

**Paper Reference(s) WCH11/01**

**Pearson Edexcel  
International Advanced Level**

**Chemistry  
International Advanced Subsidiary  
Unit 1: Structure, Bonding and Introduction to  
Organic Chemistry**

**Wednesday 9 January 2019 – 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.**

<b>Centre No.</b>					
<b>Candidate No.</b>					
<b>Surname</b>					
<b>Other names</b>					
<b>Signature</b>					
<b>Paper Reference</b>	<b>W</b>	<b>C</b>	<b>H</b>	<b>1</b>	<b>1 / 0 1</b>



- 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**

**Scientific calculator, ruler**

## **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.
- A Periodic Table is provided.

## **ADVICE TO CANDIDATES**

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

**(Turn over)**

**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 The hydroxide ion,  $\text{OH}^-$ , has a total of 9 protons.

How many neutrons and electrons are there in this ion?

	Number of neutrons	Number of electrons
<input type="checkbox"/> A	8	8
<input type="checkbox"/> B	8	10
<input type="checkbox"/> C	9	8
<input type="checkbox"/> D	9	9

(TOTAL FOR QUESTION 1 = 1 MARK)

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(Questions continue on next page)

(Turn over)

**2 A sample of silicon contains the following isotopes.**

<b>Isotope</b>	<b>Percentage abundance</b>
<b><math>^{28}\text{Si}</math></b>	<b>81.21</b>
<b><math>^{29}\text{Si}</math></b>	<b>14.10</b>
<b><math>^{30}\text{Si}</math></b>	<b>4.69</b>

**What is the relative atomic mass of silicon, to one decimal place, in this sample?**

☐ **A 28.0**

☐ **B 28.2**

☐ **C 29.0**

☐ **D 29.8**

**(TOTAL FOR QUESTION 2 = 1 MARK)**

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**(Questions continue on next page)**

**(Turn over)**

- 3 Which is the electronic configuration of a carbon atom in its ground state?

	1s	2s	2p
<input type="checkbox"/> A	<div>↑</div>	<div>↑</div>	<div>↑↓</div> <div>↑</div> <div>↑</div>
<input type="checkbox"/> B	<div>↑↓</div>	<div>↑</div>	<div>↑</div> <div>↑</div> <div>↑</div>
<input type="checkbox"/> C	<div>↑↓</div>	<div>↑↓</div>	<div>↑↓</div> <div></div> <div></div>
<input type="checkbox"/> D	<div>↑↓</div>	<div>↑↓</div>	<div>↑</div> <div>↑</div> <div></div>

(TOTAL FOR QUESTION 3 = 1 MARK)

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(Questions continue on next page)

(Turn over)

- 4 What is the maximum number of electrons in the 3p subshell, and in the third quantum shell of an atom?

	Maximum number of electrons in the 3p subshell	Maximum number of electrons in the third quantum shell
<input type="checkbox"/> A	2	8
<input type="checkbox"/> B	2	18
<input type="checkbox"/> C	6	8
<input type="checkbox"/> D	6	18

(TOTAL FOR QUESTION 4 = 1 MARK)

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(Questions continue on next page)

(Turn over)

- 5 The first six ionisation energies of an element, in  $\text{kJ mol}^{-1}$ , are shown.

578    1817    2745    11 578    14 831    18 378

Which group of the Periodic Table includes this element?

