Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

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

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

7/7/5/3/

N 3 5 1 3 1 A 0 1 2 4

SECTION A

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

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

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

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

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

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

(Total for Question 1 = 1 mark)

---

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

☐ **A** 35.5

☐ **B** 36

☐ **C** 71

☐ **D** 72

(Total for Question 2 = 1 mark)

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

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

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

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

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

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

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

(Total for Question 3 = 1 mark)

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

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

☒ **B** $Na(s) + \frac{1}{2}N_2(g) + 1\frac{1}{2}O_2(g) \rightarrow NaNO_3(s)$

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

☒ **D** $Na(g) + \frac{1}{2}N_2(g) + 1\frac{1}{2}O_2(g) \rightarrow NaNO_3(g)$

(Total for Question 4 = 1 mark)

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

☒ **A** $\frac{1}{4}CH_4(g) \rightarrow \frac{1}{4}C(g) + H(g)$

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

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

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

(Total for Question 5 = 1 mark)

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

A 1680

B 2080

C 496

D 738

(a) Which element could be an inert gas?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

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

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

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

(1)

☒ **A**

☒ **B**

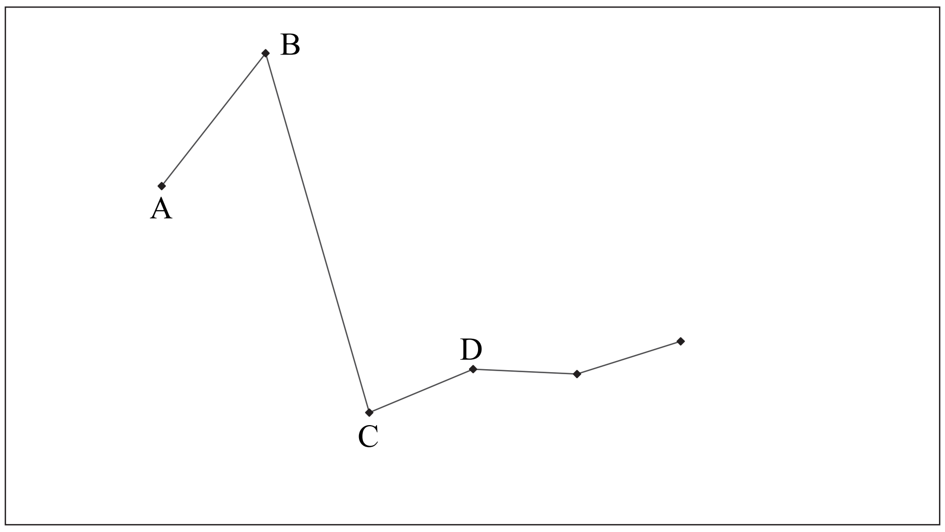
☒ **C**

☒ **D**

(Total for Question 6 = 3 marks)

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

Second ionization energy / kJ mol^{-1}



Atomic number increasing in steps of 1

Which element could be lithium?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 7 = 1 mark)

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

578 1817 2745 11 578 14 831

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

☒ **A** 1s 2s 2p 3s 3p

☒ **B** 1s 1s 2s 2s 2p

☒ **C** 3p 3s 2p 2s 1s

☒ **D** 3p 3s 3s 2p 2p

(Total for Question 8 = 1 mark)

9 Going across the Periodic Table from sodium to aluminium,

☒ **A** the melting temperature increases.

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

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

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

(Total for Question 9 = 1 mark)

---

10 Going down Group 1 from lithium to rubidium

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

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

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

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

(Total for Question 10 = 1 mark)

---

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

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

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

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

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

(Total for Question 11 = 1 mark)

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

12 The bonding in magnesium oxide, MgO, is

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

(Total for Question 12 = 1 mark)

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

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

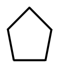
(Total for Question 13 = 1 mark)

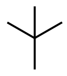
Use this space for any rough working. Anything you write in this space will gain no credit.

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

A 

B 

C 

D 

(a) Which compound is 2-methylpropane?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

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

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which compounds are isomers?

(1)

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

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

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

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

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

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 14 = 4 marks)

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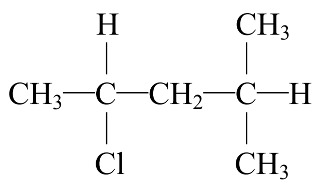
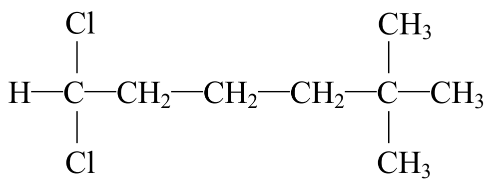
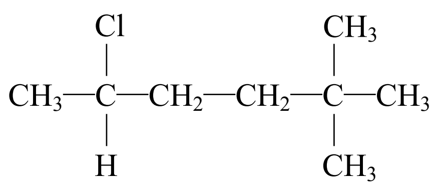
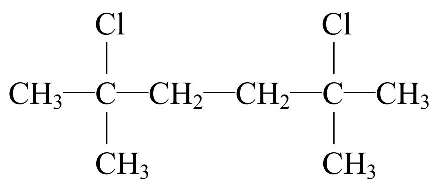
15 The structural formula of 5-chloro-2,2-dimethylhexane is

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

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

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

(2)

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

(2)

....

....

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

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

(1)

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

(1)

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

(1)

....

....

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

(1)

....

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

(2)

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

(1)

....

....

....

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

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

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

(1)

....

....

....

....

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

(2)

....

....

....

....

....

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

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

(1)

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

(1)

....

....

(Total for Question 16 = 16 marks)

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

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

(i) Calculate the empirical formula of sulfamic acid.

(3)

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

(1)

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

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

(2)

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

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

(1)

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

(2)

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

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

(1)

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

(1)

....

(Total for Question 17 = 11 marks)

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

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

(2)

Test: ....

....

Result with hexane: ....

....

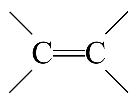
Result with hex-1-ene: ....

....

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

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

(1)



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

(2)

....

....

....

....

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

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

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

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

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

(1)

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

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

(3)

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

(2)

....

....

....

....

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

(1)

....

....

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

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

(i) What catalyst is used in this reaction?

(1)

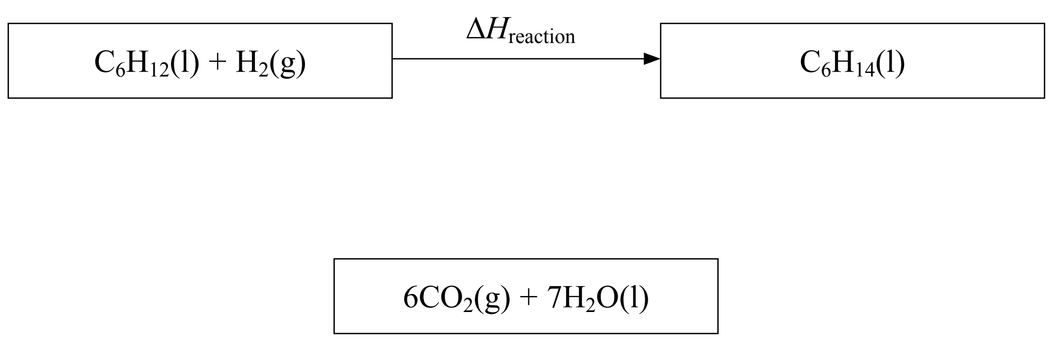
....

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

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

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

(3)



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

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

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

Explain why the values are so similar.

(1)

....

....

....

(Total for Question 18 = 17 marks)

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

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

(2)

Reagent ....

Condition ....

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

(2)

....

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

(1)

....

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

(3)

(c) Which method of making chloroethane has

(3)

- a higher atom economy? ....

- a higher percentage yield? ....

Explain your answers.

Higher atom economy ....

....

Higher percentage yield ....

....

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

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

(2)

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

(1)

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

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

(2)

(Total for Question 19 = 16 marks)

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

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The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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

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

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Mark Scheme (Results)

January 2010

GCE

GCE Chemistry (6CH01/01)

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January 2010

Publications Code US022675

General Marking Guidance

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

Using the Mark Scheme

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

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

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

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

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

6CH01/01

Section A

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Section B

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

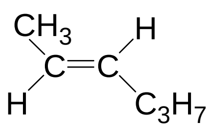
Question Number	Acceptable Answers	Reject	Mark
17 (b) (ii)	$\left(\frac{66}{24\,000}\right)$ = 2.75 x 10^{-3} / 0.00275 / 0.0028	0.003	**1**

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

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

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

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

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

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

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

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

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

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

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

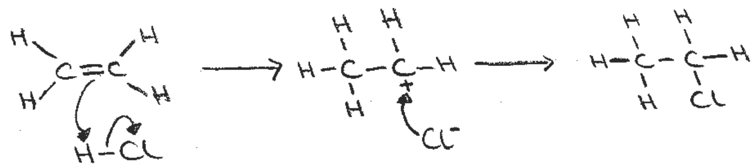
Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	Left hand arrow, pointing down, labelled ΔH_c hex-1-ene + ΔH_c hydrogen/ -4003-286/-4289 OR Pointing up with signs given above reversed (1) Right hand arrow pointing down labelled ΔH_c hexane / -4163 OR Pointing up with signs given above reversed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

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

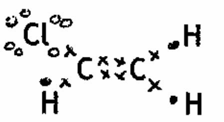
Question Number	Acceptable Answers	Reject	Mark
19 (a) (i)	Reagent: chlorine/ Cl_2 (1) Condition: uv/ sunlight (1) ALLOW light Mark independently Ignore reference to temp and pressure if given with uv light. If answers reversed/both on one line 1 out of 2	Cl Just "heat"	**2**

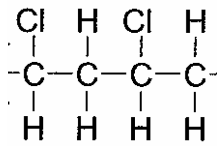
Question Number	Acceptable Answers	Reject	Mark
19 (a) (ii)	(free) radical (1) Substitution (1) Mark independently		**2**

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

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

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

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

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

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

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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 ▶

7/7/7/4/

N 3 5 6 9 1 A 0 1 2 8

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SECTION A

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

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

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

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

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

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

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

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

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

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 2 marks)

---

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

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

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

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

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

(Total for Question 2 = 1 mark)

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

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

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

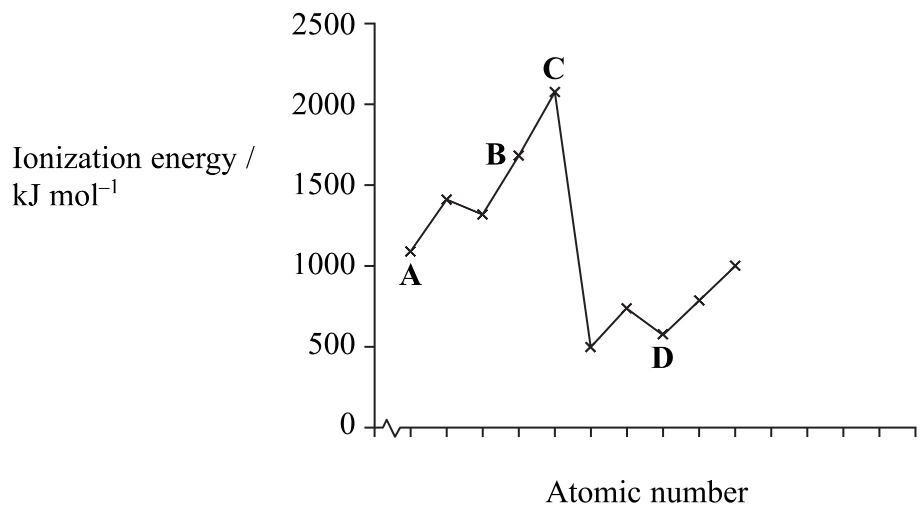
☒ **C** $Mg^{+}(g) + e^{-} \rightarrow Mg^{2+}(g)$

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

(Total for Question 3 = 1 mark)

---

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



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

(a) has atoms with five p electrons.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

N35691A0428

(b) is a member of Group 3.

(1)

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

(c) is likely to be very unreactive.

(1)

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

(d) normally forms four covalent bonds per atom.

(1)

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

(Total for Question 4 = 4 marks)

---

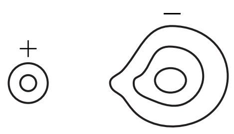
5 Which of these ions has the greatest ability to polarize an anion?

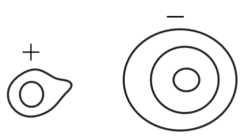
- ☒ **A** Ba^{2+}
- ☒ **B** Ca^{2+}
- ☒ **C** Cs^{+}
- ☒ **D** K^{+}

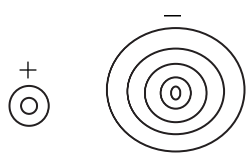
(Total for Question 5 = 1 mark)

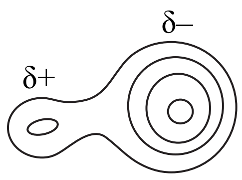
---

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

☒ **A** 

☒ **B** 

☒ **C** 

☒ **D** 

(Total for Question 6 = 1 mark)

---

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

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

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

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

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

(Total for Question 7 = 1 mark)

---

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

☒ **A** 1 : 1

☒ **B** 2.5 : 1

☒ **C** 1 : 5

☒ **D** 5 : 1

(Total for Question 8 = 1 mark)

---

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

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

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

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

☒ **A** (0.9 × 3/2) × 24

☒ **B** (0.9 × 3/2) ÷ 24

☒ **C** (0.9 × 2/3) × 24

☒ **D** (0.9 × 2/3) ÷ 24

(Total for Question 9 = 1 mark)

---

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

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

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

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

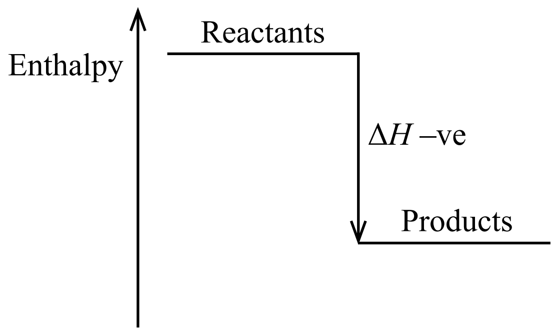
☒ **D** 13.33 cm^3 of 0.050 mol dm^{-3} $MgCl_2$(aq)

(Total for Question 10 = 1 mark)

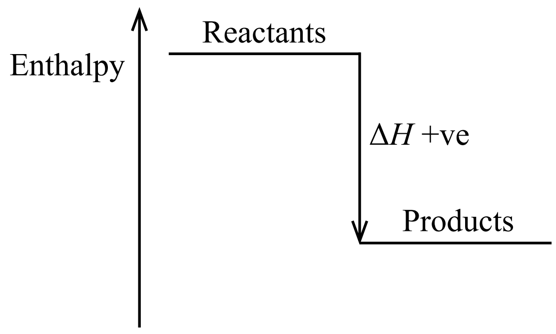
Use this space for any rough working. Anything you write in this space will gain no credit.

11 Which of these diagrams correctly represents an endothermic reaction?

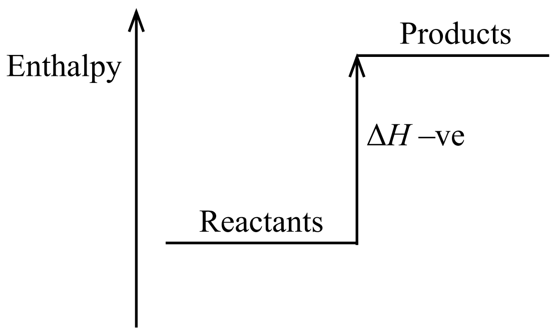
☒ **A**



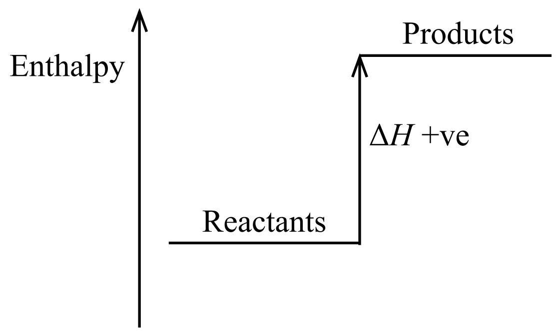
☒ **B**



☒ **C**



☒ **D**



(Total for Question 11 = 1 mark)

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

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

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

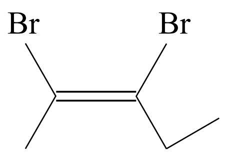
☒ **C** They have a higher electron density than a single bond.

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

(Total for Question 12 = 1 mark)

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

13 What is the correct name for the compound below?



☒ **A** *E*-2,3-dibromopent-2-ene

☒ **B** *E*-2,3-dibromopent-3-ene

☒ **C** *Z*-2,3-dibromopent-3-ene

☒ **D** *Z*-2,3-dibromopent-2-ene

(Total for Question 13 = 1 mark)

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

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

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

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

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

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

(a) Which equation shows a propagation step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which equation shows an initiation step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which equation shows a termination step?

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 14 = 3 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

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

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

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

(2)

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

(1)

$1s^2$..

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

(2)

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

(2)

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

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

(1)

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

(1)

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

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

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

(2)

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

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

(3)

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

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

(1)

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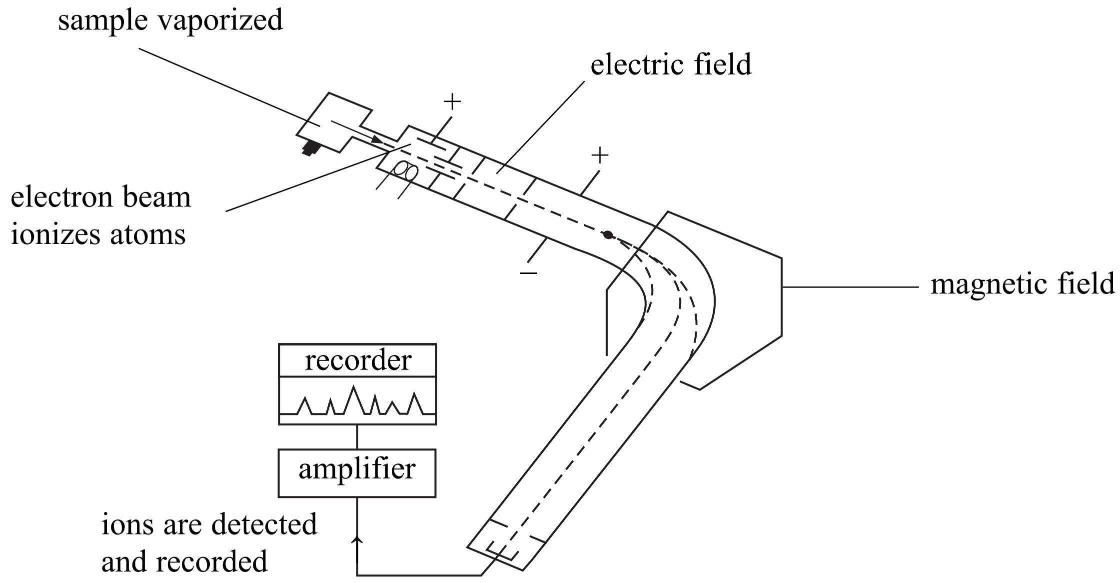
(Total for Question 15 = 15 marks)

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



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

(2)

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

(i) Electric field

(1)

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....

(ii) Magnetic field

(1)

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....

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

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

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

(2)

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

(2)

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

(1)

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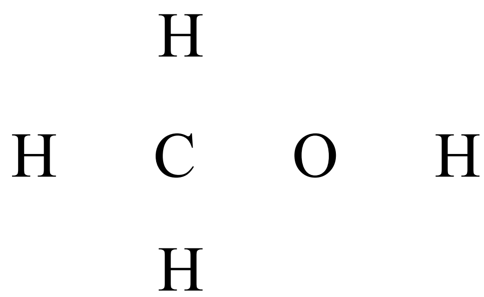
....

(Total for Question 16 = 9 marks)

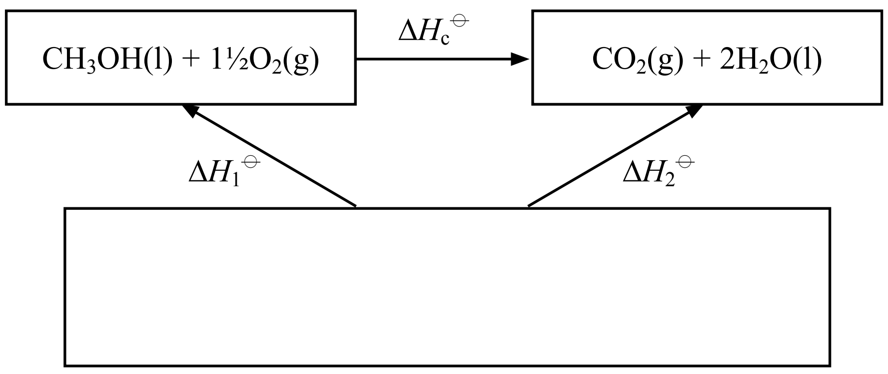
17 This question is about methanol and the energy changes that accompany some of its reactions.

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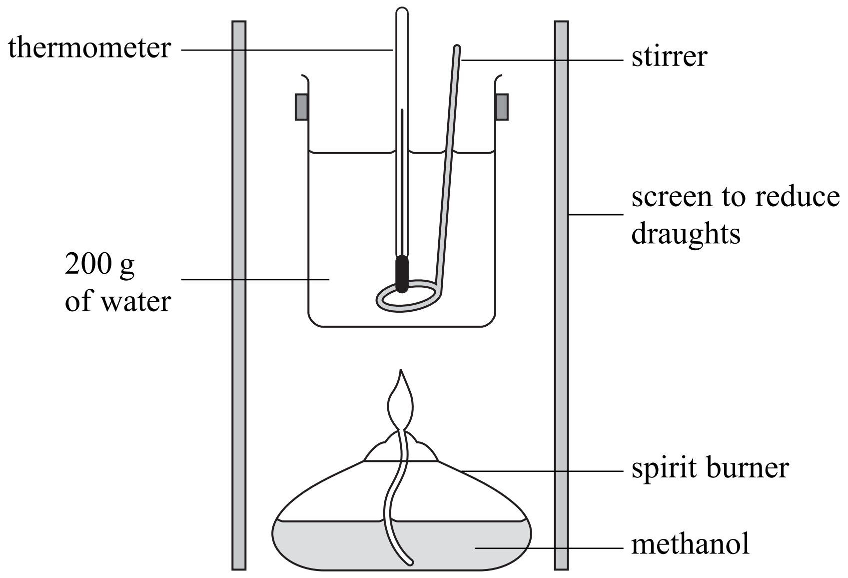
(iii) Use your cycle and the data below to calculate the standard enthalpy change of combustion of methanol, $\Delta H_c^{\ominus}$.

