

Write your name here

Surname

Other names

Pearson Edexcel
International
Advanced Level

Centre Number

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Candidate Number

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Chemistry

Advanced Subsidiary

Unit 1: The Core Principles of Chemistry

Thursday 13 October 2016 – Morning

Time: 1 hour 30 minutes

Paper Reference

WCH01/01

Candidates may use a calculator.

Total Marks

Instructions

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

Information

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

Advice

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

Turn over ►

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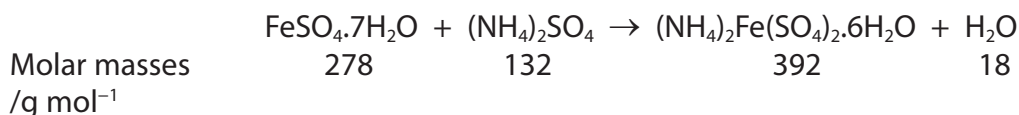
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SECTION A

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

- 1 Mohr's salt, $(\text{NH}_4)_2\text{Fe}(\text{SO}_4)_2 \cdot 6\text{H}_2\text{O}$, is a blue-green crystalline solid usually made by dissolving equimolar amounts of iron(II) sulfate and ammonium sulfate in dilute sulfuric acid and then crystallising.

The reaction may be represented by the equation



- (a) What mass of Mohr's salt would be produced from 2.78 g of iron(II) sulfate with excess ammonium sulfate, if the yield in the reaction was 80%? (1)

- A 2.22 g
- B 2.78 g
- C 3.14 g
- D 3.92 g

- (b) How many **cations** are there in each mole of Mohr's salt?

[Avogadro constant, $L = 6.0 \times 10^{23} \text{ mol}^{-1}$]

(1)

- A 6.0×10^{23}
- B 1.2×10^{24}
- C 1.8×10^{24}
- D 3.0×10^{24}

- (c) What is the percentage by mass of water in Mohr's salt? (1)

- A 4.6%
- B 18%
- C 28%
- D 72%

(Total for Question 1 = 3 marks)

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2 Magnesium carbonate reacts with hydrochloric acid.



(a) What mass of magnesium carbonate would react with excess hydrochloric acid to produce 240 cm^3 of carbon dioxide, measured at room temperature and pressure?

Data: 1 mol of any gas occupies 24.0 dm^3 at room temperature and pressure

Molar mass of magnesium carbonate = 84.3 g mol^{-1}

(1)

A 0.843 g

B 8.43 g

C 84.3 g

D 843 g

(b) What is the **minimum** mass of magnesium carbonate needed to neutralise 50.0 cm^3 of $0.250 \text{ mol dm}^{-3}$ hydrochloric acid?

(1)

A 0.423 g

B 0.527 g

C 1.05 g

D 2.11 g

(c) What would be seen at the end of the reaction with excess acid?

(1)

A A colourless solution

B A coloured solution

C A white precipitate

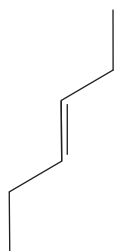
D A coloured precipitate

(Total for Question 2 = 3 marks)

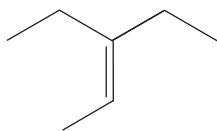
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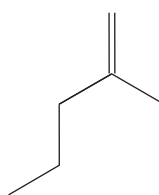
3 The following molecules are alkenes.



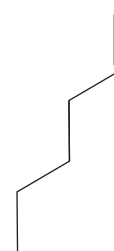
P



Q



R



S

(a) Which molecule has a geometric isomer?

(1)

- A P
 B Q
 C R
 D S

(b) Which molecule would produce 2-bromohexane as the **major** product on addition of hydrogen bromide?

(1)

- A P
 B Q
 C R
 D S

(c) Which molecule has 14 hydrogen atoms?

