Write your name here

Surname	Other names

Pearson Edexcel
International
Advanced Level

Centre Number | | | | | |

Candidate Number | | | | |

Chemistry

Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Thursday 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 ▶

P51506A

4/6/6/5/

P 5 1 5 0 6 A 0 1 2 4

PEARSON

SECTION A

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

1 Mohr's salt, $(NH_4)_2Fe(SO_4)_2.6H_2O$, is a blue-green crystalline solid usually made by dissolving equimolar amounts of iron(II) sulfate and ammonium sulfate in dilute sulfuric acid and then crystallising.

The reaction may be represented by the equation

	$FeSO_4.7H_2O$	+	$(NH_4)_2SO_4$	→	$(NH_4)_2Fe(SO_4)_2.6H_2O$	+	H_2O
Molar masses /g mol^{-1}	278		132		392		18

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

(1)

☒ **A** 2.22 g

☒ **B** 2.78 g

☒ **C** 3.14 g

☒ **D** 3.92 g

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

[Avogadro constant, $L = 6.0 \times 10^{23}$ 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)

2 Magnesium carbonate reacts with hydrochloric acid.

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

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

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

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

(1)

☒ **A** 0.843 g

☒ **B** 8.43 g

☒ **C** 84.3 g

☒ **D** 843 g

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

(1)

☒ **A** 0.423 g

☒ **B** 0.527 g

☒ **C** 1.05 g

☒ **D** 2.11 g

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

(1)

☒ **A** A colourless solution

☒ **B** A coloured solution

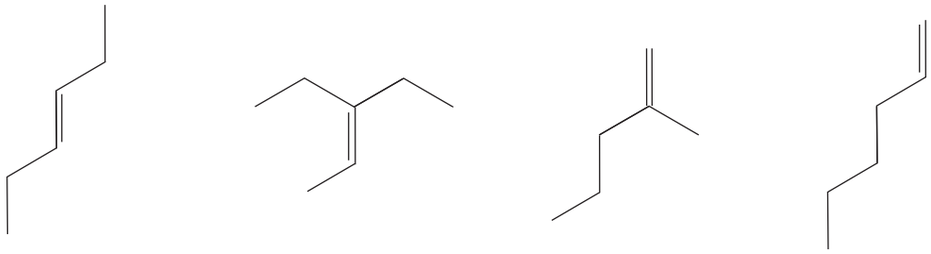
☒ **C** A white precipitate

☒ **D** A coloured precipitate

(Total for Question 2 = 3 marks)

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

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

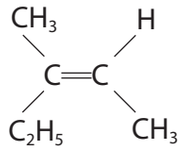
☒ **C** R

☒ **D** S

(Total for Question 3 = 3 marks)

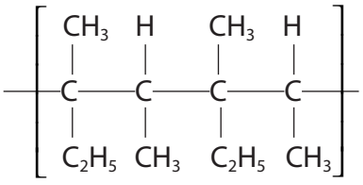
Use this space for any rough working. Anything you write in this space will gain no credit.

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

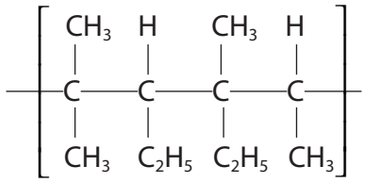


Which of the following shows **two** repeat units of the polymer made from *Z*-3-methylpent-2-ene?

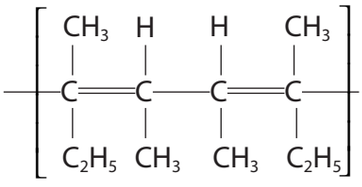
☒ **A**



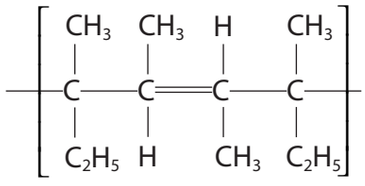
☒ **B**



☒ **C**

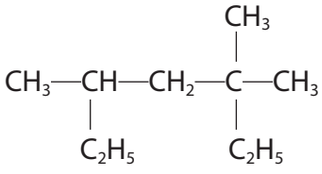


☒ **D**



(Total for Question 4 = 1 mark)