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

(2)

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



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

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

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

(1)

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

(1)

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

(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)

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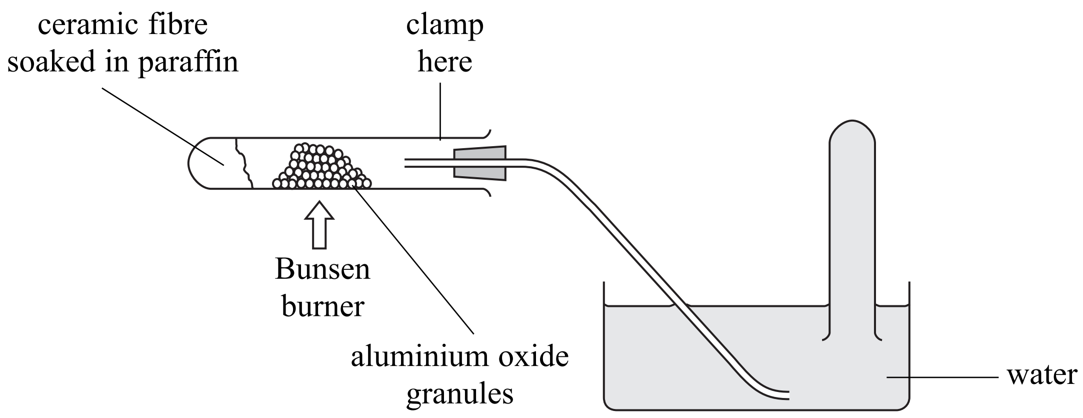
....

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



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

(4)

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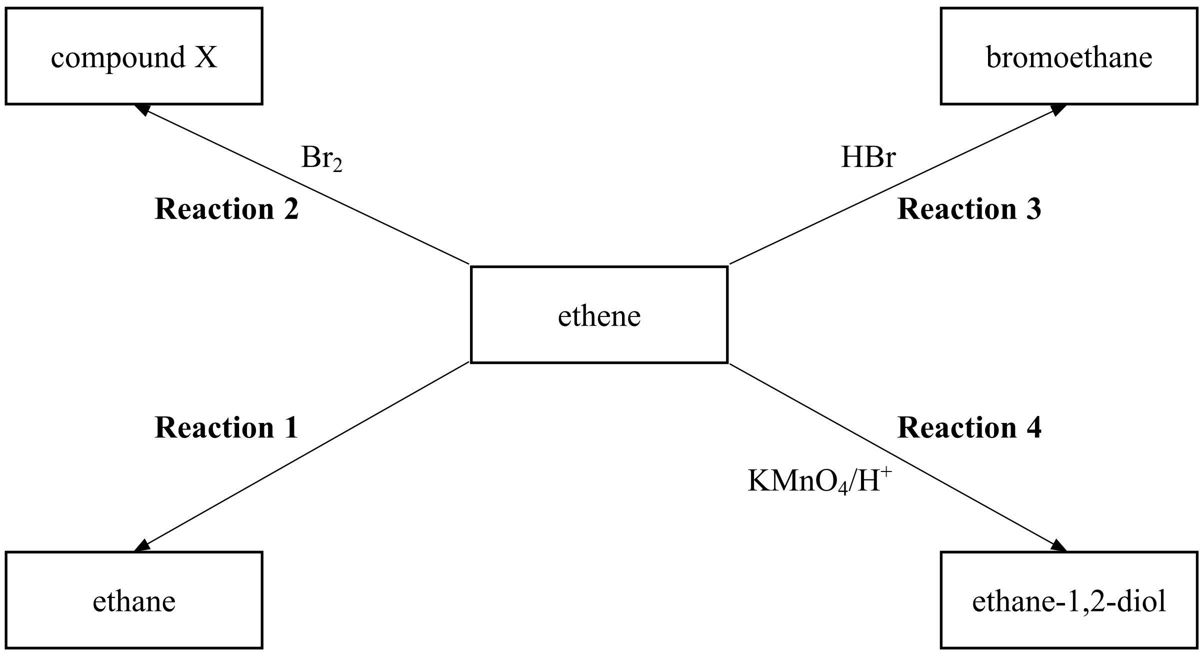
(b) Study the reaction scheme below and then answer the questions that follow.



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

(2)

Reagent ....

Catalyst ....

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

(2)

Name ....

Displayed formula

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

(1)

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

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

(3)

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

(1)

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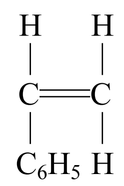
(d) The formula of the alkene phenylethene, often called styrene, is shown below. It can be used to make the polymer poly(styrene).



phenylethene

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

(2)

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

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

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

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

(2)

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

(2)

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(Total for Question 18 = 22 marks)

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

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The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1.0 **H** hydrogen 1

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
																	4.0 **He** helium 2
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

Mark Scheme (Results)

June 2010

GCE

GCE Chemistry (6CH01/01)

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Summer 2010

Publications Code US023629

Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

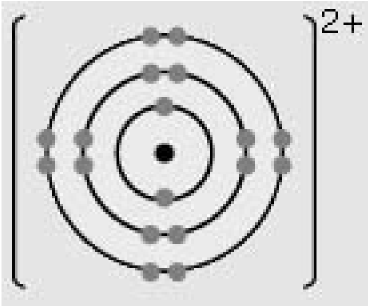
Question Number	Correct Answer	Mark
13	D	**1**

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

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

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

Section B

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

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

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

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

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

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

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

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

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

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

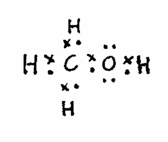
Question Number	Acceptable Answers	Reject	Mark
16 (b)(i)	(Electric field) **accelerates** ions		**1**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

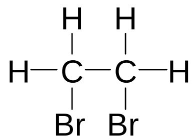
<table>
<tr><th>Risk</th><th>Amendment</th></tr>
<tr><td>exposure to harmful / toxic fumes</td><td>Set up in fume cupboard</td></tr>
<tr><td>Escape of flammable / harmful / toxic reactants or products from ill fitting bung</td><td>Correct fitting of bung</td></tr>
<tr><td>Escape of flammable / harmful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

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

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

Question Number	Acceptable Answers	Reject	Mark
18 (b)(i)	Reagent – Hydrogen/H_2 **(1)** Catalyst – Nickel/Ni/palladium/Pd/platinum/Pt **(1)** Mark independently		**2**

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

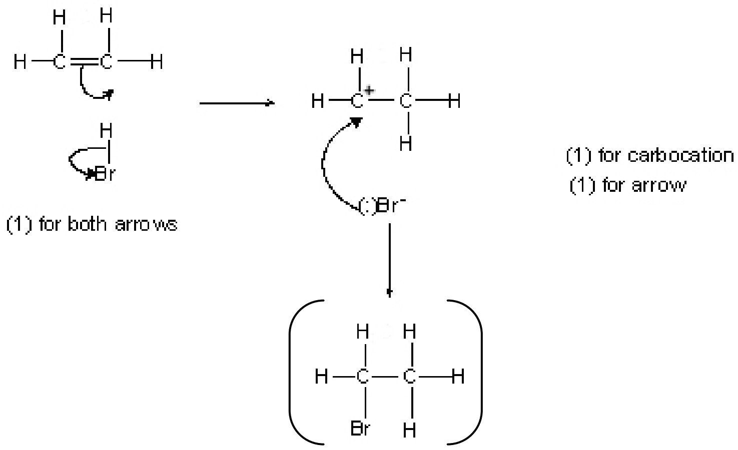
ignore punctuation

(1)

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

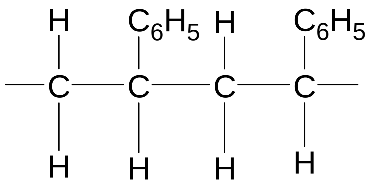
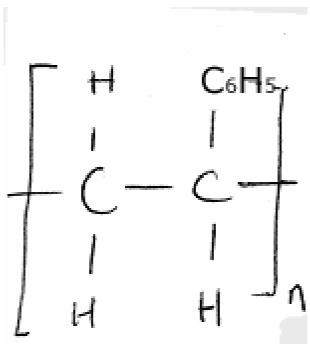
Skeletal formula

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

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

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

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

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

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

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

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

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

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

N37962A

7/7/5/2/

N 3 7 9 6 2 A 0 1 2 4

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SECTION A

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

1 The compound butane has

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

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

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

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

(Total for Question 1 = 1 mark)

---

2 For the oxidation of ammonia

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

the values of the coefficients in the balanced equation are

☐ **A** a = 2, b = 3, c = 2 and d = 3

☐ **B** a = 4, b = 7, c = 4 and d = 4

☐ **C** a = 4, b = 5, c = 4 and d = 6

☐ **D** a = 6, b = 7, c = 6 and d = 9

(Total for Question 2 = 1 mark)

---

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

☐ **A** 2.0×10^{23}

☐ **B** 6.0×10^{23}

☐ **C** 1.2×10^{24}

☐ **D** 1.8×10^{24}

(Total for Question 3 = 1 mark)

---

4 The equation for the complete combustion of octane is

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

(a) The mass of 10 mol of octane is

(1)

☒ **A** 0.66 kg

☒ **B** 1.14 kg

☒ **C** 2.10 kg

☒ **D** 2.28 kg

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

(1)

☒ **A** 240 dm^3

☒ **B** 300 dm^3

☒ **C** 3000 dm^3

☒ **D** 6000 dm^3

(Total for Question 4 = 2 marks)

---

5 The enthalpy change for the reaction

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

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

☒ **A** +329.6 kJ mol^{-1}

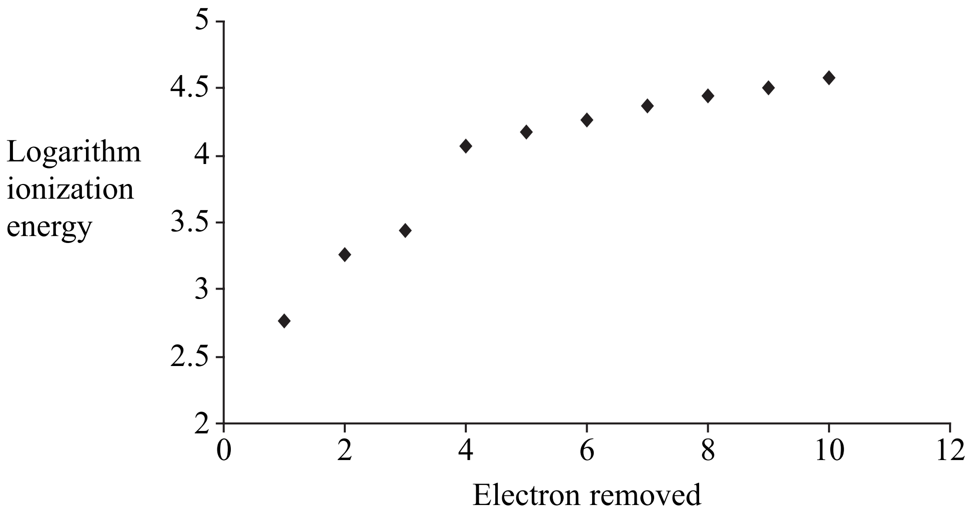
☒ **B** +412.0 kJ mol^{-1}

☒ **C** +1648 kJ mol^{-1}

☒ **D** +6592 kJ mol^{-1}

(Total for Question 5 = 1 mark)

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



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

(1)

☒ **A** Group 1

☒ **B** Group 3

☒ **C** Group 5

☒ **D** Group 7

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

(1)

☒ **A** X^{3+}

☒ **B** X^{+}

☒ **C** X^{-}

☒ **D** X^{3-}

(Total for Question 6 = 2 marks)

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

N37962A0424

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

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

(1)

☒ **A** RT

☒ **B** RT_6

☒ **C** RT_2

☒ **D** R_2T

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

(1)

☒ **A** ionic.

☒ **B** covalent.

☒ **C** dative covalent.

☒ **D** metallic.

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

(1)

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

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

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

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

(Total for Question 7 = 3 marks)

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

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

(a) The equation for this reaction is

(1)

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

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

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

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

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

(1)

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

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

☒ **C** break the C—C bond in ethane forming CH_3• free radicals.

☒ **D** break a C—H bond in ethane forming C_2H_5• free radicals.

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

(1)

☒ **A** addition.

☒ **B** homolytic fission.

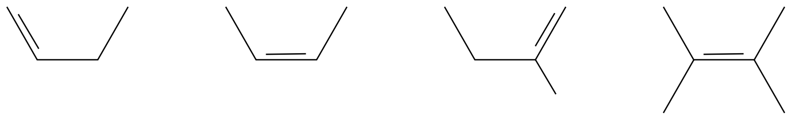
☒ **C** heterolytic fission.

☒ **D** substitution.

(Total for Question 8 = 3 marks)

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

9 This question concerns the following compounds



A **B** **C** **D**

Which of these compounds will show geometric (*E–Z* or *cis/trans*) isomerism?

⊠ **A**

⊠ **B**

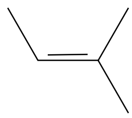
⊠ **C**

⊠ **D**

(Total for Question 9 = 1 mark)

---

10 The correct name for the compound shown below is



⊠ **A** 2-methylbut-3-ene

⊠ **B** 3-methylbut-2-ene

⊠ **C** 3-methylbut-3-ene

⊠ **D** 2-methylbut-2-ene

(Total for Question 10 = 1 mark)

---

11 Most compounds of lead are insoluble, an exception being lead(II) nitrate. Therefore a good method of preparing lead(II) sulfate is

⊠ **A** adding dilute sulfuric acid to lead metal.

⊠ **B** adding concentrated sulfuric acid to lead metal.

⊠ **C** adding dilute sulfuric acid to lead(II) nitrate solution.

⊠ **D** adding dilute sulfuric acid to solid lead(II) oxide.

(Total for Question 11 = 1 mark)

12 Metals usually have high melting temperatures and boiling temperatures because there are

☒ **A** strong attractions between the ions.

☒ **B** strong attractions between the delocalised electrons.

☒ **C** strong attractions between the ions and the delocalised electrons.

☒ **D** strong intermolecular forces.

(Total for Question 12 = 1 mark)

13 In 2006, the concentration of carbon dioxide in the atmosphere was 382 ppm. This is equivalent to

☒ **A** 0.00382%

☒ **B** 0.0382%

☒ **C** 0.382%

☒ **D** 3.82%

(Total for Question 13 = 1 mark)

14 A hazard that is particularly associated with alkanes is that they are

☒ **A** corrosive.

☒ **B** flammable.

☒ **C** toxic by inhalation.

☒ **D** toxic by skin absorption.

(Total for Question 14 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

BLANK PAGE

SECTION B

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

15 The relative atomic mass of an element is determined using a mass spectrometer.

(a) Define the term **relative atomic mass**.

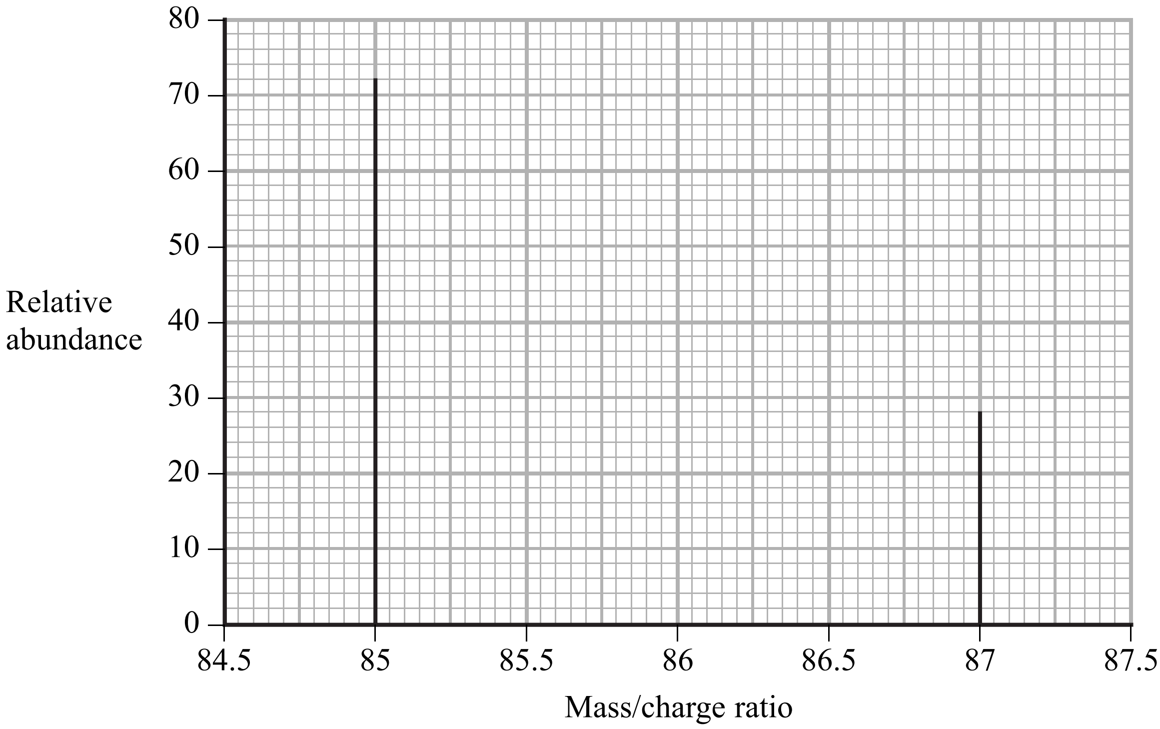
(2)

....

....

....

(b) The mass spectrum of rubidium is shown below.



(i) Explain why there are two peaks in the spectrum.

(1)

....

....

(ii) Use the spectrum to calculate the relative atomic mass of rubidium.

(2)

(Total for Question 15 = 5 marks)

16 (a) Coral reefs are produced by living organisms and predominantly made up of calcium carbonate. It has been suggested that coral reefs will be damaged by global warming because of the increased acidity of the oceans due to higher concentrations of carbon dioxide.

(i) Write a chemical equation to show how the presence of carbon dioxide in water results in the formation of carbonic acid. State symbols are **not** required.

(1)

(ii) Write the **ionic** equation to show how acids react with carbonates. State symbols are **not** required.

(2)

(b) One method of determining the proportion of calcium carbonate in a coral is to dissolve a known mass of the coral in excess acid and measure the volume of carbon dioxide formed.

In such an experiment, 1.13 g of coral was dissolved in 25 cm^3 of hydrochloric acid (an excess) in a conical flask. When the reaction was complete, 224 cm^3 of carbon dioxide had been collected over water using a 250 cm^3 measuring cylinder.

(i) Draw a labelled diagram of the apparatus that could be used to carry out this experiment.

(2)

(ii) Suggest how you would mix the acid and the coral to ensure that no carbon dioxide escaped from the apparatus.

(1)

....

....

....

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

[The molar volume of any gas is 24 000 $cm^3\ mol^{-1}$ at room temperature and pressure.]

(1)

(iv) Complete the equation below for the reaction between calcium carbonate and hydrochloric acid by inserting the missing state symbols.

(1)

$$CaCO_3(\ldots\ldots) + 2HCl(\ldots\ldots) \rightarrow CaCl_2(\ldots\ldots) + H_2O(l) + CO_2(\ldots\ldots)$$

(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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....

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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

....

....

....

....

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

(1)

....

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

(2)

....

....

....

....

....

(c) When propene reacts with hydrogen bromide, there are two possible products.

(i) Draw a displayed formula of each of these products and label the major product.

(2)

(ii) Give the mechanism for the reaction of propene with hydrogen bromide which forms the major product.

(3)

(iii) Explain, by referring to the mechanism, why the major product is formed.

(2)

....

....

....

....

(d) The polymer poly(propene) is manufactured from propene.

(i) Write an equation for the polymerization, drawing the displayed formula of the repeat unit of poly(propene).

(3)

(ii) UV radiation causes poly(propene) to degrade. Suggest one advantage and one disadvantage of this.

(2)

Advantage ....

....

Disadvantage ....

....

(Total for Question 18 = 20 marks)

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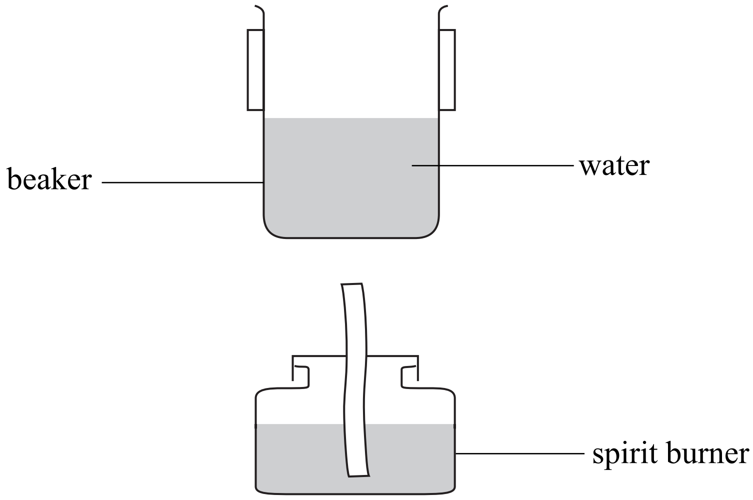
19 The enthalpy change of combustion of ethanol was determined using the apparatus shown in the diagram below. In the experiment, the temperature increase of the water in the beaker is measured when a known mass of the ethanol is burned.



(a) The results of the experiment are summarised in the table below.

Mass of water in the beaker	250.00 g
Mass of spirit burner + contents (initial)	63.21 g
Mass of spirit burner + contents (final)	62.47 g
Temperature of water (initial)	21.0 °C
Temperature of water (final)	31.5 °C

(i) Calculate the heat energy produced by the combustion of the alcohol using the equation

heat energy produced (J) = mass of water × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of ethanol burned in this experiment (the formula of ethanol is C_2H_5OH).

(3)

(iii) Use the equation below to calculate the enthalpy change of combustion of ethanol in kJ mol^{-1}. Give the value an appropriate sign.

$$\Delta H = \text{heat energy produced} \div \text{number of moles}$$

(2)

(b) The data book value for the enthalpy change of combustion of ethanol is –1370 kJ mol^{-1}.