(1)

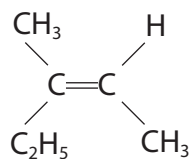
- A P
 B Q
 C R
 D S

(Total for Question 3 = 3 marks)

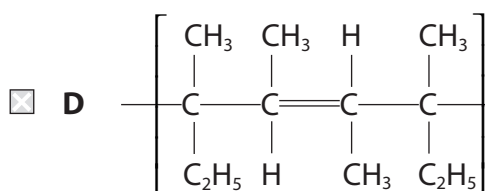
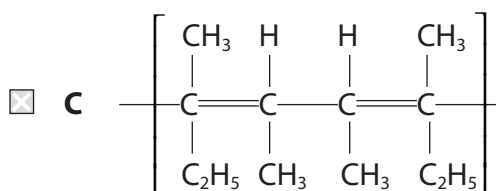
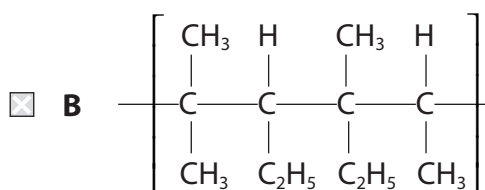
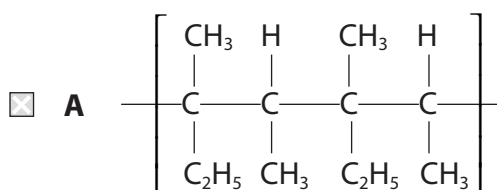
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4 The structure of Z-3-methylpent-2-ene is

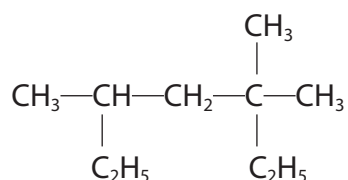


Which of the following shows **two** repeat units of the polymer made from Z-3-methylpent-2-ene?



(Total for Question 4 = 1 mark)

5 What is the systematic name for the following molecule?



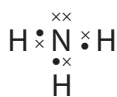
- A** 2,4-diethyl-2-methylpentane
 B 2,4-diethyl-4-methylpentane
 C 3,3,5-trimethylheptane
 D 3,5,5-trimethylheptane

(Total for Question 5 = 1 mark)

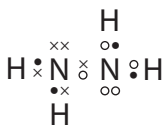
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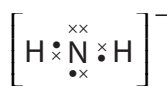
6 Nitrogen can form the following species with hydrogen:



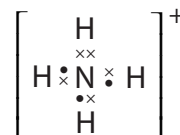
NH₃



NH₂NH₂



NH₂⁻



NH₄⁺

Which of these species has a dative covalent bond?

- A NH₃
- B NH₂NH₂
- C NH₂⁻
- D NH₄⁺

(Total for Question 6 = 1 mark)

7 Which of these elements in Period 3 has the highest melting temperature?

- A Na
- B Al
- C Si
- D P

(Total for Question 7 = 1 mark)

8 The conduction of electricity by a solution is evidence that ions are present in the solution.

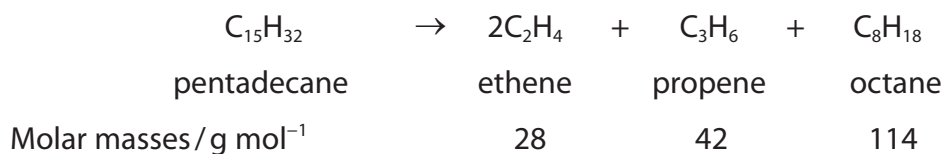
What could be formed when an electric current is passed through **aqueous** sodium chloride?

- A Chlorine at the anode
- B Hydrogen at the anode
- C Sodium at the cathode
- D Oxygen at the cathode

(Total for Question 8 = 1 mark)



9 An example of an equation to illustrate the cracking of an alkane from crude oil is



(a) What is the atom economy for this reaction in terms of production of alkenes?

Use the expression

$$\text{Atom economy} = \frac{\text{Total mass of desired product(s)}}{\text{Total mass of all products}} \times 100\% \quad (1)$$

- A 26%
- B 33%
- C 38%
- D 46%

(b) The chemical industry uses cracking in the processing of crude oil because

- A fractional distillation is too slow and expensive.
- B crude oil contains insufficient quantities of desired compounds.
- C reforming requires a catalyst.
- D cracking separates crude oil components.