☐ A    Group 2

☐ B    Group 3

☐ C    Group 4

☐ D    Group 5

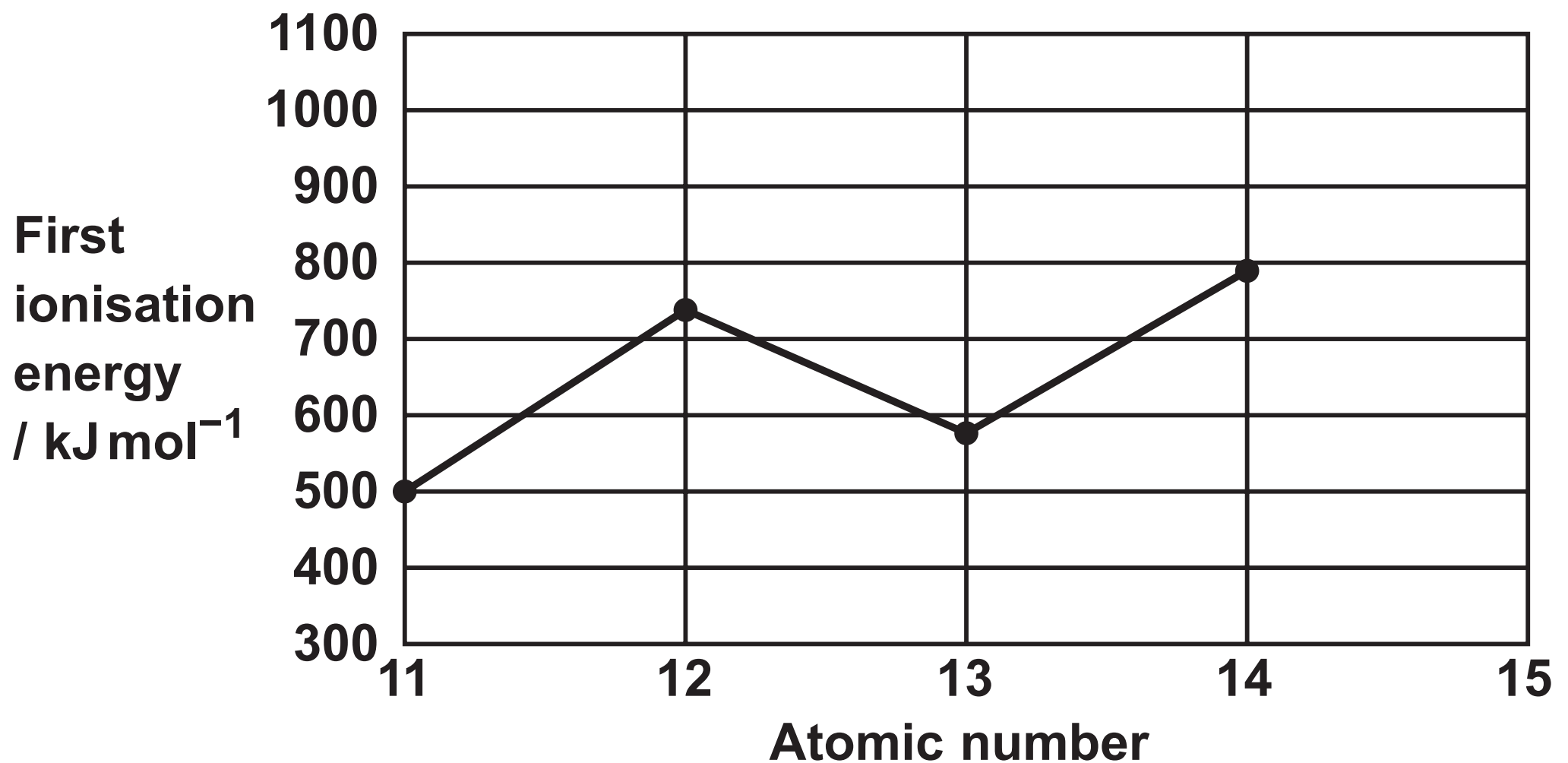
(TOTAL FOR QUESTION 5 = 1 MARK)

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(Questions continue on next page)

(Turn over)

- 6 The diagram shows the first ionisation energy for the elements from sodium to silicon.



What is the approximate first ionisation energy, in  $\text{kJ mol}^{-1}$ , of phosphorus (atomic number 15)?

- ☐ A 400
- ☐ B 500
- ☐ C 700
- ☐ D 1000

(TOTAL FOR QUESTION 6 = 1 MARK)

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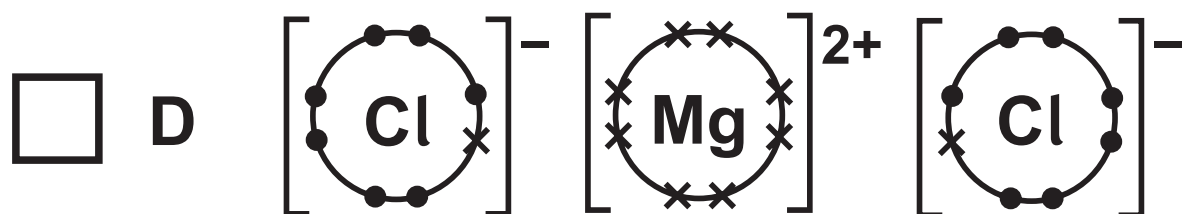
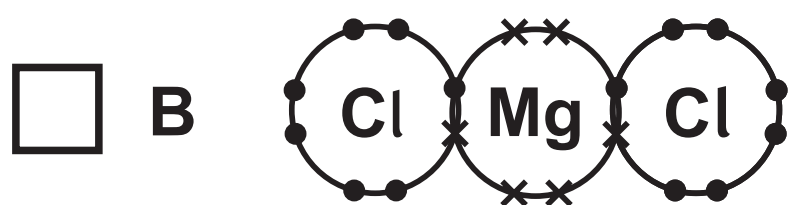
(Questions continue on next page)

(Turn over)



7 Which is the dot-and-cross diagram for magnesium chloride?

Only outer shell electrons are shown.



