Please check the examination details below before entering your candidate information

Candidate surname	Other names

Centre Number | Candidate Number

Pearson Edexcel International Advanced Level

Wednesday 09 October 2024

Afternoon (Time: 1 hour 30 minutes)

Paper reference **WCH11/01**

Chemistry

International Advanced Subsidiary/Advanced Level
UNIT 1: Structure, Bonding and Introduction to Organic Chemistry

You must have:
Scientific calculator, ruler

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- If pencil is used for diagrams/sketches/graphs it must be dark (HB or B).
- **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.*
- You will be assessed on your ability to organise and present information, ideas, descriptions and arguments clearly and logically, including your use of grammar, punctuation and spelling.
- A Periodic Table is printed on the back cover of this paper.

Advice

- Read each question carefully before you start to answer it.
- Show all your working in calculations and include units where appropriate.
- Try to answer every question.
- Check your answers if you have time at the end.

Turn over ▶

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Pearson

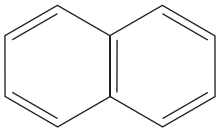
SECTION A

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

1 What is the molecular formula of naphthalene?



☒ **A** $C_{10}H_8$

☒ **B** $C_{10}H_{10}$

☒ **C** $C_{12}H_{10}$

☒ **D** $C_{12}H_{12}$

(Total for Question 1 = 1 mark)

2 Magnesium azide is an ionic compound containing the azide ion, N_3^-.

The empirical formula of magnesium azide is

☒ **A** Mg_3N

☒ **B** MgN_2

☒ **C** MgN_3

☒ **D** MgN_6

(Total for Question 2 = 1 mark)

3 How many oxygen **atoms** are there in 0.0100 mol of H_2SO_4?

[Avogadro constant, $L = 6.020 \times 10^{23}\ mol^{-1}$]

☒ **A** 6.020×10^{21}

☒ **B** 1.204×10^{22}

☒ **C** 2.408×10^{22}

☒ **D** 4.214×10^{22}

(Total for Question 3 = 1 mark)

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4 Two identical sealed flasks, containing different gases, are side by side. Each flask contains one gas, with the gases at the same temperature and pressure.

Flask **A** contains 4.0×10^{-3} mol of methane.

Flask **B** contains 160 mg of a different gas.

Which could be the gas in Flask **B**?

- ☒ **A** argon
- ☒ **B** carbon dioxide
- ☒ **C** helium
- ☒ **D** neon

(Total for Question 4 = 1 mark)

5 Diphosphane, P_2H_4, reacts spontaneously with oxygen.

$$xP_2H_4 + yO_2 \rightarrow P_4O_{10} + zH_2O$$

The equation for this reaction is balanced when

- ☒ **A** x = 1 y = 6 z = 2
- ☒ **B** x = 2 y = 6 z = 2
- ☒ **C** x = 2 y = 7 z = 4
- ☒ **D** x = 4 y = 9 z = 8

(Total for Question 5 = 1 mark)

6 Copper metal can displace silver from silver nitrate solution according to the equation shown.

$$Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$$

10 g of copper metal was added to an excess of silver nitrate solution.

The silver metal was collected, washed with deionised water and left to dry.

What is the mass of silver metal collected, assuming a 100 % yield?

- ☒ **A** between 10 g and 20 g
- ☒ **B** 20 g
- ☒ **C** between 20 g and 40 g
- ☒ **D** more than 40 g

(Total for Question 6 = 1 mark)

7 This question is about the thermal decomposition of calcium nitrate.

$$2Ca(NO_3)_2 \rightarrow 2CaO + 4NO_2 + O_2$$

What volume of gas is produced by the complete decomposition of 0.050 mol of calcium nitrate at room temperature and pressure (r.t.p.)?

[Molar volume of a gas at r.t.p. = 24 $dm^3 mol^{-1}$]

☒ **A** 600 cm^3

☒ **B** 1.20 dm^3

☒ **C** 3.00 dm^3

☒ **D** 6.00 dm^3

(Total for Question 7 = 1 mark)

8 Ethanol is formed from glucose during fermentation.

$$C_6H_{12}O_6 \rightarrow 2C_2H_5OH + 2CO_2$$

What is the atom economy by mass for the formation of ethanol in this reaction?

