EDEXCEL A-LEVEL CHEMISTRY

CHEMISTRY



EXAM QUESTION PACK

UNIT 1 OLD SPECIFICATION PAPERS

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Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 26 May 2017 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

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P 5 3 4 9 1 A 0 1 3 2

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SECTION A

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

1 The concentration of carbon monoxide in the exhaust gases of a car without a catalytic converter is 0.7 % by volume.

In units of parts per million, this concentration is

☒ **A** 7

☒ **B** 70

☒ **C** 700

☒ **D** 7000

(Total for Question 1 = 1 mark)

2 Ionization occurs in a mass spectrometer when an atom or a molecule

☒ **A** is accelerated to high kinetic energy and loses an electron.

☒ **B** is accelerated to high kinetic energy and gains an electron.

☒ **C** collides with a high energy electron and loses an electron.

☒ **D** collides with a high energy electron and gains an electron.

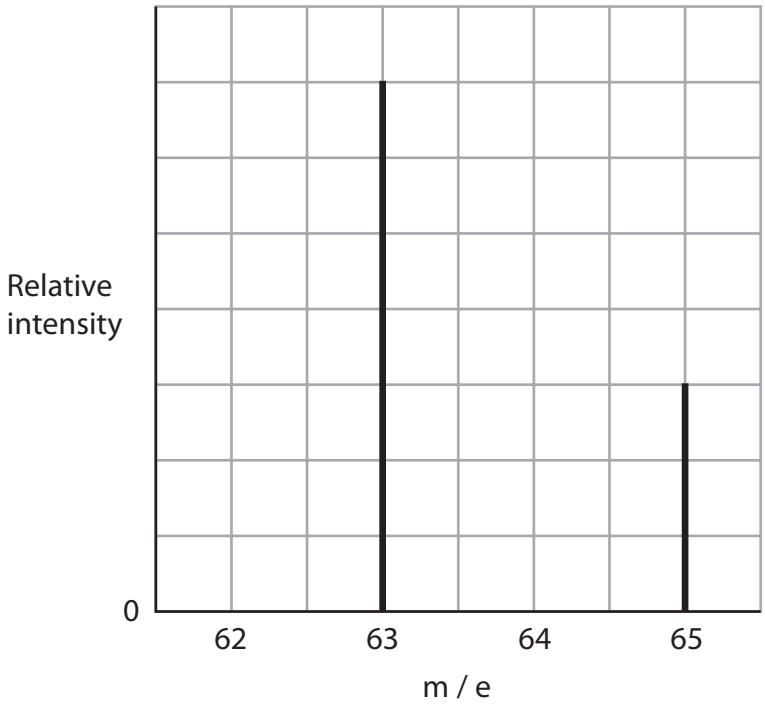
(Total for Question 2 = 1 mark)

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3 The mass spectrum of a metal has only the peaks shown in the diagram.



The relative atomic mass of the metal is

☒ **A** 63.0

☒ **B** 63.6

☒ **C** 64.0

☒ **D** 65.0

(Total for Question 3 = 1 mark)

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4 An atom and an ion with a single positive charge are isoelectronic. Therefore the

- ☒ **A** atom and the ion have the same mass number.
- ☒ **B** atom and the ion have the same atomic number.
- ☒ **C** atomic number of the atom is one more than that of the ion.
- ☒ **D** atomic number of the atom is one less than that of the ion.

(Total for Question 4 = 1 mark)

5 The electronic configuration of a species which has only one unpaired electron is

- ☒ **A** $1s^2\ 2s^2\ 2p^2$
- ☒ **B** $1s^2\ 2s^2\ 2p^3$
- ☒ **C** $1s^2\ 2s^2\ 2p^4$
- ☒ **D** $1s^2\ 2s^2\ 2p^5$

(Total for Question 5 = 1 mark)

6 The CFC dichlorodifluoromethane has the molecular formula CCl_2F_2 and its molar mass is 121 g mol^{-1}. What is the total number of **atoms** in 2.42 g of dichlorodifluoromethane?

[Avogadro constant = 6.0×10^{23} mol^{-1}]

- ☒ **A** 6.0×10^{22}
- ☒ **B** 4.8×10^{22}
- ☒ **C** 3.6×10^{22}
- ☒ **D** 1.2×10^{22}

(Total for Question 6 = 1 mark)

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7 A chemical compound has a high melting temperature and a high boiling temperature. From this it can be deduced that its bonding could be

☒ **A** ionic but not covalent.

☒ **B** covalent but not ionic.

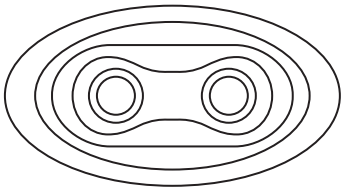
☒ **C** either ionic or covalent.

☒ **D** metallic.

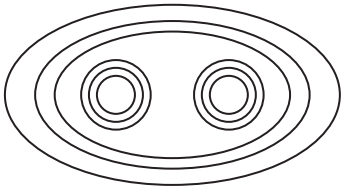
(Total for Question 7 = 1 mark)

8 Which diagram best represents the electron density map of a chlorine molecule?

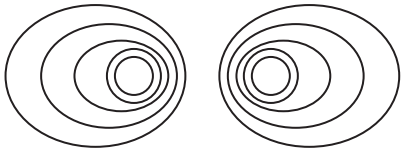
☒ **A**



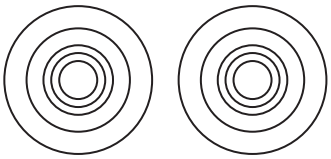
☒ **B**



☒ **C**



☒ **D**



(Total for Question 8 = 1 mark)

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9 When gold(III) oxide is heated, it decomposes to form gold and oxygen. Calculate the mass of gold formed when 2.21 g of gold(III) oxide is heated to constant mass.

[Molar masses: O = 16.0 g mol^{-1} Au = 197 g mol^{-1}]

☒ **A** 1.97 g

☒ **B** 2.04 g

☒ **C** 2.10 g

☒ **D** 2.15 g

(Total for Question 9 = 1 mark)

10 One of the reactions in the catalytic converter of a car exhaust is

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

400 cm^3 of NO is mixed with 500 cm^3 of CO. What is the **total** volume of gas when the reaction is complete? All gas volumes are measured at the same temperature and pressure.

☒ **A** 600 cm^3

☒ **B** 700 cm^3

☒ **C** 1300 cm^3

☒ **D** The volume cannot be calculated without the molar volume of gas at the appropriate temperature and pressure.

(Total for Question 10 = 1 mark)

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11 When dilute sulfuric acid is added to a solution of lead(II) nitrate, the reaction is

$$Pb(NO_3)_2(aq) + H_2SO_4(aq) \rightarrow PbSO_4(s) + 2HNO_3(aq)$$

(a) This reaction is

(1)

☒ **A** displacement.

☒ **B** neutralization.

☒ **C** precipitation.

☒ **D** redox.

(b) When excess sulfuric acid was added to a solution containing 6.62 g of lead(II) nitrate, 4.80 g of lead(II) sulfate was obtained.

What is the percentage yield by mass of lead(II) sulfate in this reaction?

(1)

[Molar masses: $Pb(NO_3)_2 = 331$ g mol^{-1} ; $PbSO_4 = 303$ g mol^{-1}]

☒ **A** 91.5 %

☒ **B** 79.2 %

☒ **C** 72.5 %

☒ **D** 66.4 %

(Total for Question 11 = 2 marks)

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12 Which is correct for chlorine?

	First ionization energy	First electron affinity
☒ **A**	exothermic	endothermic
☒ **B**	exothermic	exothermic
☒ **C**	endothermic	exothermic
☒ **D**	endothermic	endothermic

(Total for Question 12 = 1 mark)

13 In the solid state, phosphorus exists in three forms: black, red and white. These forms may be interconverted:

$$P(s, \text{white}) \rightarrow P(s, \text{black}) \quad \Delta H^{\ominus} = -43.1 \text{ kJ mol}^{-1}$$

$$P(s, \text{white}) \rightarrow P(s, \text{red}) \quad \Delta H^{\ominus} = -18.0 \text{ kJ mol}^{-1}$$

From these data, it may be calculated that the standard enthalpy change for the conversion of black phosphorus into red phosphorus is

☒ **A** +61.1 kJ mol^{-1}

☒ **B** +25.1 kJ mol^{-1}

☒ **C** −25.1 kJ mol^{-1}

☒ **D** −61.1 kJ mol^{-1}

(Total for Question 13 = 1 mark)

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14 The reaction between hydrogen and fluorine is highly exothermic. This is mainly because the

☒ **A** F—F bond is weak and the H—F bond is strong.

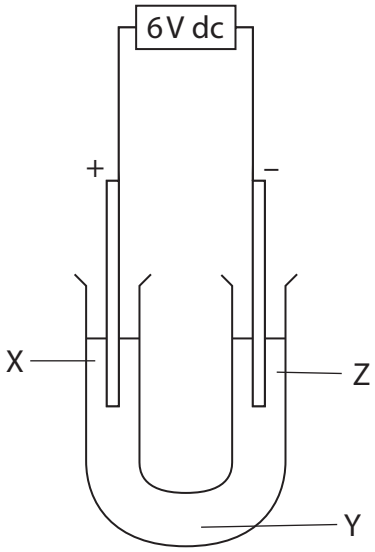
☒ **B** F—F bond is strong and the H—F bond is weak.

☒ **C** F—F bond is weak and the H—F and H—H bonds are strong.

☒ **D** F—F bond is strong and the H—F and H—H bonds are weak.

(Total for Question 14 = 1 mark)

15 An aqueous solution of copper(II) chromate(VI) was electrolysed in the apparatus shown in the diagram using platinum electrodes.



After five minutes, the colours observed in the different parts of the solution in the U-tube were

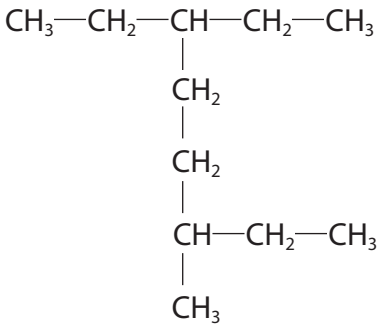
	X	Y	Z
☒ **A**	green	yellow	blue
☒ **B**	yellow	blue	green
☒ **C**	blue	green	yellow
☒ **D**	yellow	green	blue

(Total for Question 15 = 1 mark)

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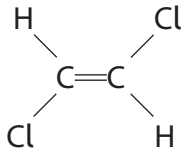
16 Give the systematic name for this hydrocarbon.



- ☒ **A** 1,1,4-triethylpentane
- ☒ **B** 2,5,5-triethylpentane
- ☒ **C** 2,5-diethylheptane
- ☒ **D** 3-ethyl-6-methyloctane

(Total for Question 16 = 1 mark)

17 A compound has the structure



Depending on the naming system used, this compound is

- ☒ **A** *cis*-1,2-dichloroethene or *E*-1,2-dichloroethene.
- ☒ **B** *cis*-1,2-dichloroethene or *Z*-1,2-dichloroethene.
- ☒ **C** *trans*-1,2-dichloroethene or *E*-1,2-dichloroethene.
- ☒ **D** *trans*-1,2-dichloroethene or *Z*-1,2-dichloroethene.

(Total for Question 17 = 1 mark)

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18 The carbon-carbon bond in ethene consists of

☒ **A** two σ bonds.

☒ **B** one π bond.

☒ **C** one σ bond and one π bond.

☒ **D** two π bonds.

(Total for Question 18 = 1 mark)

19 The terms hazard and risk are used when considering the use of chemical compounds. For a particular characteristic of a pure compound,

☒ **A** hazard is fixed but risk varies.

☒ **B** hazard varies but risk is fixed.

☒ **C** hazard and risk are fixed.

☒ **D** hazard and risk vary.

(Total for Question 19 = 1 mark)

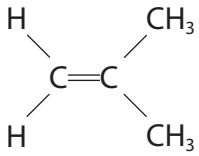
TOTAL FOR SECTION A = 20 MARKS

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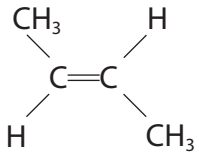
SECTION B

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

20 Compounds **A** and **B** are isomeric alkenes.



A



B

(a) (i) Name compound **A**.

(1)

(ii) Give the molecular formula of compound **B**.

(1)

(iii) Explain why **A** and **B** are isomers.

(2)

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(iv) Draw the **geometric** isomer of compound **B**.

(1)

(v) Explain why compound **B** has a geometric isomer but compound **A** does not.

(1)

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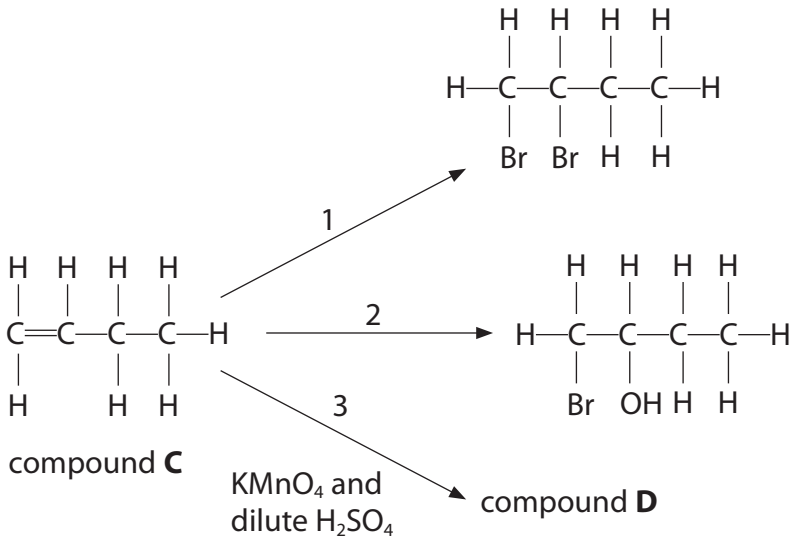
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(b) Compound **C** is an isomer of compounds **A** and **B**. Some reactions of compound **C** are shown below.



(i) **Name** the reagent(s) required for reaction 1.

(1)

.....

(ii) **Name** the reagent(s) required for reaction 2.

(1)

.....

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

(1)

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(c) Compound **C** also reacts with hydrogen chloride.

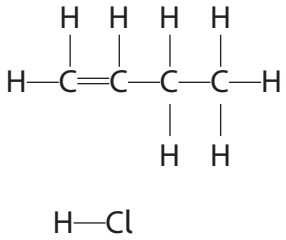
(i) Classify the type and mechanism of this reaction.

(2)

.....

(ii) Complete the diagram below by adding any dipoles and curly arrows relevant to the **first** step of the mechanism of this reaction.

(2)



H—Cl

(iii) Draw the intermediate for the reaction which produces the major product. Hence show the final step of the mechanism and the product.

Include relevant curly arrows, lone pairs and charges.

(4)

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(d) Compound **C** forms a polymer which, because of its temperature resistance, is used in hot water piping.

Draw a section of this polymer, showing **two** repeat units.

(1)

(Total for Question 20 = 18 marks)

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21 Magnesium is in Group 2 of the Periodic Table. It has a number of naturally occurring isotopes, including ^{24}Mg and ^{26}Mg.

(a) (i) Explain, in terms of the subatomic particles in the atoms, why ^{24}Mg and ^{26}Mg are isotopes.

(2)

.....

.....

.....

.....

(ii) A sample of magnesium, which contains only the isotopes ^{24}Mg and ^{26}Mg, has a relative atomic mass of 24.433.

Calculate the percentage abundance of each isotope in this sample of magnesium.

(2)

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(b) (i) Give the electronic structure of a magnesium atom, using the s, p, d notation.

(1)

(ii) Write the equation for the first ionization energy of magnesium.
Include state symbols.

(1)

*(iii) Explain why the first ionization energy of magnesium is higher than the first ionization energy of sodium.

(2)

(iv) Explain why the first ionization energy of magnesium is higher than the first ionization energy of aluminium.

(2)

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(c) Magnesium carbonate decomposes on heating:

$$MgCO_3(s) \rightarrow MgO(s) + CO_2(g) \qquad \Delta H_1$$

The enthalpy change can only be determined indirectly, by applying Hess's Law.

(i) Explain why the enthalpy change of this reaction cannot be determined directly.

(1)

.....

.....

.....

(ii) State Hess's Law.

(1)

.....

.....

.....

(d) A class of students carried out an experiment to measure ΔH_1 indirectly by determining the enthalpy changes of two reactions:

$$MgCO_3(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) + CO_2(g) \qquad \Delta H_2$$

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l) \qquad \Delta H_3$$

One group used the following method to measure ΔH_2.

- Pipette 50.0 cm^3 of 2 mol dm^{-3} hydrochloric acid (a large excess) into a polystyrene cup and note the temperature of the acid.
- Weigh accurately 2.50 g of magnesium carbonate powder.
- Add the magnesium carbonate to the acid, stir continuously and note the highest temperature.

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(i) Why is excess hydrochloric acid used?

(1)

.....

.....

(ii) The students were told that using a polystyrene cup gives better results than using a glass beaker because of its good thermal insulation and its low heat capacity. Explain why these properties improve experimental results.

(2)

Good thermal insulation .....

.....

.....

Low heat capacity .....

.....

.....

(iii) One student using this method measured a temperature increase of 18.5°C. Calculate the energy change, in joules, for this reaction. Assume the specific heat capacity of the solution is 4.18 J g^{-1} $°C^{-1}$ and use the expression

energy change (J) = 50.0 × specific heat capacity × temperature change

(1)

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*(iv) Use your answer to (d)(iii) to calculate the molar enthalpy change for the reaction between magnesium carbonate and hydrochloric acid.
Give your answer to **three** significant figures and include a sign and units.

(3)

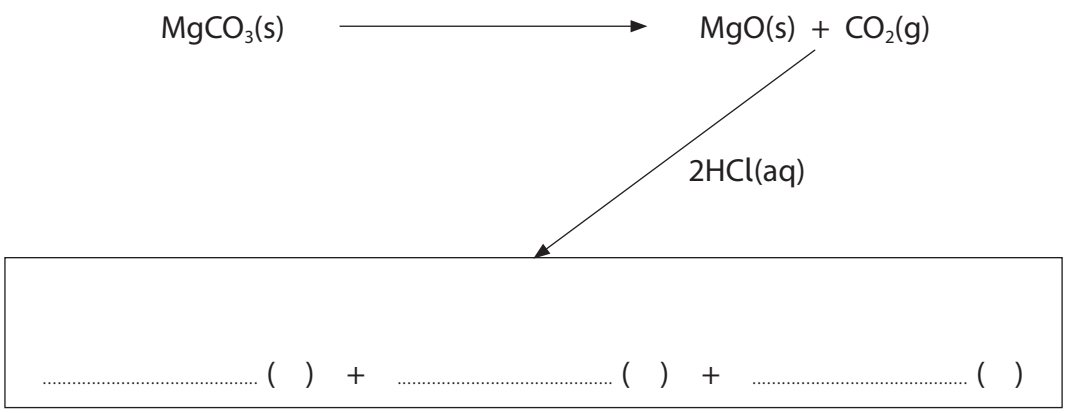
(e) The class collected all their results and, after eliminating anomalous results, calculated the mean values of ΔH_2 and ΔH_3:

$$\Delta H_2 = -126 \text{ kJ mol}^{-1}$$

$$\Delta H_3 = -231 \text{ kJ mol}^{-1}$$

(i) Complete the Hess cycle below by adding the missing arrow and species.

(1)



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(ii) Use your completed Hess cycle and the students' mean values for ΔH_2 and ΔH_3 to calculate the enthalpy change for the thermal decomposition of magnesium carbonate. Include a sign and units.

(2)

*(f) Data book values for ΔH_2 and ΔH_3 are

$$\Delta H_2 = -179.4 \text{ kJ mol}^{-1}$$

$$\Delta H_3 = -296.4 \text{ kJ mol}^{-1}$$

Most of the values obtained by the students were close to their mean values, and they suggested that the difference between their values and those from the data book was due to the measurement uncertainties in their experiments.

Evaluate this suggestion.

(2)

(Total for Question 21 = 24 marks)

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22 (a) The table below shows the experimental and calculated values for the lattice energy of sodium chloride and silver chloride.

Compound	Lattice Energy / kJ mol^{-1}	
	Experimental	Calculated
sodium chloride	−780	−770
silver chloride	−905	−833

(i) Write the equation for the lattice energy of sodium chloride.
Include state symbols.

(1)

(ii) Name the energy cycle used to calculate lattice energies from experimental data.

(1)

*(iii) Explain fully why the experimental and calculated values for the lattice energy of sodium chloride are similar, whereas those for silver chloride differ significantly.

(3)

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(b) The percentage composition by mass of a sodium compound is
Na = 29.1%; S = 40.6%; O = 30.3%.

Calculate the empirical formula of the compound.

(3)

(c) Draw the dot and cross diagram for sodium oxide.
Show the outer electrons only.

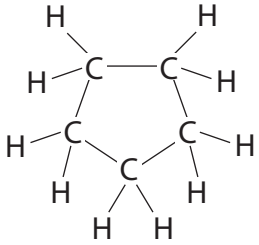
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(Total for Question 22 = 10 marks)

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23 Cycloalkanes are hydrocarbons which contain a ring of carbon atoms. Cycloalkanes have essentially the same chemical reactions as alkanes such as butane and pentane. Cyclopentane, which has a five-carbon ring, is a foam-blowing agent used to propel insulation into the doors and cases of refrigerators. The use of cyclopentane, rather than CFCs, reduces greenhouse gas emissions from this process by 99%.



cyclopentane

(a) (i) Write the **empirical** formula of cyclopentane.

(1)

.....

(ii) Suggest the general formula of the cycloalkanes.

(1)

.....

(b) Cyclopentane may be manufactured by reforming pentane, which is obtained from crude oil.

(i) Name the first stage in the process used to obtain compounds such as pentane from crude oil.

(1)

.....

(ii) Write an equation for the reforming of pentane into cyclopentane. State symbols are not required.

(1)

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(c) Cyclopentane and methane react with chlorine by the same mechanism.

(i) State the essential condition for the reaction between cyclopentane and chlorine.

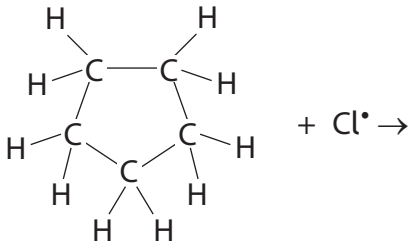
(1)

.....

(ii) Give the **propagation** stage for the reaction between cyclopentane and chlorine by completing the first equation of this stage and then writing the second equation.
Curly half-arrows are **not** required.

(2)

Equation 1



+ $Cl^{\bullet} \rightarrow$

Equation 2

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(iii) The termination stage of the reaction between cyclopentane and chlorine produces only one hydrocarbon. Draw the displayed formula of this hydrocarbon.

(1)

(Total for Question 23 = 8 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

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

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

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

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Mark Scheme (Results)

Summer 2017

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

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General marking guidance

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

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the mark scheme

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

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

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

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

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

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

Section A (multiple choice)

Question Number	Answer	Mark
1	**1.The only correct answer is D** ***A*** *is not correct because this is parts per 1000* ***B*** *is not correct because this is parts per 10000* ***C*** *is not correct because this is parts per 100000*	**(1)**

Question Number	Answer	Mark
2	**2.The only correct answer is C** ***A*** *is not correct because ionization involves impact with a high energy electron* ***B*** *is not correct because positive ions are formed* ***D*** *is not correct because ionization involves impact with a high energy electron & positive ions are formed*	**(1)**

Question Number	Answer	Mark
3	**3. The only correct answer is B** ***A*** *is not correct because this is the mass of one isotope* ***C*** *is not correct because this is a mean without weighting* ***D*** *is not correct because this is the mass of one isotope*	**(1)**

Question Number	Answer	Mark
4	**4. The only correct answer is D** ***A*** *is not correct because* isoelectronic does not relate to mass ***B*** *is not correct because* isoelectronic does not relate to Z ***C*** *is not correct because* this is true for a negative ion	**(1)**

Question Number	Answer	Mark
5	**5. The only correct answer is D** ***A*** *is not correct because this has two unpaired electrons* ***B*** *is not correct because this has three unpaired electrons* ***C*** *is not correct because this has two unpaired electrons*	**(1)**

Question Number	Answer	Mark
6	**6. The only correct answer is A** ***B*** *is not correct because this uses 4 atoms per molecule* ***C*** *is not correct because this counts types of atoms only* ***D*** *is not correct because this is the number of molecules*	**(1)**

Question Number	Answer	Mark
7	**7. The only correct answer is C** **A** is not correct because it could be covalent **B** is not correct because it could be ionic **D** is not correct because it must be a compound	**(1)**

Question Number	Answer	Mark
8	**8. The only correct answer is A** ***B*** *is not correct because there must be electron density between the atoms* ***C*** *is not correct because these are antibonding orbitals* ***D*** *is not correct because it shows no overlap of orbitals*	**(1)**

Question Number	Answer	Mark
9	**9. The only correct answer is A** ***B*** *is not correct because this uses AuO not* Au_2O_3 ***C*** *is not correct because this uses* Au_3O_2 *not* Au_2O_3 ***D*** *is not correct because this uses* Au_3O *not* Au_2O_3	**(1)**

Question Number	Answer	Mark
10	**10. The only correct answer is B** ***A*** *is not correct because this omits the residual CO* ***C*** *is not correct because this uses 800 cm^3 of CO_2 and 500 cm^3 of N_2 only* ***D*** *is not correct because T & P are the same for all measurements*	**(1)**

Question Number	Answer	Mark
11(a)	**11(a). The only correct answer is C** ***A*** *is not correct because the reaction does not involve redox so not a displacement* ***B*** *is not correct because the reaction is not a neutralization* ***D*** *is not correct because the reaction does not involve redox*	**(1)**

Question Number	Answer	Mark
11(b)	**11(b). The only correct answer is B** ***A*** *is not correct because this the ratio of molar masses expressed as a percentage* ***C*** *is not correct because this the ratio of masses expressed as a percentage* ***D*** *is not correct because the molar masses have been used the wrong way round*	**(1)**

Question Number	Answer	Mark
12	**12. The only correct answer is C** ***A*** *is not correct because IE1 is endothermic and EA1 is exothermic* ***B*** *is not correct because IE1 is exothermic and EA1 is exothermic* ***D*** *is not correct because IE1 is endothermic and EA1 is endothermic*	**(1)**

Question Number	Answer	Mark
13	**13. The only correct answer is B** ***A*** *is not correct because the ΔH values have been added and the sign reversed* ***C*** *is not correct because C because the ΔH values have been subtracted but the sign reversed* ***D*** *is not correct because the ΔH values have been added*	**(1)**

Question Number	Answer	Mark
14	**14. The only correct answer is A** ***B*** *is not correct because F−F bond is weak and H−F bond is strong* ***C*** *is not correct because the H−H bond being strong would make the reaction less exothermic* ***D*** *is not correct because the H−H bond is strong*	**(1)**

Question Number	Answer	Mark
15	**15. The only correct answer is D** ***A*** *is not correct because the yellow chromate(VI) ions would be attracted to the anode and the green mixed colour would be in the middle* ***B*** *is not correct because the blue copper(II) ions would be attracted to the cathode and the green mixed colour would be in the middle* ***C*** *is not correct because the yellow chromate(VI) ions would be attracted to the anode and blue copper(II) ions would be attracted to the cathode*	**(1)**

Question Number	Answer	Mark
16	**16. The only correct answer is D** ***A*** *is not correct because the longest chain has 8 carbons* ***B*** *is not correct because the longest chain has 8 carbons* ***C*** *is not correct because the longest chain has 8 carbons*	**(1)**

Question Number	Answer	Mark
17	**17. The only correct answer is C** ***A*** *is not correct because it is trans* ***B*** *is not correct because it is trans and E* ***D*** *is not correct because it is E*	**(1)**

Question Number	Answer	Mark
18	**18. The only correct answer is C** ***A*** *is not correct because it has a σ bond and a π bond* ***B*** *is not correct because it has a σ bond and a π bond* ***D*** *is not correct because it has a σ bond and a π bond*	**(1)**

Question Number	Answer	Mark
19	**19. The only correct answer is A** ***B*** *is not correct because* hazard is fixed but risk varies ***C*** *is not correct because* risk varies ***D*** *is not correct because* hazard is fixed	**(1)**

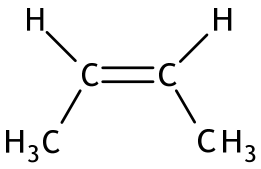
TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answer	Reject	Mark
20(a)(i)	2-methylpropene ALLOW 2-methylprop-1-ene / methylpropene IGNORE Omission of hyphens	2-methylpropan-2-ene *E*-2-methylpropene *Z*-2-methylpropene	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(a)(ii)	C_4H_8	$CH_2CHCH_2CH_3$	**(1)**

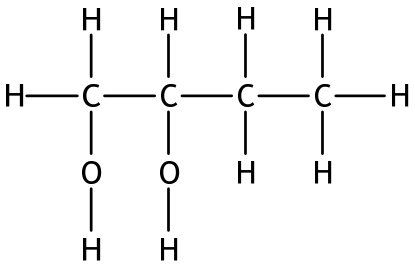
Question Number	Acceptable Answer	Reject	Mark
20(a)(iii)	**A** and **B** have the same molecular formula ALLOW Same number of C and H atoms **(1)** but different structural formulae / structures **(1)** IGNORE Reference to the carbon-carbon double bond spatial arrangement	Just 'formula' M_r	**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(a)(iv)	 ALLOW Skeletal formula		**(1)**

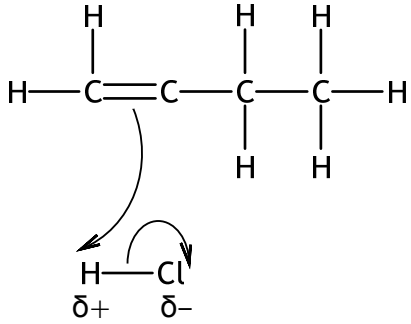
Question Number	Acceptable Answer	Reject	Mark
20(a)(v)	There are two different groups bonded to each of the carbon atoms of the double bond in compound B ALLOW Reverse argument for **A**: A has two methyl groups / H atoms attached to one C IGNORE References to energetic barriers to free rotation about the double bond		**(1)**

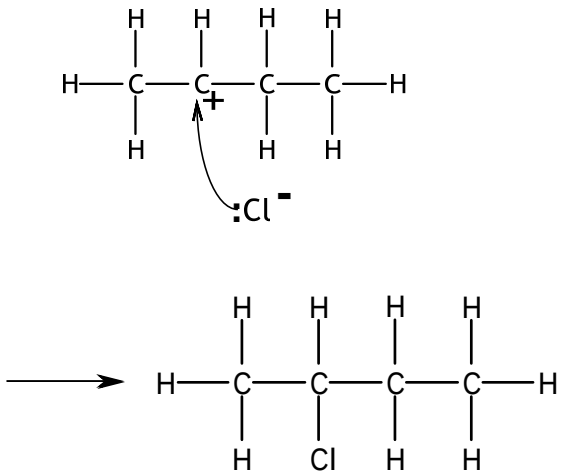
Question Number	Acceptable Answer	Reject	Mark
20(b)(i)	(Liquid) bromine OR bromine in a non-polar solvent / suitable named solvent ALLOW $Br_2(l)$ / Br_2 in an organic solvent / bromine gas / $Br_2(g)$ IGNORE Br_2	$Br_2(aq)$ / bromine water/ aqueous bromine / bromide	**(1)**

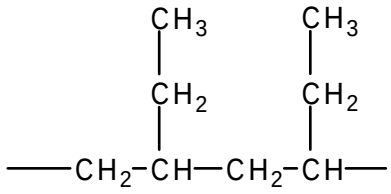
Question Number	Acceptable Answer	Reject	Mark
20(b)(ii)	Bromine water / aqueous bromine ALLOW $Br_2(aq)$ / 'bromine and water' IGNORE Concentrated/dilute	$Br_2(l)$ (Liquid) bromine Additional reagents Bromic(I) acid	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(b)(iii)	 ALLOW OH for O—H IGNORE Attachment to OH unless the bond is clearly C—H—O	Skeletal and structural formulae	**(1)**

Question Number	Acceptable Answer	Reject	Mark
20(c)(i)	Electrophilic **(1)** Addition **(1)**		**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(c)(ii)	Penalise incorrect halogen once in c(ii) and c(iii)  **MP1** Arrows Arrow from π bond to H or close to H **and** Arrow from bond to Cl or just beyond Cl **(1)** **MP2** Dipole **(1)**		**(2)**

Question Number	Acceptable Answer	Reject	Mark
20(c)(iii)	 Intermediate with correctly placed (secondary) positive charge Penalise primary intermediate here **(1)** Cl^- with correctly placed curly arrow close to C atom **(1)** lone pair at start of curly arrow **(1)** Final product **(1)** TE for MP 2, 3 and 4	Bromoalkane	**(4)**

Question Number	Acceptable Answer	Reject	Mark
20(c)(iii)	 ALLOW Branch chains in any direction C_2H_5 for CH_3CH_2 Ethyl groups on carbon atoms 2 and 3 IGNORE brackets and 'n'	One repeat unit	**(1)**

(Total for Question 20 = 18 marks)

Question Number	Acceptable Answer	Reject	Mark
21(a)(i)	(^{24}Mg and ^{26}Mg atoms) have 12 protons **(1)** IGNORE (^{24}Mg and ^{26}Mg atoms) have the same number of protons / proton number ^{24}Mg has 12 neutrons but ^{26}Mg has 14 neutrons ALLOW ^{26}Mg has two more neutrons than ^{24}Mg **(1)** ALLOW for 1 mark Just '^{24}Mg and ^{26}Mg atoms have the same number of protons/proton number **and** different numbers of neutrons /neutron number' IGNORE '^{24}Mg and ^{26}Mg atoms have the same atomic number but different mass numbers' References to electrons unless incorrect		**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(a)(ii)	Percentage ^{24}Mg = x (24x + 26(100 – x) ÷ 100 = 24.433 **(1)** 2x = 2600 – 2443.3 = 156.7 % ^{24}Mg = x = 78.35; % ^{26}Mg = 100 – x = 21.65 ALLOW 78.4 and 21.6 OR 78.3 and 21.7 **(1)** Correct answers with no working scores 2 marks. Ignore SF except 1		**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(b)(i)	$1s^2\ 2s^2\ 2p^6\ 3s^2$ OR $1s^2\ 2s^2\ 2p_x^2\ 2p_y^2\ 2p_z^2\ 3s^2$		**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(b)(ii)	$Mg(g) \rightarrow Mg^{+}(g) + e^{(-)}((g))$ OR $Mg(g) - e^{(-)}((g) \rightarrow Mg^{+}(g)$		**(1)**

Question Number	Acceptable Answer	Reject	Mark
***21(b)(iii)**	Ionized / outer electrons are in the 3s / same orbital/subshell (for each atom) ALLOW Same shell (for subshell) Atoms have the same inner shell shielding **(1)** Mg has one more proton (in the nucleus) (so attractive force is greater) ALLOW Higher proton number Greater effective nuclear charge Reverse argument **(1)** IGNORE References to atomic radius Atomic number	Filled / half-filled orbital has greater stability Magnesium is Mg^{2+} but sodium is Na^{+} Mg has higher charge density (than Na)	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(b)(iv)	(The nuclear charge is greater but ....) Ionized / outer electron of aluminium is in a (3)**p** orbital / the (3)p subshell **(1)** which is further from the nucleus than the (3)s orbital OR is at a higher energy than the (3)s orbital OR is shielded by the (inner) 3s orbital ALLOW Use of 3s subshell for 3s orbital Reverse argument **(1)** IGNORE Use of 2s and 2p for 3s and 3p if consistent	Filled 3s orbital is stable	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(c)(i)	When heat is supplied to a system, it is very difficult / impossible to measure the heat absorbed by the reaction OR When heat is supplied to a system, it is very difficult / impossible to measure the temperature change due to the reaction ALLOW When heat is supplied to a system, it is very difficult / impossible to measure the temperature change OR Difficult to measure the temperature of a solid IGNORE Reference to thermicity of the reaction	Just 'difficult / impossible to measure the temperature change'	**(1)**

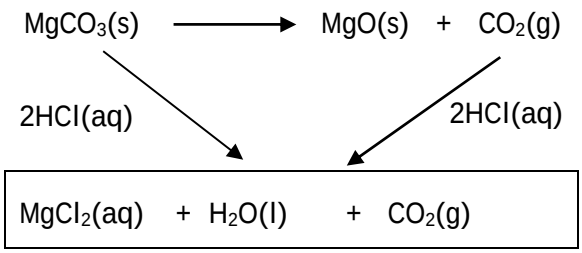
Question Number	Acceptable Answer	Reject	Mark
21(c)(ii)	Enthalpy / heat change of a reaction is independent of the route. ALLOW Enthalpy / heat change is independent of the route.		**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(d)(i)	So that all the $MgCO_3$ reacts. ALLOW So that all the solid reacts So that all the solid reacts IGNORE Reference to limiting factors	Just 'to ensure complete reaction'	**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(d)(ii)	(Good thermal insulation) reduces heat transfer with the surroundings ALLOW Reduces heat loss to the surroundings **(1)** (Low heat capacity) less / little heat is used to heat / cool the container **(1)**	No heat loss	**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(d)(iii)	(ΔE) = 50.0 x 4.18 x 18.5 = 3866.5 (J) OR 3.8665 = 3.87 **kJ** IGNORE SF except 1 SF +/− signs		**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(d)(iv)	Molar mass $MgCO_3$ = 84.3 **(1)** ΔH = (−)answer 21(d)(iii) ÷ mol $MgCO_3$ = (−)3866.5 ÷ (2.50/84.3) OR = (−)3866.5 ÷ 0.029656 OR = (−)3866.5 x 33.72 **(1)** = (−)130378 = −130 000 / −1.30 x 10^5 J mol^{-1} OR = −130 kJ mol^{-1} **(1)** TE at each stage Correct answer with no working scores 3 Correct answer with no working and no or incorrect units and / or sign scores 2	Answer not to 3 SF 130 kJ mol^{-1}	**(3)**

Question Number	Acceptable Answer	Reject	Mark
21(e)(i)	 IGNORE Omission of 2HCl(aq) (on lhs)		**(1)**

Question Number	Acceptable Answer	Reject	Mark
21(e)(ii)	$\Delta H_1 = \Delta H_2 - \Delta H_3$ **(1)** = −126 − (−231) = +105 kJ mol^{-1} **(1)** Correct answer including sign, with no working scores 2 105 kJ mol^{-1} / −105 kJ mol^{-1} / +105 all score 1 mark No TE on incorrect cycle equation		**(2)**

Question Number	Acceptable Answer	Reject	Mark
21(f)	The student values were much smaller / smaller magnitude / less negative than the Data Book values which indicates a systematic error **(1)** Uncertainties will give values scattered about the true value (so cannot explain the discrepancy) OR The results obtained by the students are precise but inaccurate **(1)** If no other mark is scored allow uncertainties are too small to account for the discrepancy scores 1 IGNORE References to likely sources of error such as heat loss		**(2)**

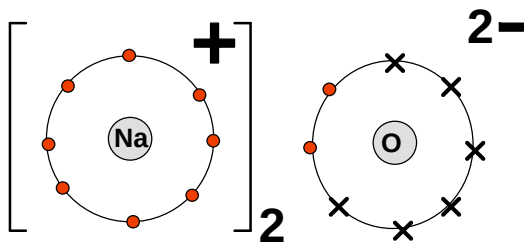
(Total for Question 21 = 24 marks)

Question Number	Acceptable Answer	Reject	Mark
22(a)(i)	$Na^+(g) + Cl^-(g) \rightarrow NaCl(s)$	$NaCl(s) \rightarrow Na^+(g) + Cl^-(g)$	**(1)**

Question Number	Acceptable Answer	Reject	Mark
22(a)(ii)	Born-Haber (cycle)		**(1)**

Question Number	Acceptable Answer	Reject	Mark
***22(a)(iii)**	Sodium chloride is purely ionic **(1)** Silver chloride is partly / significantly covalent **(1)** because silver ion / Ag^+ is polarising / has a high(er) charge density OR chloride ion / Cl^- is polarised (by Ag^+) OR There is orbital overlap between silver and chloride ions OR Large electronegativity difference between Na and Cl **and** Small(er) electronegativity difference between Ag and Cl **(1)**	silver ion has a higher charge Reference to electronegativity differences between **ions**	**(3)**

Question Number	Acceptable Answer	Reject	Mark
22(b)	<table><tr><td></td><td>Na</td><td>S</td><td>O</td></tr><tr><td>%</td><td>29.1</td><td>40.6</td><td>30.3</td></tr><tr><td>% ÷ A_r</td><td>29.1 /23</td><td>40.6 /32.1</td><td>30.3 /16</td></tr><tr><td></td><td>= 1.265</td><td>= 1.265</td><td>= 1.894</td></tr><tr><td>(÷ 1.265)</td><td>1</td><td>1</td><td>1.5</td></tr><tr><td>Ratio</td><td>2</td><td>2</td><td>3</td></tr></table> **(1)** **(1)** Formula = $Na_2S_2O_3$ **(1)** Correct answer with no working scores **(1)** ALLOW other correct methods		**(3)**

Question Number	Acceptable Answer	Reject	Mark
22(c)	 Two sodium **ions** (indicated in any way) ALLOW No electrons **(1)** Oxide ion **(1)** Penalise omission of / incorrect charges once only Charges reversed scores max 1 (for electron configurations and 2:1 ratio)	Covalent bonding	**(2)**

(Total for Question 22 = 10 marks)

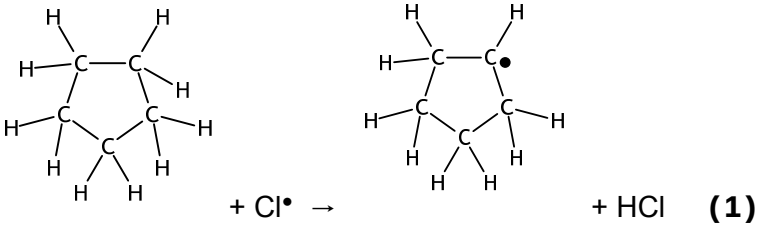
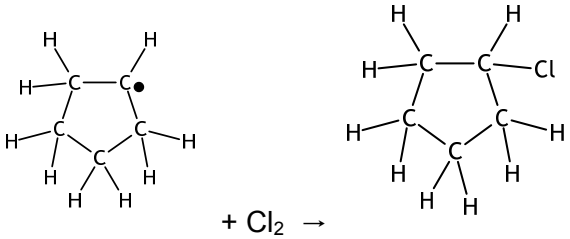
Question Number	Acceptable Answer	Reject	Mark
23(a)(i)	CH_2 ALLOW C_1H_2 H_2C		**(1)**

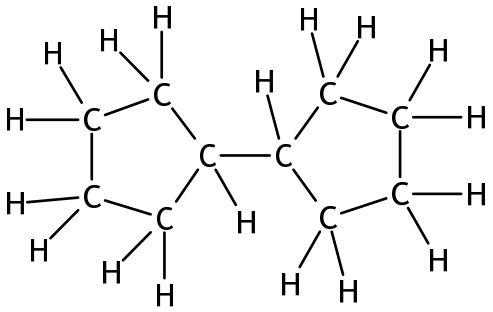
Question Number	Acceptable Answer	Reject	Mark
23(a)(ii)	C_nH_{2n} ALLOW Any general representation of n		**(1)**

Question Number	Acceptable Answer	Reject	Mark
23(b)(i)	Fractional distillation OR Fractionation	Just 'distillation' Cracking followed by fractional distillation	**(1)**

Question Number	Acceptable Answer	Reject	Mark
23(b)(ii)	$C_5H_{12} \rightarrow C_5H_{10} + H_2$ OR Displayed / skeletal /structural formulae IGNORE State symbols even if incorrect Conditions even if incorrect		**(1)**

Question Number	Acceptable Answer	Reject	Mark
23(c)(i)	Ultraviolet / UV (radiation / light) ALLOW Sunlight IGNORE heat		**(1)**

Question Number	Acceptable Answer	Reject	Mark
23(c)(ii)	See below OR $C_5H_{10} + Cl^{\bullet} \rightarrow C_5H_9^{\bullet} + HCl$ **(1)** $C_5H_9^{\bullet} + Cl_2 \rightarrow C_5H_9Cl + Cl^{\bullet}$ **(1)** Penalise omission of unpaired electron once only Penalise incorrect location of unpaired electron on displayed formulae once only  + $Cl^{\bullet}$ → + HCl **(1)**  + Cl_2 → + $Cl^{\bullet}$ **(1)**	charged species	**(2)**

Question Number	Acceptable Answer	Reject	Mark
23(c)(iii)		Structural or skeletal or molecular formulae	**(1)**

(Total for Question 23 = 8 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 22 May 2015 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

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6/6/6/6/

P 4 4 8 7 9 A 0 1 2 4

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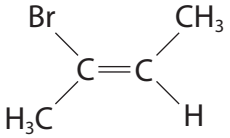
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SECTION A

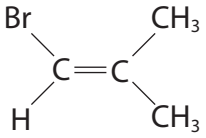
Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which molecule does **not** exhibit *E* / *Z* isomerism?

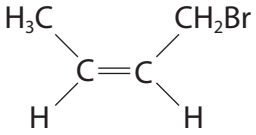
☒ **A**



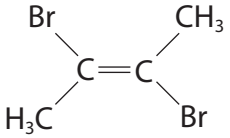
☒ **B**



☒ **C**

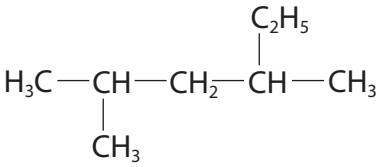


☒ **D**



(Total for Question 1 = 1 mark)

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



☒ **A** 2-methyl-4-ethylpentane

☒ **B** 2-ethyl-4-methylpentane

☒ **C** 2,4-dimethylhexane

☒ **D** 3,5-dimethylhexane

(Total for Question 2 = 1 mark)

P 4 4 8 7 9 A 0 2 2 4
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3 Which of the following molecules is formed on adding bromine **water** to ethene?