(TOTAL FOR QUESTION 7 = 1 MARK)

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(Questions continue on next page)

(Turn over)

**8 Metallic bonding is the strong electrostatic attraction between**

- ☐ **A anions and cations**
- ☐ **B atoms and delocalised electrons**
- ☐ **C ions and delocalised electrons**
- ☐ **D two nuclei and a shared pair of electrons**

**(TOTAL FOR QUESTION 8 = 1 MARK)**

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**9 The ionic radius of  $\text{Al}^{3+}$  is smaller than that of  $\text{N}^{3-}$ .**

**This is because  $\text{Al}^{3+}$  has**

- ☐ **A fewer protons but more electrons than  $\text{N}^{3-}$**
- ☐ **B more protons but fewer electrons than  $\text{N}^{3-}$**
- ☐ **C more protons than  $\text{N}^{3-}$  but the same number of electrons as  $\text{N}^{3-}$**
- ☐ **D the same number of protons as  $\text{N}^{3-}$  but fewer electrons**

**(TOTAL FOR QUESTION 9 = 1 MARK)**

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**(Questions continue on next page)**

**(Turn over)**

10 Which ion has the greatest polarising power?

☐ A  $\text{Cl}^-$

☐ B  $\text{Mg}^{2+}$

☐ C  $\text{Na}^+$

☐ D  $\text{S}^{2-}$

(TOTAL FOR QUESTION 10 = 1 MARK)

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11 Which species is NOT tetrahedral?

☐ A  $\text{CCl}_4$

☐ B  $\text{CH}_4$

☐ C  $\text{ICl}_4^-$

☐ D  $\text{NH}_4^+$

(TOTAL FOR QUESTION 11 = 1 MARK)

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(Questions continue on next page)

(Turn over)

**12 Members of the homologous series of alkanes have the same**

- ☐ **A boiling temperature**
- ☐ **B density**
- ☐ **C empirical formula**
- ☐ **D general formula**

**(TOTAL FOR QUESTION 12 = 1 MARK)**

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**13 An electrophile**

- ☐ **A accepts a pair of electrons**
- ☐ **B always has a negative charge**
- ☐ **C always has a positive charge**
- ☐ **D donates a pair of electrons**

**(TOTAL FOR QUESTION 13 = 1 MARK)**

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**(Questions continue on next page)**

**(Turn over)**

14 What is the total number of structural isomers with the molecular formula  $C_6H_{14}$ ?

☐ A 4

☐ B 5

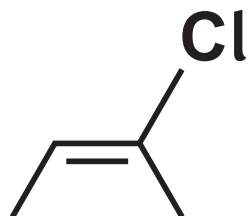
☐ C 6

☐ D 7

(TOTAL FOR QUESTION 14 = 1 MARK)

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15 What is the systematic name of compound X?



Compound X

☐ A E-2-chlorobut-2-ene

☐ B Z-2-chlorobut-2-ene

☐ C E-3-chlorobut-2-ene

☐ D Z-3-chlorobut-2-ene

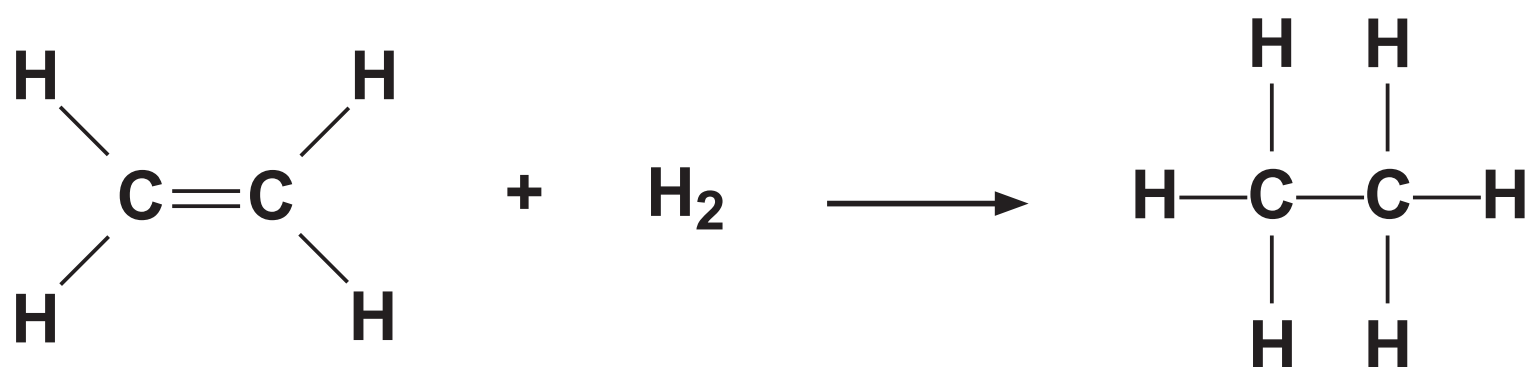
(TOTAL FOR QUESTION 15 = 1 MARK)