☒ **A** 26 %

☒ **B** 49 %

☒ **C** 51 %

☒ **D** 96 %

(Total for Question 8 = 1 mark)

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

9 The table shows some data about fundamental particles in an atom.

Particle	Mass / g
electron	0.0009×10^{-24}
neutron	1.6748×10^{-24}
proton	1.6725×10^{-24}

(a) An atom of hydrogen can be represented as ^{1}H.

What is the mass, in grams, of this hydrogen atom?

(1)

☒ **A** 1.6725×10^{-24}

☒ **B** 1.6734×10^{-24}

☒ **C** 3.3473×10^{-24}

☒ **D** 3.3482×10^{-24}

(b) Which of the particles would be deflected by an electric field?

(1)

☒ **A** electrons only

☒ **B** electrons and protons only

☒ **C** neutrons and protons only

☒ **D** electrons, neutrons and protons

(Total for Question 9 = 2 marks)

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

10 This question is about the Period 3 elements Na, Mg, Al, Si, P, S and Cl.

(a) Which statement is **not** correct for these Period 3 elements?

(1)

- ☒ **A** atoms of Cl(g) have the highest first ionisation energy
- ☒ **B** ions of $Cl^-(g)$ and $S^{2-}(g)$ have the same ionic radius
- ☒ **C** atoms of Na(g) have the largest atomic radius
- ☒ **D** atoms of P(g) have the most unpaired electrons

(b) The melting temperatures of these elements are shown in the table.

Element	Na	Mg	Al	Si	P	S	Cl
Melting temperature / K	371	922	933	1683	317	392	172

Which of the elements has the strongest **intermolecular** forces?

(1)

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

(Total for Question 10 = 2 marks)

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

11 Which row of the table shows properties consistent with the type of bonding shown?

	Bonding	Solubility in water	Melting temperature	Electrical conductivity of solid
☒ **A**	ionic	soluble	high	poor
☒ **B**	ionic	soluble	low	good
☒ **C**	metallic	soluble	low	good
☒ **D**	metallic	insoluble	high	poor

(Total for Question 11 = 1 mark)

12 Which ion is isoelectronic with a noble gas atom (Group 0/8)?

☒ **A** H^+

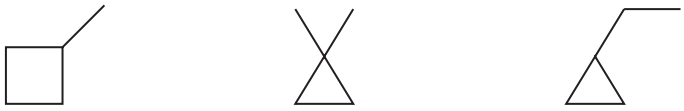
☒ **B** O^-

☒ **C** Sc^{3+}

☒ **D** Zn^{2+}

(Total for Question 12 = 1 mark)

13 Cycloalkanes undergo free radical substitution reactions by the same mechanism as methane. Three isomeric cycloalkanes are shown.



Isomer **X** Isomer **Y** Isomer **Z**

Which react with chlorine to produce four different monochlorinated products?

☒ **A** All 3 isomers

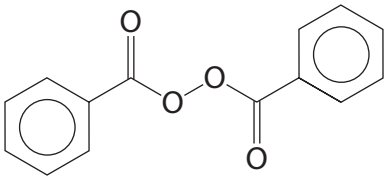
☒ **B** Isomer **X** and Isomer **Z** only

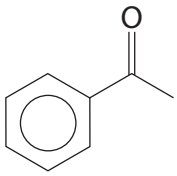
☒ **C** Isomer **Y** and Isomer **Z** only

☒ **D** Isomer **X** only

(Total for Question 13 = 1 mark)

14 Polymerisation of alkenes occurs via a free radical mechanism.
This reaction is started by the addition of small amounts of another compound.
The structure of one of these compounds is shown.



This can be represented as R—O—O—R where R— is 

Which step in the mechanism is an initiation step?

☒ **A** $R—O—O—R \rightarrow 2R—O^{\bullet}$

☒ **B** $R—O—CH_2—CH_2^{\bullet} + CH_2{=}CH_2 \rightarrow R—O—CH_2—CH_2—CH_2—CH_2^{\bullet}$

☒ **C** $2R—O—CH_2—CH_2^{\bullet} \rightarrow R—O—CH_2—CH_2—CH_2—CH_2—O—R$

☒ **D** $R—O^{\bullet} + CH_2{=}CH_2 \rightarrow R—O—CH_2—CH_2^{\bullet}$

(Total for Question 14 = 1 mark)

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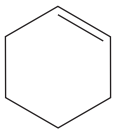
15 This question is about cyclohexene, a cyclic alkene.