(i) Calculate the percentage error in the value calculated in (a)(iii) in comparison with the data book value.

(1)

(ii) List **three** ways in which the design of the experiment causes the results to be so different from the data book value. (You should be specific but detailed explanations are not required.)

(3)

1 ....

....

2 ....

....

3 ....

....

(iii) Use the data book values for enthalpy changes of combustion given in the table below to calculate the enthalpy change of formation of ethanol.

(3)

Substance	Enthalpy change of combustion / $kJ\ mol^{-1}$
C(s, graphite)	–394
$H_2(g)$	–286
$C_2H_5OH(l)$	–1370

(Total for Question 19 = 13 marks)

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

The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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

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

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

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January 2011

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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

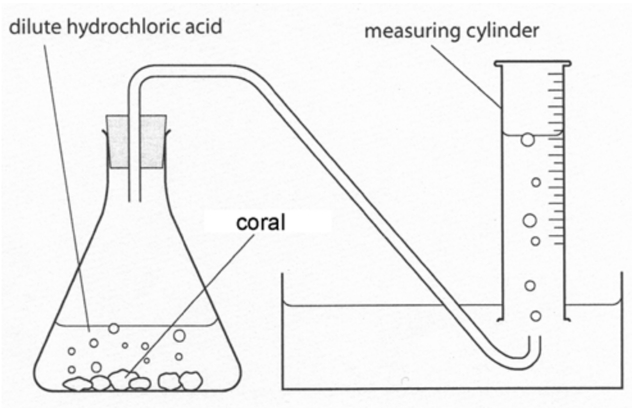
Question Number	Acceptable Answers	Reject	Mark
15 (a)	**Average/mean mass** of an atom/isotopes **(1)** (1/12 mass of an atom of) carbon–12 **(1)** **First mark:** mention of mean or average mass of either an atom/isotopes *IGNORE* "weighted" before average or mean *IGNORE* any mention of "moles" in definition **Second mark: any mention** of carbon-12 *IGNORE* any reference to "moles" or "1 mole" at any stage *IGNORE* 12 g with reference to carbon-12 **Mark the two points independently**	"weight" instead of mass mean or average mass **of an element...** without prior mention of either an atom or isotopes	**2**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (i)	(Rubidium/it has) two **isotopes** *ALLOW* (Rubidium/it has) "different **isotopes**" *ALLOW* abbreviations such as formulae of rubidium atoms or cations with isotopic masses		**1**

Question Number	Acceptable Answers	Reject	Mark
15 (b) (ii)	$\frac{85 \times 72 + 87 \times 28}{100}$ **(1)** = 85.56 or 85.6 **(1)** Correct answer with no working **(2)** **NOTE**: Rounding error giving answer 85.5 scores **(1)** *IGNORE* **any** units (for example, g/g mol^{-1}/%) **NOTE:** If 71% abundance used for ^{85}Rb and 29% for ^{87}Rb, answer = 85.58 or 85.6 scores **(1)** Second mark awarded if answer CQ correct on wrong abundances and /or wrong isotopic masses.	Calculation of simple arithmetic mean of 85 + 87 = 86 scores zero	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (i)	$H_2O + CO_2 \rightarrow H_2CO_3$ (Allow atoms in H_2CO_3 in any order) Or $H_2O + CO_2 \rightarrow H^+ + HCO_3^-$ Or $H_2O + CO_2 \rightarrow 2H^+ + CO_3^{2-}$ Or H_3O^+ in place of H^+ *IGNORE STATE SYMBOLS EVEN IF INCORRECT*		**1**

Question Number	Acceptable Answers	Reject	Mark
16 (a) (ii)	$2H^+ + CO_3^{2-} \rightarrow H_2O + CO_2$ LHS **(1)** RHS **(1)** **OR** $2H_3O^+ + CO_3^{2-} \rightarrow 3H_2O + CO_2$ LHS **(1)** RHS **(1)** *IGNORE STATE SYMBOLS, EVEN IF INCORRECT* *IGNORE* $\rightleftharpoons$ arrows	H_2CO_3 as a product $H^+ + CO_3^{2-} \rightarrow HCO_3^-$ Any other ions including spectator ions (e.g. Ca^{2+}, Cl^-) in the equation scores zero	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (i)	 Conical flask **and** a delivery tube leaving the conical flask **(1)** *IGNORE* "heat" beneath conical flask Inverted measuring cylinder with collection over water shown and cylinder above mouth of delivery tube **(1)** *ALLOW* collection over water to be shown/implied in the diagram without labels or other annotation	If collection **over water** is not somehow evident	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (ii)	Any method which is likely to bring the reactants into contact **after the apparatus is sealed**	Method suggesting mixing the reactants and then putting bung in flask very quickly	**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (iii)	(224 ÷ 24000 =) 0.009333/9.333 x 10^{-3} (mol) **Ignore SF except 1 SF** **Ignore any incorrect units**	"0.009" as answer	**1**

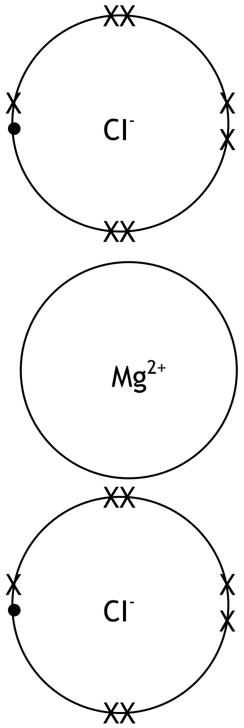
Question Number	Acceptable Answers	Reject	Mark
16 (b) (iv)	$CaCO_3$(s) + 2HCl(**aq**) → $CaCl_2$(**aq**) + H_2O(**l**) + CO_2 (**g/aq**) **ALL FOUR** state symbols must be correct for this mark		**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (v)	(Mass of 1 mol $CaCO_3$ = 40 + 12 + 3 x 16) = **100** g *ALLOW* just "100" *ALLOW* any incorrect units *ALLOW* "100.1 g " *OR* just "100.1" (Reason: this uses the Periodic Table value of A_r = 40.1 for Ca)		**1**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (vi)	(Mass of $CaCO_3$ = 100 x 0.009333) = 0.9333 (g) **(1)** *IGNORE* sig figs including 1 sf here **NOTE:** Moles of $CaCO_3$ consequential on answers to (b)(iii) and (b)(v) [**NOTE**: if A_r = 40.1 used for Ca, then the answer = 0.9339 (g)] Percentage of $CaCO_3$ in the coral = 100 x 0.9333 /1.13 = 82.6% **(1)** **NOTE:** If mass $CaCO_3$ used is 0.93, final answer is 82.3% [**NOTE***:* if A_r = 40.1 used for Ca, then the answers = 0.9339 (g) and **82.7**%]	Final % answer is **not given to 3 sf**	**2**

Question Number	Acceptable Answers	Reject	Mark
16 (b) (vii)	(Different samples of) coral have different amounts of $\mathbf{CaCO_3}$ /different proportions of $\mathbf{CaCO_3}$ / different "levels" of $\mathbf{CaCO_3}$ *ALLOW* "calcium carbonate" for $\mathbf{CaCO_3}$ OR Only one sample of coral (was) used	Answers that do not include any mention of $CaCO_3$ References to solubility of CO_2 in water References to repeating the experiment at a different temperature	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)	($1s^2$ $2s^2$) $2p^6$ $3s^2$ $3p^5$ (ignore repetition of $1s^2$ $2s^2$) *ALLOW* subscripts, correct use of p_x, p_y and p_z orbitals or normal font for electrons	2 8 7	**1**

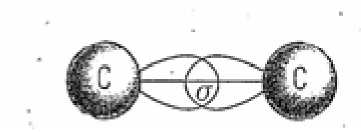
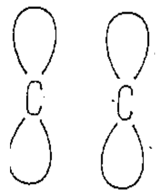
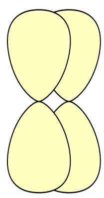
Question Number	Acceptable Answers	Reject	Mark
17 (b) (i)	 Correct number of outer electrons (ignore whether dots and / or crosses) drawn **and also** ratio of magnesium : chloride ions is 1:2 **(1)** Correct formulae and charges of the ions shown somewhere **(1)** **NOTE***:* Diagram for Mg^{2+} showing the outermost shell with $8e^-$ (dots and/or crosses) and/or Cl^- shown with a 2 in front or 2 as a subscript would also score both marks **Mark the two points independently**	Covalent bonding (0) Incorrect numbers of electrons in inner shells if drawn for first mark "MG^{2+}" and/or "CL^-" for second mark	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (ii)	4 shared pairs of electrons around the carbon labelled C **(1)** ALL outer electrons, including lone pairs, are correctly shown on each of the four chlorine atoms labelled Cl **(1)** *ALLOW* versions without circles *IGNORE* lines between the shared electrons **Mark two points independently**	Ionic bonding (0)	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (iii)	(Comparison of) charges: O^{2-} ions whereas Cl^{-} ions OR Statement to the effect that oxide ion has a greater (negative) charge / greater charge density than the chloride ion **(1)** (so the force of) attraction between **ions** is stronger in MgO (than $MgCl_2$) / stronger **ionic** bonding in MgO (than $MgCl_2$) **(1)** More **energy** is required to separate the ions in MgO (than $MgCl_2$) / more **energy** is required to break (ionic) bonds in MgO (than $MgCl_2$) / **(1)** **Mark the above three points independently** *NOTE ALTERNATIVE ANSWER WITH A MAXIMUM OF TWO MARKS:-* **O^{2-}** (ions) **smaller** (than Cl^{-} ions) **(1)** so (force of) attraction between **ions** is stronger in MgO (than $MgCl_2$) /stronger **ionic** bonding in MgO (than $MgCl_2$) **(1)** Ignore *ANY* references to polarization of ions / covalent character / degree of covalency. **Mark the above two points independently**	Use of term chlorine and/or oxygen "atoms" or "molecules" **(0) for answer overall** "More bonds need to be broken" **(0) for answer overall** if mentions "intermolecular forces"	**3**

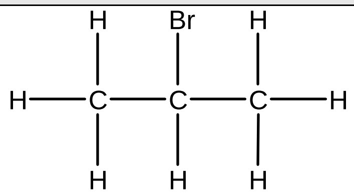
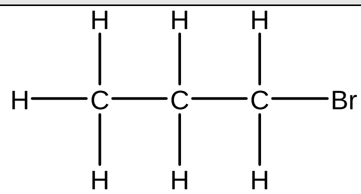
Question Number	Acceptable Answers	Reject	Mark
17 (c)	**First Mark:** *EITHER* Magnesium reacts with chlorine to form only magnesium chloride/ magnesium reacts with chlorine to form only one product / magnesium reacts with hydrochloric acid to form hydrogen (as well as magnesium chloride) / magnesium reacts with hydrochloric acid to form more than one product / magnesium reacts with hydrochloric acid to form a waste product *OR* **Both** equations $Mg + Cl_2 \rightarrow MgCl_2$ **and** $Mg + 2HCl \rightarrow MgCl_2 + H_2$ *IGNORE* state symbols, even if incorrect **(1)** **Second Mark:** *EITHER* The reaction with chlorine has an atom economy which is higher /100% ALLOW "high" *OR* Any mention of numbers comparing 100 % v. 97.9% **(1)** *IGNORE* any comments about **yield** **Mark the two points independently**		**2**

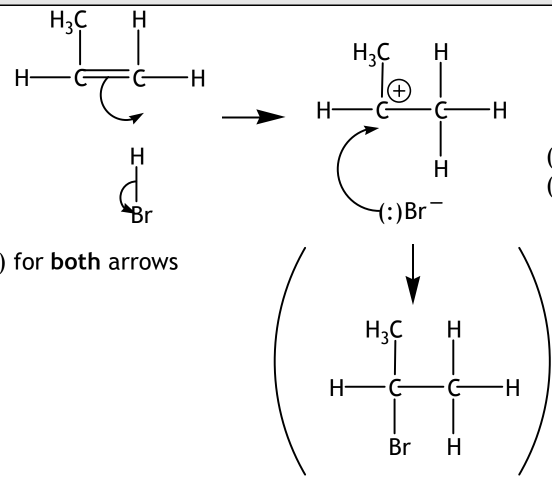
Question Number	Acceptable Answers	Reject	Mark
18 (a)	$C_{10}H_{22} \rightarrow C_7H_{16} + C_3H_6$ *ALLOW* structural or displayed formulae instead of molecular formulae *IGNORE* any state symbols, even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (i)	**diagram for the σ-bond** e.g.  **First Mark:** *EITHER* Diagram shows **overlap** of **any-shaped orbitals** along the line between the two nuclei *OR* Mentions/implies rotation around a sigma/single bond **(1)** **Second Mark:** Any written mention, or clear evidence from the diagram (e.g. shading), of the resultant (high) electron density (along the line) **between** the two nuclei **(1)** **diagram for the π-bond** e.g. *EITHER*  *OR*  **Third Mark:** *EITHER* Diagram shows two dumb-bell shaped (p-) orbitals(these can be separate dumb-bells or the diagram can show the p-orbitals overlapping sideways) *OR* Restricted /lack of /no rotation about a pi/double bond **(1)** **Fourth Mark:** Any written mention, or clear evidence from the diagram (e.g. shading), of the resultant (high) electron density **above and below (**the line between) the two nuclei **(1)**	Just a line between the two nuclei Just curved lines above and below the two nuclei	4

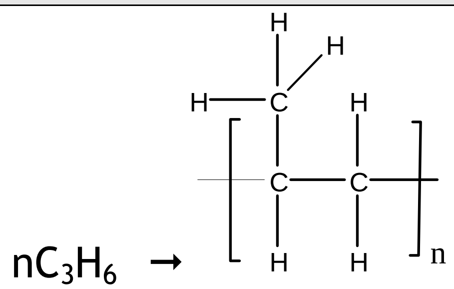
Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	Electrophilic addition *BOTH words needed* *ALLOW* "heterolytic" before electrophilic addition		**1**

Question Number	Acceptable Answers	Reject	Mark
18 (b) (iii)	π bond weaker than σ (bond) / less energy needed to break π bond *ALLOW* π bond weak(er) / π bond easy to break **(1)** π – electrons / π bonds (more) accessible (to electrophilic attack) *ALLOW* high/higher/more electron density in π bond (so alkenes more susceptible to electrophilic attack) **(1)** **Mark the two points independently**		**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (i)	 **and**  (main product) both DISPLAYED structures, with ALL bonds and atoms shown **(1)** major product identified or shown as product in (c)(ii) if NOT identified in (c)(i) **(1)** **NOTE:** if only one isomer of C_3H_7Br is named, assume this is the required "labelling" of the major product **Mark the two points independently**	CH_3 not fully displayed Incorrect name of isomer for 2nd mark	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (c) (ii)	 (1) for carbocation (1) for arrow (1) for **both** arrows **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 $Br^{\partial-}$	**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)** A*LLOW* CH_3 fully displayed or just as CH_3 Continuation bond at each end (with or without bracket shown in equation) **(1)** Unsaturated polymer scores max **(1)** **Mark the three points independently**	"x" instead of "n"	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	**(Advantage):** polypropene will decompose (naturally) *ALLOW* "rot" or "break down" *OR* polypropene will not require landfill (as it can decompose in sunlight) *OR* no need to incinerate /burn *IGNORE* "good for environment" / "no pollution" **(1)** **(Disadvantage):** poly(propene) cannot be used when exposed to (bright) sunlight / UV / outdoors *OR* cannot be recycled / cannot be reused **(1)** **Mark the two points independently**	"Can be recycled" (0) for first scoring point Biodegradable for 1st mark Answers which do not imply exposure to UV/sunlight Biodegradable for 2nd mark	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (a) (i)	(q = 250 x (31.5 — 21.0) x 4.18 =) **10972.5** (J) *IGNORE* sf except 1 sf *IGNORE* units even if incorrect *IGNORE* any sign at this stage *ALLOW* 10.97 (kJ)	10000 (J)	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a) (ii)	(M_r ethanol) = 46 **(1)** (Mass ethanol burned = 63.21 — 62.47 =) 0.74 (g) *ALLOW* 63.21 — 62.47 as alternative to 0.74 **(1)** (Amount of ethanol = 0.74 ÷ 46 =) 0.0161 (mol) **(1)** **NOTE***:* Moles of ethanol are CQ on molar mass and /or mass of ethanol burned *IGNORE* sf except 1 sf **NOTE***:* Correct answer with no working /limited working scores **(3)** **Mark the three points independently**	0.02 (mol) ethanol	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (a) (iii)	Answer (i) ÷ (1000 x answer (ii)) **(1)** **NOTE***:* Be aware of numbers held in calculator not corresponding to what is written in answer Value and negative sign **(1)** *IGNORE* sf except 1 sf **NOTE***:* Answer consistent with (a)(i) and (a)(ii) with no working scores **(2)** **<u>E.g.</u>** 10.9725 ÷ (0.74 ÷ 46) = — 682 (kJ mol^{-1}) *ALLOW* Just kJ as the units **NOTE***:* If correct answer is given in J mol^{-1}, the units of J mol^{-1} must be clearly given for the second mark to be awarded.	Correct answer in J instead of J mol^{-1}	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b) (i)	100 x (1370 — Answer to (iii)) ÷ 1370 = value e.g. 100 x (1370 — 682) ÷ 1370 = 50.2 %	Incorrect rounding of final answer **(0)**	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b) (ii)	Any **three** from: Heat loss (from the beaker)/beaker not insulated/heat loss as no lid on beaker (containing the water) /no stirring **(1)** Incomplete combustion (of the alcohol)/formation of soot (on beaker) **(1)** Not all of the energy from the flame is used to heat the beaker and/or the water OR Too large a distance between flame and beaker / no draught excluder **(1)** Heat capacity of the beaker is neglected/beaker absorbs heat/glass absorbs heat **(1)** Evaporation of the (hot) alcohol **(1)** Evaporation of the (hot) water **(1)**	More accurate thermometer **Just** "experimental /human error" Experiment carried out at a different (laboratory) temperature	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (b) (iii)	$2\,C(s) + 3H_2(g) + \frac{1}{2}\,O_2(g) \rightarrow C_2H_5OH(l)$ $\downarrow \qquad\qquad \downarrow$ $2CO_2 + 3H_2O$ $\triangle H_f = 2 \times (-394) + 3 \times (-286) - (-1370)$ $= -276$ (kJ mol^{-1}) Correct expression or cycle **(1)** Evidence for **both** doubling ΔH^{θ}_{c} [C] **and** trebling ΔH^{θ}_{c} [H_2] **(1)** Correct sign and answer **(1)** Correct answer with no working scores **(3)** Correct answer with an incorrect cycle **(3)** *IGNORE* units even if incorrect **Alternatively the following answers score as shown even with incorrect cycle or incorrect units** **NOTE**: (+)276 with or without working scores **(2)** (+)690 with or without working scores **(2)** −690 with or without working scores **(1)** −552 with or without working scores **(2)** −1134 with or without working scores **(2)** (+)1134 with or without working scores **(1)** (+)10 with or without working scores **(2)** **REMINDER IF ANY OTHER ANSWER IS GIVEN: ALL WORKING MUST BE CHECKED TO SEE IF ANY MARKS CAN BE AWARDED**		**3**

TOTAL FOR SECTION B = 60 MARKS

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Centre Number | Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Monday 23 May 2011 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

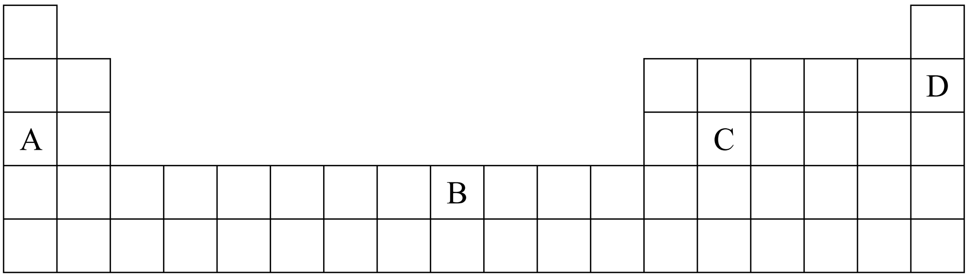
Turn over ▸

7/7/5/2/

SECTION A

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

1 In the following outline of the Periodic Table, the letters A to D are **not** the symbols of the elements.



Select from **A to D** the element which

(a) is a non-metal with a high melting temperature and boiling temperature.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) is in the d block of the Periodic Table.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) has a very stable electronic structure.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) is a metal with a high melting temperature and boiling temperature.

(1)

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

(Total for Question 1 = 4 marks)

2 The elements in Group 1 of the Periodic Table have very similar chemical properties. This is because

- ☒ **A** they have the same number of outer electrons.
- ☒ **B** they have the same number of filled shells of electrons.
- ☒ **C** their outer electrons are in the s sub-shell.
- ☒ **D** their outer electrons have very similar shielding.

(Total for Question 2 = 1 mark)

3 The European Union has set a limit (with effect from January 2010) of 3.13 ppm for the proportion of the toxic gas carbon monoxide in the air that we breathe. This is equivalent to

- ☒ **A** 3.13%
- ☒ **B** 0.0313%
- ☒ **C** 0.000313%
- ☒ **D** 0.00000313%

(Total for Question 3 = 1 mark)

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

- ☒ **A** 17.4 mol dm^{-3}
- ☒ **B** 1.74 mol dm^{-3}
- ☒ **C** 0.0174 mol dm^{-3}
- ☒ **D** 0.00174 mol dm^{-3}

(Total for Question 4 = 1 mark)

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

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

In this reaction, when 500 cm^3 of CO reacts with 500 cm^3 of NO at 650 °C (the operating temperature of the catalyst) and at 1 atm, the **total** volume of gases produced at the same temperature and pressure is

☒ **A** 500 cm^3

☒ **B** 750 cm^3

☒ **C** 1000 cm^3

☒ **D** impossible to calculate without knowing the molar volume of gases under these conditions.

(Total for Question 5 = 1 mark)

---

6 When a solution of barium chloride is added to sulfuric acid, a white precipitate is formed. The ionic equation (including state symbols) for this reaction is

☒ **A** $H^+(aq) + Cl^-(aq) \rightarrow HCl(s)$

☒ **B** $Ba^+(aq) + SO_4^-(aq) \rightarrow BaSO_4(s)$

☒ **C** $Ba^{2+}(aq) + 2SO_4^-(aq) \rightarrow Ba(SO_4)_2(s)$

☒ **D** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

(Total for Question 6 = 1 mark)

---

7 The enthalpy change for the reaction between hydrochloric acid and sodium hydroxide is –56 kJ mol^{-1}. Therefore

☒ **A** the reaction is exothermic and the temperature rises.

