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 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

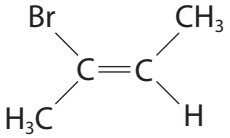
PEARSON

SECTION A

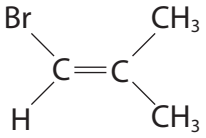
Answer ALL the questions in this section. You should aim to spend no more than 20 minutes on this section. For each question, select one answer from A to D and put a cross in the box ☒. If you change your mind, put a line through the box ☒ and then mark your new answer with a cross ☒.

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

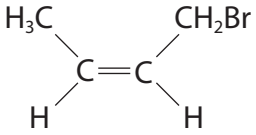
☒ **A**



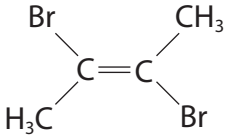
☒ **B**



☒ **C**

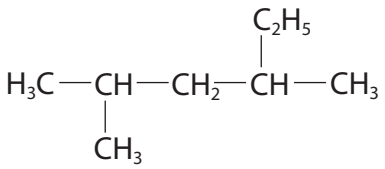


☒ **D**



(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)

3 Which of the following molecules is formed on adding bromine **water** to ethene?

☒ **A** ethanol

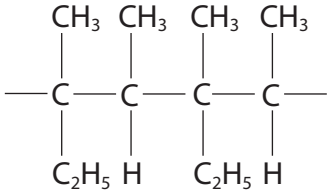
☒ **B** ethane-1,2-diol

☒ **C** bromoethane

☒ **D** 2-bromoethanol

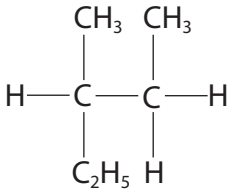
(Total for Question 3 = 1 mark)

4 A section of a polymer is shown below.

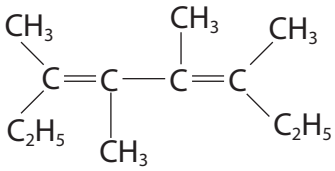


What is the monomer for this polymer?

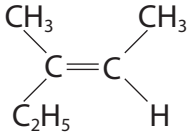
☒ **A**



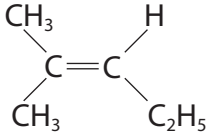
☒ **B**



☒ **C**



☒ **D**



(Total for Question 4 = 1 mark)

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)** → $MgCl_2$**(s)** + H_2O**(l)**

☒ **B** MgO**(s)** + $2HCl$**(aq)** → $MgCl_2$**(aq)** + H_2O**(l)**

☒ **C** MgO**(s)** + $2HCl$**(l)** → $MgCl_2$**(s)** + H_2O**(l)**

☒ **D** MgO**(s)** + $2HCl$**(l)** → $MgCl_2$**(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)

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)

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)