(a) What is the general formula of cyclic alkenes such as cyclohexene?

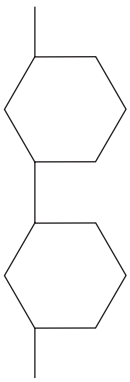
(1)

- ☒ **A** C_nH_{2n-4}
- ☒ **B** C_nH_{2n-2}
- ☒ **C** C_nH_{2n}
- ☒ **D** C_nH_{2n+2}

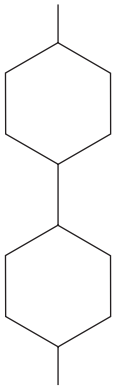
(b) Cyclohexene can form an addition polymer.

Which diagram shows two repeat units of this addition polymer?

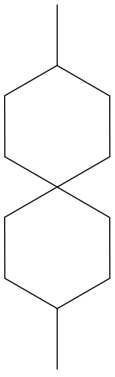
(1)



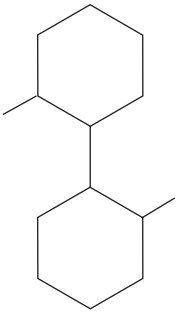
☒ **A**



☒ **B**



☒ **C**



☒ **D**

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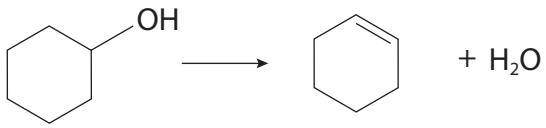
(c) Cyclohexanol can be converted into cyclohexene.



What mass of cyclohexanol is needed to make 7.20 g of cyclohexene, if the yield of this reaction is 72.0 %?

[M_r values: cyclohexanol = 100 cyclohexene = 82.0]

(1)

☒ **A** 4.25 g

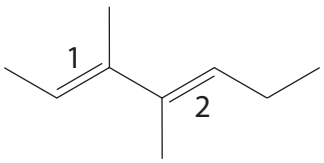
☒ **B** 5.90 g

☒ **C** 8.78 g

☒ **D** 12.2 g

(Total for Question 15 = 3 marks)

16 The molecule shown has two double bonds.



Which is the correct identification for each double bond?

	Double bond 1	Double bond 2
☒ **A**	*E*	*E*
☒ **B**	*E*	*Z*
☒ **C**	*Z*	*E*
☒ **D**	*Z*	*Z*

(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 Sodium hydroxide can be obtained as a hydrate, $NaOH \cdot xH_2O$.
When heated, the water of crystallisation is lost, leaving anhydrous sodium hydroxide, NaOH, as shown in the equation.

$$NaOH \cdot xH_2O \rightarrow NaOH + xH_2O$$

An experiment was carried out to determine the value of x in $NaOH \cdot xH_2O$.

Procedure

Step **1** Weigh and record the mass of a clean, dry crucible.

Step **2** Add approximately 1.0 g of $NaOH \cdot xH_2O$ to the crucible and record the mass.

Step **3** Heat the crucible and its contents until a constant mass has been reached.

Step **4** After allowing to cool, reweigh the crucible and the anhydrous solid.

Step **5** Calculate and record the mass of the anhydrous solid.

Repeat Steps **1** to **5** using a different mass of the hydrated sodium hydroxide.