☒ **B** the reaction is exothermic and the temperature falls.

☒ **C** the reaction is endothermic and the temperature rises.

☒ **D** the reaction is endothermic and the temperature falls.

(Total for Question 7 = 1 mark)

---

8 The standard enthalpy changes of formation of some sulfur species are:

Species	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$S_8(s)$	0
$S_8(g)$	+103
$S(g)$	+279

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

☒ **A** $103 \div 8$

☒ **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** $HI(g) \rightarrow ½H_2(g) + ½I_2(s)$

☒ **B** $HI(g) \rightarrow ½H_2(g) + ½I_2(g)$

☒ **C** $HI(g) \rightarrow H(g) + I(g)$

☒ **D** $HI(g) \rightarrow H^+(g) + I^-(g)$

(Total for Question 9 = 1 mark)

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

10 The equation for the complete combustion of pentane is

$$C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l) \qquad \Delta H_c^{\ominus} = -3509 \text{ kJ mol}^{-1}$$

The standard enthalpy change of formation of $CO_2(g)$ is –394 kJ mol^{-1} and that of $H_2O(l)$ is –286 kJ mol^{-1}.

The standard enthalpy change of formation of pentane (in kJ mol^{-1}) is

☒ **A** 5(–394) + 6(–286) + (–3509)

☒ **B** 5(–394) + 6(–286) – (–3509)

☒ **C** –5(–394) – 6(–286) + (–3509)

☒ **D** –5(–394) – 6(–286) – (–3509)

(Total for Question 10 = 1 mark)

11 All alkenes have

☒ **A** the same empirical formula and the same general formula.

☒ **B** the same molecular formula and the same general formula.

☒ **C** the same molecular formula and the same empirical formula.

☒ **D** the same empirical formula and the same structural formula.

(Total for Question 11 = 1 mark)

12 Covalent bonding results from the strong electrostatic attractions between

☒ **A** instantaneous dipoles.

☒ **B** electron clouds.

☒ **C** electrons in the bonding pair.

☒ **D** bonding pairs of electrons and nuclei.

(Total for Question 12 = 1 mark)

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

13 This question concerns the reaction of hydrogen bromide with propene.

(a) This reaction requires

(1)

☒ **A** normal laboratory conditions.

☒ **B** the presence of UV light.

☒ **C** the presence of a suitable catalyst.

☒ **D** heating under reflux.

(b) The reaction is best described as

(1)

☒ **A** nucleophilic substitution.

☒ **B** electrophilic substitution.

☒ **C** nucleophilic addition.

☒ **D** electrophilic addition.

(c) The major product of the reaction will be

(1)

☒ **A** 1-bromopropane

☒ **B** 2-bromopropane

☒ **C** 1,2-dibromopropane

☒ **D** 2-bromopropene

(Total for Question 13 = 3 marks)

---

14 Many organic compounds have toxic vapours. For this reason

☒ **A** a naked flame should never be used when carrying out experiments with organic compounds.

☒ **B** gloves should usually be worn when carrying out experiments with organic compounds.

☒ **C** a fume cupboard should be used wherever possible when carrying out experiments with organic compounds.

☒ **D** most experiments with organic compounds are banned in schools and colleges.

(Total for Question 14 = 1 mark)

15 Ethanol (molar mass 46 g mol^{-1}) is manufactured by the hydration of ethene (molar mass 28 g mol^{-1}):

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

In a typical process 28 tonnes of ethene produces 43.7 tonnes of ethanol. The percentage yield of ethanol in this process is

☒ **A** 64%

☒ **B** 95%

☒ **C** 100%

☒ **D** 156%

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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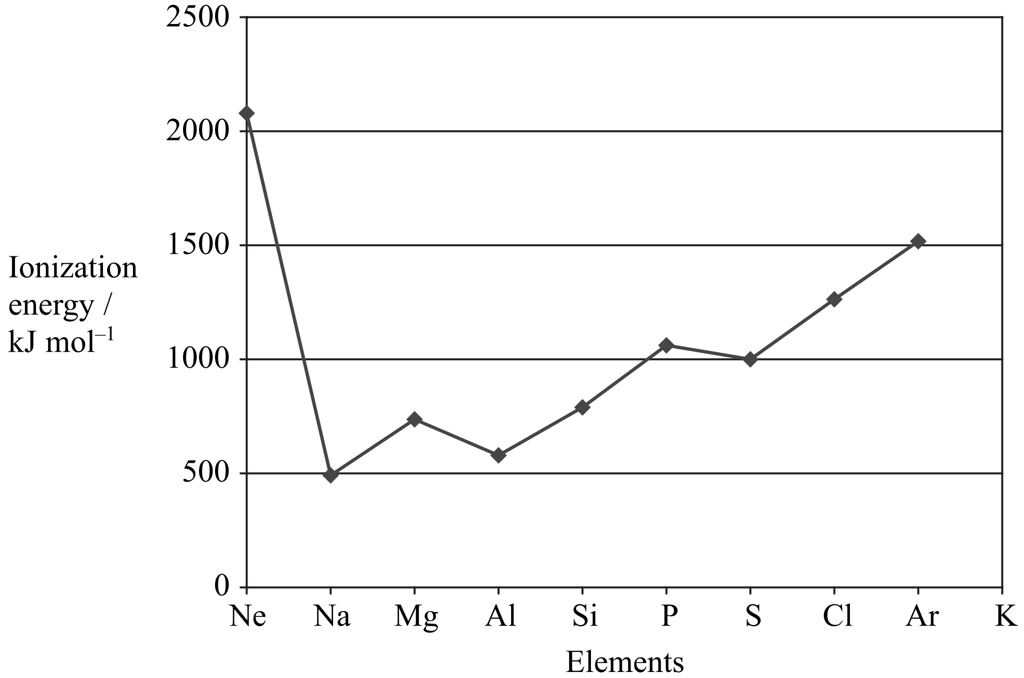
SECTION B

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

16 The first ionization energy of each of the elements from neon to argon is shown on the graph below. The first ionization energy of potassium has been omitted.



(a) Define the term **first ionization energy**.

(3)

....

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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)

....

....

....

....

....

....

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

(2)

....

....

....

....

(d) Estimate the value of the first ionization energy of potassium, K, and write your answer below.

(1)

.... $kJ\ mol^{-1}$

(Total for Question 16 = 9 marks)

17 0.400 g of magnesium ribbon reacted with exactly 22.2 cm^3 of hydrochloric acid of concentration 1.50 mol dm^{-3}.

400 cm^3 of hydrogen gas was formed, the volume being measured at room temperature and pressure.

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

$$Mg = 24.0 \text{ g mol}^{-1}$$
$$Cl = 35.5 \text{ g mol}^{-1}$$

(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 cm^3 mol^{-1}]

(1)

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

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

(1)

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

(3)

(Total for Question 17 = 7 marks)

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

$$\underset{\text{blue}}{CuSO_4.5H_2O(s)} + aq \rightarrow CuSO_4(aq) \qquad \Delta H_1 = +11.5 \text{ kJ mol}^{-1}$$

$$\underset{\text{white}}{CuSO_4(s)} + aq \rightarrow CuSO_4(aq) \qquad \Delta H_2 = -66.1 \text{ kJ mol}^{-1}$$

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

(3)

$$CuSO_4.5H_2O(s) \xrightarrow{\Delta H_{reaction}} CuSO_4(s) + 5H_2O(l)$$

$$\boxed{\qquad\qquad\qquad\qquad}$$

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

(2)

(b) Suggest why it is not possible to directly measure the enthalpy change for the conversion of the blue hydrated copper(II) sulfate crystals into the white anhydrous crystals.

(1)

....

....

....

....

*(c) (i) $CuSO_4.5H_2O(s) + aq \rightarrow CuSO_4(aq)$ $\Delta H_1 = +11.5 \text{ kJ mol}^{-1}$

Describe briefly the experimental procedure that **you** would use to obtain the data necessary to calculate ΔH_1, given a known mass of hydrated copper(II) sulfate crystals, $CuSO_4.5H_2O(s)$.

You should state the apparatus that you would use and any measurements that you would make.

You are **not** required to calculate the amounts of substances or to explain how you would use the data obtained.

(4)

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(ii) The value for the enthalpy change from (c)(i) obtained by experiments in a school laboratory is likely to be significantly different from a data book value.

List **three** possible reasons for this which do **not** relate to the quality of the apparatus or chemicals used or possible mistakes in carrying out the procedure.

(3)

1 ....

....

2 ....

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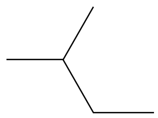
3 ....

....

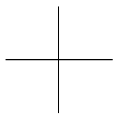
(Total for Question 18 = 13 marks)

19 This question is about alkanes.

(a) The skeletal formulae of two alkanes (**A** and **B**) are shown below.



A



B

(i) Write the general formula of the alkanes.

(1)

(ii) Compounds **A** and **B** are .... of each other.

(1)

(iii) Draw the displayed formula of compound **A**.

(1)

(iv) Give the systematic name of compound **B**.

(1)

....

(b) The largest use for alkanes is as fuels. However, there are problems associated with the combustion of alkanes, whether complete or incomplete.

(i) An incomplete combustion of methane, CH_4, results in the formation of carbon monoxide and water only.

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

(2)

(ii) When does incomplete combustion occur?

(1)

....

....

(iii) State **two** problems that result from the incomplete combustion of alkane fuels.

(2)

1 ....

....

2 ....

....

*(iv) State and explain the main environmental problem arising from the **complete** combustion of alkane fuels.

(3)

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(c) The reactions of organic compounds, including alkanes, may be broken down into a series of steps; this is the mechanism for the reaction. The reaction between methane and chlorine may be represented by a mechanism involving three stages – **initiation**, **propagation** and **termination**.

(i) Reaction mechanisms often involve the use of ‘curly arrows’. Explain the meaning of the curly arrows shown below.

(2)

Arrow I Arrow II

Arrow I ....

....

Arrow II ....

....

(ii) Using the curly arrow notation, show the **initiation** step of the reaction between methane and chlorine.

(2)

(iii) Give the two **propagation** steps of the reaction between methane and chlorine.

Curly arrows are **not** required.

(2)

(iv) Suggest why a small amount of UV light can result in the formation of a large amount of product.

(1)

....

....

(v) Ethane is a trace product of this reaction. By means of an equation, show how the ethane is formed.

(1)

(d) Scientists never detect molecular hydrogen, H_2, amongst the products of the chlorination of methane.

Use the data below to suggest why this is so.

The frequency of UV light used corresponds to an energy of about 400 kJ mol^{-1}.

Bond	Bond enthalpy / kJ mol^{-1}
C—H	435
Cl—Cl	243

(2)

....

....

....

....

(Total for Question 19 = 22 marks)

20 Metals are good conductors of heat and electricity and usually have high melting temperatures and boiling temperatures.

(a) (i) Describe the **structure** of a metal.

(2)

....

....

....

....

....

(ii) Describe the **bonding** in a metal.

(2)

....

....

....

....

....

(b) Explain why the melting temperature of magnesium (650 °C) is much higher than that of sodium (98 °C).

(3)

....

....

....

....

....

....

(c) Explain how metals conduct electricity.

(2)

....

....

....

....

(Total for Question 20 = 9 marks)

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

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The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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

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Mark Scheme (Results)

June 2011

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

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June 2011
Publications Code US027559

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 <u>meaning</u> of the phrase or the actual word is **essential** to the answer.

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

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

Quality of Written Communication

Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear

- select and use a form and style of writing appropriate to purpose and to complex subject matter

- organise information clearly and coherently, using specialist vocabulary when appropriate.

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

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Question Number	Correct Answer	Mark
13 (a)	A	**1**

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

Question Number	Correct Answer	Mark
13 (c)	B	**1**

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

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

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
16 (a)	**First mark** The energy (allow enthalpy / heat) required (allow change) per mole **(1)** **Second mark** to form (gaseous) singly charged positive ions Or to remove (1 mole of) electrons **(1)** **Third mark** from **gaseous** atoms (of the element) **(1)** $X(g) \longrightarrow X^{+}(g) + e^{(-)}$ scores last 2 marks Ignore standard conditions Per mole scores at any point	Energy / enthalpy produced Just gaseous element	**3**

Question Number	Acceptable Answers	Reject	Mark
16 (b)	Nuclear charge / effective nuclear charge / number of protons / atomic number increases **(1)** **Two of** (Outer) electrons in the **same** (quantum) shell / **same** number of electron shells **(1)** Shielding (of nucleus)(about) the same **(1)** Distance from nucleus/atomic radius less **(1)**	charge density orbitals, sub-shell	**3**

Question Number	Acceptable Answers	Reject	Mark
16 (c)	**Route 1** Electrons (in the p sub-shell) are **paired** (for the first time) (in S) / two electrons occupy the same (p) orbital / full orbital / electrons-in-boxes diagram **(1)** **repulsion** between the (paired) electrons (reduces IE) **(1)** **Route 2** P has a half-filled p sub-shell / half-filled p orbitals which is stable **(1)** (on ionization) S gains a half-filled p sub-shell / half-filled p orbitals **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (d)	200 – 490 (kJ mol^{-1})	Negative values	**1**

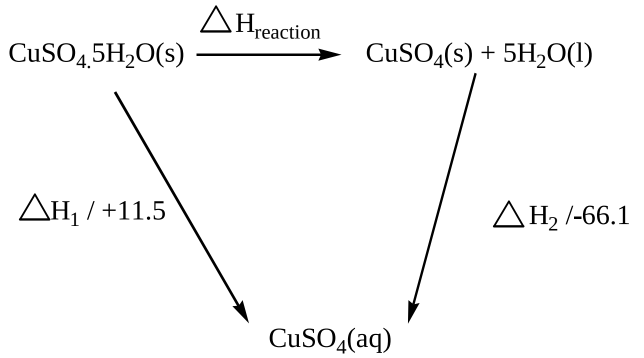
Question Number	Acceptable Answers	Reject	Mark
17 (a)	Do not penalize the use of A_r (Mg) = 24.3 at any stage in this question. Penalize SF errors (1 SF, incorrect SF (eg. 0.02) and incorrect rounding to 2 SF (e.g. 0.016)) only once in parts (a – d) Allow 0.0166 Allow fractions (e.g. 1/60) Amount Mg = (0.4 ÷ 24) = 0.016666 = 0.0167 (mol) Allow Amount Mg = (0.4 ÷ 24.3) = 0.016461 = 0.0165 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)	Amount HCl = 1.5 x 22.2/1000 = 0.033333 = 0.0333 (mol) Allow Amount HCl = 2 x answer in (a)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)	Amount of H_2 = 400 ÷ 24 000 = 0.016666 = 0.0167 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d)	Ratio mol Mg:HCl:H_2 = 0.0167 (0.165) : 0.0333 : 0.0167 = 1:2:1 Allow answers in which the mole ratios of the reactant and products are compared separately	Just stating the molar ratio	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (e)	M_r ($MgCl_2$) = 24 + 2 x 35.5 = 95 **(1)** Mol $MgCl_2$ = (mol Mg) = 0.0166666 (or 0.0167) **(1)** Mass $MgCl_2$ = 95 x 0.0166666 = 1.58 (g) **3 sf (1)** Or 95 x 0.0167 = 1.59 (g) 3sf Or 95.3 x 0.0166666 = 1.59 Or 95 x 0.0165 = 1.58 Or 95.3 x 0.0165 = 1.57 Correct answer with no working scores **(3)** TE on 17(a)		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (i)	Product in box: $CuSO_4$**(<u>aq</u>) (1)** **Either** Mark the arrows and then the labels: Two downward arrows **(1)** labelled with symbols or values with or without units **(1)** **OR** Mark each arrow and label separately Downward arrow & ΔH_1 or value **(1)** Downward arrow & ΔH_2 or value **(1)** Allow reversed arrows **with** reversed signs on ΔH Ignore any other labels on the arrows. Ignore $5H_2O$ in bottom product 		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	**Award higher mark from:** **Route 1** **Mark the calculation based on their cycle** TE from (a)(i) ignoring incorrect bottom product **Route 2** **Mark a calculation which is independent of the cycle** $\triangle H_{reaction} = \triangle H_1 - \triangle H_2$ stated or implied $= +11.5 - (-66.1)$ **(1)** $= (+)\ 77.6\ (kJ\ mol^{-1})$ **(1)** Correct answer alone scores **(2)** **−**77.6 (kJ mol^{-1}) alone or from a correct addition scores **(1)**		**2**

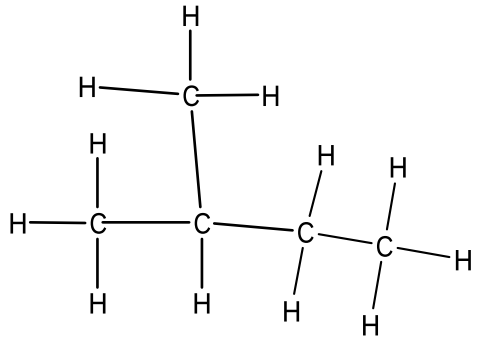
Question Number	Acceptable Answers	Reject	Mark
18 (b)	Dehydration reaction cannot be controlled OR temperature change (of dehydration reaction) cannot be measured OR $CuSO_4.5H_2O$ would need heating (so temperature change cannot be measured) OR impossible to add exact amount of water (to obtain value by reverse process) OR cannot mix solid with water to obtain perfect crystals	Temperature of solid / crystals cannot be measured	**1**

Question Number	Acceptable Answers	Reject	Mark
***18 (c)(i)**	First & second marks stand alone 1. Pipette/burette / measuring cylinder / balance to transfer (a known amount of) (water) **(1)** 2. to (expanded) polystyrene cup / calorimeter / any *insulated* container allow coffee / plastic cup **(1)** Third & fourth marks only awarded if correct chemicals **and** procedure used 3. add solid and **stir** (allow mix or shake) mixture **(1)** 4. measure initial **and** final temperature allow temperature change **(1)**	Just mass / volume measured Temperature **increase** unless exothermic penalised in (b)	**4**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Any three from: • heat transfer (from surroundings) (allow loss or gain) • approximation in (specific) heat capacity of solution • neglecting (specific) heat capacity of calorimeter/apparatus (allow energy absorbed by the apparatus) • reaction / dissolving may be incomplete/slow • temperature change is very small (and difficult to measure) • Density of solution is taken as the same as water • conditions not standard (allow)	Errors in calculation including adding mass of solid to mass of water loss of reagents / water incomplete combustion Just 'difficult to measure'	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	C_nH_{2n+2} or any symbol in place of n Ignore C_5H_{12}		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	(structural / chain) isomers		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	 (any orientation of this structure) Ignore non-displayed formulae	Structures in which **any** bonds or atoms are omitted Structures with CH_3 groups	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iv)	2,2-dimethylpropane **(1)** Allow dimethylpropane, 2-dimethylpropane 2,2 dimethylpropane, 2 dimethylpropane Ignore hyphens, commas, spaces		**1**

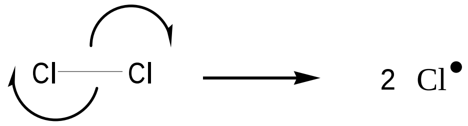
Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	$CH_4 + 1\frac{1}{2}O_2 \rightarrow CO + 2H_2O$ Formulae **(1)** balance **(1)** Or multiples Ignore state symbols No TE on **any** other species		**2**

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) CO_2 in the atmosphere / CO_2 is a greenhouse gas **(1)** Traps the heat **from the earth** / IR radiation (re-radiating) **from the earth (1)** If reference to damage to ozone layer then max **(2)** Photochemical smog is formed **(0)** NO_x is produced (by reaction of nitrogen & oxygen) **(1)** and reacts with (volatile) organic compounds in sunlight **(1)** Ignore references to increase in (of concentration) of H_2O in the atmosphere Ignore references to the effects of climate change	(heat) from the sun Global dimming due to complete combustion of hydrocarbon fuels Effects (e.g. reactions of unburned hydrocarbons) due to *incomplete* combustion	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	The arrows show the movement of electrons **(1)** Single-headed/I denotes 1 electron and Double-headed/II denotes a pair of / 2 electrons /allow lone pair **(1)** Allow Explanations just in terms of electron movement in bond fission	Just stating homolytic and heterolytic fission	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	 Equation **(1)** two arrows correctly showing a homolytic fission **(1)** Here and in subsequent mechanisms the covalent bonds may be shown as lines or electron pairs or both The mechanism arrows may be shown on the same side or on different sides of the bond The single electrons need not be shown		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iii)	$CH_4 + Cl^{\bullet} \rightarrow CH_3^{\bullet} + HCl$ **(1)** $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ **(1)** Ignore state symbols and curly arrows. Ignore order of equations so these marks may be scored if an initiation step with fission of C – H bond in methane is given in c(ii)		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iv)	Because a (chlorine) radical is regenerated / reformed / reproduced / recycled (by the propagation reactions each time a molecule of product is formed) **(1)** Allow methyl radical regenerated if initiation step with fission of C – H bond in methane is given in c(ii) and propagation order reversed Ignore references to chain reaction	radical is regenerated by UV light (chlorine) radical is a catalyst	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(v)	$CH_3^\bullet + CH_3^\bullet \rightarrow C_2H_6$ / $2CH_3^\bullet \rightarrow C_2H_6$ Ignore state symbols The single electrons need not be shown		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)	UV light does not have enough energy to (ALLOW 'cannot') break the C-H bond **(1)** So no H free radicals / atoms are formed (therefore cannot combine to form H_2) **(1)**	Just 'hydrogen' Just 'so no H_2 formed	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)	**(i) Structure** Lattice /close-packed **(1)** (or a diagram with at least 3 rows) positive ions or cations (allow metal ions) **(1)** delocalized electrons / sea of electrons **(1)** **(ii) Bonding** (Electrostatic) **attraction** between positive ions / cations (allow metal ions) and delocalized electrons / sea of electrons **(1)**	layers protons 'free' electrons	**4**

Question Number	Acceptable Answers	Reject	Mark
20 (b)	Any three from 1. Magnesium ion / Mg^{2+} (allow magnesium) has a larger charge (density) than the sodium ion (allow sodium) / Na^+ some comparison of the ions is required **(1)** 2. magnesium ions / Mg^{2+} smaller than sodium ions **(1)** 3. Magnesium / Mg^{2+} contributes two / more electrons (per atom) to the "sea" of electrons **(1)** 4. magnesium ions / Mg^{2+} have greater attraction for the delocalized "sea" of electrons **(1)** Ignore reference to number of outer electrons in Mg / Na Any references to the bonding being ionic, covalent or intermolecular (max 2) Reverse argument can gain full marks	Just Mg^{2+} and Na^+ More bonds	**3**

Question Number	Acceptable Answers	Reject	Mark
20 (c)	The delocalized electrons / sea of electrons **(1)** Flow (allow move / free to move) **(1)** (When a potential difference/voltage is applied) 'Carry the current' is not sufficient for the mark	'free' electrons	**2**

TOTAL FOR SECTION B = 60 MARKS

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Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Monday 23 May 2011 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

P38433A

7/7/5/2/

P 3 8 4 3 3 A 0 1 2 4

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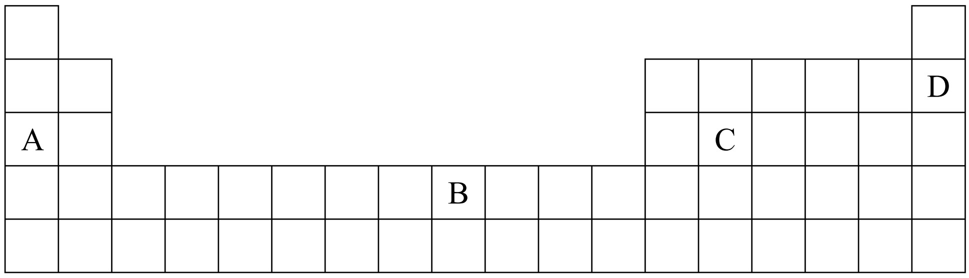
SECTION A

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

1 In the following outline of the Periodic Table, the letters A to D are **not** the symbols of the elements.



Select from **A to D** the element which

(a) is a non-metal with a high melting temperature and boiling temperature.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) is in the d block of the Periodic Table.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) has a very stable electronic structure.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(d) is a metal with a high melting temperature and boiling temperature.