(Total for Question 9 = 2 marks)

10 Scientists are developing alternatives to fossil fuels.

Which of the following is **not** a result of carbon dioxide emissions?

- A The increase in global warming.
- B The melting of the ice caps.
- C The increase in pH of the oceans.
- D The rise in sea level.

(Total for Question 10 = 1 mark)

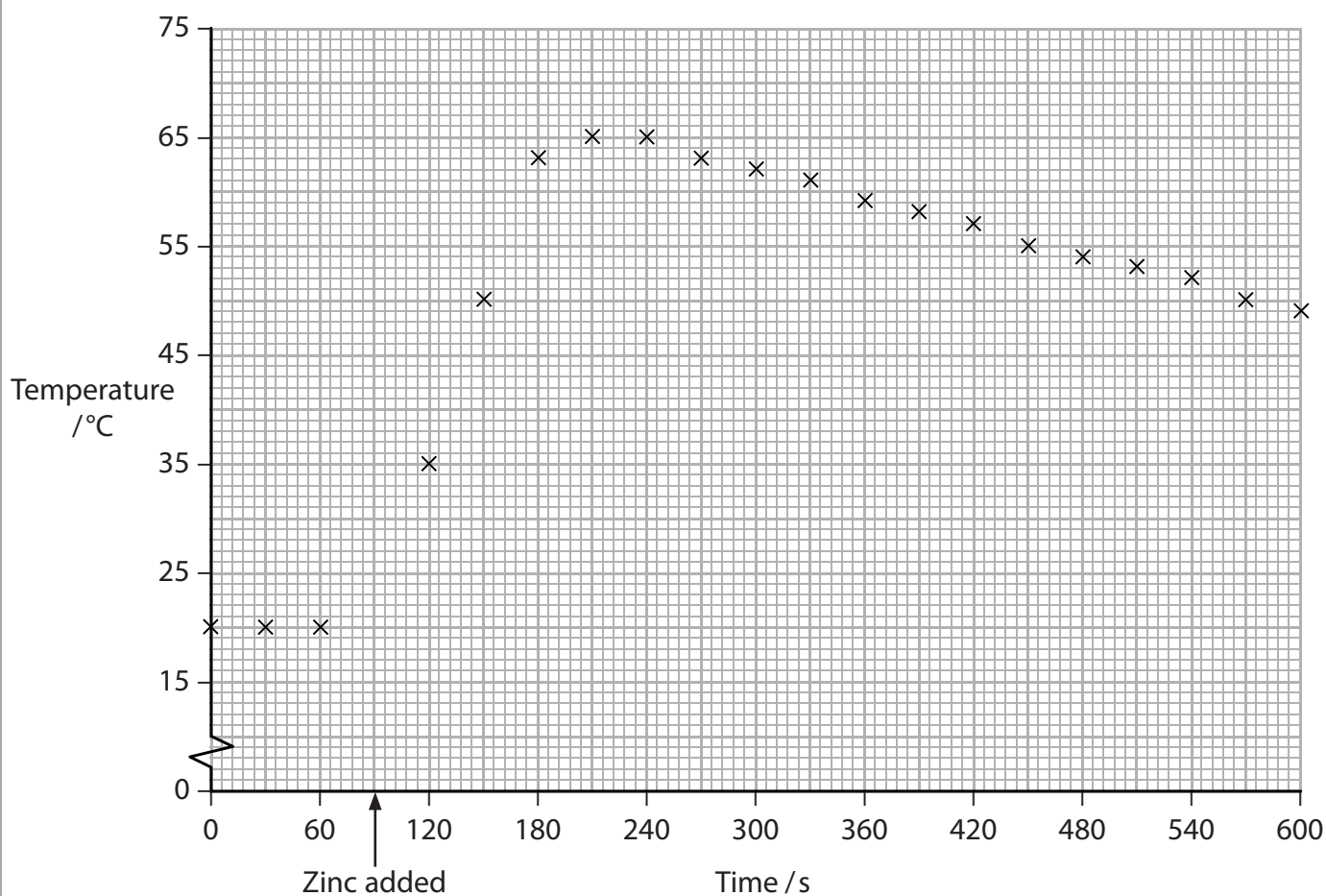


11 Which of the following is isoelectronic with the chloride ion, Cl^- ?

- A F^-
 B Br^-
 C Na^+
 D Ar

(Total for Question 11 = 1 mark)

12 An excess of zinc powder was added to 50 cm^3 of 1.0 mol dm^{-3} copper(II) sulfate in a polystyrene cup. The temperature of the copper(II) sulfate solution was measured at 30 s intervals. The zinc was added after 90 s. The results are shown on the graph.