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(Questions continue on next page)

(Turn over)

- 16 Ethene reacts with hydrogen in the presence of a heated nickel catalyst to form ethane.



Which types of bond are broken and formed in this reaction?

	Bonds broken	Bonds formed
<input type="checkbox"/> A	$\sigma$ only	$\pi$ only
<input type="checkbox"/> B	$\pi$ only	$\sigma$ only
<input type="checkbox"/> C	$\sigma$ and $\pi$	$\sigma$ only
<input type="checkbox"/> D	$\sigma$ and $\pi$	$\pi$ only

(TOTAL FOR QUESTION 16 = 1 MARK)

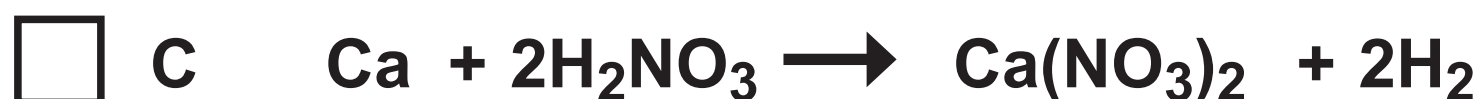
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(Questions continue on next page)

(Turn over)

- 17 Calcium reacts with dilute nitric acid to form calcium nitrate and hydrogen.

Which is the balanced equation for this reaction?



(TOTAL FOR QUESTION 17 = 1 MARK)

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- 18 What mass of anhydrous sodium carbonate is needed to make  $50.0\text{ cm}^3$  of a  $0.0800\text{ mol dm}^{-3}$  solution of sodium carbonate,  $\text{Na}_2\text{CO}_3$ ?

[ $A_r$  values: C = 12.0, O = 16.0, Na = 23.0]



(TOTAL FOR QUESTION 18 = 1 MARK)

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- 19 A sample of air, with a mass of 5.0 kg, contained carbon monoxide with a concentration of 12 parts per million by mass.

What is the mass of carbon monoxide in this sample of air?

☐ A  $6.0 \times 10^{-2} \text{ g}$

☐ B  $6.0 \times 10^{-5} \text{ g}$

☐ C  $2.4 \times 10^{-6} \text{ g}$

☐ D  $2.4 \times 10^{-9} \text{ g}$

(TOTAL FOR QUESTION 19 = 1 MARK)

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(Questions continue on next page)

(Turn over)



- 20 What is the maximum volume of hydrogen formed, at room temperature and pressure (r.t.p.), when 0.207 g of lithium is added to excess water?



[ $A_r\text{Li} = 6.9$  Molar volume of gas at r.t.p. =  $24.0\text{ dm}^3\text{ mol}^{-1}$ ]

☐ A 0.36 dm<sup>3</sup>

☐ B 0.72 dm<sup>3</sup>

☐ C 1.44 dm<sup>3</sup>

☐ D 2.48 dm<sup>3</sup>

(TOTAL FOR QUESTION 20 = 1 MARK)

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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.**

**21 Heptane,  $C_7H_{16}$  , is one of the compounds present in crude oil.**

**(a) When heptane is reformed, the products include 2,2,3-trimethylbutane and cycloheptane.**

**(i) Give a reason why petrol should NOT contain a high proportion of heptane. (1 mark)**

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**(Question continues on next page)**

**(Turn over)**

(ii) Draw the **SKELETAL** formula of 2,2,3-trimethylbutane. (1 mark)

(iii) Write the equation for reforming heptane into cycloheptane.  
Use **MOLECULAR** formulae.