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 1 = 4 marks)

2 The elements in Group 1 of the Periodic Table have very similar chemical properties. This is because

☒ **A** they have the same number of outer electrons.

☒ **B** they have the same number of filled shells of electrons.

☒ **C** their outer electrons are in the s sub-shell.

☒ **D** their outer electrons have very similar shielding.

(Total for Question 2 = 1 mark)

3 The European Union has set a limit (with effect from January 2010) of 3.13 ppm for the proportion of the toxic gas carbon monoxide in the air that we breathe. This is equivalent to

☒ **A** 3.13%

☒ **B** 0.0313%

☒ **C** 0.000313%

☒ **D** 0.00000313%

(Total for Question 3 = 1 mark)

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

☒ **A** 17.4 mol dm^{-3}

☒ **B** 1.74 mol dm^{-3}

☒ **C** 0.0174 mol dm^{-3}

☒ **D** 0.00174 mol dm^{-3}

(Total for Question 4 = 1 mark)

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

$$2CO(g) + 2NO(g) \rightarrow 2CO_2(g) + N_2(g)$$

In this reaction, when 500 cm^3 of CO reacts with 500 cm^3 of NO at 650 °C (the operating temperature of the catalyst) and at 1 atm, the **total** volume of gases produced at the same temperature and pressure is

☒ **A** 500 cm^3

☒ **B** 750 cm^3

☒ **C** 1000 cm^3

☒ **D** impossible to calculate without knowing the molar volume of gases under these conditions.

(Total for Question 5 = 1 mark)

6 When a solution of barium chloride is added to sulfuric acid, a white precipitate is formed. The ionic equation (including state symbols) for this reaction is

☒ **A** $H^+(aq) + Cl^-(aq) \rightarrow HCl(s)$

☒ **B** $Ba^+(aq) + SO_4^-(aq) \rightarrow BaSO_4(s)$

☒ **C** $Ba^{2+}(aq) + 2SO_4^-(aq) \rightarrow Ba(SO_4)_2(s)$

☒ **D** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

(Total for Question 6 = 1 mark)

7 The enthalpy change for the reaction between hydrochloric acid and sodium hydroxide is –56 kJ mol^{-1}. Therefore

☒ **A** the reaction is exothermic and the temperature rises.

☒ **B** the reaction is exothermic and the temperature falls.

☒ **C** the reaction is endothermic and the temperature rises.

☒ **D** the reaction is endothermic and the temperature falls.

(Total for Question 7 = 1 mark)

8 The standard enthalpy changes of formation of some sulfur species are:

Species	$\Delta H_f^{\ominus}$ / kJ mol^{-1}
$S_8(s)$	0
$S_8(g)$	+103
$S(g)$	+279

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

☒ **A** $103 \div 8$

☒ **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** $HI(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}I_2(s)$

☒ **B** $HI(g) \rightarrow \frac{1}{2}H_2(g) + \frac{1}{2}I_2(g)$

☒ **C** $HI(g) \rightarrow H(g) + I(g)$

☒ **D** $HI(g) \rightarrow H^+(g) + I^-(g)$

(Total for Question 9 = 1 mark)

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

10 The equation for the complete combustion of pentane is

$$C_5H_{12}(g) + 8O_2(g) \rightarrow 5CO_2(g) + 6H_2O(l) \qquad \Delta H_c^{\ominus} = -3509 \text{ kJ mol}^{-1}$$

The standard enthalpy change of formation of $CO_2(g)$ is –394 kJ mol^{-1} and that of $H_2O(l)$ is –286 kJ mol^{-1}.

The standard enthalpy change of formation of pentane (in kJ mol^{-1}) is

☒ **A** 5(–394) + 6(–286) + (–3509)

☒ **B** 5(–394) + 6(–286) – (–3509)

☒ **C** –5(–394) – 6(–286) + (–3509)

☒ **D** –5(–394) – 6(–286) – (–3509)

(Total for Question 10 = 1 mark)

11 All alkenes have

☒ **A** the same empirical formula and the same general formula.

☒ **B** the same molecular formula and the same general formula.

☒ **C** the same molecular formula and the same empirical formula.

☒ **D** the same empirical formula and the same structural formula.

(Total for Question 11 = 1 mark)

12 Covalent bonding results from the strong electrostatic attractions between

☒ **A** instantaneous dipoles.

☒ **B** electron clouds.

☒ **C** electrons in the bonding pair.

☒ **D** bonding pairs of electrons and nuclei.

(Total for Question 12 = 1 mark)

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

13 This question concerns the reaction of hydrogen bromide with propene.

(a) This reaction requires

(1)

☒ **A** normal laboratory conditions.

☒ **B** the presence of UV light.

☒ **C** the presence of a suitable catalyst.

☒ **D** heating under reflux.

(b) The reaction is best described as

(1)

☒ **A** nucleophilic substitution.

☒ **B** electrophilic substitution.

☒ **C** nucleophilic addition.

☒ **D** electrophilic addition.

(c) The major product of the reaction will be

(1)

☒ **A** 1-bromopropane

☒ **B** 2-bromopropane

☒ **C** 1,2-dibromopropane

☒ **D** 2-bromopropene

(Total for Question 13 = 3 marks)

---

14 Many organic compounds have toxic vapours. For this reason

☒ **A** a naked flame should never be used when carrying out experiments with organic compounds.

☒ **B** gloves should usually be worn when carrying out experiments with organic compounds.

☒ **C** a fume cupboard should be used wherever possible when carrying out experiments with organic compounds.

☒ **D** most experiments with organic compounds are banned in schools and colleges.

(Total for Question 14 = 1 mark)

15 Ethanol (molar mass 46 g mol^{-1}) is manufactured by the hydration of ethene (molar mass 28 g mol^{-1}):

$$C_2H_4 + H_2O \rightarrow C_2H_5OH$$

In a typical process 28 tonnes of ethene produces 43.7 tonnes of ethanol. The percentage yield of ethanol in this process is

☒ **A** 64%

☒ **B** 95%

☒ **C** 100%

☒ **D** 156%

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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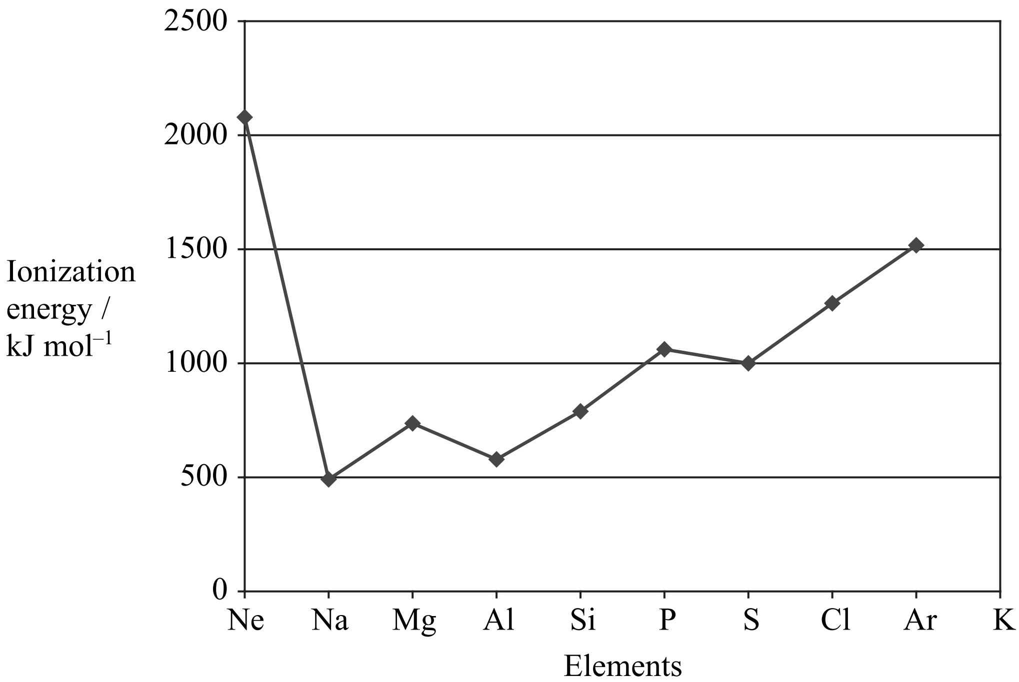
SECTION B

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

16 The first ionization energy of each of the elements from neon to argon is shown on the graph below. The first ionization energy of potassium has been omitted.



(a) Define the term **first ionization energy**.

(3)

....

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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)

....

....

....

....

....

....

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

(2)

....

....

....

....

(d) Estimate the value of the first ionization energy of potassium, K, and write your answer below.

(1)

.... kJ mol^{-1}

(Total for Question 16 = 9 marks)

17 0.400 g of magnesium ribbon reacted with exactly 22.2 cm^3 of hydrochloric acid of concentration 1.50 mol dm^{-3}.

400 cm^3 of hydrogen gas was formed, the volume being measured at room temperature and pressure.

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

$$Mg = 24.0\ g\,mol^{-1}$$
$$Cl = 35.5\ g\,mol^{-1}$$

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

(1)

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

(1)

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

[Molar volume of any gas at room temperature and pressure = 24 000 $cm^3\ mol^{-1}$]

(1)

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

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

(1)

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

(3)

(Total for Question 17 = 7 marks)

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

$$\underset{\text{blue}}{CuSO_4.5H_2O(s)} + aq \rightarrow CuSO_4(aq) \qquad \Delta H_1 = +11.5 \text{ kJ mol}^{-1}$$

$$\underset{\text{white}}{CuSO_4(s)} + aq \rightarrow CuSO_4(aq) \qquad \Delta H_2 = -66.1 \text{ kJ mol}^{-1}$$

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

(3)

$$CuSO_4.5H_2O(s) \xrightarrow{\Delta H_{reaction}} CuSO_4(s) + 5H_2O(l)$$

$$\boxed{}$$

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

(2)

(b) Suggest why it is not possible to directly measure the enthalpy change for the conversion of the blue hydrated copper(II) sulfate crystals into the white anhydrous crystals.

(1)

....

....

....

....

*(c) (i) $CuSO_4.5H_2O(s) + aq \rightarrow CuSO_4(aq)$ $\Delta H_1 = +11.5 \text{ kJ mol}^{-1}$

Describe briefly the experimental procedure that **you** would use to obtain the data necessary to calculate ΔH_1, given a known mass of hydrated copper(II) sulfate crystals, $CuSO_4.5H_2O(s)$.

You should state the apparatus that you would use and any measurements that you would make.

You are **not** required to calculate the amounts of substances or to explain how you would use the data obtained.

(4)

....

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(ii) The value for the enthalpy change from (c)(i) obtained by experiments in a school laboratory is likely to be significantly different from a data book value.

List **three** possible reasons for this which do **not** relate to the quality of the apparatus or chemicals used or possible mistakes in carrying out the procedure.

(3)

1 ....

....

2 ....

....

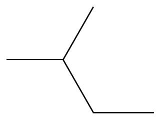
3 ....

....

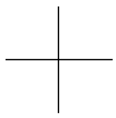
(Total for Question 18 = 13 marks)

19 This question is about alkanes.

(a) The skeletal formulae of two alkanes (**A** and **B**) are shown below.



A



B

(i) Write the general formula of the alkanes.

(1)

(ii) Compounds **A** and **B** are .... of each other.

(1)

(iii) Draw the displayed formula of compound **A**.

(1)

(iv) Give the systematic name of compound **B**.

(1)

....

P 3 8 4 3 3 A 0 1 6 2 4

(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)

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(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)

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(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)

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(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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The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1.0
H
hydrogen
1

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
																	4.0 **He** helium 2
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

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Mark Scheme (Results)

June 2011

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

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June 2011
Publications Code US027559

General Marking Guidance

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

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:

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

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.

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

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

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

Quality of Written Communication

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

- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear

- select and use a form and style of writing appropriate to purpose and to complex subject matter

- organise information clearly and coherently, using specialist vocabulary when appropriate.

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

Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Question Number	Correct Answer	Mark
13 (a)	A	**1**

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

Question Number	Correct Answer	Mark
13 (c)	B	**1**

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

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

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
16 (a)	**First mark** The energy (allow enthalpy / heat) required (allow change) per mole **(1)** **Second mark** to form (gaseous) singly charged positive ions Or to remove (1 mole of) electrons **(1)** **Third mark** from **gaseous** atoms (of the element) **(1)** $X(g) \longrightarrow X^{+}(g) + e^{(-)}$ scores last 2 marks Ignore standard conditions Per mole scores at any point	Energy / enthalpy produced Just gaseous element	**3**

Question Number	Acceptable Answers	Reject	Mark
16 (b)	Nuclear charge / effective nuclear charge / number of protons / atomic number increases **(1)** **Two of** (Outer) electrons in the **same** (quantum) shell / **same** number of electron shells **(1)** Shielding (of nucleus)(about) the same **(1)** Distance from nucleus/atomic radius less **(1)**	charge density orbitals, sub-shell	**3**

Question Number	Acceptable Answers	Reject	Mark
16 (c)	**Route 1** Electrons (in the p sub-shell) are **paired** (for the first time) (in S) / two electrons occupy the same (p) orbital / full orbital / electrons-in-boxes diagram **(1)** **repulsion** between the (paired) electrons (reduces IE) **(1)** **Route 2** P has a half-filled p sub-shell / half-filled p orbitals which is stable **(1)** (on ionization) S gains a half-filled p sub-shell / half-filled p orbitals **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
16 (d)	200 – 490 (kJ mol^{-1})	Negative values	**1**

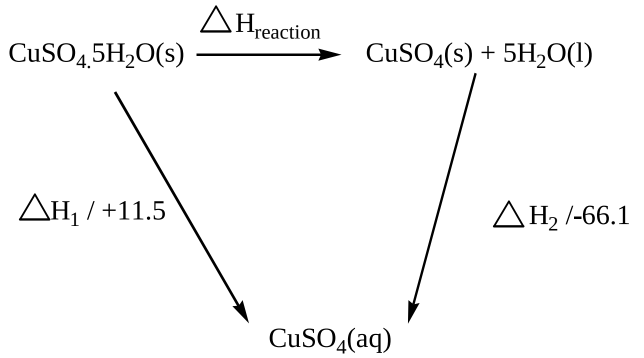
Question Number	Acceptable Answers	Reject	Mark
17 (a)	Do not penalize the use of A_r (Mg) = 24.3 at any stage in this question. Penalize SF errors (1 SF, incorrect SF (eg. 0.02) and incorrect rounding to 2 SF (e.g. 0.016)) only once in parts (a – d) Allow 0.0166 Allow fractions (e.g. 1/60) Amount Mg = (0.4 ÷ 24) = 0.016666 = 0.0167 (mol) Allow Amount Mg = (0.4 ÷ 24.3) = 0.016461 = 0.0165 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)	Amount HCl = 1.5 x 22.2/1000 = 0.033333 = 0.0333 (mol) Allow Amount HCl = 2 x answer in (a)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (c)	Amount of H_2 = 400 ÷ 24 000 = 0.016666 = 0.0167 (mol)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (d)	Ratio mol Mg:HCl:H_2 = 0.0167 (0.165) : 0.0333 : 0.0167 = 1:2:1 Allow answers in which the mole ratios of the reactant and products are compared separately	Just stating the molar ratio	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (e)	M_r ($MgCl_2$) = 24 + 2 x 35.5 = 95 **(1)** Mol $MgCl_2$ = (mol Mg) = 0.0166666 (or 0.0167) **(1)** Mass $MgCl_2$ = 95 x 0.0166666 = 1.58 (g) **3 sf (1)** Or 95 x 0.0167 = 1.59 (g) 3sf Or 95.3 x 0.0166666 = 1.59 Or 95 x 0.0165 = 1.58 Or 95.3 x 0.0165 = 1.57 Correct answer with no working scores **(3)** TE on 17(a)		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a) (i)	Product in box: $CuSO_4$**(<u>aq</u>) (1)** **Either** Mark the arrows and then the labels: Two downward arrows **(1)** labelled with symbols or values with or without units **(1)** **OR** Mark each arrow and label separately Downward arrow & ΔH_1 or value **(1)** Downward arrow & ΔH_2 or value **(1)** Allow reversed arrows **with** reversed signs on ΔH Ignore any other labels on the arrows. Ignore $5H_2O$ in bottom product 		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (a)(ii)	**Award higher mark from:** **Route 1** **Mark the calculation based on their cycle** TE from (a)(i) ignoring incorrect bottom product **Route 2** **Mark a calculation which is independent of the cycle** $\triangle H_{reaction} = \triangle H_1 - \triangle H_2$ stated or implied $= +11.5 - (-66.1)$ **(1)** $= (+)\ 77.6\ (kJ\ mol^{-1})$ **(1)** Correct answer alone scores **(2)** **−**77.6 (kJ mol^{-1}) alone or from a correct addition scores **(1)**		**2**

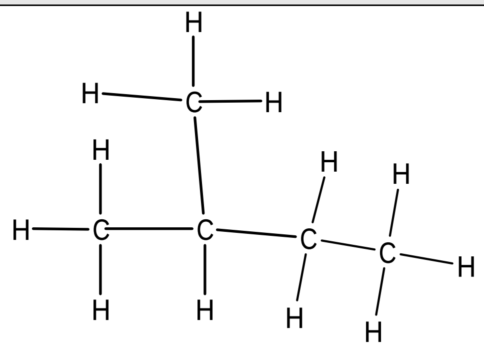
Question Number	Acceptable Answers	Reject	Mark
18 (b)	Dehydration reaction cannot be controlled OR temperature change (of dehydration reaction) cannot be measured OR $CuSO_4.5H_2O$ would need heating (so temperature change cannot be measured) OR impossible to add exact amount of water (to obtain value by reverse process) OR cannot mix solid with water to obtain perfect crystals	Temperature of solid / crystals cannot be measured	**1**

Question Number	Acceptable Answers	Reject	Mark
***18 (c)(i)**	First & second marks stand alone 1. Pipette/burette / measuring cylinder / balance to transfer (a known amount of) (water) **(1)** 2. to (expanded) polystyrene cup / calorimeter / any *insulated* container allow coffee / plastic cup **(1)** Third & fourth marks only awarded if correct chemicals **and** procedure used 3. add solid and **stir** (allow mix or shake) mixture **(1)** 4. measure initial **and** final temperature allow temperature change **(1)**	Just mass / volume measured Temperature **increase** unless exothermic penalised in (b)	**4**

Question Number	Acceptable Answers	Reject	Mark
18 (c)(ii)	Any three from: • heat transfer (from surroundings) (allow loss or gain) • approximation in (specific) heat capacity of solution • neglecting (specific) heat capacity of calorimeter/apparatus (allow energy absorbed by the apparatus) • reaction / dissolving may be incomplete/slow • temperature change is very small (and difficult to measure) • Density of solution is taken as the same as water • conditions not standard (allow)	Errors in calculation including adding mass of solid to mass of water loss of reagents / water incomplete combustion Just 'difficult to measure'	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(i)	C_nH_{2n+2} or any symbol in place of n Ignore C_5H_{12}		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(ii)	(structural / chain) isomers		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iii)	 (any orientation of this structure) Ignore non-displayed formulae	Structures in which **any** bonds or atoms are omitted Structures with CH_3 groups	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (a)(iv)	2,2-dimethylpropane **(1)** Allow dimethylpropane, 2-dimethylpropane 2,2 dimethylpropane, 2 dimethylpropane Ignore hyphens, commas, spaces		**1**

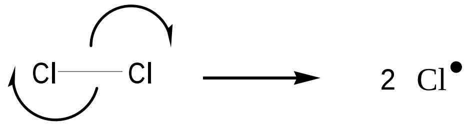
Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	$CH_4 + 1½O_2 \rightarrow CO + 2H_2O$ Formulae **(1)** balance **(1)** Or multiples Ignore state symbols No TE on **any** other species		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(ii)	Insufficient / not excess oxygen / air	Reactant does not react completely with oxygen Just 'methane in excess'	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (b)(iii)	**Any two from** **CO** is toxic / poisonous (allow harmful) **(1)** Less energy is produced (allow (methane) becomes a less efficient fuel) **(1)** Unburned hydrocarbons react to form compounds which are toxic / harmful **(1)** Allow sooty deposits / carbon / particulates in atmosphere (ignore reference to global dimming) **(1)** Unburned hydrocarbons are toxic / harmful **(1)** If reference to damage to ozone layer, global warming and / or acid rain then max **(1)**	Explosive Reactants wasted Air pollution	**2**

