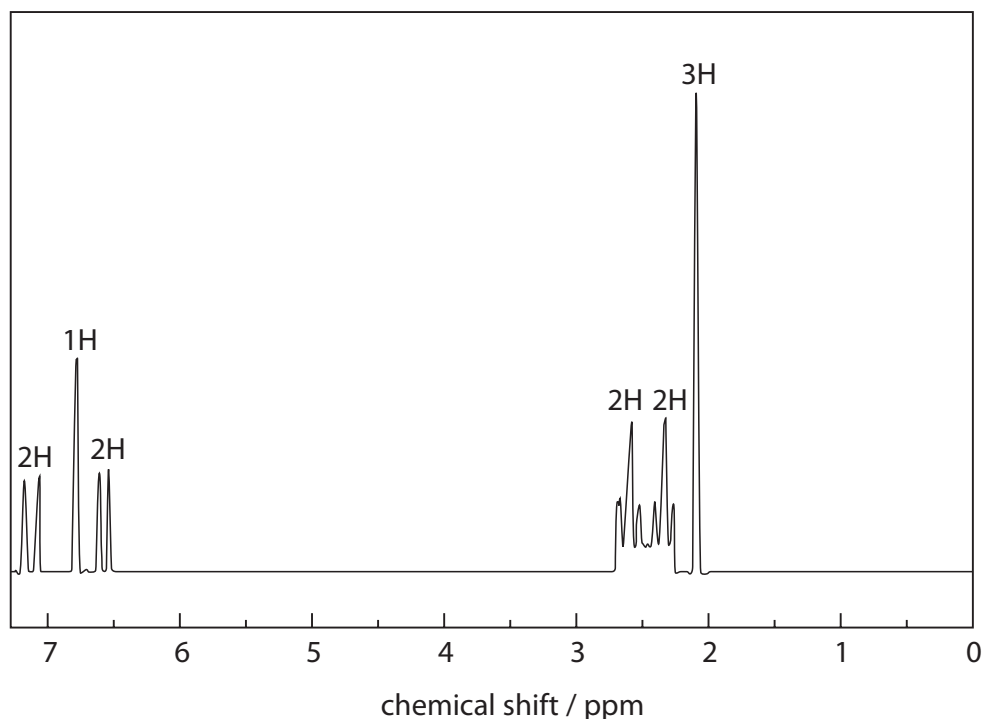
(1)

(iii) Fehling's (or Benedict's) solution remains blue when warmed with compound **X**.

