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Advanced Level									
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<h1>Chemistry</h1> <h2>Advanced Subsidiary</h2> <h3>Unit 1: The Core Principles of Chemistry</h3>									
Wednesday 10 January 2018 – Morning							Paper Reference		
Time: 1 hour 30 minutes							WCH01/01		
Candidates must have: Scientific calculator								Total Marks	
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Instructions

- Use **black** ink or **black** 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.
- Try to answer every question.
- Check your answers if you have time at the end.
- Show all your working in calculations and include units where appropriate.

Turn over ►

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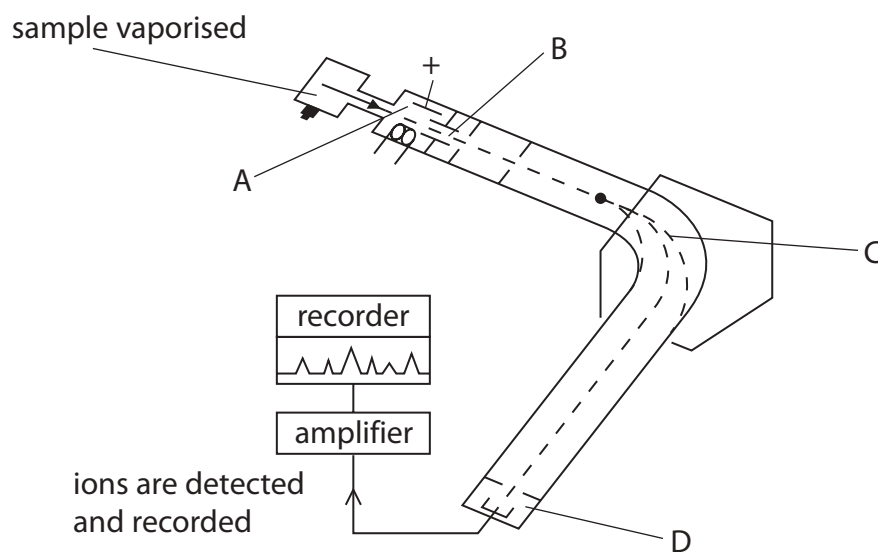



Pearson

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 . If you change your mind, put a line through the box and then mark your new answer with a cross .

1 The diagram shows a mass spectrometer.



The region of the mass spectrometer in which ions are accelerated is

(1)

- A A
- B B
- C C
- D D

(Total for Question 1 = 1 mark)

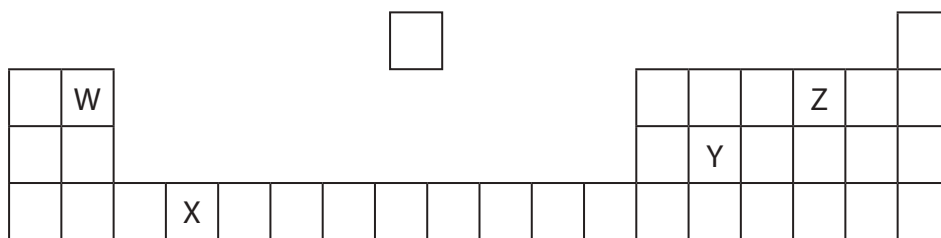
2 The electronic configuration of the nitride ion, N^{3-} , is

- A $1s^2 2s^2$
- B $1s^2 2s^2 2p^1$
- C $1s^2 2s^2 2p^3$
- D $1s^2 2s^2 2p^6$

(Total for Question 2 = 1 mark)



3 W, X, Y and Z represent four elements in the Periodic Table. These are not the symbols for the elements.



(a) Which is a p block element with only two electrons in its outer p subshell?

(1)

- A W
- B X
- C Y
- D Z

(b) Elements **W** and **Z** form a compound **WZ**. The types of bonding in **W**, **Z** and **WZ** are

(1)

	W	Z	WZ
<input type="checkbox"/> A	ionic	covalent	ionic
<input type="checkbox"/> B	metallic	covalent	ionic
<input type="checkbox"/> C	metallic	covalent	covalent
<input type="checkbox"/> D	metallic	ionic	covalent

(Total for Question 3 = 2 marks)

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



P 5 0 7 0 4 A 0 3 2 4

4 Alstonite is a rare salt with the formula, $\text{BaCa}(\text{CO}_3)_2$. It reacts with hydrochloric acid.

Data: molar mass of alstonite = 297.4 g mol^{-1}

$$L = 6.02 \times 10^{23} \text{ mol}^{-1}$$

(a) The percentage by mass of oxygen in alstonite is

(1)

- A 16.1%
- B 26.9%
- C 32.3%
- D 34.3%

(b) What is the **total** number of ions in one mole of alstonite?