☒ **A** ethanol

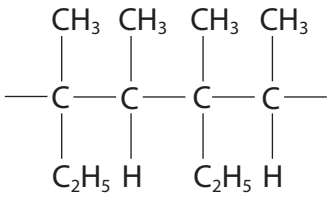
☒ **B** ethane-1,2-diol

☒ **C** bromoethane

☒ **D** 2-bromoethanol

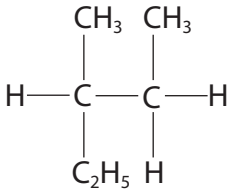
(Total for Question 3 = 1 mark)

4 A section of a polymer is shown below.

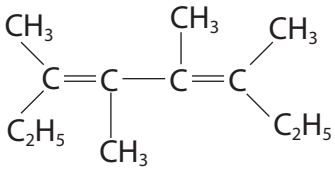


What is the monomer for this polymer?

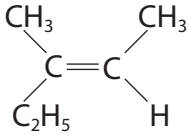
☒ **A**



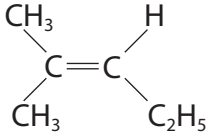
☒ **B**



☒ **C**



☒ **D**



(Total for Question 4 = 1 mark)

P 4 4 8 7 9 A 0 3 2 4

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5 Which of the following equations has the correct state symbols for the reaction of dilute hydrochloric acid with magnesium oxide?

- ☒ **A** $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(s) + H_2O(l)$
- ☒ **B** $MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$
- ☒ **C** $MgO(s) + 2HCl(l) \rightarrow MgCl_2(s) + H_2O(l)$
- ☒ **D** $MgO(s) + 2HCl(l) \rightarrow MgCl_2(aq) + H_2O(l)$

(Total for Question 5 = 1 mark)

6 This question is about the reaction between sodium carbonate solution and dilute nitric acid.

$$Na_2CO_3(aq) + 2HNO_3(aq) \rightarrow 2NaNO_3(aq) + CO_2(g) + H_2O(l)$$

(a) What is the **ionic** equation for this reaction?

(1)

- ☒ **A** $Na_2CO_3(aq) + 2H^+(aq) \rightarrow 2Na^+(aq) + CO_2(g) + H_2O(l)$
- ☒ **B** $Na^+(aq) + NO_3^-(aq) \rightarrow NaNO_3(aq)$
- ☒ **C** $CO_3^{2-}(aq) + 2H^+(aq) \rightarrow CO_2(g) + H_2O(l)$
- ☒ **D** $CO_3^{2-}(aq) + 2HNO_3(aq) \rightarrow 2NO_3^-(aq) + CO_2(g) + H_2O(l)$

(b) What is the volume of carbon dioxide produced from the complete reaction of 0.10 mol of nitric acid at room temperature and pressure?

[1 mol of any gas occupies 24 dm^3 at room temperature and pressure.]

(1)

- ☒ **A** 1.2 dm^3
- ☒ **B** 1.8 dm^3
- ☒ **C** 2.4 dm^3
- ☒ **D** 3.6 dm^3

(c) What volume of sodium carbonate solution of concentration 0.500 mol dm^{-3}, would be needed to completely react with 25.0 cm^3 of nitric acid of concentration 0.250 mol dm^{-3}?

(1)

- ☒ **A** 6.25 cm^3
- ☒ **B** 12.50 cm^3
- ☒ **C** 18.75 cm^3
- ☒ **D** 25.00 cm^3

(Total for Question 6 = 3 marks)

P 4 4 8 7 9 A 0 4 2 4
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7 Lithium reacts with water to produce hydrogen.

$$Li(s) + H_2O(l) \rightarrow LiOH(aq) + \tfrac{1}{2}H_2(g)$$

(a) In an experiment, 0.069 g (0.01 mol) of lithium produced 90 cm^3 of hydrogen at room temperature and pressure. What is the percentage yield of hydrogen?

[1 mol of any gas occupies 24 dm^3 at room temperature and pressure.]

(1)

☒ **A** 45%

☒ **B** 60%

☒ **C** 75%

☒ **D** 90%

(b) Which of the following is **not** a possible reason for the yield being less than 100%?

(1)

☒ **A** Some oil remained on the surface of the lithium.

☒ **B** Hydrogen gas is very soluble in water.

☒ **C** A layer of oxide was present on the surface of the lithium.

☒ **D** Some of the hydrogen gas escaped collection.

(Total for Question 7 = 2 marks)

8 How many moles of **atoms** are present in 240 cm^3 of carbon dioxide at room temperature and pressure?

[1 mol of any gas occupies 24 dm^3 at room temperature and pressure.]

☒ **A** 0.010

☒ **B** 0.020

☒ **C** 0.024

☒ **D** 0.030

(Total for Question 8 = 1 mark)

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9 What is the percentage by mass of nitrogen in ammonium nitrate, NH_4NO_3?

[Molar masses/g mol^{-1}: N = 14.0; H = 1.0; O = 16.0]

☒ **A** 14.0%

☒ **B** 17.5%

☒ **C** 28.0%

☒ **D** 35.0%

(Total for Question 9 = 1 mark)

10 The first five successive ionization energies for an element J, in kJ mol^{-1}, are

1st	2nd	3rd	4th	5th
738	1450	7733	10543	13630

The formula of the compound of chlorine with element J is

☒ **A** JCl

☒ **B** JCl_2

☒ **C** JCl_3

☒ **D** J_2Cl_3

(Total for Question 10 = 1 mark)

11 Which of the following is the correct order of increasing melting temperature of elements of Period 3?

☒ **A** Na, Mg, Al, Si

☒ **B** Na, Mg, Si, Al

☒ **C** Si, Na, Mg, Al

☒ **D** Si, Al, Mg, Na

(Total for Question 11 = 1 mark)

P 4 4 8 7 9 A 0 6 2 4
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12 Which one of the following elements undergoes the change in electronic configuration shown when it forms the stated ion?

Atom $1s^2 2s^2 2p^6 3s^2 3p^3$ Ion $1s^2 2s^2 2p^6 3s^2 3p^6$

☒ **A** B to B^{3+}

☒ **B** Al to Al^{3+}

☒ **C** N to N^{3-}

☒ **D** P to P^{3-}

(Total for Question 12 = 1 mark)

13 Which of the following compounds has the most polarized **anion**?

☒ **A** Na_2O

☒ **B** MgO

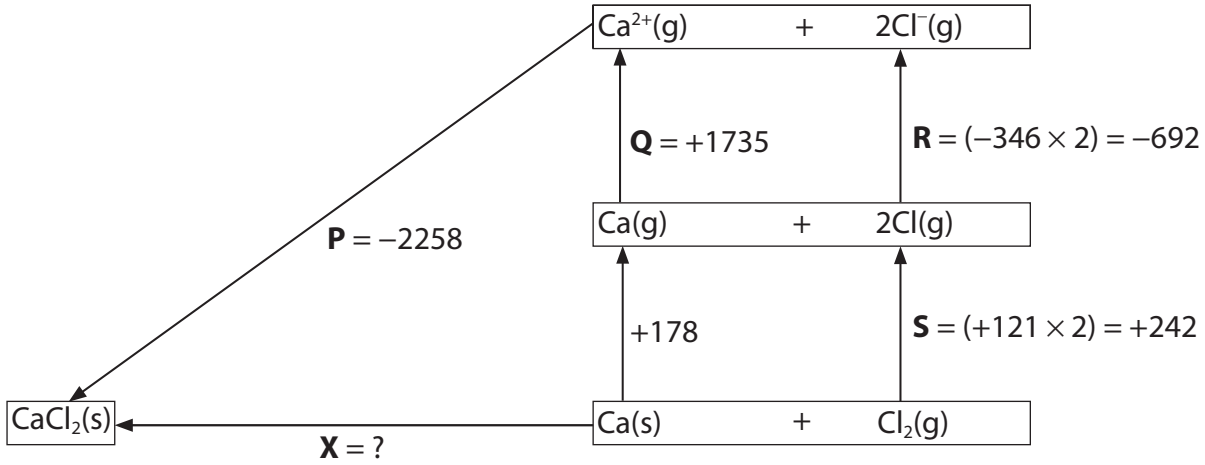
☒ **C** K_2O

☒ **D** CaO

(Total for Question 13 = 1 mark)

P 4 4 8 7 9 A 0 7 2 4
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14 The diagram shows a Born-Haber cycle for calcium chloride. It is not drawn to scale. All units are in kJ mol^{-1}.



(a) Which enthalpy change is correctly labelled on the diagram?

(1)

☒ **A** Enthalpy change for the formation of calcium chloride (**P**).

☒ **B** First ionization energy of calcium (**Q**).

☒ **C** Electron affinity of chlorine (**R**).

☒ **D** Twice the enthalpy change of atomization of chlorine (**S**).

(b) What is the value of **X**, in kJ mol^{-1}?

(1)

☒ **A** +795

☒ **B** −795

☒ **C** +3721

☒ **D** −3721

(Total for Question 14 = 2 marks)

P 4 4 8 7 9 A 0 8 2 4
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15 Calculate the enthalpy change, in kJ mol^{-1}, for the reaction

$$H_2(g) + \tfrac{1}{2}O_2(g) \rightarrow H_2O(g)$$

DATA:

Bond	Bond enthalpy / kJ mol^{-1}
H—H	+436
O=O	+498
H—O	+464

☒ **A** −243

☒ **B** −6

☒ **C** +6

☒ **D** +221

(Total for Question 15 = 1 mark)

16 The chemical properties of an element are determined by its

☒ **A** electronic structure.

☒ **B** number of neutrons.

☒ **C** relative atomic mass.

☒ **D** number of protons plus neutrons.

(Total for Question 16 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

17 This question is about the use of mass spectrometers.

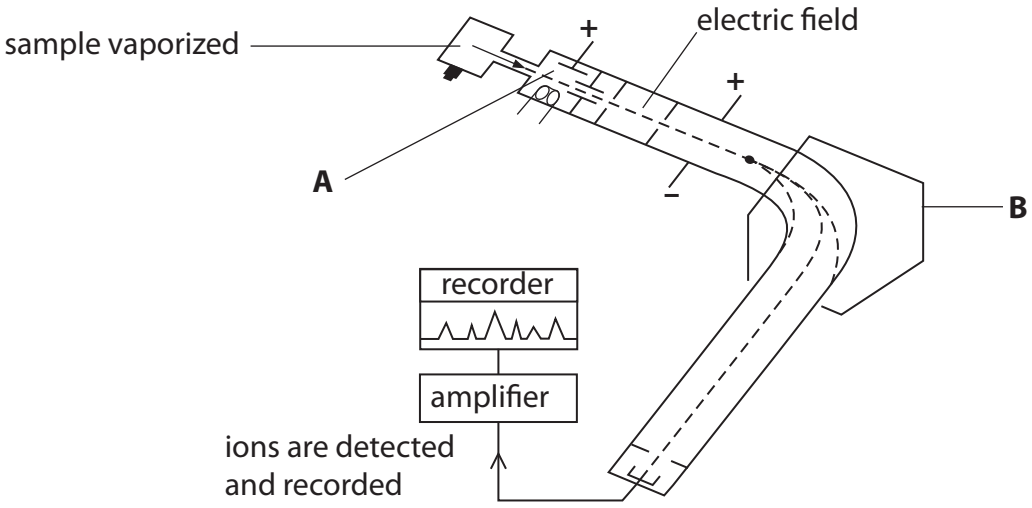
(a) Bromine has two isotopes, ^{79}Br and ^{81}Br. Explain the term **isotopes**, by reference to sub-atomic particles.

(1)

.....

.....

(b) The presence and abundance of these isotopes can be determined by using a mass spectrometer such as that shown in the diagram below.



(i) Explain how ions are produced in the area labelled **A**.

(2)

.....

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(ii) State what is used to deflect the ions moving through the mass spectrometer in the area labelled **B**.

(1)

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(iii) Explain why there is a vacuum in a mass spectrometer.

(1)

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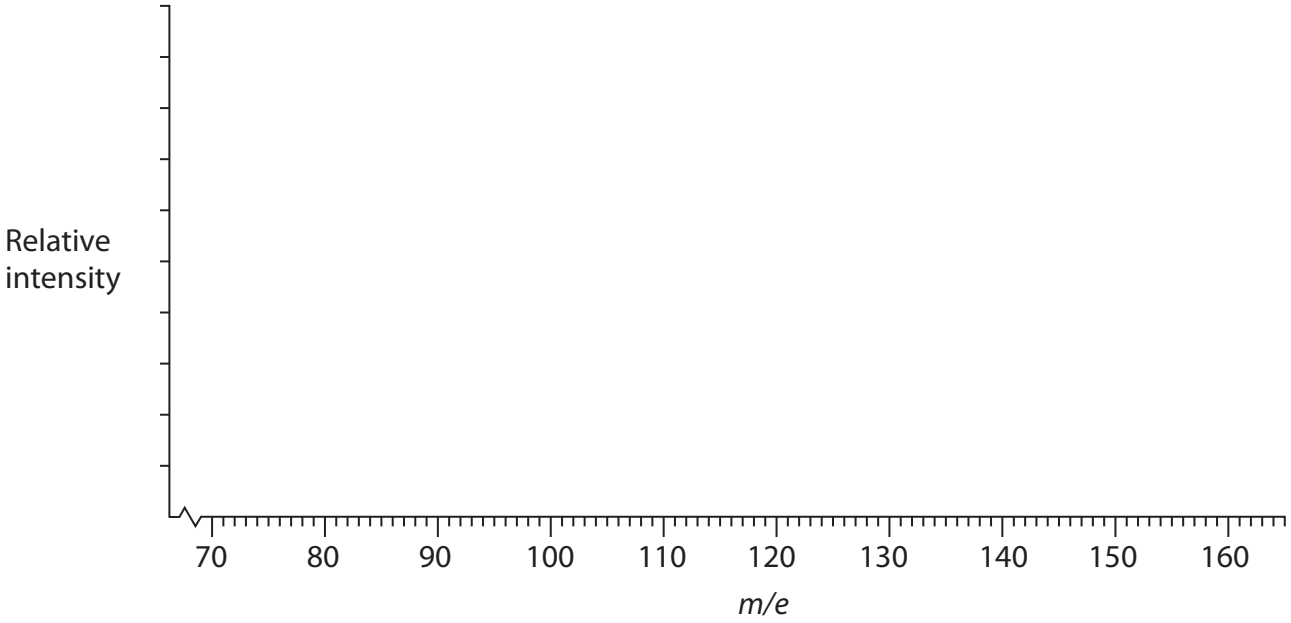
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(c) Complete the mass spectrum below for a sample of bromine **gas** that contains approximately half ^{79}Br isotope and half ^{81}Br isotope.

(4)



(d) Calculate the relative atomic mass of bromine for a sample which was found to contain 47.0% ^{79}Br and 53.0% ^{81}Br.

Give your answer to **three** significant figures.

(2)

(e) What would be the effect, if any, on the *m/e* value of the peak if the ion detected had lost two electrons rather than one electron?

(1)

.....

.....

P 4 4 8 7 9 A 0 1 2 2 4
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*(f) One of the uses of mass spectrometers is for the detection of banned substances, such as anabolic steroids, in a blood or urine sample taken from competitors in sports events.

(i) Suggest **two** precautions that are necessary to ensure that the result of any analysis would be valid.

(2)

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.....

.....

(ii) These substances can give competitors an unfair advantage. Suggest why the use of these substances may be of concern to the user.

(1)

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(g) Suggest **one** other use for mass spectrometers.

(1)

.....

.....

(Total for Question 17 = 16 marks)

P 4 4 8 7 9 A 0 1 3 2 4
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18 Alkenes and cycloalkanes have the same general formula, but react very differently with halogens.

(a) Give the general formula that applies to both alkenes and cycloalkanes.

(1)

(b) Using structural formulae, complete the overall equation for the reaction of an alkene of your own choice, containing fewer than four carbon atoms, with liquid bromine.

Name the product.

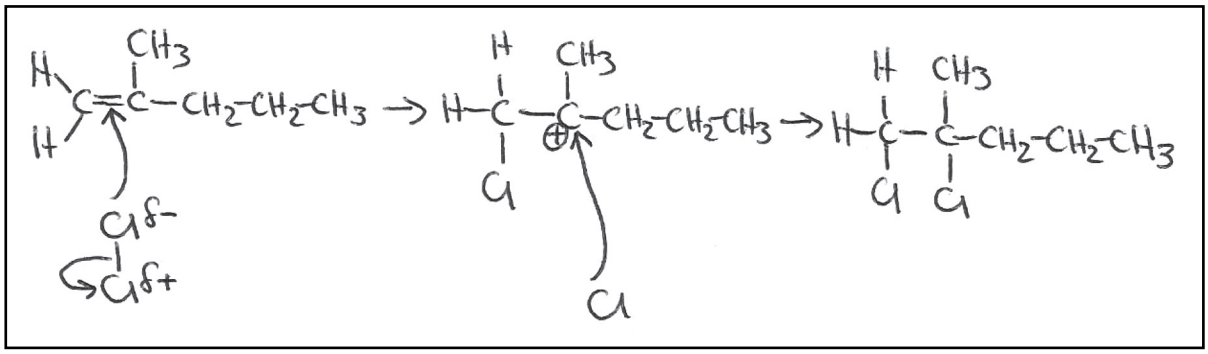
(3)

$$\quad + \quad Br_2 \quad \rightarrow$$

Name: .....

P 4 4 8 7 9 A 0 1 4 2 4
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*(c) An example of an alkene with six carbon atoms is 2-methylpent-1-ene. It reacts with chlorine by means of an electrophilic addition reaction. The diagram below shows a student's attempt at drawing the mechanism for this reaction.



(i) Identify the three errors in this student's drawing of the mechanism.

(3)

Error 1 .....

.....

Error 2 .....

.....

Error 3 .....

.....

(ii) The structure of the carbocation intermediate is correctly drawn. Explain why the positive charge is on the carbon atom shown.

(1)

.....

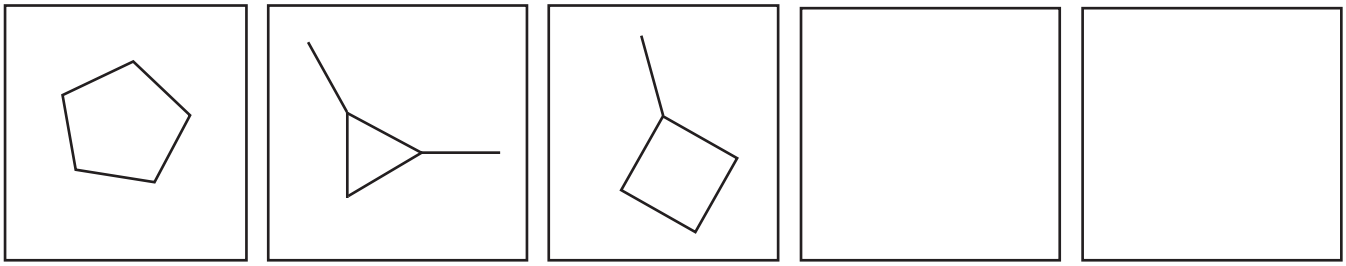
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(d) There are five possible cycloalkanes, each containing five carbon atoms. Three of the isomers are given below. Complete the other two boxes, by adding the skeletal formulae of the other two structural isomers.

(2)



(e) Define the term **structural isomerism**.

(1)

(f) Another example of a cycloalkane is cyclobutane. This compound, like other cycloalkanes, can also react with chlorine.

The overall reaction of cyclobutane with chlorine is as follows:

$$C_4H_8 + Cl_2 \rightarrow C_4H_7Cl + HCl$$

(i) This reaction can occur at room temperature and pressure.
What further condition is needed for this reaction to take place?

(1)

(ii) Using the appropriate arrows, complete the equation for the initiation step of the reaction mechanism for the reaction of chlorine with cyclobutane.

(2)

Cl — Cl →

P 4 4 8 7 9 A 0 1 6 2 4
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(iii) Using molecular formulae, write equations for the **two** propagation steps of this mechanism.

(2)

First propagation step:

Second propagation step:

(iv) Name the type of bond fission which occurs in these propagation steps.

(1)

.....

(v) There are also termination steps in this mechanism. Explain how these differ from the other steps in the mechanism and why these result in the reaction ending.

(2)

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(g) If the reaction with cyclobutane is carried out with an excess of chlorine, how are the products of the reaction affected?

(1)

.....

.....

(Total for Question 18 = 20 marks)

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19 Sodium and chlorine react together to produce sodium chloride. The bonding in the product is different from that in both of the reactants. Evidence for the type of bonding present can be obtained in a number of different ways.

(a) Draw the electron density map for a chlorine molecule to show covalent bonding.

(1)

(b) Sodium chloride is ionically bonded. What is meant by the term **ionic bond**?

(1)

.....

.....

.....

(c) Electrolysis is an experiment which you could carry out in a school or college laboratory on an aqueous solution of sodium chloride, to provide evidence for the presence of ionic bonding.

Draw a labelled diagram of the apparatus that you would use for this experiment, indicating how your results would show that the bonding was ionic.

(3)

P 4 4 8 7 9 A 0 1 8 2 4
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(d) Chlorine gains an electron when it reacts with sodium to form sodium chloride.

(i) Draw the dot and cross diagram of a chloride ion showing outer electrons only.

(1)

(ii) Give the formula of an ion from **Period 3** that is isoelectronic with the chloride ion.

(1)

.....

(e) Sodium and sodium chloride can both be good conductors of electricity.

Under what conditions do these substances conduct electricity?

Compare the method of conductivity in each case.

(3)

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.....

(Total for Question 19 = 10 marks)

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20 The reaction of calcium oxide with hydrochloric acid is an exothermic reaction.

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l)$$

In an experiment to investigate this reaction, the following procedure was carried out.

1. 50.0 cm^3 of hydrochloric acid, concentration 2.0 mol dm^{-3} (an excess), was pipetted into a polystyrene cup and the initial temperature measured using a thermometer with 0.5 °C graduations.

2. 1.46 g of calcium oxide powder was weighed out and added to the acid. The mixture was stirred and the maximum temperature measured.

Maximum temperature / °C	35.0
Initial temperature / °C	19.5

(a) Calculate the enthalpy change, in joules, for the quantities in this experiment. Assume that the specific heat capacity of the solution is 4.18 J g^{-1} C^{-1}.

Use the expression:

energy transferred in joules = 50.0 × specific heat capacity × temperature change

(1)

(b) Using your answer from (a), calculate the molar enthalpy change for the reaction between calcium oxide and hydrochloric acid. Include a sign and units in your answer.

(2)

P 4 4 8 7 9 A 0 2 0 2 4
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(c) The standard molar enthalpy change for the reaction between calcium oxide and hydrochloric acid is −196.8 kJ mol^{-1}.

(i) Suggest **three** reasons why the calculated value in part (b) is different from this value.

(3)

Reason 1 .....

.....

Reason 2 .....

.....

Reason 3 .....

.....

(ii) Using the standard enthalpy change of −196.8 kJ mol^{-1}, calculate the minimum mass of calcium oxide that would be needed to raise the temperature of 250 cm^3 of hydrochloric acid (an excess) by 25.0 °C.

(3)

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(d) The reaction of calcium carbonate with hydrochloric acid has the following standard molar enthalpy change.

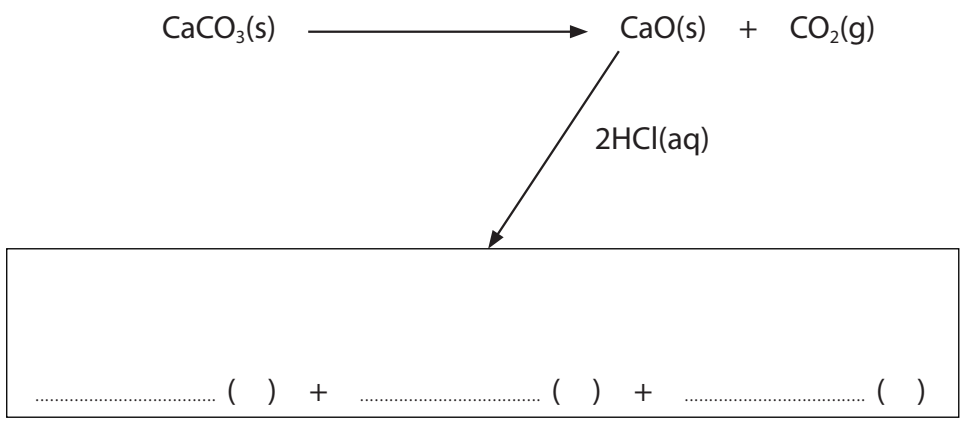
$$\Delta H^{\ominus} = -18.8 \text{ kJ mol}^{-1}$$

This value can be used, with the enthalpy change for the reaction of calcium oxide with hydrochloric acid, to determine the enthalpy change for the thermal decomposition of calcium carbonate. This cannot be measured directly.

(i) Complete the Hess energy cycle below by adding the missing arrow and entities.

Use the cycle, and the standard enthalpy change for the reaction of calcium oxide and hydrochloric acid (−196.8 kJ mol^{-1}), to determine the standard enthalpy change for the decomposition of calcium carbonate.

(4)



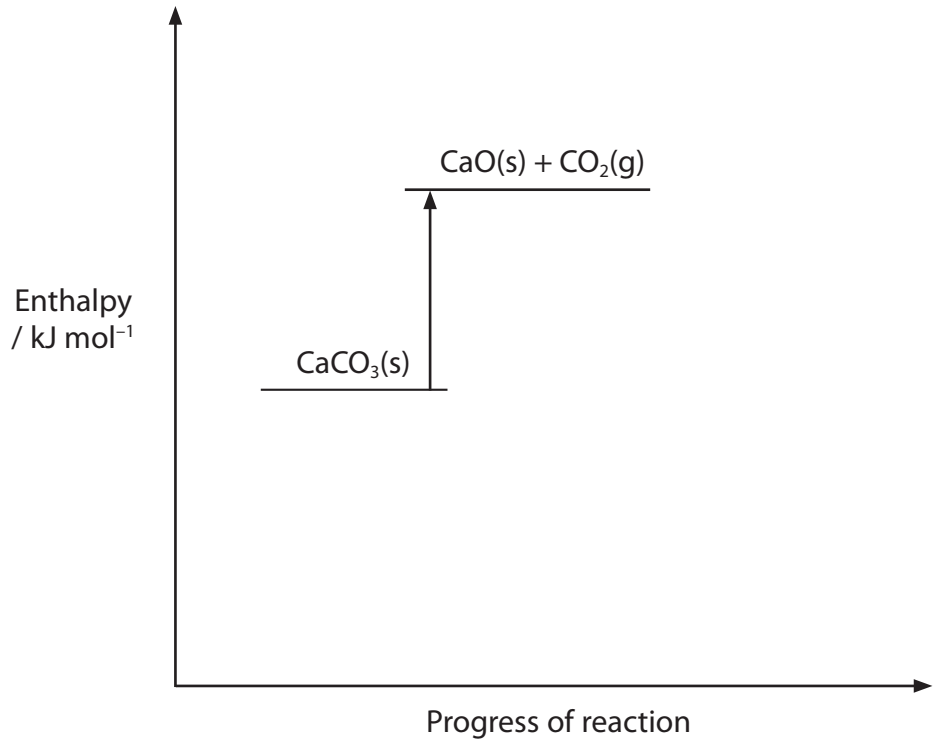
Enthalpy change = ... kJ mol^{-1}

P 4 4 8 7 9 A 0 2 2 4
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(ii) Complete and label the enthalpy level diagram below, for the series of reactions in (d)(i).

Your diagram does not have to be to scale.

(1)



(Total for Question 20 = 14 marks)

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

P 4 4 8 7 9 A 0 2 3 2 4
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The Periodic Table of Elements

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

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

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

* Lanthanide series

* Actinide series

P 4 4 8 7 9 A 0 2 4 2 4
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Mark Scheme (Results)

Summer 2015

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

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General Marking Guidance

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

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Section A (multiple choice)

Question Number	Correct Answer	Reject	Mark
1	B		1

Question Number	Correct Answer	Reject	Mark
2	C		1

Question Number	Correct Answer	Reject	Mark
3	D		1

Question Number	Correct Answer	Reject	Mark
4	C		1

Question Number	Correct Answer	Reject	Mark
5	B		1

Question Number	Correct Answer	Reject	Mark
6(a)	C		1

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

Question Number	Correct Answer	Reject	Mark
6(c)	A		1

Question Number	Correct Answer	Reject	Mark
7(a)	C		1

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

Question Number	Correct Answer	Reject	Mark
8	D		1

Question Number	Correct Answer	Reject	Mark
9	D		1

Question Number	Correct Answer	Reject	Mark
10	B		1

Question Number	Correct Answer	Reject	Mark
11	A		1

Question Number	Correct Answer	Reject	Mark
12	D		1

Question Number	Correct Answer	Reject	Mark
13	B		1

Question Number	Correct Answer	Reject	Mark
14(a)	D		1

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

Question Number	Correct Answer	Reject	Mark
15	A		1

Question Number	Correct Answer	Reject	Mark
16	A		1

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17(a)	(Atoms/elements/isotopes with) the same number of protons (and electrons) **and** different numbers of neutrons ALLOW answers in terms of bromine isotopes, 35 protons **and** 44 or 46 neutrons. IGNORE different number of nucleons IGNORE same atomic number but different mass number		1

Question Number	Acceptable Answers	Reject	Mark
17(b)(i)	(High energy) **electrons** are 'fired' at/ **Electrons** bombard/Use of an '**electron** gun' (1) (result in) loss of electron/electrons (thus forming an ion) This can be shown in an equation $X + e \rightarrow X^+ + 2e$ OR $X \rightarrow X^+ + e$ (1) Stand alone marks	Magnetic field (0) Forms an anion	2

Question Number	Acceptable Answers	Reject	Mark
17(b)(ii)	Magnet/Magnetic field/Electromagnet	Electric field Magnetic shield Magnetic radiation	1

Question Number	Acceptable Answers	Reject	Mark
17(b)(iii)	Particles (of gas/air) will interfere with the movement of the **ions**/collide with the **ions**/deflect **ions** OR Additional peaks will be detected/peaks at incorrect m/e IGNORE references to chemical reactions	Atoms for ions	1

Question Number	Acceptable Answers	Reject	Mark
17(c)	**Marking point 1** Twin peaks of about the same height at 79 and 81 (1) **Marking point 2** Twin peaks of about the same height at 158 and 162 (1) **Marking point 3** Peak at 160 (1) **Marking point 4** Peak at 160 approximately twice the height of the peaks at 158 and 162 (1) IGNORE **Small** peak at 80 which could be due to Br_2^{2+} (79-81) In MPs 1 and 2 penalise height difference once only		4

Question Number	Acceptable Answers	Reject	Mark
17(d)	$\left(\frac{47 \times 79) + (53 \times 81)}{100}\right) = 80.06$ (1) (answer =) 80.1 (1) Correct final answer without working scores (2) No TE on incorrect expression	Incorrect units of mass/%	2

Question Number	Acceptable Answers	Reject	Mark
17(e)	The (m/e) value would be **halved**	Peak half as high	1

Question Number	Acceptable Answers	Reject	Mark
17(f)(i)	Any two from: Sample kept sealed/ tamper-proof (1) Sample stored and labelled clearly (1) Sample stored in preservative/sample tested immediately after being taken (1) Sample kept under temperature control (1) Monitor sample is being taken from named competitor (1) Check that other non-banned substances do not give similar mass spectrometry result (1) Analysis repeated (to confirm result)/ Multiple samples taken/ Sample divided into two and tested at different times/ locations (1) Container/equipment sterile/cleaned (1) Run a control sample/ compare to a sample without drugs (1) Sampling to take place immediately after event (1) Precautions need to be **actions / activities** that are carried out and not just a statement that something must or must not happen but **how** this is ensured or prevented There will likely be other suggestions in addition to those given above which can be given credit if they are reasonable actions	References to medication being taken Just 'no contamination'	2

Question Number	Acceptable Answers	Reject	Mark
17(f)(ii)	Health concerns/depression/bursts of anger/ acts of violence/heart attack/strokes/liver damage/masculine features in women/ harmful side effects Allow any suitable health concern	Just 'Fear of being banned/prosecuted' Just 'side effects'	1

Question Number	Acceptable Answers	Reject	Mark
17(g)	Any suitable use such as: RAM/RMM calculations/Relative isotopic mass calculations/Space probes/ Pharmaceutical purity/testing of new pharmaceuticals/Age of rocks from Helium content/ Identification of unknown substances/ Carbon dating/Radioactive dating	Alcohol testing C-12 dating	1

TOTAL FOR QUESTION 17 = 16 MARKS

Question Number	Acceptable Answers	Reject	Mark
18(a)	C_nH_{2n} ALLOW any letter for n	C_2H_{2n} C_nH_{2n+2}	1

Question Number	Acceptable Answers	Reject	Mark
18(b)	Either one of the following options: $CH_2CH_2 + Br_2 \rightarrow CH_2BrCH_2Br$ 1,2-dibromoethane OR $CH_3CHCH_2 + Br_2 \rightarrow CH_3CHBrCH_2Br$ 1,2-dibromopropane **Marking Point 1** Correct reactant – ethene or propene (1) **Marking Point 2** Correct product from the number of carbon atoms in the reactant (1) **Marking Point 3** Correct name from the number of carbon atoms in the reactant (1) IGNORE punctuation on product ALLOW displayed/ skeletal formulae Penalise molecular formula of product only No TE on name if product incorrect		3

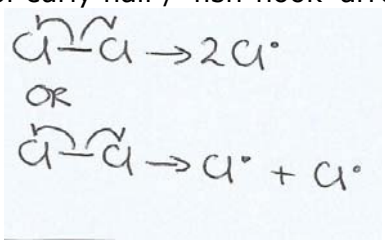
Question Number	Acceptable Answers	Reject	Mark
18(c)(i)	(Error 1) the dipole on the chlorine molecule should be the other way round (1) (Error 2) the arrow should be going from the double bond (to the chlorine)/electrons move from the double bond to the chlorine (1) (Error 3) the chlorine should have a **negative** charge (and a lone pair) (1)	Chlorine molecule	3

Question Number	Acceptable Answers	Reject	Mark
18(c)(ii)	Because **tertiary** carbocation is more stable (than a primary carbocation) OR the positive carbon has more **positively-inductive**/ **electron-releasing** alkyl groups (to help stabilization than the other carbon of the double bond) IGNORE references to carbon only having three bonds or being electron deficient	Just Secondary carbocation	1

Question Number	Acceptable Answers	Reject	Mark
18(d)	 OR  (1)  (1)		2

Question Number	Acceptable Answers	Reject	Mark
18(e)	Same molecular formula/same number of atoms/same amount of each element but different (Structural) arrangement (of atoms)/ structure/ structural formulae/ displayed formulae/ skeletal formulae	 'in space'	1

Question Number	Acceptable Answers	Reject	Mark
18(f)(i)	Ultraviolet (radiation)/ UV (radiation) / (Sun) light	High temperature	1

Question Number	Acceptable Answers	Reject	Mark
18(f)(ii)	Cl-Cl →2Cl● OR Cl-Cl →Cl● + Cl● (1) Correct use of curly half / 'fish-hook' arrows (1)  Curly half arrows can start from anywhere on the bond and extend beyond the Cl The half arrows can be above or below the bond or a combination of the two.		2

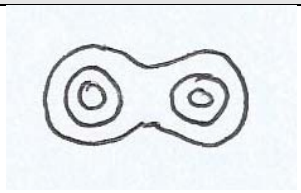
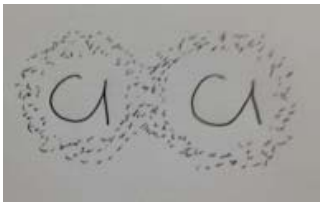
Question Number	Acceptable Answers	Reject	Mark
18(f)(iii)	(First propagation step) $C_4H_8 + Cl\bullet \rightarrow HCl + C_4H_7\bullet$ (1) (Second propagation step) $C_4H_7\bullet + Cl_2 \rightarrow C_4H_7Cl + Cl\bullet$ (1) The position of ● is not essential Penalise lack of ● once only	Reference to H/ H● scores (0)	2

Question Number	Acceptable Answers	Reject	Mark
18(f)(iv)	Homolytic/ homolytic fission/ homolytic bond fission		1

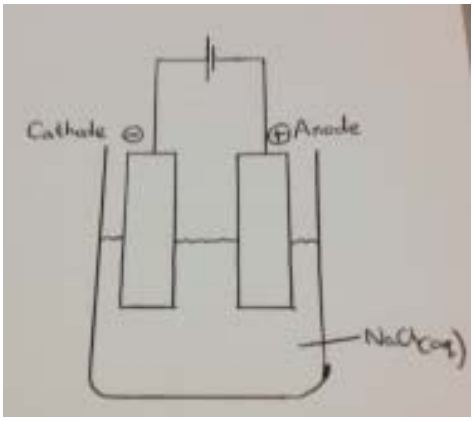
Question Number	Acceptable Answers	Reject	Mark
18(f)(v)	**Marking point 1** **Two** free radicals are combining/reacting with each other/suitable termination equation (1) **Marking point 2** The product is a stable species/No free radicals produced/ The product is not a free radical/ Concentration of free radicals decreases / lowers the number of radicals (1)		2

Question Number	Acceptable Answers	Reject	Mark
18(g)	Further substitution/polysubstitution can occur OR Other products such as $C_4H_6Cl_2$/ $C_4H_5Cl_3$ **COMMENT:** ALLOW Forms C_4Cl_8		1

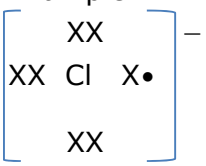
(TOTAL FOR QUESTION 18 =20 MARKS)

Question Number	Acceptable Answers	Reject	Mark
19(a)	 Drawing must have at least 1 circle around each chlorine atom OR  Random dots to indicate electron density around both chlorine atoms and a concentrated area between the atoms		**1**

Question Number	Acceptable Answers	Reject	Mark
19(b)	(Electrostatic) **attraction** between oppositely charged ions IGNORE comments on the formation of ions		**1**

Question Number	Acceptable Answers	Reject	Mark
19(c)	**Marking point 1** Either Diagram of U-tube / beaker with electrodes and sodium chloride solution OR Diagram of microscope slide with electrodes attached and either filter paper soaked in sodium chloride solution or dampened/wet filter paper on the top of the slide with the sample added (in the centre) (1) **Marking point 2** Suitable circuit (1) If electrodes labelled ± or named they must be consistent with the cell For example the following would not score this marking point:  **Marking point 3** Ammeter/ light bulb showing conductivity OR Chlorine (gas) evolved/ Test for chlorine/hydrogen (gas) evolved/Test for hydrogen (1) ALLOW any other reasonable electrolysis apparatus that would work to show ionic bonding. For MP3 if the electrode at which the gas is	Sodium electrode Sodium formed	**3**

	evolved is stated then it must have the correct sign or charge, although it is not necessary to name or give a sign for the electrode, ie chlorine at the electrode with a positive sign and hydrogen at the electrode with a negative sign. Use of other ionic compounds can only score MP2		

Question Number	Acceptable Answers	Reject	Mark
19(d)(i)	Correct dot and cross diagram with charge Example  ALLOW all dots or all crosses IGNORE any sodium dot and cross diagram		**1**

Question Number	Acceptable Answers	Reject	Mark
19(d)(ii)	(Isoelectronic example) $S^{2-}/S^{-2}/P^{3-}/P^{-3}$	$Si^{4-}/K^{+}/Ca^{2+}$/Ar	**1**

Question Number	Acceptable Answers	Reject	Mark
19(e)	**Marking point 1** Sodium conducts when solid (and liquid/molten) (1) **Marking point 2** Sodium chloride conducts when molten (and in solution but not as a solid) (1) **Marking point 3** Charge carriers in sodium are (delocalised) electrons but ions in sodium chloride OR Conductivity in sodium due to the movement of (delocalised) electrons but the movement of ions in sodium chloride (1)	Sodium in solution/dissolved	**3**

(TOTAL FOR QUESTION 19 = 10 MARKS)

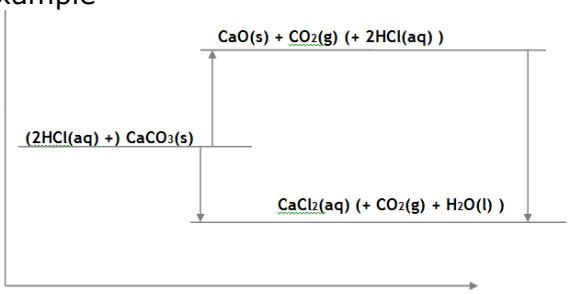
Question Number	Acceptable Answers	Reject	Mark
20(a)	(50 x 4.18 x 15.5 =) 3239.5 (J) IGNORE any sign given ALLOW 3.2395 kJ (units are essential for this answer)		**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)	(1.46 ÷ 56.1 =) 0.026025.. (mol) (1) (ΔH = 3.2395 ÷ 0.026025 = −124.47…) −124 kJ mol^{-1} (1) OR (1.46 ÷ 56.1 =) 0.0260 (mol) (1) (ΔH = 3.2395 ÷ 0.0260 = −124.596154) −125 kJ mol^{-1} (1) ALLOW the use of CaO = 56 = (−124.255 kJ mol^{-1}) −124 kJ mol^{-1} ALLOW TE from answer to (a)	+ sign	**2**

Question Number	Acceptable Answers	Reject	Mark
20(c)(i)	Any three reasons from: Heat/energy loss (to the surroundings / to the apparatus)/ Lack of lid/no lid/ heat capacity of the cup not taken into account/heat capacity of the cup is not zero (1) Inaccuracy of thermometer/temperature readings (1) Impure CaO/Absorbed moisture from the air (1) Heat capacity is not 4.18/ the mass of solution is not 50 g/ density of solution is not 1 g cm^{-3} (1) IGNORE non-standard conditions/ stirring/human error/incomplete transfer of solid	Incomplete reaction Just 'heat lost to the thermometer'	**3**

Question Number	Acceptable Answers	Reject	Mark
20(c)(ii)	**Marking point 1** (Q=(250 x 4.18 x 25) = 26125(J) OR (26125 ÷ 1000 =) 26.125 (kJ) (1) **Marking point 2** (n = 26.125 ÷ 196.8 =) 0.132749 (mol) (1) **Marking point 3** Mass = (0.132749 x 56.1 =) 7.4472189 = 7.45 (g) (1) ALLOW (0.132749 x 56 =) 7.433944 = 7.43 (g) Correct answer alone scores 3 marks	7.5	3

Question Number	Acceptable Answers	Reject	Mark
20(d)(i)	**Marking point 1** Arrow downwards from $CaCO_3$ to the box, with 2HCl((aq)) alongside (1) **Marking point 2** Correct entities and states in box $CaCl_2(aq) + H_2O(l) + CO_2(g)$ (1) **Marking point 3** Correct use of Hess' Law ($\Delta H = \Delta H_{CaCO3} - \Delta H_{CaO}$) e.g. $-18.8 - -196.8 =$ (1) **Marking point 4** $\Delta H = +178$(kJ mol^{-1}) (1)		4

Question Number	Acceptable Answers	Reject	Mark
20(d)(ii)	Products on line below $CaCO_3(s)$ with both arrows going down from $CaCO_3$ and CaO Example  ALLOW the word 'products' for formulae		1

(Total for Question 20 = 14 marks)

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

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Write your name here

Surname	Other names

Pearson Edexcel GCE

Centre Number | Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 23 May 2014 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

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6/6/6/5/

P 4 2 9 7 0 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 correct sequence for the processes that occur in a mass spectrometer is

☒ **A** vaporization, ionization, acceleration, deflection and detection.

☒ **B** vaporization, acceleration, ionization, deflection and detection.

☒ **C** ionization, vaporization, acceleration, deflection and detection.

☒ **D** ionization, vaporization, deflection, acceleration and detection.

(Total for Question = 1 mark)

---

2 Which of the following ions would be deflected **most** in a mass spectrometer?

☒ **A** $^{35}Cl^{+}$

☒ **B** $^{37}Cl^{+}$

☒ **C** $^{37}Cl^{2+}$

☒ **D** $(^{35}Cl —^{37}Cl)^{+}$

(Total for Question 2 = 1 mark)

---

3 A particle with a **single** positive charge and with the electronic configuration $1s^2\ 2s^2\ 2p^6$ is

☒ **A** a sodium ion.

☒ **B** a fluoride ion.

☒ **C** an oxide ion.

☒ **D** a potassium ion.

(Total for Question 3 = 1 mark)

P 4 2 9 7 0 A 0 2 2 4
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4 In which of the following electronic configurations are only two of the electrons unpaired?

☒ **A** $1s^2\ 2s^2$

☒ **B** $1s^2\ 2s^2\ 2p^3$

☒ **C** $1s^2\ 2s^2\ 2p^4$

☒ **D** $1s^2\ 2s^2\ 2p^5$

(Total for Question 4 = 1 mark)

5 Which of the following contains a dative covalent bond?

☒ **A** N_2

☒ **B** NH_3

☒ **C** NH_2^-

☒ **D** NH_4^+

(Total for Question 5 = 1 mark)

6 Which of the following ions has the **largest** ionic radius?

☒ **A** F^-

☒ **B** Mg^{2+}

☒ **C** Na^+

☒ **D** O^{2-}

(Total for Question 6 = 1 mark)

7 Which of the following observations provides the best evidence for the presence of ionic bonding in an unknown substance?

The substance conducts electricity

☒ **A** in the solid state.

☒ **B** in the solid state and in aqueous solution.

☒ **C** in the solid state and when molten.

☒ **D** when molten but not in the solid state.

(Total for Question 7 = 1 mark)

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8 Which of the following can be determined, for an unknown alkene, using **only** percentage composition by mass data?

☒ **A** Molecular formula

☒ **B** Empirical (simplest) formula

☒ **C** Both the molecular formula and the empirical (simplest) formula

☒ **D** Structural formula

(Total for Question 8 = 1 mark)

---

9 1.12 g of iron reacts with oxygen to form 1.60 g of an oxide of iron.
Use relative atomic masses: Fe = 56, O = 16.

What is the formula of this oxide of iron?

