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| Centre Number        |                      |                      |                      |                      | Candidate Number     |                      |                      |                      |  |
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**Pearson Edexcel International Advanced Level**

**Time** 1 hour 30 minutes

**Paper reference** **WCH11/01**

**Chemistry**

**International Advanced Subsidiary/Advanced Level**

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

|                                                        |                    |
|--------------------------------------------------------|--------------------|
| <p><b>You must have:</b><br/>Scientific calculator</p> | <p>Total Marks</p> |
|--------------------------------------------------------|--------------------|

## 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.*
- 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.
- 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 Element **X** is in Group 2 of the Periodic Table and element **Y** is in Group 7.  
**X** and **Y** are not the symbols of the elements.

(a) What is the formula of the compound formed from **X** and **Y**?

(1)

- ☐ **A** **XY**  
☐ **B** **X<sub>2</sub>Y**  
☐ **C** **XY<sub>2</sub>**  
☐ **D** **X<sub>2</sub>Y<sub>2</sub>**

(b) Under what conditions does the compound formed from **X** and **Y** conduct electricity?

(1)

- ☐ **A** in the solid state and in the liquid state and in aqueous solution  
☐ **B** in the solid state and in aqueous solution only  
☐ **C** in the solid state and in the liquid state only  
☐ **D** in the liquid state and in aqueous solution only

(Total for Question 1 = 2 marks)

- 2 Which of these compounds would you expect to have the highest melting temperature?

- ☐ **A** NaCl  
☐ **B** NaF  
☐ **C** KCl  
☐ **D** KF

(Total for Question 2 = 1 mark)

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



- 3 A drop of an aqueous solution of green copper(II) chromate(VI) is placed in the centre of a strip of damp filter paper.

The ends of the filter paper are connected to a DC power supply.

What is observed after a few minutes?

- ☐ A a green colour has moved to the negative end
- ☐ B a green colour has moved to the positive end
- ☐ C a yellow colour has moved to the positive end and a blue colour to the negative end
- ☐ D a blue colour has moved to the positive end and a yellow colour to the negative end

(Total for Question 3 = 1 mark)

- 4 Which of these isoelectronic ions has the smallest ionic radius?

- ☐ A  $\text{N}^{3-}$
- ☐ B  $\text{F}^-$
- ☐ C  $\text{Na}^+$
- ☐ D  $\text{Al}^{3+}$

(Total for Question 4 = 1 mark)

- 5 Which properties of a **cation** result in the greatest polarising power?

- ☐ A large radius and large charge
- ☐ B large radius and small charge
- ☐ C small radius and small charge
- ☐ D small radius and large charge

(Total for Question 5 = 1 mark)

- 6 Which properties of an **anion** result in it being most easily polarised?

- ☐ A large radius and large charge
- ☐ B large radius and small charge
- ☐ C small radius and small charge
- ☐ D small radius and large charge

(Total for Question 6 = 1 mark)



7 What is the ionic equation for the reaction between aqueous solutions of barium nitrate and sodium sulfate?

- ☐ A  $\text{Na}^+(\text{aq}) + \text{NO}_3^-(\text{aq}) \rightarrow \text{NaNO}_3(\text{s})$
- ☐ B  $2\text{Ba}^+(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{Ba}_2\text{SO}_4(\text{s})$
- ☐ C  $\text{Na}^{2+}(\text{aq}) + 2\text{NO}_3^-(\text{aq}) \rightarrow \text{Na}(\text{NO}_3)_2(\text{s})$
- ☐ D  $\text{Ba}^{2+}(\text{aq}) + \text{SO}_4^{2-}(\text{aq}) \rightarrow \text{BaSO}_4(\text{s})$

(Total for Question 7 = 1 mark)

8 Which of these molecules is **not** polar?

- ☐ A  $\text{CO}_2$
- ☐ B  $\text{HCl}$
- ☐ C  $\text{H}_2\text{O}$
- ☐ D  $\text{NH}_3$

(Total for Question 8 = 1 mark)

9 The concentration of nitrogen dioxide in a sample of air is 0.5 ppm.

What is the percentage of nitrogen dioxide molecules in this sample of air?

- ☐ A 0.5 %
- ☐ B 0.005 %
- ☐ C 0.00005 %
- ☐ D 0.0000005 %

(Total for Question 9 = 1 mark)

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



10 Ethane reacts with bromine in the presence of ultraviolet radiation.

(a) What is the equation for the reaction?