5 What is the systematic name for the following molecule?



☒ **A** 2,4-diethyl-2-methylpentane

☒ **B** 2,4-diethyl-4-methylpentane

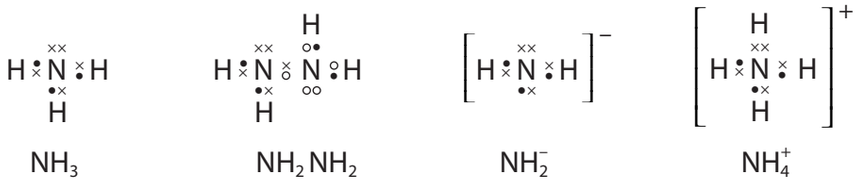
☒ **C** 3,3,5-trimethylheptane

☒ **D** 3,5,5-trimethylheptane

(Total for Question 5 = 1 mark)

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

6 Nitrogen can form the following species with hydrogen:



NH_3 NH_2NH_2 NH_2^- NH_4^+

Which of these species has a dative covalent bond?

- ☒ **A** NH_3
- ☒ **B** NH_2NH_2
- ☒ **C** NH_2^-
- ☒ **D** NH_4^+

(Total for Question 6 = 1 mark)

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

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

(Total for Question 7 = 1 mark)

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

What 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

	$C_{15}H_{32}$	$\rightarrow$	$2C_2H_4$	+	C_3H_6	+	C_8H_{18}
	pentadecane		ethene		propene		octane
Molar masses / g mol^{-1}			28		42		114

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

Use the expression

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

(1)

☒ **A** 26%

☒ **B** 33%

☒ **C** 38%

☒ **D** 46%

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

(1)

☒ **A** fractional distillation is too slow and expensive.

☒ **B** crude oil contains insufficient quantities of desired compounds.

☒ **C** reforming requires a catalyst.

☒ **D** cracking separates crude oil components.

(Total for Question 9 = 2 marks)

10 Scientists are developing alternatives to fossil fuels.

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

☒ **A** The increase in global warming.

☒ **B** The melting of the ice caps.

☒ **C** The increase in pH of the oceans.

☒ **D** The rise in sea level.

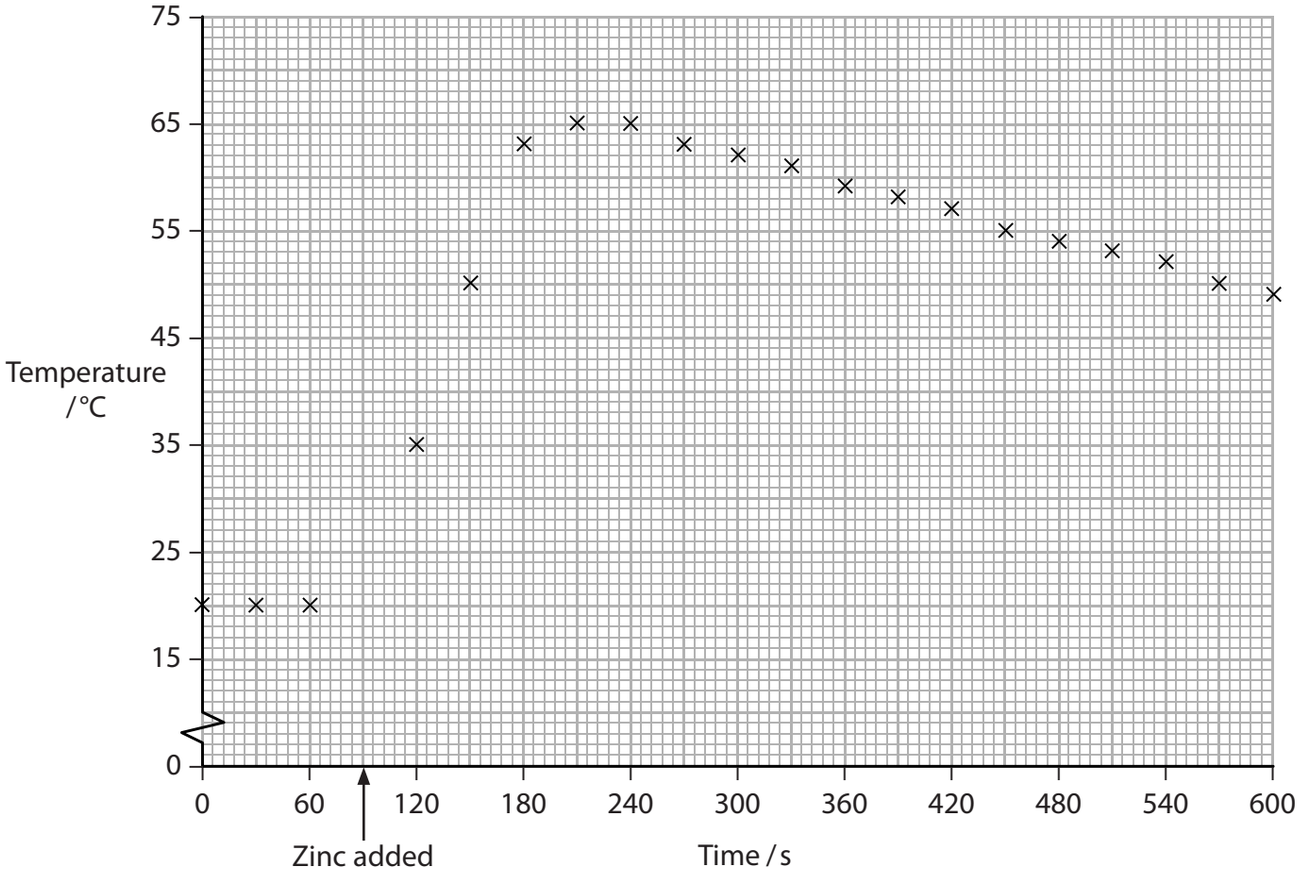
(Total for Question 10 = 1 mark)