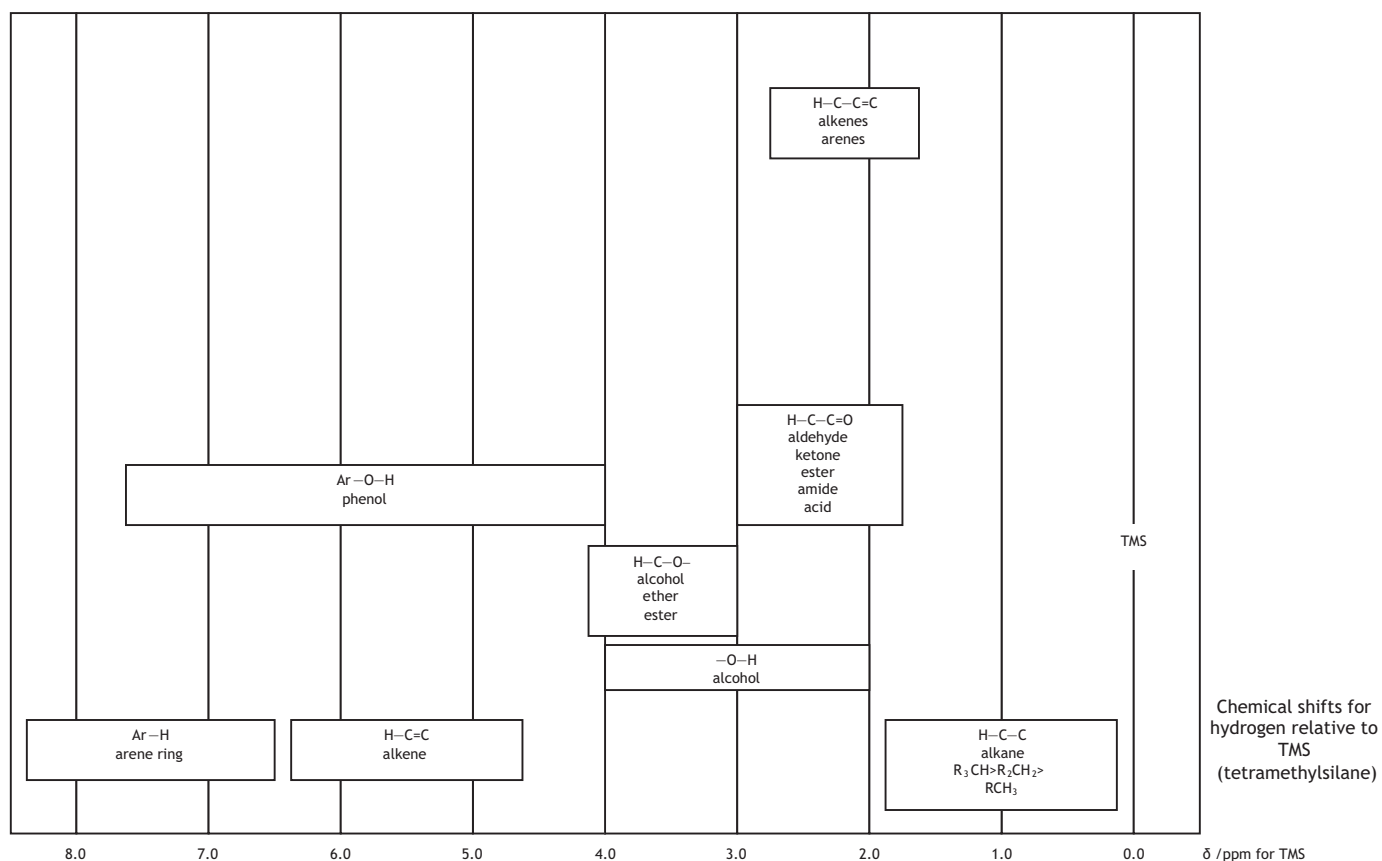
(1)



- (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.



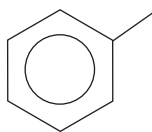
Nuclear Magnetic Resonance



- (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)

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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)

