Paper Reference(s)   **WCH01/01**

Pearson Edexcel
International Advanced Level

Chemistry
Advanced Subsidiary
Unit 1: The Core Principles of Chemistry

Friday 26 May 2017 – Morning

Time: 1 hour 30 minutes plus your additional time allowance

INSTRUCTIONS TO CANDIDATES
Write your centre number, candidate number, surname, other names and your signature in the boxes below. Check that you have the correct question paper.

Centre No.					
Candidate No.					

Surname	
Other names	
Signature	

Paper Reference	W	C	H	0	1	/	0	1

Pearson

- **Use BLACK ink or BLACK ball-point pen.**
- **Answer ALL questions.**
- **Answer the questions in the spaces provided – there may be more space than you need.**

MATERIALS REQUIRED FOR EXAMINATION
Nil

ITEMS INCLUDED WITH QUESTION PAPERS
Periodic Table

INFORMATION FOR CANDIDATES
- **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.**
- **Candidates may use a calculator.**
- **A Periodic Table is provided.**

ADVICE TO CANDIDATES
- **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.**

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   Sea water contains 2·7 mg of sulfate ions per kilogram.

What is the concentration of sulfate ions in parts per million by mass?

☐ A $2·7 \times 10^{-6}$

☐ B $2·7 \times 10^{-3}$

☐ C $2·7$

☐ D $2·7 \times 10^{3}$

(TOTAL FOR QUESTION 1 = 1 MARK)

(Questions continue on next page)

2   How many IONS are in 284 g of sodium sulfate, Na_2SO_4?

Avogadro constant = $6 \cdot 0 \times 10^{23} \, mol^{-1}$

Molar mass of sodium sulfate = $142 \, g \, mol^{-1}$

☐ A $1 \cdot 2 \times 10^{24}$

☐ B $2 \cdot 4 \times 10^{24}$

☐ C $3 \cdot 6 \times 10^{24}$

☐ D $8 \cdot 4 \times 10^{24}$

(TOTAL FOR QUESTION 2 = 1 MARK)

3   Calculate the empirical formula of the compound with the percentage composition by mass: Li = $17 \cdot 9\%$; P = $26 \cdot 8\%$; O = $55 \cdot 3\%$

Molar masses / $g \, mol^{-1}$ Li = $6 \cdot 9$, P = $31 \cdot 0$, O = $16 \cdot 0$

☐ A $Li_2P_3O_6$

☐ B Li_3PO_3

☐ C $LiPO_3$

☐ D Li_3PO_4

(TOTAL FOR QUESTION 3 = 1 MARK)

(Questions continue on next page)

4 **What is the empirical formula of the oxide formed when 2·6 g of chromium produces 3·8 g of chromium oxide?**

Molar masses / g mol^{-1} Cr = 52·0, O = 16·0

☐ **A   CrO**

☐ **B CrO_2**

☐ **C Cr_2O_3**

☐ **D Cr_3O_4**

(TOTAL FOR QUESTION 4 = 1 MARK)

(Questions continue on next page)

5   **Consider the reaction**

$$2SO_2(g) + O_2(g) \longrightarrow 2SO_3(g)$$

What is the maximum volume, in dm^3, of sulfur trioxide that could be obtained when $0.5\,dm^3$ of sulfur dioxide is mixed with $1\,dm^3$ of oxygen, under suitable conditions?

All measurements are made at the same temperature and pressure.

☐ **A   0·5**

☐ **B   1·5**

☐ **C   2·0**

☐ **D   2·5**

(TOTAL FOR QUESTION 5 = 1 MARK)

(Questions continue on next page)

6 **Identify the atom with two unpaired electrons in its lowest energy state (ground state).**

☐ **A** **Be**

☐ **B** **C**

☐ **C** **Cl**

☐ **D** **Ca**

(TOTAL FOR QUESTION 6 = 1 MARK)

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7 **Which ion has the LARGEST ionic radius?**

☐ **A** Ca^{2+}

☐ **B** Cl^{-}

☐ **C** K^{+}

☐ **D** S^{2-}

(TOTAL FOR QUESTION 7 = 1 MARK)