(1)

- ☐ A  $\text{C}_2\text{H}_6 + \text{Br}_2 \rightarrow \text{C}_2\text{H}_4\text{Br}_2 + \text{H}_2$
- ☐ B  $\text{C}_2\text{H}_6 + \text{Br}_2 \rightarrow \text{C}_2\text{H}_5\text{Br} + \text{HBr}$
- ☐ C  $\text{C}_2\text{H}_6 + \text{Br}_2 \rightarrow 2\text{CH}_3\text{Br}$
- ☐ D  $\text{C}_2\text{H}_6 + \text{Br}_2 \rightarrow \text{CH}_4 + \text{CH}_2\text{Br}_2$

(b) The ultraviolet radiation is needed for

(1)

- ☐ A homolytic breaking of a Br—Br bond
- ☐ B heterolytic breaking of a Br—Br bond
- ☐ C homolytic breaking of a C—H bond
- ☐ D heterolytic breaking of a C—H bond

(Total for Question 10 = 2 marks)

11 All alkanes have the same

- ☐ A empirical formula
- ☐ B general formula
- ☐ C molecular formula
- ☐ D structural formula

(Total for Question 11 = 1 mark)

12 A single molecule of decane,  $\text{C}_{10}\text{H}_{22}$ , is cracked.

Which of these mixtures could **not** be formed?

- ☐ A pentene and pentane
- ☐ B ethene, butene and butane
- ☐ C propene, propane and butene
- ☐ D hexene and propane

(Total for Question 12 = 1 mark)

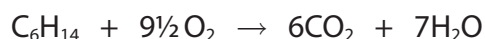


13 How many structural isomers have the formula  $\text{C}_3\text{H}_6\text{Cl}_2$ ?

- ☐ A 2
- ☐ B 3
- ☐ C 4
- ☐ D 5

(Total for Question 13 = 1 mark)

14 The equation for the complete combustion of hexane is shown.



How many molecules of carbon dioxide are formed when  $2 \times 10^{-3}$  mol of hexane undergoes complete combustion?

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

- ☐ A  $1.20 \times 10^{21}$
- ☐ B  $7.22 \times 10^{21}$
- ☐ C  $8.43 \times 10^{21}$
- ☐ D  $3.18 \times 10^{23}$

(Total for Question 14 = 1 mark)

15 Which pollutant **cannot** form when alkane fuels are burned in car engines?

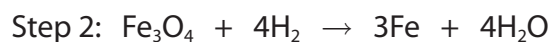
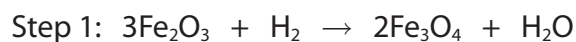
- ☐ A hydrogen chloride
- ☐ B sulfur dioxide
- ☐ C carbon particulates
- ☐ D carbon monoxide

(Total for Question 15 = 1 mark)

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



**16** Iron(III) oxide is reduced by hydrogen in a two-step process.



What is the maximum mass of iron that could be produced from 39.9 tonnes of  $\text{Fe}_2\text{O}_3$ ?

[ $A_r$  values: H = 1.0 O = 16.0 Fe = 55.8]

- ☐ **A** 6.98 tonnes
- ☐ **B** 13.95 tonnes
- ☐ **C** 27.90 tonnes
- ☐ **D** 41.85 tonnes

(Total for Question 16 = 1 mark)

**17** Which of these solutions contains the greatest number of ions?

- ☐ **A** 20.0 cm<sup>3</sup> of 0.5 mol dm<sup>-3</sup> KCl
- ☐ **B** 0.40 dm<sup>3</sup> of 0.03 mol dm<sup>-3</sup> KCl
- ☐ **C** 10.0 cm<sup>3</sup> of 0.6 mol dm<sup>-3</sup> CaCl<sub>2</sub>
- ☐ **D** 0.15 dm<sup>3</sup> of 0.04 mol dm<sup>-3</sup> CaCl<sub>2</sub>

(Total for Question 17 = 1 mark)

**18** Potassium chlorate(V) decomposes on heating to form oxygen.



What is the atom economy (by mass) for the formation of oxygen?