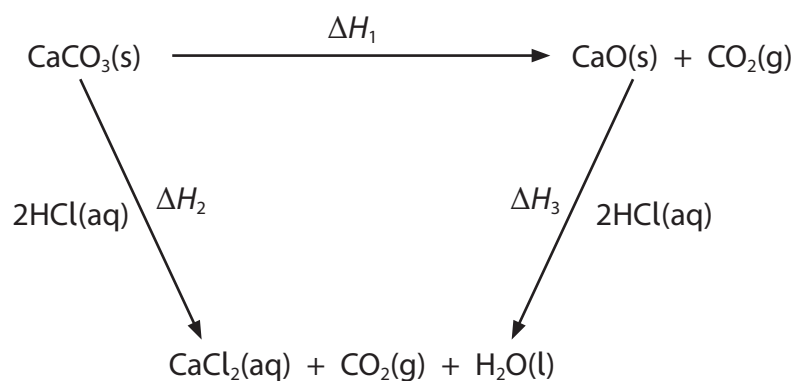
What temperature change should be used when calculating the energy transfer?

- A 45°C
 B 52°C
 C 65°C
 D 72°C

(Total for Question 12 = 1 mark)



- 13 Hess's law can be used to determine enthalpy changes which cannot be measured directly, such as the thermal decomposition of calcium carbonate.



Using Hess's law, the expression to determine ΔH_1 is

- A $\Delta H_1 = \Delta H_2 - \Delta H_3$
 B $\Delta H_1 = \Delta H_2 + \Delta H_3$
 C $\Delta H_1 = 2\Delta H_2 - 2\Delta H_3$
 D $\Delta H_1 = 2\Delta H_2 + 2\Delta H_3$

(Total for Question 13 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS



SECTION B

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

14 This question is about isotopes, and the use of mass spectrometry to detect their presence and measure their abundance.

(a) Boron has two naturally occurring isotopes, ^{10}B and ^{11}B .

(i) A sample of boron contained 13.9% of isotope ^{10}B and 86.1% of isotope ^{11}B . Calculate the relative atomic mass of boron in this sample. Give your answer to **three** significant figures.

(2)

(ii) Complete the following definition of relative atomic mass.

(1)

The relative atomic mass is the weighted mean mass of an atom of an element

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(iii) Boron-12 is a short-lived radioactive isotope.

Name the subatomic particles in an atom of boron-12 and give the number of each.

(2)

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(b) (i) A mass spectrometer operates under a vacuum. Suggest the effect on the ions in a mass spectrometer if particles from the air were present.

(1)

(ii) Suggest how, if at all, the electric field in the mass spectrometer would affect molecules that are **not** ionised.

(1)

*(iii) The reaction of ethene with aqueous potassium manganate(VII), KMnO_4 , produces ethane-1,2-diol, $\text{CH}_2\text{OHCH}_2\text{OH}$.