(Questions continue on next page)

8   The compound with the greatest covalent character is

☐ A   NaF

☐ B   NaI

☐ C   AlF$_3$

☐ D   AlI$_3$

(TOTAL FOR QUESTION 8 = 1 MARK)

9   What is the sequence of the orbitals from which electrons are removed in the first four ionisations of boron?

	1st Ionisation	2nd Ionisation	3rd Ionisation	4th Ionisation
☐ A	1s	1s	2s	2s
☐ B	1s	2s	2s	2p
☐ C	2p	2s	2s	1s
☐ D	2p	2s	1s	1s

(TOTAL FOR QUESTION 9 = 1 MARK)

(Questions continue on next page)

10   Calcium chloride can be prepared by reacting calcium carbonate with dilute hydrochloric acid.

$$CaCO_3(s) + 2HCl(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$$

(a)   The ionic equation for the reaction is   (1 mark)

☐ A $Ca^{2+}(s) + 2Cl^-(aq) \longrightarrow CaCl_2(aq)$

☐ B $CaCO_3(s) + 2H^+(aq) \longrightarrow Ca^{2+}(aq) + H_2O(l) + CO_2(g)$

☐ C $CO_3^{2-}(s) + 2H^+(aq) \longrightarrow H_2O(l) + CO_2(g)$

☐ D $CaCO_3(s) + 2H^+(aq) + 2Cl^-(aq) \longrightarrow CaCl_2(aq) + H_2O(l) + CO_2(g)$

(Question continues on next page)

(b) An excess of calcium carbonate is used in the preparation. The sequence of processes needed to obtain crystals of calcium chloride from the reaction mixture is (1 mark)

☐ A   filtering, concentrating the solution, slowly evaporating.

☐ B   filtering, slowly evaporating, distilling.

☐ C   concentrating the solution, filtering, distilling.

☐ D   concentrating the solution, slowly evaporating, filtering.

(Question continues on next page)

(c) The excess calcium carbonate was added to $100\,cm^3$ of $2 \cdot 00\,mol\,dm^{-3}$ hydrochloric acid. The mass of calcium chloride crystals obtained was $10 \cdot 4$ g.

Molar mass of calcium chloride crystals, $CaCl_2.2H_2O = 147\,g\,mol^{-1}$.

The percentage yield, by mass, of calcium chloride crystals is (1 mark)

☐ A 71·2

☐ B 70·7

☐ C 35·4

☐ D 17·7

(TOTAL FOR QUESTION 10 = 3 MARKS)

11 Which of the following series shows the elements in order of increasing melting temperature?

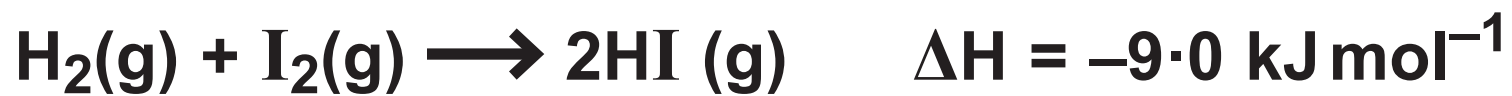☐ A Li, Na, K

☐ B Al, Si, P

☐ C Na, Mg, Al

☐ D S, Cl, Ar

(TOTAL FOR QUESTION 11 = 1 MARK)

(Questions continue on next page)

(Turn over)

12 **Consider the reaction**

$$H_2(g) + I_2(g) \longrightarrow 2HI\,(g) \qquad \Delta H = -9 \cdot 0\ kJ\,mol^{-1}$$