State symbols are not required. (1 mark)

(Question continues on next page)

(Turn over)

**(iv) When petrol is burned in a car engine, oxides of nitrogen are formed.**

**Explain how these compounds result in damage to trees. (2 marks)**

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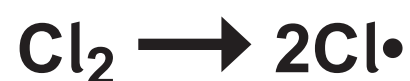
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**(b) Heptane reacts with chlorine in sunlight.**

- (i) Chlorine radicals are formed in the first step in the mechanism.**



**Name this step in the mechanism. (1 mark)**

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- (ii) Give the TWO propagation steps for the formation of chloroheptane.  
Use molecular formulae. Curly arrows are NOT required. (2 marks)**

**(Question continues on next page)**

**(Turn over)**

- (iii) Give the termination step which forms a hydrocarbon. (1 mark)

(Question continues on next page)

- (iv) Explain how some dichloroheptane,  $\text{C}_7\text{H}_{14}\text{Cl}_2$ , also forms during this reaction.

You may include equation(s) in your answer.  
(2 marks)

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**(TOTAL FOR QUESTION 21 = 11 MARKS)**

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**(Questions continue on next page)**

**(Turn over)**

**22 This question is about nitrogen.**

**(a) The table shows the successive ionisation energies of nitrogen.**

<b>Ionisation number</b>	<b>Ionisation energy / kJ mol<sup>-1</sup></b>	<b>log (ionisation energy)</b>
<b>1</b>	<b>1 402</b>	<b>3·15</b>
<b>2</b>	<b>2 856</b>	<b>3·46</b>
<b>3</b>	<b>4 578</b>	<b>3·66</b>
<b>4</b>	<b>7 475</b>	<b>3·87</b>
<b>5</b>	<b>9 445</b>	<b>3·98</b>
<b>6</b>	<b>53 268</b>	
<b>7</b>	<b>64 362</b>	