☒ **A** FeO_5

☒ **B** Fe_2O_{10}

☒ **C** Fe_3O_2

☒ **D** Fe_2O_3

(Total for Question 9 = 1 mark)

---

10 In an experiment, 1.226 g of potassium chlorate(V), $KClO_3$, was heated. A mass of 0.320 g of oxygen gas, O_2, was collected.

$$2KClO_3(s) \rightarrow 2KCl(s) + 3O_2(g)$$

Use the molar mass of $KClO_3$ = 122.6 g mol^{-1} and relative atomic mass O = 16.

The percentage yield of oxygen in this experiment is

☒ **A** 17.4%

☒ **B** 26.1%

☒ **C** 66.7%

☒ **D** 100%

(Total for Question 10 = 1 mark)

P 4 2 9 7 0 A 0 4 2 4
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11 Oxygen gas, O_2, can be converted into ozone, O_3, by passing it through an electric discharge.

$$3O_2(g) \rightarrow 2O_3(g)$$

In an experiment, a volume of 300 cm^3 of oxygen was used but only 10% of the oxygen was converted into ozone. All volumes were measured at the same temperature and pressure.

The **total** volume of gas present at the end of the experiment, in cm^3, was

☒ **A** 200

☒ **B** 210

☒ **C** 290

☒ **D** 300

(Total for Question 11 = 1 mark)

12 1.40 g of an alkene gave 3.77 g of a dichloroalkane on reaction with chlorine.

What is the molecular formula of the alkene?

☒ **A** C_2H_4

☒ **B** C_3H_6

☒ **C** C_4H_8

☒ **D** C_6H_{12}

(Total for Question 12 = 1 mark)

13 The standard enthalpy change for the combustion of graphite is –393.5 kJ mol^{-1} and that of diamond is –395.4 kJ mol^{-1}.

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

$$C(s, \text{graphite}) \rightarrow C(s, \text{diamond})$$

☒ **A** –1.9

☒ **B** +1.9

☒ **C** –788.9

☒ **D** +788.9

(Total for Question 13 = 1 mark)

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14 The standard enthalpy change of neutralization when an acid reacts with an alkali is the number of kilojoules released by the

☒ **A** formation of one mole of salt.

☒ **B** formation of one mole of water.

☒ **C** neutralization of one mole of acid.

☒ **D** neutralization of one mole of alkali.

(Total for Question 14 = 1 mark)

15 Consider the following bond enthalpy values.

Bond	Bond enthalpy / kJ mol^{-1}
O—O	+146
O—H	+463
O═O	+496

For the reaction

$$H—O—O—H(g) \rightarrow H—O—H(g) + \tfrac{1}{2}O═O(g)$$

the enthalpy change, in kJ mol^{-1}, is

☒ **A** –102

☒ **B** +102

☒ **C** +350

☒ **D** +394

(Total for Question 15 = 1 mark)

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

P 4 2 9 7 0 A 0 6 2 4
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16 Using the data in the table below, calculate the standard enthalpy change, in kJ mol^{-1}, for the reaction between carbon disulfide, CS_2, and oxygen shown in the following equation.

$$CS_2(g) + 3O_2(g) \rightarrow CO_2(g) + 2SO_2(g)$$

Substance	Standard enthalpy change of formation, $\Delta H_f^{\ominus}$ / kJ mol^{-1}
$CS_2(g)$	+110
$CO_2(g)$	−390
$SO_2(g)$	−290

☒ **A** −570

☒ **B** −790

☒ **C** −860

☒ **D** −1080

(Total for Question 16 = 1 mark)

---

17 (a) Which of the following represents a step in the mechanism during the reaction between ethene and hydrogen bromide?

(1)

☒ **A** $C_2H_4 + Br^+ \rightarrow C_2H_4Br^+$

☒ **B** $C_2H_4 + HBr \rightarrow C_2H_5^+ + Br^-$

☒ **C** $C_2H_4 + HBr \rightarrow C_2H_5^{\bullet} + Br^{\bullet}$

☒ **D** $C_2H_4 + HBr \rightarrow C_2H_4Br^- + H^+$

(b) The mechanism of the reaction between ethene and hydrogen bromide is

(1)

☒ **A** electrophilic addition.

☒ **B** electrophilic substitution.

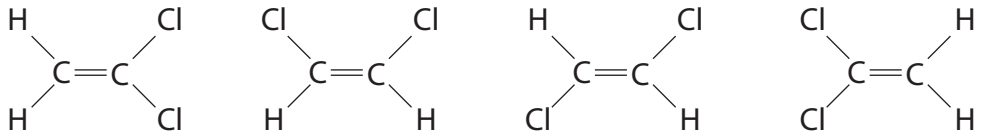
☒ **C** nucleophilic addition.

☒ **D** nucleophilic substitution.

(Total for Question 17 = 2 marks)

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18 Which of the following pairs are *cis-trans* isomers?

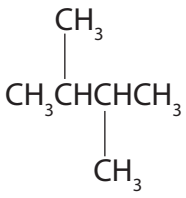


1 **2** **3** **4**

- ☒ **A** **1** and **2**
- ☒ **B** **1** and **4**
- ☒ **C** **2** and **3**
- ☒ **D** **3** and **4**

(Total for Question 18 = 1 mark)

19 What is the systematic name for the hydrocarbon shown below?



- ☒ **A** 1,4-dimethylbutane
- ☒ **B** 2,3-dimethylbutane
- ☒ **C** 2,3-dimethylhexane
- ☒ **D** 1,1,2,2-tetramethylethane

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

20 Crude oil is composed mainly of alkanes, which are saturated hydrocarbons.

(a) (i) Define the term **hydrocarbon**.

(1)

.....

.....

(ii) State what is meant by the term **saturated**, as applied to a hydrocarbon.

(1)

.....

.....

(b) Crude oil can be separated into fractions.

(i) What property allows crude oil to be separated by fractional distillation?

(1)

.....

.....

(ii) Many chemists are of the opinion that we should use fuels such as biodiesel rather than petrol and diesel.

Suggest **one** reason to support this opinion.

(1)

.....

.....

.....

.....

P 4 2 9 7 0 A 0 1 0 2 4
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(c) A molecule of a hydrocarbon, **X**, can be cracked to form one molecule of pentane, C_5H_{12}, and two molecules of ethene only.

(i) Deduce the molecular formula of **X**.

(1)

(ii) Give **one** reason why cracking reactions are carried out in industry and suggest why high temperatures are used in this process other than to speed up the reaction.

(2)

(d) Butane, C_4H_{10}, is a hydrocarbon which is used as a fuel. It is a gas under standard conditions.

(i) Explain what is meant by the term **fuel**.

(1)

(ii) Write an equation for the **complete** combustion of butane under standard conditions. Include state symbols in your answer.

(2)

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(iii) Write an equation for the **incomplete** combustion of butane to form carbon monoxide and water only. State symbols are not required.

(1)

(iv) Under what conditions would you expect incomplete combustion to occur?

(1)

.....

.....

(e) Butane can react with bromine, in the presence of ultraviolet radiation, according to the following equation.

$$C_4H_{10} + Br_2 \rightarrow C_4H_9Br + HBr$$

(i) Calculate the atom economy by mass for the formation of C_4H_9Br.
Use the expression

$$\text{atom economy} = \frac{\text{molar mass of the desired product}}{\text{sum of the molar masses of all products}} \times 100\ \%$$

Use the Periodic Table as a source of data.

(2)

Final answer.....%

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*(ii) Describe the mechanism of the reaction between butane and bromine that forms the products given in the equation below.

$$C_4H_{10} + Br_2 \rightarrow C_4H_9Br + HBr$$

In your answer you should include

- equations for each step of the mechanism (curly arrows are **not** required)
- the name of each step occurring in the mechanism.

(7)

(Total for Question 20 = 21 marks)

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21 Lattice energies can be calculated from experimental data using Born-Haber cycles.

In the table below are the enthalpy changes needed to calculate the lattice energy of sodium oxide, Na_2O.

Letter	Enthalpy change	Value / kJ mol^{-1}
A	1st electron affinity of oxygen	–141
B	2nd electron affinity of oxygen	+790
C	1st ionization energy of sodium	+496
D	enthalpy change of atomization of sodium	+108
E	enthalpy change of atomization of oxygen, $\frac{1}{2}O_2(g)$	+249
F	enthalpy change of formation of sodium oxide	–414
G	lattice energy of sodium oxide	

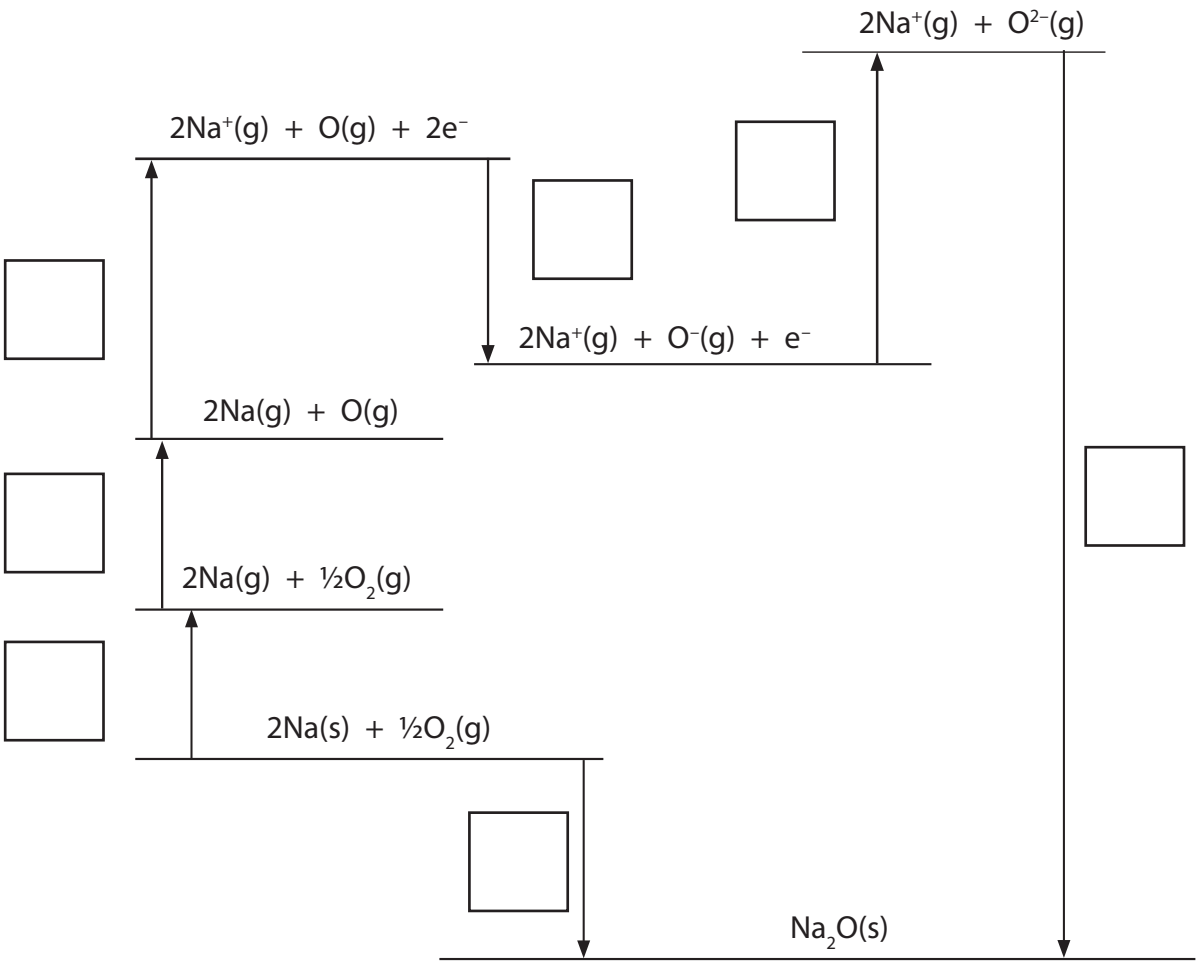
(a) Define the term **lattice energy**.

(2)

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(b) (i) Write the correct letters from the table of data to label the Born-Haber cycle below.

(3)



(ii) Calculate the lattice energy of sodium oxide, enthalpy change **G**, in kJ mol^{-1}.

(2)

Answer = ... kJ mol^{-1}

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*(c) Predict whether the lattice energy of magnesium oxide, MgO, is more or less exothermic than the lattice energy of magnesium sulfide, MgS.

Justify your answer in terms of the sizes and the charges of the ions involved.

(4)

(Total for Question 21 = 11 marks)

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22 Nickel is an element in the d-block of the Periodic Table.

(a) Complete the electronic configuration of a nickel atom using the s, p, d notation.

(1)

$1s^2$ .....

(b) A sample of nickel is made up of three isotopes. The percentage abundances are shown in the table below.

Isotope	Percentage abundance
^{58}Ni	69.02
^{60}Ni	27.32
^{62}Ni	3.66

Calculate the relative atomic mass of nickel. Give your answer to **two** decimal places.

(2)

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(c) Nickel reacts with carbon monoxide, CO, to give the compound nickel carbonyl, $Ni(CO)_4$.

$$Ni(s) + 4CO(g) \rightarrow Ni(CO)_4(g)$$

(i) Calculate the volume of carbon monoxide, in dm^3, measured at room temperature and pressure, that is required to react completely with 5.87 g of nickel.

[Relative atomic mass: Ni = 58.7
Molar volume of a gas = 24 dm^3 mol^{-1} at room temperature and pressure.]

(3)

(ii) Calculate the **number** of carbon monoxide molecules present in the volume of gas you have calculated in (c)(i).

[The Avogadro constant, $L = 6.02 \times 10^{23}$ mol^{-1}]

(1)

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(d) Nickel(II) nitrate, $Ni(NO_3)_2$, can be made by several different methods.

Method 1

Nickel(II) oxide, NiO, was reacted with dilute nitric acid according to the equation

$$NiO(s) + 2HNO_3(aq) \rightarrow Ni(NO_3)_2(aq) + H_2O(l)$$

(i) Calculate the volume of 2.00 mol dm^{-3} dilute nitric acid, in cm^3, that was required to exactly neutralize 1.494 g of nickel(II) oxide.

Use the relative atomic masses: Ni = 58.7, O = 16.0

(3)

Method 2

A volume of 25.0 cm^3 of 2.00 mol dm^{-3} nitric acid, HNO_3, was transferred to a beaker. Solid nickel(II) carbonate, $NiCO_3$, was added until it was in excess.

(ii) Why was **excess** nickel(II) carbonate used?

(1)

.....

.....

(iii) Why must the beaker be **much** larger than the volume of acid used?

(1)

.....

.....

.....

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(iv) Write a balanced equation for the reaction between nickel(II) carbonate and dilute nitric acid, including state symbols.

(2)

*(v) For **Method 2**, describe the practical steps that you would take to obtain pure dry crystals of hydrated nickel(II) nitrate, $Ni(NO_3)_2.6H_2O$, from a mixture of nickel(II) nitrate solution and unreacted solid nickel(II) carbonate.

(4)

(Total for Question 22 = 18 marks)

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23 This question concerns the Periodic Table.

(a) An atom of argon has mass number 40. Complete the table below showing the numbers of sub-atomic particles in this atom of argon. Use the Periodic Table as a source of data.

(1)

Sub-atomic particles present in one atom of ^{40}Ar	Number
protons	
electrons	
neutrons	

(b) An atom of potassium has mass number 39. Explain why argon is placed before potassium in the modern Periodic Table.

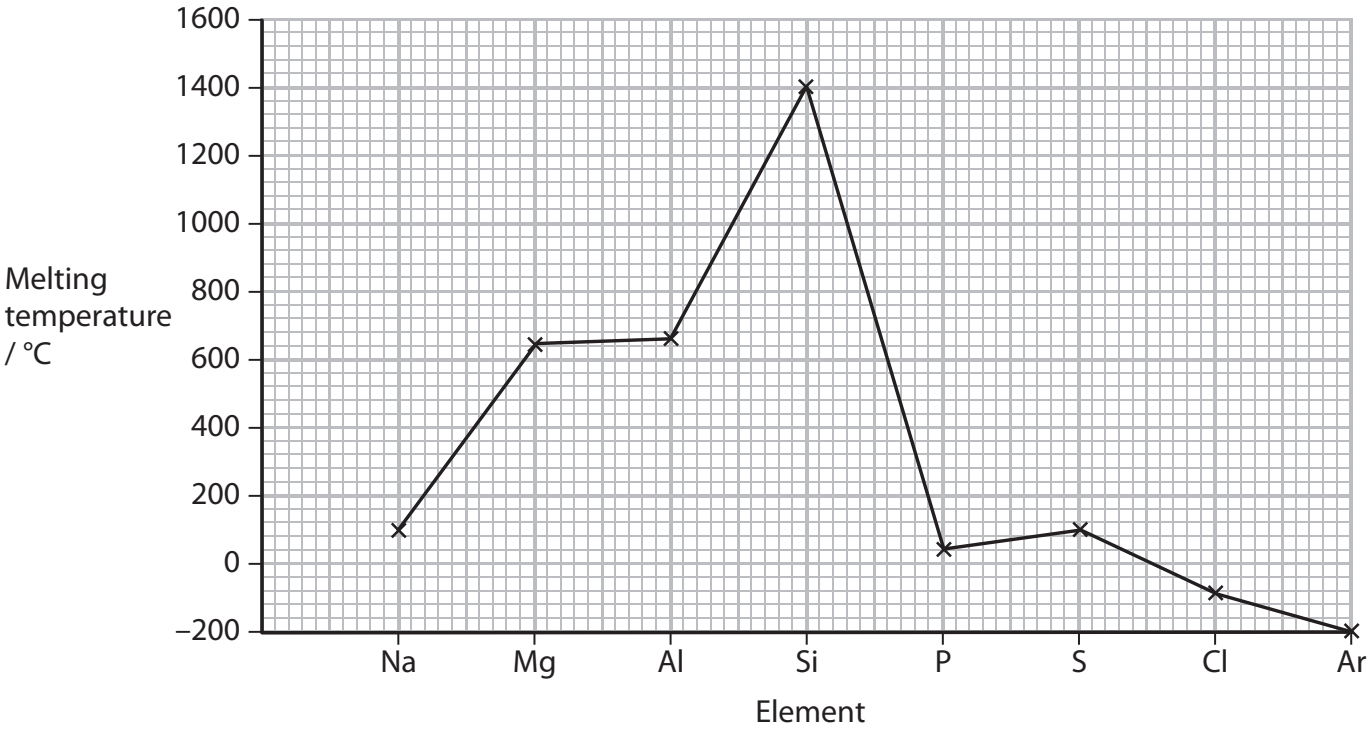
(1)

(c) In the context of the Periodic Table, explain what is meant by the term **periodicity**.

(2)

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



(i) Name **one** of the elements above that is composed of **simple molecules** at room temperature and pressure.

(1)

.....

(ii) Silicon has a giant atomic structure. Explain how this structure results in the high melting temperature shown on the graph.

(2)

.....

.....

.....

.....

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(iii) Explain why the melting temperature of magnesium is higher than that of sodium.

(3)

(Total for Question 23 = 10 marks)

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

P 4 2 8 7 0 A 0 2 3 2 4
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The Periodic Table of Elements

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

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

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

* Lanthanide series

* Actinide series

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Mark Scheme (Results)
Summer 2014

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

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General Marking Guidance

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

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

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

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

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

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

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

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

Section A

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Total for Section A: 20 marks

Section B

Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	(Compound of) carbon and hydrogen **ONLY/ENTIRELY/PURELY**	"**Mixture** of carbon and hydrogen only"	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (a)(ii)	(Contains) **only** (C—C) single bonds/ **only** σ bond(s) OR (Contains) no (C=C) double bond(s)/no triple bond(s) OR Cannot undergo addition (reactions) ALLOW Has maximum number of hydrogen atoms / has maximum amount of hydrogen /can form no more bonds IGNORE references to alkanes		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(i)	**Boiling** point(s) / **boiling** temperatures / **boiling** ranges ALLOW Different sizes of molecules / different chain lengths / different numbers of carbon atoms IGNORE References to melting points / melting temperatures / condensing	**Just** 'different temperatures' Breaking of hydrocarbon chains	**1**

Question Number	Acceptable Answers	Reject	Mark
20 (b)(ii)	Save fossil fuels / saves finite resources / saves petrol / saves diesel OR More sustainable OR Uses renewable resources / biodiesel made from 'natural resources' OR Biodiesel is a renewable fuel OR Plants (more) carbon neutral / use of plants improves carbon footprint (of fuel) OR Biodiesel has smaller carbon footprint / zero carbon footprint OR Biodiesel (more) carbon neutral ALLOW Reverse argument for petrol / 'normal' diesel (eg crude oil is non-renewable) IGNORE Less impact on the environment / references to 'environmentally friendly' / less polluting / acid rain IGNORE References to 'global warming' or 'Greenhouse Effect' or 'climate change'.		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	**C_9H_{20}** IGNORE Any structures drawn out		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	**First mark:** Any ONE of:- (Greater) demand for smaller molecules / (Greater) demand for smaller alkanes / (Greater) demand for alkenes / To make more useful products / To make more reactive product / To make smaller molecules / To make shorter molecules / To make alkenes / To make shorter chains NOTE: ALLOW 'To produce fuel(s)' **(1)** **Second mark:** (High temperatures needed to) **break** (the C-C and / or C-H) **bonds** OR To break (down) the (hydrocarbon) chain(s) / To break (down) the molecule(s) / To split the molecule(s) / To break the hydrocarbon OR (Reaction is) endothermic ALLOW To overcome the (high) activation energy / the reaction has a high activation energy / provide activation energy IGNORE C-C bond is stable References to increasing rate (of reaction) References to yield / equilibrium References to efficiency / producing less CO **(1)** **Marks are stand-alone**	**No 2nd mark if any of the following are mentioned:** **Separation** of molecules Breaking **intermolecular** forces References to (high) boiling temperatures / (high) boiling points References to (high) melting temperatures / (high) melting points	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(i)	(Substance that) produces **energy** or produces **heat** IGNORE:- References to 'power' References to **just** 'exothermic' References to burning or combustion or heating the fuel or reference to oxygen		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (d)(ii)	$C_4H_{10}(g) + 6½O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ OR $C_4H_{10}(g) + 6.5O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ OR $C_4H_{10}(g) + \frac{13}{2} O_2(g) \rightarrow 4CO_2(g) + 5H_2O(l)$ OR $2C_4H_{10}(g) + 13\ O_2(g) \rightarrow 8CO_2(g) + 10H_2O(l)$ OR Any other correct multiples Correct species **(1)** Balancing and state symbols correct **(1)** 2nd mark is dependent on the 1st mark	H_2O(**g**) C_4H_{10}(**l**)	**2**

Question Number	Acceptable Answers	Reject	Mark
20(d)(iii)	$C_4H_{10} + 4½O_2 \rightarrow 4CO + 5H_2O$ OR $C_4H_{10} + 4.5\ O_2 \rightarrow 4CO + 5H_2O$ OR $C_4H_{10} + \frac{9}{2} O_2 \rightarrow 4CO + 5H_2O$ OR $2C_4H_{10} + 9\ O_2 \rightarrow 8CO + 10H_2O$ OR Any other correct multiples IGNORE State symbols even if incorrect		**1**

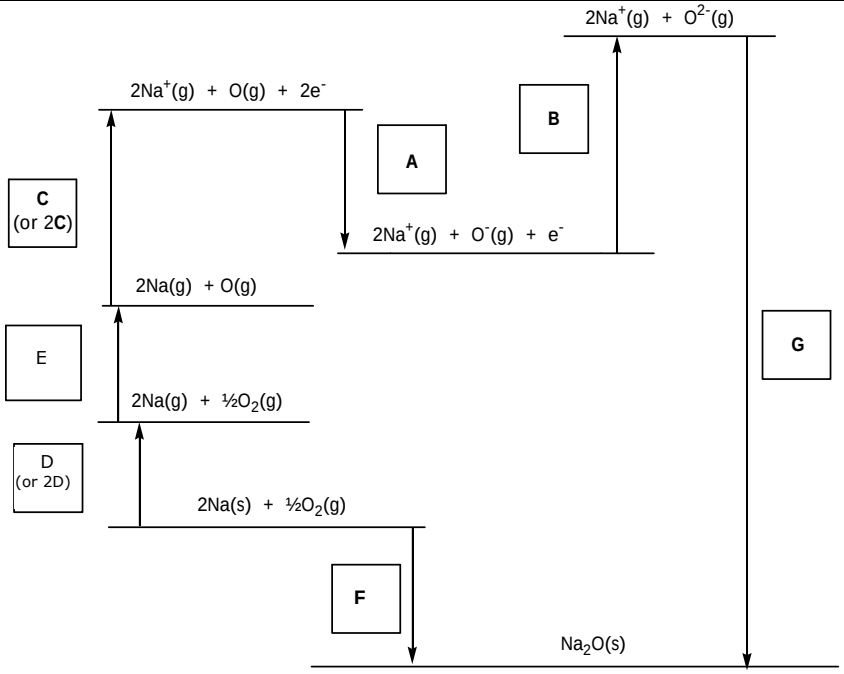
Question Number	Acceptable Answers	Reject	Mark
20(d)(iv)	Limited (supply of) air / oxygen OR insufficient (supply of) air / oxygen OR Oxygen / air not in excess OR Not enough air / not enough oxygen ALLOW 'Lack of oxygen' / lack of ventilation IGNORE "It is not completely oxidized"	'**no** air' / '**no** oxygen'	**1**

Question Number	Acceptable Answers	Reject	Mark
20(e)(i)	**First mark** Calculation of the sum of the M_r values of all the products = **217.8** If using Br = 80, M_r = 218 **(1)** **Second mark** Calculation of % atom economy using value of total M_r **[** = $\frac{136.9}{217.8}$ (x 100%) **]** = 62.856 (%) **(1)** NOTE If using Br = 80, final answer = 62.844 (%) ALLOW ECF for the 2nd mark on an incorrect total M_r value IGNORE sf except 1 sf Correct answer with no working **(2)** **Check rounding of answer** **NOTE** **If one error only is made, (1) mark awarded**	For M_r = **217.8**, **62.8**% (no 2nd mark, as this is a rounding error)	**2**

Question Number	Acceptable Answers	Reject	Mark
***20(e)(ii)**	**First mark:** **Initiation** (step) **(1)** **Second mark:** Br—Br → Br• + Br• / Br_2 → 2Br• **(1)** **Third mark:** **Propagation** (steps) **(1)** **Fourth and fifth marks:** Br• + C_4H_{10} → C_4H_9• + HBr **(1)** Br_2 + C_4H_9• → C_4H_9Br + Br• **(1)** Allow in either order **Sixth mark:** **Termination (**step(s) **(1)** **Seventh mark:** **Any one of** Br• + Br• → Br_2 OR C_4H_9• + Br• → C_4H_9Br OR C_4H_9• + C_4H_9• → C_8H_{18} **(1)**	H• (the fourth and fifth marks cannot be awarded if H• appears in **either** propagation step)	**7**

(Total for Question 20 = 21 marks)

Question Number	Acceptable Answers	Reject	Mark
21(a)	(The energy / enthalpy change that accompanies the formation of) **one mole** of a(n ionic) compound **(1)** ALLOW as alternative for compound: lattice /crystal / substance / solid / product / salt from (its) **gaseous ions** **(1)** IGNORE References to 'standard conditions' or any incorrect standard conditions **ALTERNATIVE RESPONSE** If no mark(s) already awarded from above, can answer by giving:- energy change / enthalpy change **per mole** **(1)** $2Na^+(g) + O^{2-}(g) \rightarrow Na_2O(s)$ **(1)** **NOTE** If lattice energy of dissociation is given (e.g. "energy required to break down 1 mol of an ionic lattice into its gaseous ions") max (1) for the 2nd scoring point 'gaseous ions'	'energy required' / 'energy needed' / 'energy it takes' 'from **one mole of gaseous ions**' (no 2nd mark) 'from gaseous **elements**' (no 2nd mark)	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	 All seven letters correct **(3)** Five **OR** six letters correct **(2)** Three **OR** four letters correct **(1)** ALLOW Either D or 2D Either C or 2C ALLOW Correct numerical values (see question paper) may be given as an alternative to the correct letters		**3**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	**FIRST, CHECK THE FINAL ANSWER** **IF answer = −2520 (kJ mol^{-1})** **then** **award (2) marks, with or without working** Otherwise look for $-414 = (2 \times 108) + 249 + (2 \times 496) + (-141) + 790) + \Delta H_{LE}$ **OR** $\Delta H_{LE} = -414 - [(2 \times 108) + 249 + (2 \times 496) + (-141) + 790]$ **OR** A correct expression using letters e.g. F = (2)D + E + (2)C + A + B + G **(1)** (=−414 − 2106) = **−2520** (kJ mol^{-1}) **(1)** NOTE **ALLOW** for **1 mark**: −1692 (wrong sign for 414) −1916 (2 × 108 and 2 × 496 not used for Na^+) −2412 (2 × 108 not used for Na^+) −2024 (2 × 496 not used for Na^+) +2520 (wrong sign for final answer) −2802 (sign changed for 1st electron affinity of oxygen) −2395.5 (atomization of oxygen halved) NOTE Penalise incorrect units (e.g. kJ mol) ONCE only **NO ECF** from incorrect answers to (b)(i)	−1088 (kJ mol^{-1}) scores **(0)** overall (as two errors) (+)1088 (kJ mol^{-1}) also scores **(0)** overall (as several errors)	**2**

Question Number	Acceptable Answers	Reject	Mark
***21(c)**	ALLOW reverse argument where appropriate **First mark** MgO more exothermic (than MgS) IGNORE 'greater' / 'higher' / 'larger' **(1)** **Second mark** S^{2-} larger than O^{2-} **(1)** **Third mark** Charges on O^{2-} and S^{2-} same OR Charges on (all) ions same OR S^{2-} smaller **charge density** than O^{2-} NOTE This mark is awarded if both formulae for the ions O^{2-} and S^{2-} are mentioned **(1)** **Fourth mark** O^{2-} (forms) **stronger** (electrostatic) **attractions** (than S^{2-}) IGNORE just 'stronger (ionic) bonds' **(1)** **Penalise ONCE ONLY** the use of the word 'atom(s)' or 'molecule(s)'/ use of **formulae** such as 'Mg' 'O' 'O_2', etc. AND/OR **Penalise ONCE ONLY** use of **words** such as **just** 'magnesium' (instead of magnesium ions/Mg^{2+}) and/or **just** 'oxygen' (instead of oxide ions/O^{2-}) **Mark each point independently**	"**MgS** is larger than **MgO**" S^{2-} has a larger **atomic** radius than O^{2-}	**4**

(Total for Question 21 = 11 marks)

Question Number	Acceptable Answers	Reject	Mark
22(a)	$(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 3d^8\ 4s^2$ OR $(1s^2)\ 2s^2\ 2p^6\ 3s^2\ 3p^6\ 4s^2\ 3d^8$ ALLOW capital S P D Allow subscripts (e.g. $(1s^2)\ 2s_2\ 2p_6\ 3s_2\ 3p_6\ 4s_2\ 3d_8$)		**1**

Question Number	Acceptable Answers	Reject	Mark
22(b)	(A_r for Ni) = (58 x 0.6902) + (60 x 0.2732) + (62 x 0.0366) or a correct fraction using percentages **(1)** (= 58.6928) [calculator value] = 58.69 (**must be to 2 dp**) **(1)** 2^{nd} mark CQ on numbers transcribed Correct answer with no working **(2)** IGNORE Units of any kind (e.g. 'g', 'g mol^{-1}', 'amu', etc.)	58.68 (as rounding error)	**2**

Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	Moles of nickel = $\frac{5.87}{58.7}$ = 0.1(00) (mol) **(1)** Moles CO = 0.1(00) x 4 = 0.4(00) (mol) Answer CQ on 4 x mol Ni **(1)** Volume of CO = 0.4(00) x 24 (dm^3) = 9.6 (dm^3) ALLOW 9600 **cm^3** Answer CQ on 24 x mol CO **(1)** Correct answer with no working scores **(3)**	9.6 dm^3 **mol^{-1}** (no 3rd mark) 9.6 dm^{-3} (no 3rd mark) OR Any other incorrect units (no 3rd mark)	**3**

Question Number	Acceptable Answers	Reject	Mark
22(c)(ii)	(Number of CO molecules = 0.400 x 6.02 x 10^{23}) = 2.408 x 10^{23} Answer CQ on moles / volume of CO in (c)(i) IGNORE sf except 1 sf IGNORE Any units, even if incorrect		**1**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	Moles of NiO = $\frac{1.494}{74.7}$ = 0.02(00) (mol) **(1)** Moles HNO_3 = 0.02(00) x 2 = 0.04(00) (mol) Answer CQ on 2 x mol NiO **(1)** Volume of HNO_3 = $\frac{0.04(00) \times 1000}{2.00}$ = 20(.0) (cm^3) ALLOW 0.02(00) **dm^3** Answer CQ on mol HNO_3 **(1)** Correct answer with no working scores **(3)** Penalise wrong units ONCE only		**3**

Question Number	Acceptable Answers	Reject	Mark
22(d)(ii)	To ensure all the **acid** reacts / all the **acid** is used up / all the **acid** is neutralized IGNORE References to 'yield' / reaction going to completion / just 'acid is the limiting reagent'	To ensure all the **reactants** are used up	**1**

Question Number	Acceptable Answers	Reject	Mark
22(d)(iii)	Fizzing / effervescence / frothing / bubbles / gas released IGNORE spilling (over) / spillage References to 'vigorous', 'exothermic', 'violent' / **just** 'safety'	(Mixture) **boils** Quantity of reagents / 'displacement' of solution on adding solid	**1**

Question Number	Acceptable Answers	Reject	Mark
22(d) (iv)	$NiCO_3$(**s**) + $2HNO_3$(**aq**) → $Ni(NO_3)_2$(**aq**) + H_2O(**l**) + CO_2(**g**) ALLOW correct ionic equation $NiCO_3$(**s**) + $2H^+$(**aq**) → Ni^{2+}(**aq**) + H_2O(**l**) + CO_2(**g**) All species correct **(1)** Balancing and all state symbols correct **(1)** 2nd mark is dependent on 1st mark (ie all species correct)	H_2CO_3(aq) scores **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
***22(d)(v)**	**First mark:** **Filter** (off the excess nickel(II) carbonate / solid) **(1)** **Second mark:** **Boil / heat** (to drive off some of the water) **(1)** **IGNORE** just 'evaporation' (as the technique of boiling / heating is required here) **Third mark:** Leave to cool / leave to crystallize / evaporate (water) slowly / leave (for water) to evaporate **(1)** **Fourth mark:** **Dry** (the crystals) **(1)** IGNORE Any washing of the crystals immediately prior to drying them NOTE If heat **to dryness** in the second stage, award (1) mark if filtration is **first** stage If filtration is not the first stage, award (1) mark for **steps 2, 3 and 4 all correct**	**Just** "warm" the filtrate / solution OR 'heat the filtrate **to dryness**' (Adding to a) drying agent Use of Bunsen burner or direct heating to dry crystals	**4**

(Total for Question 22 = 18 marks)

Question Number	Acceptable Answers	Reject	Mark
23(a)	(Protons) **18** (Electrons) **18** (Neutrons) **22** All three numbers correct for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)	(Position in the Periodic Table) depends upon atomic number / proton number OR Ar (atom) has (one) fewer proton(s) (than K atom) OR K (atom) has (one) more proton(s) (than Ar atom) OR K has atomic number 19 (whereas) Ar has atomic number 18 OR Ar has 18 protons, K has 19 protons IGNORE 'Elements are not arranged in order of (relative) atomic mass' IGNORE Mention of numbers of electrons / numbers of shells (of electrons) IGNORE Arranged in vertical groups in accordance to properties / Argon is a noble gas		**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark** Property / trend / pattern ALLOW Any named property (e.g. atomic radius, ionization energy, melting temperature) **(1)** **Second mark** **Repeated** (across each period) OR **Regular** (across each period) OR **Re-occurring** (across each period) **(1)** NOTE Statement such as: "A repeating trend across a period / across each period" scores **(2)**		**2**

Question Number	Acceptable Answers	Reject	Mark
23(d)(i)	Phosphorus / P / P_4 OR Sulfur / S / S_8 OR Chlorine / Cl / Cl_2 IGNORE Argon / Ar		**1**

Question Number	Acceptable Answers	Reject	Mark
23(d)(ii)	(The covalent) **bonds** are **strong** (throughout the lattice) **(1)** (therefore) a lot of **energy** is required to break the bonds / a lot of **energy** is needed to overcome the attractions (between atoms) / 'more **energy**' is required to break the bonds /'more **energy**' is needed to overcome the attractions (between atoms) / 'greater amount of **energy**' is required to break the bonds /'greater amount of **energy**' is needed to overcome the attractions (between atoms) **(1)**	**MENTION OF ANY OF THE FOLLOWING SCORES (0) OVERALL** '(simple) molecular silicon' **(0)** 'molecules of silicon' **(0)** 'silicon has ions' / 'silicon is ionic' **(0)** 'intermolecular forces' / 'van der Waals' forces' / 'London forces' / 'forces between the molecules' **(0)** 'metallic bonding' **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
23(d)(iii)	**ALLOW reverse arguments in each case** **Any two from four:-** ●magnesium ions / magnesium atoms are small**er** (than sodium ions / sodium atoms) **(1)** **NOTE:** Allow symbols (e.g. Mg or Mg^{2+}) ●magnesium **ions** are Mg^{2+} whereas sodium **ions** are Na^{+} OR Mg^{2+} / magnesium **ions** have a larg**er** charge (density) (than Na^{+} /sodium **ions**) **(1)** **[NOTE:** It follows that the statement that "Mg^{2+} ions are smaller than Na^{+} ions" would score the first two scoring points above**]** ●magnesium has more **delocalised** electrons (than sodium) **(1)** IGNORE 'free electrons' IGNORE just 'sea of electrons' ●magnesium is close-packed (but sodium is not close-packed) **(1)** **Third mark (stand-alone):** · more / a lot of (heat) energy is needed to break (metallic) bonds in Mg (than in Na) OR · attraction between the positive ions and (delocalised) electrons is strong**er** in magnesium (than in sodium) **(1)**	attraction between **nucleus** and (delocalised) electrons (no third mark) mention of **intermolecular forces / molecules** (no third mark)	**3**

	IGNORE Just 'metallic bonding in Mg stronger than that in Na'	ionic bonding (no third mark) attraction between Mg^{2+} ions (no third mark) **NOTE:** arguments based on ionization energies scores **(0) overall** **OR** any suggestion of removal of outer shell electrons as part of the melting process scores **(0) overall**	

(Total for Question 23 = 10 marks)

TOTAL FOR SECTION B = 60 marks

TOTAL FOR PAPER = 80 marks

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Write your name here

Surname	Other names

Edexcel GCE

Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 23 May 2013 – Morning
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

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10/5/6/7/

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SECTION A

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

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

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

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

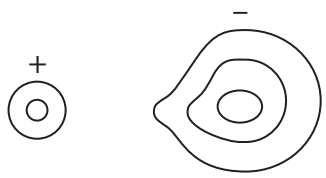
☒ **C** The first electron affinity of oxygen.

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

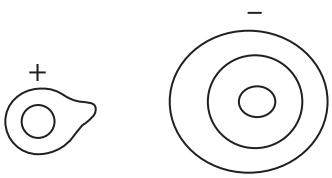
(Total for Question 1 = 1 mark)

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

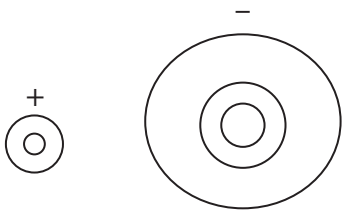
☒ **A**



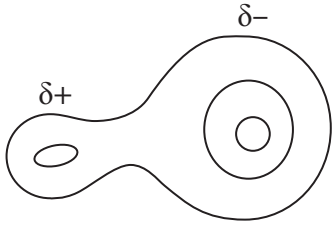
☒ **B**



☒ **C**



☒ **D**



(Total for Question 2 = 1 mark)

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

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

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

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

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

(Total for Question 3 = 1 mark)

4 Which pair of ions is isoelectronic?

☒ **A** Ca^{2+} and O^{2-}

☒ **B** Na^+ and O^{2-}

☒ **C** Li^+ and Cl^-

☒ **D** Mg^{2+} and Cl^-

(Total for Question 4 = 1 mark)

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

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

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

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

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

(Total for Question 5 = 1 mark)

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

☒ **A** 0.0050

☒ **B** 0.0030

☒ **C** 0.0020

☒ **D** 0.0010

(Total for Question 6 = 1 mark)

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

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

(Total for Question 7 = 1 mark)

8 The equation for the complete combustion of ethane is

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

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

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

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

(Total for Question 8 = 1 mark)

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

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

(Total for Question 9 = 1 mark)

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

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

(Total for Question 10 = 1 mark)

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

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

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

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

(Total for Question 11 = 1 mark)

12 Which of the following has the largest ionic radius?

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

(Total for Question 12 = 1 mark)

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

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

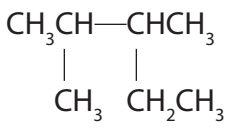
(Total for Question 13 = 1 mark)

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

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

(Total for Question 14 = 1 mark)

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



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

(Total for Question 15 = 1 mark)

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

P 4 1 6 4 9 A 0 6 2 4
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16 This question is about the reaction of methane with bromine in sunlight.

(1)

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

(a) This reaction is best described as

- ☒ **A** electrophilic addition.
- ☒ **B** electrophilic substitution.
- ☒ **C** free radical addition.
- ☒ **D** free radical substitution.

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

(1)

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

This step is

- ☒ **A** initiation.
- ☒ **B** propagation.
- ☒ **C** termination.
- ☒ **D** reduction.

(c) This reaction produces a mixture of products.

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

(1)

- ☒ **A** ethane
- ☒ **B** propane
- ☒ **C** butane
- ☒ **D** pentane

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

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

(1)

- ☒ **A** microwaves
- ☒ **B** infrared
- ☒ **C** visible light
- ☒ **D** ultraviolet

(Total for Question 16 = 4 marks)

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

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

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

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

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

(Total for Question 17 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

P 4 1 6 4 9 A 0 8 2 4
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SECTION B

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

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

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

(2)

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

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

(1)

.....

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

Suggest a suitable iodine compound which could be used.

(1)

.....

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

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

(1)

.....

.....

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.....

(Total for Question 18 = 5 marks)

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

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

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

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

(2)

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

(2)

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

(2)

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

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

(2)

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

(2)

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

(2)

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

(1)

(Total for Question 19 = 13 marks)

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P 4 1 6 7 4 9 A 0 1 2 2 4
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20 Copper(II) sulfate solution, $CuSO_4(aq)$, can be made by adding an excess of solid copper(II) oxide, CuO, to boiling dilute sulfuric acid. This is an exothermic reaction.

The balanced equation for this reaction is

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

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

(2)

$$CuO(s) +$$

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

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

(2)

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

(2)

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.....

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P 4 1 6 3 4 9 A 0 1 3 2 4
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(ii) When the reaction is complete, the excess copper(II) oxide is removed by filtration.

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

How would you know when sufficient water had been removed?

(1)

.....

.....

.....

.....

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

(1)

.....

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

(1)

.....

.....

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

(2)

P 4 1 6 4 9 A 0 1 4 2 4
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(ii) Calculate the percentage yield if 2.7 g of copper(II) sulfate-5-water is obtained from 0.020 mol of sulfuric acid.

(2)

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

(1)

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.....

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

(1)

.....

.....

(Total for Question 20 = 15 marks)

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

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

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

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

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

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

(1)

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

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

(2)

P 4 1 6 7 4 9 A 0 1 7 2 4
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*(b) The standard enthalpy change for the reaction between sodium carbonate and dilute hydrochloric acid is found by a similar method to be

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

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

Remember to show your reasoning clearly.

(5)

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

2HCl(aq)

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

P 4 1 6 4 9 A 0 1 8 2 4
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(c) The uncertainty for each thermometer reading is ± 0.5 °C.
Calculate the percentage error in the temperature rise of 11 °C.

(1)

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

(2)

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.....

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.....

(Total for Question 21 = 11 marks)

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22 This question is about ethene and its reactions.

Ethene is produced in industry by cracking.

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

(1)

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

(4)

P 4 1 6 9 4 9 A 0 1 2 4
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(b) Draw a diagram to show the regions of electron density in both parts of the double bond between the carbon atoms in ethene. Label each region with appropriate symbols.

(2)

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

(2)

Name .....

Formula

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

(3)

P 4 1 6 7 4 9 A 0 1 2 2 4
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(d) Give the displayed formula for the organic product of the reaction between ethene and acidified potassium manganate(VII).

(1)

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

(2)

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

(1)

.....

.....