The bond energy of H—H = 436 kJ mol^{-1}

The bond energy of H—I = 298 kJ mol^{-1}

It can be deduced that the bond energy of I—I, in kJ mol^{-1}, is

☐ **A** **75·5**

☐ **B** **84·5**
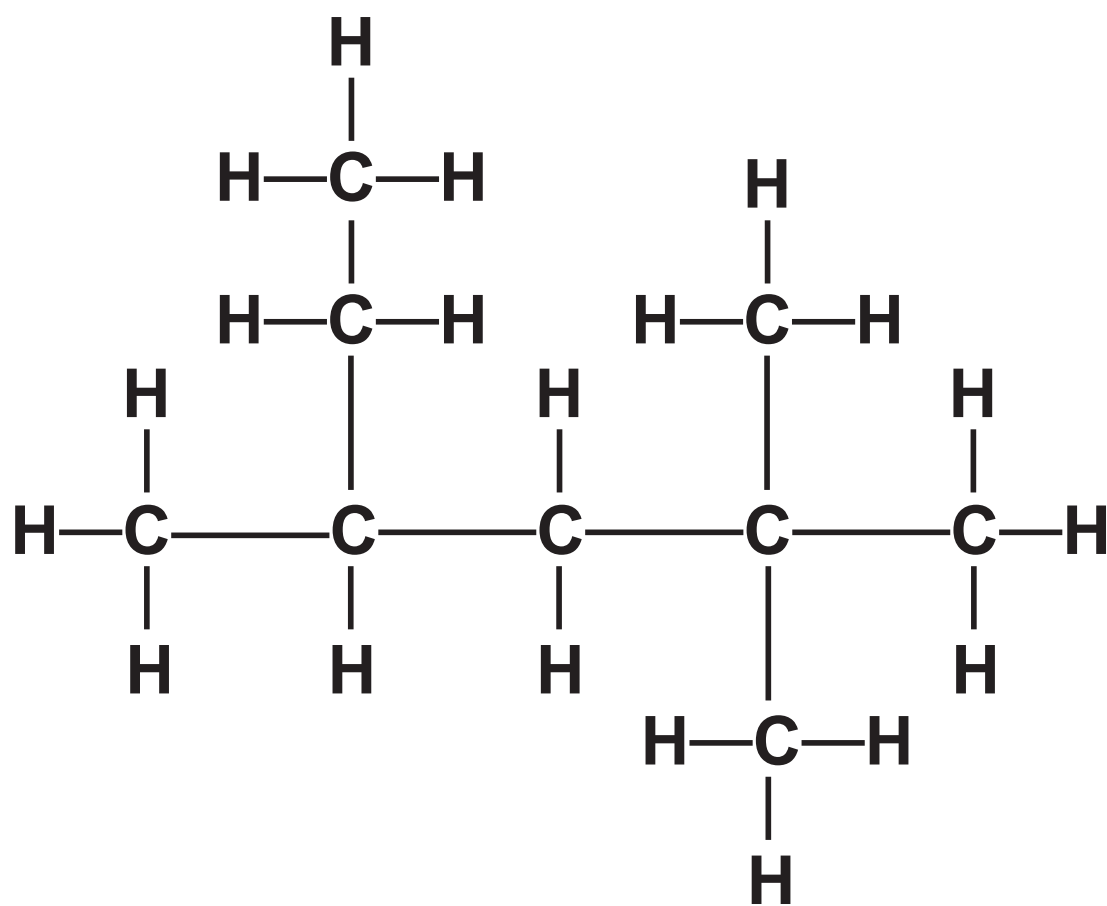
☐ **C** **151**

☐ **D** **169**

(TOTAL FOR QUESTION 12 = 1 MARK)

(Questions continue on next page)

13 **What is the systematic name for the hydrocarbon shown?**

☐ **A** **2,2-dimethyl-4-ethylpentane**

☐ **B** **2-ethyl-4,4-dimethylpentane**

☐ **C** **3,5,5-trimethylhexane**

☐ **D** **2,2,4-trimethylhexane**

(TOTAL FOR QUESTION 13 = 1 MARK)

(Questions continue on next page)
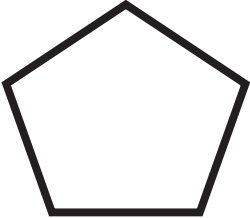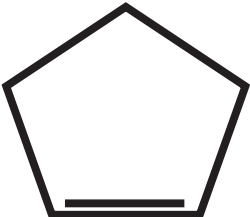
14 **Which compound has E-Z isomers?**