Question Number	Acceptable Answers	Reject	Mark
***19 (b)(iv)**	Global warming / climate change **(1)** Due to (increase in concentration of) CO_2 in the atmosphere / CO_2 is a greenhouse gas **(1)** Traps the heat **from the earth** / IR radiation (re-radiating) **from the earth (1)** If reference to damage to ozone layer then max **(2)** Photochemical smog is formed **(0)** NO_x is produced (by reaction of nitrogen & oxygen) **(1)** and reacts with (volatile) organic compounds in sunlight **(1)** Ignore references to increase in (of concentration) of H_2O in the atmosphere Ignore references to the effects of climate change	(heat) from the sun Global dimming due to complete combustion of hydrocarbon fuels Effects (e.g. reactions of unburned hydrocarbons) due to *incomplete* combustion	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	The arrows show the movement of electrons **(1)** Single-headed/I denotes 1 electron and Double-headed/II denotes a pair of / 2 electrons /allow lone pair **(1)** Allow Explanations just in terms of electron movement in bond fission	Just stating homolytic and heterolytic fission	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	 Equation **(1)** two arrows correctly showing a homolytic fission **(1)** Here and in subsequent mechanisms the covalent bonds may be shown as lines or electron pairs or both The mechanism arrows may be shown on the same side or on different sides of the bond The single electrons need not be shown		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iii)	$CH_4 + Cl^{\bullet} \rightarrow CH_3^{\bullet} + HCl$ **(1)** $CH_3^{\bullet} + Cl_2 \rightarrow CH_3Cl + Cl^{\bullet}$ **(1)** Ignore state symbols and curly arrows. Ignore order of equations so these marks may be scored if an initiation step with fission of C – H bond in methane is given in c(ii)		**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(iv)	Because a (chlorine) radical is regenerated / reformed / reproduced / recycled (by the propagation reactions each time a molecule of product is formed) **(1)** Allow methyl radical regenerated if initiation step with fission of C – H bond in methane is given in c(ii) and propagation order reversed Ignore references to chain reaction	radical is regenerated by UV light (chlorine) radical is a catalyst	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(v)	$CH_3^\bullet + CH_3^\bullet \rightarrow C_2H_6$ / $2CH_3^\bullet \rightarrow C_2H_6$ Ignore state symbols The single electrons need not be shown		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)	UV light does not have enough energy to (ALLOW 'cannot') break the C-H bond **(1)** So no H free radicals / atoms are formed (therefore cannot combine to form H_2) **(1)**	Just 'hydrogen' Just 'so no H_2 formed	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (a)	**(i) Structure** Lattice /close-packed **(1)** (or a diagram with at least 3 rows) positive ions or cations (allow metal ions) **(1)** delocalized electrons / sea of electrons **(1)** **(ii) Bonding** (Electrostatic) **attraction** between positive ions / cations (allow metal ions) and delocalized electrons / sea of electrons **(1)**	layers protons 'free' electrons	**4**

Question Number	Acceptable Answers	Reject	Mark
20 (b)	Any three from 1. Magnesium ion / Mg^{2+} (allow magnesium) has a larger charge (density) than the sodium ion (allow sodium) / Na^{+} some comparison of the ions is required **(1)** 2. magnesium ions / Mg^{2+} smaller than sodium ions **(1)** 3. Magnesium / Mg^{2+} contributes two / more electrons (per atom) to the "sea" of electrons **(1)** 4. magnesium ions / Mg^{2+} have greater attraction for the delocalized "sea" of electrons **(1)** Ignore reference to number of outer electrons in Mg / Na Any references to the bonding being ionic, covalent or intermolecular (max 2) Reverse argument can gain full marks	Just Mg^{2+} and Na^{+} More bonds	**3**

Question Number	Acceptable Answers	Reject	Mark
20 (c)	The delocalized electrons / sea of electrons **(1)** Flow (allow move / free to move) **(1)** (When a potential difference/voltage is applied) 'Carry the current' is not sufficient for the mark	'free' electrons	**2**

TOTAL FOR SECTION B = 60 MARKS

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Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Tuesday 15 May 2012 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

P39306A

7/7/5/5/5/

P 3 9 3 0 6 A 0 1 2 4

PEARSON

SECTION A

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

1 A solution contains 66 ppm of a solute. The mass of the solute dissolved in 1 kg of this solution is

☐ **A** 66 g

☐ **B** 0.66 g

☐ **C** 0.066 g

☐ **D** 0.000066 g

(Total for Question 1 = 1 mark)

---

2 Complete combustion of 50 cm^3 of a hydrocarbon vapour gave 350 cm^3 of carbon dioxide, both gas volumes being measured at the same temperature and pressure. The formula of the hydrocarbon could be

☐ **A** C_8H_{18}

☐ **B** C_7H_{16}

☐ **C** C_6H_{14}

☐ **D** C_5H_{12}

(Total for Question 2 = 1 mark)

---

3 Which of the following statements is true? The Avogadro constant is the number of

☐ **A** grams of any element which contains 6.02×10^{23} atoms of that element.

☐ **B** atoms contained in one mole of any element.

☐ **C** atoms contained in one mole of any monatomic element.

☐ **D** particles (atoms, molecules or ions) required to make one gram of a substance.

(Total for Question 3 = 1 mark)

---

4 In an experiment to determine the enthalpy change of combustion of an alcohol, a spirit burner containing the alcohol was weighed, lit and placed under a copper can containing a known volume of water. The temperature rise of the water was measured and the burner re-weighed. The enthalpy change calculated from the results was much less exothermic than the value reported in the literature.

Which of the following factors is **most** likely to be the cause of this error?

☒ **A** Heat loss around the side of the copper can.

☒ **B** The use of a thermometer with a range of 0 – 110 °C rather than 0 – 50 °C.

☒ **C** The use of a measuring cylinder for measuring the water rather than a pipette.

☒ **D** Evaporation of the alcohol during the weighing.

(Total for Question 4 = 1 mark)

---

5 The standard enthalpy changes of formation of carbon dioxide and of methanoic acid are −394 kJ mol^{-1} and −409 kJ mol^{-1} respectively. Calculate the enthalpy change for the reaction

$$H_2(g) + CO_2(g) \rightarrow HCOOH(l)$$

☒ **A** −803 kJ mol^{-1}

☒ **B** −15 kJ mol^{-1}

☒ **C** +803 kJ mol^{-1}

☒ **D** +15 kJ mol^{-1}

(Total for Question 5 = 1 mark)

---

6 For which of the following changes is the value of **Δ*H*** negative?

☒ **A** $K(g) \rightarrow K^+(g) + e^-$

☒ **B** $K^+Cl^-(s) \rightarrow K^+(g) + Cl^-(g)$

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

☒ **D** $Cl_2(g) \rightarrow 2Cl(g)$

(Total for Question 6 = 1 mark)

7 In which of the following cases would a cation be most polarizing?

	Radius	Charge
☒ **A**	small	small
☒ **B**	small	large
☒ **C**	large	small
☒ **D**	large	large

(Total for Question 7 = 1 mark)

8 Magnesium chloride, $MgCl_2$, has two lattice energy values quoted in the data booklet. The first is the experimental value, obtained from the Born-Haber cycle, -2526 kJ mol^{-1}; the second is the theoretical value, -2326 kJ mol^{-1}. Why are the two values different?

☒ **A** The cation polarizes the anion leading to some covalent bonding.

☒ **B** The anion polarizes the cation leading to some covalent bonding.

☒ **C** Magnesium chloride is a covalent substance.

☒ **D** The results from the Born-Haber cycle are too inaccurate to be reliable.

(Total for Question 8 = 1 mark)

9 Which of the following represents the process occurring when the enthalpy change of atomization of bromine is measured?

☒ **A** $\frac{1}{2}Br_2(l) \rightarrow Br(g)$

☒ **B** $\frac{1}{2}Br_2(g) \rightarrow Br(g)$

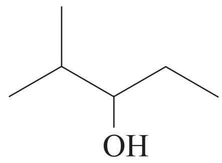
☒ **C** $Br_2(l) \rightarrow Br^+(g) + Br^-(g)$

☒ **D** $Br_2(g) \rightarrow Br^+(g) + Br^-(g)$

(Total for Question 9 = 1 mark)

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

10 An organic compound is represented by the skeletal formula shown below.



The compound is

☒ **A** $CH_3CH_2CH_2CH(OH)CH_2CH_3$

☒ **B** $(CH_3)_2CHC(OH)(CH_3)_2$

☒ **C** $(CH_3)_2CHCH_2CH(OH)CH_3$

☒ **D** $(CH_3)_2CHCH(OH)CH_2CH_3$

(Total for Question 10 = 1 mark)

---

11 How many structural isomers does the alkane C_5H_{12} have?

☒ **A** 4

☒ **B** 3

☒ **C** 2

☒ **D** 1

(Total for Question 11 = 1 mark)

---

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

☒ **A** C_2H_6

☒ **B** CH_3Cl

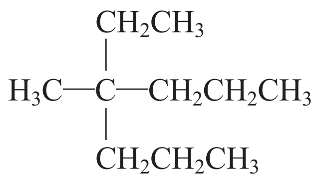
☒ **C** HCl

☒ **D** $CHCl_3$

(Total for Question 12 = 1 mark)

---

13 What is the IUPAC name of the compound shown below?



- ☒ **A** 2-ethyl-2-propylpentane
- ☒ **B** 3-methyl-3-propylhexane
- ☒ **C** 4-methyl-4-propylhexane
- ☒ **D** 4-ethyl-4-methylheptane

(Total for Question 13 = 1 mark)

---

14 The reaction of bromine with propene is an example of

- ☒ **A** electrophilic substitution.
- ☒ **B** free radical substitution.
- ☒ **C** electrophilic addition.
- ☒ **D** free radical addition.

(Total for Question 14 = 1 mark)

---

15 A compound **Z** contains, by mass, 26.7% carbon, 2.2% hydrogen, and 71.1% oxygen.
The empirical formula of **Z** is

- ☒ **A** CHO_2
- ☒ **B** $C_2H_2O_4$
- ☒ **C** CHO
- ☒ **D** $C_2H_2O_2$

(Total for Question 15 = 1 mark)

---

16 In which of the following series does the melting temperature of the element **increase** from left to right?

☒ **A** Li, Na, K

☒ **B** Al, Si, P

☒ **C** Si, P, S

☒ **D** Na, Mg, Al

(Total for Question 16 = 1 mark)

---

17 If **X** represents the element of atomic number 9 and **Y** the element of atomic number 20, the compound formed between these two elements is

☒ **A** covalent, $\mathbf{YX_2}$.

☒ **B** ionic, $\mathbf{YX_2}$.

☒ **C** covalent, **YX**.

☒ **D** ionic, **YX**.

(Total for Question 17 = 1 mark)

---

18 The equation representing the reaction between copper(II) oxide and dilute sulfuric acid is

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

The **ionic** equation for the reaction is

☒ **A** $Cu^{2+}(s) + SO_4^{2-}(aq) \rightarrow CuSO_4(aq)$

☒ **B** $O^{2-}(s) + H_2SO_4(aq) \rightarrow H_2O(l) + SO_4^{2-}(aq)$

☒ **C** $CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$

☒ **D** $CuO(s) + H_2SO_4(aq) \rightarrow Cu^{2+}SO_4^{2-}(aq) + H_2O(l)$

(Total for Question 18 = 1 mark)

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

	1*s*	2*s*	2*p*		
☒ **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?

	1*s*	2*s*	2*p*		
☒ **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)

....

....

....

....

(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)

....

....

....

*(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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....

....

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....

....

(c) The eleven successive ionization energies for sodium are given below.

Electron removed	1	2	3	4	5	6	7	8	9	10	11
Ionization energy / kJ mol^{-1}	496	4563	6913	9544	13352	16611	20115	24491	28934	141367	159079

(i) Explain why the successive ionization energies increase.

(1)

....

....

....

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

(2)

....

....

....

....

....

(d) The first ionization energy of aluminium (element 13) is lower than that of magnesium (element 12).

(i) Give the electronic structures of magnesium and of aluminium in *s*, *p* and *d* notation.

(1)

Magnesium ....

Aluminium ....

*(ii) Explain the difference in the first ionization energies of the two metals.

(1)

....

....

....

....

(Total for Question 22 = 9 marks)

23 (a) State Hess's Law.

(1)

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....

....

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

$$CH_4(g) + 1\tfrac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(l)$$

The enthalpy change for this reaction cannot be determined directly, but can be found using the standard enthalpy changes of combustion of methane and carbon monoxide, together with Hess's Law.

The standard enthalpy changes of combustion needed are for CH_4, −890 kJ mol^{-1}, and for CO, −283 kJ mol^{-1}.

(i) Draw a Hess's Law diagram which would enable you to calculate the enthalpy change for the combustion of methane to carbon monoxide.

$$CH_4(g) + 1\tfrac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(l)$$

(2)

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

(2)

(iii) Explain why the enthalpy change for this reaction cannot be determined directly.

(1)

....

....

....

(c) Explain why the calculation in part (b)(ii) would give an incorrect result for the enthalpy change for the reaction below.

$$CH_4(g) + 1\tfrac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(g)$$

(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)

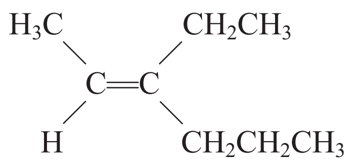
....

....

....

....

(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, $CH_2{=}CH_2$, with

(i) hydrogen.

(1)

(ii) chlorine.

(1)

(iii) acidified aqueous potassium manganate(VII).

(1)

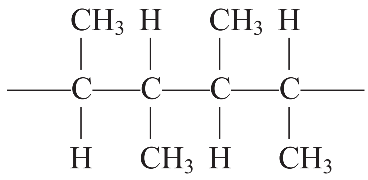
(iv) bromine **water**.

(1)

(e) Draw the mechanism for the reaction of **propene** with hydrogen bromide to give the major product.

(4)

(f) The structure below shows **two** repeat units of a polymer.



(i) Give the displayed formulae of **two** isomeric alkenes, either of which could have given rise to this polymer.

(2)

(ii) State why the empirical formula of a poly(alkene) is the same as that of the monomer from which it is produced.

(1)

(iii) State, with a reason, the atom economy for the production of a poly(alkene) from an alkene.

(1)

(Total for Question 24 = 17 marks)

25 Sodium burns in oxygen to give a pale yellow solid **X**.

(a) (i) 1.73 g of sodium reacts with 1.20 g of oxygen.

Calculate the empirical formula of **X**.

(2)

(ii) The molar mass of **X** is 78 g mol^{-1}. Give the molecular formula of **X**.

(1)

....

(iii) Write the equation, including state symbols, for the reaction of sodium with oxygen to produce **X**.

(2)

(iv) Calculate the volume of oxygen in dm^3 (at room temperature and pressure) which reacts with 1.73 g of sodium. (The molar volume of any gas at room temperature and pressure is 24 dm^3 mol^{-1}.)

(2)

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

(1)

(b) If sodium is burnt in **air**, compound **X** is not the only product. Suggest why this is so.

(1)

....

....

....

(Total for Question 25 = 9 marks)

26 (a) Explain how the atoms are held together by the covalent bond in a molecule of hydrogen.

(1)

....

....

....

(b) Draw the dot and cross diagrams for

(i) methane, CH_4

(1)

(ii) ethene, $CH_2{=}CH_2$

(1)

(iii) nitrogen, N_2

(1)

(iv) the ammonium ion, NH_4^+

(1)

(c) Silicon exists in a giant covalent lattice.

(i) The electrical conductivity of pure silicon is very low. Explain why this is so in terms of the bonding.

(2)

....

....

....

....

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

(2)

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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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The Periodic Table of Elements

Key

relative atomic mass **atomic symbol** name atomic (proton) number

1 (1)	2 (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	3 (13)	4 (14)	5 (15)	6 (16)	7 (17)	0 (8) (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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

Mark Scheme (Results)

Summer 2012

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

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Summer 2012
Publications Code US031856

General Marking Guidance

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

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

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

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

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

Quality of Written Communication

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

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

Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)	**First mark:** Mass of **an atom**/mass of **an isotope** (of an element) **(1)** IGNORE any references to average or (weighted) mean **Second mark:** relative to 1/12th the mass of a ^{12}C atom **(1)** NOTE: The second mark is awarded for **any mention of ^{12}C** IGNORE throughout the candidate's answer any references to 'moles' or '1 mol' or '12 g' Mark the two points independently	Mass of (all the) isotope**s** /atom**s** 'Mass of an element'	2

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	{(35 x 75.53) + (37 x 24.47)} ÷ 100 **(1)** = 35.4894 = 35.49 **(1)** **Answer to 4 s.f. only**. Correct answer no working **(2)** IGNORE units of any kind (e.g. 'g' 'g mol^{-1}' 'amu', etc.)		2

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$^{35}Cl_2^+$/(^{35}Cl —$^{35}Cl)^+$ **(1)** $^{37}Cl_2^+$/(^{37}Cl —$^{37}Cl)^+$ **(1)** ALLOW (^{35}Cl + $^{35}Cl)^+$ and/or (^{37}Cl + $^{37}Cl)^+$ OR ($^{35}Cl^{35}Cl)^+$ and/or ($^{37}Cl^{37}Cl)^+$ OR (^{35}Cl and $^{35}Cl)^+$ and/or (^{37}Cl and $^{37}Cl)^+$ If the 'formal' charge is omitted on either ion (or both the ions), then award **(1)** mark only. NOTE: $^{35}Cl^+$ $^{35}Cl^+$ and $^{37}Cl^+$ $^{37}Cl^+$ scores **(1)** as each ion has an extra + charge. $2^{35}Cl^+$ and $2^{37}Cl^+$ scores **(1)** Accept mass number written as superscript to right of symbol.	$^{70}Cl_2^+$ $^{74}Cl_2^+$ $2^{35}Cl$ and/or $2^{37}Cl$ scores **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	**72** **(1)** ^{35}Cl —$^{37}Cl^{(+)}$ **(1)** ALLOW (^{35}Cl + $^{37}Cl)^{(+)}$ and/or (^{37}Cl + $^{35}Cl)^{(+)}$ OR ($^{37}Cl^{35}Cl)^{(+)}$ and/or ($^{37}Cl^{35}Cl)^{(+)}$ OR (^{35}Cl and $^{37}Cl)^{(+)}$ and/or (^{37}Cl and $^{35}Cl)^{(+)}$ NOTE: The + charge is not needed on **this ion** IGNORE extra + charges, so ALLOW $^{35}Cl^+$ $^{37}Cl^+$ and/or $^{37}Cl^+$ $^{35}Cl^+$		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)	**First mark:-** Makes mention of energy/enthalpy/(heat) energy/heat (change) AND to remove an electron AND one mole/1 mol **Second mark:** Makes mention of **gaseous atom(s)** **ALTERNATIVE ANSWER** Energy change per mole for **(1)** $X(g) \rightarrow X^{+}(g) + e^{(-)}$ **(1)** Mark the two points independently IGNORE any references to standard conditions	"Energy **given out**…" for first mark **Just** 'gaseous element'/ 'gaseous substance'	**2**

Question Number	Acceptable Answers	Reject	Mark
***22(b)**	**Any two from three:-** (Atomic) radius increases/there are more shells/(outermost) electron further from the nucleus **(1)** there is '**more** shielding' or '**more** screening' (down group) **(1)** the nuclear attraction decreases OR attraction between nucleus and (outermost) electron decreases OR the increased shielding/increased distance outweighs the increased nuclear charge **(1)** IGNORE any references to 'more protons' and/just 'increasing nuclear charge' IGNORE references to "effective nuclear charge"	**Ionic** radius increases	**2**

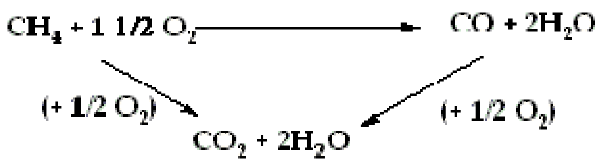
Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	**Any ONE from:** (Electrons are being removed from an) increasingly positive ion/ charge on the ion (successively) increases/ increasing proton : electron ratio/ same number of protons (attracting) fewer electrons / ions get smaller/ the electron repulsion decreases/ the shielding decreases/ electrons (being removed are) closer to the nucleus/ **effective** nuclear charge increases		**1**

Question Number	Acceptable Answers	Reject	Mark
***22(c)(ii)**	**First mark: <u>Two</u> jumps** **Two** (large) jumps (between 1st and 2nd and 9th and 10th IEs) **(1)** NOTE: A sketch graph with **two** (large) jumps can score this first mark Note if the jumps are specified, they must be between 1st and 2nd **and** 9th and 10th IEs **Second mark: Electronic configuration of Na** 2, 8, 1 mentioned in words, **annotated** on a sketch graph or drawn out in a diagram (e.g. electrons shown in orbits/shells around the centre of the atom) but NOT just inferred **(1)** ALLOW "1, 8, 2" OR $1s^2 2s^2 2p^6 3s^1$ Mark the two points independently	1st mark if the graph is sketched 'back to front'	**2**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	Credit any of the following representations (but need **BOTH** Mg **AND** Al to be correct) Mg $1s^2 2s^2 2p^6 3s^2$ **and** Al $1s^2 2s^2 2p^6 3s^2 3p^1$ Mg $1s_2 2s_2 2p_6 3s_2$ **and** Al $1s_2 2s_2 2p_6 3s_2 3p_1$ Mg $1S^2 2S^2 2P^6 3S^2$ **and** Al $1S^2 2S^2 2P^6 3S^2 3P^1$ Mg $1S_2 2S_2 2P_6 3S_2$ **and** Al $1S_2 2S_2 2P_6 3S_2 3P_1$		**1**

Question Number	Acceptable Answers	Reject	Mark
***22(d)(ii)**	NOTE: ALLOW an argument focusing on **either** the Al **or** the Mg atom **EITHER** **In Al**, (3p) **electron** (lost is) at higher energy/more shielded (by 3s electrons)/further from the nucleus IGNORE any reference to an unpaired electron in Al **OR** **In Mg**, (3s) **electron** (lost is) at lower energy/less shielded/ nearer to the nucleus/from a **full subshell**/from a full orbital/from (stable) (3)s^2 Any reference to an Al atom being **larger** in size than an Mg atom scores zero overall.	Al has one more **shell** than Mg **Just** (lost from) a new sub-shell Electron lost in Mg from a "full **shell**"	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)	The heat/enthalpy/energy change (for a reaction) is independent of the path(way)/route IGNORE any extra detail referring to "initial and final states"		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	 CO_2 + **2**H_2O **(1)** Both arrows in correct direction downwards **(1)** IGNORE state symbols, even if incorrect Mark the two points independently		**2**