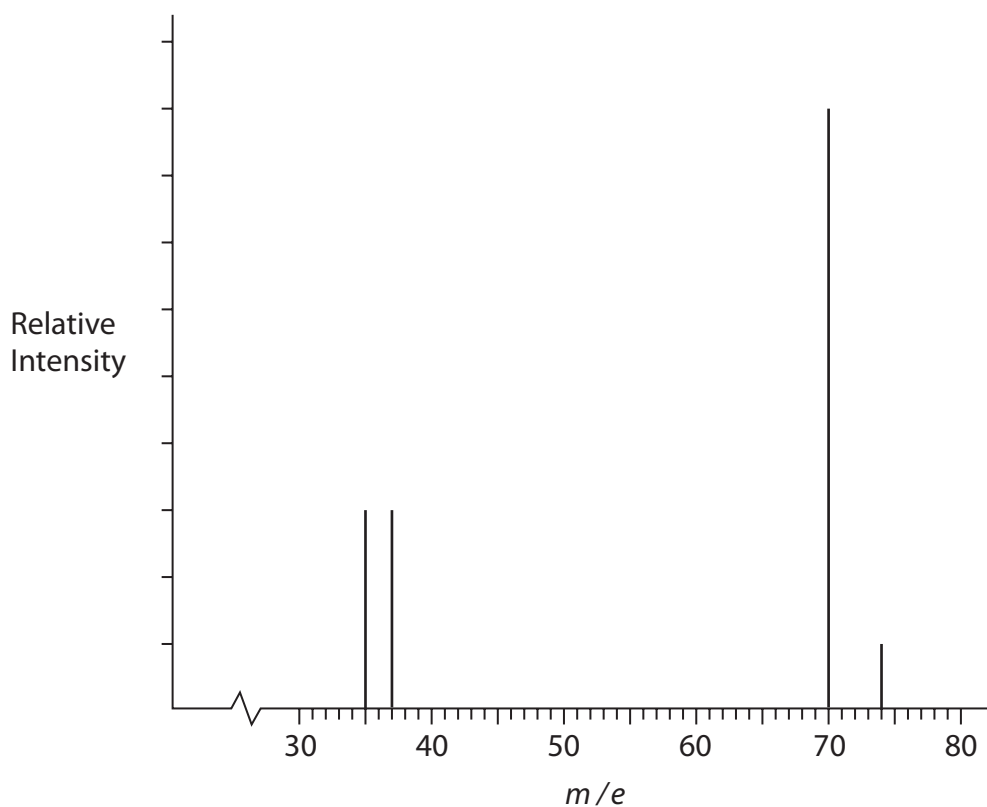
Data: molar mass of ethane-1,2-diol = 62 g mol^{-1}

In an experiment, KMnO_4 containing only ^{18}O reacts with ethene. Suggest how the mass spectrum of ethane-1,2-diol data could be used to decide whether the oxygen atoms in ethane-1,2-diol came from the manganate(VII) ion, water, or a combination of the two.

(2)



- (c) A student sketched the mass spectrum of chlorine gas which contained 75% of the ^{35}Cl isotope and 25% of the ^{37}Cl isotope.



- (i) Identify and correct the **two** errors made by the student in this sketch.

(2)

Error 1

Correction 1

Error 2

Correction 2

- (ii) Give the formula of the ion responsible for the peak with $m/e = 74$, showing the isotope(s) present.

(1)

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(Total for Question 14 = 12 marks)



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15 Alkanes react with halogens in the presence of ultraviolet (UV) light.

(a) Write the equation for the overall reaction of bromine with methane to form bromomethane. State symbols are not required.

(1)

(b) Propane reacts with chlorine to produce C_3H_7Cl . There are two possible isomers with this molecular formula.

Draw the **skeletal** formulae of these two isomers and give their systematic names.

(4)

Name:	Name:
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(c) Ethane reacts with chlorine in UV light by a free radical substitution mechanism involving a number of steps.

(i) Explain why ethane does not react with electrophiles.

(1)

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(ii) Explain why ethane undergoes substitution and not addition reactions.

(1)

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- (iii) The first step of the reaction of chlorine with ethane in UV light involves homolytic fission.

Write the equation for this fission and state the name of this reaction step.

Curly half-arrows are not required.

(2)

Equation:

Name of reaction step

- (iv) The ethyl free radical is an intermediate in the propagation stage of the reaction. Draw the dot-and-cross diagram of this free radical.

Use dots (•) for the hydrogen electrons, crosses (x) for the electrons of one of the carbon atoms and asterisks (*) for the electrons of the other carbon atom. Show only outer shell electrons.