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

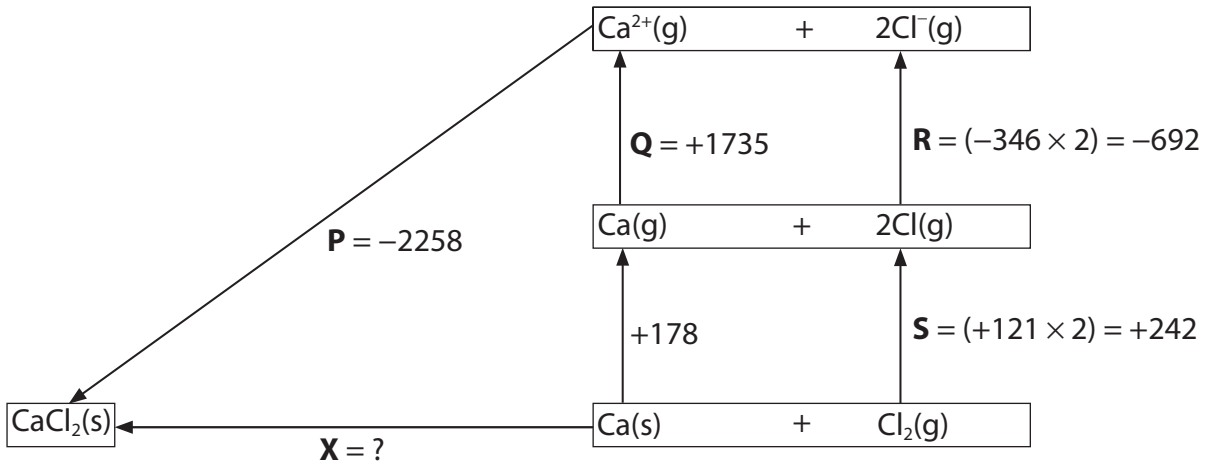
☒ **B** MgO

☒ **C** K_2O

☒ **D** CaO

(Total for Question 13 = 1 mark)

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)

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

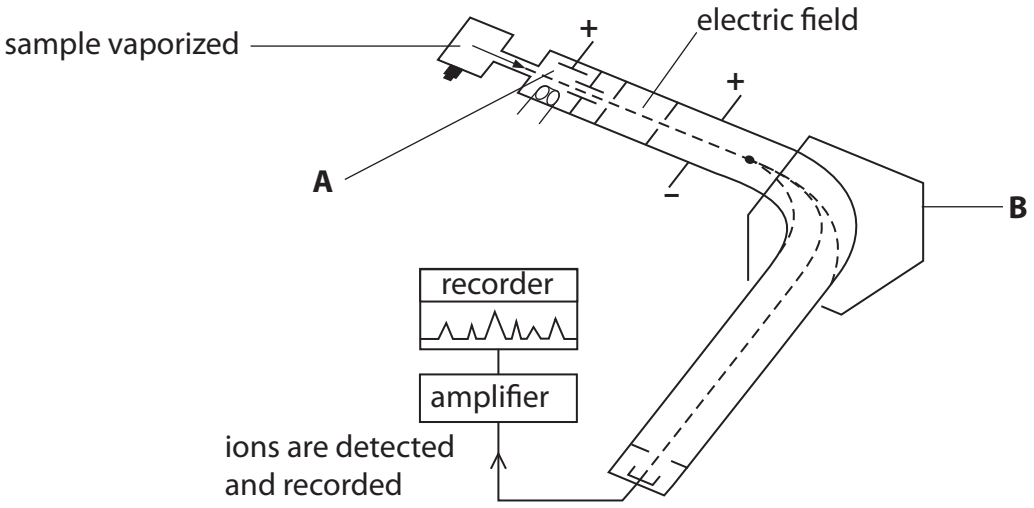
Answer ALL the questions. Write your answers in the spaces provided.

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)

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

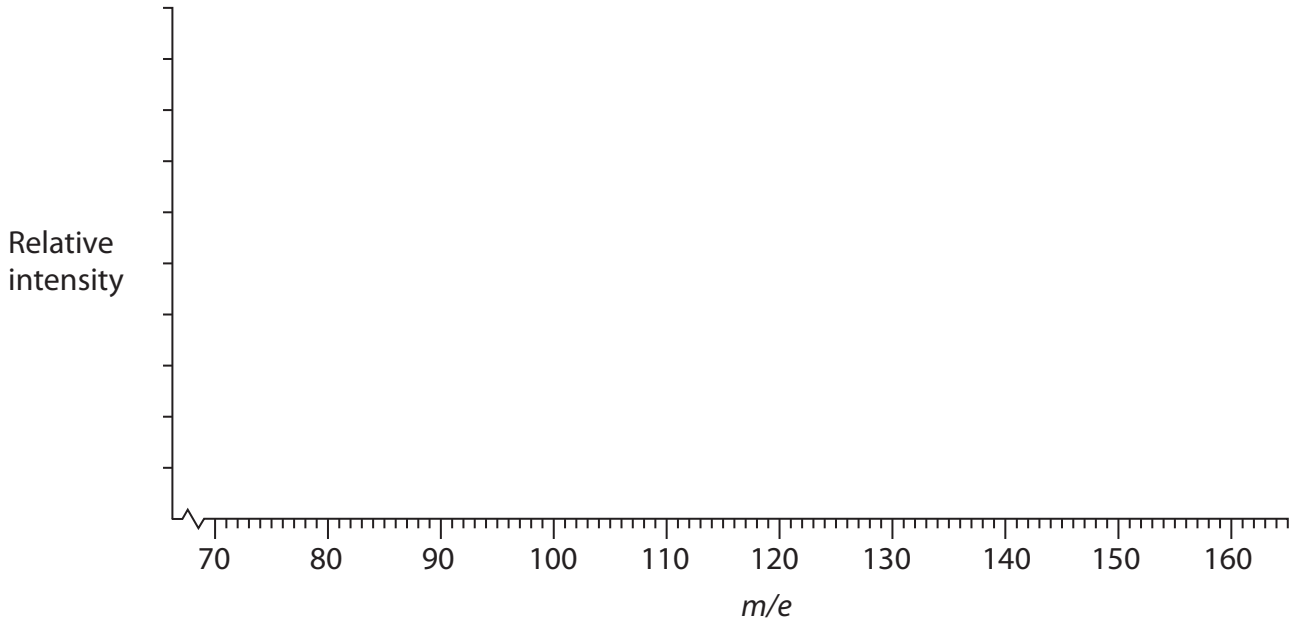
(1)