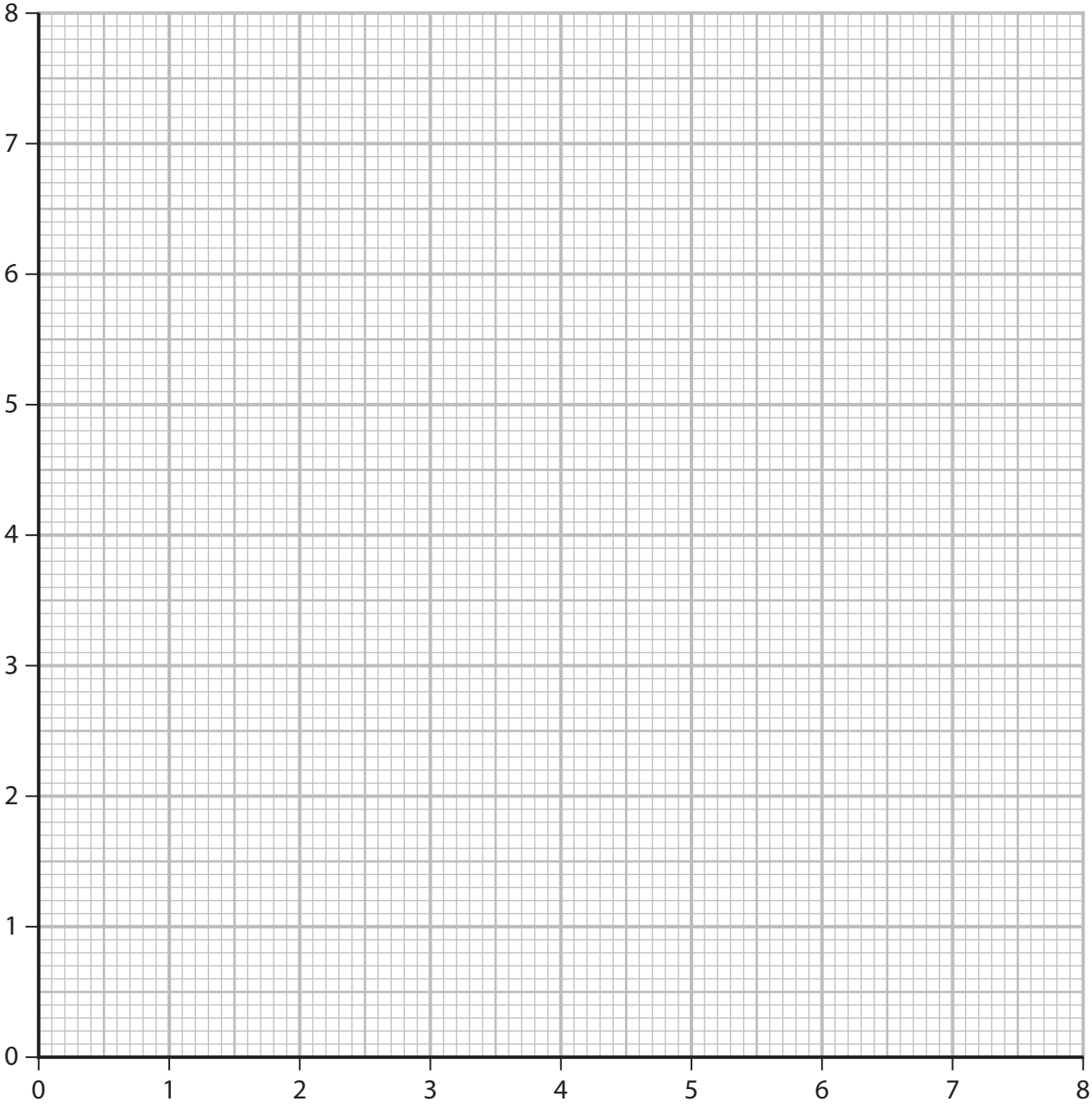
Results

Mass of $NaOH \cdot xH_2O$ / g	Mass of NaOH / g
1.00	0.69
2.10	1.45
3.50	2.41
4.90	3.38
6.60	4.55
8.00	5.52

(a) (i) Complete a graph of the results by

- plotting the points
- labelling the axes
- including a straight line of best fit.

(3)



(ii) Use your graph to determine the mass of $NaOH \cdot xH_2O$ needed to form 4.0 g of NaOH. You must show your working on the graph.

(1)

.....

(iii) Calculate the value of x in $NaOH \cdot xH_2O$ using your answer to (a)(ii) and the equation for the reaction.

$$NaOH \cdot xH_2O \rightarrow NaOH + xH_2O$$

(3)

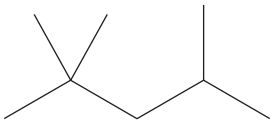
(b) Sodium hydroxide also forms a heptahydrate, $NaOH \cdot 7H_2O$.