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.

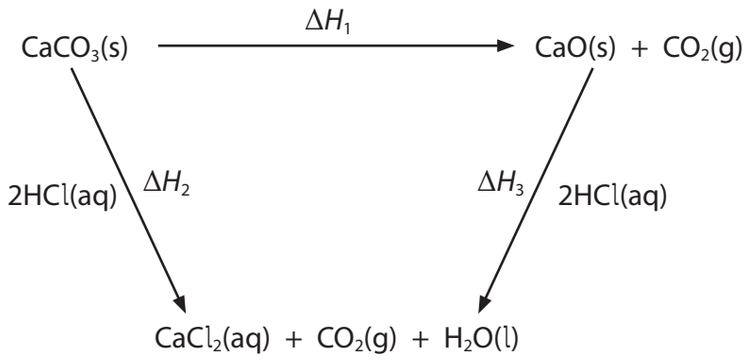


What temperature change should be used when calculating the energy transfer?

- ☒ **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

.....

.....

(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)

.....

.....

.....

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

(1)

.....

.....

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

(1)

.....

.....

*(iii) The reaction of ethene with aqueous potassium manganate(VII), $KMnO_4$, produces ethane-1,2-diol, CH_2OHCH_2OH.

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

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

(2)

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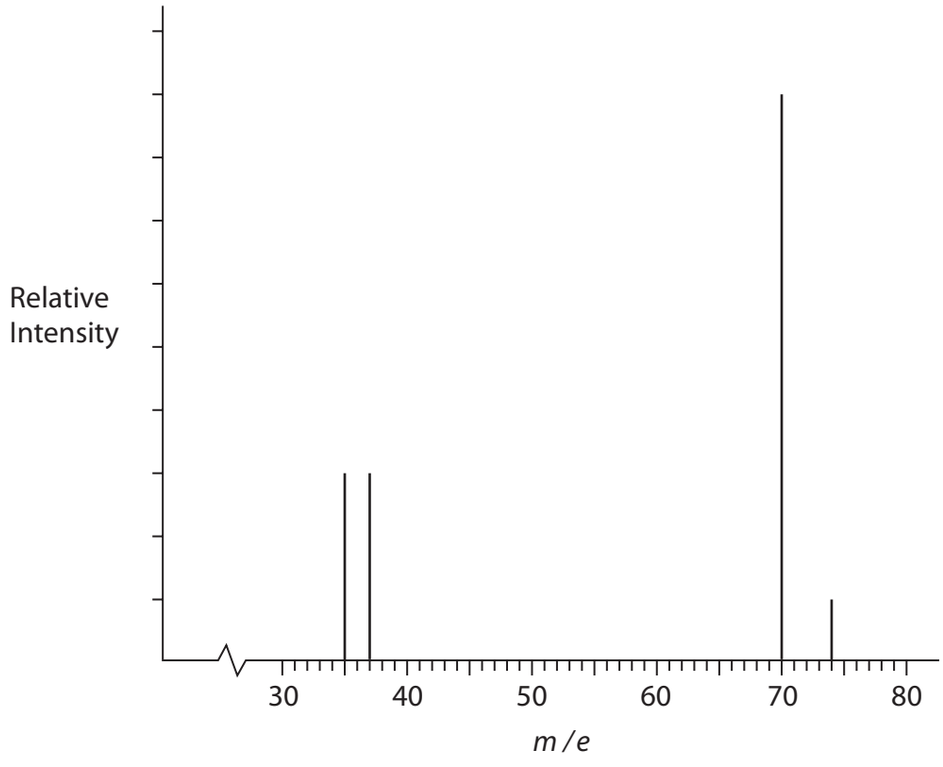
(c) A student sketched the mass spectrum of chlorine gas which contained 75% of the ^{35}Cl isotope and 25% of the ^{37}Cl isotope.



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

(2)

Error 1 .....

Correction 1 .....

Error 2 .....

Correction 2 .....