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

(1)

(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)

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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)

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(Total for Question 17 = 16 marks)

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.

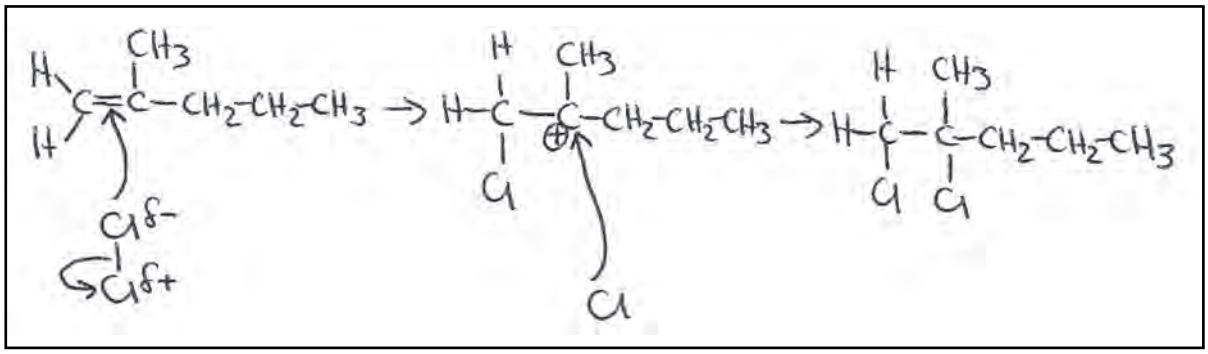
Name the product.

(3)

$+ \quad Br_2 \quad \rightarrow$

Name: .....

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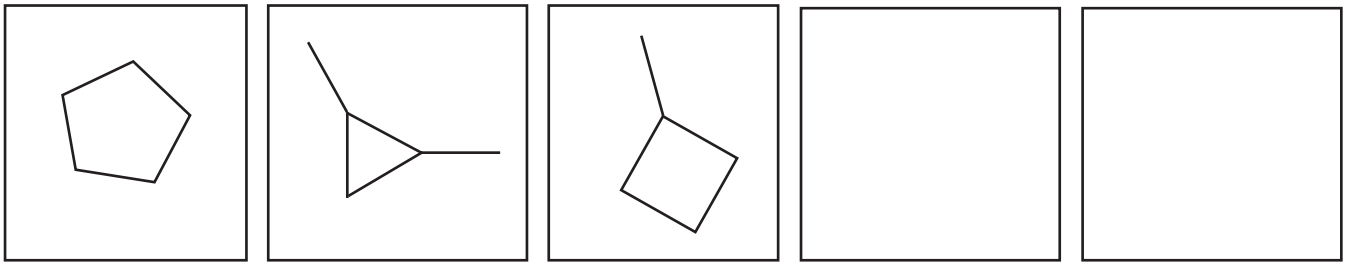
(d) There are five possible cycloalkanes, each containing five carbon atoms. Three of the isomers are given below. Complete the other two boxes, by adding the skeletal formulae of the other two structural isomers.