Calculate the mass of this heptahydrate needed to make 250 cm^3 of a solution of sodium hydroxide of concentration 0.150 mol dm^{-3}.

(2)

(Total for Question 17 = 9 marks)

18 Molecules of isooctane, found in petrol, have eight carbon atoms.
The skeletal formula of isooctane is shown.



(a) Give the molecular formula, empirical formula and IUPAC name for isooctane.

(3)

Molecular formula .....

Empirical formula .....

IUPAC name .....

(b) Isooctane and octane are isomers that are both found in crude oil.
Octane has a boiling temperature of 125 °C, and isooctane has a boiling temperature of 99 °C.

This difference in boiling temperature can be used to separate the two isomers in a laboratory.
The technique is the same as that used to separate crude oil.

(i) Name the technique that could be used for this separation.

(1)

.....

(ii) Describe how this technique separates isooctane from octane.

(2)

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(c) Isooctane is added to petrol to increase its octane rating.
Some high-performance engines need fuel with a higher octane rating.

(i) Write the equation for the complete combustion of isooctane.
State symbols are not required.

(1)

(ii) Carbon monoxide and nitrogen monoxide are both pollutants produced in car engines.
Describe how each pollutant is formed in car engines, including the conditions required.
You may include appropriate equations.

(4)

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(iii) Identify another pollutant, other than carbon dioxide, carbon monoxide and nitrogen monoxide, produced in car engines.

(1)

.....

(d) Isooctane reacts with an excess of chlorine to form a mixture of chlorinated compounds containing the same number of carbon atoms as isooctane.

(i) State the type and mechanism of this reaction.

(1)

.....

(ii) Give the essential condition required.

(1)

.....

(iii) One of the chlorinated compounds contains 44.1% carbon and 6.9% hydrogen by mass.

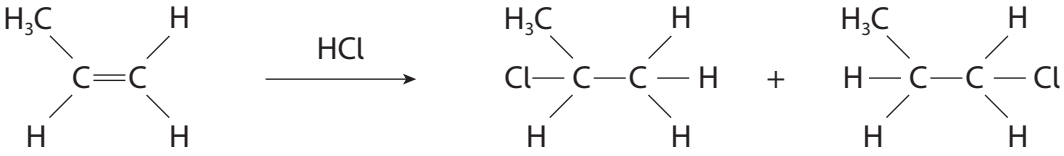
Calculate the molecular formula of this compound.

(3)

(Total for Question 18 = 17 marks)

19 This question is about two reactions of propene.

Reaction **1**

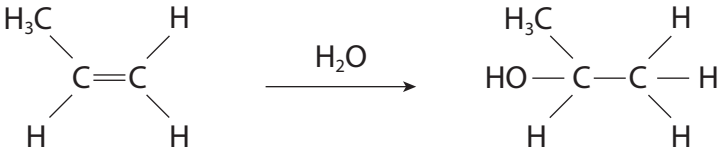


propene

2-chloropropane (major product)

1-chloropropane (minor product)

Reaction **2**



(a) (i) Name the mechanism and type of reaction for Reaction **1**.

(1)

.....

(ii) Explain why the structures of the intermediates in Reaction **1** mean that 2-chloropropane is formed in greater yield than 1-chloropropane.

(3)