☐ **A** **but-1-ene**

☐ **B** **but-2-ene**

☐ **C** **1,1-dichloroethene**

☐ **D** **2-methylbut-2-ene**

(TOTAL FOR QUESTION 14 = 1 MARK)

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15 **Which compound has an empirical formula different from its molecular formula?**

☐ **A**

☐ **B**

☐ **C**

☐ **D**

(TOTAL FOR QUESTION 15 = 1 MARK)

(Questions continue on next page)

16 **Which reagent reacts with propene to form this compound?**

HO — CH₂ — CH(CH₃) with OH (structure shown: $HOCH_2CH(OH)CH_3$)

☐ **A** hydrogen peroxide solution

☐ **B** oxygen and water

☐ **C** aqueous sodium hydroxide

☐ **D** acidified potassium manganate(VII)

(TOTAL FOR QUESTION 16 = 1 MARK)

17 **Propene reacts with hydrogen bromide to form**

☐ **A** a mixture of 1-bromopropane and 2-bromopropane

☐ **B** 1,2-dibromopropane

☐ **C** 2-bromopropan-1-ol

☐ **D** 1-bromopropan-2-ol

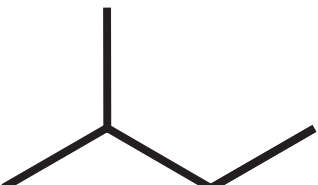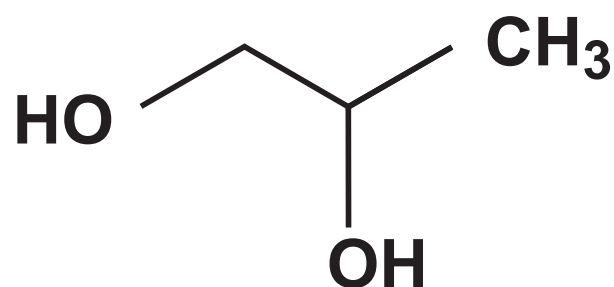**(TOTAL FOR QUESTION 17 = 1 MARK)**

(Questions continue on next page)

18   **Copolymers are formed from two different monomers.**

The repeat unit of a copolymer is

$$\overset{\displaystyle \overset{H}{|}\ \overset{H}{|}\ \overset{H}{|}\quad \overset{H}{|}}{-C-C-C-C-}\underset{\displaystyle \underset{H}{|}\ \underset{H}{|}\ \underset{CH_3}{|}\ \underset{H}{|}}{}$$
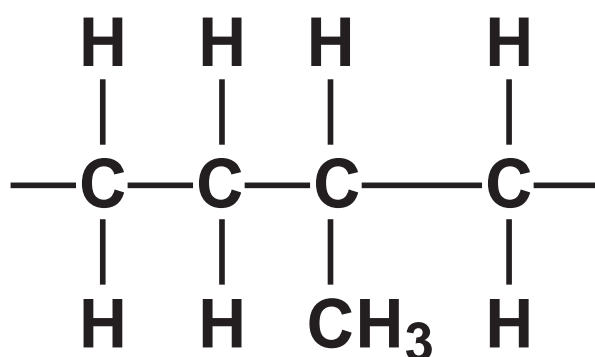
This copolymer is formed from ethene and

☐   **A   propane.**

☐   **B   propene.**

☐   **C   2-methylbutane.**

☐   **D   2-methylbut-1-ene.**

(TOTAL FOR QUESTION 18 = 1 MARK)

TOTAL FOR SECTION A = 20 MARKS

(Section B begins on next page)

(Turn over)

SECTION B

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

19 A sample of an element, X, was extracted from a meteorite.

The table gives the percentage abundance of the isotopes of X obtained from the mass spectrum of the sample.

m/e	% abundance
54	6·10
56	92·0
57	1·90

(a) (i) Calculate the relative atomic mass of the element in this sample.