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	$\Delta H = - 890 -(- 283)$ **(1)** $= - 607$ (kJ mol^{-1}) **(1)** Correct answer with no working scores **(2)** NOTE: **+**607 (kJ mol^{-1}) scores **(1)** only		**2**

Question Number	Acceptable Answers	Reject	Mark
***23 (b) (iii)**	Cannot stop the reaction at CO OR the reaction produces CO_2/complete combustion occurs OR may produce some carbon/soot OR cannot react exact amounts of methane to oxygen	non-standard conditions **Just** incomplete combustion occurs **Just** forming 'other products' /**just** a 'mixture of products' **Just** methane is 'very reactive'/ 'explosive' **Just** heat loss Cannot measure the temperature change	**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark: State of the H_2O** Water is in the gas phase/water is (formed) as steam/water is not in its standard state/water is not (formed as a) liquid **(1)** **Second mark: Idea of an energy change when there is a change of state** Change of state involves an energy change /energy change (for the reaction given) is less exothermic **(1)** ALLOW ‘more endothermic’ instead of ‘less exothermic’ IGNORE references to non-standard conditions	Energy change is more exothermic /less endothermic Heat loss ‘Incomplete combustion’	**2**

Question Number	Acceptable Answers	Reject	Mark
24(a)	C_nH_{2n} ALLOW letters other than *n*		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)	A compound which contains (C=C) double bonds OR A compound that will undergo addition reactions OR Does not contain the maximum number of hydrogen atoms		**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	*E*-3-ethylhex-2-ene **(2)** **(1)** mark for 3-ethylhex-2-ene **(1)** mark for '**E**' IGNORE any missing hyphens or any hyphens replaced by commas Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	The four atoms/four groups around the C=C double bond are different OR No two groups are the same OR There are no common groups on either side of the C=C double bond OR There are two alkyl groups on one of the carbon atoms (in the C=C double bond) OR There are three alkyl groups around the double bond OR An indication of the existence of Priority Rules (for E-Z nomenclature) OR One of the carbon atoms (of the C=C double bond) is not bonded to a hydrogen atom ALLOW ‘functional groups’ for ‘groups’	Each side is not symmetrical	**1**

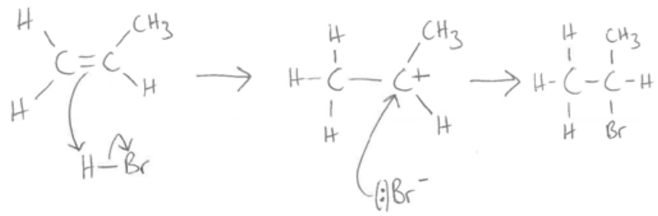
ALLOW displayed or skeletal formulae throughout 24(d)

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	CH_3CH_3 ALLOW displayed or skeletal formulae throughout 24(d)	C_2H_6	**1**

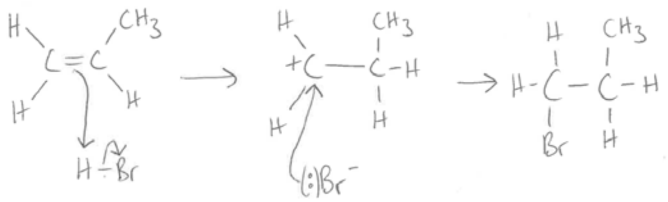
Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	$ClCH_2CH_2Cl$ / CH_2ClCH_2Cl	$C_2H_4Cl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	$HOCH_2CH_2OH$ / CH_2OHCH_2OH	$C_2H_6O_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iv)	$HOCH_2CH_2Br$ / CH_2OHCH_2Br	$BrCH_2CH_2Br$; C_2H_5OBr; $C_2H_4Br_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(e)	Major product route:  **First mark:** Curly arrow from C=C to the H (in H-Br) **AND** curly arrow from the bond in H—Br to the Br **(1)** **Second mark:** Structure of correct secondary carbocation **(1)** **Third mark:** Curly arrow from anywhere on the bromide ion towards the C+ on the carbocation **(1)** NOTE: The bromide ion must have a full negative charge, but the lone pair of electrons on the Br^- NEED NOT be shown **Fourth mark:** Choice of 2-bromopropane as major product **(1)** For showing the major product mechanism correctly **(4)** • both arrows **(1)** • carbocation intermediate **(1)** • attack by bromide ion **(1)** (Bromide ion must show a full negative charge. The lone pair of electrons need not be shown) • choice of 2-bromopropane as major product **(1)**		**4**

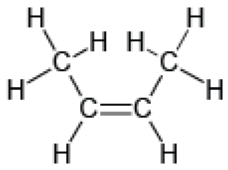
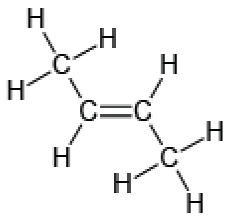
Single-headed arrows used throughout **max (3)**
Minor product route **max (3)**



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

- both arrows **(1)**
- carbocation intermediate **(1)**
- attack of bromide ion **(1)**
  (NOTE: The bromide ion must show a full negative charge. The lone pair of electrons need not be shown)

NOTE:
If a correct mechanism for the electrophilic addition of HBr to **ethene** is shown then max **(2)** (i.e. the first and the third marks in the mechanism)

Question Number	Acceptable Answers	Reject	Mark
24(f)(i)	 **(1)**  **(1)** NOTE: CH_3 group does not have to be displayed. IGNORE if any connectivity is shown from the $\mathbf{H_3}$ in a C$\mathbf{H_3}$ group IGNORE bond angles ALLOW one mark for just but-2-ene's structural formula		**2**

Question Number	Acceptable Answers	Reject	Mark
24(f)(ii)	**Any ONE of:-** • No atoms lost (or gained) • No elements lost (or gained) • (Only) one product (is formed) • (Produced by) an addition reaction • Addition polymer(ization) • Polymer is a repeat of the monomer • No small molecules (formed) • No co-products • No waste products • Same C:H ratio • Same ratio of carbon:hydrogen atoms • Same ratio of each element • Same ratio of atoms	(Monomer and polymer have) '**same number** of carbon and hydrogen atoms'	**1**

Question Number	Acceptable Answers	Reject	Mark
24(f)(iii)	**100% AND** some correct justification is needed **ONE answer from:-** 100% as addition reaction 100% because all the atoms are incorporated into the polymer 100% because (only) one product is formed 100% because (only) one desired product is formed 100% because no atoms are lost 100% because no waste products 100% because no small molecules (formed) 100% as no co-products 100% as no by-products	Statements such as 'the atom economy is **almost** 100%' OR **Just** "it has a high atom economy"	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	Amount Na = 1.73 (g) ÷ 23 (g mol^{-1}) = 0.075(22) (mol) Amount O = 1.20 (g) ÷ 16 (g mol^{-1}) = 0.075 (mol) **(1)** IGNORE sf, even if 1 sf NaO **(1)** Correct answer no working **(2)** NOTE: Correct answer can be obtained via incorrect working and all responses should be read carefully e.g. Amount Na = 23 ÷ 1.73 = 13.3 Amount O = 16 ÷ 1.20 = 13.3 scores second mark only for NaO if obtained by incorrect working OR e.g. Use of atomic numbers gives the Na : O ratio as 0.157 : 0.150 and an empirical formula of NaO. This scores (1) overall (i.e. the 2nd mark). OR e.g Use of atomic number ONLY for Na (i.e. Na = 11) gives the Na : O ratio as 0.157 : 0.075 and an empirical formula of Na_2O. This scores (1) overall (i.e. the 2nd mark). NOTE: Use of **O** = 32 gives Na_2O and scores second mark	 Na_2O_2	**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	(NaO = 39 hence molar mass twice that of NaO ∴) so $\mathbf{Na_2O_2}$	'2NaO'	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	$2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$ All species correct **(1)** State symbols and balancing **(1)** NOTE: 2nd mark is conditional on correct species. NOTE: $2Na(s) + O_2(g) \rightarrow 2NaO(s)$ scores **(1)** $Na(s) + O_2(g) \rightarrow NaO_2(s)$ scores **(1)** $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$ scores **(2)**		**2**

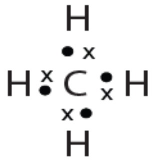
Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	Moles of O_2 = 0.075 ÷ 2 = 0.0375 OR 1.2 ÷ 32 = 0.0375 (mol) **(1)** 0.0375 mol x 24 dm^3 mol^{-1} = 0.9(0) (dm^3) **(1)** ALLOW 900 **cm^3 (units must be present here)** Correct answer no working **(2)** OR Moles of Na = 1.73 ÷ 23 = 0.075217 = moles of O Moles of O_2 = 0.075217 ÷ 2 = 0.0376085 0.0376085 x 24 = 0.903 (dm^3) or 903 **cm^3** IGNORE s.f., including ONE s.f. NOTE: If number of moles x 24 (dm^3 mol^{-1}) is clearly evident and correctly calculated in stated units, award second mark		**2**

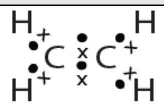
Question Number	Acceptable Answers	Reject	Mark
25(a)(v)	0.0375 x 6.02 x 10^{23} (= 2.2575 x 10^{22} (molecules)) = 2.26 x 10^{22} (molecules) IGNORE s.f. unless 1 s.f.		**1**

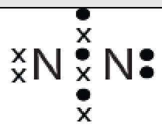
Question Number	Acceptable Answers	Reject	Mark
25(b)	Sodium might react with nitrogen in the air/sodium forms a nitride/ nitrogen (gas) is present in the air (which reacts with the sodium) OR sodium might form a different oxide (e.g. Na_2O or allow NaO_2) NOTE: If nitrogen / N_2 is mentioned as part of a 'list' of substances that can be present in air, award the mark	**Just** 'very reactive' OR 'very explosive' sodium forms Na_2O_2 alone References to hydrogen in the air **Just** 'reacts with other substances in the air' (as nitrogen not identified Sodium nitrate formation **Just** sodium hydroxide formation	**1**

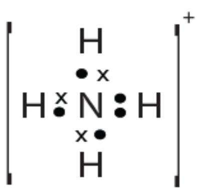
Question Number	Acceptable Answers	Reject	Mark
26(a)	(Electrostatic) attraction between (bonding) electrons and nuclei/protons	**Just** a 'shared pair of electrons'	**1**

- IGNORE ANY INNER SHELL ELECTRONS DRAWN
- ONLY THE TOTAL NUMBERS OF ELECTRONS IN OUTER SHELLS ARE BEING ASSESSED
- ALLOW ELECTRONS TO BE ALL DOTS OR ALL CROSSES OR BOTH

Question Number	Acceptable Answers	Reject	Mark
26(b)(i)			**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(ii)			**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(iii)	 NOTE: The lone pair of electrons on each N atom do not have to be shown as a pair		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(iv)	 The **+** sign can be shown anywhere Ignore missing brackets Ignore if the **+** is missing		**1**

Question Number	Acceptable Answers	Reject	Mark
26(c)(i)	IGNORE any references to 'molecules' in this part only **First mark: Location of silicon's electrons** Silicon's (outer) electrons are fixed (in covalent bonds)/ silicon's (outer) electrons are in fixed positions (in covalent bonds)/ silicon's (outer) electrons are involved in bonding **(1)** **Second mark: Lack of mobility of silicon's electrons** (therefore) silicon's electrons are not free (to move)/ silicon has no free electrons/ there are no mobile electrons in silicon/ silicon has no delocalized electrons/ silicon's electrons cannot flow **(1)** IGNORE references to **lack of** ions	'Silicon is ionic' scores **(0)** for the question 'silicon's **ions** are not free to move' scores **(0)** for the question	**2**

Question Number	Acceptable Answers	Reject	Mark
26(c)(ii)	(The covalent) bonds are **strong** (throughout the lattice) **(1)** (therefore) a lot of **energy** is required to break the bonds / a lot of **energy** is needed to overcome the attractions **(1)** IGNORE any references to 'giant molecular'	'(simple) molecular silicon' **(0)** /'molecules of silicon' **(0)** /'silicon has ions' **(0)** /'intermolecular forces' / 'van der Waals' forces'/ 'London forces' **(0)** ALL THE ABOVE SCORE **(0)** OVERALL	**2**

TOTAL FOR SECTION B = 60 MARKS

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Centre Number	Candidate Number

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

7/6/5/5/4/5/

P 4 1 2 1 2 A 0 1 2 4

SECTION A

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

1 When aqueous solutions of barium chloride and potassium sulfate are mixed, a white precipitate forms. The ionic equation for the reaction is

☐ **A** $K^+(aq) + Cl^-(aq) \rightarrow KCl(s)$

☐ **B** $K^{2+}(aq) + 2Cl^-(aq) \rightarrow KCl_2(s)$

☐ **C** $Ba^+(aq) + SO_4^-(aq) \rightarrow BaSO_4(s)$

☐ **D** $Ba^{2+}(aq) + SO_4^{2-}(aq) \rightarrow BaSO_4(s)$

(Total for Question 1 = 1 mark)

---

2 Which of the following processes has the highest atom economy?

☐ **A** Making poly(ethene) from ethene.

☐ **B** Making ethene from eicosane, $C_{20}H_{42}$.

☐ **C** Making chloromethane from methane.

☐ **D** Making magnesium chloride from magnesium and hydrochloric acid.

(Total for Question 2 = 1 mark)

---

3 How many molecules are present in 16 g of oxygen gas, $O_2(g)$?

[Avogadro constant = 6×10^{23} mol^{-1}]

☐ **A** 96×10^{23}

☐ **B** 12×10^{23}

☐ **C** 6×10^{23}

☐ **D** 3×10^{23}

(Total for Question 3 = 1 mark)

---

4 Nickel(II) sulfate is prepared by adding an excess of nickel(II) carbonate to 0.010 mol of dilute sulfuric acid.

$$NiCO_3(s) + H_2SO_4(aq) \rightarrow NiSO_4(aq) + H_2O(l) + CO_2(g)$$

Solid nickel(II) sulfate crystals are produced with a 20% yield. How many moles of nickel(II) sulfate crystals are obtained?

☒ **A** 0.001

☒ **B** 0.002

☒ **C** 0.010

☒ **D** 0.050

(Total for Question 4 = 1 mark)

---

5 When 0.635 g of copper (relative atomic mass, RAM = 63.5) is added to an excess of silver nitrate solution, 2.158 g of silver (RAM = 107.9) form. The ionic equation for the reaction is

☒ **A** $Cu(s) + Ag^{2+}(aq) \rightarrow Cu^{2+}(aq) + Ag(s)$

☒ **B** $Cu(s) + Ag^{+}(aq) \rightarrow Cu^{+}(aq) + Ag(s)$

☒ **C** $2Cu(s) + Ag^{2+}(aq) \rightarrow 2Cu^{+}(aq) + Ag(s)$

☒ **D** $Cu(s) + 2Ag^{+}(aq) \rightarrow Cu^{2+}(aq) + 2Ag(s)$

(Total for Question 5 = 1 mark)

---

6 In an experiment to measure the enthalpy change of a reaction involving gases, which of the following conditions must always be kept constant?

☒ **A** Pressure

☒ **B** Temperature

☒ **C** Volume

☒ **D** Temperature and pressure

(Total for Question 6 = 1 mark)

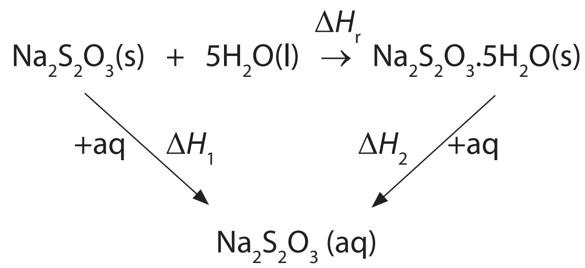
7 In an endothermic reaction in aqueous solution, which of the following is correct?

	Temperature	Sign of enthalpy change
☒ **A**	Increases	Positive
☒ **B**	Increases	Negative
☒ **C**	Decreases	Positive
☒ **D**	Decreases	Negative

(Total for Question 7 = 1 mark)

8 The enthalpy change for the reaction to form hydrated sodium thiosulfate crystals cannot be measured directly.

The following Hess cycle can be used.



The enthalpy change for the reaction, ΔH_r, is equal to

☒ **A** $\Delta H_1 + \Delta H_2$

☒ **B** $\Delta H_1 - \Delta H_2$

☒ **C** $-\Delta H_1 - \Delta H_2$

☒ **D** $-\Delta H_1 + \Delta H_2$

(Total for Question 8 = 1 mark)

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

9 When 10 cm^3 of 2 mol dm^{-3} hydrochloric acid is reacted with 10 cm^3 of 2 mol dm^{-3} sodium hydroxide solution, the temperature change is ΔT.

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

When the reaction is repeated with 50 cm^3 of each solution, the temperature change is

☒ **A** ΔT

☒ **B** $5 \times \Delta T$

☒ **C** $\frac{1}{5} \times \Delta T$

☒ **D** $10 \times 2 \times \Delta T$

(Total for Question 9 = 1 mark)

---

10 An isotope of an element, atomic number z, has mass number 2z + 4. How many neutrons are in the nucleus of the element?

☒ **A** z + 4

☒ **B** z + 2

☒ **C** z

☒ **D** 4

(Total for Question 10 = 1 mark)

---

11 When an Al^{4+} ion is formed from an Al atom, the fourth electron is lost from the

☒ **A** 1s sub-shell.

☒ **B** 2s sub-shell.

☒ **C** 2p sub-shell.

☒ **D** 3s sub-shell.

(Total for Question 11 = 1 mark)

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

12 Metals are good conductors of electricity because

- ☒ **A** metal atoms are arranged in a regular lattice.
- ☒ **B** metal ions are very close to each other.
- ☒ **C** metal ions are free to move through the lattice.
- ☒ **D** electrons are free to move through the lattice.

(Total for Question 12 = 1 mark)

13 Which of the following statements is evidence for the existence of ions in ionic compounds?

- ☒ **A** Ionic compounds, in the solid state, conduct electricity.
- ☒ **B** When **any** ionic compound in solution is electrolysed, the migration of ions can be seen.
- ☒ **C** In electron density maps for ionic compounds, there is no single line representing electron density that surrounds both cations and anions.
- ☒ **D** In electron density maps for ionic compounds, there are some single lines representing electron density that surround both cations and anions.

(Total for Question 13 = 1 mark)

14 White phosphorus consists of

- ☒ **A** a giant structure of atoms.
- ☒ **B** a giant structure of ions.
- ☒ **C** small molecules.
- ☒ **D** single atoms.

(Total for Question 14 = 1 mark)

15 Isomers have different

- ☒ **A** empirical formulae.
- ☒ **B** molecular formulae.
- ☒ **C** skeletal formulae.
- ☒ **D** molar masses.

(Total for Question 15 = 1 mark)

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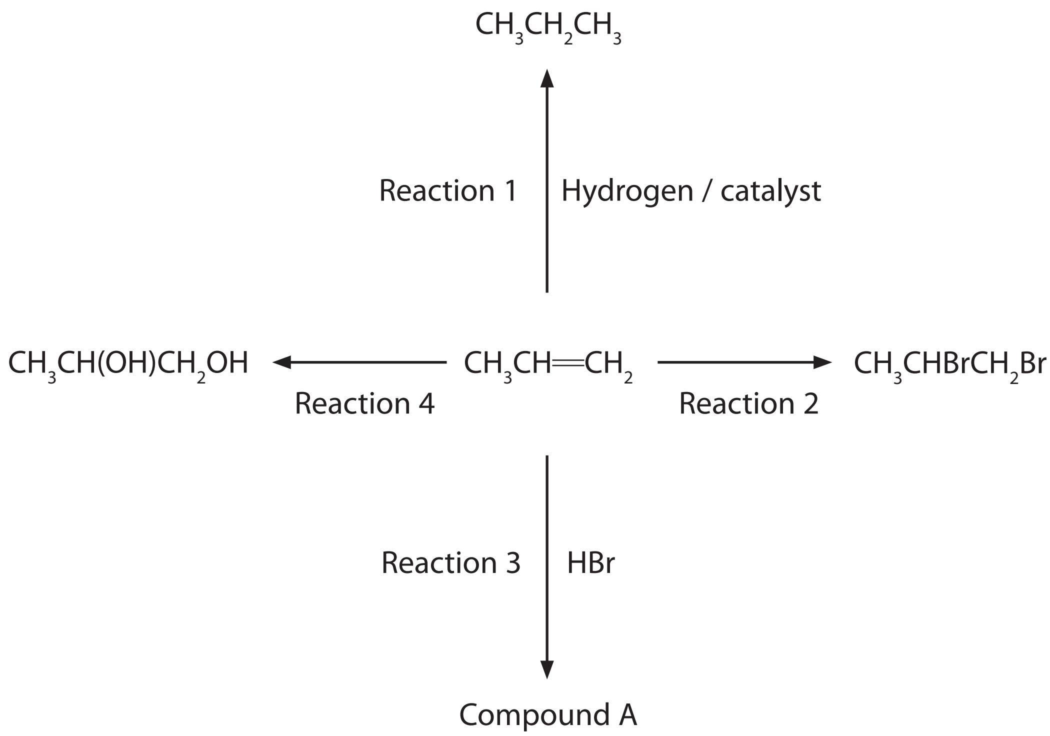
16 Four of the reactions of propene are shown on the diagram below.



(a) Nickel is often used as the catalyst for Reaction 1. Use your Periodic Table to select which of the following metals can be used instead of nickel to catalyse Reaction 1.

(1)

- ☒ **A** Potassium
- ☒ **B** Calcium
- ☒ **C** Gallium
- ☒ **D** Palladium

(b) The name of the reagent and the product for Reaction 2 are

(1)

	Reagent	Product
☒ **A**	bromine water	dibromopropane
☒ **B**	bromine	dibromopropane
☒ **C**	bromine water	1,2-dibromopropane
☒ **D**	bromine	1,2-dibromopropane

(c) What is formed in Reaction 3?

(1)

☒ **A** Only 1-bromopropane

☒ **B** Only 2-bromopropane

☒ **C** A mixture of bromopropanes containing mainly 2-bromopropane

☒ **D** A mixture of bromopropanes containing mainly 1-bromopropane

(d) A mixture of dilute sulfuric acid and which of the following reagents is needed for Reaction 4?

(1)

☒ **A** KOH

☒ **B** $KMnO_4$

☒ **C** H_2O_2

☒ **D** O_2

(e) The reaction of propene in Reaction 4 can be classified both as

(1)

☒ **A**	addition and reduction.
☒ **B**	addition and oxidation.
☒ **C**	free radical substitution and reduction.
☒ **D**	free radical substitution and oxidation.