(Total for Question 22 = 16 marks)

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

P 4 1 6 7 4 9 A 0 1 2 3 2 4
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The Periodic Table of Elements

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

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

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

* Lanthanide series

* Actinide series

P 4 1 6 T 4 M U P . A C O U N 2 4 2 4

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Mark Scheme (Results)

Summer 2013

GCE Chemistry 6CH01/01
The Core Principles of Chemistry

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General Marking Guidance

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

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

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

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

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

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

Quality of Written Communication

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

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

Section A

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Question Number	Correct Answer	Reject	Mark
16a	D		**1**

Question Number	Correct Answer	Reject	Mark
16b	C		**1**

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

Question Number	Correct Answer	Reject	Mark
16d	D		**1**

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

Total for Section A = 20 Marks

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

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

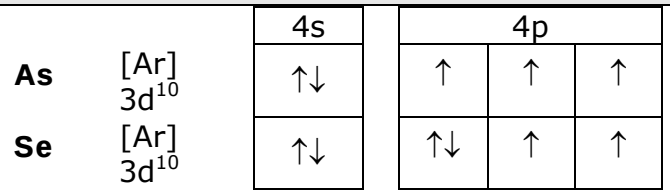
Question Number	Acceptable Answers	Reject	Mark
18(c)	Potassium iodide / KI Accept any soluble, non-toxic iodide or iodate Wrong name, correct formula (0) Correct name, wrong formula (0)	HI KI_3 Wrong formulae like CaI, MgI Wrong name like calcium idodate BaI_2 (toxic) AgI (insoluble) Potassium iodine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

Question Number	Acceptable Answers	Reject	Mark
18(d)	Country /ALLOW state **and** justification Both needed for one mark e.g. Japan / New Zealand / California etc Country / state at risk from Earthquake / tsunami / flooding Further examples: Italy with volcanoes Afghanistan / middle eastern / African countries terrorist / (nuclear) weapon threat / war zone / political instability / abuse of nuclear power. USA /America / Jamaica etc risk of hurricane / tornado California San Andreas fault	…population density …landslide …too hot … surrounded by other countries Antarctica	**1**

Total for Question 18 = 5 Marks

Question Number	Acceptable Answers	Reject	Mark
19(a)	$As(g) - e^{(-)} \rightarrow As^{+}(g)$ OR $As(g) \rightarrow As^{+}(g) + e^{(-)}$ Entities **(1)** All species gaseous **(1)** providing a reasonable attempt at an ionization energy Examples: $As(g) + e^{(-)} \rightarrow As^{+}(g)$ $As(g) - e^{(-)} \rightarrow As^{-}(g)$ $As^{2+}(g) - e^{(-)} \rightarrow As^{3+}(g)$ IGNORE state symbol of electron ALLOW upper case / large S in arsenic ALLOW $As(g) + e^{(-)} \rightarrow As^{+}(g) + 2e^{(-)}$ **(2)**	$As(g)+e^{(-)} \rightarrow As^{-}(g)$ (electron affinity)	**2**

Question Number	Acceptable Answers	Reject	Mark
19(b)	AsH_3 / H_3As **(1)** H_2Se / SeH_2 **(1)** IGNORE charges ALLOW upper case / large S in arsenic **NOTE:** If two or more answers given for one element mark that element on a plus minus basis	SE for Selenium	**2**

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

Question Number	Acceptable Answers	Reject	Mark
19(c)(ii)	**For parts c(ii),d and e it is important to keep in mind the two elements involved in each part** **As and Se** **First mark:** EITHER In Se, (spin) pairing has occurred (for the first time in that p sub-shell) OR electron removed from orbital containing two electrons **(1)** ALLOW sub-shell for orbital **Second mark:** EITHER (Increase in) repulsion (so electron lost more easily) OR Half-filled (sub-) shell/allow orbital (particularly) stable (in As) ALLOW orbital for sub-shell **(1)** Mark each point independently IGNORE reference to distance from nucleus and shielding		**2**

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

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

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

Total for Question 19 = 13 Marks

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	$CuO(s) + 2H^+(aq) \rightarrow Cu^{2+}(aq) + H_2O(l)$ Left hand side **(1)** right hand side **(1)** If SO_4^{2-} are on both sides max one mark ALLOW correct entities and balancing with no or incorrect state symbols for one mark. ALLOW multiples It is sometimes difficult to be sure of the '2' on the Cu^{2+}. Give BOD provided $2H^+$ on the left of the equation	Charges within water molecule	**2**

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

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	Add in small portions / use a spatula / use a **small** spoon / slowly / gradually **(1)** To prevent (mixture / acid) boiling over / frothing / spilling / splashing / splash back **(1)** Mark independently Bubbles are neutral IGNORE add carefully / cautiously alone	Spitting / violent reaction / fizzing Because reaction is exothermic alone Bubbles of carbon dioxide	**2**

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

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

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

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

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

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

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

Total for Question 20 = 15 Marks

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

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

Question Number	Acceptable Answers	Reject	Mark
21(b)	$2NaHCO_3(s) \square Na_2CO_3(s)+CO_2(g)+H_2O(l)$ 2HCl(aq) (2HCl(aq)) $2NaCl(aq) + 2CO_2(g) + 2H_2O(l)$ **First mark** Arrow from products in top line to lower line and correct entities **(1)** $NaCl + CO_2 + H_2O$ **Second mark** **2**$NaCl$**(aq)** + **2**CO_2**(g)** + **2**H_2O**(l)** Correct state symbols and balancing **(1)** ΔH^o = **+**91.6 OR +91.7 (kJ mol^{-1}) ALLOW no positive sign only if correct Working with correct signs given **(3)** OR **Third mark** Correct use of Hess's Law (in numbers or symbols) consistent with arrow direction **(1)** **Fourth mark** **2x**(-115) = ΔH^o - 321.6 Correct multiples and numbers **(1)** ALLOW 2 x any number (including -4600 and -3.86) except 2 x +/- 321.6 Notice Third and Fourth marks can be scored by $\Delta H^o = 2(-115) - (-321.6)$		**5**

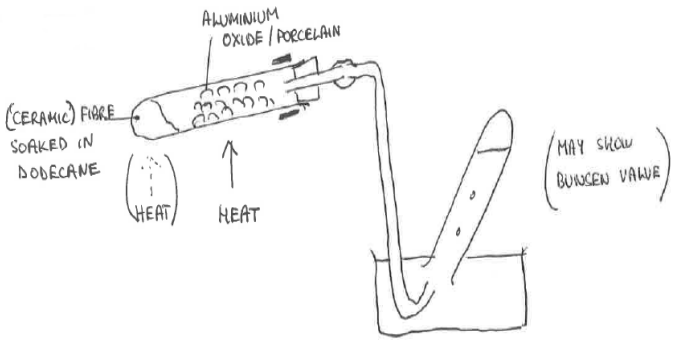
	Fifth mark ΔH^o = 2(−115) − (-321.6) = **+**91.6 (kJ mol^{-1}) OR ΔH^o = 2(−114.95) − (-321.6) = **+**91.7 (kJ mol^{-1}) Correct value for their calculation with correct sign IGNORE SF except 1 ALLOW no positive sign only if correct working with correct signs given **(1)** Omitting 2x gives +206.6 (could get 4 marks) -4600 gives -598.4 -3.86 gives +313.88		

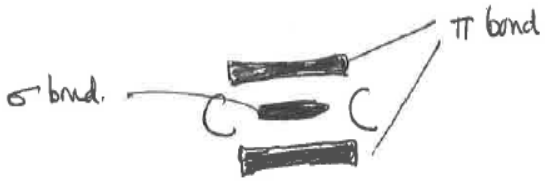
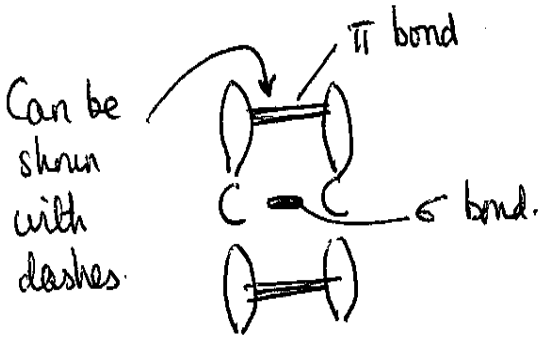
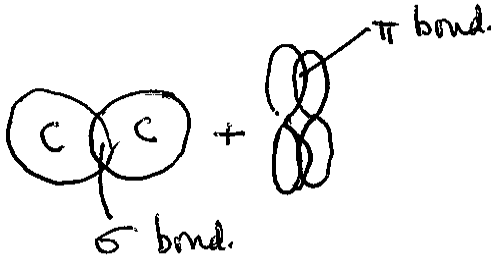
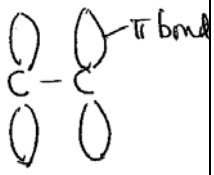
Question Number	Acceptable Answers	Reject	Mark
21(c)	((±) 0.5 x 2 x 100 /11) = (±)9.09 (%) ALLOW at 9.0909/9.091/9.1 and 9	 9.10/9.0	**1**

Question Number	Acceptable Answers	Reject	Mark
21(d)	**First mark** It is used as a raising agent / self raising flour / baking soda / baking powder OR Causes cakes / (soda) bread to rise / expand. **(1)** **Second mark** Carbon dioxide (released on heating causes cakes / bread to rise) OR It reacts with acid to form carbon dioxide (in baking powder) providing bread /cake etc is mentioned **(1)** ALLOW Used in cooking green vegetables To keep green colour	To make pastry rise Bicarbonate of soda Gas Air Neutralizing acid foods	**2**

Total for Question 21 = 11 Marks

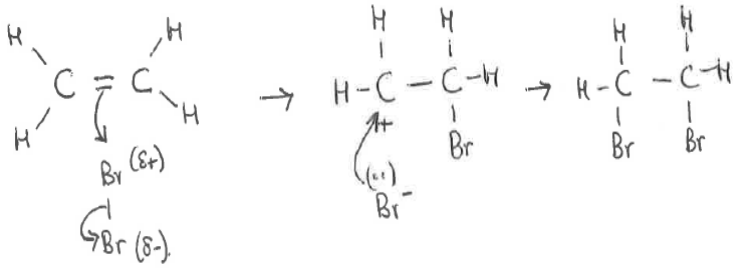
Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	$C_{12}H_{26} \rightarrow C_{10}H_{22} + C_2H_4$ IGNORE state symbols even if incorrect ALLOW displayed and structural formula for ethene		**1**

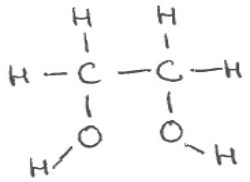
Question Number	Acceptable Answers	Reject	Mark
22 (a)(ii)	Collection over water or in gas syringe **(1)** IGNORE solid bung with delivery tube coming out / accidental sealing in drawing / clamps This is the only stand alone mark **Dependent on diagram including roughly horizontal tube:** Labelled ceramic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

Question Number	Acceptable Answers	Reject	Mark
22(b)	EITHER  Diagram of bonds, the single bond must be shown as a region of space and not as a single or double straight line **(1)** Labelled σ and π in correct places on correctly drawn bonds.ie this mark can only be awarded if bonds correctly drawn **(1)** OR   Labelled pi bond **(1)** Labelled sigma bond **(1)** Whichever scores more Bonds may be shown by overlap of appropriate orbitals, when any orbital or region of overlap may be labelled Only one pi lobe / bond need be labelled Carbons need not be shown Bonds may be drawn on separate diagrams	 	**2**

	IGNORE C-H bonds IGNORE any additional electron density maps IGNORE any partial charges		

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

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

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

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

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

Total for Question 22 = 16 Marks

Total for Paper = 80 Marks

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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 ▶

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7/6/5/5/4/5/

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SECTION A

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

1 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)

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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)

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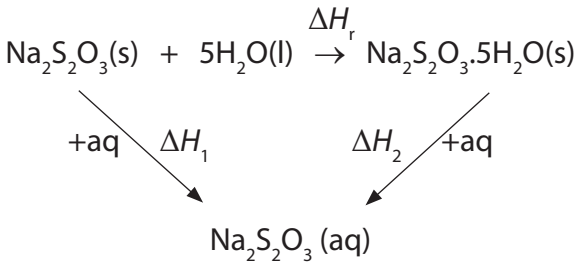
7 In an endothermic reaction in aqueous solution, which of the following is correct?

	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.

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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.

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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.

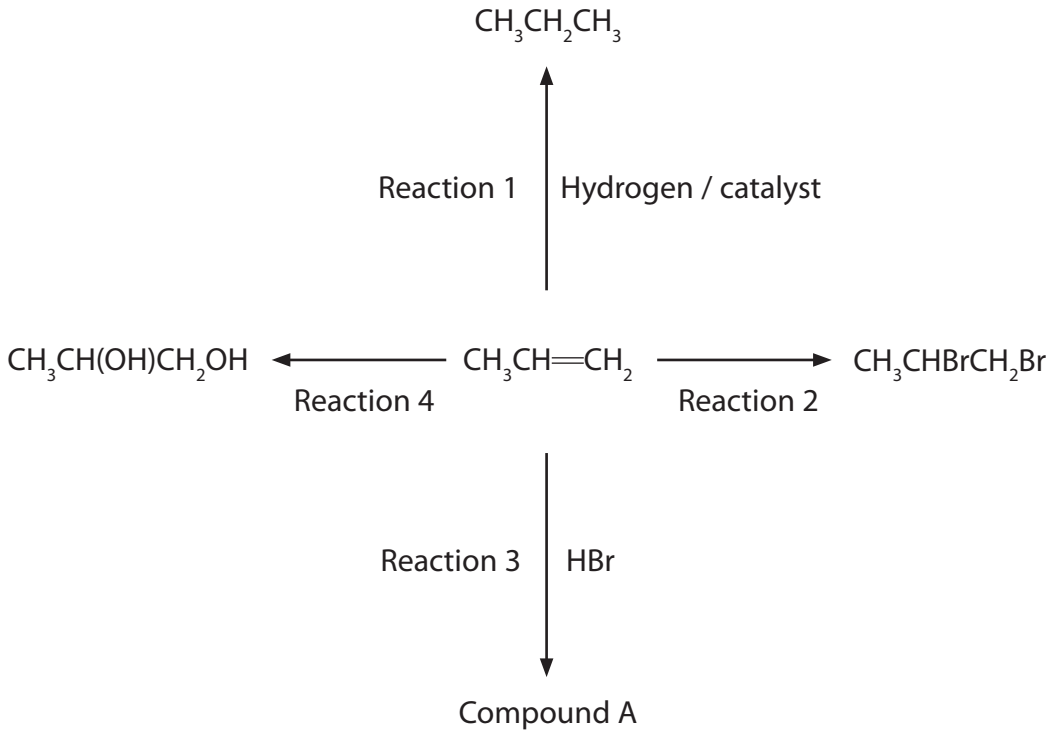
(Total for Question 15 = 1 mark)

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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

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(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

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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)

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(v) Calculate the total mass of aluminium added to the potassium hydroxide if a 10% excess of aluminium is required.

(1)

(vi) Identify **two** hazards in this first step of the preparation.

(2)

Hazard 1 .....

.....

Hazard 2 .....

.....

(b) The second step of the reaction is the addition of a slight excess of 1 mol dm^{-3} sulfuric acid.

(i) Balance the following equation for the reaction

(1)

$$KAlO_2(aq) + H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + H_2O(l)$$

(ii) Calculate the volume of the 1 mol dm^{-3} sulfuric acid that reacts with the potassium aluminate.

(1)

(iii) State how you would show that the acid had been added in excess.

(2)

.....

.....

.....

.....

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

(4)

(v) Suggest the colour of the crystals.

(1)

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

(1)

(Total for Question 17 = 17 marks)

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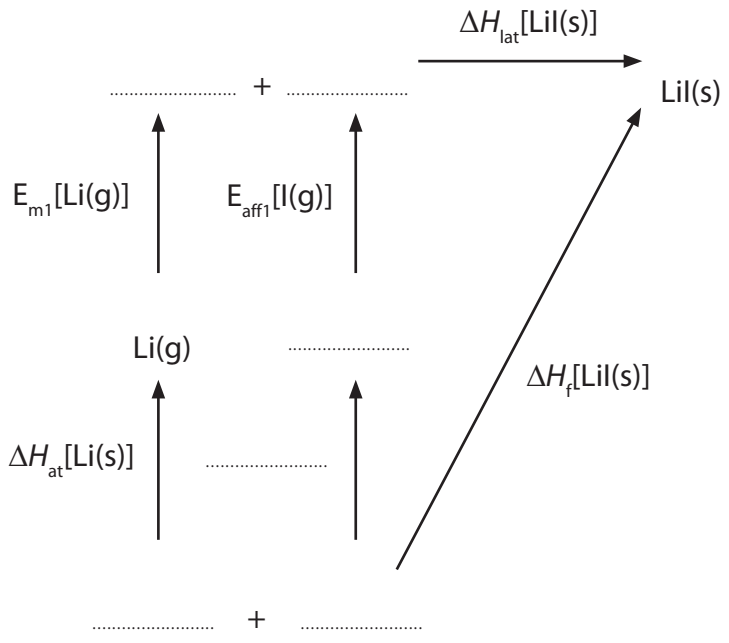
18 This question is about lithium iodide, an ionic salt.

(a) Draw dot and cross diagrams for the lithium and iodide ions. Show all the electrons in the lithium ion but only outer shell electrons in the iodide ion.

(2)

(b) On the Born-Haber cycle below, fill in the missing formulae (including state symbols) and the missing enthalpy change.

(3)



(c) Calculate the electron affinity of iodine, E_{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)

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

(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)

P 4 1 2 3 5 A 0 5 2 4

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)

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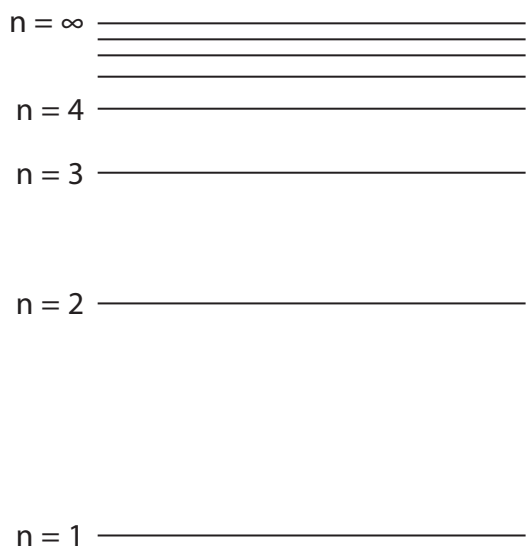
(d) Tritium is not usually included in calculations of the relative atomic mass of hydrogen, because it is radioactive and has a relatively short half-life.

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)

.....

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.....

(Total for Question 19 = 15 marks)

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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)

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(c) This reaction takes place in a number of steps, some of which are shown below.

Step 1 $Cl_2 \rightarrow 2Cl\bullet$

Step 2 $CH_3CH_3 + Cl\bullet \rightarrow HCl + CH_3CH_2\bullet$

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

(2)

Type .....

Conditions .....

(ii) Complete the equation below for the third step of the reaction, and show the movement of electrons using the appropriate arrows.

(3)

$CH_3CH_2\bullet + Cl—Cl \rightarrow$

(iii) Write equations for **two** termination steps in this reaction.

(2)

(d) Ethane can be cracked in industry. Write an equation for the cracking of ethane.

(1)

(e) Suggest **two** reasons why cracking of larger alkane molecules is important in industry.

(2)

Reason 1: .....

.....

Reason 2: .....

.....

(Total for Question 20 = 16 marks)

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

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The Periodic Table of Elements

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

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

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

* Lanthanide series

* Actinide series

P 4 1 2 8 T E M P . A C O U N 2 4 2 4

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Mark Scheme (Results)

January 2013

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

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General Marking Guidance

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

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

Using the Mark Scheme

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

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

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

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

Quality of Written Communication

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

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

Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Question Number	Correct Answer	Mark
16(a)	D	**1**
(b)	D	**1**
(c)	C	**1**
(d)	B	**1**
(e)	B	**1**

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
17 (a) (i)	$2Al(s) + 2OH^-(aq) + 2H_2O(l) \rightarrow 2AlO_2^-(aq) + 3H_2(g)$	$2O_2^{2-}(aq)$	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(ii)	$\left(\frac{2 \times 10}{1000} = 0.02 / 2 \times 10^{-2}\right)$ Ignore trailing zeroes		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(iii)	$0.02 / 2 \times 10^{-2}$ Accept TE answer to (ii)		**1**

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

Question Number	Acceptable Answers	Reject	Mark
17 (a)(v)	$(1.1 \times 0.54) = 0.59(4) / 5.9(4) \times 10^{-1}$(g) TE answer to (iv) x 1.1 Ignore sf except 1 Only penalise sf once		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (a)(vi)	**Potassium hydroxide / KOH** (solution) is corrosive / burns / caustic **OR** **KOH** damages / harms / is harmful to / dissolves / reacts with **skin / eye(s)** **(1)** **OR** **KOH** in **eye(s)** **(1)** **Ignore** Harmful, irritant, highly reactive alone **Hydrogen / H_2** is flammable / explodes / explosive **(1)** Allow mention of both potassium hydroxide and hydrogen alone scores **(1)** Allow Al foil can cut your skin **(1)** Correct answer with additional incorrect chemistry e.g. KOH is oxidising so corrosive scores **(0)**	Toxic, carcinogenic, alone or in combination with correct answer Burns alone Additional chemicals	**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(i)	$KAlO_2(aq) + \mathbf{2}H_2SO_4(aq) \rightarrow KAl(SO_4)_2(aq) + \mathbf{2}H_2O(l)$ Allow multiples		**1**

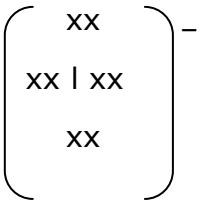
Question Number	Acceptable Answers	Reject	Mark
17 (b)(ii)	$\frac{2 \times 1000 \times 0.02}{1} = 40\ (cm^3)$ Allow 0.04(0) **dm^3** TE answer to (a)(ii) x 2000 and TE from (b)(i)		**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iii)	Litmus (paper / solution) **(1)** Red / pink (in acid) **(1)** OR any other named acid-base indicator including universal indicator **(1)** with a correct acidic colour **(1)** NB phenolphthalein must be spelt correctly to score **(1)** and no mark for colour Notice that other indicators only require recognisable spellings Red litmus turns blue scores for the indicator **(1)** OR pH meter / universal indicator **(1)** with value < 7 **(1)** NB measure pH alone (0) pH < 7 **(1)** OR add a (metal) carbonate / suitable metal eg Mg **(1)** bubbles / fizzing **(1)** Calculation of amounts / moles of **both** reactants (1 maximum)		**2**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(iv)	**Each point must be made in full** **The second and final scoring points, which are asterisked, can only be gained through these statements. Two further marks can be scored for any two of the other four points.** 1 Filter (to remove any aluminium / impurities) **(1)** NB This mark can only be awarded if it is the first action **and** the mixture is subsequently heated. 2 *Boil / heat / evaporate to reduce the volume of water **(1)** NB boil / heat to remove water only gets the mark if it is clear, subsequently, that some solution is left 3 Cool / set aside / leave to allow crystals to form **(1)** 4 Filter OR pick out / remove / take out crystals (to separate) **(1)** 5 Wash with a **little / cold** water **(1)** 6 *Place between filter papers / dab with paper towel / use dessicator (to dry) **(1)**	Leave in the sun If boiled to dry stop marking here Heat in oven	**4**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(v)	White / colourless Ignore clear / transparent / cloudy / opaque e.g. accept clear and colourless	Any other colours with or without white	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b)(vi)	Cr^{3+}/ Fe^{3+}/ Sc^{3+} / Ga^{3+} Accept any feasible triply positive metal ion Allow B^{3+} Allow any name or symbol for a Group 3 element Allow named existing transition metal ions with (III) after the name (if they exist) Fully correct formula for an alum or intermediate starting entity Eg $KGa(SO_4)_2$ / $KGaO_2$	Al^{3+} and anything else Group 3 element with incorrect charge	**1**

Question Number	Acceptable Answers	Reject	Mark
18 (a)	$[:Li]^+$ (1)  (1) Accept all or mixture of dots and crosses **Check inner electrons present on lithium** If no element symbols but fully correct with Li first give **1 max** If no / incorrect charge(s) if the electrons are correct **1 max** If arrow drawn from third / outer shell electron on lithium to join electrons in iodine / iodide with correct charges scores **1 max** Brackets are not essential		**2**

Question Number	Acceptable Answers	Reject	Mark
18 (b)	Li(s) **and** $Li^+(g)$ **and** $I^-(g)$ **(1)** $\frac{1}{2}I_2(s)$ **and** I(g) **(1)** (ΔH_{at}) **[**$\frac{1}{2}I_2(s)$**]** **(1)** Notice the square brackets are essential for this mark If wrong state for iodine element ie if $\frac{1}{2}I_2(g/l)$ and consistent (ΔH_{at})[$\frac{1}{2}I_2(g/l)$] allow third mark If I(s) given for element and (ΔH_{at}) [I(s)] allow third mark If wrong state with monatomic iodine both the last two marks lost If $Li^+(g)$ + e appears ignore electron		**3**

Question Number	Acceptable Answers	Reject	Mark
18 (c)	**First mark for one of:** −270 = + 159 + 107 + 520 + electron affinity − 759 Or Electron affinity = −270 − (159 + 520 + 107 − 759) **(1)** OR Electron affinity = −270 - 159 - 520 - 107 + 759 **(1)** **Second mark for:** (Electron affinity =) −297 (kJ mol^{-1}) **(1)** −297 (kJ mol^{-1}) alone scores **(2)** NB providing method is recognisable with one transcription error eg 795 for 759 and the final answer is consistent **1 max** NB (+) 297 (kJ mol^{-1}) **1 max**	Wrong unit e.g. J	**2**

Question Number	Acceptable Answers	Reject	Mark
18 (d)	(Experimental lattice energy is) more negative / exothermic **(1)** OR Theoretical lattice energy is less negative / exothermic **(1)** OR Recognition that more energy **released** **(1)** Irrespective of first answer then, any two from: Due to a degree of covalency **(1)** Deviation from pure ionic model (in experimental value) OR The theoretical model is pure ionic bonding **(1)** **Polarization / distortion** of the iod**ide** / negative ions (by the lithium ion). Can be shown by diagram **(1)** Iodine/ I / I_2 ion is not acceptable but iodine / I **anion** is allowed Note I_2 anion is not allowed	Greater / less Increase / decrease alone	**3**

Question Number	Acceptable Answers	Reject	Mark
18 (e)	Electron affinities become less negative / less exothermic / more positive (going down Group 7) **(1)** As (added) **electron** further from the nucleus OR **More** shielding / shielded (from the nucleus) **(1)** Second mark stands alone Ignore larger (ionic) radius / atom / ion / charge density	Greater / less / Increase / decrease alone Any indication of ionization/ removing an electron	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (a)	All have the same number of electrons / all have one (s) electron / same electron configuration **(1)** All have the same number of protons / all have one proton **(1)** The first has no neutrons, the second one neutron and the third two neutrons Allow deuterium has one more neutron, tritium two more neutrons **(1)** Ignore references to same atomic number and different mass numbers	All have one p electron Different number of neutrons alone	**3**

Question Number	Acceptable Answers	Reject	Mark
19 (b)	($^{14}_{7}N$ + $^{1}_{0}n$ → $^{3}_{1}H$ +) $^{12}_{6}C$ Numbers can be on either side or both sides		**1**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(i)	**Molar mass / M(r) / 3+2 / 2+3** = 5 (g mol^{-1}) (1) Number of moles = 4/5 = 0.8 **(1)** O.8 with correct working, with wrong working, or with no working **(2)** Allow internal TE if Molar mass clearly indicated and incorrect eg Molar mass / M(r) = 6 (g mol^{-1}) **(0)** Number of moles = 4/6 = 0.67 **(1)**	Penalise incorrect units	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (c)(ii)	24 000 x 0.8 = 19 200 (cm^3) Allow 19.2 **dm^3** Allow TE from (c)(i)	Incorrect units	**1**

Question Number	Acceptable Answers	Reject	Mark
19 (d)	$\frac{1.0078 \times 99.9850 + 2.0141 \times 0.0150}{100}$ OR $\frac{1.0078 \times 99.9850 + 2.0141 \times 0.0150}{99.9850 + 0.0150}$ **(1)** Notice this working must be shown in full to score first mark. (= 1.007951) = 1.0080 **(1)** 1.008 max 1 with or without working Correct answer no working **(2)** Only give second mark for correct answer to 4 decimal places Ignore g mol^{-1}	Incorrect units e.g. g	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (e)(i)	Single arrow **upwards** from lowest line to infinity line (allow above or very close below) Allow double headed arrow	More than one line	**1**

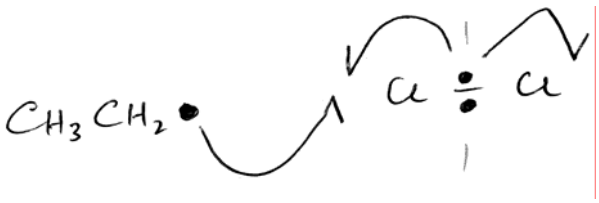
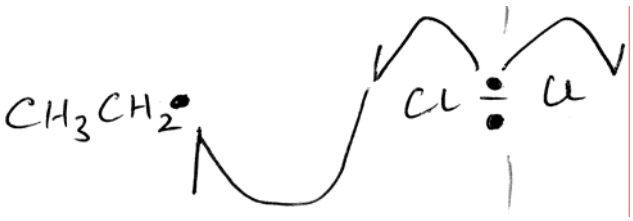
Question Number	Acceptable Answers	Reject	Mark
19 (e)(ii)	Hydrogen $1s^1$ **and** Sodium $1s^2\ 2s^2\ 2p^6\ 3s^1$ **(1)** Electron numbers may be on lines or subscript. Both have one (s) electron in the **outer** shell / orbital / sub shell OR same number of electrons / same electron(ic) configuration in **outer** shell / orbital / sub shell OR Both have an/one unpaired electron in their **outer** / **last** shell / orbital / sub shell **(1)** Second mark depends on one outer shell s electron shown for each electronic configuration	$1s^2\ 2s^1$ half filled s outer shell same electron(ic) configuration alone	**2**

Question Number	Acceptable Answers	Reject	Mark
19 (f)	Helium **(1)** Any two from the following points: Electron removed is closest / close to the nucleus **(1)** Little shielding, allow no shielding **(1)** More protons / higher nuclear charge than hydrogen. Allow higher effective nuclear charge **(1)** **NB** second and third marks can be gained if **hydrogen** is given: Electron removed is close / closest to the nucleus **(1)** No shielding **(1)**	Any other elements	3

Question Number	Acceptable Answers	Reject	Mark
20(a)	$C_2H_6(g) + 3½O_2(g) \rightarrow 2CO_2(g) + 3H_2O(l)$ Formulae and states **(1)** Balancing of correct entities **(1)**	Multiples	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)	Notice the first mark is for the equation and there are 3 separate additional marks for the calculation H H H H | | | | H-C-C-H + Cl-Cl → H-C-C-Cl + H-Cl | | | | H H H H **(1)** Check all bonds displayed especially Cl-Cl and H-Cl **Calculation marks:** +413 + 243 **(1)** (−)(346 + 432) **(1)** OR 656 **(1)** (−) 778 **(1)** = −122 (kJ mol^{-1}) **(1)** Fully correct answer to calculation with no working **(3)** Extra 5x413 and 347 may be included on both sides, giving 3068 and (-)3190 Allow other same values(s) missing from both sides Bonds breaking **(1)** Bonds making **(1)** [Bonds breaking - bonds making] to give correct answer **with sign** **(1)**	Incorrect / no sign and / or incorrect units Incorrect units loses this mark	**4**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(i)	Initiation **(1)** Allow homolysis / atomization / homolytic (fission) Ignore any reference to free radical substitution UV / (sun)light **(1)** Ignore reference to high temperature	Free radical substitution alone Photolysis	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(ii)	$CH_3CH_2\bullet + Cl\text{-}Cl \rightarrow CH_3CH_2Cl + Cl\bullet$ OR $CH_3CH_2\bullet + Cl\text{-}Cl \rightarrow C_2H_5Cl + Cl\bullet$ Both products correct including dot (1) Two half headed arrows showing homolytic breaking of Cl-Cl bond **(1)** Half headed arrow from radical to pair with a Cl arrow OR One arrow from chlorine bond clearly to ethyl radical **(1)** Arrows must be single-headed     The two dots in the covalent bond do not have to be shown		**3**

Question Number	Acceptable Answers	Reject	Mark
20 (c)(iii)	$Cl\bullet + Cl\bullet \rightarrow Cl_2$ **(1)** $\bullet CH_2CH_3 + \bullet CH_2CH_3 \rightarrow CH_3CH_2CH_2CH_3$ / C_4H_{10} **(1)** $\bullet CH_2CH_3 + Cl\bullet \rightarrow CH_3CH_2Cl$ **(1)** Penalise missing dots once Allow $\bullet C_2H_5$ for $\bullet CH_2CH_3$ Di and tri substitution steps	C_4H_{12} $CH_3CH_2CH_3CH_2$	**2**

Question Number	Acceptable Answers	Reject	Mark
20 (d)	$C_2H_6 \rightarrow C_2H_4 + H_2$ Allow **2**$C_2H_6 \rightarrow C_2H_4 +$ **2**CH_4		**1**

Question Number	Acceptable Answers	Reject	Mark
20 (e)	Any two from: (It) produces (more) petrol / gasoline / diesel / jet fuel / LPG / liquid petroleum gas / fuel **(1)** Short chain alkanes / lighter fractions are more useful products **(1)** Demand is greater for shorter chain alkanes / lighter fractions / smaller molecules OR converts surplus of low demand fractions **(1)** It produces ethane / short chain alkenes for making poly(ethene) / ethane-1,2-diol / ethanol / plastics / polymers **(1)** Smaller alkanes give less pollution/burn more efficiently **(1)** Recycles waste products **(1)** As a source of hydrogen **(1)** **NB** examiners need to look carefully at the vowel in the middle of alk**a**ne / alk**e**ne / eth**a**ne / eth**e**ne if not clear do not give BOD	Points based on atom economy / renewable fuels alone Easier to transport / store Short chain alkenes / ethene more useful alone Recycles alone	2

TOTAL FOR SECTION B = 60

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Surname	Other names

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Tuesday 15 May 2012 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

P39306A

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P 3 9 3 0 6 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 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)

P 3 9 3 0 6 A 0 2 2 4
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4 In an experiment to determine the enthalpy change of combustion of an alcohol, a spirit burner containing the alcohol was weighed, lit and placed under a copper can containing a known volume of water. The temperature rise of the water was measured and the burner re-weighed. The enthalpy change calculated from the results was much less exothermic than the value reported in the literature.

Which of the following factors is **most** likely to be the cause of this error?

☒ **A** Heat loss around the side of the copper can.

☒ **B** The use of a thermometer with a range of 0 – 110 °C rather than 0 – 50 °C.

☒ **C** The use of a measuring cylinder for measuring the water rather than a pipette.

☒ **D** Evaporation of the alcohol during the weighing.

(Total for Question 4 = 1 mark)

---

5 The standard enthalpy changes of formation of carbon dioxide and of methanoic acid are -394 kJ mol^{-1} and -409 kJ mol^{-1} respectively. Calculate the enthalpy change for the reaction

$$H_2(g) + CO_2(g) \rightarrow HCOOH(l)$$

☒ **A** -803 kJ mol^{-1}

☒ **B** -15 kJ mol^{-1}

☒ **C** $+803$ kJ mol^{-1}

☒ **D** $+15$ kJ mol^{-1}

(Total for Question 5 = 1 mark)

---

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

☒ **A** $K(g) \rightarrow K^+(g) + e^-$

☒ **B** $K^+Cl^-(s) \rightarrow K^+(g) + Cl^-(g)$

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

☒ **D** $Cl_2(g) \rightarrow 2Cl(g)$

(Total for Question 6 = 1 mark)

---

7 In which of the following cases would a cation be most polarizing?

		Radius	Charge
☒	**A**	small	small
☒	**B**	small	large
☒	**C**	large	small
☒	**D**	large	large

(Total for Question 7 = 1 mark)

8 Magnesium chloride, $MgCl_2$, has two lattice energy values quoted in the data booklet. The first is the experimental value, obtained from the Born-Haber cycle, -2526 kJ mol^{-1}; the second is the theoretical value, -2326 kJ mol^{-1}. Why are the two values different?

☒ **A** The cation polarizes the anion leading to some covalent bonding.

☒ **B** The anion polarizes the cation leading to some covalent bonding.

☒ **C** Magnesium chloride is a covalent substance.

☒ **D** The results from the Born-Haber cycle are too inaccurate to be reliable.

(Total for Question 8 = 1 mark)

9 Which of the following represents the process occurring when the enthalpy change of atomization of bromine is measured?

☒ **A** $\frac{1}{2}Br_2(l) \rightarrow Br(g)$

☒ **B** $\frac{1}{2}Br_2(g) \rightarrow Br(g)$

☒ **C** $Br_2(l) \rightarrow Br^+(g) + Br^-(g)$

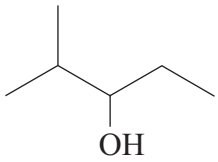
☒ **D** $Br_2(g) \rightarrow Br^+(g) + Br^-(g)$

(Total for Question 9 = 1 mark)

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

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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

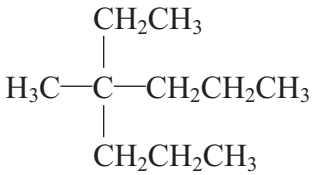
☒ **B** CH_3Cl

☒ **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)

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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

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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)

(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)

P 3 9 3 6 0 A 0 1 0 2 4
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*(ii) Explain how these ionization energies give evidence for the electronic structure of sodium. You may use a sketch graph if you wish.

(2)

(d) The first ionization energy of aluminium (element 13) is lower than that of magnesium (element 12).

(i) Give the electronic structures of magnesium and of aluminium in *s*, *p* and *d* notation.

(1)

Magnesium .....

Aluminium .....

*(ii) Explain the difference in the first ionization energies of the two metals.

(1)

(Total for Question 22 = 9 marks)

23 (a) State Hess's Law.

(1)

.....

.....

.....

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

$$CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(l)$$

The enthalpy change for this reaction cannot be determined directly, but can be found using the standard enthalpy changes of combustion of methane and carbon monoxide, together with Hess's Law.

The standard enthalpy changes of combustion needed are for CH_4, -890 kJ mol^{-1}, and for CO, -283 kJ mol^{-1}.

(i) Draw a Hess's Law diagram which would enable you to calculate the enthalpy change for the combustion of methane to carbon monoxide.

$$CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(l)$$

(2)

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

(2)

P 3 9 3 6 A 0 1 2 4
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(iii) Explain why the enthalpy change for this reaction cannot be determined directly.

(1)

.....

.....

.....

(c) Explain why the calculation in part (b)(ii) would give an incorrect result for the enthalpy change for the reaction below.

$$CH_4(g) + 1\frac{1}{2}O_2(g) \rightarrow CO(g) + 2H_2O(g)$$

(2)

.....

.....

.....

.....

(Total for Question 23 = 8 marks)

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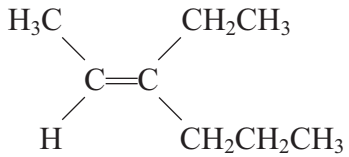
24 (a) Give the general formula for the homologous series of **alkenes**.

(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**.

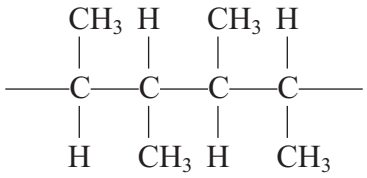
(1)

(e) Draw the mechanism for the reaction of **propene** with hydrogen bromide to give the major product.

(4)

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(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)

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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)

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(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)

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(c) Silicon exists in a giant covalent lattice.

(i) The electrical conductivity of pure silicon is very low. Explain why this is so in terms of the bonding.

(2)

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

(2)

(Total for Question 26 = 9 marks)

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

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The Periodic Table of Elements

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

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

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

* Lanthanide series

* Actinide series

P 3 3 9 3 T O M 6 P . A C O U N 2 4 2 4

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Mark Scheme (Results)

Summer 2012

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

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General Marking Guidance

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

Using the Mark Scheme

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

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

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

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

Quality of Written Communication

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

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

Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TOTAL FOR SECTION A = 20 MARKS

Section B

Question Number	Acceptable Answers	Reject	Mark
21(a)	**First mark:** Mass of **an atom**/mass of **an isotope** (of an element) **(1)** IGNORE any references to average or (weighted) mean **Second mark:** relative to 1/12th the mass of a ^{12}C atom **(1)** NOTE: The second mark is awarded for **any mention of ^{12}C** IGNORE throughout the candidate's answer any references to 'moles' or '1 mol' or '12 g' Mark the two points independently	Mass of (all the) isotope**s** /atom**s** 'Mass of an element'	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(i)	{(35 x 75.53) + (37 x 24.47)} ÷ 100 **(1)** = 35.4894 = 35.49 **(1)** **Answer to 4 s.f. only**. Correct answer no working **(2)** IGNORE units of any kind (e.g. 'g' 'g mol^{-1}' 'amu', etc.)		**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(ii)	$^{35}Cl_2^+/(^{35}Cl—^{35}Cl)^+$ **(1)** $^{37}Cl_2^+/(^{37}Cl—^{37}Cl)^+$ **(1)** ALLOW $(^{35}Cl + ^{35}Cl)^+$ and/or $(^{37}Cl + ^{37}Cl)^+$ OR $(^{35}Cl^{35}Cl)^+$ and/or $(^{37}Cl^{37}Cl)^+$ OR $(^{35}Cl$ and $^{35}Cl)^+$ and/or $(^{37}Cl$ and $^{37}Cl)^+$ If the 'formal' charge is omitted on either ion (or both the ions), then award **(1)** mark only. NOTE: $^{35}Cl^+$ $^{35}Cl^+$ and $^{37}Cl^+$ $^{37}Cl^+$ scores **(1)** as each ion has an extra + charge. $2^{35}Cl^+$ and $2^{37}Cl^+$ scores **(1)** Accept mass number written as superscript to right of symbol.	$^{70}Cl_2^+$ $^{74}Cl_2^+$ $2^{35}Cl$ and/or $2^{37}Cl$ scores **(0)**	**2**

Question Number	Acceptable Answers	Reject	Mark
21(b)(iii)	**72** **(1)** $^{35}Cl—^{37}Cl^{(+)}$ **(1)** ALLOW $(^{35}Cl + ^{37}Cl)^{(+)}$ and/or $(^{37}Cl + ^{35}Cl)^{(+)}$ OR $(^{37}Cl^{35}Cl)^{(+)}$ and/or $(^{37}Cl^{35}Cl)^{(+)}$ OR $(^{35}Cl$ and $^{37}Cl)^{(+)}$ and/or $(^{37}Cl$ and $^{35}Cl)^{(+)}$ NOTE: The + charge is not needed on **this ion** IGNORE extra + charges, so ALLOW $^{35}Cl^+$ $^{37}Cl^+$ and/or $^{37}Cl^+$ $^{35}Cl^+$		**2**

Question Number	Acceptable Answers	Reject	Mark
22(a)	**First mark:-** Makes mention of energy/enthalpy/(heat) energy/heat (change) AND to remove an electron AND one mole/1 mol **Second mark:** Makes mention of **gaseous atom(s)** **ALTERNATIVE ANSWER** Energy change per mole for **(1)** $X(g) \rightarrow X^{+}(g) + e^{(-)}$ **(1)** Mark the two points independently IGNORE any references to standard conditions	"Energy **given out**…" for first mark **Just** 'gaseous element'/ 'gaseous substance'	**2**

Question Number	Acceptable Answers	Reject	Mark
***22(b)**	**Any two from three:-** (Atomic) radius increases/there are more shells/(outermost) electron further from the nucleus **(1)** there is '**more** shielding' or '**more** screening' (down group) **(1)** the nuclear attraction decreases OR attraction between nucleus and (outermost) electron decreases OR the increased shielding/increased distance outweighs the increased nuclear charge **(1)** IGNORE any references to 'more protons' and/just 'increasing nuclear charge' IGNORE references to "effective nuclear charge"	**Ionic** radius increases	**2**

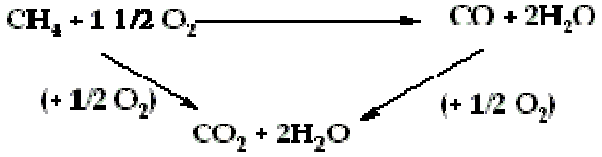
Question Number	Acceptable Answers	Reject	Mark
22(c)(i)	**Any ONE from:** (Electrons are being removed from an) increasingly positive ion/ charge on the ion (successively) increases/ increasing proton : electron ratio/ same number of protons (attracting) fewer electrons / ions get smaller/ the electron repulsion decreases/ the shielding decreases/ electrons (being removed are) closer to the nucleus/ **effective** nuclear charge increases		**1**

Question Number	Acceptable Answers	Reject	Mark
***22(c)(ii)**	**First mark: <u>Two</u> jumps** **Two** (large) jumps (between 1st and 2nd and 9th and 10th IEs) **(1)** NOTE: A sketch graph with **two** (large) jumps can score this first mark Note if the jumps are specified, they must be between 1st and 2nd **and** 9th and 10th IEs **Second mark: Electronic configuration of Na** 2, 8, 1 mentioned in words, **annotated** on a sketch graph or drawn out in a diagram (e.g. electrons shown in orbits/shells around the centre of the atom) but NOT just inferred **(1)** ALLOW "1, 8, 2" OR $1s^2 2s^2 2p^6 3s^1$ Mark the two points independently	1st mark if the graph is sketched 'back to front'	**2**

Question Number	Acceptable Answers	Reject	Mark
22(d)(i)	Credit any of the following representations (but need **BOTH** Mg **AND** Al to be correct) Mg $1s^2 2s^2 2p^6 3s^2$ **and** Al $1s^2 2s^2 2p^6 3s^2 3p^1$ Mg $1s_2 2s_2 2p_6 3s_2$ **and** Al $1s_2 2s_2 2p_6 3s_2 3p_1$ Mg $1S^2 2S^2 2P^6 3S^2$ **and** Al $1S^2 2S^2 2P^6 3S^2 3P^1$ Mg $1S_2 2S_2 2P_6 3S_2$ **and** Al $1S_2 2S_2 2P_6 3S_2 3P_1$		**1**

Question Number	Acceptable Answers	Reject	Mark
***22(d)(ii)**	NOTE: ALLOW an argument focusing on **either** the Al **or** the Mg atom **EITHER** **In Al**, (3p) **electron** (lost is) at higher energy/more shielded (by 3s electrons)/further from the nucleus IGNORE any reference to an unpaired electron in Al **OR** **In Mg**, (3s) **electron** (lost is) at lower energy/less shielded/ nearer to the nucleus/from a **full subshell**/from a full orbital/from (stable) $(3)s^2$ Any reference to an Al atom being **larger** in size than an Mg atom scores zero overall.	Al has one more **shell** than Mg **Just** (lost from) a new sub-shell Electron lost in Mg from a "full **shell**"	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)	The heat/enthalpy/energy change (for a reaction) is independent of the path(way)/route IGNORE any extra detail referring to "initial and final states"		**1**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	 CO_2 + **2**H_2O **(1)** Both arrows in correct direction downwards **(1)** IGNORE state symbols, even if incorrect Mark the two points independently		**2**

Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	ΔH = − 890 −(− 283) **(1)** = − 607 (kJ mol^{-1}) **(1)** Correct answer with no working scores **(2)** NOTE: **+**607 (kJ mol^{-1}) scores **(1)** only		**2**

Question Number	Acceptable Answers	Reject	Mark
***23 (b) (iii)**	Cannot stop the reaction at CO OR the reaction produces CO_2/complete combustion occurs OR may produce some carbon/soot OR cannot react exact amounts of methane to oxygen	non-standard conditions **Just** incomplete combustion occurs **Just** forming 'other products' /**just** a 'mixture of products' **Just** methane is 'very reactive'/ 'explosive' **Just** heat loss Cannot measure the temperature change	**1**

Question Number	Acceptable Answers	Reject	Mark
23(c)	**First mark: State of the H_2O** Water is in the gas phase/water is (formed) as steam/water is not in its standard state/water is not (formed as a) liquid **(1)** **Second mark: Idea of an energy change when there is a change of state** Change of state involves an energy change /energy change (for the reaction given) is less exothermic **(1)** ALLOW 'more endothermic' instead of 'less exothermic' IGNORE references to non-standard conditions	Energy change is more exothermic /less endothermic Heat loss 'Incomplete combustion'	**2**

Question Number	Acceptable Answers	Reject	Mark
24(a)	C_nH_{2n} ALLOW letters other than *n*		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)	A compound which contains (C=C) double bonds OR A compound that will undergo addition reactions OR Does not contain the maximum number of hydrogen atoms		**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	*E*-3-ethylhex-2-ene **(2)** **(1)** mark for 3-ethylhex-2-ene **(1)** mark for '**E**' IGNORE any missing hyphens or any hyphens replaced by commas Mark independently		**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	The four atoms/four groups around the C=C double bond are different OR No two groups are the same OR There are no common groups on either side of the C=C double bond OR There are two alkyl groups on one of the carbon atoms (in the C=C double bond) OR There are three alkyl groups around the double bond OR An indication of the existence of Priority Rules (for E-Z nomenclature) OR One of the carbon atoms (of the C=C double bond) is not bonded to a hydrogen atom ALLOW 'functional groups' for 'groups'	Each side is not symmetrical	**1**

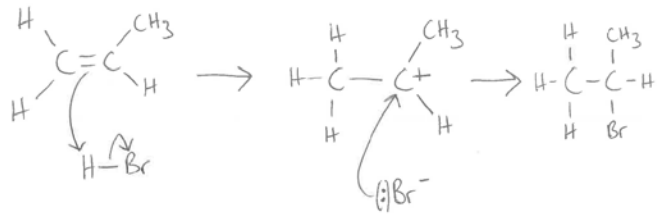
ALLOW displayed or skeletal formulae throughout 24(d)

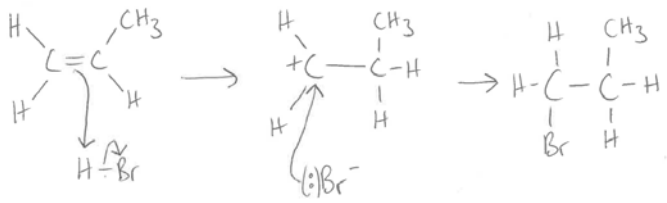
Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	CH_3CH_3 ALLOW displayed or skeletal formulae throughout 24(d)	C_2H_6	**1**

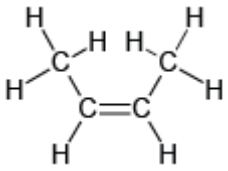
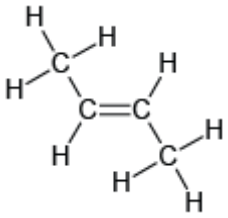
Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	$ClCH_2CH_2Cl$ / CH_2ClCH_2Cl	$C_2H_4Cl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iii)	$HOCH_2CH_2OH$ / CH_2OHCH_2OH	$C_2H_6O_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(iv)	$HOCH_2CH_2Br$ / CH_2OHCH_2Br	$BrCH_2CH_2Br$; C_2H_5OBr; $C_2H_4Br_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
24(e)	Major product route:  **First mark:** Curly arrow from C=C to the H (in H-Br) **AND** curly arrow from the bond in H—Br to the Br **(1)** **Second mark:** Structure of correct secondary carbocation **(1)** **Third mark:** Curly arrow from anywhere on the bromide ion towards the C+ on the carbocation **(1)** NOTE: The bromide ion must have a full negative charge, but the lone pair of electrons on the Br^- NEED NOT be shown **Fourth mark:** Choice of 2-bromopropane as major product **(1)** For showing the major product mechanism correctly **(4)** • both arrows **(1)** • carbocation intermediate **(1)** • attack by bromide ion **(1)** (Bromide ion must show a full negative charge. The lone pair of electrons need not be shown) • choice of 2-bromopropane as major product **(1)**		**4**

	Single-headed arrows used throughout **max (3)** Minor product route **max (3)**  If the minor product route is shown, the last mark is lost, but the first three marks can be scored consequentially as follows:- • both arrows **(1)** • carbocation intermediate **(1)** • attack of bromide ion **(1)** (NOTE: The bromide ion must show a full negative charge. The lone pair of electrons need not be shown) NOTE: If a correct mechanism for the electrophilic addition of HBr to **ethene** is shown then max **(2)** (i.e. the first and the third marks in the mechanism)		

Question Number	Acceptable Answers	Reject	Mark
24(f)(i)	 **(1)**  **(1)** NOTE: CH_3 group does not have to be displayed. IGNORE if any connectivity is shown from the **H_3** in a C**H_3** group IGNORE bond angles ALLOW one mark for just but-2-ene's structural formula		**2**

Question Number	Acceptable Answers	Reject	Mark
24(f)(ii)	**Any ONE of:-** • No atoms lost (or gained) • No elements lost (or gained) • (Only) one product (is formed) • (Produced by) an addition reaction • Addition polymer(ization) • Polymer is a repeat of the monomer • No small molecules (formed) • No co-products • No waste products • Same C:H ratio • Same ratio of carbon:hydrogen atoms • Same ratio of each element • Same ratio of atoms	(Monomer and polymer have) '**same number** of carbon and hydrogen atoms'	**1**

Question Number	Acceptable Answers	Reject	Mark
24(f)(iii)	**100% AND** some correct justification is needed **ONE answer from:-** 100% as addition reaction 100% because all the atoms are incorporated into the polymer 100% because (only) one product is formed 100% because (only) one desired product is formed 100% because no atoms are lost 100% because no waste products 100% because no small molecules (formed) 100% as no co-products 100% as no by-products	Statements such as 'the atom economy is **almost** 100%' OR **Just** "it has a high atom economy"	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	Amount Na = 1.73 (g) ÷ 23 (g mol^{-1}) = 0.075(22) (mol) Amount O = 1.20 (g) ÷ 16 (g mol^{-1}) = 0.075 (mol) **(1)** IGNORE sf, even if 1 sf NaO **(1)** Correct answer no working **(2)** NOTE: Correct answer can be obtained via incorrect working and all responses should be read carefully e.g. Amount Na = 23 ÷ 1.73 = 13.3 Amount O = 16 ÷ 1.20 = 13.3 scores second mark only for NaO if obtained by incorrect working OR e.g. Use of atomic numbers gives the Na : O ratio as 0.157 : 0.150 and an empirical formula of NaO. This scores (1) overall (i.e. the 2nd mark). OR e.g Use of atomic number ONLY for Na (i.e. Na = 11) gives the Na : O ratio as 0.157 : 0.075 and an empirical formula of Na_2O. This scores (1) overall (i.e. the 2nd mark). NOTE: Use of **O** = 32 gives Na_2O and scores second mark	 Na_2O_2	**2**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	(NaO = 39 hence molar mass twice that of NaO ∴) so **Na_2O_2**	'2NaO'	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	$2Na(s) + O_2(g) \rightarrow Na_2O_2(s)$ All species correct **(1)** State symbols and balancing **(1)** NOTE: 2nd mark is conditional on correct species. NOTE: $2Na(s) + O_2(g) \rightarrow 2NaO(s)$ scores **(1)** $Na(s) + O_2(g) \rightarrow NaO_2(s)$ scores **(1)** $4Na(s) + O_2(g) \rightarrow 2Na_2O(s)$ scores **(2)**		**2**

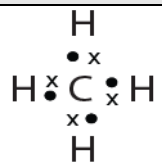
Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	Moles of O_2 = 0.075 ÷ 2 = 0.0375 OR 1.2 ÷ 32 = 0.0375 (mol) **(1)** 0.0375 mol x 24 dm^3 mol^{-1} = 0.9(0) (dm^3) **(1)** ALLOW 900 **cm^3 (units must be present here)** Correct answer no working **(2)** OR Moles of Na = 1.73 ÷ 23 = 0.075217 = moles of O Moles of O_2 = 0.075217 ÷ 2 = 0.0376085 0.0376085 x 24 = 0.903 (dm^3) or 903 **cm^3** IGNORE s.f., including ONE s.f. NOTE: If number of moles x 24 (dm^3 mol^{-1}) is clearly evident and correctly calculated in stated units, award second mark		**2**

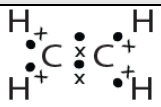
Question Number	Acceptable Answers	Reject	Mark
25(a)(v)	0.0375 x 6.02 x 10^{23} (= 2.2575 x 10^{22} (molecules)) = 2.26 x 10^{22} (molecules) IGNORE s.f. unless 1 s.f.		**1**

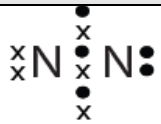
Question Number	Acceptable Answers	Reject	Mark
25(b)	Sodium might react with nitrogen in the air/sodium forms a nitride/ nitrogen (gas) is present in the air (which reacts with the sodium) OR sodium might form a different oxide (e.g. Na_2O or allow NaO_2) NOTE: If nitrogen / N_2 is mentioned as part of a 'list' of substances that can be present in air, award the mark	**Just** 'very reactive' OR 'very explosive' sodium forms Na_2O_2 alone References to hydrogen in the air **Just** 'reacts with other substances in the air' (as nitrogen not identified Sodium nitrate formation **Just** sodium hydroxide formation	**1**

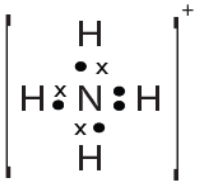
Question Number	Acceptable Answers	Reject	Mark
26(a)	(Electrostatic) attraction between (bonding) electrons and nuclei/protons	**Just** a 'shared pair of electrons'	**1**

- IGNORE ANY INNER SHELL ELECTRONS DRAWN
- ONLY THE TOTAL NUMBERS OF ELECTRONS IN OUTER SHELLS ARE BEING ASSESSED
- ALLOW ELECTRONS TO BE ALL DOTS OR ALL CROSSES OR BOTH

Question Number	Acceptable Answers	Reject	Mark
26(b)(i)			**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(ii)			**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(iii)	 NOTE: The lone pair of electrons on each N atom do not have to be shown as a pair		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(iv)	 The **+** sign can be shown anywhere Ignore missing brackets Ignore if the **+** is missing		**1**

Question Number	Acceptable Answers	Reject	Mark
26(c)(i)	IGNORE any references to 'molecules' in this part only **First mark: Location of silicon's electrons** Silicon's (outer) electrons are fixed (in covalent bonds)/ silicon's (outer) electrons are in fixed positions (in covalent bonds)/ silicon's (outer) electrons are involved in bonding **(1)** **Second mark: Lack of mobility of silicon's electrons** (therefore) silicon's electrons are not free (to move)/ silicon has no free electrons/ there are no mobile electrons in silicon/ silicon has no delocalized electrons/ silicon's electrons cannot flow **(1)** IGNORE references to **lack of** ions	'Silicon is ionic' scores **(0)** for the question 'silicon's **ions** are not free to move' scores **(0)** for the question	**2**

Question Number	Acceptable Answers	Reject	Mark
26(c)(ii)	(The covalent) bonds are **strong** (throughout the lattice) **(1)** (therefore) a lot of **energy** is required to break the bonds / a lot of **energy** is needed to overcome the attractions **(1)** IGNORE any references to 'giant molecular'	'(simple) molecular silicon' **(0)** /'molecules of silicon' **(0)** /'silicon has ions' **(0)** /'intermolecular forces' / 'van der Waals' forces'/ 'London forces' **(0)** ALL THE ABOVE SCORE **(0)** OVERALL	**2**

TOTAL FOR SECTION B = 60 MARKS

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Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Friday 13 January 2012 – Afternoon
Time: 1 hour 30 minutes

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

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7/7/5/3/

P 3 9 2 9 5 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 A molecule is

☒ **A** a group of atoms bonded by ionic bonds.

☒ **B** a group of atoms bonded by covalent bonds.

☒ **C** a group of ions bonded by covalent bonds.

☒ **D** a group of atoms bonded by metallic bonds.

(Total for Question 1 = 1 mark)

2 The relative atomic mass is defined as

☒ **A** the mass of an atom of an element relative to 1/12 the mass of a carbon-12 atom.

☒ **B** the mass of an atom of an element relative to the mass of a hydrogen atom.

☒ **C** the average mass of an element relative to 1/12 the mass of a carbon atom.

☒ **D** the average mass of an atom of an element relative to 1/12 the mass of a carbon-12 atom.

(Total for Question 2 = 1 mark)

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

P 3 9 2 9 5 A 0 2 2 4
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3 The definition of the mole is

☒ **A** the amount of any substance which occupies a volume of 24 dm^3 at room temperature and pressure.

☒ **B** the amount of any substance containing the same number of identical entities as there are in exactly 12 g of the carbon-12 isotope.

☒ **C** the number of atoms in exactly 12 g of the carbon-12 isotope.

☒ **D** the number of molecules in exactly 2 g of hydrogen at room temperature and pressure.

(Total for Question 3 = 1 mark)

---

4 The concentration of blood glucose is usually given in millimoles per dm^3 or mmol dm^{-3}. A reading of 5.0 mmol dm^{-3} is within the normal range. Glucose has a molar mass of 180 g mol^{-1}. What mass of glucose dissolved in 1 dm^3 of blood would give this normal reading?

☒ **A** 0.090 g

☒ **B** 0.18 g

☒ **C** 0.90 g

☒ **D** 9.0 g

(Total for Question 4 = 1 mark)

---

5 In an experiment performed to measure the enthalpy change for the reaction

$$Cu^{2+}(aq) + Zn(s) \rightarrow Cu(s) + Zn^{2+}(aq)$$

3.0 g of zinc powder (an excess) was added to 30.0 cm^3 of copper(II) sulfate solution of concentration 1.00 mol dm^{-3}. The temperature rise of the mixture was 47.6 K. Assuming that the heat capacity of the solution is 4.2 J K^{-1} g^{-1}, the enthalpy change for the reaction is given by

☒ **A** $\Delta H = -(30 \times 4.2 \times 47.6) \div 0.03$

☒ **B** $\Delta H = -(33 \times 4.2 \times 47.6) \div 0.03$

☒ **C** $\Delta H = -(30 \times 4.2 \times 47.6) \times 0.03$

☒ **D** $\Delta H = -(33 \times 4.2 \times 47.6) \times 0.03$

(Total for Question 5 = 1 mark)

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6 The enthalpy change of atomization of iodine is the value of ΔH for the process

☒ **A** $I_2(s) \rightarrow I_2(g)$

☒ **B** $I_2(s) \rightarrow 2I(g)$

☒ **C** $I_2(g) \rightarrow 2I(g)$

☒ **D** $\frac{1}{2}I_2(s) \rightarrow I(g)$

(Total for Question 6 = 1 mark)

7 The enthalpy change for the reaction

$$C(s, \text{graphite}) + \tfrac{1}{2}O_2(g) \rightarrow CO(g)$$

cannot be measured directly since some carbon dioxide is always formed in the reaction. It can be calculated using Hess's Law and the enthalpy changes of combustion of graphite and of carbon monoxide.

$$C(s, \text{graphite}) + O_2(g) \rightarrow CO_2(g) \quad \Delta H = -394 \text{ kJ mol}^{-1}$$

$$CO(g) + \tfrac{1}{2}O_2(g) \rightarrow CO_2(g) \quad \Delta H = -283 \text{ kJ mol}^{-1}$$

The enthalpy change for the reaction of graphite with oxygen to give carbon monoxide is

☒ **A** -677 kJ mol^{-1}

☒ **B** $+111 \text{ kJ mol}^{-1}$

☒ **C** -111 kJ mol^{-1}

☒ **D** $+677 \text{ kJ mol}^{-1}$

(Total for Question 7 = 1 mark)

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

P 3 9 5 4 2 4 A 0 1 6
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8 The molar enthalpy change of combustion of some alkanes is given below in kJ mol^{-1}.

C_3H_8	−2219
C_4H_{10}	−2877
C_5H_{12}	−3509
C_6H_{14}	−4163

Another alkane was found to have an enthalpy change of combustion of −6125 kJ mol^{-1}.
The alkane is

☒ **A** C_7H_{16}

☒ **B** C_8H_{18}

☒ **C** C_9H_{20}

☒ **D** $C_{10}H_{22}$

(Total for Question 8 = 1 mark)

---

9 If the mean C—H bond enthalpy is **+*x***, which of the following represents a process with an enthalpy change of **+4*x***?

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

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

☒ **C** $CH_4(g) \rightarrow C(s, \text{graphite}) + 2H_2(g)$

☒ **D** $C(s, \text{graphite}) + 2H_2(g) \rightarrow CH_4(g)$

(Total for Question 9 = 1 mark)

---

10 The first eight ionization energies of an element are (in kJ mol^{-1}):

789, 1577, 3232, 4356, 16091, 19785, 23787, 29253.

The element is in

☒ **A** Group 1

☒ **B** Group 2

☒ **C** Group 3

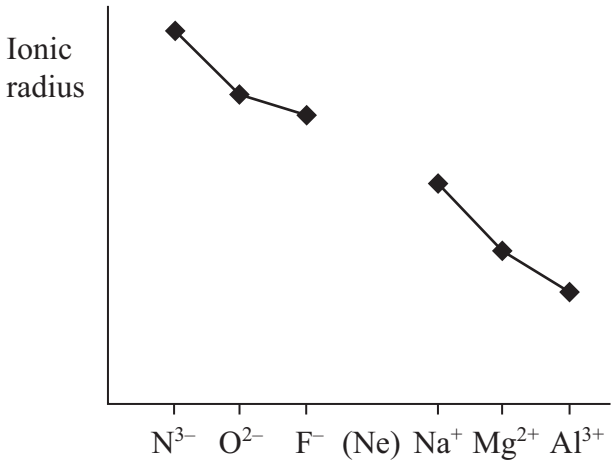
☒ **D** Group 4

(Total for Question 10 = 1 mark)

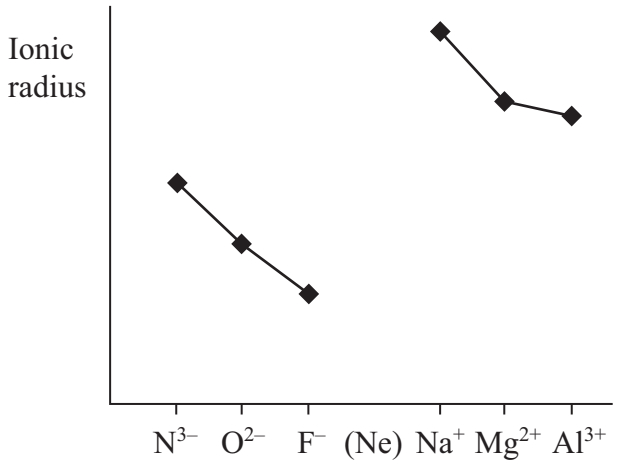
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11 Which of the graphs shows (from left to right) the trend in the ionic radius of the isoelectronic ions N^{3-}, O^{2-}, F^-, Na^+, Mg^{2+}, Al^{3+}?

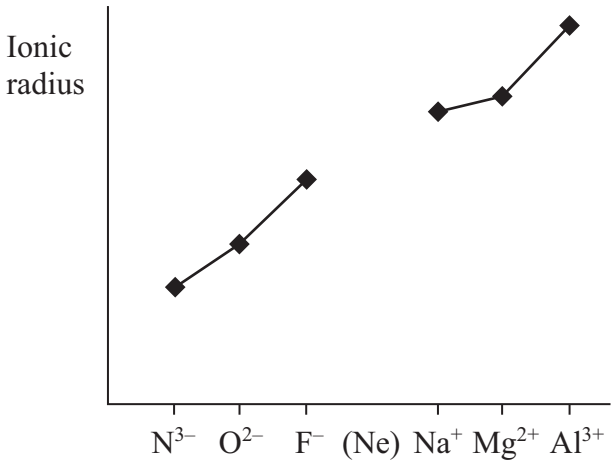
☒ **A**



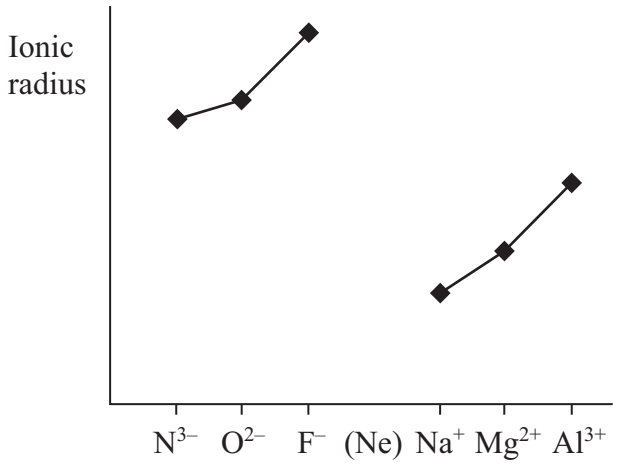
☒ **B**



☒ **C**



☒ **D**



(Total for Question 11 = 1 mark)

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

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12 Oxygen can be prepared using several different reactions. Which of those given below has the highest atom economy by mass?

☒ **A** $NaNO_3 \rightarrow NaNO_2 + ½O_2$

☒ **B** $H_2O_2 \rightarrow H_2O + ½O_2$

☒ **C** $Cl_2 + H_2O \rightarrow 2HCl + ½O_2$

☒ **D** $PbO_2 \rightarrow PbO + ½O_2$

(Total for Question 12 = 1 mark)

13 The ionic radii in nm of some ions are given below.

Li^+	0.074	F^-	0.133
Ca^{2+}	0.100	Cl^-	0.180
		O^{2-}	0.140
		S^{2-}	0.185

(a) Which of the following compounds has the most exothermic lattice energy? They all have the same crystal structure.

(1)

☒ **A** LiF

☒ **B** LiCl

☒ **C** CaO

☒ **D** CaS

(b) Which of the following compounds will show the greatest difference between the experimental (Born-Haber) lattice energy and that calculated from a purely ionic model?

(1)

☒ **A** LiF

☒ **B** Li_2O

☒ **C** CaO

☒ **D** CaS

(Total for Question 13 = 2 marks)

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14 Which of the following is the correct order for the processes used to obtain petrol from petroleum (crude oil)?

☒ **A** Petroleum → fractional distillation → reforming → cracking → petrol.

☒ **B** Petroleum → reforming → fractional distillation → cracking → petrol.

☒ **C** Petroleum → cracking → reforming → fractional distillation → petrol.

☒ **D** Petroleum → fractional distillation → cracking → reforming → petrol.

(Total for Question 14 = 1 mark)

15 In the reaction between ethene and bromine, the bromine molecule acts as an electrophile.

$$CH_2{=}CH_2 + Br_2 \rightarrow BrCH_2CH_2Br$$

Which of the following statements is true?

☒ **A** Ethene acts as a nucleophile because it is polar.

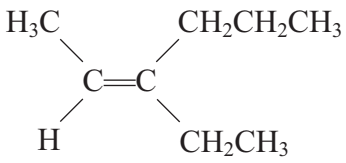
☒ **B** Ethene acts as a nucleophile because it can donate a pair of electrons to bromine.

☒ **C** Ethene is not a nucleophile in this reaction.

☒ **D** Ethene acts as a nucleophile because it donates a single electron to bromine.

(Total for Question 15 = 1 mark)

16 Name the alkene shown below.



☒ **A** *Z*-4-ethylhex-4-ene

☒ **B** *E*-3-ethylhex-2-ene

☒ **C** *Z*-3-ethylhex-2-ene

☒ **D** *E*-3-propylpent-2-ene

(Total for Question 16 = 1 mark)

P 3 9 5 8 2 A 0 8 2 4
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17 If propene, $CH_3CH{=}CH_2$, is reacted with aqueous acidified potassium manganate(VII) the organic product is

- ☒ **A** $CH_3CH(OH)CH_2OH$
- ☒ **B** $CH_3CH(OH)CH_3$
- ☒ **C** $HOCH_2CH_2CH_2OH$
- ☒ **D** $CH_3CH_2CH_2OH$

(Total for Question 17 = 1 mark)

18 How many compounds have the formula C_5H_{12}?

- ☒ **A** 1
- ☒ **B** 2
- ☒ **C** 3
- ☒ **D** 4

(Total for Question 18 = 1 mark)

19 An organic compound reacts with chlorine in the presence of ultraviolet light. The relative molecular mass of the product has increased by 34.5 compared with the original compound. What is the reaction mechanism?

- ☒ **A** Free radical substitution
- ☒ **B** Electrophilic substitution
- ☒ **C** Nucleophilic substitution
- ☒ **D** Free radical addition

(Total for Question 19 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

SECTION B

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

20 (a) An impure sample of sodium hydrogencarbonate, $NaHCO_3$, of mass 0.227 g, was reacted with an excess of hydrochloric acid. The volume of carbon dioxide evolved was measured at room temperature and pressure and found to be 58.4 cm^3.

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2$$

The molar volume of any gas at the temperature and pressure of the experiment is 24 $dm^3\ mol^{-1}$. The molar mass of sodium hydrogencarbonate is 84 $g\ mol^{-1}$.

(i) Calculate the number of moles of carbon dioxide given off.

(1)

(ii) Calculate the mass of sodium hydrogencarbonate present in the impure sample.

(2)

(iii) Calculate the percentage purity of the sodium hydrogencarbonate. Give your answer to two significant figures.

(2)

P 3 9 2 3 9 5 A 0 0 2 4
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(b) (i) The total error in reading the gas syringe is ±0.4 cm^3. Calculate the percentage error in measuring the gas volume of 58.4 cm^3.

(1)

(ii) Suggest why the carbon dioxide should not be collected over water in this experiment.

(1)

.....

.....

(Total for Question 20 = 7 marks)

P 3 9 2 9 5 A 0 1 1 2 4
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21 (a) On strong heating, calcium carbonate decomposes to calcium oxide and carbon dioxide:

$$CaCO_3(s) \rightarrow CaO(s) + CO_2(g)$$

Owing to the conditions under which the reaction occurs, it is not possible to measure the enthalpy change directly.

An indirect method employs the enthalpy changes when calcium carbonate and calcium oxide are neutralized with hydrochloric acid.

(i) Write the equation for the reaction of calcium carbonate with hydrochloric acid. State symbols are **not** required.

[ΔH_1 is the enthalpy change for this reaction]

(1)

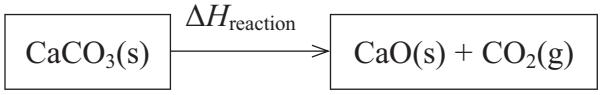
.....ΔH_1

(ii) The reaction of calcium oxide with hydrochloric acid is

$$CaO(s) + 2HCl(aq) \rightarrow CaCl_2(aq) + H_2O(l) \qquad \Delta H_2$$

Use the equations in parts (i) and (ii) to complete the Hess's Law cycle below to show how you could calculate the enthalpy change for the decomposition of calcium carbonate, $\Delta H_{reaction}$. Label the arrows in your cycle.

(3)



P 3 9 2 5 5 A 0 1 2 2 4
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(iii) Complete the expression for $\Delta H_{reaction}$ in terms of $\mathbf{\Delta H_1}$ and $\mathbf{\Delta H_2}$.

(1)

$\Delta H_{reaction}$ =

(b) Suggest **two** reasons why the value obtained by carrying out these two experiments and using the equation gives a value different to the data booklet value for the decomposition reaction of calcium carbonate.

(2)

1 .....

.....

2 .....

.....

(Total for Question 21 = 7 marks)

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22 (a) State how the following processes are achieved in a mass spectrometer.

(i) Ionization of the sample.

(1)

(ii) Acceleration of the ions.

(1)

(iii) Deflection of the ions.

(1)

(b) State how you could find the molecular mass of a substance from its mass spectrum.

(1)

(c) Living things take up the radioactive isotope carbon-14 from the atmosphere. In recent years a particular linen cloth was shown, using mass spectrometry, to have been made from flax grown in the early 14th century. Suggest how mass spectrometry can be used to estimate the age of the cloth.

(2)

(Total for Question 22 = 6 marks)

***23** The melting temperatures of the elements of Period 3 are given in the table below. Use these values to answer the questions that follow.

Element	Na	Mg	Al	Si	P (white)	S (monoclinic)	Cl	Ar
Melting temperature / K	371	922	933	1683	317	392	172	84

(a) Explain why the melting temperature of sodium is very much less than that of magnesium.

(3)

(b) Explain why the melting temperature of silicon is very much greater than that of white phosphorus.

(3)

P 3 9 2 3 9 5 A 0 1 6 2 4
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(c) Explain why the melting temperature of argon is the lowest of all the elements of Period 3.

(1)

.....

.....

(d) Explain why magnesium is a good conductor of electricity whereas sulfur is a non-conductor.

(2)

.....

.....

.....

.....

(Total for Question 23 = 9 marks)

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24 (a) Briefly describe an experiment, with a diagram of the apparatus you would use, which shows that there are oppositely charged ions in copper(II) chromate(VI), $CuCrO_4$. Describe what you would expect to see.

Formula of ion	Colour
$Cu^{2+}(aq)$	blue
$CrO_4^{2-}(aq)$	yellow

(4)

Diagram

(b) The ions in an ionic lattice are held together by an **overall** force of attraction.

(i) Describe the forces of attraction in an ionic lattice.

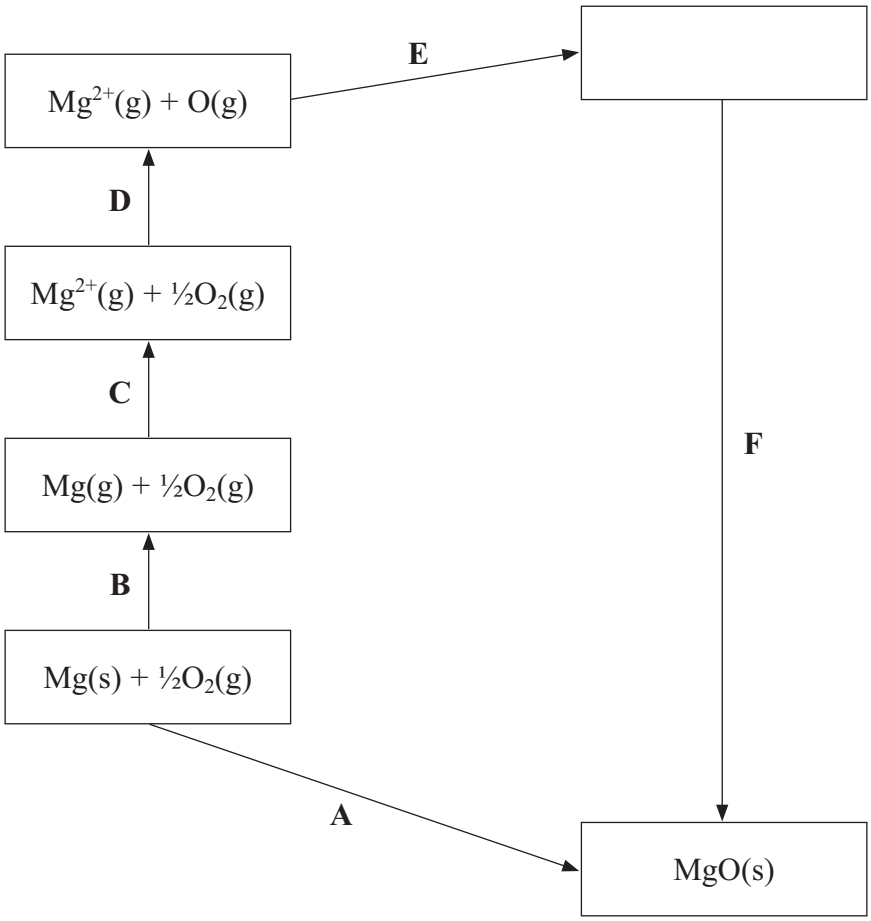
(1)

(ii) Suggest **two** forces of repulsion which exist in an ionic lattice.

(2)

P 3 9 2 3 9 5 A 0 1 8 2 4
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(c) Part of the Born-Haber cycle for magnesium oxide, MgO, is shown below.



(i) Complete the empty box with the appropriate formulae and state symbols.

(2)

(ii) Identify the enthalpy changes represented by the letters **A** and **C**.

(2)

A .....

C .....

(iii) Give the expression for the enthalpy change **F** in terms of the other enthalpy changes **A** to **E**.

(1)

F =

P 3 9 2 9 5 A 0 1 9 2 4
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(d) The lattice composed of the ions Mg^{2+} and O^{2-} is stronger than a lattice composed of the ions Mg^{+} and O^{-}.

(i) Explain, in terms of the charges on the ions and the size of the cations, why this is so.

(2)

.....

.....

.....

.....

(ii) Suggest how the lattice energy of $Mg^{2+}O^{2-}$ would differ from that of $Mg^{+}O^{-}$.

(1)

.....

.....

(Total for Question 24 = 15 marks)

P 3 9 2 3 9 5 A 0 1 2 0 2 4
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25 Chloroethane can be made from ethane and chlorine in the gas phase in the presence of ultraviolet light. The equation for the reaction is

$$CH_3CH_3 + Cl_2 \rightarrow CH_3CH_2Cl + HCl$$

(a) Complete the mechanism for the reaction. Two of the steps have been given for you.

(4)

Initiation: $Cl_2 \rightarrow 2Cl\cdot$

Propagation (two steps)

(i)

(ii)

Termination (three steps)

$2Cl\cdot \rightarrow Cl_2$

(iii)

(iv)

(b) This reaction gives a poor yield of chloroethane. Give the structural formula and name of another organic product, not included in your mechanism for part (a), which could be produced in the reaction.

(2)

Formula

Name .....

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(c) Chlorine gas is extremely toxic and is therefore a significant hazard. The preparation must be performed so as to minimise the risk to the experimenter.

(i) Explain the difference between **hazard** and **risk**.

(2)

.....

.....

.....

.....

(ii) Give one precaution that you would use in this experiment to minimise the risk, other than the use of a laboratory coat and safety goggles.

(1)

.....

.....

(Total for Question 25 = 9 marks)

P 3 9 2 9 5 A 0 1 2 2 4
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26 (a) The alkenes have the general formula C_nH_{2n}. However, a compound with this general formula is not necessarily an alkene. Suggest why this is so.

(1)

.....

.....

.....

(b) Give the equation, using skeletal formulae, for the reaction of propene with each of the following.

(i) Hydrogen:

(1)

(ii) Hydrogen bromide to form the major product:

(2)

(c) Give the mechanism for the reaction of propene with hydrogen bromide, HBr, to form the major product.

(3)

(Total for Question 26 = 7 marks)

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

P 3 9 2 9 5 A 0 2 3 2 4
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The Periodic Table of Elements

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

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

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

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

* Lanthanide series

* Actinide series

P 3 9 2 T 9 M 5 P . A 0 0 U 2 4 2 4

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Mark Scheme (Results)
January 2012

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

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General Marking Guidance

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

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Using the Mark Scheme

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

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

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

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

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

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

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Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

Question Number	Correct Answer	Reject	Mark
13(a)	C **(1)**		
13(b)	D **(1)**		**2**

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

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

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

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

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

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

TOTAL FOR SECTION A = 20 MARKS

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Section B

Question Number	Acceptable Answers	Reject	Mark
20(a)(i)	(Amount CO_2 = 0.0584 dm^3 ÷ 24 dm^3 mol^{-1}) = 0.0024333/2.4333 x 10^{-3} (mol) IGNORE sf except 1 No working needed Mark final answer	0.002/2 x 10^{-3} or any other value WRONG units with correct numerical answer scores (0)	**1**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	**First mark:** amount CO_2 = amount $NaHCO_3$ **OR** use of candidate's answer to (a)(i) stated (or implied by final answer given) **(1)** **Second mark:** ∴ mass $NaHCO_3$ = 0.0024333 (mol) **x 84** (g mol^{-1}) = 0.2044 (g) ALLOW **0.2 (g)** This mark is for evidence of multiplying their moles of $NaHCO_3$ **by 84** **(1)** IGNORE sf including 1 sf Correct answer with no working scores **(2)** ALLOW consequentially from (i).		**2**

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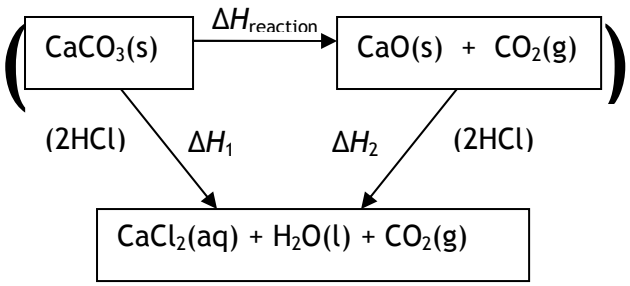
Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	**%** purity **=** (0.2044 g x 100) ÷ 0.227g = 90.04 **%** **(1)** = 90% **(1) (2 sf only)** ALLLOW consequentially from (i) and (ii) NOTE: The second mark to be awarded for 2sf answers less than a 100% (e.g. 10% scores **(1).** This is the percentage **impurity**) Correct answer with no working scores **(2)** Can score both marks via moles rather than masses	Answers not to 2 sf or answers incorrectly rounded up do not score 2nd mark Answers > 100% score **(0)** overall	**2**

Question Number	Acceptable Answers	Reject	Mark
20(b)(i)	0.4 / 58.4 x 100 = (±) 0.68493(%) IGNORE sf (including 1 sf so (±) 0.7 (%) **is** OK here)	(±) 1.37 (%) etc., as the uncertainty should NOT be doubled Answers incorrectly rounded (e.g. 0.684 / 0.67 / 0.68492)	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)(ii)	Any one of:- CO_2 dissolves /soluble (in water) CO_2 reacts (with water) / CO_2 forms carbonic acid / $CO_2 + H_2O \rightarrow H_2CO_3$ ALLOW CO_2 absorbed (by water) IGNORE suggestions to use a gas syringe	"CO_2 not the only gas given off" CO_2 diffuses/is lost/mixes with water "Water is also a product of the experiment" "Suck-back"	**1**

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Question Number	Acceptable Answers	Reject	Mark
21(a)(i)	$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2$ ALLOW multiples No other species to be allowed IGNORE state symbols even if incorrect	H_2CO_3 instead of "$H_2O + CO_2$" on right hand side of equation	**1**

Question Number	Acceptable Answers	Reject	Mark
21(a)(ii)	 **Mark each point independently** **First mark:** All three formulae in box, ignoring state symbols (even if incorrect) **This mark is stand alone, NOT to be marked CQ on answer to (a)(i)** **(1)** **Second mark:** Two arrows, BOTH pointing downwards **(1)** **Third mark:** Left hand arrow labelled as ΔH_1 **AND** right hand arrow labelled ΔH_2 (whatever the direction of the arrows) **(1)**	Any other formulae	**3**

Question Number	Acceptable Answers	Reject	Mark
21(a)(iii)	$(\Delta H_{reaction}) = \mathbf{\Delta H_1 - \Delta H_2}$ This is a stand alone answer NOT to be marked CQ on (a)(ii) and/or (a)(i)	Any other expression	**1**

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Question Number	Acceptable Answers	Reject	Mark
21(b)	**Any two from:** Heat /energy loss OR Heat /energy loss to surroundings OR Heat /energy loss to apparatus **(1)** Measured under non-standard conditions **(1)** Specific heat capacity of solutions is approximate **(1)** Density of solution assumed to be 1 g cm^{-3}/same as (pure) water **(1)** Large relative error in temperature measurement **(1)**	"Incomplete reaction" "Incomplete combustion" "Inaccuracy of equipment/apparatus" "Human error" CO_2 escapes Bond enthalpies Impurity of reactants Transfer losses Side-reactions	**2**

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Question Number	Acceptable Answers	Reject	Mark
22(a)(i)	**The mark is for the idea of impact by high energy electrons** **Any ONE of:** High-energy electrons Bombard with electrons Fast electrons (fired at sample) Accelerated electrons (fired at sample) (High-energy) electrons fired (at sample) (Sample) blasted with electrons Electron gun ALLOW "beam of electrons" IGNORE any comments (correct or incorrect) re subsequent ionization of the sample	High-**density** electrons	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(ii)	Electric field /electrostatic field / charged plates /voltage plates	**Positively-charged** plates /electronic field /electric current /(electro) magnetic field / electric coil	**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)(iii)	Magnetic field/magnet / electromagnet /magnetic plates/ electromagnetic field	**"Negative** magnetic field"/ negatively-charged magnet	**1**

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Question Number	Acceptable Answers	Reject	Mark
22(b)	(Molecular mass of a substance is) that of the molecular ion/parent ion OR (m/e value for) peak/ion of largest mass OR (m/e value for) peak/ion furthest to the right ALLOW "last peak"/"peak at the end"	Highest peak/ tallest peak/ comments about determination of relative atomic mass	**1**

Question Number	Acceptable Answers	Reject	Mark
22(c)	**Mark independently:** **First mark:** Any mention of (determination of) amount /mass/abundance of ^{14}**C** (in cloth) ALLOW Any mention of (determination of) concentration/content/percentage of ^{14}**C** (in cloth) **OR** find proportion of ^{12}**C : ^{14}C** (in cloth) **(1)** **Second mark:** Any mention of any one of the following:- (Use) half-life of ^{14}**C** / mention that amount of ^{14}**C** (in cloth) decreases (over time) / ^{14}**C** decays over time / comparison of amount of ^{14}**C** in living systems / comparison of amount of ^{14}**C** in modern materials / compare with ^{12}**C : ^{14}C** in living systems **(1)**	amount of ^{14}**C** (in cloth) increases (over time)	**2**

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Question Number	Acceptable Answers	Reject	Mark
***23(a)**	**ALLOW reverse arguments in each case** **Any three from:-** • **sodium atoms/sodium ions** are larger (than magnesium atoms/ions) **NOTE:** Allow symbols (eg Na or Na^+) **(1)** • sodium ions are Na^+ whereas magnesium ions are Mg^{2+} OR Na^+/sodium **ions** have smaller charge (density) than Mg^{2+}/ magnesium **ions** **(1)** **[NOTE:** It follows that the statement that "Na^+ ions are larger than Mg^{2+} ions" would score the first two scoring points above**]** • sodium has fewer **delocalized** electrons (than magnesium) **(1)** • attraction between the positive ions and (delocalized) electrons is weaker in sodium (than magnesium) **(1)** • sodium is not close-packed (but magnesium is close-packed) **(1)** • less energy needed (to break bonds) **(1)**	Attraction between **nucleus** and (delocalized) electrons Mention of **intermolecular forces/molecules** negates the energy mark **NOTE:** Arguments based on ionization energies **OR** suggestion of removal of outer shell electrons as part of the melting process scores **(0) overall**	**3**

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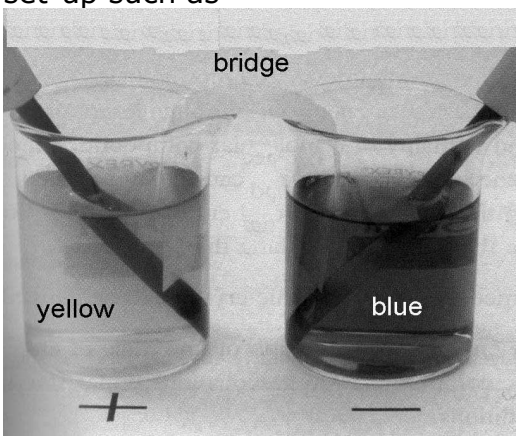
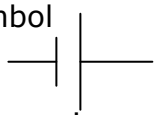
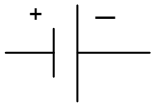
Question Number	Acceptable Answers	Reject	Mark
***23(b)**	**First mark:** Idea of (breaking) **covalent bonds** in silicon **(1)** **Second and third marks:** **ANY TWO FROM** • Silicon is **giant** covalent / giant atomic/giant molecular/ macromolecular/giant structure/giant lattice IGNORE just "giant" **(1)** • Phosphorus made up of simple molecules /small molecules/ P_4 molecules /phosphorus is molecular covalent /molecular/simple covalent IGNORE just "simple"/"simple structure" **(1)** • Between phosphorus molecules: weak forces/weak intermolecular forces/weak London forces/weak van der Waals' forces/weak dispersion forces/weak induced-dipole forces **(1)** **[ALLOW** "weak bonds" if implies between phosphorus **molecules]** • More energy needed (to break bonds in silicon) **(1)**	Intermolecular forces broken in silicon/ covalent bonds broken in phosphorus "silicon giant ionic"/"silicon giant metallic" Weak bonds between phosphorus **atoms**	**3**

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Question Number	Acceptable Answers	Reject	Mark
***23(c)**	**IGNORE any references to "energy" in this part of the question** Argon monatomic/argon (composed of) single atoms **NOTE:** This must be stated in words, not just by use of its symbol Ar IGNORE any comments about argon atoms having a full outer shell or argon being a noble gas IGNORE any comment about forces/bonds between argon particles	Any suggestion that argon is molecular Argon having a giant structure (of atoms)	**1**

Question Number	Acceptable Answers	Reject	Mark
***23(d)**	**First mark:** Mg has mobile electrons/delocalized electrons/free electrons/sea of electrons (to carry the charge) ALLOW Mg^{2+} instead of Mg or magnesium **(1)** **Second mark:** Sulfur's electrons are fixed (in covalent bonds)/sulfur's electrons are involved in bonding/sulfur's electrons are not free (to move)/no delocalized electrons in sulfur/no mobile electrons in sulfur **(1)**	Mg has free ions/Mg has mobile ions Sulfur has 'no free **ions**'/sulfur **has** delocalized electrons/just "sulfur has covalent bonds"/ just "sulfur is not a metal"	**2**