Give your answer to THREE significant figures.
(2 marks)

(ii) **Identify X and hence give the numbers of subatomic particles present in the species at m/e = 56 in the mass spectrum. (2 marks)**

X _____

Number of particles present in the species at m/e = 56		
protons	electrons	neutrons

(iii) **A peak at m/e = 28 was also detected in the mass spectrum of X.**

Identify the species which produced this peak. (1 mark)

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(Question continues on next page)

(iv) **Explain why the three isotopes of X have the same chemical properties. (2 marks)**

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(b) (i) **Outline how a solid sample of element X is converted into ions in a mass spectrometer. (2 marks)**

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(Question continues on next page)

(ii) Following the formation of ions, there are three steps in the production of a spectrum in the mass spectrometer.

Name the three steps IN ORDER and state how the first two are carried out. (3 marks)

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(TOTAL FOR QUESTION 19 = 12 MARKS)

(Questions continue on next page)

(Turn over)

20 (a) The element sodium and the compound sodium bromide are both solid at room temperature.

(i) Name the type of bonding in sodium and explain how this bonding holds the structure together. (2 marks)

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(Question continues on next page)

(ii) **Name the type of bonding in sodium bromide and explain how this bonding holds the structure together. (1 mark)**

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(Question continues on next page)

(Turn over)

(iii) The table shows the melting temperatures of sodium and of sodium bromide.

Substance	Sodium	Sodium bromide
Melting temperature / K	371	1020

What can you deduce from these data about the bonding in the two substances? (1 mark)

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(Question continues on next page)

(iv) Name ONE physical property, other than melting or boiling temperature, in which sodium and sodium bromide differ due to the difference in their bonding.

Describe how this property differs for each of the two substances. (2 marks)

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(Question continues on next page)

(b) The ammonium ion, NH_4^+, contains covalent bonds and a dative covalent bond.

(i) Describe the difference between a covalent bond and a dative covalent bond. (2 marks)

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(Question continues on next page)

(ii) Draw a dot and cross diagram for an ammonium ion. Use the symbol **X** for electrons from the hydrogen atoms and ● for electrons from the outer shell of the nitrogen atom. (2 marks)

(iii) Suggest how an electron density map of ammonium chloride would provide evidence for the presence of ions in the compound. (1 mark)

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(TOTAL FOR QUESTION 20 = 11 MARKS)

21 (a) The table below shows some of the ionisation energies of magnesium.

	First	Second	Third	Fourth	Fifth
Ionisation energy / kJ mol^{-1}	738	1451		10 541	13 629

(i) Complete the table by predicting a value for the THIRD ionisation energy of magnesium. **(1 mark)**

(ii) Write the equation for the third ionisation of magnesium. Include state symbols. **(2 marks)**

(Question continues on next page)