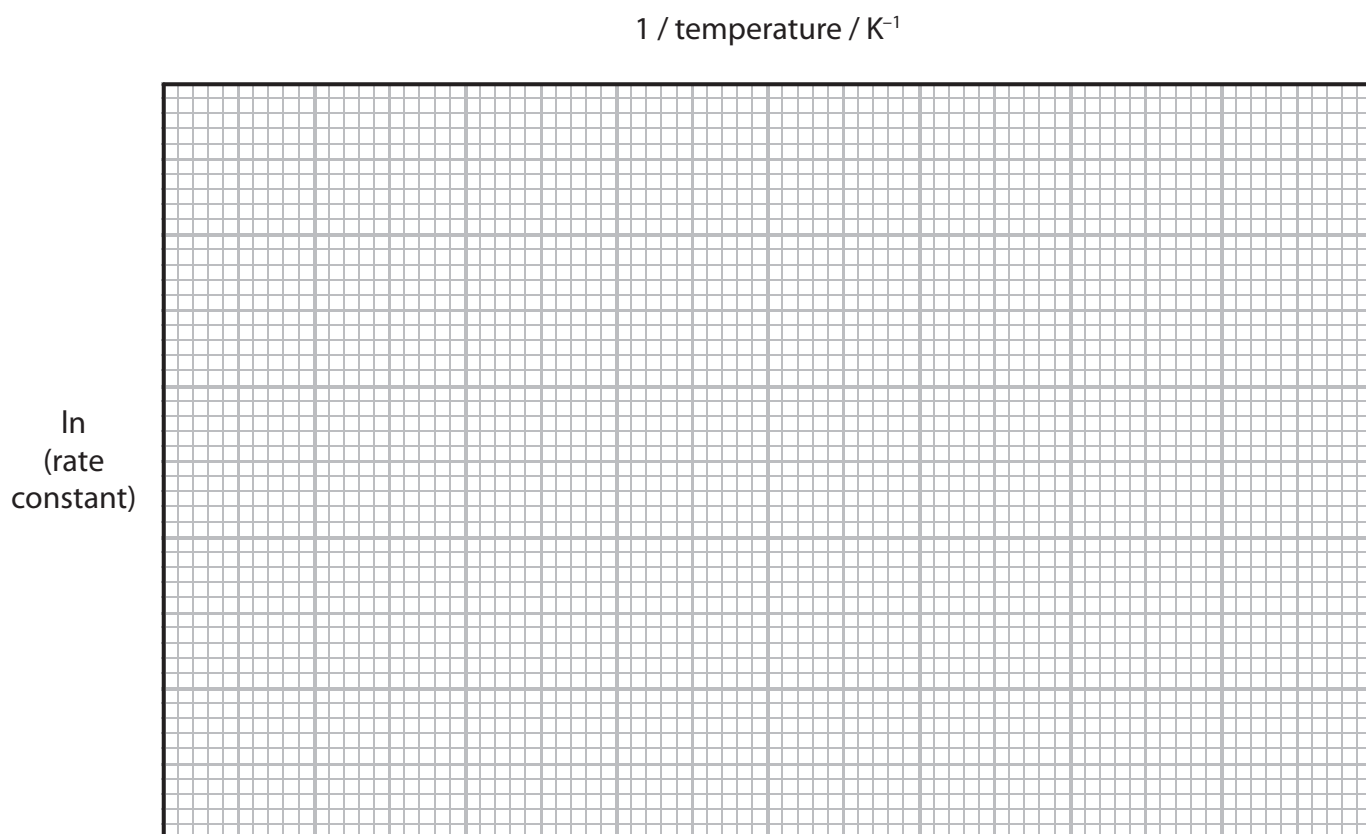


- (b) Experiment A was repeated at different temperatures and the time taken for the potassium manganate(VII) to change colour was recorded. The results were processed to find values of $1/\text{temperature}$ and $\ln(\text{rate constant})$ and these are shown in the table below.

Experiment	$1 / \text{temperature} / \text{K}^{-1}$	$\ln(\text{rate constant})$
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 $\ln(\text{rate constant})$ against $1 / \text{temperature}$ on the axes below.

(3)



- (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 cm³ 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)

.....

.....

(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



6

P 4 1 6 5 3 A 0 1 6 1 6

Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH01/01
The Core Principles of Chemistry

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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

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)			2
	Isotope	$^{131}_{53}\text{I}$ $^{127}_{53}\text{I}$	
	Number of protons	53 53	
	Number of neutrons	78 74	

Question Number	Acceptable Answers	Reject	Mark
18(b)	Xenon / Xe / $_{54}\text{Xe}$ / Xe_{54} / $^{131}_{54}\text{Xe}$	Anything else including: $^{130}\text{Xe}_{54}$ 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 iodate 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)	$\text{As(g)} - \text{e}^{(-)} \rightarrow \text{As}^{+}(\text{g})$ OR $\text{As(g)} \rightarrow \text{As}^{+}(\text{g}) + \text{e}^{(-)}$ Entities (1) All species gaseous (1) providing a reasonable attempt at an ionization energy Examples: $\text{As(g)} + \text{e}^{(-)} \rightarrow \text{As}^{+}(\text{g})$ $\text{As(g)} - \text{e}^{(-)} \rightarrow \text{As}^{-}(\text{g})$ $\text{As}^{2+}(\text{g}) - \text{e}^{(-)} \rightarrow \text{As}^{3+}(\text{g})$ IGNORE state symbol of electron ALLOW upper case / large S in arsenic ALLOW $\text{As(g)} + \text{e}^{(-)} \rightarrow \text{As}^{+}(\text{g}) + 2\text{e}^{(-)}$ (2)	$\text{As(g)} + \text{e}^{(-)} \rightarrow \text{As}^{-}(\text{g})$ (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	4s	4p				2
		↑↓	↑	↑	↑		
		↑↓	↑↓	↑	↑		
	One mark for each row						
	Arrows may be half-headed						
Se [Ar] 3d ¹⁰	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						