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Question Number	Acceptable Answers	Reject	Mark
24(a)	**First mark:** **Diagram** showing U-tube OR filter paper on a microscope slide OR electrodes in a beaker OR other feasible set-up such as  **but a + and a — sign must be shown somewhere on the diagram by signs or words, positive and negative.** **NOTES** If set-up in the picture above is used, in addition to the + and — signs a bridge between the two beakers must also be shown. External circuits do not have to be complete (e.g. wires can be shown attached to a slide, provided the **+** and **—** labels included). **If** the words cathode and/or anode are included, for the first mark to be awarded the cathode must be shown as —ve and/or the anode as +ve **If** a battery symbol  shown, IGNORE any incorrect polarities, that is  **IGNORE** any electrode materials **EXCEPT** Cu^{2+} and/or CrO_4^{2-} **(1)**		4

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	Second mark: Description to include the idea that the **ions move/ions** are **mobile/ions migrate** **MUST BE IN WORDS** ALLOW if description focuses on the movement of one of the ions to the oppositely-charged electrode **(1)** **Third mark:** Yellow ion/yellow (colour)/CrO_4^{2-} moves towards the/+ve (electrode)/ anode **(1)** **Fourth mark:** Blue ion/blue (colour)/Cu^{2+} moves towards cathode /—ve (electrode) **(1)** Mark CQ on candidate's cathode and anode signs for the **3rd** and **4th** marks	**Just** ions are attracted to the electrodes of opposite charge	

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	(Forces of attraction between) oppositely-charged ions/positive and negative ions/cations and anions IGNORE comments about electron transfer	Just ionic bonds/ Just "electrostatic forces of attraction"	**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	**First mark:** Ions of the same charge (repel)/ positive ions (repel)/negative ions (repel) **(1)** **Second mark:** Nuclei (of the ions repel) ALLOW 'protons' (in the ions repel) OR Electron clouds OR electrons (in the ions repel) **(1)**	"**Magnetic** repulsion" negates first mark "Electrons repel nuclei"	**2**

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Question Number	Acceptable Answers	Reject	Mark
24(c)(i)	$Mg^{2+}(g)$ **(1)** O^{2-} (g) **(1)** Penalise missing /incorrect state symbols once only Max 1 if include "$2e^-$"		**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(ii)	(**A** is enthalpy change of) **formation** (of MgO) **(1)** ALLOW just "ΔH_f" ALLOW (enthalpy change of) combustion **of magnesium** (**C** is) (sum of) first plus second ionization energies (of Mg) / $IE_1 + IE_2$ (for Mg) **(1)** ALLOW "first and second ionization energies (of Mg)" IGNORE references to "standard"	"(enthalpy change of) **reaction**" Just "ionization energy"/ "second ionization energy" (of Mg)	**2**

Question Number	Acceptable Answers	Reject	Mark
24(c)(iii)	(**F** =) A – B – C – D – E NOTE: These letters may be in any order, but the signs MUST be correct ALLOW answers when the enthalpy changes are identified correctly in words or symbols in lieu of the letters		**1**

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Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	**First mark:** **Mg^{2+} AND O^{2-}** higher charge / **Mg^{2+} AND O^{2-}** higher charge density (than Mg^{+} and O^{-}) NOTE: **both** ions needed **(1)** **Second mark:** Mg^{2+} smaller (than Mg^{+}) **(1)** IGNORE comparisons of the relative sizes of O^{-} with O^{2-} even if INCORRECT IGNORE any references to polarization (of ions) and/or covalent character	Any mention of 'intermolecular forces' scores **(0)** overall for this question	**2**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	(Lattice energy of $Mg^{2+}O^{2-}$ is) more exothermic/more negative ALLOW greater/increased/higher/ more/larger/bigger IGNORE "stronger lattice"	"energy **required**" OR Lower/less/ smaller	**1**

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N.B. Throughout, ALLOW C_2H_6 for CH_3CH_3 and C_2H_5Cl for CH_3CH_2Cl and $C_2H_5\bullet$ for $CH_3CH_2\bullet$ and C_4H_{10} for $CH_3CH_2CH_2CH_3$ etc

If CH_4 used instead of CH_3CH_3 max (1) mark overall for (a)(i) and (a)(ii) taken together
Then mark (a)(iii) and (a)(iv) CQ as for CH_4

IGNORE positions of the dots in free radicals; dots must be shown in each radical

Question Number	Acceptable Answers	Reject	Mark
25(a)(i)	$CH_3CH_3 + Cl\cdot \rightarrow CH_3CH_2\cdot + HCl$ OR $CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$		**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(ii)	$CH_3CH_2\cdot + Cl_2 \rightarrow CH_3CH_2Cl + Cl\cdot$ OR $CH_3CH_3 + Cl\cdot \rightarrow CH_3CH_2\cdot + HCl$ N.B. different answers for (i) and (ii) needed		**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iii)	$2CH_3CH_2\cdot \rightarrow CH_3CH_2CH_2CH_3$ OR $CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$	$Cl\cdot + Cl\cdot \rightarrow Cl_2$	**1**

Question Number	Acceptable Answers	Reject	Mark
25(a)(iv)	$CH_3CH_2\cdot + Cl\cdot \rightarrow CH_3CH_2Cl$ OR $2CH_3CH_2\cdot \rightarrow CH_3CH_2CH_2CH_3$ N.B. different answers for (iii) and (iv) needed		**1**

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Question Number	Acceptable Answers	Reject	Mark
25(b)	**First mark:** Structural formula (enough to see the structure) **of any polyhalogenated ethane derivative** OR **any polyhalogenated methane derivative** ALLOW correct displayed or skeletal formula **(1)** **Second mark:** If first mark awarded the name must be consequentially correct IGNORE any missing or incorrect numbering in name (e.g. "dichloroethane" scores the mark) IGNORE missing or incorrect hyphens If first mark NOT awarded then only ALLOW correct name **of any polyhalogenated ethane or polyhalogenated methane derivative** **(1)**	Butane /C_4H_{10} / $CH_3CH_2CH_2CH_3$ / chlorobutane / hexane / chloromethane	**2**

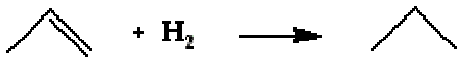
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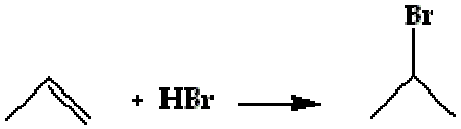
Question Number	Acceptable Answers	Reject	Mark
25(c)(i)	**1st mark for HAZARD:** This mark is for the idea of: (substance or procedure that) can cause harm/may cause harm/has the potential to do harm/can be dangerous ALLOW references to specific hazards such as toxic/flammable /harmful/ irritant /corrosive /oxidizing/ carcinogenic for the mark **(1)** **2nd mark for RISK:** This mark is for the idea of likelihood/probability/chance that harm will result (from the use of a substance or a procedure) **(1)**	**Just** "causes harm"/**just** "is a danger"	**2**

Question Number	Acceptable Answers	Reject	Mark
25(c)(ii)	fume cupboard OR gloves OR **u.v.** goggles	**Just** 'open windows'/**Just** well-ventilated lab/**Just** 'gas mask'/**Just** "use of smaller quantities"/closed system/closed experiment	**1**

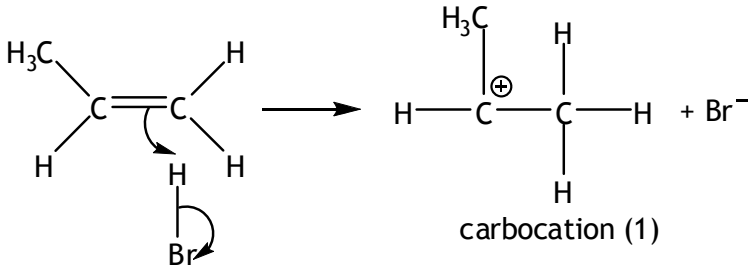
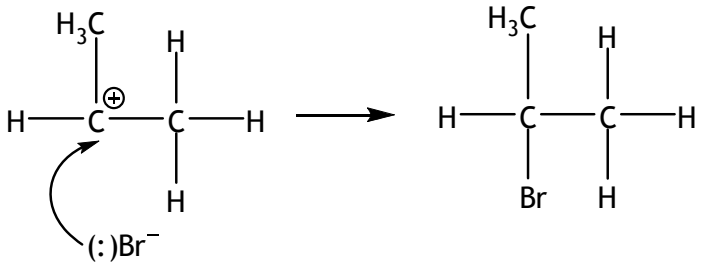
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Question Number	Acceptable Answers	Reject	Mark
26(a)	(C_nH_{2n} could be a) ring / cyclic (compound) ALLOW identification of any specific cyclic compound (e.g. cyclohexane) IGNORE any reference to "fewer hydrogen atoms"		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(i)	 All must be correct for the mark		**1**

Question Number	Acceptable Answers	Reject	Mark
26(b)(ii)	 **First mark:-** An equation with the reactants shown correctly and EITHER 2-bromopropane OR 1-bromopropane shown as the product NOTE: The C-Br bond MUST be shown in the skeletal formula for the first mark **(1)** **Second mark (stand alone, even if no equation attempted or left-hand side of equation incorrect):-** Correct skeletal formula of **2-bromopropane** **(1)** Penalise lack of skeletal formulae once only in (b)(i) and (b)(ii) when taken together		**2**

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Question Number	Acceptable Answers	Reject	Mark
26(c)	 both arrows (1) carbocation (1)  attack of bromide ion (1) **First mark:** Curly arrow from C=C to H (in H-Br) **AND** curly arrow from bond in H-Br to the Br IGNORE polarity of HBr even if incorrect **(1)** **Second mark:** Structure of correct secondary carbocation **(1)** **Third mark:** Curly arrow from anywhere on the bromide ion towards the C+ on the carbocation **NOTE:** The bromide ion must have a full negative charge, but the lone pair of electrons on the Br^- NEED NOT be shown **NOTE:** A correct mechanism leading to the formation of 1-bromopropane scores the **first** and **third** marks only (so max **(2)**) Skeletal formulae can be used	**Full** + and - charges on HBr Extra / spare bond dangling from the C+ carbon δ^- on bromide ion instead of Br^-	3

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	If but-2-ene is the starting alkene, only 3rd mark can be awarded If but-1-ene is the starting alkene, 2nd and 3rd marks can be awarded ***If single-headed arrows used throughout but all else correct, then max (2) can be awarded for mechanism***		

TOTAL FOR SECTION B = 60 MARKS

TOTAL FOR PAPER = 80 MARKS

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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 ▶

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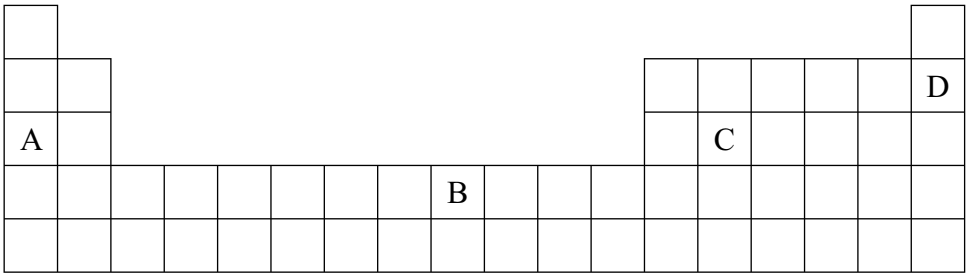
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SECTION A

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

1 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**

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(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)

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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)

P 3 8 4 3 3 A 0 4 2 4
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8 The standard enthalpy changes of formation of some sulfur species are:

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

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

☒ **A** 103 ÷ 8

☒ **B** 279 ÷ 8

☒ **C** 279

☒ **D** (103 ÷ 8) + 279

(Total for Question 8 = 1 mark)

9 For which of the following reactions is the enthalpy change equal to the bond enthalpy of H–I?

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

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

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

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

(Total for Question 9 = 1 mark)

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

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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.

P 3 8 4 3 3 A 0 6 2 4
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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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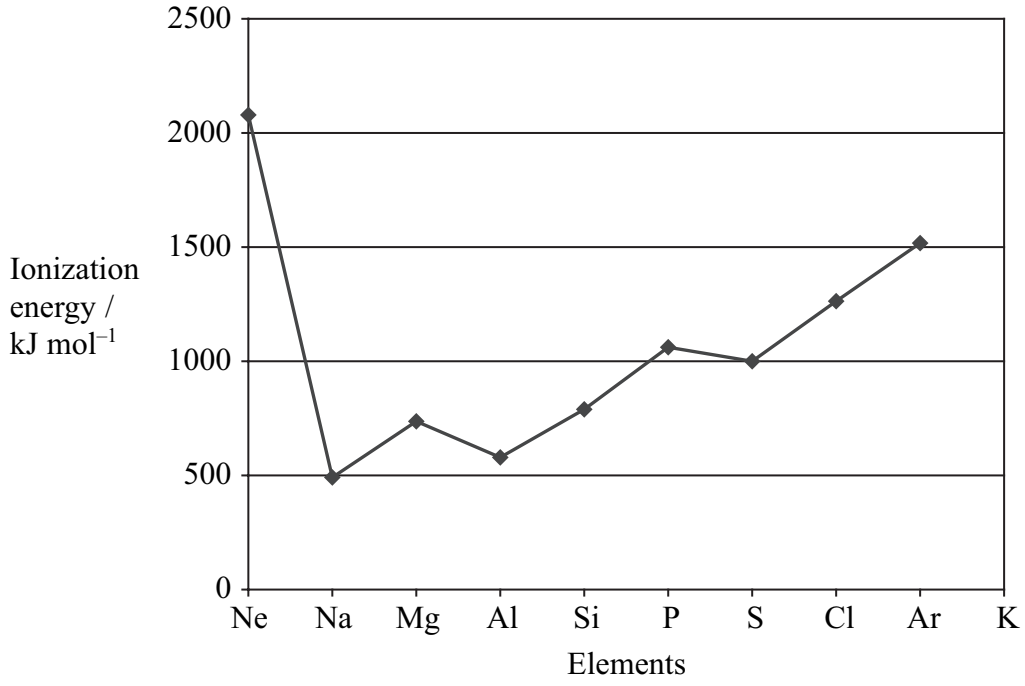
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SECTION B

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)

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

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

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

(3)

(Total for Question 17 = 7 marks)

P 3 8 4 3 3 A 0 1 3 2 4
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18 Copper(II) sulfate exists as blue hydrated crystals and white anhydrous crystals. The enthalpy changes of solution for these two substances may be represented by the following simplified equations:

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

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

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

(3)

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

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

(2)

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

(1)

.....

.....

.....

.....

P 3 8 4 3 3 A 0 1 4 2 4
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*(c) (i) $CuSO_4.5H_2O(s) + aq \rightarrow CuSO_4(aq)$ $\Delta H_1 = +11.5$ kJ mol^{-1}

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

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

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

(4)

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

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

(3)

1

2

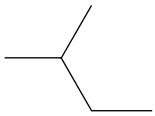
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(Total for Question 18 = 13 marks)

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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)

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(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)

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(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)

P 3 8 4 3 3 A 0 1 9 2 4
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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)

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(c) Explain how metals conduct electricity.

(2)

.....

.....

.....

.....

(Total for Question 20 = 9 marks)

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

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The Periodic Table of Elements

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

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

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

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Mark Scheme (Results)

June 2011

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

ALWAYS LEARNING

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General Marking Guidance

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

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Using the Mark Scheme

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

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

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

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

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

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

Quality of Written Communication

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

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

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

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

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

Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

TOTAL FOR SECTION A = 20 MARKS

Section B

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

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

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

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

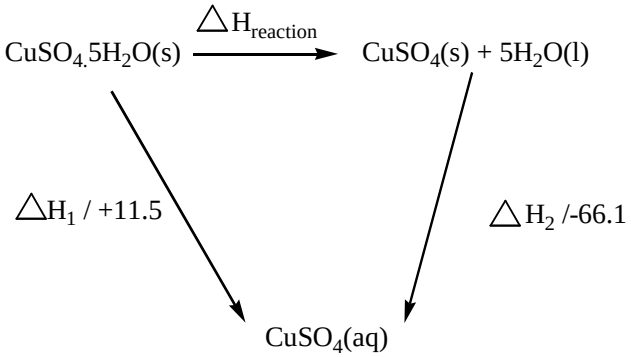
Question Number	Acceptable Answers	Reject	Mark
17 (a)	Do not penalize the use of A_r (Mg) = 24.3 at any stage in this question. Penalize SF errors (1 SF, incorrect SF (eg. 0.02) and incorrect rounding to 2 SF (e.g. 0.016)) only once in parts (a – d) Allow 0.0166 Allow fractions (e.g. 1/60) Amount Mg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

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

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

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

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

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

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

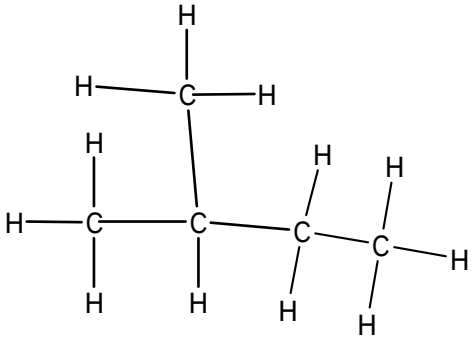
Question Number	Acceptable Answers	Reject	Mark
18 (b)	Dehydration reaction cannot be controlled OR temperature change (of dehydration reaction) cannot be measured OR $CuSO_4.5H_2O$ would need heating (so temperature change cannot be measured) OR impossible to add exact amount of water (to obtain value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

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

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

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

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

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

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

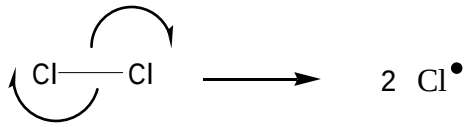
Question Number	Acceptable Answers	Reject	Mark
19 (b)(i)	$CH_4 + 1½O_2 \rightarrow CO + 2H_2O$ Formulae **(1)** balance **(1)** Or multiples Ignore state symbols No TE on **any** other species		**2**

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

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

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

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

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

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

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

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

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

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

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

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

TOTAL FOR SECTION B = 60 MARKS

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Edexcel GCE

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 ▶

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7/7/5/2/

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SECTION A

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

1 The 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)

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

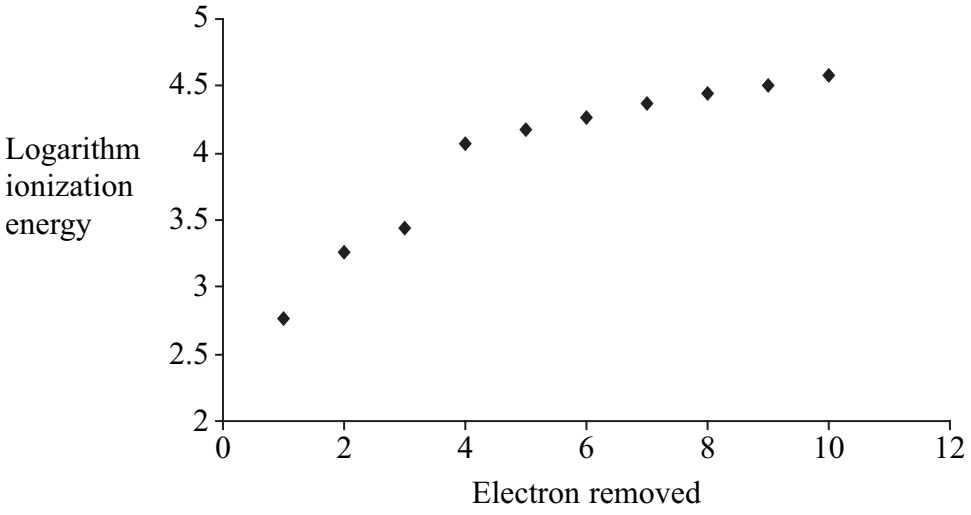
☒ **C** +1648 kJ mol^{-1}

☒ **D** +6592 kJ mol^{-1}

(Total for Question 5 = 1 mark)

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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.

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

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

(a) The equation for this reaction is

(1)

☒ **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.

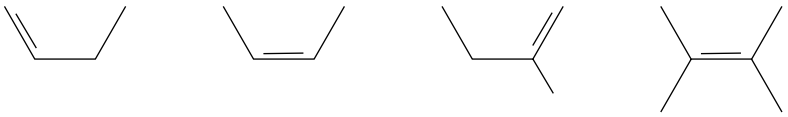
☒ **D** substitution.

(Total for Question 8 = 3 marks)

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

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9 This question concerns the following compounds



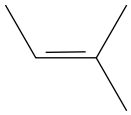
A **B** **C** **D**

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)

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

- ☒ **A** strong attractions between the ions.
- ☒ **B** strong attractions between the delocalised electrons.
- ☒ **C** strong attractions between the ions and the delocalised electrons.
- ☒ **D** strong intermolecular forces.

(Total for Question 12 = 1 mark)

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

- ☒ **A** 0.00382%
- ☒ **B** 0.0382%
- ☒ **C** 0.382%
- ☒ **D** 3.82%

(Total for Question 13 = 1 mark)

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

- ☒ **A** corrosive.
- ☒ **B** flammable.
- ☒ **C** toxic by inhalation.
- ☒ **D** toxic by skin absorption.

(Total for Question 14 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

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

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

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

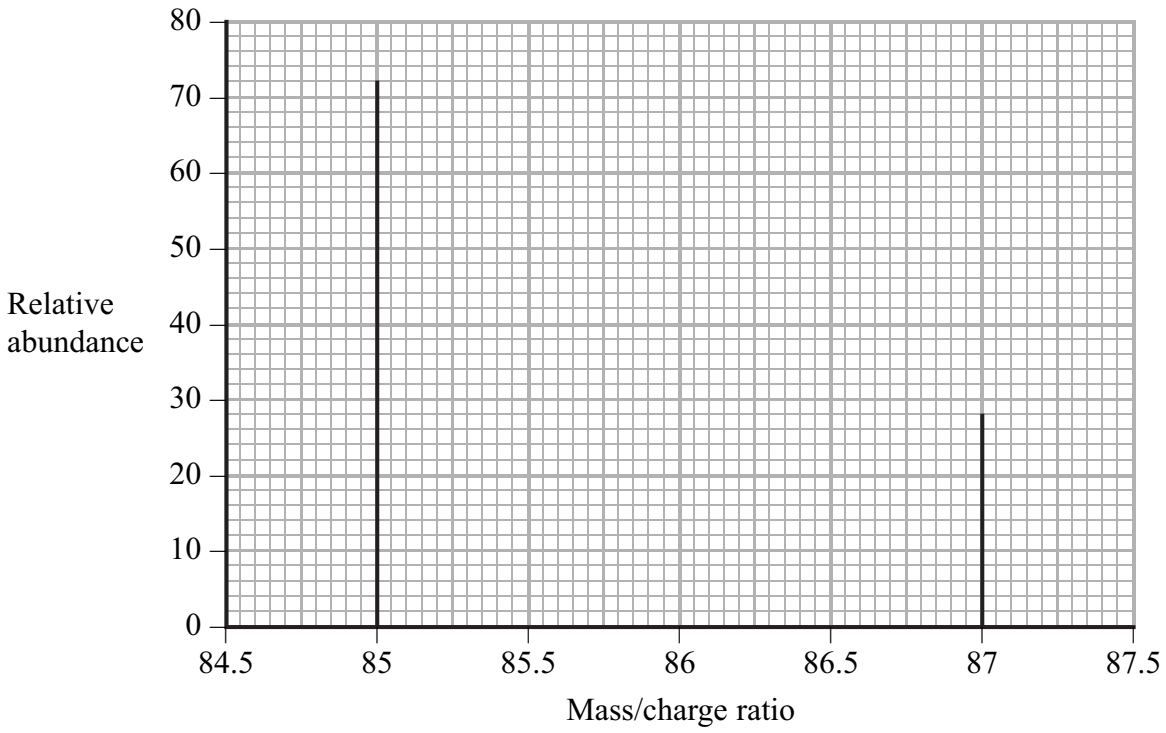
(2)

.....

.....

.....

(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)

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

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(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)

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

(1)

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

(v) Calculate the mass of 1 mol of calcium carbonate.

[Assume relative atomic masses: Ca = 40, C = 12, O = 16.]

(1)

(vi) Use your data and the equation in (iv) to calculate the mass of calcium carbonate in the sample and the percentage by mass of calcium carbonate in the coral. Give your final answer to **three** significant figures.

(2)

(vii) When this experiment is repeated, the results are inconsistent. Suggest a reason for this other than errors in the procedure, measurements or calculations.

(1)

.....

.....

(Total for Question 16 = 12 marks)

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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)

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*(iii) Suggest why the melting temperature of magnesium oxide is higher than that of magnesium chloride, even though both are almost 100% ionic.

(3)

(c) Magnesium chloride may be prepared from magnesium by reaction with chlorine or with hydrochloric acid. Compare these two preparations in terms of the atom economies of the reactions. No calculation is required.

(2)

(Total for Question 17 = 10 marks)

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18 Alkenes are unsaturated hydrocarbons which, because of their reactivity, are important industrial starting materials. Alkenes for industrial use are obtained by cracking alkanes.

(a) Write the equation for the cracking of decane ($C_{10}H_{22}$) to form 1 molecule of propene as the only alkene.

(1)

(b) The carbon–carbon double bond in alkenes consists of a σ and a π bond.

(i) Explain, using diagrams, the difference between the σ and the π bond in the carbon–carbon double bond of an alkene.

(4)

Diagrams

Explanation

.....

.....

.....

.....

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

(1)

.....

N 3 7 9 6 2 A 0 1 7 2 4
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*(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)

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(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 .....

.....

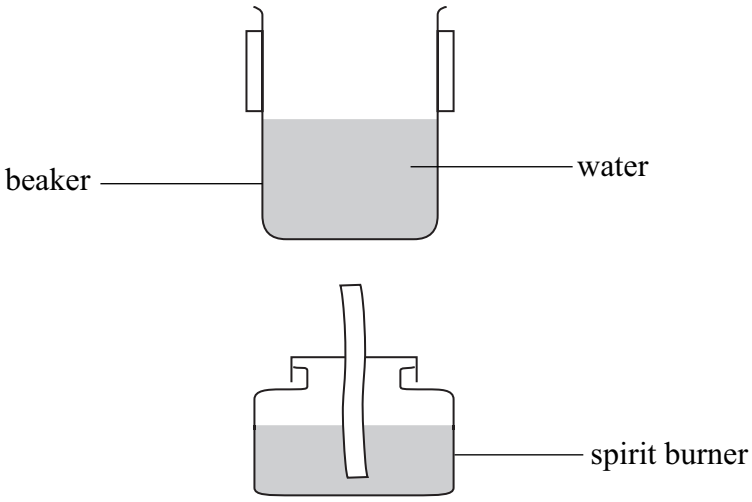
(Total for Question 18 = 20 marks)

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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)

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

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(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

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The Periodic Table of Elements

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

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

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

* Lanthanide series

* Actinide series

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Mark Scheme (Results)
January 2011

GCE

GCE Chemistry (6CH01/01)

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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**

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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

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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**

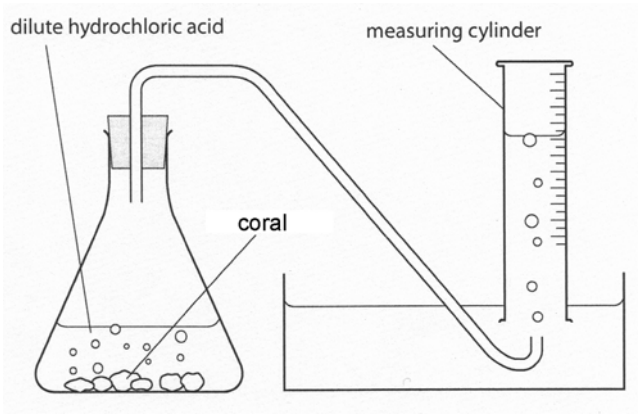
Question Number	Acceptable Answers	Reject	Mark
15 (b) (i)	(Rubidium/it has) two **isotopes** *ALLOW* (Rubidium/it has) "different **isotopes**" *ALLOW* abbreviations such as formulae of rubidium atoms or cations with isotopic masses		**1**

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**

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

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

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

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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**

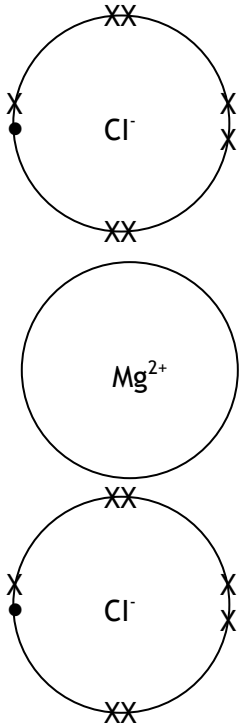
Question Number	Acceptable Answers	Reject	Mark
16 (b) (vi)	(Mass of $CaCO_3$ = 100 x 0.009333) = 0.9333 (g) **(1)** *IGNORE* sig figs including 1 sf here **NOTE:** Moles of $CaCO_3$ consequential on answers to (b)(iii) and (b)(v) [**NOTE**: if A_r = 40.1 used for Ca, then the answer = 0.9339 (g)] Percentage 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**

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

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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**

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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**

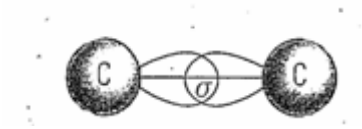
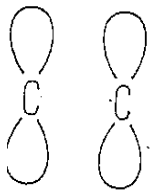
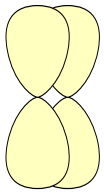
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Question Number	Acceptable Answers	Reject	Mark
17 (c)	**First Mark:** *EITHER* Magnesium reacts with chlorine to form only magnesium chloride/ magnesium reacts with chlorine to form only one product / magnesium reacts with hydrochloric acid to form 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**

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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**

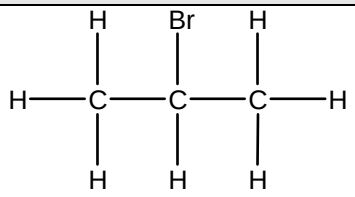
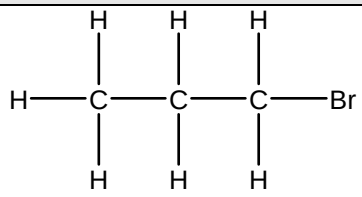
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Question Number	Acceptable Answers	Reject	Mark
18 (b) (i)	**diagram for the σ-bond** e.g.  **First Mark:** *EITHER* Diagram shows **overlap** of **any-shaped orbitals** along the line between the two nuclei *OR* Mentions/implies rotation around a sigma/single 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**

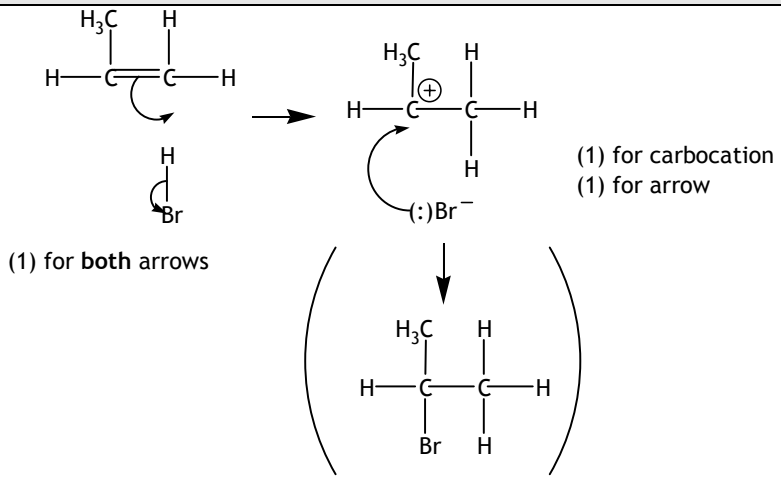
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Question Number	Acceptable Answers	Reject	Mark
18 (b) (ii)	Electrophilic addition *BOTH words needed* *ALLOW* "heterolytic" before electrophilic addition		**1**

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**

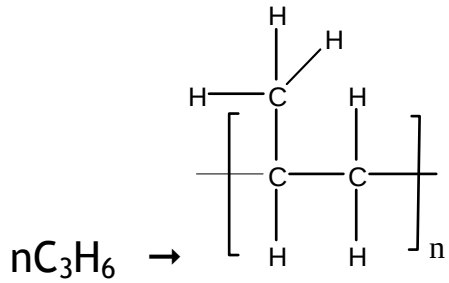
Question Number	Acceptable Answers	Reject	Mark
18 (c) (i)	 **and**  (main product) both DISPLAYED structures, with ALL bonds and atoms shown **(1)** major product identified or shown as product in (c)(ii) if NOT identified in (c)(i) **(1)** **NOTE**: if only one isomer of C_3H_7Br is named, assume this 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**

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Question Number	Acceptable Answers	Reject	Mark
18 (c) (ii)	 **1st mark:** Curly arrows must start from the bonds NOT the atoms **3rd mark:** Bromide ion must clearly have a 1^- charge to get this mark **NOTE**: The arrow from the bromide ion can start from anywhere on the Br^- ion (including the minus sign) or from a lone pair on Br^- if shown Curly arrow can go to the C or the + sign on the intermediate TE for mechanism on the isomer identified in (c)(i) or either mechanism if no major product has been identified in (c)(i) **Mark the three points independently**	**half** arrow-heads $Br^{\delta-}$	**3**

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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**

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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**

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

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

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

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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**

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Question Number	Acceptable Answers	Reject	Mark
19 (b) (iii)	$2\ C(s) + 3H_2(g) + ½\ O_2(g) \rightarrow C_2H_5OH(l)$ $\downarrow \qquad\qquad \downarrow$ $2CO_2 + 3H_2O$ $\triangle H_f = 2 \times (-394) + 3 \times (-286) - (-1370)$ $= -276\ (kJ\ mol^{-1})$ Correct expression or cycle **(1)** Evidence for **both** doubling ΔH^{θ}_c [C] **and** trebling ΔH^{θ}_c [H_2] **(1)** Correct sign and answer **(1)** Correct answer with no working scores **(3)** Correct answer with an incorrect cycle **(3)** *IGNORE* units even if incorrect **Alternatively the following answers score as shown even with incorrect cycle or incorrect units** **NOTE***:* (+)276 with or without working scores **(2)** (+)690 with or without working scores **(2)** −690 with or without working scores **(1)** −552 with or without working scores **(2)** −1134 with or without working scores **(2)** (+)1134 with or without working scores **(1)** (+)10 with or without working scores **(2)** **REMINDER IF ANY OTHER ANSWER IS GIVEN: ALL WORKING MUST BE CHECKED TO SEE IF ANY MARKS CAN BE AWARDED**		**3**

TOTAL FOR SECTION B = 60 MARKS

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

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

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

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N 3 5 6 9 1 A 0 2 2 8

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)

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

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

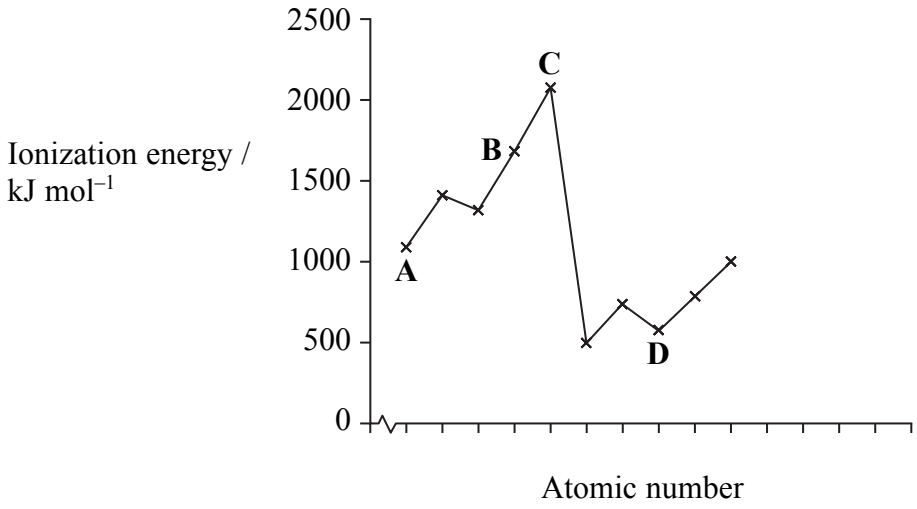
☒ **B** $Mg(g) \rightarrow Mg^{2+}(g) + 2e^{-}$

☒ **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**

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(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^{+}

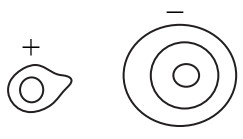
☒ **D** K^{+}

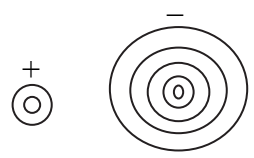
(Total for Question 5 = 1 mark)

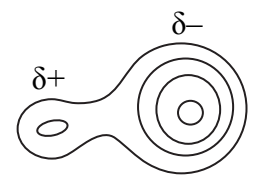
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6 Which of these electron density maps best represents the bonding in the compound lithium iodide, LiI?

☒ **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)

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

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

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

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

☒ **A** $(0.9 \times 3/2) \times 24$

☒ **B** $(0.9 \times 3/2) \div 24$

☒ **C** $(0.9 \times 2/3) \times 24$

☒ **D** $(0.9 \times 2/3) \div 24$

(Total for Question 9 = 1 mark)

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

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

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

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

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

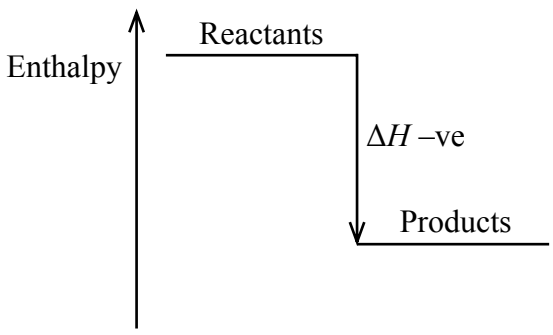
(Total for Question 10 = 1 mark)

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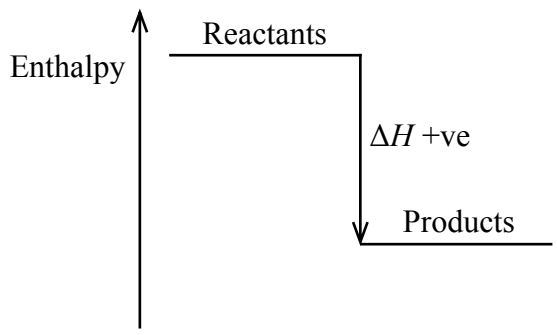
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11 Which of these diagrams correctly represents an endothermic reaction?

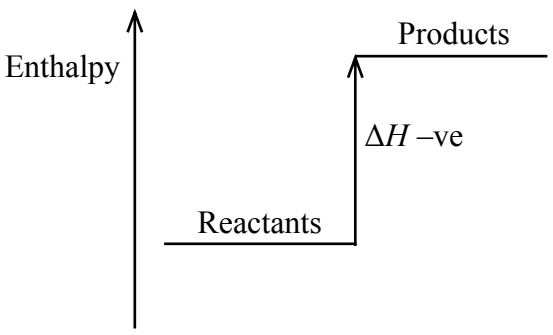
☒ **A**



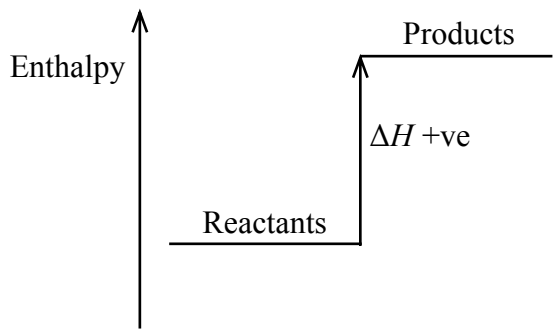
☒ **B**



☒ **C**



☒ **D**



(Total for Question 11 = 1 mark)

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

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

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

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

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

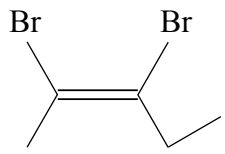
(Total for Question 12 = 1 mark)

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N 3 5 6 9 1 A 0 8 2 8

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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.

N 3 5 6 9 1 A 0 9 2 8

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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

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

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SECTION B

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

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

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

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

(2)

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

(1)

$1s^2$ .....

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

(2)

.....

.....

.....

.....

.....

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

(2)

.....

.....

.....

.....

.....

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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)

.....

.....

(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)

.....

.....

.....

(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

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

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

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

(3)

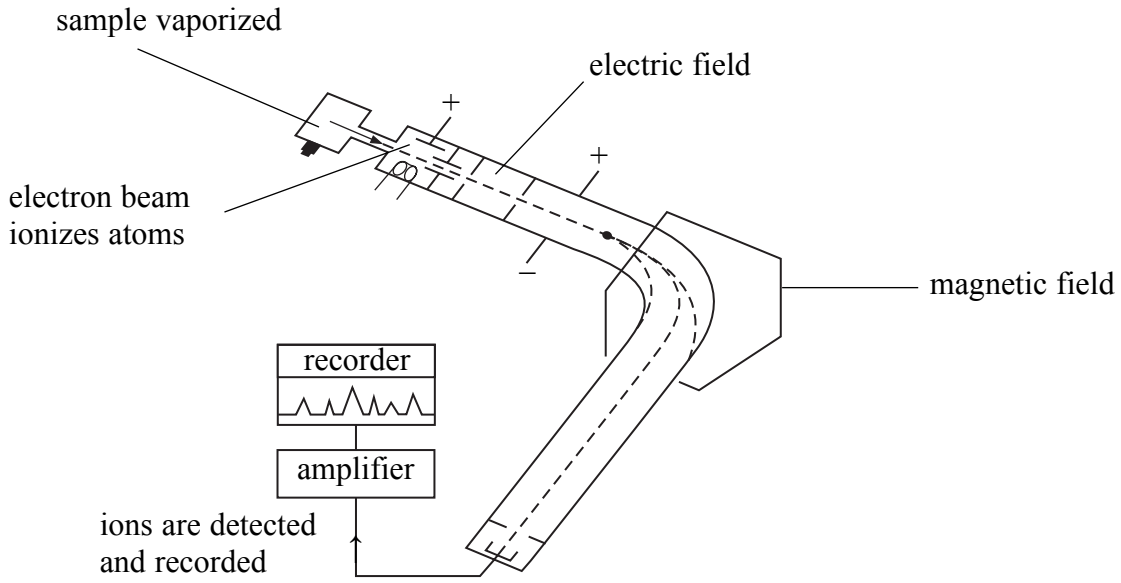
(d) The lattice energy of calcium chloride, $CaCl_2$, is -2258 kJ mol^{-1} based on an experimental Born-Haber cycle and -2223 kJ mol^{-1} based on theoretical calculations.

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

(1)

(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)

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

(i) Electric field

(1)

(ii) Magnetic field

(1)

N 3 5 6 9 1 A 0 1 4 2 8

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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)

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

(1)

(Total for Question 16 = 9 marks)

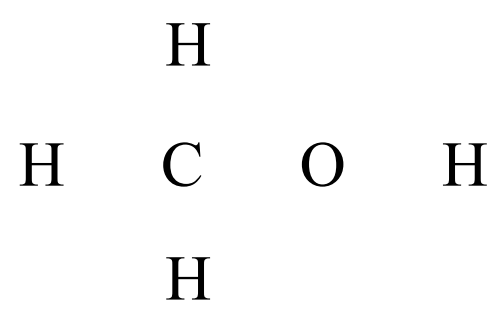
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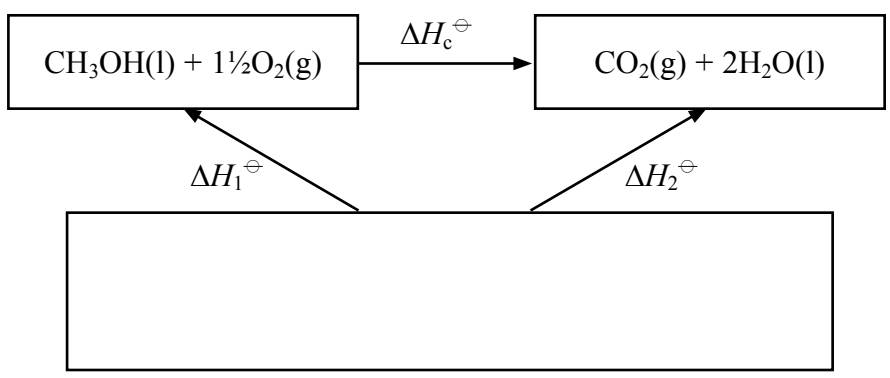
17 This question is about methanol and the energy changes that accompany some of its reactions.

(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)

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

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

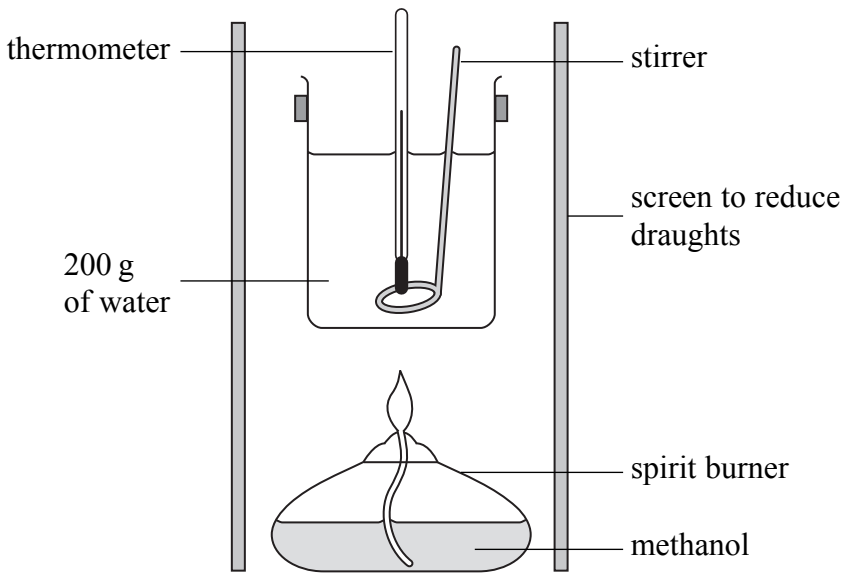
	$\Delta H_f^{\ominus}$/kJ mol^{-1}
$CO_2(g)$	–393.5
$H_2O(l)$	–285.8
$CH_3OH(l)$	–239.1

(2)

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

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(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

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(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)

.....