(1)

- A 6.02×10^{23}
- B 1.20×10^{24}
- C 1.81×10^{24}
- D 2.41×10^{24}

(c) What is the number of moles of hydrochloric acid required for complete reaction with one mole of alstonite?

(1)

- A one
- B two
- C three
- D four

(Total for Question 4 = 3 marks)

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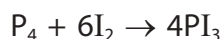
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5 Phosphorus reacts with iodine to produce phosphorus(III) iodide:



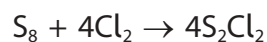
What is the minimum mass of iodine required to produce 1 kg of phosphorus(III) iodide when the phosphorus is in excess?

Data: molar mass of phosphorus(III) iodide = 411.7 g mol^{-1}

- A 0.616 kg
- B 0.925 kg
- C 2.466 kg
- D 3.700 kg

(Total for Question 5 = 1 mark)

6 Sulfur reacts with chlorine to produce disulfur dichloride:



What is the maximum mass of disulfur dichloride that could be produced from the reaction of 0.100 mol of sulfur, S_8 , with 0.394 mol of chlorine?

Data: molar mass of disulfur dichloride = 135.2 g mol^{-1}

- A 13.32 g
- B 13.52 g
- C 53.27 g
- D 54.08 g

(Total for Question 6 = 1 mark)

7 Which of these Period 2 elements has the highest melting temperature?

- A Lithium
- B Boron
- C Nitrogen
- D Neon

(Total for Question 7 = 1 mark)



8 Chlorine can be prepared by the reaction between concentrated hydrochloric acid and concentrated sodium chlorate(I).
Chlorine is a hazardous substance and the risk due to the chlorine is best lowered by

- A using a fume cupboard.
- B wearing gloves.
- C wearing goggles.
- D working in groups.

(Total for Question 8 = 1 mark)

9 Metallic bonding is best described as the electrostatic attraction between

- A cations and anions.
- B cations and delocalised electrons.
- C nuclei and shared pairs of electrons.
- D nuclei and two electrons from one atom.

(Total for Question 9 = 1 mark)

10 The ionic equation for the reaction between hydrochloric acid and aqueous sodium hydroxide is

- A $\text{H}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{H}_2\text{O}(\text{l})$
- B $\text{Cl}^-(\text{aq}) + \text{Na}^+(\text{aq}) \rightarrow \text{NaCl}(\text{aq})$
- C $\text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq}) + \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{Cl}^-(\text{aq}) + \text{Na}^+(\text{aq}) + \text{H}_2\text{O}(\text{l})$
- D $\text{H}^+(\text{aq}) + \text{Cl}^-(\text{aq}) + \text{Na}^+(\text{aq}) + \text{OH}^-(\text{aq}) \rightarrow \text{NaCl}(\text{aq}) + \text{H}_2\text{O}(\text{l})$

(Total for Question 10 = 1 mark)

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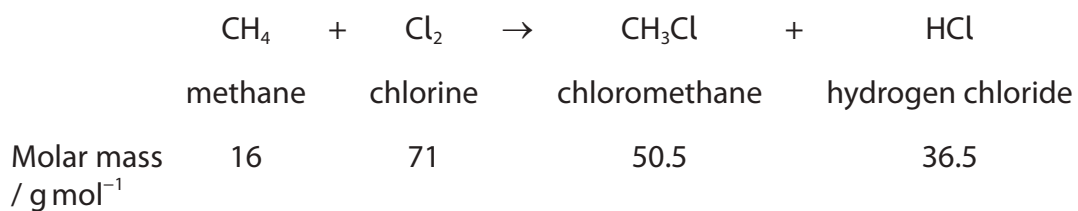
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11 Methane reacts with chlorine in the presence of UV radiation to produce chloromethane:



(a) What is the atom economy by mass for the production of chloromethane in this reaction?