(b) **A version of the Born-Haber cycle for magnesium chloride is shown below.**

$$Mg^{2+}(g) + 2Cl(g)$$

ΔH_2

ΔH_3

$$Mg^{2+}(g) + 2Cl^-(g)$$

$$Mg(g) + 2Cl(g)$$

ΔH_1

ΔH_4

$$Mg(s) + Cl_2(g)$$

ΔH_5

$$MgCl_2(s)$$
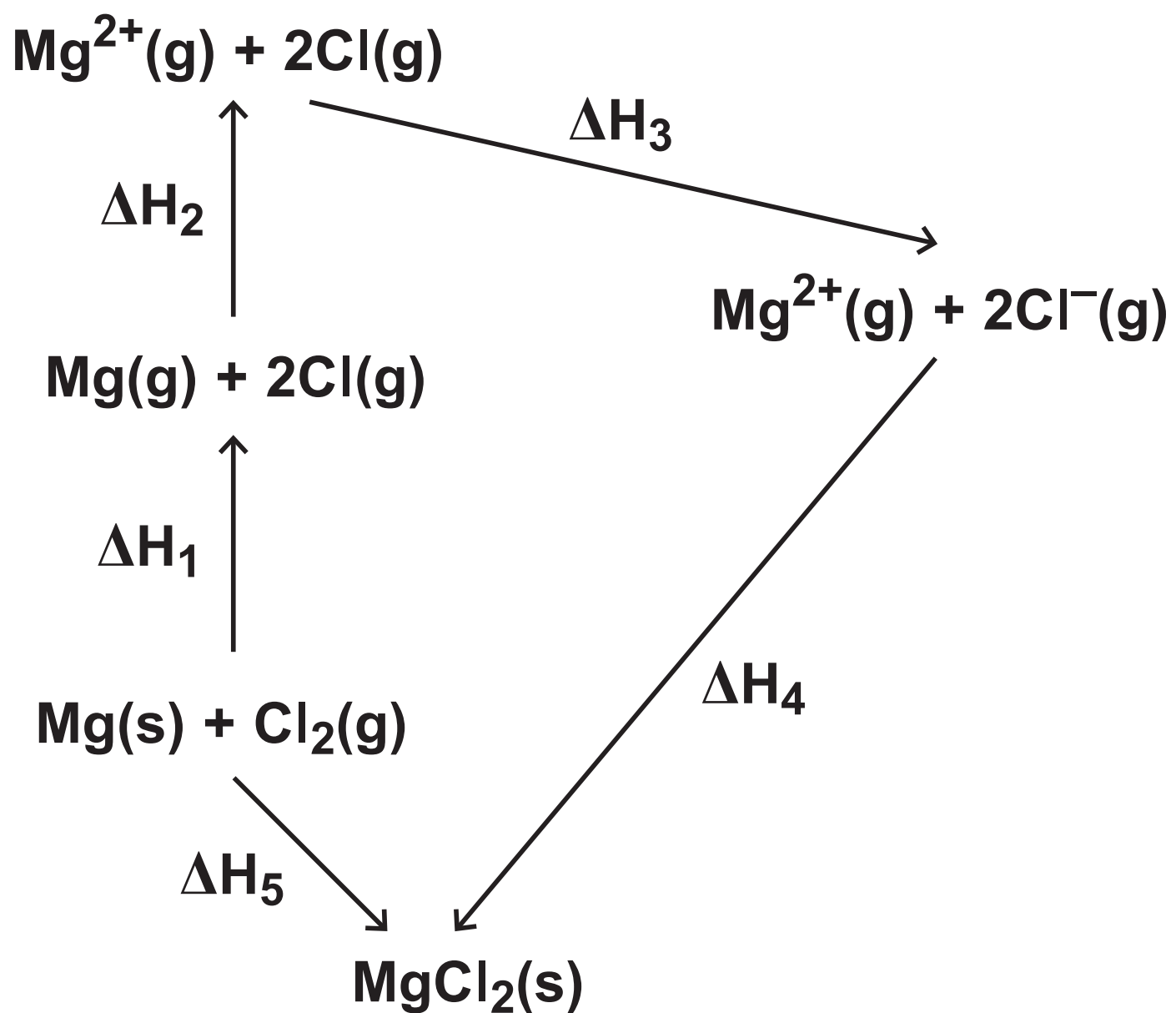
(Question continues on next page)

(i)   Identify the enthalpy changes from the Born-Haber cycle by completing the table.

ΔH_1 is the sum of TWO enthalpy changes and you should give both. (3 marks)

Enthalpy change	Identity of enthalpy change
ΔH_1	
ΔH_3	
ΔH_5	

(ii) Use the data in (a) to calculate the value of ΔH_2. (1 mark)

$\Delta H_2 =$

(Question continues on next page)

(Turn over)

(iii) Use your answer to (ii) and the following data to calculate the lattice energy of magnesium chloride, ΔH_4. (2 marks)

Enthalpy change	Value of enthalpy change / $kJ\,mol^{-1}$
ΔH_1	+391·1
ΔH_3	−697·6
ΔH_5	−641·3

(Question continues on next page)

(Turn over)

(c) A similar Born-Haber cycle can be drawn for calcium chloride.