(2)

- (v) What change to the reaction mixture of ethane and chlorine would increase the production of polychlorinated alkanes such as 1,1-dichloroethane and 1,2-dichloroethane?

(1)

(Total for Question 15 = 12 marks)



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16 This is a question about ionisation energies.

(a) Define **in words** the term 'first ionisation energy'.

(3)

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(b) Write the equation for the **second** ionisation energy of lithium.

(1)

(c) Why is it not possible to determine the **third** ionisation energy for helium?

(1)

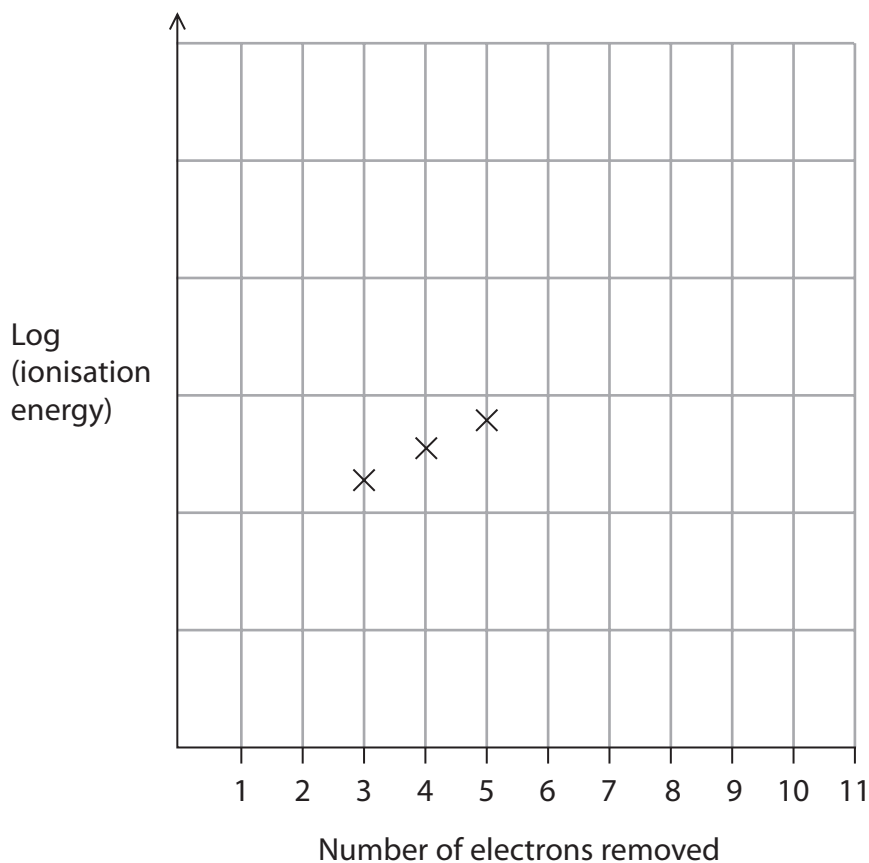
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(d) Complete the sketch of the log (ionisation energy) of sodium.

(4)



*(e) Explain why there is a general decrease in the values of the first ionisation energy on descending a group in the Periodic Table.

(3)

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* (f) Explain why the first ionisation energy of sulfur is less than that of phosphorus. (2)

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* (g) The first ionisation energy for sodium is $+496 \text{ kJ mol}^{-1}$ and for magnesium is $+738 \text{ kJ mol}^{-1}$. Hence suggest a value for the first ionisation energy of aluminium and justify your choice. (3)

Ionisation Energy Value:

Justification

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(Total for Question 16 = 17 marks)