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)	$\text{CuO(s)} + 2\text{H}^+(\text{aq}) \rightarrow \text{Cu}^{2+}(\text{aq}) + \text{H}_2\text{O(l)}$ 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 = 79.5×0.02 OR $=1.59$ (1) OR TE from incorrect mass for one mark Their mass $\times 1.1 =$ 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

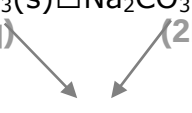
Question Number	Acceptable Answers	Reject	Mark
20(c)(iii)	(Copper(II) sulfate is soluble) so some remains in solution / some remains on the filter paper IGNORE other transfer errors Incomplete crystallization / not all the crystals are formed	Experimental error/ incomplete reaction Filtering alone Efflorescence	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)	$25 \times 4.18 \times 11 = 1149.5 \text{ (J)}$ ALLOW 1.1495 kJ Otherwise ignore units even if incorrect IGNORE sign IGNORE SF except one or two SF	1149.5 kJ	1

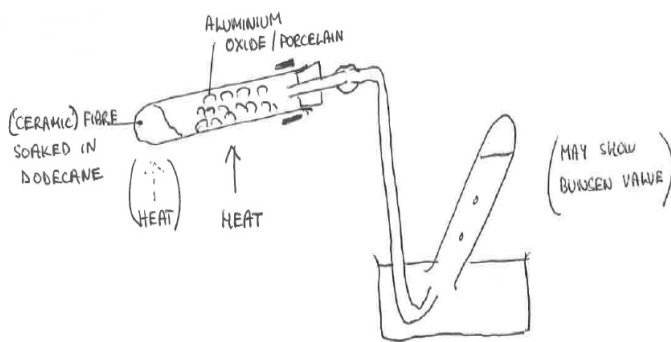
Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	-115 kJ mol^{-1} ALLOW -115000 J mol⁻¹ Sign with correct value (1) Units and three significant figures (1) Mark independently ALLOW TE from (i) -114 kJ mol^{-1} (rounding error) scores 1 $-115.0 \text{ kJ mol}^{-1}$ scores 1 Values of -4600 and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

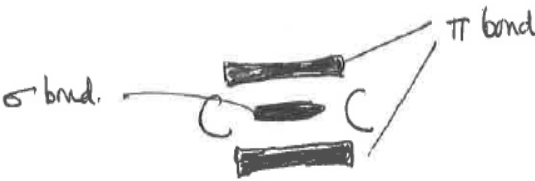
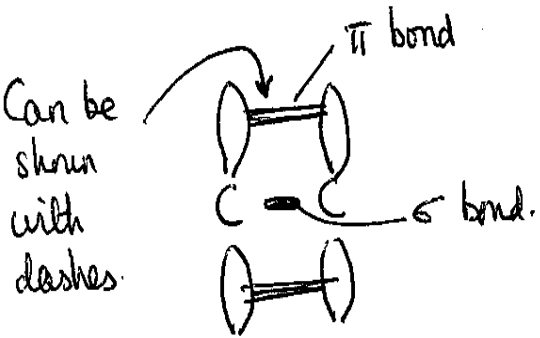
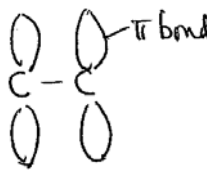
Question Number	Acceptable Answers	Reject	Mark
21(b)	$2\text{NaHCO}_3(\text{s}) \rightarrow \text{Na}_2\text{CO}_3(\text{s}) + \text{CO}_2(\text{g}) + \text{H}_2\text{O}(\text{l})$ $2\text{HCl}(\text{aq}) \quad \quad \quad (2\text{HCl}(\text{aq}))$  $2\text{NaCl}(\text{aq}) + 2\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$ First mark Arrow from products in top line to lower line and correct entities (1) $\text{NaCl} + \text{CO}_2 + \text{H}_2\text{O}$ Second mark $2\text{NaCl}(\text{aq}) + 2\text{CO}_2(\text{g}) + 2\text{H}_2\text{O}(\text{l})$ Correct state symbols and balancing (1) $\Delta H^\circ = +91.6 \text{ OR } +91.7 \text{ (kJ mol}^{-1}\text{)}$ 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 $2 \times (-115) = \Delta H^\circ - 321.6$ 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 $\Delta H^\circ = 2(-115) - (-321.6)$		5