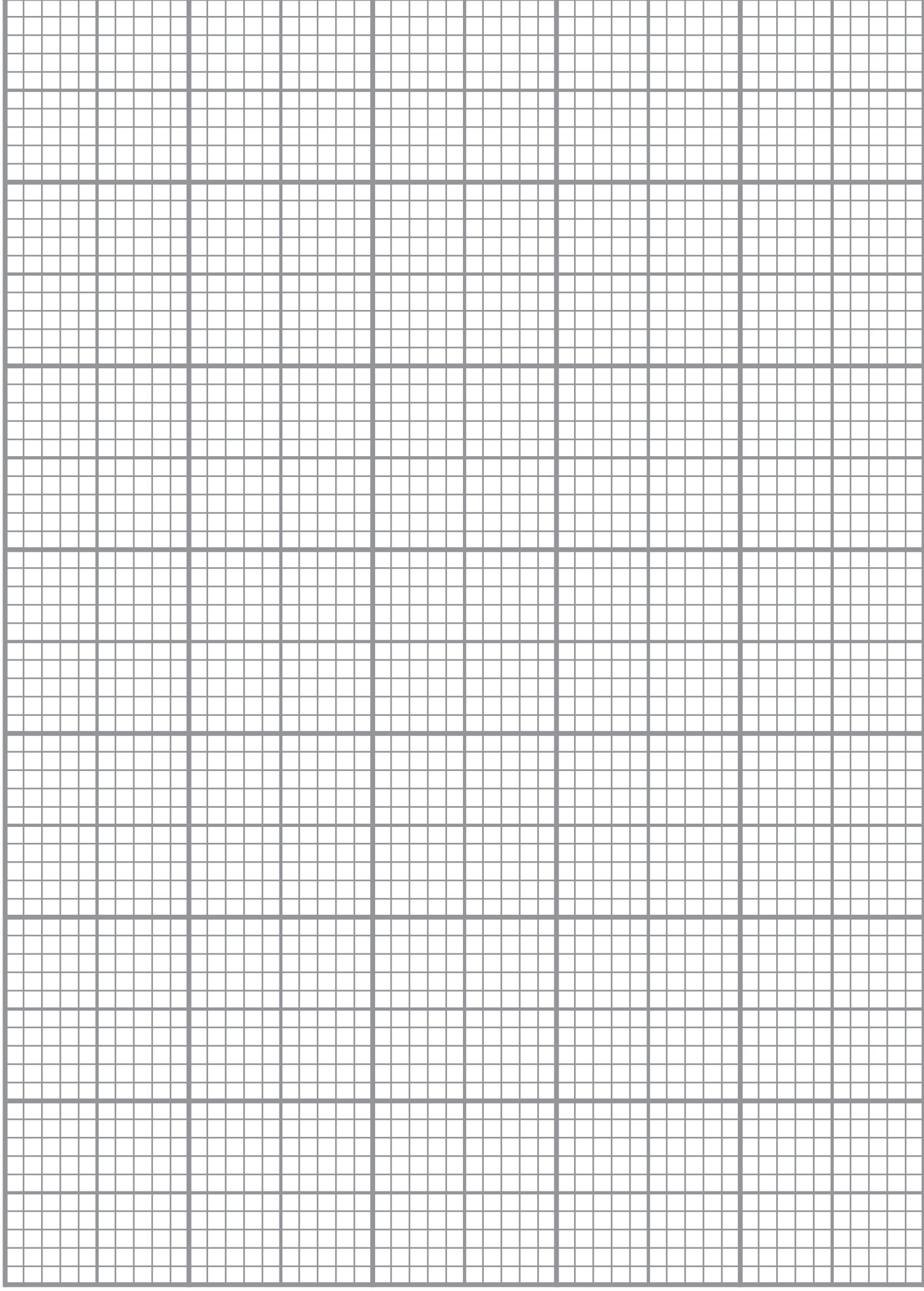
**(i) Complete the table. (1 mark)**

**(Question continues on next page)**

**(Turn over)**



**(ii) Plot a graph of log (ionisation energy) against ionisation number. (3 marks)**



- (iii) Give a reason why the logarithm of the ionisation energy, rather than just the ionisation energy, is used to plot this graph.  
(1 mark)

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(Question continues on next page)

- (iv) Explain what can be deduced from the graph about the electronic structure of nitrogen.  
(3 marks)

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- (v) Explain why the first ionisation energy of oxygen is lower than that of nitrogen.  
(3 marks)

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**(b) Nitrogen gas consists of nitrogen molecules.**

- (i) Draw a dot-and-cross diagram to show the bonding in a molecule of nitrogen. (1 mark)**

**(Question continues on next page)**

- (ii) Calculate the number of nitrogen ATOMS in 5.60 g of nitrogen gas. (2 marks)

[Avogadro constant =  $6.02 \times 10^{23} \text{ mol}^{-1}$ ]

- (iii) A sample of nitrogen gas occupied  $108\text{ cm}^3$  at a temperature of  $25^\circ\text{C}$  and a pressure of  $1.36 \times 10^5\text{ Pa}$ .

Using the ideal gas equation, calculate the number of moles of nitrogen gas in this sample. (4 marks)

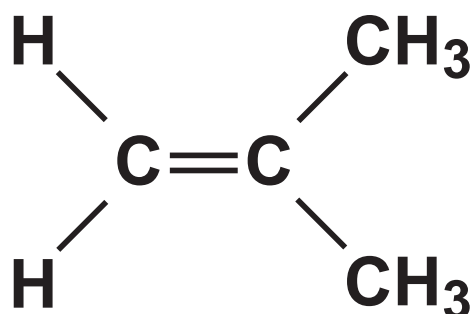
$$[pV = nRT \quad R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}]$$

**(TOTAL FOR QUESTION 22 = 18 MARKS)**

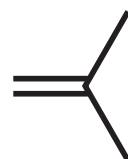
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23 This question is about the alkene 2-methylpropene.

The formulae show two different ways of representing a molecule of 2-methylpropene.



formula 1



formula 2

(a) Give the EMPIRICAL formula of 2-methylpropene.  
(1 mark)

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(Question continues on next page)