(2)



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

(1)

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(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 →

(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)

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(Total for Question 18 = 20 marks)

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)

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(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)

(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)

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)

(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)

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

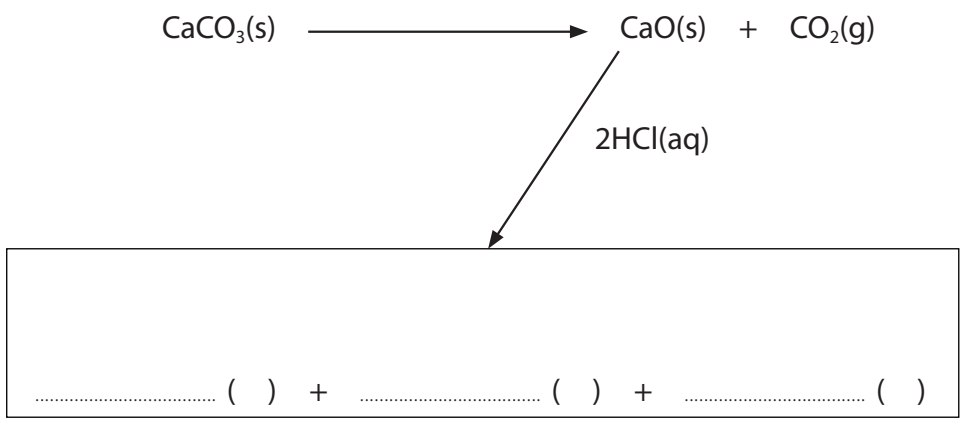
$$\Delta H^{\ominus} = -18.8 \text{ kJ mol}^{-1}$$

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)

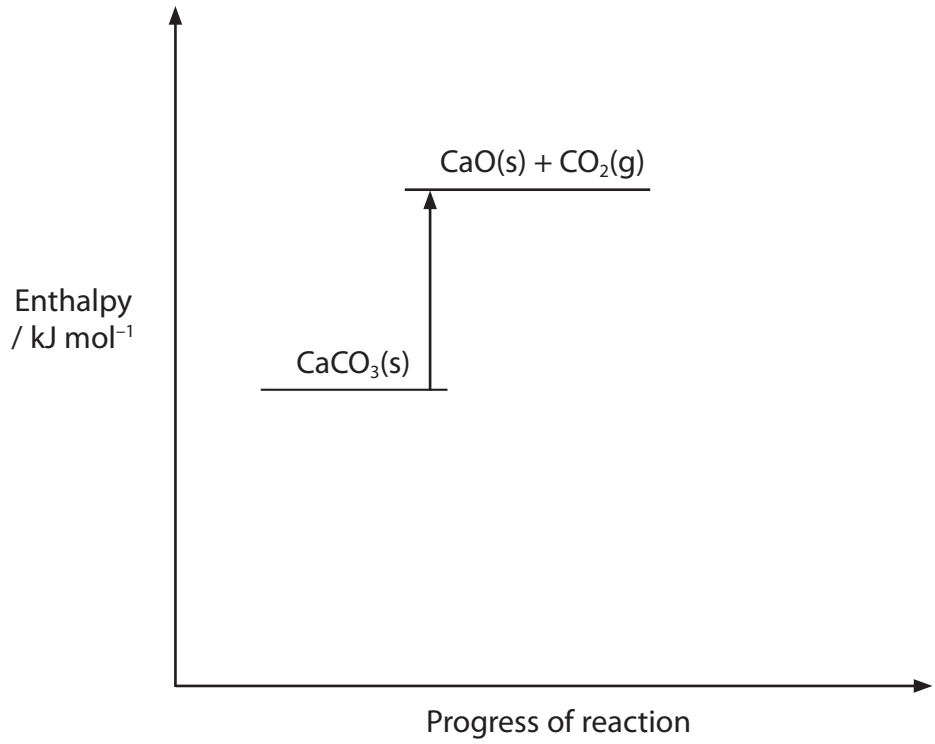


Enthalpy change = ... kJ mol^{-1}

(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

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