(Total for Question 16 = 5 marks)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

17 This question is about the preparation of the alum, potassium aluminium sulfate, $KAl(SO_4)_2 \cdot 12H_2O$. It is a double salt consisting of potassium ions, aluminium ions and sulfate ions, and water of crystallization.

(a) The first step of the preparation involves adding an excess of aluminium foil to 10 cm^3 of 2 mol dm^{-3} potassium hydroxide to form potassium aluminate.

The equation for this reaction is

$$2Al(s) + 2KOH(aq) + 2H_2O(l) \rightarrow 2KAlO_2(aq) + 3H_2(g)$$

(i) Write a balanced **ionic** equation for this reaction.

(1)

(ii) Calculate the number of moles of potassium hydroxide used.

(1)

(iii) Hence state the number of moles of aluminium that react with the potassium hydroxide.

(1)

(iv) Use your answer to (iii) to calculate the mass of aluminium that reacts with the potassium hydroxide. Use the Periodic Table as a source of data.

(1)

(v) Calculate the total mass of aluminium added to the potassium hydroxide if a 10% excess of aluminium is required.

(1)

(vi) Identify **two** hazards in this first step of the preparation.

(2)

Hazard 1 ....

....

Hazard 2 ....

....

(b) The second step of the reaction is the addition of a slight excess of 1 mol dm^{-3} sulfuric acid.

(i) Balance the following equation for the reaction

(1)

$$KAlO_2(aq) \;+\; \quad H_2SO_4(aq) \;\rightarrow\; KAl(SO_4)_2(aq) \;+\; \quad H_2O(l)$$

(ii) Calculate the volume of the 1 mol dm^{-3} sulfuric acid that reacts with the potassium aluminate.

(1)

(iii) State how you would show that the acid had been added in excess.

(2)

....

....

....

....

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

(4)

....

....

....

....

....

....

....

....

(v) Suggest the colour of the crystals.

(1)

....

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

(1)

....

(Total for Question 17 = 17 marks)

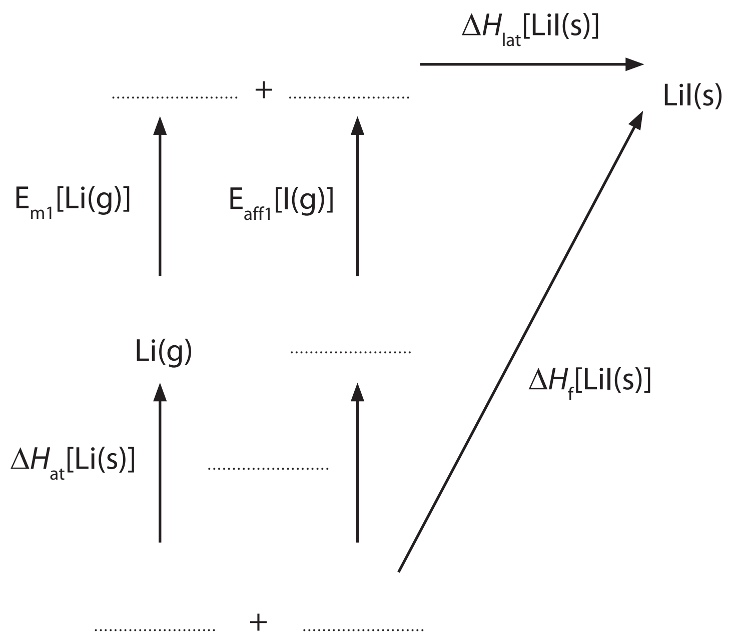
18 This question is about lithium iodide, an ionic salt.

(a) Draw dot and cross diagrams for the lithium and iodide ions. Show all the electrons in the lithium ion but only outer shell electrons in the iodide ion.

(2)

(b) On the Born-Haber cycle below, fill in the missing formulae (including state symbols) and the missing enthalpy change.

(3)



P41212A01324

Turn over

(c) Calculate the electron affinity of iodine, $E_{aff1}[I(g)]$, using the data below.

	ΔH/kJ mol^{-1}
Lattice energy for lithium iodide, ΔH_{lat}	–759
Enthalpy change of atomization of lithium, ΔH_{at}	+159
Enthalpy change of atomization of iodine, ΔH_{at}	+107
First ionization energy of lithium, E_{m1}	+520
Enthalpy change of formation of lithium iodide, ΔH_f	–270

(2)

(d) The experimental lattice energy for lithium iodide is -759 kJ mol^{-1}. The theoretical lattice energy is different from this value.

Will the experimental lattice energy be more negative or less negative than the theoretical lattice energy? Justify your answer.

(3)

....

....

....

....

....

....

(e) State and explain how electron affinity values change as you go down Group 7 from chlorine to iodine.

(2)

....

....

....

....

(Total for Question 18 = 12 marks)

19 Hydrogen has three isotopes, ^{1}H, known as protium, ^{2}H, deuterium, and ^{3}H, tritium.

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

(3)

....

....

....

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

(1)

$$^{14}_{7}N + ^{1}_{0}n \rightarrow ^{3}_{1}H + \text{..........................}$$

(c) Tritium-deuterium gas, consisting of molecules each containing one deuterium atom and one tritium atom, is used in some nuclear warheads. Typically, each warhead has about 4.0 g of the gas added.

(i) Calculate the number of moles of tritium-deuterium in 4.0 g.

(2)

(ii) Calculate the volume, in cm^3, of 4.0 g of tritium-deuterium gas.

[Molar volume of a gas under these conditions = 24 000 cm^3 mol^{-1}]

(1)

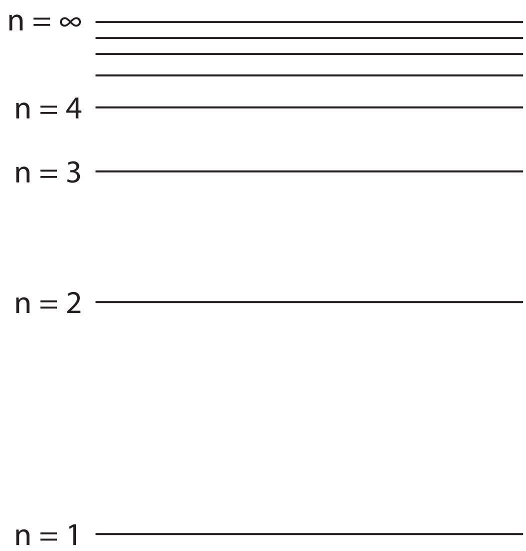
(d) Tritium is not usually included in calculations of the relative atomic mass of hydrogen, because it is radioactive and has a relatively short half-life.

Calculate the relative atomic mass of hydrogen with the following isotopic composition. Give your answer to four decimal places.

(2)

Isotope	Mass number	Relative abundance
^{1}H	1.0078	99.9850
^{2}H	2.0141	0.0150

(e) The electronic energy levels in hydrogen are shown below.



(i) Mark on the energy level diagram, with an arrow, the transition that represents the ionization energy of hydrogen.

(1)

(ii) In some versions of the Periodic Table, hydrogen is placed in the same group as sodium. Give the electronic configurations for both a hydrogen atom and a sodium atom, using the *s* and *p* notation.

Use these electronic configurations to suggest why this is a reasonable grouping.

(2)

H ....

Na ....

....

....

*(f) Which element in the Periodic Table has the highest first ionization energy? Justify your answer.

(3)

....

....

....

....

....

....

(Total for Question 19 = 15 marks)

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

(a) Write the equation, including state symbols, which represents the reaction taking place when the standard enthalpy change of combustion of ethane is measured.

(2)

(b) Ethane can react with chlorine to form chloroethane and hydrogen chloride.

$$C_2H_6(g) + Cl_2(g) \rightarrow C_2H_5Cl(g) + HCl(g)$$

Bond	Bond enthalpy/kJ mol^{-1}
C—H	413
C—C	347
C—Cl	346
H—Cl	432
Cl—Cl	243

Rewrite this equation using displayed formulae.

Use the equation you have written, together with the bond enthalpy data, to calculate the enthalpy change for the reaction.

(4)

(c) This reaction takes place in a number of steps, some of which are shown below.

Step 1 $Cl_2 \rightarrow 2Cl\bullet$

Step 2 $CH_3CH_3 + Cl\bullet \rightarrow HCl + CH_3CH_2\bullet$

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

(2)

Type ....

Conditions ....

(ii) Complete the equation below for the third step of the reaction, and show the movement of electrons using the appropriate arrows.

(3)

$CH_3CH_2\bullet + Cl{-}Cl \rightarrow$

(iii) Write equations for **two** termination steps in this reaction.

(2)

(d) Ethane can be cracked in industry. Write an equation for the cracking of ethane.

(1)

(e) Suggest **two** reasons why cracking of larger alkane molecules is important in industry.

(2)

Reason 1: ....

....

Reason 2: ....

....

(Total for Question 20 = 16 marks)

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

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The Periodic Table of Elements

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

1 (1)	**2** (2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	**3** (13)	**4** (14)	**5** (15)	**6** (16)	**7** (17)	**0 (8)** (18)
							1.0 **H** hydrogen 1										4.0 **He** helium 2
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

Mark Scheme (Results)

January 2013

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

ALWAYS LEARNING

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January 2013
Publications Code US034330

General Marking Guidance

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

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

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

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

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

Quality of Written Communication

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

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

Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Question Number	Correct Answer	Mark
16(a)	D	**1**
(b)	D	**1**
(c)	C	**1**
(d)	B	**1**
(e)	B	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a) (i)	$2Al(s) + 2OH^-(aq) + 2H_2O(l) \rightarrow 2AlO_2^-(aq) + 3H_2(g)$	$2O_2^{2-}(aq)$	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	$\left(\frac{2 \times 10}{1000} = 0.02 / 2 \times 10^{-2}\right)$ Ignore trailing zeroes		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iii)	$0.02 / 2 \times 10^{-2}$ <u>Accept TE answer to (ii)</u>		**1**

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

Question Number	Acceptable Answers	Reject	Mark
17 (a)(v)	$(1.1 \times 0.54) = 0.59(4) / 5.9(4) \times 10^{-1}$(g) TE answer to (iv) x 1.1 Ignore sf except 1 Only penalise sf once		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(vi)	**Potassium hydroxide / KOH** (solution) is corrosive / burns / caustic **OR** **KOH** damages / harms / is harmful to / dissolves / reacts with **skin / eye(s)** **(1)** **OR** **KOH** in **eye(s)** **(1)** **Ignore** Harmful, irritant, highly reactive alone **Hydrogen / H_2** is flammable / explodes / explosive **(1)** Allow mention of both potassium hydroxide and hydrogen alone scores **(1)** Allow Al foil can cut your skin **(1)** Correct answer with additional incorrect chemistry e.g. KOH is oxidising so corrosive scores **(0)**	Toxic, carcinogenic, alone or in combination with correct answer Burns alone Additional chemicals	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(i)	$KAlO_2(aq) + \mathbf{2}H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + \mathbf{2}H_2O(l)$ Allow multiples		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	$\frac{2 \times 1000 \times 0.02}{1} = 40$ (cm^3) Allow 0.04(0) **dm^3** TE answer to (a)(ii) x 2000 and TE from (b)(i)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iii)	Litmus (paper / solution) **(1)** Red / pink (in acid) **(1)** OR any other named acid-base indicator including universal indicator **(1)** with a correct acidic colour **(1)** NB phenolphthalein must be spelt correctly to score **(1)** and no mark for colour Notice that other indicators only require recognisable spellings Red litmus turns blue scores for the indicator **(1)** OR pH meter / universal indicator **(1)** with value < 7 **(1)** NB measure pH alone (0) pH < 7 **(1)** OR add a (metal) carbonate / suitable metal eg Mg **(1)** bubbles / fizzing **(1)** Calculation of amounts / moles of **both** reactants (1 maximum)		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iv)	**Each point must be made in full** **The second and final scoring points, which are asterisked, can only be gained through these statements. Two further marks can be scored for any two of the other four points.** 1 Filter (to remove any aluminium / impurities) **(1)** NB This mark can only be awarded if it is the first action **and** the mixture is subsequently heated. 2 *Boil / heat / evaporate to reduce the volume of water **(1)** NB boil / heat to remove water only gets the mark if it is clear, subsequently, that some solution is left 3 Cool / set aside / leave to allow crystals to form **(1)** 4 Filter OR pick out / remove / take out crystals (to separate) **(1)** 5 Wash with a **little / cold** water **(1)** 6 *Place between filter papers / dab with paper towel / use dessicator (to dry) **(1)**	Leave in the sun If boiled to dry stop marking here Heat in oven	**4**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(v)	White / colourless Ignore clear / transparent / cloudy / opaque e.g. accept clear and colourless	Any other colours with or without white	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(vi)	Cr^{3+}/ Fe^{3+}/ Sc^{3+} / Ga^{3+} Accept any feasible triply positive metal ion Allow B^{3+} Allow any name or symbol for a Group 3 element Allow named existing transition metal ions with (III) after the name (if they exist) Fully correct formula for an alum or intermediate starting entity Eg $KGa(SO_4)_2$ / $KGaO_2$	Al^{3+} and anything else Group 3 element with incorrect charge	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a)	$[:Li]^+$ (1) $\left[\begin{array}{c} xx \\ xx\ I\ xx \\ xx \end{array}\right]^-$ (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)** ½I_2(s) **and** I(g) **(1)** (ΔH_{at})**[**½I_2(s)**]** **(1)** Notice the square brackets are essential for this mark If wrong state for iodine element ie if ½I_2(g/l) and consistent (ΔH_{at})[½I_2(g/l)] allow third mark If I(s) given for element and (ΔH_{at}) [I(s)] allow third mark If wrong state with monatomic iodine both the last two marks lost If Li^+(g) + e appears ignore electron		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c)	**First mark for one of:** −270 = + 159 + 107 + 520 + electron affinity − 759 Or Electron affinity = −270 − (159 + 520 + 107 − 759) **(1)** OR Electron affinity = −270 - 159 - 520 - 107 + 759 **(1)** **Second mark for:** (Electron affinity =) −297 (kJ mol^{-1}) **(1)** −297 (kJ mol^{-1}) alone scores **(2)** NB providing method is recognisable with one transcription error eg 795 for 759 and the final answer is consistent **1 max** NB (+) 297 (kJ mol^{-1}) **1 max**	Wrong unit e.g. J	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (d)	(Experimental lattice energy is) more negative / exothermic **(1)** OR Theoretical lattice energy is less negative / exothermic **(1)** OR Recognition that more energy **released** **(1)** Irrespective of first answer then, any two from: Due to a degree of covalency **(1)** Deviation from pure ionic model (in experimental value) OR The theoretical model is pure ionic bonding **(1)** **Polarization / distortion** of the iod**ide** / negative ions (by the lithium ion). Can be shown by diagram **(1)** Iodine/ I / I_2 ion is not acceptable but iodine / I **anion** is allowed Note I_2 anion is not allowed	Greater / less Increase / decrease alone	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (e)	Electron affinities become less negative / less exothermic / more positive (going down Group 7) **(1)** As (added) **electron** further from the nucleus OR **More** shielding / shielded (from the nucleus) **(1)** Second mark stands alone Ignore larger (ionic) radius / atom / ion / charge density	Greater / less / Increase / decrease alone Any indication of ionization/ removing an electron	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (a)	All have the same number of electrons / all have one (s) electron / same electron configuration **(1)** All have the same number of protons / all have one proton **(1)** The first has no neutrons, the second one neutron and the third two neutrons Allow deuterium has one more neutron, tritium two more neutrons **(1)** Ignore references to same atomic number and different mass numbers	All have one p electron Different number of neutrons alone	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (b)	$({}^{14}_{7}N + {}^{1}_{0}n \rightarrow {}^{3}_{1}H +)\ {}^{12}_{6}C$ Numbers can be on either side or both sides		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	**Molar mass / M(r) / 3+2 / 2+3** = 5 (g mol^{-1}) (1) Number of moles = 4/5 = 0.8 **(1)** O.8 with correct working, with wrong working, or with no working **(2)** Allow internal TE if Molar mass clearly indicated and incorrect eg Molar mass / M(r) = 6 (g mol^{-1}) **(0)** Number of moles = 4/6 = 0.67 **(1)**	Penalise incorrect units	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	24 000 x 0.8 = 19 200 (cm^3) Allow 19.2 **dm^3** Allow TE from (c)(i)	Incorrect units	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)	$\frac{1.0078 \times 99.9850 + 2.0141 \times 0.0150}{100}$ OR $\frac{1.0078 \times 99.9850 + 2.0141 \times 0.0150}{99.9850 + 0.0150}$ **(1)** Notice this working must be shown in full to score first mark. (= 1.007951) = 1.0080 **(1)** 1.008 max 1 with or without working Correct answer no working **(2)** Only give second mark for correct answer to 4 decimal places Ignore g mol^{-1}	Incorrect units e.g. g	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (e)(i)	Single arrow **upwards** from lowest line to infinity line (allow above or very close below) Allow double headed arrow	More than one line	**1**

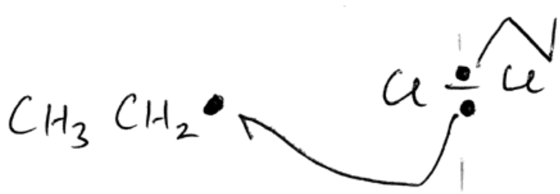
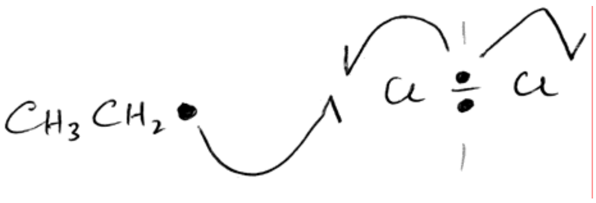
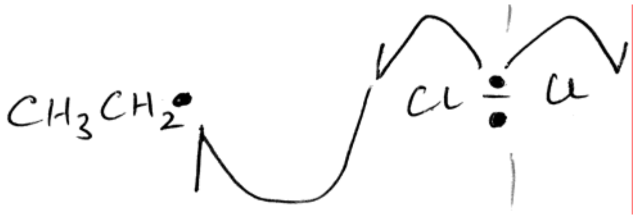
Question Number	Acceptable Answers	Reject	Mark
19 (e)(ii)	Hydrogen $1s^1$ **and** Sodium $1s^2\ 2s^2\ 2p^6\ 3s^1$ **(1)** Electron numbers may be on lines or subscript. Both have one (s) electron in the **outer** shell / orbital / sub shell OR same number of electrons / same electron(ic) configuration in **outer** shell / orbital / sub shell OR Both have an/one unpaired electron in their **outer** / **last** shell / orbital / sub shell **(1)** Second mark depends on one outer shell s electron shown for each electronic configuration	$1s^2\ 2s^1$ half filled s outer shell same electron(ic) configuration alone	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (f)	Helium **(1)** Any two from the following points: Electron removed is closest / close to the nucleus **(1)** Little shielding, allow no shielding **(1)** More protons / higher nuclear charge than hydrogen. Allow higher effective nuclear charge **(1)** **NB** second and third marks can be gained if **hydrogen** is given: Electron removed is close / closest to the nucleus **(1)** No shielding **(1)**	Any other elements	3

Question Number	Acceptable Answers	Reject	Mark
20(a)	$C_2H_6(g) + 3½O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ Formulae and states **(1)** Balancing of correct entities **(1)**	Multiples	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)	Notice the first mark is for the equation and there are 3 separate additional marks for the calculation H H H H | | | | H-C-C-H + Cl-Cl → H-C-C-Cl + H-Cl | | | | H H H H **(1)** Check all bonds displayed especially Cl-Cl and H-Cl **Calculation marks:** +413 + 243 **(1)** (−)(346 + 432) **(1)** OR 656 **(1)** (−) 778 **(1)** = −122 (kJ mol^{-1}) **(1)** Fully correct answer to calculation with no working **(3)** Extra 5x413 and 347 may be included on both sides, giving 3068 and (-)3190 Allow other same values(s) missing from both sides Bonds breaking **(1)** Bonds making **(1)** [Bonds breaking - bonds making] to give correct answer **with sign** **(1)**	Incorrect / no sign and / or incorrect units Incorrect units loses this mark	**4**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	Initiation **(1)** Allow homolysis / atomization / homolytic (fission) Ignore any reference to free radical substitution UV / (sun)light **(1)** Ignore reference to high temperature	Free radical substitution alone Photolysis	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	$CH_3CH_2\bullet$ + Cl-Cl → CH_3CH_2Cl + Cl• OR $CH_3CH_2\bullet$ + Cl-Cl → C_2H_5Cl + Cl• Both products correct including dot (1) Two half headed arrows showing homolytic breaking of Cl-Cl bond **(1)** Half headed arrow from radical to pair with a Cl arrow OR One arrow from chlorine bond clearly to ethyl radical **(1)** Arrows must be single-headed     The two dots in the covalent bond do not have to be shown		**3**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iii)	$Cl\bullet + Cl\bullet \rightarrow Cl_2$ **(1)** $\bullet CH_2CH_3 + \bullet CH_2CH_3 \rightarrow CH_3CH_2CH_2CH_3$ / C_4H_{10} **(1)** $\bullet CH_2CH_3 + Cl\bullet \rightarrow CH_3CH_2Cl$ **(1)** Penalise missing dots once Allow $\bullet C_2H_5$ for $\bullet CH_2CH_3$ Di and tri substitution steps	C_4H_{12} $CH_3CH_2CH_3CH_2$	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (d)	$C_2H_6 \rightarrow C_2H_4 + H_2$ Allow $\mathbf{2}C_2H_6 \rightarrow C_2H_4 + \mathbf{2}CH_4$		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (e)	Any two from: (It) produces (more) petrol / gasoline / diesel / jet fuel / LPG / liquid petroleum gas / fuel **(1)** Short chain alkanes / lighter fractions are more useful products **(1)** Demand is greater for shorter chain alkanes / lighter fractions / smaller molecules OR converts surplus of low demand fractions **(1)** It produces ethane / short chain alkenes for making poly(ethene) / ethane-1,2-diol / ethanol / plastics / polymers **(1)** Smaller alkanes give less pollution/burn more efficiently **(1)** Recycles waste products **(1)** As a source of hydrogen **(1)** **NB** examiners need to look carefully at the vowel in the middle of alk**a**ne / alk**e**ne / eth**a**ne / eth**e**ne if not clear do not give BOD	Points based on atom economy / renewable fuels alone Easier to transport / store Short chain alkenes / ethene more useful alone Recycles alone	2

TOTAL FOR SECTION B = 60

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