(1)

- A 29%
- B 42%
- C 58%
- D 71%

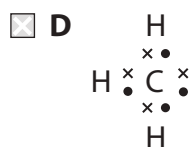
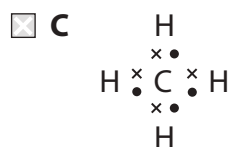
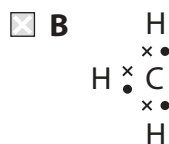
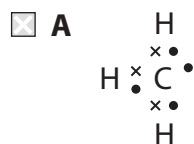
(b) When 3.20 g of methane reacted with excess chlorine, 5.05 g of chloromethane was made. What was the percentage yield?

(1)

- A 10%
- B 20%
- C 50%
- D 63%

(c) A methyl free radical forms in this reaction. The dot-and-cross diagram for the methyl free radical is

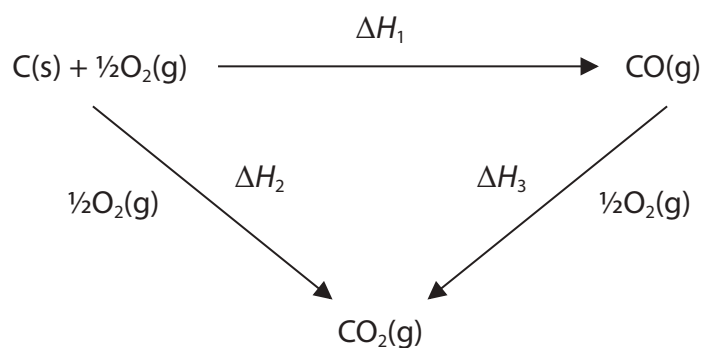
(1)



(Total for Question 11 = 3 marks)



- 12 Hess's law can be used to determine enthalpy changes, such as the formation of carbon monoxide from carbon and oxygen, which cannot be obtained directly.



From Hess's law

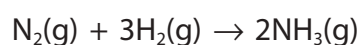
- A $\Delta H_1 = \Delta H_2 - \Delta H_3$
- B $\Delta H_1 = \Delta H_2 + \Delta H_3$
- C $\Delta H_1 = \frac{1}{2}\Delta H_2 - \frac{1}{2}\Delta H_3$
- D $\Delta H_1 = \frac{1}{2}\Delta H_2 + \frac{1}{2}\Delta H_3$

(Total for Question 12 = 1 mark)

- 13 Consider the bond enthalpy values given in the table.

Bond	Bond enthalpy / kJ mol^{-1}
$\text{N}\equiv\text{N}$	+945
$\text{H}-\text{H}$	+436
$\text{N}-\text{H}$	+391

For the reaction



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

- A +1080
- B +852
- C -93
- D -529

(Total for Question 13 = 1 mark)



14 The enthalpy change of combustion of ethanol was determined by using a spirit burner containing ethanol to heat 250 cm³ of water in a copper calorimeter. The experimental value obtained was less exothermic than the Data Booklet value.

Which is the **least** likely reason for this difference in the enthalpy values?

- A** Heat loss from the copper calorimeter
- B** Incomplete combustion of the ethanol
- C** Use of non-standard conditions
- D** Loss of ethanol by evaporation

(Total for Question 14 = 1 mark)

15 A drop of copper(II) sulfate solution was placed at the centre of a damp piece of filter paper covering a microscope slide. A direct current was passed through the paper and after a short time the following observations were noted:

	Moving towards the anode	Moving towards the cathode
<input type="checkbox"/> A	blue colour	nothing visible
<input type="checkbox"/> B	blue colour	yellow colour
<input type="checkbox"/> C	yellow colour	blue colour
<input type="checkbox"/> D	nothing visible	blue colour

(Total for Question 15 = 1 mark)