	Fifth mark $\Delta H^\circ = 2(-115) - (-321.6)$ $= +91.6 \text{ (kJ mol}^{-1}\text{)}$ OR $\Delta H^\circ = 2(-114.95) - (-321.6)$ $= +91.7 \text{ (kJ mol}^{-1}\text{)}$ 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		
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Question Number	Acceptable Answers	Reject	Mark
21(c)	$((\pm) 0.5 \times 2 \times 100 / 11)$ $= (\pm)9.09 \text{ (\%)}$ ALLOW at 9.0909/9.091/9.1 and 9	9.10/9.0	1

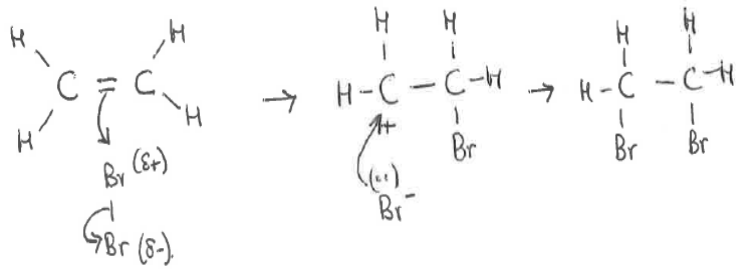
Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	$C_{12}H_{26} \rightarrow C_{10}H_{22} + C_2H_4$ IGNORE state symbols even if incorrect ALLOW displayed and structural formula for ethene		1

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 ₂ BrCH ₂ Br (1) ALLOW displayed / skeletal formula Mark independently Bromoethane with CH ₂ BrCH ₃ (0)	C ₂ H ₄ Br 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 bromide 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)	$n\text{CH}_2=\text{CH}_2 \rightarrow \{\text{CH}_2-\text{CH}_2\}_n$ Left side (1) Right side extension bonds must be shown (1) Mark independently Accept $n\text{C}_2\text{H}_4 \rightarrow \{\text{CH}_2-\text{CH}_2\}_n$ Penalise omission of n only once ALLOW $n\text{CH}_2=\text{CH}_2 + n\text{CH}_2=\text{CH}_2 \rightarrow \{\text{CH}_2-\text{CH}_2\}_n$ for (2) ALLOW multiples of C_2H_4 in product	$(\text{CH}_2=\text{CH}_2)_n$ 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 products	1

Total for Question 22 = 16 Marks

Total for Paper = 80 Marks

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Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH01/01R
The Core Principles of Chemistry

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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

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

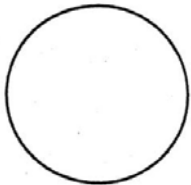
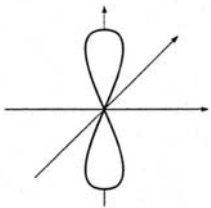
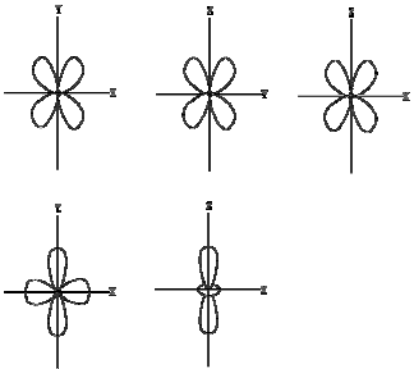
Question Number	Correct Answer	Mark
20	D	1

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"	1s	2s	2p	3s	3p	4s	3d	4p	'4p 4d' or '4d 4p' gets 0	2
1s	2s	2p	3s	3p	4s	3d	4p				