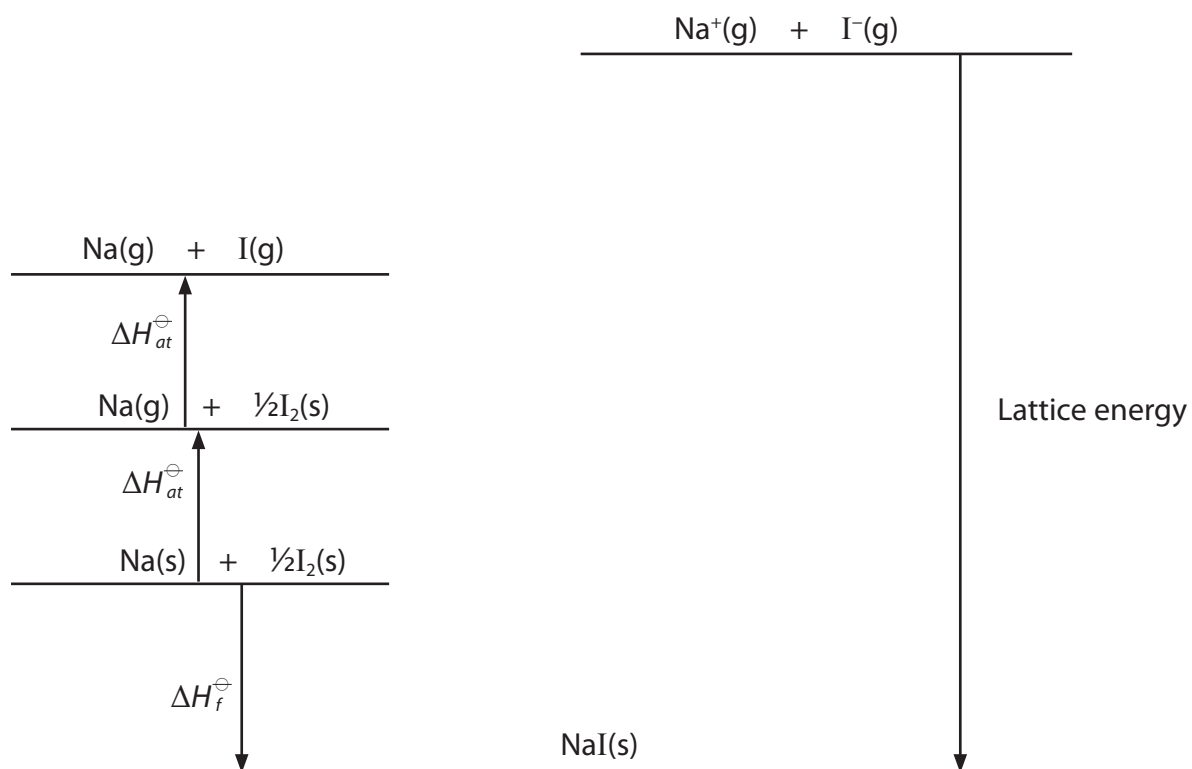


17 The following data can be used in the Born-Haber cycle for sodium iodide, NaI.

Energy change	$\Delta H / \text{kJ mol}^{-1}$
Enthalpy change of atomisation of iodine	+107
Enthalpy change of atomisation of sodium	+107
First ionisation energy of sodium	+496
First electron affinity of iodine	-295
Enthalpy change of formation of sodium iodide	-288

- (a) Complete the Born-Haber cycle diagram for sodium iodide by adding the first ionisation energy of sodium and the first electron affinity of iodine. Include any relevant entities and arrow directions.

(3)



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(b) Calculate the lattice energy for sodium iodide.

Give a sign and units in your answer.

(1)

(c) Explain why the enthalpy changes of atomisation of sodium and of iodine are endothermic. For each substance, state the type of bonding present in the solid.

(3)

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(d) The numerical value for the lattice energy of sodium iodide obtained from the Born-Haber cycle is more negative than the theoretical value.

(i) Explain why the Born-Haber value is more negative than the theoretical value.

(2)

.....

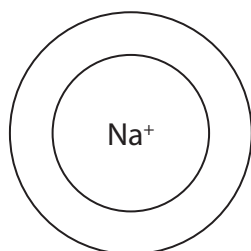
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(ii) Draw an electron density map for the iodide ion in sodium iodide showing any effect the sodium ion has on the iodide ion.

(1)



I⁻

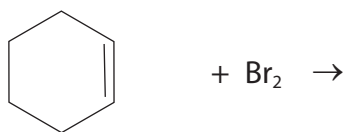
(Total for Question 17 = 10 marks)



18 The reaction of liquid bromine is a standard test for alkenes.

- (a) (i) Complete the equation for the reaction of cyclohexene with liquid bromine, using a skeletal formula.