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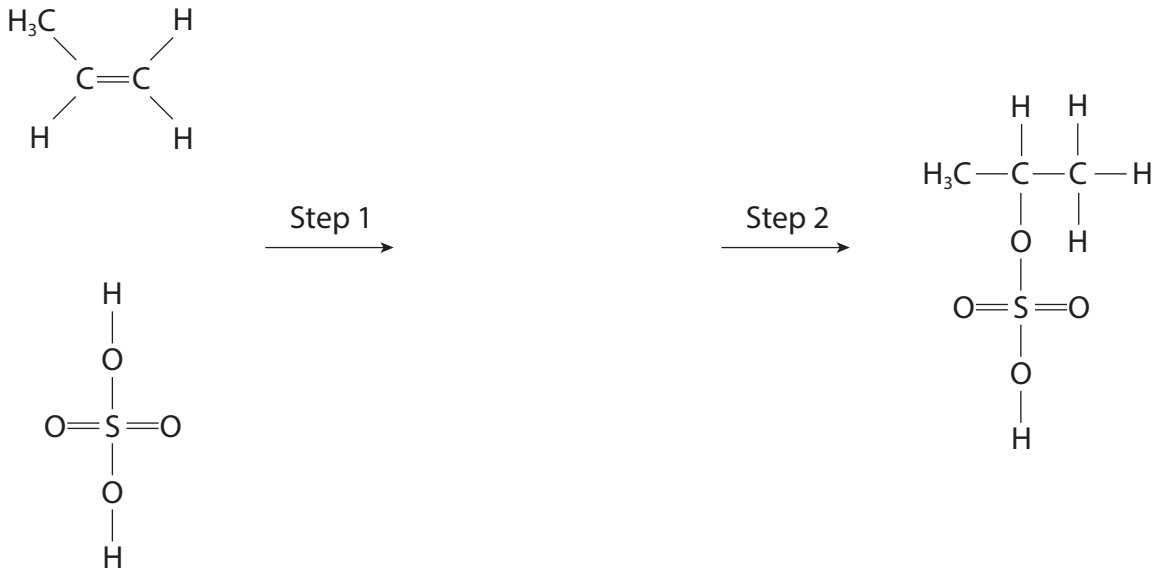
(b) Reaction **2** proceeds in two stages.
The equation for the first stage is shown.

$$CH_3CH{=}CH_2 + H_2SO_4 \rightarrow CH_3CH(OSO_2OH)CH_3$$

The mechanism for this reaction is the same as Reaction **1**.

Complete the mechanism by including the intermediate structure, curly arrows and relevant dipoles, charges and lone pairs.

(4)



(Total for Question 19 = 8 marks)

20 The periods in the Periodic Table show trends in physical properties.

(a) (i) Explain the general trend in first ionisation energies for the Period 2 elements.

(2)

(ii) Explain which **one** of the elements from **lithium** to **nitrogen** deviates from this general trend.

(3)

(b) Identify the **Period 3** element that has the following successive ionisation energies.

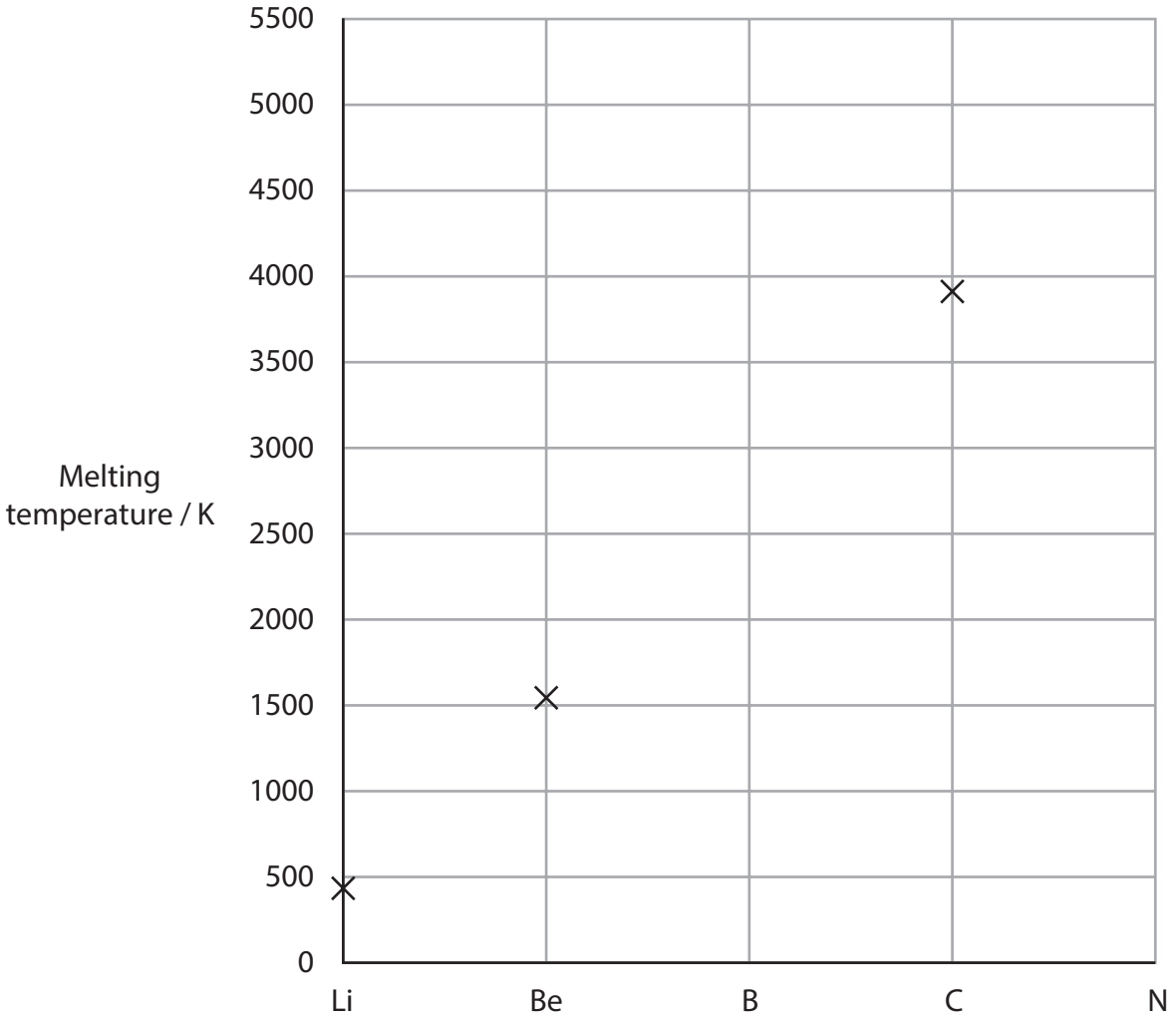
Ionisation energy / kJ mol^{-1}							
First	Second	Third	Fourth	Fifth	Sixth	Seventh	Eighth
1000	2251	3361	4564	7012	8496	27 107	31 671