**(b) Give a reason why 2-methylpropene does NOT show geometric isomerism. (1 mark)**

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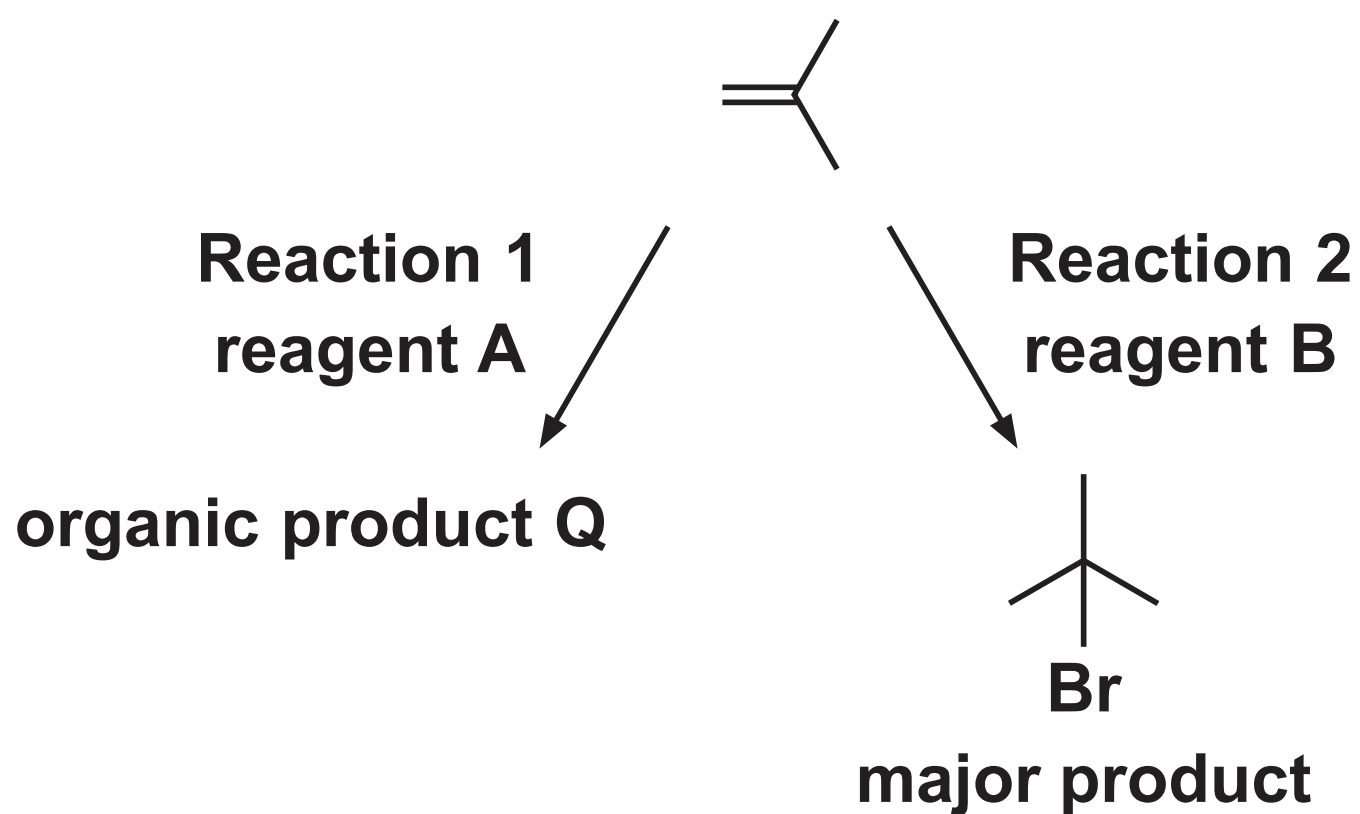
**(Question continues on next page)**

- (c) Draw the mechanism for the reaction between 2-methylpropene and bromine,  $\text{Br}_2$ . Include curly arrows, and relevant lone pairs and dipoles. Use formula 1 to represent 2-methylpropene. (4 marks)**

**(Question continues on next page)**

**(Turn over)**

(d) Two reactions of 2-methylpropene are shown.



- (i) In Reaction 1 the reagent A is acidified potassium manganate(VII).

Give the **SKELETAL** formula of organic product Q. (1 mark)

(Question continues on next page)

(Turn over)

**(ii) Give the colour change seen during Reaction 1. (1 mark)**

**From** \_\_\_\_\_

**To** \_\_\_\_\_

**(iii) Identify, by name or formula, reagent B in Reaction 2. (1 mark)**

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**(Question continues on next page)**

- (iv) Explain why 2-bromo-2-methylpropane is the major organic product in Reaction 2. (2 marks)