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	456 3	691 3	954 4	1335 2	1661 1	2011 5	2549 1	2893 4	14136 7	15907 9	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

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)	$(194 \times 32.8) + (195 \times 30.6) + (196 \times 25.4) + (198 \times 11.2) \div 100$ (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) (Na₂O): 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) Na₂O: does not conduct when solid as no mobile ions / ions unable to move / ions in fixed position (1) Na₂O: conducts when molten as has mobile ions (1)	Ions with reference to either form of sodium metal electrons electrons	3

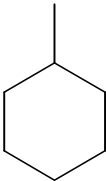
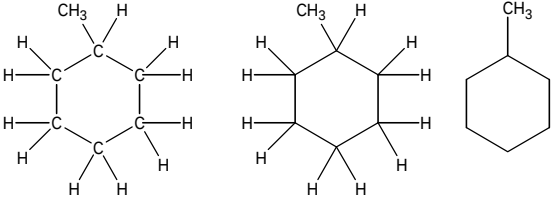
Total for Question 22 = 11 marks

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)	$C_{10}H_{22} + 10\frac{1}{2}O_2 \rightarrow 10CO + 11H_2O$ 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

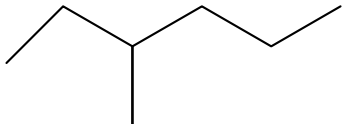
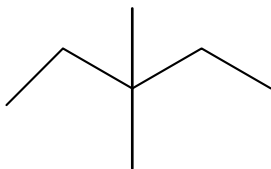
Question Number	Acceptable Answers	Reject	Mark
23(c)	First mark Dative pair of e⁻ between S and right-hand O (1) Second mark Two bond pairs between S and left-hand O (1) Third mark Two lone pairs on left-hand O, one lone pair on central S and three lone pairs on right-hand O atom (1) If 2 double bonds 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-dimethylpentane 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)	$\text{Cl}_2 \rightarrow \text{Cl}^\bullet + \text{Cl}^\bullet$ / $\text{Cl}_2 \rightarrow 2\text{Cl}^\bullet$ 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) $\text{C}_4\text{H}_{10} + \text{Cl}^\bullet \rightarrow \text{C}_4\text{H}_9^\bullet + \text{HCl}$ (1) (Second propagation step) $\text{C}_4\text{H}_9^\bullet + \text{Cl}_2 \rightarrow \text{C}_4\text{H}_9\text{Cl} + \text{Cl}^\bullet$ (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: $\text{C}_4\text{H}_9^\bullet + \text{Cl}^\bullet \rightarrow \text{C}_4\text{H}_9\text{Cl}$ OR $\text{Cl}^\bullet + \text{Cl}^\bullet \rightarrow \text{Cl}_2$ OR $\text{C}_4\text{H}_9^\bullet + \text{C}_4\text{H}_9^\bullet \rightarrow \text{C}_8\text{H}_{18}$		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/ CH₃ for example CH₂BrCH₃CBBrCH₃		4

Question Number	Acceptable Answers	Reject	Mark
24(b)	(1) for both arrows (1) for carbocation (1) for arrow First mark Double-headed arrow from alkene must start from somewhere on C=C bond Partial charge on Br₂ 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 C₂H₅OH gives 28 g C₂H₄ so 9.2 g C₂H₅OH gives maximum mass of) 5.6 g C₂H₄ (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 $\frac{4.2}{9.2} \times 100\%$	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 (cm³ / g) (1) Second mark $\Delta T = 13.5\text{ }^{\circ}\text{C}$ (energy released) = $100 \times 4.18 \times 13.5$ = 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)	$(\text{Moles HCl} = c_{\text{HCl}} \times V_{\text{HCl}} / 1000 =)$ $\frac{2.00 \times 50.0}{1000}$ $= 0.1(00) \text{ (mol HCl)}$ IGNORE s.f.		1

Question Number	Acceptable Answers	Reject	Mark
25(b)(iii)	$\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow / = \text{H}_2\text{O}(\text{l})$ 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)	$-\frac{5.643}{0.1(00)} = -56.43 \text{ kJ mol}^{-1}$ 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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