(1)

(c) (i) The diagram shows the melting temperatures of the elements in Period 2 from lithium to nitrogen.

Complete the diagram by putting crosses to show the approximate melting temperatures of boron and nitrogen.

(2)



(ii) Explain why the melting temperature of carbon is high, with reference to its structure and bonding.

(3)

(Total for Question 20 = 11 marks)

21 Boron, aluminium and thallium are in Group 3 of the Periodic Table.
These elements form molecular compounds with chlorine with the formulae BCl_3, $AlCl_3$ and $TlCl_3$. The shape of these molecules depends on the electronic structures of the Group 3 elements.

(a) (i) Give the electronic configuration of aluminium.

(1)

(ii) Compare and contrast the electronic structures of boron, aluminium and thallium.

(2)

(iii) Deduce, using electron-pair repulsion theory, the expected shape of BCl_3, $AlCl_3$ and $TlCl_3$. Justify your answer.

(3)

(b) Aluminium chloride is a solid at room temperature.
At the relatively low temperature of 453 K it sublimes.

(i) A sample of 5.00 g of aluminium chloride was heated to 455 K at a pressure of 1.01×10^5 Pa.
When all the aluminium chloride had vaporised, the final volume of gas was 700 cm^3.

Show that the data is consistent with the formula of aluminium chloride in the gas phase being Al_2Cl_6.

[Gas constant $R = 8.31\ J\,mol^{-1}\,K^{-1}$ Ideal gas equation $pV = nRT$]

(3)

(ii) Draw the dot-and-cross diagram for Al_2Cl_6. Use dots (•) for the electrons of aluminium and crosses (×) for the electrons of chlorine.

(3)

(c) Thallium also forms ions containing chlorine, for example the $TlCl_4^{3-}$ ion.
In this ion, the thallium atom has 10 electrons in its outermost shell.
Phosphorus in phosphorus pentachloride, PCl_5, also has 10 electrons in its outer shell.

Draw the shape of the $TlCl_4^{3-}$ ion and predict the bond angles.
Include any lone pairs of electrons that influence the shape.

(3)

(Total for Question 21 = 15 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									(13)	(14)	(15)	(16)	(17)	
6.9 Li lithium 3	9.0 Be beryllium 4		relative atomic mass atomic symbol name atomic (proton) number									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