*(i) In the calcium chloride cycle, the corresponding value for ΔH_2 is less positive. Explain why this is so. (2 marks)

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(Question continues on next page)

*(ii) Explain why the value for the lattice energy, ΔH_4, is less negative for calcium chloride than for magnesium chloride. (2 marks)

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(TOTAL FOR QUESTION 21 = 13 MARKS)

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(Questions continue on next page)

22 **Sodium hydrogencarbonate decomposes on heating to form sodium carbonate, carbon dioxide and water.**

REACTION 1

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

(a) **Suggest why it is difficult to measure the enthalpy change of this reaction directly. (1 mark)**

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(Question continues on next page)

(Turn over)

(b) The enthalpy change can be measured indirectly using the enthalpy changes for the following two reactions and applying Hess's Law.

REACTION 2

$NaHCO_3(s) + HCl(aq) \longrightarrow NaCl(aq) + H_2O(l) + CO_2(g)$

REACTION 3

$Na_2CO_3(s) + 2HCl(aq) \longrightarrow 2NaCl(aq) + H_2O(l) + CO_2(g)$.

An experiment was carried out to measure the enthalpy change of REACTION 2.

$100\,cm^3$ of $1{\cdot}25\,mol\,dm^{-3}$ hydrochloric acid was placed in a polystyrene beaker with capacity $200\,cm^3$. The initial temperature of the acid was $21{\cdot}5\,^{\circ}C$.

$8{\cdot}00\,g$ of solid sodium hydrogencarbonate was added, a lid was placed on the beaker and the mixture was stirred. The lowest temperature of the mixture was $14{\cdot}2\,^{\circ}C$.

(i) Explain why the beaker used in this experiment is large. (1 mark)

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(Question continues on next page)

(Turn over)

(ii) **Show by calculation that the hydrochloric acid is present in excess. (2 marks)**

(Question continues on next page)

(iii) Calculate the energy transferred and hence the enthalpy change of the reaction in $kJ\,mol^{-1}$.

Include a sign and units in your answer.

Use the equation:
Energy transferred (J) = 100 ✕ 4·18 ✕ temperature change. (3 marks)

(Question continues on next page)

(iv) **The enthalpy change for REACTION 3 was found to be –36·3 kJ mol^{-1}.**

Complete the Hess cycle by adding the appropriate arrows and formulae to the outline.

Use your completed cycle to calculate the enthalpy change for REACTION 1. (4 marks)

2NaHCO$_3$(s)	$\xrightarrow{\text{Reaction 1}}$	Na$_2$CO$_3$(s) + H$_2$O(l) + CO$_2$(g)

ΔH for REACTION 1 = _____ kJ mol^{-1}

(TOTAL FOR QUESTION 22 = 11 MARKS)

(Questions continue on next page)

(Turn over)

23 **(a)** **Ethane reacts with chlorine in the presence of ultraviolet light forming chloroethane, C_2H_5Cl and other products.**

(i) **Ultraviolet light causes HOMOLYTIC FISSION of chlorine molecules.**

Draw a dot and cross diagram of a chlorine molecule and use it to explain what happens to the molecule when homolytic fission occurs, naming the species produced.
(2 marks)

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(Question continues on next page)

(ii) **Write the equations for the TWO propagation steps which occur in the reaction producing chloroethane. (2 marks)**

Equation 1:

Equation 2:

(iii) **Write the equation for the termination step which produces a hydrocarbon as a product in this reaction. (1 mark)**

(Question continues on next page)

(Turn over)

(b) Ethene also reacts with chlorine but by a different mechanism.

*(i) Describe how the π bond in ethene forms and explain why this bond causes ethene to take part in addition reactions with halogens. (2 marks)

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(Question continues on next page)

*(ii) Write the mechanism for the reaction of ethene with chlorine.

Use curly arrows to show movements of electron pairs. (3 marks)

(iii) Name the product of the reaction of chlorine with ethene. (1 mark)

(c) The halogenoalkene,1-chloroethene, is used to make a widely used polymer, poly(chloroethene), commonly known as PVC.

Write a balanced equation for the polymerisation of 1-chloroethene to PVC.

Use displayed formulae to show the bonds in both the monomer and the polymer. (2 marks)

(TOTAL FOR QUESTION 23 = 13 MARKS)

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