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

(1)

.....

(Total for Question 14 = 12 marks)

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

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

(1)

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

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

(4)

Name:	Name: .....

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

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

(1)

.....

.....

.....

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

(1)

.....

.....

.....

(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)

16 This is a question about ionisation energies.

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

(3)

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

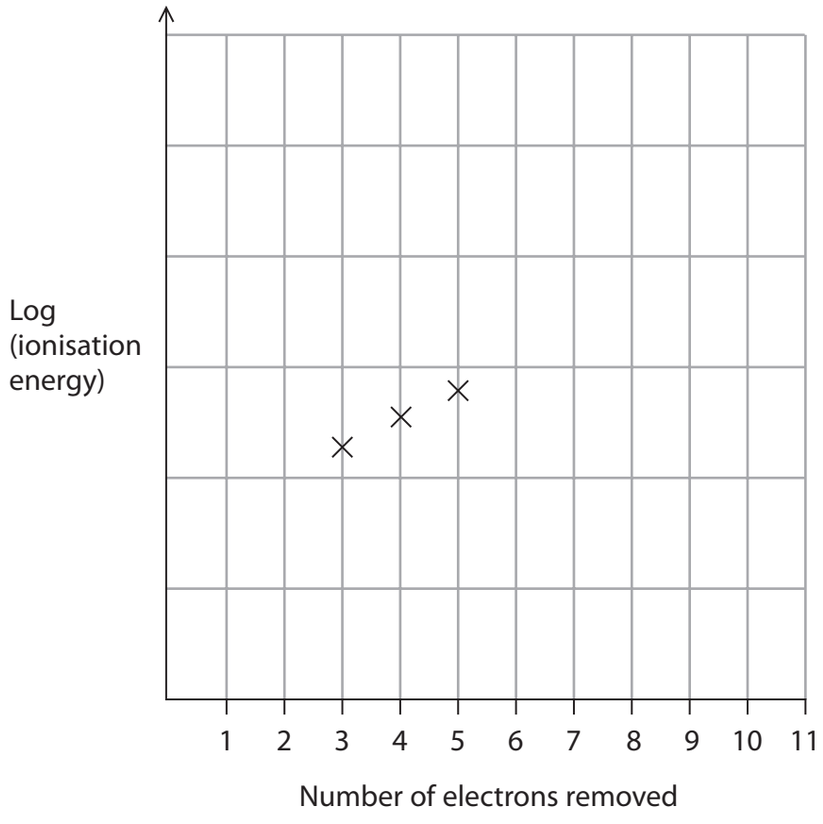
(1)

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

(1)

(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)

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

(2)

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

(3)

Ionisation Energy Value: .....