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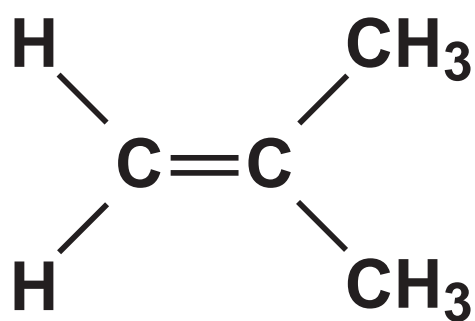
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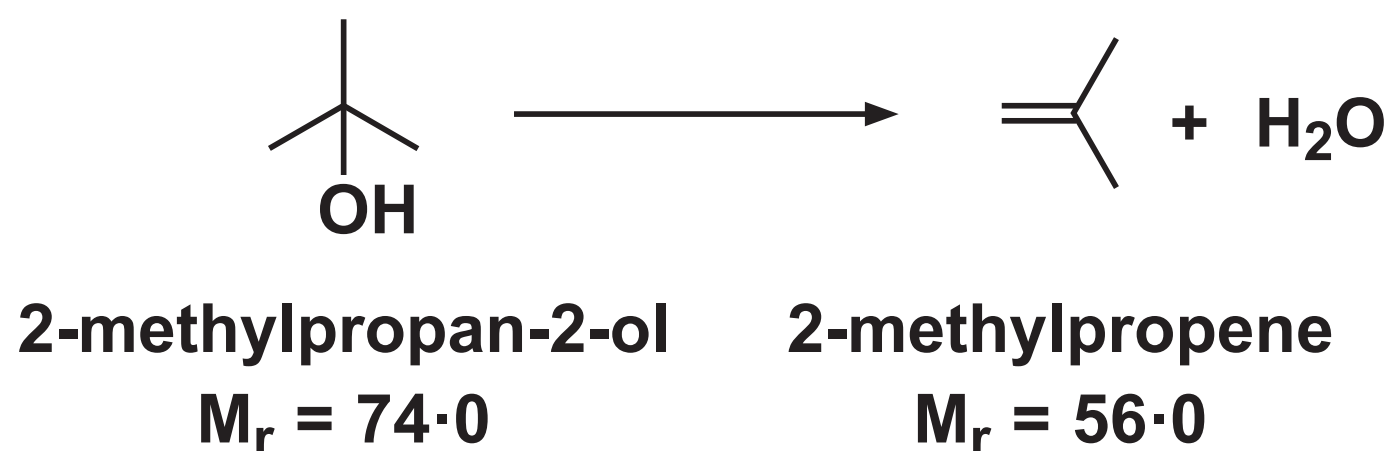
(Turn over)

- (e) Draw TWO repeat units of poly(2-methylpropene).  
(2 marks)



2-methylpropene

- (f) A sample of 2-methylpropene was prepared from 2-methylpropan-2-ol.



The yield of this reaction was 58.2%.

Calculate the mass of 2-methylpropene formed from 6.85 g of 2-methylpropan-2-ol.

Give your answer to an appropriate number of significant figures. (4 marks)

**(TOTAL FOR QUESTION 23 = 17 MARKS)**

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**(Questions continue on next page)**

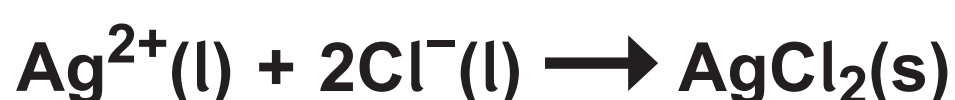
**(Turn over)**



**24 This question is about compounds containing chlorine.**

- (a) A precipitate of silver chloride is formed when silver nitrate solution reacts with sodium chloride solution.**

**A student wrote an ionic equation for the reaction.**



**Explain why this equation is incorrect, even though it is balanced. (2 marks)**

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- (b) A sample of a compound is analysed and found to contain ONLY 3.09 g carbon, 0.26 g hydrogen and 9.15 g chlorine.

The molar mass of the compound is  $97.0 \text{ g mol}^{-1}$ .

Calculate the molecular formula of this compound.  
You MUST show your working. (3 marks)

(Question continues on next page)

(Turn over)

**(c) Nitrogen trichloride has the formula  $\text{NCl}_3$ .**

- (i) A sample of nitrogen trichloride contained only nitrogen atoms with mass number 14, and chlorine atoms with mass numbers 35 and 37.**

**Give the formula and mass/charge ratio for each of the FOUR ions responsible for the molecular ion peaks in the mass spectrum of nitrogen trichloride. (2 marks)**

- (ii) Complete the table to predict the shape and Cl—N—Cl bond angle in nitrogen trichloride.  
(3 marks)

Number of bonding pairs of electrons on nitrogen	
Number of lone pairs of electrons on nitrogen	
Shape of molecule	
Cl—N—Cl bond angle	

(Question continues on next page)

**(d) Aluminium chloride exists as an ionic lattice in the solid state and as a covalent dimer,  $\text{Al}_2\text{Cl}_6$ , in the gas phase, just above its boiling temperature.**

**(i) Explain why aluminium chloride in the solid state has significant covalent character. (2 marks)**

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- (ii) Describe how two  $\text{AlCl}_3$  molecules are joined together in the dimer.  
Include a diagram in your answer. (2 marks)

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**(TOTAL FOR QUESTION 24 = 14 MARKS)**

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**TOTAL FOR SECTION B = 60 MARKS**

**TOTAL FOR PAPER = 80 MARKS**

**END**