TOTAL FOR SECTION A = 20 MARKS

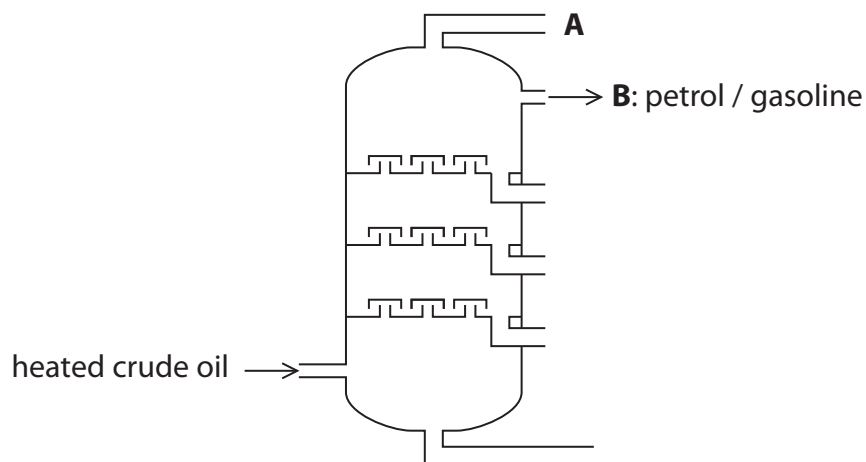


SECTION B

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

- 16 This question is about alkanes and their use as fuels.
Crude oil is a mixture of alkanes which can be processed in various ways.

- (a) Fractional distillation is the method used to separate crude oil into fractions containing similar sized alkanes.



- (i) On what physical property does the separation of alkanes using fractional distillation depend?

(1)

- (ii) Suggest the name of an alkane that would be present in the fraction labelled **A**.

(1)

- (iii) State why fractions in addition to **B** are also processed to produce petrol.

(1)

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(b) Substances obtained from crude oil can be processed by cracking to obtain alkanes and alkenes.

(i) Industrial catalysts are used for the cracking process. What other condition is required?

(1)

(ii) The kerosene fraction contains the hydrocarbon, $C_{12}H_{26}$, which can be cracked to produce octane and ethene **only**.

Write the equation for this cracking reaction. State symbols are not required.

(2)

(c) Substances obtained from crude oil can be processed by reforming to produce branched-chain alkanes from straight-chain alkanes.

(i) State the advantage of using petrol containing branched-chain alkanes.

(1)

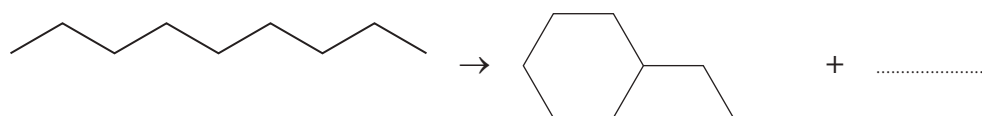
(ii) Using **skeletal** formulae, write an equation for the reforming of hexane into an alkane with a single branch as the only product. Name your product. State symbols are not required.

(3)

Name

(iii) Reforming can also produce cyclic alkanes from straight-chain alkanes. Complete the equation for the reforming of nonane into propylcyclohexane.

(1)



(d) Pentane, C₅H₁₂, is used as a fuel.

- (i) Calculate the volume of carbon dioxide produced at room temperature and pressure (r.t.p.) from the complete combustion of 10.0 cm³ of liquid pentane. Give your answer to **three** significant figures.

Data: one mole of any gas occupies 24 000 cm³ at r.t.p.
density of liquid pentane = 0.626 g cm⁻³



(4)

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

(1)

- *(e) Crude oil is a non-renewable resource and some chemists are of the opinion that, because its use causes climate change, other energy sources should be used.

Explain the meaning of the term 'non-renewable' and how the use of crude oil causes climate change.

(2)

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(Total for Question 16 = 18 marks)



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17 This is a question about the structure and chemical properties of alkenes.

(a) The carbon-carbon double bond consists of both a sigma (σ) bond and a pi (π) bond.

(i) Describe **two** differences in the orbital overlap of a sigma bond and in the orbital overlap of a pi bond between carbon atoms.

(2)

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(ii) What feature of a pi bond can result in *E-Z* isomers?

(1)

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(iii) Not all alkenes exhibit *E-Z* isomerism.