(1)



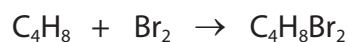
- (ii) What colour change would you see when this reaction occurs?

(1)

From to

- (b) Gaseous but-1-ene is another alkene that readily reacts with liquid bromine.

Using molecular formulae, the equation for the reaction is



- (i) Using the bond enthalpy values in the table, calculate the enthalpy change for this reaction.

(2)

Bond	Bond enthalpy /kJ mol ⁻¹
C—H	413
C—C	347
C=C	612
C—Br	290
Br—Br	193



- (ii) Give **one** reason why the value calculated for the reaction in part (b)(i) using bond enthalpies is different from the true value.
Do **not** consider experimental error, mean bond enthalpy values or non-standard conditions.

(1)

- (iii) Using appropriate curly arrows, write the mechanism of the reaction between but-1-ene and bromine.

(3)

- (iv) Identify, by name or by displayed formula, the product formed when bromine **water** is added to but-1-ene.

(1)

(Total for Question 18 = 9 marks)

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

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P 5 1 5 0 6 A 0 2 3 2 4

The Periodic Table of Elements

1	2	3	4	5	6	7	0 (8)
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
(18)	(17)	(16)	(15)	(14)	(13)	(12)	(11)
4.0 He helium 2	20.2 Ne neon 10	16.0 O oxygen 8	14.0 N nitrogen 7	12.0 C carbon 6	10.8 B boron 5	65.4 Zn zinc 30	63.5 Cu copper 29
19.0 F fluorine 9	35.5 Cl chlorine 17	32.1 S sulfur 16	31.0 P phosphorus 15	28.1 Si silicon 14	27.0 Al aluminium 13	79.9 Br bromine 35	79.9 Se selenium 34
126.9 I iodine 53	127.6 Te tellurium 52	121.8 Sb antimony 51	118.7 Sn tin 50	114.8 In indium 49	112.4 Cd cadmium 48	107.9 Ag silver 47	106.4 Pd palladium 46
[222] Rn radon 86	[210] At astatine 85	[209] Po polonium 84	209.0 Bi bismuth 83	207.2 Pb lead 82	204.4 Tl thallium 81	197.0 Au gold 79	195.1 Pt platinum 78
Elements with atomic numbers 112-116 have been reported but not fully authenticated							
[272] Rg roentgenium 111	[271] Ds darmstadtium 110	[268] Mt meitnerium 109	[277] Hs hassium 108	[264] Bh bohrium 107	[266] Sg seaborgium 106	[261] Rf rutherfordium 104	[227] Ac* actinium 89
159 Tb terbium 65	157 Gd gadolinium 64	152 Eu europium 63	150 Sm samarium 62	[147] Pm promethium 61	144 Nd neodymium 60	140 Ce cerium 58	138.9 Ba barium 56
169 Tm thulium 69	173 Yb ytterbium 70	163 Dy dysprosium 66	165 Ho holmium 67	167 Er erbium 68	170 Lu lutetium 71	137.3 Ba barium 56	137.3 Ba barium 56
[257] Lr lawrencium 103	[254] No nobelium 102	[256] Md mendelevium 101	[253] Fm fermium 100	[255] Mn mendelevium 101	[254] Es einsteinium 99	90 Th thorium 90	88 Ra radium 88
[251] Cf californium 98	[245] Bk berkelium 97	[243] Am americium 95	[242] Pu plutonium 94	[237] Np neptunium 93	92 U uranium 92	91 Pa protactinium 91	91 Pa protactinium 91
[257] Lr lawrencium 103	[254] No nobelium 102	[256] Md mendelevium 101	[253] Fm fermium 100	[255] Mn mendelevium 101	[254] Es einsteinium 99	90 Th thorium 90	88 Ra radium 88

1.0
H
hydrogen
1

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

* Lanthanide series
* Actinide series



P 5 1 5 0 6 A 0 2 4 2 4

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