.....

.....

.....

.....

.....

(Total for Question 17 = 14 marks)

18 This question is about ethene and related compounds.

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

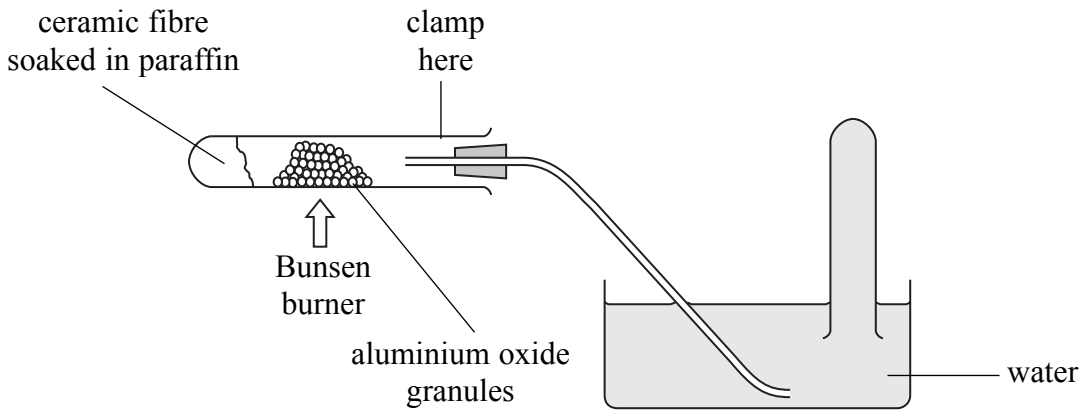
(i) Name a raw material from which liquid paraffin can be obtained.

(1)

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

(2)

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



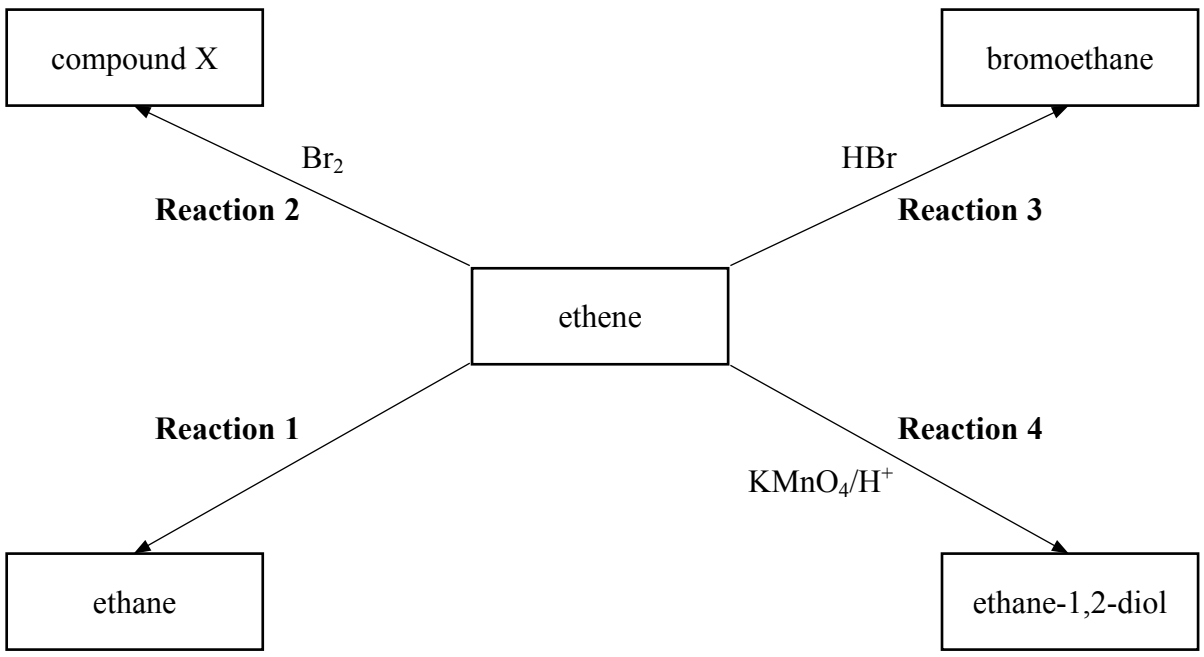
State TWO of the **risks** of using the apparatus in this way and suggest how you would amend the set-up to minimise each risk.

(4)

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

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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**.....

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

(3)

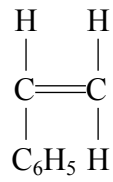
(ii) Explain why the alkene, propene, could form two products when it reacts with hydrogen bromide in a similar way.

(1)

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

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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)

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

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(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)

N 3 5 6 9 1 A 0 2 4 2 8

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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)

.....

.....

.....

.....

.....

(Total for Question 18 = 22 marks)

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

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

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

The Periodic Table of Elements

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

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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

* 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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GCE

GCE Chemistry (6CH01/01)

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Summer 2010

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Section A (multiple choice)

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

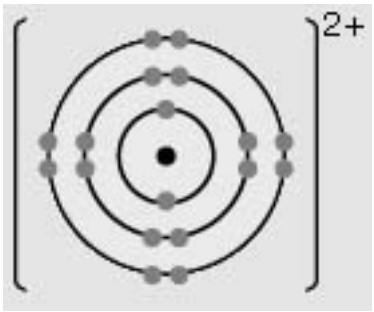
Question Number	Correct Answer	Mark
13	D	**1**

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

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

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

Section B

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

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

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

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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**

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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**

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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**

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

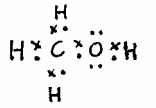
Question Number	Acceptable Answers	Reject	Mark
16 (b)(i)	(Electric field) **accelerates** ions		**1**

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

<table><tr><th>Risk</th><th>Amendment</th></tr><tr><td>exposure to harmful / toxic fumes</td><td>Set up in fume cupboard</td></tr><tr><td>Escape of flammable / harmful / toxic reactants or products from ill fitting bung</td><td>Correct fitting of bung</td></tr><tr><td>Escape of flammable / harmful /toxic reactants or products from poorly positioned delivery tube</td><td>Placement of delivery tube below mouth of test tube / use a longer delivery tube</td></tr><tr><td>suck back</td><td>Attach Bunsen valve / remove delivery tube from water before stopping heating etc</td></tr></table>
Mark all 4 points independently
If escaping gases linked to 2 amendments but no risk mentioned then allow 1 for risk</td><td>Dangerous

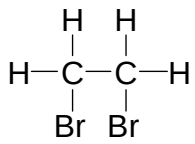
collect in syringe</td><td>4</td></tr>
</table>

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

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

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

ignore punctuation


(1)

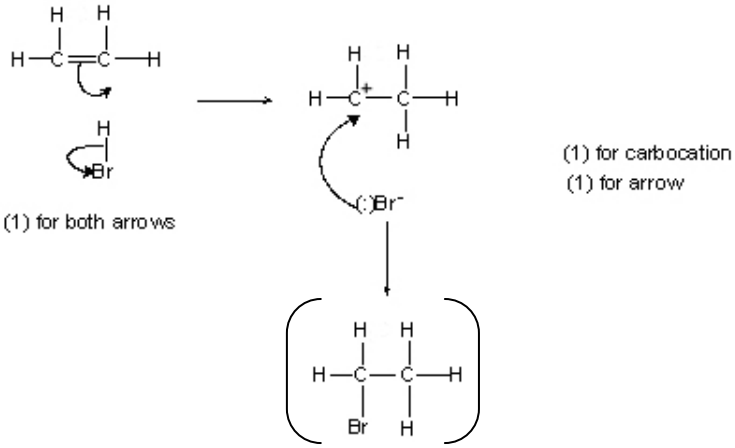
Mark independently
Allow CH_2BrCH_2Br</td><td>1,2 - bromoethane
dibromoethane

Skeletal formula

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

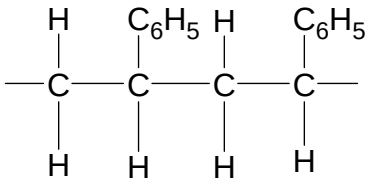
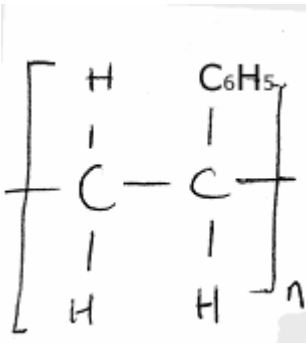
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Question Number	Acceptable Answers	Reject	Mark
18 (b)(iii)	From purple / pink → colourless	clear	**1**

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	∂- 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**

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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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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 ▶

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7/7/5/3/

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SECTION A

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

1 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.

N 3 5 1 3 1 A 0 2 2 4

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

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

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

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

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

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

(Total for Question 3 = 1 mark)

---

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

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

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

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

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

(Total for Question 4 = 1 mark)

---

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

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

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

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

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

(Total for Question 5 = 1 mark)

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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**

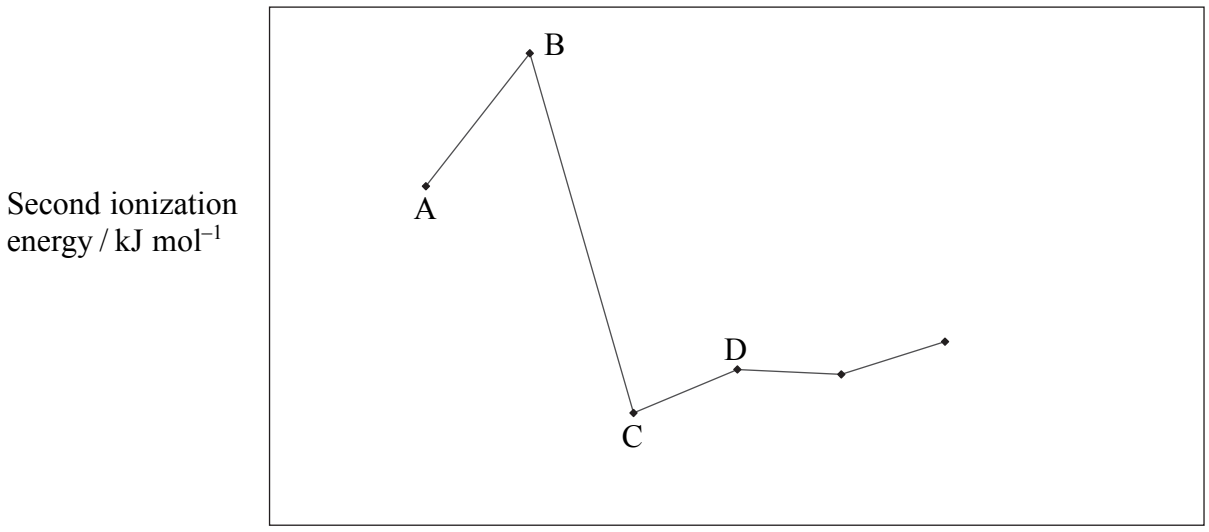
☒ **D**

(Total for Question 6 = 3 marks)

N 3 5 1 3 1 A 0 4 2 4

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



Which element could be lithium?

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 7 = 1 mark)

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

578 1817 2745 11 578 14 831

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

☒ **A** 1s 2s 2p 3s 3p

☒ **B** 1s 1s 2s 2s 2p

☒ **C** 3p 3s 2p 2s 1s

☒ **D** 3p 3s 3s 2p 2p

(Total for Question 8 = 1 mark)

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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.

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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

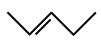
(Total for Question 13 = 1 mark)

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

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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**

N 3 5 1 3 1 A 0 8 2 4

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

(1)

☒ **A**

☒ **B**

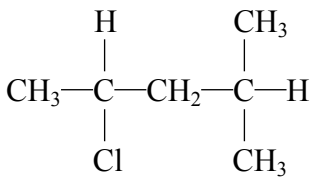
☒ **C**

☒ **D**

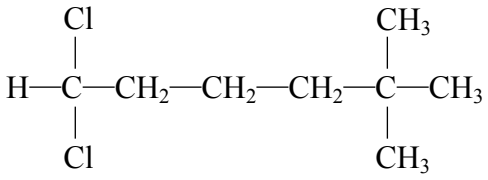
(Total for Question 14 = 4 marks)

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

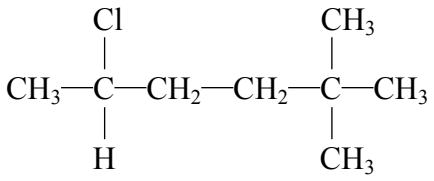
☒ **A**



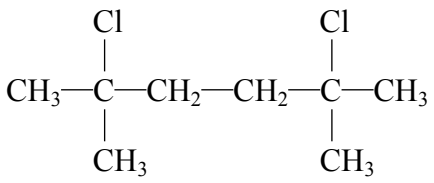
☒ **B**



☒ **C**



☒ **D**



(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

N 3 5 1 3 1 A 0 9 2 4

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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)

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

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(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)

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

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

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

(1)

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

(1)

.....

.....

(Total for Question 16 = 16 marks)

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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)

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

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(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)

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

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

(2)

Test: .....

.....

Result with hexane: .....

.....

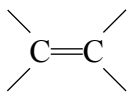
Result with hex-1-ene: .....

.....

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

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

(1)



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

(2)

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

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

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

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

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

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

(1)

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

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

(3)

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

(2)

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(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)

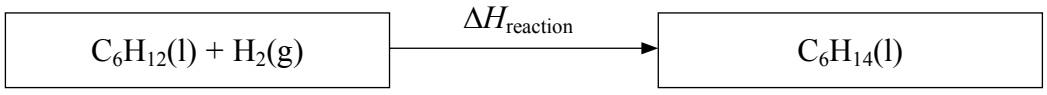
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(ii) The enthalpy change of this reaction $\Delta H_{reaction}$ can be calculated from the following enthalpy changes of combustion.

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}

N 3 5 1 3 1 A 0 1 8 2 4

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(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)

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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)

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

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(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)

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(Total for Question 19 = 16 marks)

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

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

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

The Periodic Table of Elements

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

Key

relative atomic mass
atomic symbol
name
atomic (proton) number

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

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

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Mark Scheme (Results)
January 2010

GCE

GCE Chemistry (6CH01/01)

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January 2010

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General Marking Guidance

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

Using the Mark Scheme

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

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

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

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

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

6CH01/01

Section A

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Section B

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

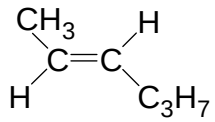
Question Number	Acceptable Answers	Reject	Mark
17 (b) (ii)	$\frac{66}{24\,000} = 2.75 \times 10^{-3}$ / 0.00275 / 0.0028	0.003	**1**

Question Number	Acceptable Answers	Reject	Mark
17 (b) (iii)	1 mol sulfamic acid $\rightarrow$ 0.5 mol H_2 OR ratio sulfamic acid : hydrogen gas = 2:1 OR 5.5 (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) ($9614 / 3.72 \times 10^{-3}$) = 2584000 J/ 2584 kJ (1) **ΔH = -2600 kJ mol^{-1}** /-2 600 000 J mol^{-1} / -2.6×10^{6} J mol^{-1} (1) Allow TE: **0.32g** in (i) (gives 61.53J), **ΔH = -17 kJ mol^{-1}** /-17 000 J mol^{-1} /-1.7×10^{4} J mol^{-1} **50.32g** in (i) (gives 9676J) **ΔH = -2600 kJ mol^{-1}** /-2 600 000 J mol^{-1} /-2.6×10^{6} J mol^{-1} **Rounding of moles to 4×10^{-3}** gives –**2400 kJ mol^{-1} or-15 kJ mol^{-1}** max 2 (loses moles mark) Answer alone (3) Max 2 if negative sign missing and/or more than 2 sf or error in units		**3**

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

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

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

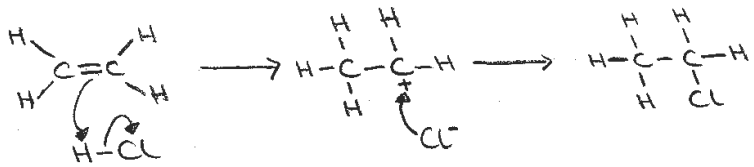
Question Number	Acceptable Answers	Reject	Mark
18 (d) (ii)	Left hand arrow, pointing down, labelled ΔH_c hex-1-ene + ΔH_c hydrogen/ -4003-286/-4289 OR Pointing up with signs given above reversed (1) Right hand arrow pointing down labelled ΔH_c hexane / -4163 OR Pointing up with signs given above reversed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

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

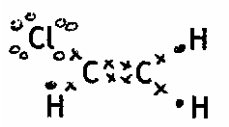
Question Number	Acceptable Answers	Reject	Mark
19 (a) (i)	Reagent: chlorine/ Cl_2 (1) Condition: uv/ sunlight (1) ALLOW light Mark independently Ignore reference to temp and pressure if given with uv light. If answers reversed/both on one line 1 out of 2	Cl Just "heat"	**2**

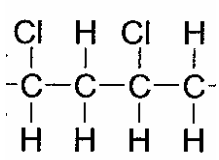
Question Number	Acceptable Answers	Reject	Mark
19 (a) (ii)	(free) radical (1) Substitution (1) Mark independently		**2**

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

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

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

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

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

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

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Centre Number	Candidate Number

Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

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

Paper Reference
6CH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ▶

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7/7/3/

H 3 4 4 7 1 A 0 1 2 8

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SECTION A

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

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

☒ **A** 11 protons and 12 neutrons.

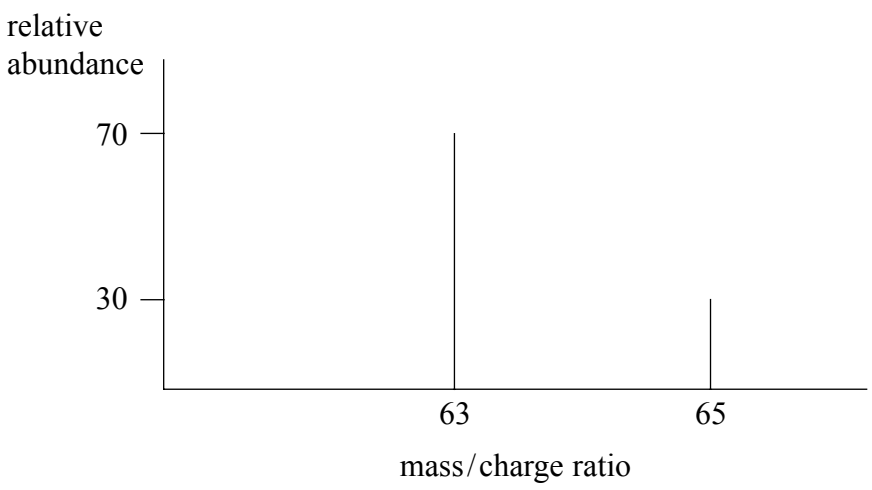
☒ **B** 11 protons and 12 electrons.

☒ **C** 23 protons and 11 neutrons.

☒ **D** 23 protons and 11 electrons.

(Total for Question 1 = 1 mark)

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



The relative atomic mass of the metal is

☒ **A** 63.2

☒ **B** 63.4

☒ **C** 63.6

☒ **D** 64.0

(Total for Question 2 = 1 mark)

H 3 4 4 7 1 A 0 2 2 8

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

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

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

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

☒ **A** +436 + 151 – 299 = +288

☒ **B** –436 – 151 + 299 = –288

☒ **C** +436 +151 – (2 × 299) = –11

☒ **D** –436 – 151 + (2 × 299) = +11

(Total for Question 3 = 1 mark)

4 A compound was analysed and found to contain

1.45 g carbon 0.482 g hydrogen 1.69 g nitrogen

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

The empirical formula of the compound is

☒ **A** CH_3N

☒ **B** CH_4N

☒ **C** CH_5N

☒ **D** C_2H_4N

(Total for Question 4 = 1 mark)

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

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

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

☒ **A** 3×10^{21}

☒ **B** 1×10^{22}

☒ **C** 3×10^{22}

☒ **D** 9×10^{22}

(Total for Question 5 = 1 mark)

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

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

☒ **A** 0.570 g

☒ **B** 0.740 g

☒ **C** 1.85 g

☒ **D** 3.70 g

(Total for Question 6 = 1 mark)

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

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

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

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

☒ **A** X^+

☒ **B** X^{2+}

☒ **C** X^{3+}

☒ **D** X^{4+}

(Total for Question 7 = 1 mark)

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

☒ **A** $H_3CCH{=}C(CH_3)_2$

☒ **B** $(CH_3)_2C{=}CH_2$

☒ **C** $H_2C{=}CHCH_2CH_3$

☒ **D** $H_3CCH{=}CHCH_3$

(Total for Question 8 = 1 mark)

9 Which of the following covalent bonds is the shortest?

☒ **A** H—F

☒ **B** H—Cl

☒ **C** H—Br

☒ **D** H—I

(Total for Question 9 = 1 mark)

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

☒ **A** refinery gas

☒ **B** kerosene

☒ **C** diesel oil

☒ **D** lubricating oil

(Total for Question 10 = 1 mark)

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

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

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

Calculate the volume of sodium hydroxide required.

☒ **A** 20.0 cm^3

☒ **B** 50.0 cm^3

☒ **C** 100 cm^3

☒ **D** 500 cm^3

(Total for Question 11 = 1 mark)

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

☒ **A** $^{35}Cl^{2+}$

☒ **B** $^{35}Cl^{+}$

☒ **C** $^{37}Cl^{+}$

☒ **D** $^{35}Cl^{37}Cl^{+}$

(Total for Question 12 = 1 mark)

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

☒ **A** 4, 8

☒ **B** 6, 12

☒ **C** 8, 16

☒ **D** 10, 20

(Total for Question 13 = 1 mark)

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

☒ **A** $1s^2\ 2s^2\ 2p^2$

☒ **B** $1s^2\ 2s^2\ 2p^4$

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

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

(Total for Question 14 = 1 mark)

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

☒ **A** GeF_3

☒ **B** GeS_2

☒ **C** GeO_2

☒ **D** GeH_4

(Total for Question 15 = 1 mark)

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

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

☒ **A** $1s^1$

☒ **B** $1s^2$

☒ **C** $1s^2\ 2s^1$

☒ **D** $1s^2\ 2s^2$

(Total for Question 16 = 1 mark)

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

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

☒ **A** 1 gram of ethane

☒ **B** 1 gram of oxygen

☒ **C** 1 gram of fluorine

☒ **D** 1 gram of neon

(Total for Question 17 = 1 mark)

18 Which of the following has the smallest ionic radius?

☒ **A** F^-

☒ **B** Na^+

☒ **C** Mg^{2+}

☒ **D** O^{2-}

(Total for Question 18 = 1 mark)

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

☒ **A** An ion of fluorine, F^-

☒ **B** A molecule of methane, CH_4

☒ **C** A molecule of nitrogen, N_2

☒ **D** An ion of sodium, Na^+

(Total for Question 19 = 1 mark)

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

☒ **A** The carbon dioxide is toxic and kills plants.

☒ **B** The smoke produced reflects sunlight and leads to global warming.

☒ **C** The water produced results in a damaging increase in rainfall.

☒ **D** The carbon dioxide produced absorbs heat radiated from the Earth and leads to global warming.

(Total for Question 20 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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

SECTION B

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

21 This question is about hydrocarbons.

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

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

(1)

.....

.....

(ii) There are two C_4 alkanes.

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

Name each alkane.

(4)

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

(iii) Complete the following sentence.

(1)

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

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

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

The mechanism for this reaction is described in three stages.

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

(2)

Initiation step

Condition .....

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

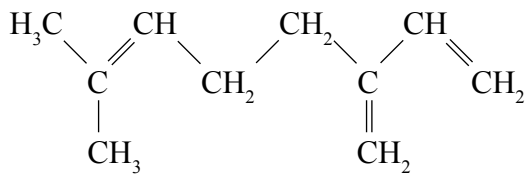
(2)

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

(1)

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



Myrcene

(i) Name the functional group in myrcene.

(1)

.....

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

(1)

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

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

(2)

.....

.....

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

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

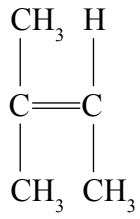
[Assume the molar volume of H_2 under the conditions of the experiment is 24 $dm^3\,mol^{-1}$.]

(2)

Calculation

Hence structural formula of the product

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



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

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

(2)

(Total for Question 21 = 19 marks)

H 3 4 4 7 1 A 0 1 4 2 8

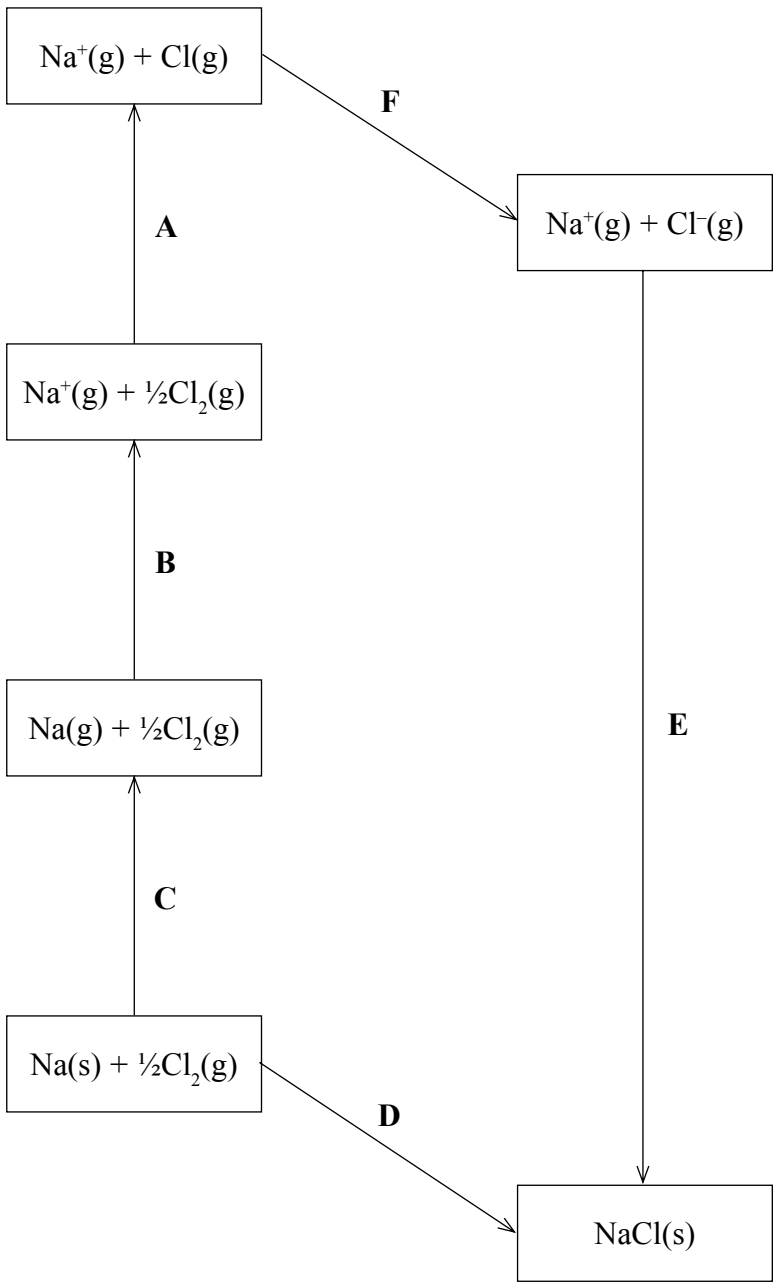
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H 3 4 4 7 1 A 0 1 5 2 8

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



H 3 4 4 7 1 A 0 1 6 2 8

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

(3)

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

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

(2)

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

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

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

(1)

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

(2)

H 3 4 4 7 1 A 0 1 8 2 8

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

(2)

.....

.....

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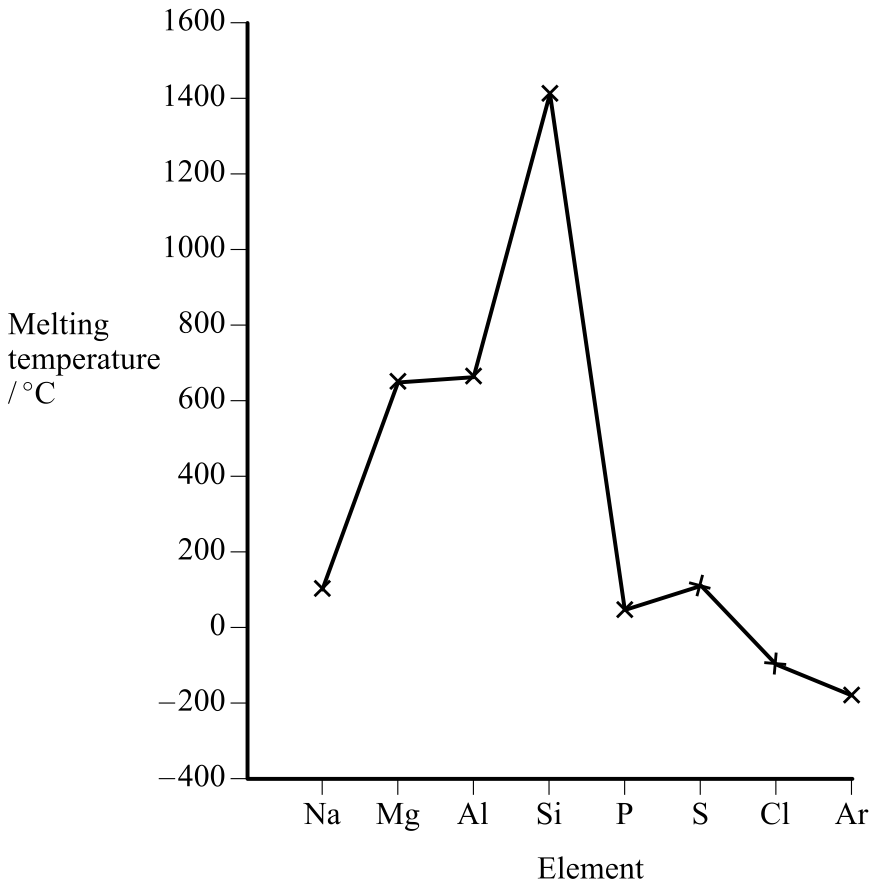
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(Total for Question 22 = 10 marks)

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



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

(3)

Element	Structure	Bonding
sodium		
silicon		
sulfur		

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

(2)

H 3 4 4 7 1 A 0 2 0 2 8

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

(2)

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

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

(5)

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

(1)

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

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

Magnesium carbonate reacts with dilute sulfuric acid.

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

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

(1)

.....

.....

.....

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

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

(2)

(Total for Question 23 = 16 marks)

H 3 4 4 7 1 A 0 2 2 2 8

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

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

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

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

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

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

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

(1)

(ii) Use the expression

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

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

(2)

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

(3)

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

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

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

(1)

.....

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

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

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

(2)

Difference .....

Justification .....

.....

.....

.....

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

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

(3)

.....

.....

.....

.....

.....

.....

H 3 4 4 7 1 A 0 2 4 2 8

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

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

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

(3)

(Total for Question 24 = 15 marks)

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

H 3 4 4 7 1 A 0 2 5 2 8

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H 3 4 4 7 1 A 0 2 6 2 8

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H 3 4 4 7 1 A 0 2 7 2 8

The Periodic Table of Elements

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

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

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

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Mark Scheme Summer 2009

GCE

GCE Chemistry (8CH01)

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Summer 2009

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2.	6CH02/01 Mark Scheme	19

General Marking Guidance

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

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

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

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

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

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

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

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

Using the mark scheme

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

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

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

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

5 OWTTE means or words to that effect

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

Quality of Written Communication

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

· show clarity of expression

· construct and present coherent arguments

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

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

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

6CH01/01

Section A

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

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

Question Number	Correct Answer	Reject	Mark
3	C		**1**

Question Number	Correct Answer	Reject	Mark
4	B		**1**

Question Number	Correct Answer	Reject	Mark
5	D		**1**

Question Number	Correct Answer	Reject	Mark
6	B		**1**

Question Number	Correct Answer	Reject	Mark
7	B		**1**

Question Number	Correct Answer	Reject	Mark
8	D		**1**

Question Number	Correct Answer	Reject	Mark
9	A		**1**

Question Number	Correct Answer	Reject	Mark
10	A		**1**

Question Number	Correct Answer	Reject	Mark
11	B		**1**

Question Number	Correct Answer	Reject	Mark
12	A		**1**

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Question Number	Correct Answer	Reject	Mark
13	C		**1**

Question Number	Correct Answer	Reject	Mark
14	B		**1**

Question Number	Correct Answer	Reject	Mark
15	A		**1**

Question Number	Correct Answer	Reject	Mark
16	B		**1**

Question Number	Correct Answer	Reject	Mark
17	D		**1**

Question Number	Correct Answer	Reject	Mark
18	C		**1**

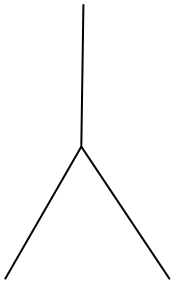
Question Number	Correct Answer	Reject	Mark
19	C		**1**

Question Number	Correct Answer	Reject	Mark
20	D		**1**

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Section B

Question Number	Correct Answer	Reject	Mark
21 (a)(i)	Easier to transport / easier to store / less space / less volume needed for storage / easier to handle / easier to transfer *IGNORE* references to "safety" **Accept** Denser/cheaper to transport OWTTE	Just "cost"	**1**

Question Number	Correct Answer	Reject	Mark
21 (a)(ii)	**skeletal formula (1)**  **Name**: butane **(1)** Stand alone **skeletal formula (1)**  **Name**: methylpropane **OR** 2-methylpropane **(1)** *IGNORE* incorrect punctuation [e.g. extra/missing hyphens, etc.] Stand alone *IGNORE* displayed formulae if also given with skeletal formulae if 2 correct displayed formulae are given **max** 1 out of 2 for the structures		**4**

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Question Number	Correct Answer	Reject	Mark
21 (a)(iii)	(Structural) isomers		**1**

Question Number	Correct Answer	Reject	Mark
21 (b)(i)	$Cl_2 \rightarrow Cl\cdot + Cl\cdot$ / $Cl_2 \rightarrow 2Cl\cdot$ **(1)** (U.V.) light / sunlight **(1)** Must show the dots · *IGNORE* any subsequent propagation steps in (b)(i)	heat alone	**2**

Question Number	Correct Answer	Reject	Mark
21 (b)(ii)	$C_3H_8 + Cl\cdot \rightarrow C_3H_7\cdot + HCl$ **(1)** $C_3H_7\cdot + Cl_2 \rightarrow C_3H_7Cl + Cl\cdot$ **(1)** Must show the dots ·		**2**

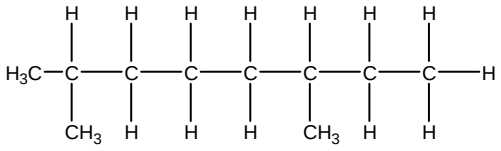
Question Number	Correct Answer	Reject	Mark
21 (b)(iii)	$C_3H_7\cdot + Cl\cdot \rightarrow C_3H_7Cl$ **OR** $Cl\cdot + Cl\cdot \rightarrow Cl_2$ **OR** $C_3H_7\cdot + C_3H_7\cdot \rightarrow C_6H_{14}$ Must show dots in termination step		**1**

Question Number	Correct Answer	Reject	Mark
21 (c)(i)	Alkene / triene **Accept** Diene Carbon-carbon double bond		**1**

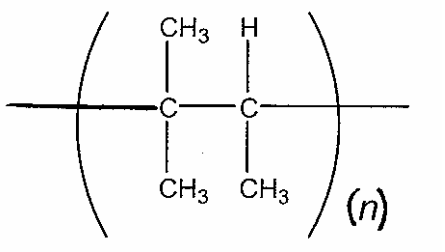
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Question Number	Correct Answer	Reject	Mark
21 (c)(ii)	**From:** Red / brown / orange / yellow or combinations of these colours **To:** colourless *both colours needed*	 "clear" instead of colourless	**1**

Question Number	Correct Answer	Reject	Mark
21 (c)(iii)	Electrophilic **(1)** addition **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
21 (c)(iv)	**Calculation:** 0.01 mol myrcene reacts with 0.03 mol H_2 **OR** 1 mol myrcene reacts with 3 mol H_2 **(1)** **Structural formula**: $(CH_3)_2CH(CH_2)_3CH(CH_3)CH_2CH_3$ **OR**  **(1)** **Accept** Fully displayed formula/skeletal formula Mark calculation and structural formula **independently**.		**2**

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Question Number	Correct Answer	Reject	Mark
21 (d)	 repeat unit **(1)** continuation bonds shown (but these bonds do not have to cut through the brackets) **(1)** *n* **not essential** *IGNORE* the position of "*n*" relative to the repeat unit (e.g. can be written as a superscript)		**2**

Question Number	Correct Answer	Reject	Mark
22 (a)(i)			**3**

Energy change	**Letter**	**ΔH/kJ mol^{-1}**
Lattice energy for sodium chloride	**E**	-775
Enthalpy change of atomization of sodium	**C**	+109
Enthalpy change of atomization of chlorine	**A**	+121
First ionization energy of sodium	**B**	+494
First electron affinity of chlorine	**F**	
Enthalpy change of formation of sodium chloride	**D**	-411

6 correct letters **(3)**
5 or 4 correct letters **(2)**
3 or 2 correct letters **(1)**
1 or 0 correct letters **(0)**

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Question Number	Correct Answer	Reject	Mark
22 (a)(ii)	Expression such as: D = C + B + A + F + E - 411 = + 109 + 494 + 121 + F + (- 775) F = - 411 - 109 - 494 - 121 + 775 **(1)** Answer: F = −360 (kJ mol^{-1}) **(1)** *Check empty box in 22(a)(i), as answer may be written there.* Answer must follow from working Correct answer only **(2)** Correct answer with some consistent working **(2)**		**2**

Question Number	Correct Answer	Reject	Mark
22 (b)(i)	(Bonding in NaCl) 100% ionic **OR** almost completely ionic **OR** no covalent character/(very) little covalent character	'Molecule' **(0)**	**1**

Question Number	Correct Answer	Reject	Mark
22 (b)(ii) QWC	AgI has (a degree of) covalent character **(1)** due to polarization or distortion (of the anion) **(1)**		**2**

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Question Number	Correct Answer	Reject	Mark
22 (c) QWC	Any **two** of the following: • (outermost) electron further from the nucleus/atoms get bigger/more shells • (outermost) electron more shielded (by inner shells of e^-) • (force of) attraction between nucleus and (outermost) electron decreases (down the Group) **OR** (outermost) electron held less strongly (down the Group) **OR** (outermost) electron becomes easier to remove (down the Group) *IGNORE* any references to(effective) nuclear charge or more protons.	**"ions"** get bigger (down Group)	**2**

Question Number	Correct Answer	Reject	Mark
23 (a)	<table><tr><td>element</td><td>structure</td><td>bonding</td></tr><tr><td>sodium</td><td>**Giant**</td><td>**metallic**</td></tr><tr><td>silicon</td><td>**Giant (atomic)/ macromolecular/ giant molecular**</td><td>**covalent**</td></tr><tr><td>sulfur</td><td>**simple / small molecules** **OR** **(simple) molecular** **OR** **S_8 molecules**</td><td>**covalent or van der Waals' forces/ London forces/ intermolecular forces/dispersion forces/induced-dipole forces**</td></tr></table> *IGNORE* the word "lattice" **OR** "crystalline" 6 boxes correct (3) 5,4 boxes correct (2) 3,2 boxes correct (1) 1,0 boxes correct (0)		**3**

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Question Number	Correct Answer	Reject	Mark
23 (b)	**Si** : covalent bonds / many bonds/ strong bonds (between atoms) **(1)** **S** : weak forces /van der Waals' forces/London forces/dispersion forces/intermolecular forces/induced-dipole forces **(1)** (need to be overcome)	any reference to **intermolecular forces in Si** suggestion that covalent bonds are broken	**2**

Question Number	Correct Answer	Reject	Mark
23 (c) **QWC**	Cations/ions decrease in size (from Na^+ to Al^{3+}) **OR** charge increases/charge density on (cat)ions increases/ "**effective** nuclear charge" increases (from Na^+ to Al^{3+}) **(1)** more e^- (per atom in 'sea' of delocalized electrons) / more delocalized electrons **OR** (force of) attraction between (cat)ions/nucleus and (delocalised) electrons increases (from Na to Al) **(1)** *IGNORE* "nuclear charge increases"/ "increasing no. of protons"	**atoms** decrease in size any mention of "molecules"/ "covalent bonds"/ "van der Waals' forces"/ "ionic bonds" **(0)** overall	**2**

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Question Number	Correct Answer	Reject	Mark
23 (d)(i) QWC	• Add MgO to acid/react MgO with acid/dissolve MgO in acid **(1)** *[NOTE:* mention of heating not required. **IGNORE** water bath/reflux] • Filter **(1)** • **Heat/boil** filtrate /$MgSO_4$ solution (until volume reduced by half) **(1)** • Leave to cool/leave to crystallise/evaporate slowly/leave to evaporate **(1)** (decant / filter / pick out crystals, then) Leave to dry/pat dry/dry between filter papers/put in an oven/put in a desiccator/dry the crystals **(1)** *IGNORE* any washing of crystals immediately prior to drying them	Just **"warm"** the filtrate/$MgSO_4$ solution Use of a **desiccant** (added to crystals)	**5**

Question Number	Correct Answer	Reject	Mark
23 (d)(ii)	Rinse with (plenty of) water /use a damp cloth or damp (paper) towel / add a (named) weak alkali (e.g. solid or aqueous sodium hydrogencarbonate)	Any named strong alkali/just "strong alkali"	**1**

Question Number	Correct Answer	Reject	Mark
23 (e)(i)	**Insoluble strontium sulfate/insoluble $SrSO_4$** (forms on the strontium carbonate)		**1**

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Question Number	Correct Answer	Reject	Mark
23 (e)(ii)	$Sr^{2+}(aq) + SO_4^{2-}(aq) \rightarrow SrSO_4(s)$ species **(1)** state symbols **(1)** **2nd mark is cq on first mark** $Sr^{2+}(aq) + 2Cl^-(aq) + 2Na^+(aq) + SO_4^{2-}(aq) \rightarrow SrSO_4(s) + 2Cl^-(aq) + 2Na^+(aq)$ scores **(1)** $SrCl_2(aq) + Na_2SO_4(aq) \rightarrow SrSO_4(s) + 2NaCl(aq)$ scores **(1)**		**2**

Question Number	Correct Answer	Reject	Mark
24 (a)(i)	$\frac{2.90}{58} = 0.05(00)$ (mol) correct answer only **(1)**		**1**

Question Number	Correct Answer	Reject	Mark
24 (a)(ii)	200 x 4.18 x **58.2** = 48655 (J) **OR** 48.655 kJ **(1)** for correct ΔT **(1)** *IGNORE* sf *IGNORE* signs at this stage		**2**

Question Number	Correct Answer	Reject	Mark
24 (a)(iii)	$-\frac{48655}{0.0500} = -973\ 100$ (J mol^{-1}) = −973 kJ mol^{-1} (3 s.f.) / −973000 J mol^{-1} (3 s.f.) answer **(1)** sign and units **(1)** [Do not award sign and units mark **if units given are just** "kJ" or **just** "J"] **three sig figs (1)** *CQ on (a)(i) & (ii)*		**3**

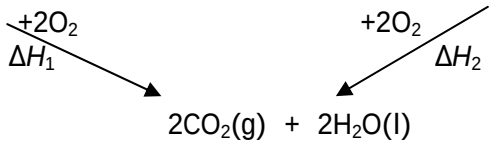
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Question Number	Correct Answer	Reject	Mark
24 (b)(i)	Heat loss/energy loss **Accept** Incomplete combustion OWTTE *IGNORE* "experimental error"/ "departure from standard conditions"	Anything related to "average values" **(0)**	**1**

Question Number	Correct Answer	Reject	Mark
24 (b)(ii)	**Difference:** less exothermic / less negative *IGNORE* "higher" **if** written **with** less exothermic/less negative **Accept just "**lower"/ "less" **(1)** **Justification:** energy taken in to form gas/energy required to form gas/energy needed to form gas/takes heat in to form gas/heat required to form gas **Or reverse argument** **(1)** *Mark these two points independently*	**Just** "higher" (**0)** **Just** "$H_2O(g)$ is not water's standard state"	**2**

Question Number	Correct Answer	Reject	Mark
24 (c)(i)	Enthalpy / energy / heat (energy) change (when) one mole of a substance/one mole of a compound **(1)** is formed from its elements (in their most stable states) **(1)** 298K / 25°C / a stated temperature **AND** 1 atm pressure/100 kPa **(1)** *IGNORE* any references to concentration	"energy required" **OR** "energy released" "one mole of **product(s)**" is formed from its **reactants** room temperature/rtp	**3**

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Question Number	Correct Answer	Reject	Mark
24 (c)(ii)	Cycle or formula expression  $\Delta H^{\theta}_{f} = \Delta H_1 - \Delta H_2$ = (2 x - 394) + (2 x - 286) - (- 870) = **−490** (kJ mol^{-1}) • correct expression or cycle **(1)** • evidence for doubling **both** ΔH^{θ}_{c} [C] **and** ΔH^{θ}_{c} [H_2] **(1)** • answer **(1)** Correct answer with no working scores full marks		**3**

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Write your name here

Surname	Other names

Centre Number | Candidate Number

Edexcel GCE

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 9 January 2009 – Afternoon **Time: 1 hour 15 minutes**	Paper Reference **6CH01/01**

Candidates may use a calculator.