For the molecular formula C_4H_8

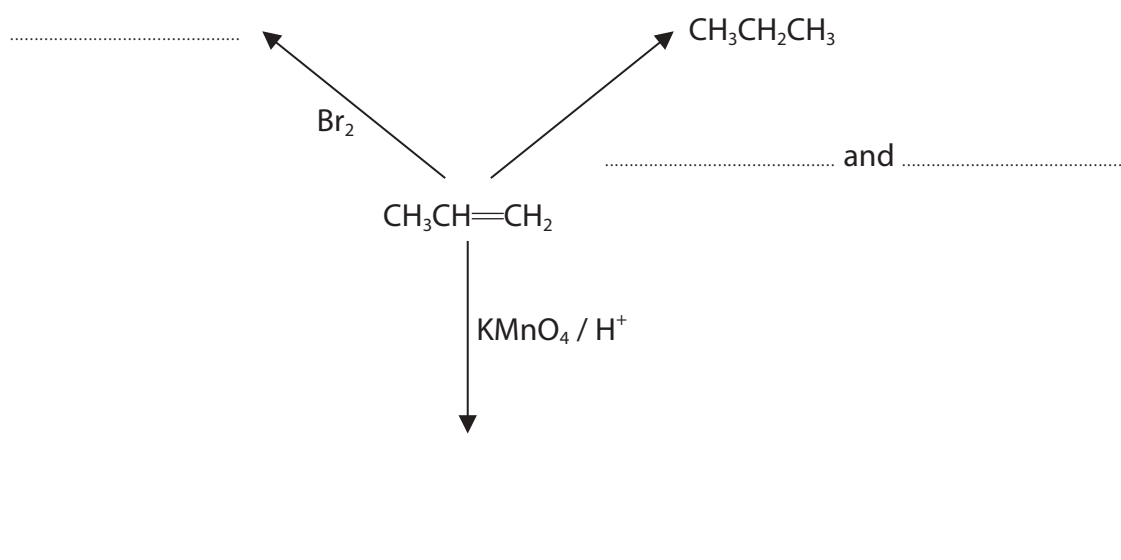
- draw the displayed formula of the *E* isomer and of the *Z* isomer
- draw the displayed formula and give the name of **one** alkene which does not exhibit *E-Z* isomerism. Name this alkene.

(4)

<i>E</i> isomer	<i>Z</i> isomer
Alkene with no <i>E-Z</i> isomerism	
Name	

(b) (i) Complete the reaction scheme for propene using structural formulae for the organic products.

(3)



(ii) Draw the repeat unit of the polymer formed from propene.

(1)

(c) Draw the mechanism for the reaction between hydrogen bromide and propene to form the **major** product.

- Use curly arrows and show any relevant dipoles and lone pairs of electrons
- State the name of the reaction mechanism
- Give the name of the **major** product.

(6)

Reaction mechanism

Name of **major** product

(Total for Question 17 = 17 marks)



18 Ionisation energies provide evidence for the electronic structures of atoms.

(a) Complete the definition of the term first ionisation energy.

(2)

The energy required to remove one electron from each atom

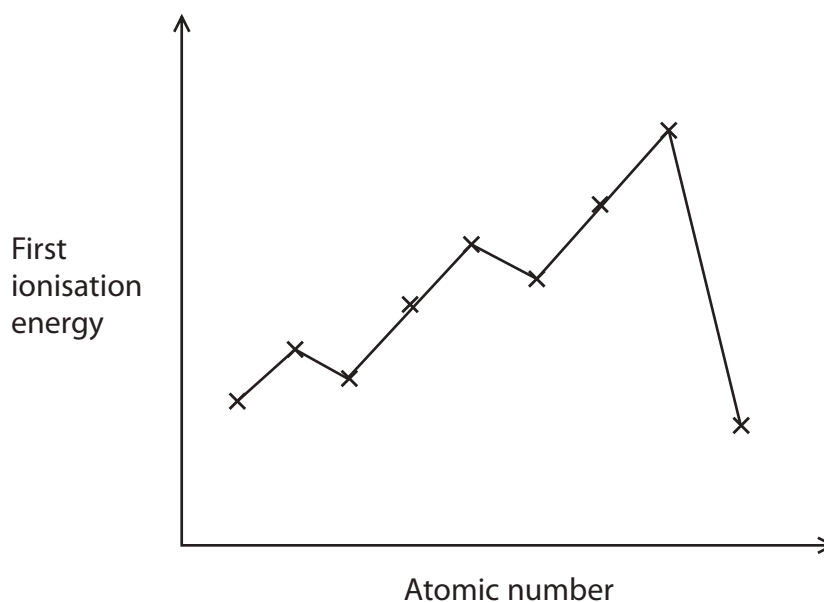
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(b) Explain why ionisation is an endothermic process.