Justification .....

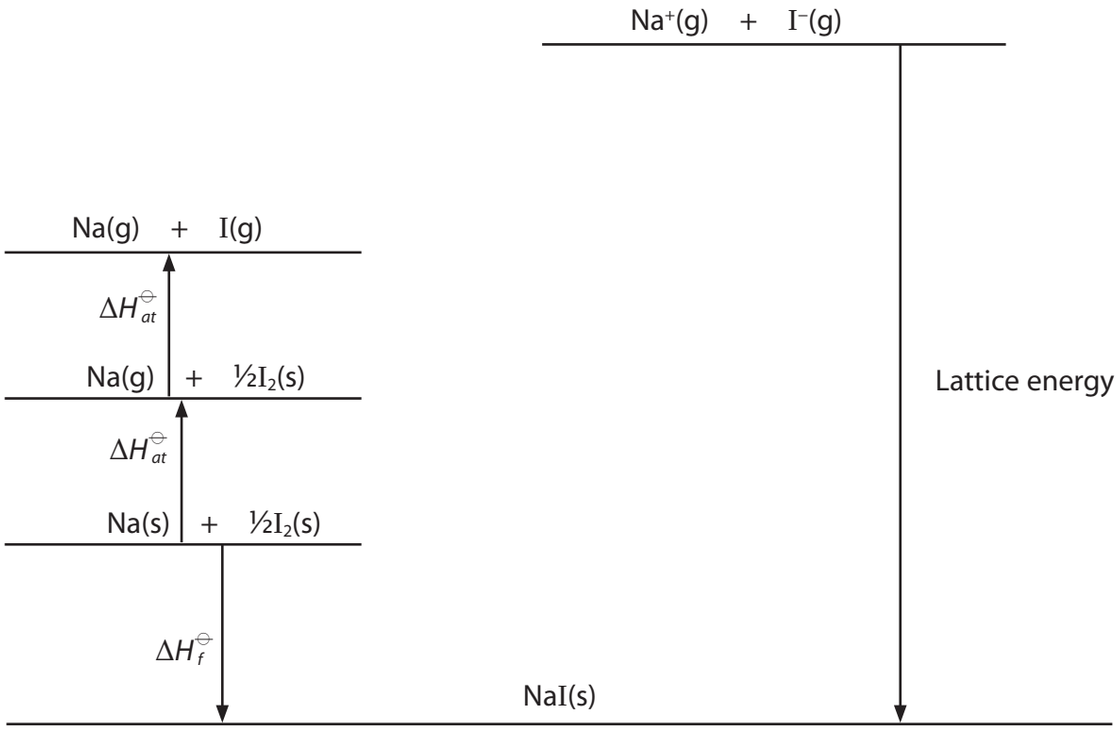
(Total for Question 16 = 17 marks)

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

Energy change	ΔH / kJ mol^{-1}
Enthalpy change of atomisation of iodine	+107
Enthalpy change of atomisation of sodium	+107
First ionisation energy of sodium	+496
First electron affinity of iodine	−295
Enthalpy change of formation of sodium iodide	−288

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

(3)



(b) Calculate the lattice energy for sodium iodide.

Give a sign and units in your answer.

(1)

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

(3)

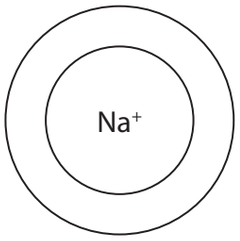
(d) The numerical value for the lattice energy of sodium iodide obtained from the Born-Haber cycle is more negative than the theoretical value.

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

(2)

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

(1)

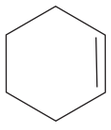


(Total for Question 17 = 10 marks)

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)



$+ Br_2 \rightarrow$

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

(1)

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

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

Using molecular formulae, the equation for the reaction is

$$C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$$

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

(2)

Bond	Bond enthalpy /kJ mol^{-1}
C—H	413
C—C	347
C═C	612
C—Br	290
Br—Br	193

(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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The Periodic Table of Elements

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

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

* Lanthanide series

* Actinide series

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