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and candidate number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- Questions labelled with an **asterisk** (*) are ones where the quality of your written communication will be assessed
  – *you should take particular care with your spelling, punctuation and grammar, as well as the clarity of expression, on these questions.*
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Keep an eye on the time.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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7/7/7/7/2/3

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SECTION A

Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

1 Which equation represents the reaction for which the enthalpy change is the lattice energy of sodium fluoride, NaF?

☒ **A** $Na(s) + \frac{1}{2}F_2(g) \rightarrow NaF(s)$

☒ **B** $Na(g) + F(g) \rightarrow NaF(s)$

☒ **C** $Na^+(g) + F^-(g) \rightarrow NaF(s)$

☒ **D** $Na(g) + \frac{1}{2}F_2(g) \rightarrow NaF(s)$

(Total for Question 1 = 1 mark)

2 **Theoretical** lattice energies can be calculated from electrostatic theory. Which of the following affects the magnitude of the theoretical lattice energy of an alkali metal halide, M^+X^-?

☒ **A** The first electron affinity of X.

☒ **B** The first ionization energy of M.

☒ **C** The enthalpy of atomization of M.

☒ **D** The radius of the X^- ion.

(Total for Question 2 = 1 mark)

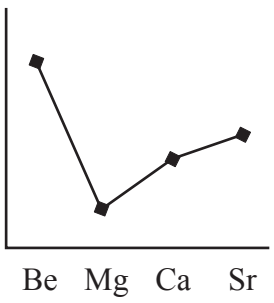
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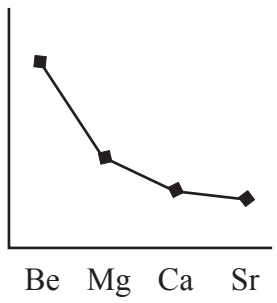
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3 Which of the following graphs shows the variation in the ionic radius of the Group 2 elements?

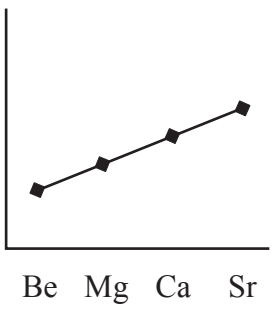
☒ **A**



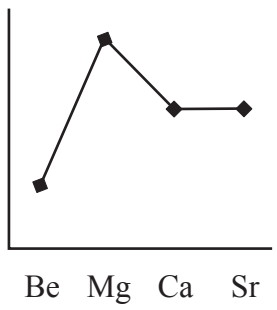
☒ **B**



☒ **C**



☒ **D**



(Total for Question 3 = 1 mark)

4 The first five ionization energies of an element, **Z**, are:

790, 1600, 3200, 4400, 16100 kJ mol^{-1}

In which group of the Periodic Table is **Z** found?

☒ **A** 2

☒ **B** 3

☒ **C** 4

☒ **D** 5

(Total for Question 4 = 1 mark)

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5 The standard enthalpy changes of combustion of carbon, hydrogen and methane are shown in the table below.

Substance	Standard enthalpy change of combustion / kJ mol^{-1}
carbon, C(s)	–394
hydrogen, $H_2(g)$	–286
methane, $CH_4(g)$	–891

Which one of the following expressions gives the correct value for the standard enthalpy change of formation of methane in kJ mol^{-1}?

$$C(s) + 2H_2(g) \rightarrow CH_4(g)$$

☒ **A** 394 + (2 × 286) – 891

☒ **B** –394 – (2 × 286) + 891

☒ **C** 394 + 286 – 891

☒ **D** –394 – 286 + 891

(Total for Question 5 = 1 mark)

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N 3 4 4 1 0 A 0 4 2 8

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6 This question is about some standard enthalpy changes, $\Delta H^{\ominus}$

A enthalpy of reaction

B enthalpy of combustion

C mean bond enthalpy

D bond enthalpy

(a) Which enthalpy change is represented by **p**?

$CH_4(g) \rightarrow CH_3(g) + H(g)$ $\Delta H^{\ominus} = p$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(b) Which enthalpy change is represented by **q**?

$CH_4(g) \rightarrow C(g) + 4H(g)$ $\Delta H^{\ominus} = 4q$

(1)

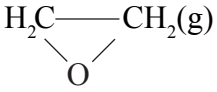
☒ **A**

☒ **B**

☒ **C**

☒ **D**

(c) Which enthalpy change is represented by **r**?

$H_2C{=}CH_2(g) + \frac{1}{2}O_2(g) \rightarrow$  $\Delta H^{\ominus} = r$

(1)

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for Question 6 = 3 marks)

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7 Given the following data:

$\Delta H_f^{\ominus}[FeO(s)] = -270\ kJ\ mol^{-1}$

$\Delta H_f^{\ominus}[Fe_2O_3(s)] = -820\ kJ\ mol^{-1}$

select the expression which gives the enthalpy change, in kJ mol^{-1}, for the reaction:

$$2FeO(s) + \tfrac{1}{2}O_2(g) \rightarrow Fe_2O_3(s)$$

☒ **A** $(-820 \times \frac{1}{2}) + 270 = -140$

☒ **B** $(+820 \times \frac{1}{2}) - 270 = +140$

☒ **C** $-820 + (270 \times 2) = -280$

☒ **D** $+820 - (270 \times 2) = +280$

(Total for Question 7 = 1 mark)

8 An organic compound contains 38.4 % carbon, 4.80 % hydrogen and 56.8 % chlorine by mass. What is the empirical formula of the compound?

☒ **A** C_2H_3Cl

☒ **B** CH_3Cl

☒ **C** C_2H_5Cl

☒ **D** $C_3H_5Cl_3$

(Total for Question 8 = 1 mark)

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9 Which of the following contains the greatest number of hydrogen atoms?

- ☒ **A** 2 moles of water, H_2O
- ☒ **B** 1.5 moles of ammonia, NH_3
- ☒ **C** 1 mole of hydrogen gas, H_2
- ☒ **D** 0.5 moles of methane, CH_4

(Total for Question 9 = 1 mark)

10 Magnesium oxide reacts with dilute hydrochloric acid according to the following equation.

$$MgO(s) + 2HCl(aq) \rightarrow MgCl_2(aq) + H_2O(l)$$

How many **moles** of magnesium oxide, MgO, are required to neutralize 20 cm^3 of 0.50 mol dm^{-3} hydrochloric acid, HCl?

- ☒ **A** 0.0010
- ☒ **B** 0.0050
- ☒ **C** 0.010
- ☒ **D** 0.020

(Total for Question 10 = 1 mark)

11 Hydrogen and oxygen react according to the following equation.

$$2H_2(g) + O_2(g) \rightarrow 2H_2O(g)$$

If all volumes are measured at 110 °C and one atmosphere pressure, the volume of steam produced after 50 cm^3 of hydrogen react completely with 25 cm^3 of oxygen is

- ☒ **A** 25 cm^3
- ☒ **B** 50 cm^3
- ☒ **C** 75 cm^3
- ☒ **D** 100 cm^3

(Total for Question 11 = 1 mark)

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12 Hydrogen peroxide decomposes on heating as follows:

$$2H_2O_2 \rightarrow 2H_2O + O_2$$

What mass of hydrogen peroxide is required to give 16 g of oxygen gas?

- ☒ **A** 8.5 g
- ☒ **B** 17 g
- ☒ **C** 34 g
- ☒ **D** 68 g

(Total for Question 12 = 1 mark)

13 The equation for the dehydration of cyclohexanol, $C_6H_{11}OH$, to cyclohexene, C_6H_{10} is:

$$C_6H_{11}OH \rightarrow C_6H_{10} + H_2O$$

50.0 g of cyclohexanol produced 32.8 g of cyclohexene.

[Molar masses / g mol^{-1} : cyclohexanol = 100; cyclohexene = 82]

Calculate the percentage yield of cyclohexene.

- ☒ **A** 32.8 %
- ☒ **B** 40.0 %
- ☒ **C** 65.6 %
- ☒ **D** 80.0 %

(Total for Question 13 = 1 mark)

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14 How many isomers are there of C_5H_{12}?

- ☒ **A** Two
- ☒ **B** Three
- ☒ **C** Four
- ☒ **D** Five

(Total for Question 14 = 1 mark)

15 In a molecule of ethene, C_2H_4, how many π (pi) bonds are present?

- ☒ **A** One
- ☒ **B** Two
- ☒ **C** Three
- ☒ **D** Four

(Total for Question 15 = 1 mark)

16 The mechanism of the reaction represented by the equation

$$C_2H_4 + Br_2 \rightarrow CH_2BrCH_2Br$$

is an example of

- ☒ **A** Free radical substitution
- ☒ **B** Free radical addition
- ☒ **C** Electrophilic substitution
- ☒ **D** Electrophilic addition

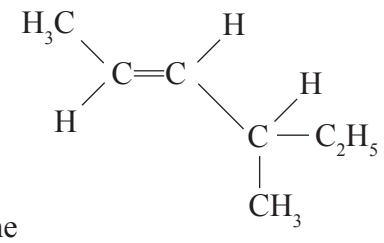
(Total for Question 16 = 1 mark)

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17 What is the systematic name for the following compound?



- ☒ **A** *Z*-4-methylhex-2-ene
- ☒ **B** *E*-2-ethylpent-3-ene
- ☒ **C** *Z*-4-ethylpent-2-ene
- ☒ **D** *E*-4-methylhex-2-ene

(Total for Question 17 = 1 mark)

18 Propene reacts with hydrogen chloride gas to give mainly

- ☒ **A** 1-chloropropane ($CH_3CH_2CH_2Cl$)
- ☒ **B** 2-chloropropane ($CH_3CHClCH_3$)
- ☒ **C** 3-chloroprop-1-ene ($CH_2{=}CHCH_2Cl$)
- ☒ **D** 1,2-dichloropropane ($CH_3CHClCH_2Cl$)

(Total for Question 18 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

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SECTION B

Answer ALL the questions. Write your answers in the spaces provided.

19 (a) (i) Complete the electronic configuration of the magnesium atom.

(1)

$1s^2$ .....

(ii) Complete the electronic configuration of the chlorine atom.

(1)

$1s^2$ .....

(b) (i) Write the equation, including state symbols, for the reaction of magnesium with chlorine.

(2)

(ii) Name the type of bonding present in magnesium chloride.

(1)

.....

(iii) Draw a diagram (using dots or crosses) to show the bonding in magnesium chloride. Include **ALL** the electrons in each species and the charges present.

(3)

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(c) State the type of bonding that exists in solid magnesium.

(1)

Type .....

*(d) Explain fully why the melting temperature of magnesium is higher than that of sodium.

(3)

.....

.....

.....

.....

.....

.....

.....

.....

.....

(Total for Question 19 = 12 marks)

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20 (a) A gaseous sample of an element can be analysed using a mass spectrometer.

(i) Describe briefly how positive ions are formed from gaseous atoms in a mass spectrometer.

(2)

.....

.....

.....

.....

.....

(ii) What is used to accelerate the positive ions in a mass spectrometer?

(1)

.....

(iii) What is used to deflect the positive ions in a mass spectrometer?

(1)

.....

(b) The following data were obtained from the mass spectrum of a sample of chromium.

Mass/charge ratio	% abundance
50.0	4.3
52.0	83.8
53.0	9.5
54.0	2.4

Calculate the relative atomic mass of chromium in this sample. Give your answer to **three** significant figures.

(2)

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(c) Explain why the four isotopes of chromium behave identically in chemical reactions.

(1)

(d) In which block of the Periodic Table is chromium found?

(1)

(Total for Question 20 = 8 marks)

21 (a) Define the term **first ionization energy**.

(3)

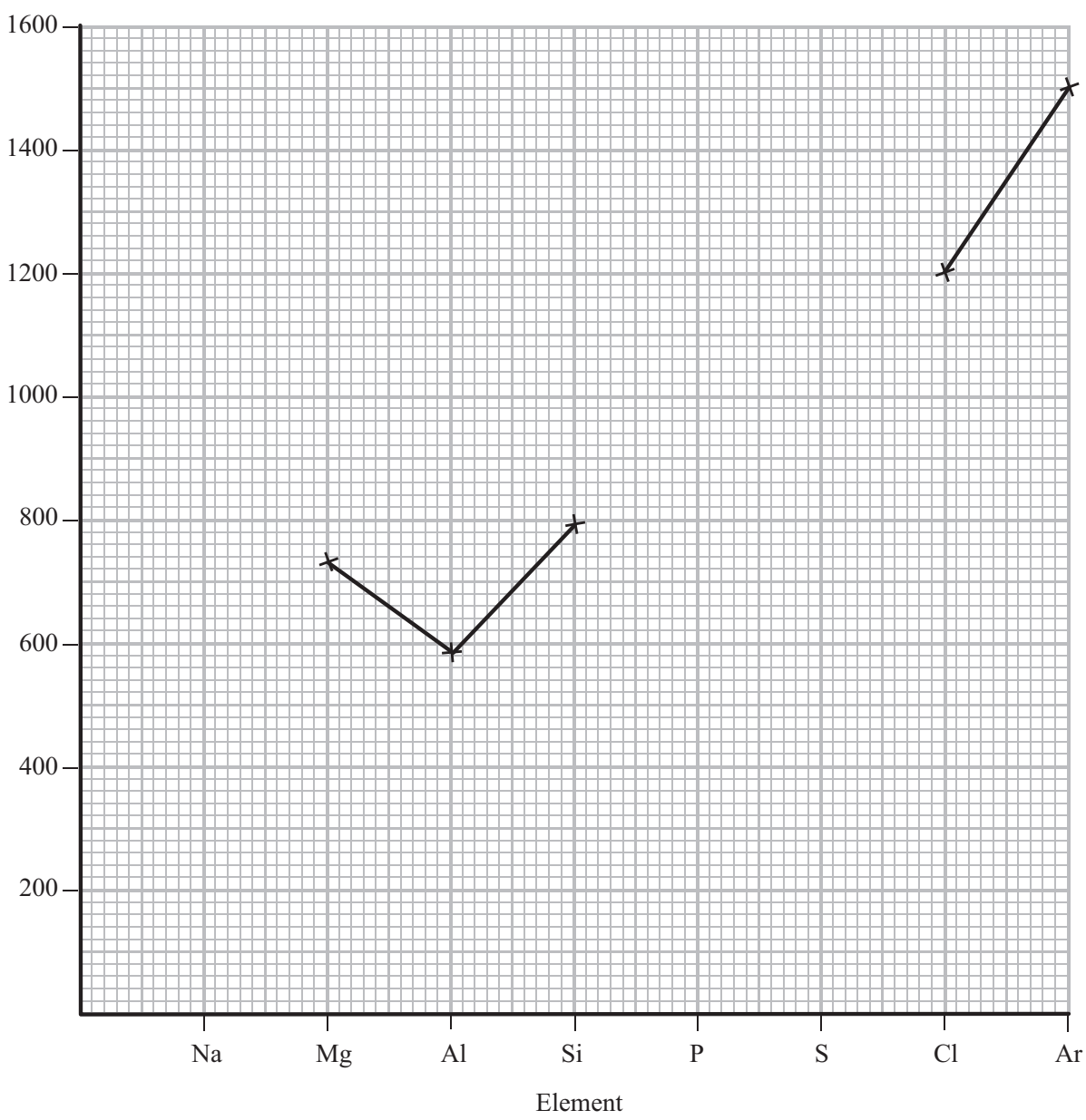
(b) Write an equation, with state symbols, to illustrate the process occurring when the **second** ionization energy of sodium is measured.

(2)

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(c) The graph below shows the variation in the **first** ionization energies of some of the elements in Period 3.



(i) On the graph, use crosses to show the approximate values of the first ionization energies for the elements Na, P and S.

Join the crosses to complete your graph.

(3)

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*(ii) Explain why the first ionization energies generally increase across the period sodium to argon (Na to Ar).

(3)

*(iii) Explain why the first ionization energy of aluminium is less than that of magnesium.

(2)

(d) Place the following species

S^+ S S^-

in order of increasing first ionization energy, starting with the lowest.

(1)

Lowest first ionization energy		Highest first ionization energy
.....	.....	.....

(Total for Question 21 = 14 marks)

N 3 4 4 1 0 A 0 1 6 2 8

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22 (a) Define the term **covalent bond**.

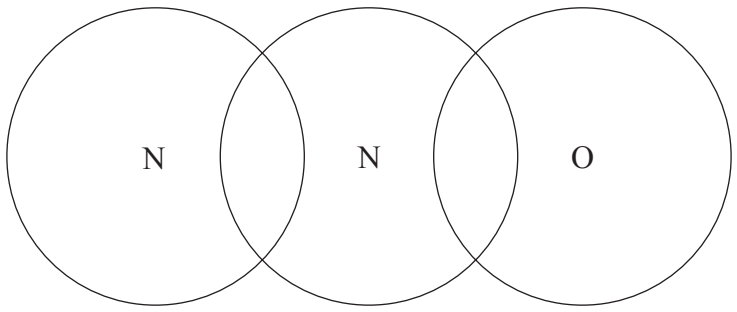
(2)

(b) Nitrogen forms an oxide called nitrous oxide, N_2O. The bonding in nitrous oxide can be represented as:

$$N \equiv N \rightarrow O$$

Complete the diagram below for the N_2O molecule using dots or crosses to represent electrons. Just show all of the outer shell electrons.

(3)



(Total for Question 22 = 5 marks)

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23 The standard enthalpy change, $\Delta H_1^{\ominus}$, for the decomposition of potassium hydrogencarbonate, $KHCO_3$, is impossible to determine directly.

$$2KHCO_3(s) \rightarrow K_2CO_3(s) + CO_2(g) + H_2O(l)$$

The value of $\Delta H_1^{\ominus}$ can be calculated from the standard enthalpy changes which accompany the reactions below:

$KHCO_3(s) + HCl(aq) \rightarrow KCl(aq) + CO_2(g) + H_2O(l)$ $\Delta H_2^{\ominus}$

$K_2CO_3(s) + 2HCl(aq) \rightarrow 2KCl(aq) + CO_2(g) + H_2O(l)$ $\Delta H_3^{\ominus}$

Procedure:

- The solids were added to separate 30 cm^3 portions of dilute hydrochloric acid. The acid was in excess for both solids.
- The maximum temperature change for each experiment was noted.

Results:

- The following results were obtained **with $KHCO_3(s)$**.

  Mass of $KHCO_3$ used = 2.00 g

  Temperature change = −4.9 °C

- The experiment with $K_2CO_3(s)$ gave a $\Delta H_3^{\ominus}$ value of −34 kJ mol^{-1}.

Assumption:

- The dilute hydrochloric acid solution has a density of 1 g cm^{-3}.

N 3 4 4 1 0 A 0 1 8 2 8

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(a) (i) Calculate the heat energy absorbed, in joules, by the reaction of the $KHCO_3(s)$ with the solution of dilute hydrochloric acid.

Use the expression

energy absorbed (J) = mass of solution × 4.18 × temperature change

(1)

(ii) Calculate the number of moles of $KHCO_3(s)$ used. Assume that the molar mass of $KHCO_3(s)$ is 100 g mol^{-1}.

(1)

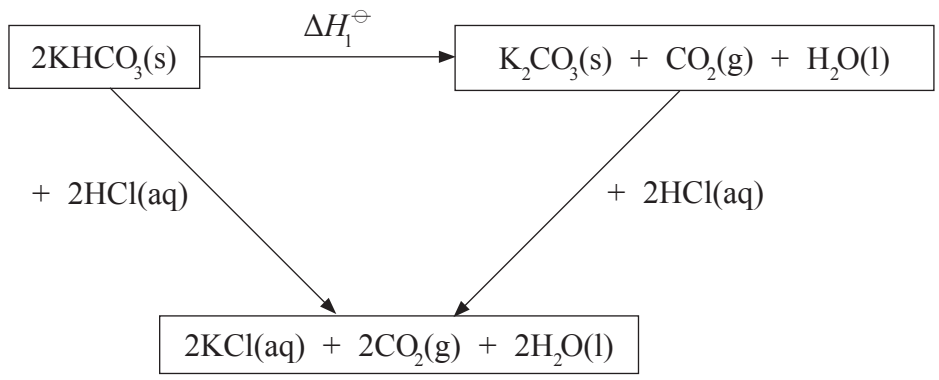
(iii) Use your answers to (a)(i) and (ii) to calculate, in **kJ mol^{-1}**, the enthalpy change when one mole of $KHCO_3(s)$ reacts completely with the acid (i.e. $\Delta H_2^{\ominus}$). Include a sign in your answer.

(2)

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(b) A Hess Cycle based on these reactions is shown below.



(i) Apply Hess's Law to obtain an expression for $\Delta H_1^{\ominus}$ in terms of $\Delta H_2^{\ominus}$ and $\Delta H_3^{\ominus}$.

(1)

$\Delta H_1^{\ominus}$ =

(ii) Use your answers to (a)(iii) and (b)(i), and the $\Delta H_3^{\ominus}$ value of –34 kJ mol^{-1}, to calculate a value for $\Delta H_1^{\ominus}$ in kJ mol^{-1}. Include a sign in your answer.

(2)

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(c) The maximum errors for the apparatus used in the experiment with the $KHCO_3(s)$ were as follows:

Balance	± 0.01 g
Measuring cylinder	± 0.5 cm^3

(i) Calculate the maximum percentage error in using each of the following pieces of apparatus in the $KHCO_3(s)$ experiment:

(2)

Balance

Measuring cylinder

(ii) Suggest a piece of apparatus that could have been used to measure the volume of dilute hydrochloric acid more accurately in this experiment.

(1)

(Total for Question 23 = 10 marks)

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24 (a) State the general formula of the alkanes, using the letter ***n*** to denote the number of carbon atoms in each molecule.

(1)

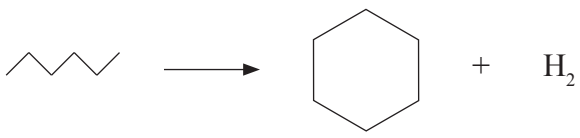
(b) Alkanes are used as fuels. In the petrochemical industry, useful hydrocarbons are often produced from longer chain molecules.

Name the type of reaction shown below.

(i) 

(1)

Type of reaction .....

(ii) 

(1)

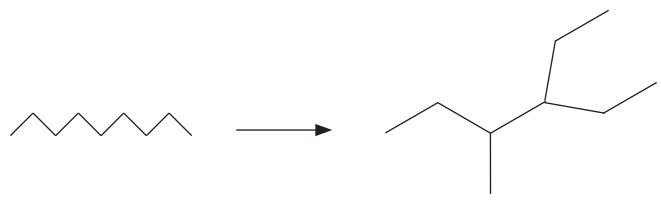
Type of reaction .....

(c) By what **type** of formula are the **organic** molecules in (b) represented?

(1)

.....

(d) Another reaction carried out in industry can be represented as shown below.



compound 1 **compound 2**

(i) Give the molecular formula of **compound 2**.

(1)

.....

(ii) Give the name of **compound 2**.

(1)

.....

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(e) An equation for the reaction between methane and chlorine is:

$$CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$$

The reaction occurs in the presence of ultraviolet (UV) light via a free-radical chain mechanism.

The initiation step is $Cl_2 \rightarrow 2Cl\bullet$

The next step could be

EITHER $CH_4 + Cl\bullet \rightarrow \bullet CH_3 + HCl$ (Step **A**)

OR $CH_4 + Cl\bullet \rightarrow CH_3Cl + H\bullet$ (Step **B**)

(i) Use the following data to calculate a value for the enthalpy change for each of the Steps, **A** and **B**.

(3)

Bond	Mean bond enthalpy / kJ mol^{-1}
C – H	+ 413
C – Cl	+ 346
H – Cl	+ 432

Enthalpy change for Step A $CH_4 + Cl\bullet \rightarrow \bullet CH_3 + HCl$

Answer ..... kJ mol^{-1}

Enthalpy change for Step B $CH_4 + Cl\bullet \rightarrow CH_3Cl + H\bullet$

Answer ..... kJ mol^{-1}

(ii) Use your answer to (i) to justify which of the Steps, **A** or **B**, is the more likely.

(1)

.....

.....

QUESTION 24 CONTINUES ON THE NEXT PAGE.

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(f) Another halogenoalkane, bromomethane, CH_3Br, is a toxic gas used to protect plants against insects.

Health and Safety advice states that concentrations above 5 parts per million (ppm) by volume of this gas are harmful.

A research laboratory contains 2.5×10^5 dm^3 of air. Calculate the maximum volume of bromomethane, in dm^3, allowed in the laboratory to comply with the advice given.

(1)

(Total for Question 24 = 11 marks)

TOTAL FOR SECTION B = 60 MARKS
TOTAL FOR PAPER = 80 MARKS

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The Periodic Table of Elements

1	2											3	4	5	6	7	0 (8)
							1.0 H hydrogen 1										(18) 4.0 He helium 2
(1)	(2)											(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4											10.8 B boron 5	12.0 C carbon 6	14.0 N nitrogen 7	16.0 O oxygen 8	19.0 F fluorine 9	20.2 Ne neon 10
23.0 Na sodium 11	24.3 Mg magnesium 12	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	27.0 Al aluminium 13	28.1 Si silicon 14	31.0 P phosphorus 15	32.1 S sulfur 16	35.5 Cl chlorine 17	39.9 Ar argon 18
39.1 K potassium 19	40.1 Ca calcium 20	45.0 Sc scandium 21	47.9 Ti titanium 22	50.9 V vanadium 23	52.0 Cr chromium 24	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	58.7 Ni nickel 28	63.5 Cu copper 29	65.4 Zn zinc 30	69.7 Ga gallium 31	72.6 Ge germanium 32	74.9 As arsenic 33	79.0 Se selenium 34	79.9 Br bromine 35	83.8 Kr krypton 36
85.5 Rb rubidium 37	87.6 Sr strontium 38	88.9 Y yttrium 39	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	[98] Tc technetium 43	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	106.4 Pd palladium 46	107.9 Ag silver 47	112.4 Cd cadmium 48	114.8 In indium 49	118.7 Sn tin 50	121.8 Sb antimony 51	127.6 Te tellurium 52	126.9 I iodine 53	131.3 Xe xenon 54
132.9 Cs caesium 55	137.3 Ba barium 56	138.9 La* lanthanum 57	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	186.2 Re rhenium 75	190.2 Os osmium 76	192.2 Ir iridium 77	195.1 Pt platinum 78	197.0 Au gold 79	200.6 Hg mercury 80	204.4 Tl thallium 81	207.2 Pb lead 82	209.0 Bi bismuth 83	[209] Po polonium 84	[210] At astatine 85	[222] Rn radon 86
[223] Fr francium 87	[226] Ra radium 88	[227] Ac* actinium 89	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[264] Bh bohrium 107	[277] Hs hassium 108	[268] Mt meitnerium 109	[271] Ds darmstadtium 110	[272] Rg roentgenium 111							

Key: relative atomic mass / **atomic symbol** / name / atomic (proton) number

Elements with atomic numbers 112-116 have been reported but not fully authenticated

* 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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GCE

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General Marking Guidance

- All candidates must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do rather than penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed out work should be marked UNLESS the candidate has replaced it with an alternative response.
- Mark schemes will indicate within the table where, and which strands of QWC, are being assessed. The strands are as follows:

  i) ensure that text is legible and that spelling, punctuation and grammar are accurate so that meaning is clear
  ii) select and use a form and style of writing appropriate to purpose and to complex subject matter
  iii) organise information clearly and coherently, using specialist vocabulary when appropriate

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Using the Mark Scheme

Examiners should look for qualities to reward rather than faults to penalise. This does NOT mean giving credit for incorrect or inadequate answers, but it does mean allowing candidates to be rewarded for answers showing correct application of principles and knowledge. Examiners should therefore read carefully and consider every response: even if it is not what is expected it may be worthy of credit.

The mark scheme gives examiners:
- an idea of the types of response expected
- how individual marks are to be awarded
- the total mark for each question
- examples of responses that should NOT receive credit.

/ means that the responses are alternatives and either answer should receive full credit.
( ) means that a phrase/word is not essential for the award of the mark, but helps the examiner to get the sense of the expected answer.
Phrases/words in **bold** indicate that the meaning of the phrase or the actual word is **essential** to the answer.
ecf/TE/cq (error carried forward) means that a wrong answer given in an earlier part of a question is used correctly in answer to a later part of the same question.

Candidates must make their meaning clear to the examiner to gain the mark. Make sure that the answer makes sense. Do not give credit for correct words/phrases which are put together in a meaningless manner. Answers must be in the correct context.

Quality of Written Communication
Questions which involve the writing of continuous prose will expect candidates to:
- write legibly, with accurate use of spelling, grammar and punctuation in order to make the meaning clear
- select and use a form and style of writing appropriate to purpose and to complex subject matter
- organise information clearly and coherently, using specialist vocabulary when appropriate.

Full marks will be awarded if the candidate has demonstrated the above abilities.
Questions where QWC is likely to be particularly important are indicated (QWC) in the mark scheme, but this does not preclude others.

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Section A

Question Number	Answer	Mark
1	C	**1**

Question Number	Answer	Mark
2	D	**1**

Question Number	Answer	Mark
3	C	**1**

Question Number	Answer	Mark
4	C	**1**

Question Number	Answer	Mark
5	B	**1**

Question Number	Answer	Mark
6(a)	D	**1**

Question Number	Answer	Mark
6(b)	C	**1**

Question Number	Answer	Mark
6(c)	A	**1**

Question Number	Answer	Mark
7	C	**1**

Question Number	Answer	Mark
8	A	**1**

Question Number	Answer	Mark
9	B	**1**

Question Number	Answer	Mark
10	B	**1**

Question Number	Answer	Mark
11	B	**1**

Question Number	Answer	Mark
12	C	**1**

Question Number	Answer	Mark
13	D	**1**

Question Number	Answer	Mark
14	B	**1**

Question Number	Answer	Mark
15	A	**1**

Question Number	Answer	Mark
16	D	**1**

Question Number	Answer	Mark
17	D	**1**

Question Number	Answer	Mark
18	B	**1**

Section B

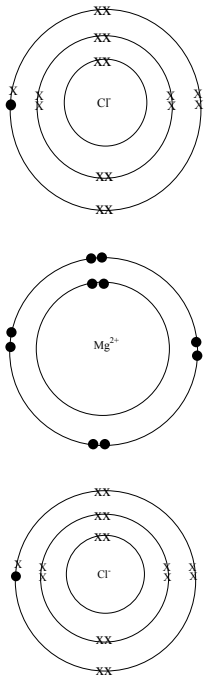
Question Number	Acceptable Answers	Reject	Mark
19(a)(i)	$(1s^2)2s^22p^63s^2$ *ALLOW* subscripts *IGNORE* capital letters *ALLOW* 2p as p_x p_y p_z with two e^- in each	Noble gas core	**1**

Question Number	Acceptable Answers	Reject	Mark
19(a)(ii)	$(1s^2)2s^22p^63s^23p^5$ *ALLOW* subscripts *IGNORE* capital letters *ALLOW* 2p as p_x p_y p_z with two e^- in each ALLOW 3p as p_x p_y p_z with two, two, one e^- in each	Noble gas core	**1**

Question Number	Acceptable Answers	Reject	Mark
19(b)(i)	$Mg_{(s)} + Cl_{2(g)} \rightarrow MgCl_{2(s)}$ Species and balancing **(1)** State symbols CQ on correct species **(1)** *NOTE* $Mg_{(s)} + 2Cl_{(g)} \rightarrow MgCl_{2(s)}$ scores **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
19(b)(ii)	Ionic / electrovalent *IGNORE* "lattice"/"bonding"/"giant"		**1**

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Question Number	Acceptable Answers	Reject	Mark
19(b)(iii)	Correct number of electrons on each ion **(1)** Correct charges and symbols for each ion **(1)** Correct ratio of ions **(1)**  *ALLOW* **all** dots or all crosses *ALLOW* correct charges shown outside the ions *ALLOW* Cl^- correctly with "2" in front **or** after the Cl^-	Any covalency shown **(0)** i.e. any overlap of circles (e.g. Mg with a Cl or a Cl with a Cl) scores **(0) overall,** even if correct charges on ions and/or ratio of ions has been shown	**3**

Question Number	Acceptable Answers	Reject	Mark
19(c)	(Giant) metallic / metal		**1**

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Question Number	Acceptable Answers	Reject	Mark
19(d) **QWC**	Magnesium **ion** / Mg^{2+} has a larger charge (density) (than the sodium ion / Na^{+}) **OR** Magnesium/Mg/Mg atom/Mg^{2+} (ion) contributes two electrons/more electrons (to the "sea" of electrons) **(1)** magnesium ions / Mg^{2+} smaller (than sodium ions) **(1)** *NOTE* "Mg^{2+} is smaller than Na^{+}" would score first 2 marks above magnesium ions / Mg^{2+} have greater attraction for ("sea" of) electrons (than sodium ions / Na^{+}) **OR** More **energy/heat** required to overcome (attractive) forces/bonds (between cations and "sea" of electrons) in magnesium (compared to sodium) **(1)** Mark each point independently	Any references to the bonding being ionic scores **(0)** overall Any references to "molecules"/intermolecular forces scores **(0)** overall **JUST** "stronger bonds in Mg" **JUST** "stronger bonds in Mg"	**3**

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Question Number	Acceptable Answers	Reject	Mark
20 (a)(i)	• **Idea of impact by electrons, with energy:** fast **electrons** strike sample / high energy **electrons** / accelerated **electrons** / **electrons** fired at sample/sample bombarded with **electrons**/blasted with **electrons** from electron gun **(1)** • **Idea of electron removal:** removes an electron/knocks out electron(s)/X → $X^+ + e^-$ **(1)** Mark each point independently	"electron gun" **alone** an incorrect equation negates second mark	**2**

Question Number	Acceptable Answers	Reject	Mark
20(a)(ii)	Electric field/electrostatic field / charged plates / voltage differential across plates/negative field/negatively charged plates	Electric current/electric coil/magnetic field	**1**

Question Number	Acceptable Answers	Reject	Mark
20(a)(iii)	Magnetic field / magnet / electromagnet / magnetic plates	"Negative magnetic field"	**1**

Question Number	Acceptable Answers	Reject	Mark
20(b)	((50.0 x 4.3) + (52.0 x 83.8) + (53.0 x 9.5) + (54.0 x 2.4)) ÷ 100 **(1)** = 52.1 (must be to 3 SF) **(1)** NOTE: 52.057/52.06 scores **(1)** with or without any working *IGNORE* g or g mol^{-1} but **wrong units** lose a mark Correct answer with no working **(2)**		**2**

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Question Number	Acceptable Answers	Reject	Mark
20(c)	Same electronic structures/same electronic configurations/same electronic arrangements/same number of electrons/same total number of electrons *ALLOW* "same number of protons and same number of electrons"	**Just** "same number of **outer** electrons" **(0)** OR **Just** "same number of protons" **(0)**	**1**

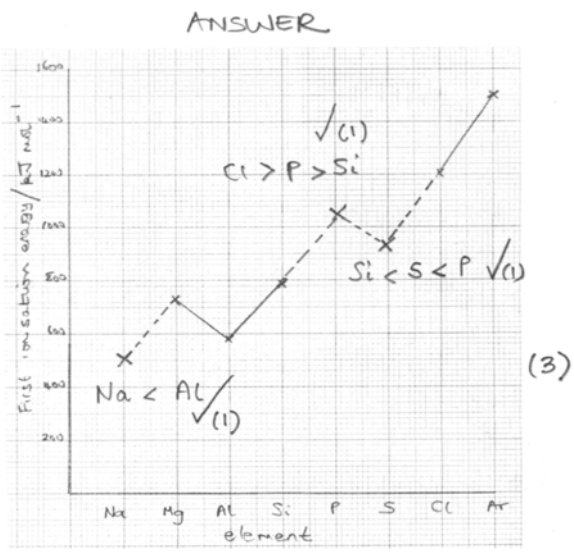
Question Number	Acceptable Answers	Reject	Mark
20(d)	d (block) *ALLOW* "D" (BLOCK) *IGNORE* "transition metal/element" **if** d (block) stated in answer *IGNORE* "group"	**Just** transition element(s) / transition metal(s)	**1**

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Question Number	Acceptable Answers	Reject	Mark
21(a)	Enthalpy / (heat) energy / heat **required** **OR** enthalpy / (heat) energy / heat **change (1)** to remove one electron **(1)** from each atom of **one mole** of **gaseous** atoms **OWTTE** **(1)** (e.g. "energy required to remove one mole of electrons from one mole of gaseous atoms" scores all **three** marks) **NOTE:** The equation: $X_{(g)} \rightarrow X^{+}_{(g)} + e^{-}$ scores the last **two** marks.	"Energy **given out**…." for first mark. If an incorrect equation is given after a correct definition, **(2)** scored.	**3**

Question Number	Acceptable Answers	Reject	Mark
21(b)	$Na^{+}_{(g)} \rightarrow Na^{2+}_{(g)} + e^{-}$ **OR** $Na^{+}_{(g)} - e^{-} \rightarrow Na^{2+}_{(g)}$ Species **(1)** *ALLOW* **"e" for "e^{-}"** State symbols **(1)** 2nd mark is CQ on 1st The following score max **(1):** $X^{+}_{(g)} \rightarrow X^{2+}_{(g)} + e^{-}$ **(1)** **OR** $X^{+}_{(g)} - e^{-} \rightarrow X^{2+}_{(g)}$ **(1)** $Na_{(g)} \rightarrow Na^{2+}_{(g)} + 2e^{-}$ **(1)** OR $Na_{(g)} \rightarrow Na^{+}_{(g)} + e^{-}$ **(1)** **OR** $Na^{+}_{(g)} + e^{-} \rightarrow Na^{2+}_{(g)}$ **(1)** **OR** $Na^{+}_{(g)} - e^{-} \rightarrow Na^{2+}_{(g)} + e^{-}$ **(1)**	"e^{2-}" $Na^{2+}_{(g)} + e^{-} \rightarrow Na^{+}_{(g)}$ **(0)**	**2**

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Question Number	Acceptable Answers	Reject	Mark
21(c)(i)	 Correct line alone can score all 3 marks with no points specifically plotted		**3**

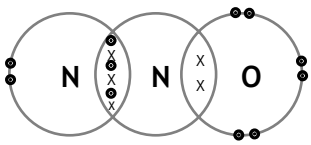
Question Number	Acceptable Answers	Reject	Mark
21(c)(ii) **QWC**	More protons / greater nuclear charge/proton number increases **(1)** *ALLOW* "effective nuclear charge increases across the Period" **outer** electrons in same shell / energy level **OR** same shielding **OR** similar shielding **OR** decrease in atomic radius **OR** outer electron closer to nucleus **OR** attracting the same number of (occupied) electron shells / energy levels **(1)** greater (force of) attraction between nucleus and (outer) electron(s) / (outer) electron(s) held more strongly by nucleus **(1)** Mark each point independently	**Just** "increasing atomic number"	**3**

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Question Number	Acceptable Answers	Reject	Mark
21(c)(iii) QWC	(Outermost) **electron** in (3-)**p sub**-shell/**sub**-level/orbital **(1)** of higher energy **OR** (slightly) shielded by (3-)**s** (electrons) **OR** (sub-shell) further from nucleus **(1)** *NOTE:* Penalise use of the terms "s-shell" or "p-shell" **once** only.		**2**

Question Number	Acceptable Answers	Reject	Mark
21(d)	S^- S S^+		**1**

Question Number	Acceptable Answers	Reject	Mark
22(a)	(Electrostatic attraction between two nuclei and the) **shared pair (1)** **of electrons** (between them) **(1)**		**2**

Question Number	Acceptable Answers	Reject	Mark
22(b)	(Dative) pair of e^- between N and O **(1)** Three bond pairs between N and N **(1)** Lone pair on left-hand N **and** three lone pairs on O atom **(1)**  *ALLOW* dots and crosses **OR** all dots **OR** all crosses Stand alone marks Non-bonding electrons on N and O do **not** have to be shown **in pairs**		**3**

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Ignore sig figs in this question

Question Number	Acceptable Answers	Reject	Mark
23(a)(i)	Energy absorbed = 30 x 4.18 x 4.9 = 614 (J) Note: 610 to 2 sig figs 614.5 to 4 sig figs 614.46 to 5 sig figs **Ignore any signs, + OR -** Answer alone scores the mark *ALLOW* "0.614 **kJ**"	615 "614 **kJ**" etc	**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(ii)	Moles = $\frac{2.00}{100}$ = 0.02(00)(mol) Answer alone scores the mark *ALLOW* 0.01998 etc for use of Mr = 100.1		**1**

Question Number	Acceptable Answers	Reject	Mark
23(a)(iii)	$\Delta H^{\ominus}_2 =$ $\frac{\text{Answer to (a)(i) **in kJ**}}{\text{Answer to (a)(ii)}}$ $= \frac{0.614}{0.02(00)}$ $(\Delta H^{\ominus}_2) = +31 / +30.7$ (kJ mol^{-1}) **(2)** Positive sign **(1) stand alone** Answer **(1)** If mass of solution used is 32 g in a(i), answer is $\Delta H^{\ominus}_2 = +32.8 / +33$ (kJ mol^{-1}) If mass of solution used is 2 g in a(i), $\Delta H^{\ominus}_2 = +2.05 / +2.0 / +2.048$ (kJ mol^{-1})		**2**

Question Number	Acceptable Answers	Reject	Mark
23(b)(i)	$\Delta H^{\ominus}_1 = 2 \times \Delta H^{\ominus}_2 - \Delta H^{\ominus}_3$		**1**

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Question Number	Acceptable Answers	Reject	Mark
23(b)(ii)	$\Delta H^{\ominus}_1$ = 2 x +31 – (-34) ($\Delta H^{\ominus}_1$) = + 96 (kJ mol^{-1}) OR 2 x +30.7 – (-34) = +95.4 / +95 Answer **(1)** Positive sign **(1)** *NOTE:* For +ve answers, penalise the omission of the "+" sign ONCE ONLY in (a)(iii) and (b)(ii) Consequential on (a)(iii) and formula in (b)(i) – **the arithmetic must be checked** *ALLOW:* + 96 /+95.4 / +95 (kJ mol^{-1}) **(2) EVEN IF $\Delta H^{\ominus}_1 = \Delta H^{\ominus}_2 - \Delta H^{\ominus}_3$ GIVEN IN (b)(i)** *NOTE* If use $\Delta H^{\ominus}_1 = \Delta H^{\ominus}_2 - \Delta H^{\ominus}_3$ and mass of solution used is 30 g $\Delta H^{\ominus}_1$ = +65 (kJ mol^{-1}) If use $\Delta H^{\ominus}_1 = \Delta H^{\ominus}_2 - \Delta H^{\ominus}_3$ and mass of solution used is 32 g $\Delta H^{\ominus}_1$ = +67 (kJ mol^{-1}) If use $\Delta H^{\ominus}_1 = \Delta H^{\ominus}_2 - \Delta H^{\ominus}_3$ and mass of solution used is 2 g $\Delta H^{\ominus}_1$ = +36 (kJ mol^{-1}) If use $\Delta H^{\ominus}_1 = 2\Delta H^{\ominus}_2 - \Delta H^{\ominus}_3$ and mass of solution used is 32 g $\Delta H^{\ominus}_1$ = +100 (kJ mol^{-1}) If use $\Delta H^{\ominus}_1 = 2\Delta H^{\ominus}_2 - \Delta H^{\ominus}_3$ and mass of solution used is 2 g $\Delta H^{\ominus}_1$ = +38(kJ mol^{-1})		**2**

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Question Number	Acceptable Answers	Reject	Mark
23(c)(i)	**Error for balance:** = (±) **2 x** $\frac{0.01}{2.00}$ x 100% = (±) 1.00%/1.0%/1% **(1)** ALLOW (±) 0.5% also scores **(1)** Correct answer with no working scores **(1)** **Error for measuring cylinder:** = (±) $\frac{0.5}{30}$ x 100% = (±) 1.7%/1.67% **(1)** Correct answer with no working scores **(1)**	1.6(6)% **(0)**	**2**

Question Number	**Acceptable Answers**	Reject	Mark
23(c)(ii)	Pipette or burette	"biuret"	**1**

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Question Number	Acceptable Answers	Reject	Mark
24(a)	C_nH_{2n+2}		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(i)	Cracking		**1**

Question Number	Acceptable Answers	Reject	Mark
24(b)(ii)	Reforming / dehydrogenation		**1**

Question Number	Acceptable Answers	Reject	Mark
24(c)	Skeletal		**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(i)	C_9H_{20}	Structural / displayed formulae	**1**

Question Number	Acceptable Answers	Reject	Mark
24(d)(ii)	3-ethyl-4-methylhexane *ALLOW* methyl before ethyl 4-methyl-3-ethylhexane 3-methyl-4-ethylhexane 4-ethyl-3-methylhexane 3,4-ethylmethylhexane *IGNORE* incorrect “punctuation”		**1**

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Question Number	Acceptable Answers	Reject	Mark
24(e)(i)	**Enthalpy change Step A:** $\bar{E}$(C-H) + - $\bar{E}$ (H-Cl) = + 413 + (-432) = - 19 (kJ mol^{-1}) **(1)** Correct answer with no working **(1)** **Enthalpy change Step B:** $\bar{E}$(C-H) + - $\bar{E}$ (C-Cl) = + 413 + (-346) = (+) 67 (kJ mol^{-1}) **(1)** Correct answer with no working **(1)** *NOTE* Both values correct scores **(3)** One of the two values correct scores **(2)** *NOTE* Neither value is correct, but a clear statement that ΔH = bonds broken + bonds made scores **(1)**	(+)19 scores **(0)** for this mark -67 scores **(0)** for this mark	**3**

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Question Number	Acceptable Answers	Reject	Mark
24(e)(ii)	Step A as (ΔH) is **negative/exothermic** (compared with a positive/endothermic value for Step B) OR Step A as it is the more energetically favourable **Mark CQ on the energy changes in (e)(i)** e.g if +19 and -67 given in (e)(i), Step B will be justified for the CQ mark; e.g. if both values endothermic, selects the less endothermic value OR if both values exothermic, selects the more exothermic value *IGNORE* statements such as "no harmful by-products" etc.		**1**

Question Number	Acceptable Answers	Reject	Mark
24(f)	Volume of bromomethane = $\frac{5}{1\,000\,000} \times 2.5 \times 10^5$ = 1.25 (dm^3) Correct answer with no working scores the mark		**1**

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