(1)

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(c) The sketch below shows the first ionisation energies of nine successive elements.



(i) Circle **all** the crosses on the sketch which represent electrons being removed from an s orbital.

(2)

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(ii) Draw the shape of a single p orbital.

(1)

* (d) Describe the trend in the values of the first four ionisation energies for the element aluminium. Hence show that aluminium is in Group 3 of the Periodic Table.

(2)

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(e) Why are orbitals of the same sub shell occupied singly by electrons, before pairing of electrons occurs?

(1)

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(Total for Question 18 = 9 marks)



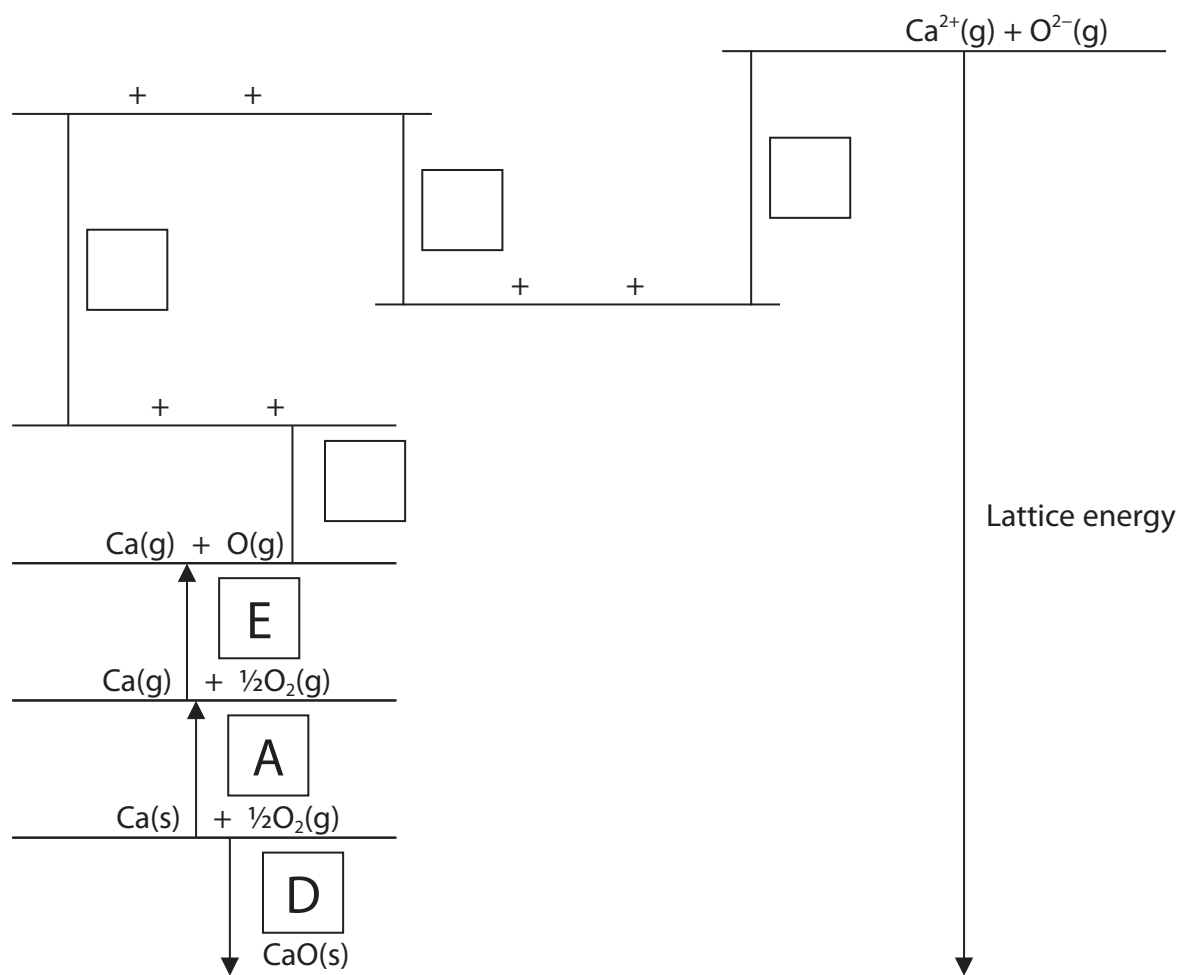
19 The following data can be used in a Born-Haber cycle for calcium oxide, CaO.

Letter	Enthalpy change	Value / kJ mol^{-1}
A	Enthalpy change of atomisation of calcium	+178
B	First ionisation energy of calcium	+590
C	Second ionisation energy of calcium	+1145
D	Enthalpy change of formation of calcium oxide	-635
E	Enthalpy change of atomisation of oxygen ($\frac{1}{2}\text{O}_2(\text{g}) \rightarrow \text{O}(\text{g})$)	+249
F	First electron affinity of oxygen	-141
G	Second electron affinity of oxygen	+798

(a) Complete the Born-Haber cycle for calcium oxide by adding

- letters in the boxes for the ionisation energies of calcium and the electron affinities of oxygen
- any relevant chemical species and electrons on the blank lines
- arrow heads to indicate enthalpy change direction

(3)



(b) Use the data to calculate a value for the lattice energy of calcium oxide.

Give a sign and units in your answer.

(2)

* (c) The numerical value for the calcium oxide lattice energy based on the Born-Haber cycle and the theoretical value based on calculation are very similar. However, there is an 8% difference between the values for calcium iodide, with the Born-Haber cycle value being more negative.

Compare the bonding in calcium oxide with that of calcium iodide and explain fully why there is a significant difference between the experimental and theoretical lattice energy values for calcium iodide.

(4)

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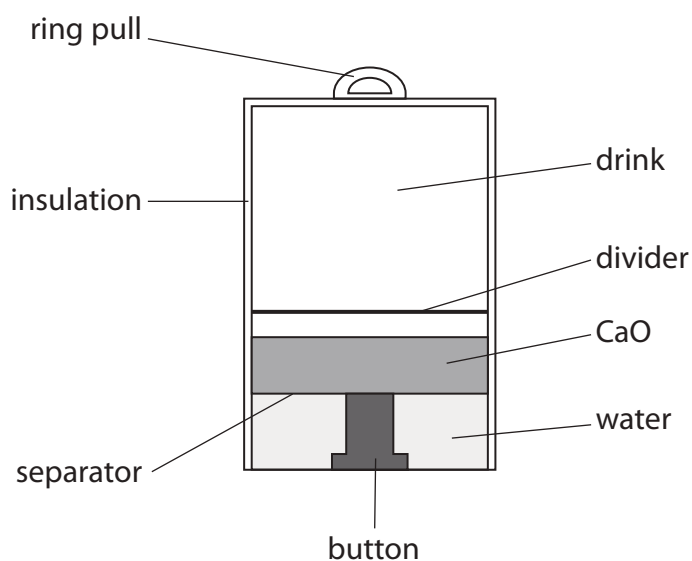
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- (d) The reaction between calcium oxide and water to produce calcium hydroxide is exothermic, and is used to warm canned drinks. A typical arrangement is shown in the diagram.



The enthalpy change of reaction is $-65.1 \text{ kJ mol}^{-1}$

Assume that the energy transferred to the drink is given by the following equation:

$$\text{energy (J)} = \text{volume of drink (cm}^3\text{)} \times 4.18 \text{ (J cm}^{-3}\text{ }^\circ\text{C}^{-1}\text{)} \times \text{temperature change (}^\circ\text{C)}$$

- (i) Calculate the mass of calcium oxide that would be required to raise the temperature of 200 cm^3 of drink by 40°C .

(3)

- (ii) Give **two** reasons why this drink can is insulated.

(2)

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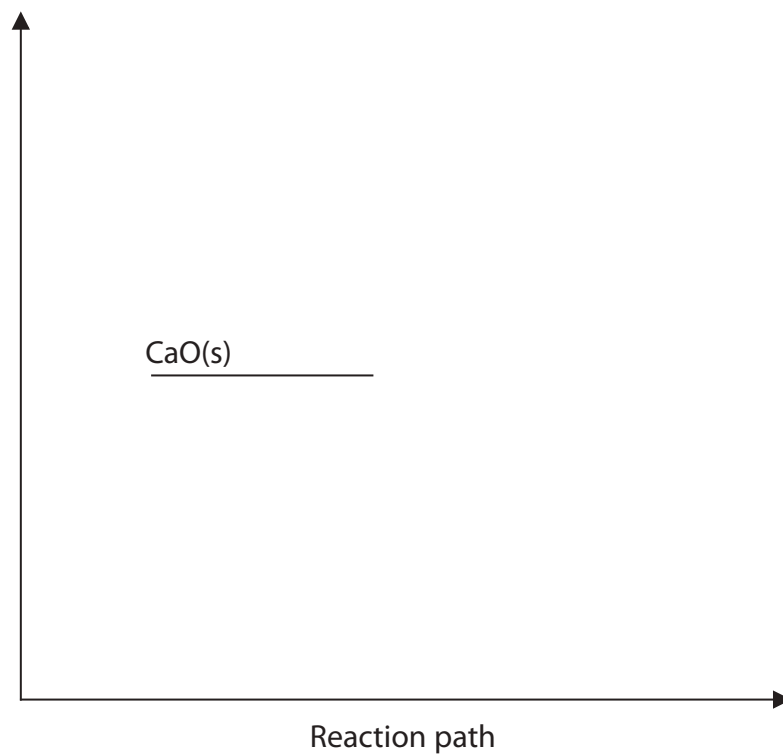
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(iii) Complete the enthalpy level diagram for the reaction between calcium oxide and water. Include state symbols, the value for the enthalpy change and a label for the y axis.

(2)



(Total for Question 19 = 16 marks)

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





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P 5 0 7 0 4 A 0 2 3 2 4

The Periodic Table of Elements

1	2	3	4	5	6	7	0 (8)
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	47.9 Ti titanium 22	50.9 V vanadium 23	54.9 Mn manganese 25	55.8 Fe iron 26	58.9 Co cobalt 27	63.5 Cu copper 29
85.5 Rb rubidium 37	87.6 Sr strontium 38	91.2 Zr zirconium 40	92.9 Nb niobium 41	95.9 Mo molybdenum 42	101.1 Ru ruthenium 44	102.9 Rh rhodium 45	107.9 Ag silver 47
132.9 Cs caesium 55	137.3 Ba barium 56	178.5 Hf hafnium 72	180.9 Ta tantalum 73	183.8 W tungsten 74	190.2 Os osmium 76	192.2 Ir iridium 77	197.0 Au gold 79
[223] Fr francium 87	[226] Ra radium 88	[261] Rf rutherfordium 104	[262] Db dubnium 105	[266] Sg seaborgium 106	[277] Hs hassium 108	[268] Mt meitnerium 109	[272] Rg roentgenium 111
[223] Fr francium 87	[227] Ac actinium 89	[271] Ds darmstadtium 110	[272] Rg roentgenium 111	[272] Rg roentgenium 111	[271] Ds darmstadtium 110	[271] Ds darmstadtium 110	[272] Rg roentgenium 111

(13)	(14)	(15)	(16)	(17)	(18)
108 B boron 5	120 C carbon 6	140 N nitrogen 7	160 O oxygen 8	190 F fluorine 9	202 Ne neon 10
270 Al aluminium 13	281 Si silicon 14	310 P phosphorus 15	321 S sulfur 16	355 Cl chlorine 17	399 Ar argon 18
697 Ga gallium 31	726 Ge germanium 32	749 As arsenic 33	790 Se selenium 34	799 Br bromine 35	838 Kr krypton 36
1148 In indium 49	1187 Sn tin 50	1218 Sb antimony 51	1276 Te tellurium 52	1269 I iodine 53	1313 Xe xenon 54
2044 Tl thallium 81	2072 Pb lead 82	2090 Bi bismuth 83	209 Po polonium 84	[210] At astatine 85	[222] Rn radon 86

(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
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
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
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
[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	[272] Rg roentgenium 111

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

1.0
H
hydrogen
1

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
* Actinide series

DO NOT WRITE IN THIS AREA

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