[ $A_r$  values: O = 16.0 Cl = 35.5 K = 39.1]

- ☐ **A** 13.1 %
- ☐ **B** 26.1 %
- ☐ **C** 39.2 %
- ☐ **D** 64.3 %

(Total for Question 18 = 1 mark)

**TOTAL FOR SECTION A = 20 MARKS**



## SECTION B

Answer ALL the questions.

Write your answers in the spaces provided.

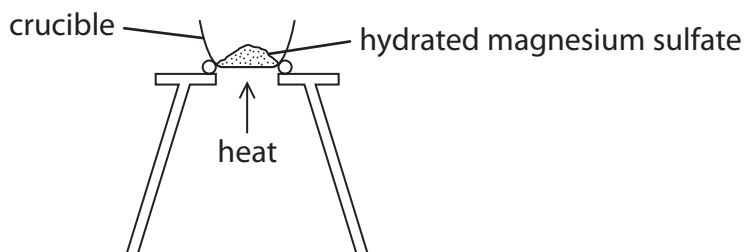
**19** This question is about the amount of water of crystallisation in hydrated magnesium sulfate,  $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ .

(a) The value of  $x$  in the formula was determined in an experiment.

### Procedure

**Step 1** A crucible was weighed, a spatula measure of hydrated magnesium sulfate was added and the crucible was reweighed.

**Step 2** The crucible containing the hydrated magnesium sulfate was heated using the apparatus shown.



**Step 3** After heating for two minutes, the crucible containing the magnesium sulfate was allowed to cool and was reweighed.

(i) Complete the table of results.

(1)

| Measurement                                                          | Mass / g |
|----------------------------------------------------------------------|----------|
| Mass of empty crucible                                               | 21.21    |
| Mass of crucible and hydrated magnesium sulfate before heating       | 26.71    |
| Mass of crucible and magnesium sulfate after heating for two minutes | 24.12    |
| Mass of magnesium sulfate after heating for two minutes              |          |
| Mass of water lost                                                   |          |



- (ii) Use these results to calculate the value of  $x$  in  $\text{MgSO}_4 \cdot x\text{H}_2\text{O}$ .  
Give your answer to the nearest whole number.

[ $A_r$  values: H = 1.0 O = 16.0 Mg = 24.3 S = 32.1]

(4)

- (b) The correct value of  $x$  is greater than the value calculated in (a) (ii).

Suggest a way of improving the method to obtain a more accurate result,  
using the same apparatus.  
Justify your answer.

(2)

(Total for Question 19 = 7 marks)



**20** This question is about copper and its compounds.

(a) Complete the electronic configurations of Cu and Cu<sup>2+</sup>.

(2)

Cu [Ar].....

Cu<sup>2+</sup> [Ar].....

(b) A sample of copper contains the isotopes <sup>63</sup>Cu and <sup>65</sup>Cu.

(i) Complete the table to show the numbers of subatomic particles in the atoms of these two isotopes of copper.

(2)

| Isotope          | Protons | Neutrons | Electrons |
|------------------|---------|----------|-----------|
| <sup>63</sup> Cu |         |          |           |
| <sup>65</sup> Cu |         |          |           |

(ii) Explain the term isotopes, using the information in the table.

(2)

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(iii) State why the two isotopes of copper have the same chemical reactions.

(1)

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(iv) The relative atomic mass of copper in this sample is 63.4.

Calculate the percentage abundances of the isotopes  $^{63}\text{Cu}$  and  $^{65}\text{Cu}$  in this sample.

You **must** show your working.

(2)

(c) Copper(II) sulfate,  $\text{CuSO}_4$ , can be made by reacting solid copper(II) carbonate with dilute sulfuric acid.

- (i) Write an equation for the reaction that occurs.  
State symbols are not required.

(1)



- (ii) An experiment was carried out to produce pure, dry crystals of hydrated copper(II) sulfate,  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$ .  
Copper(II) carbonate was mixed with  $50.0\text{ cm}^3$  of  $1.00\text{ mol dm}^{-3}$  sulfuric acid until no more reacted.  
The mass of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$  obtained was  $10.87\text{ g}$ .

Calculate the percentage yield for this reaction, giving your answer to an appropriate number of significant figures.

[Molar mass of  $\text{CuSO}_4 \cdot 5\text{H}_2\text{O} = 249.6\text{ g mol}^{-1}$ ]

(4)

(Total for Question 20 = 14 marks)



21 This question is about alkenes.

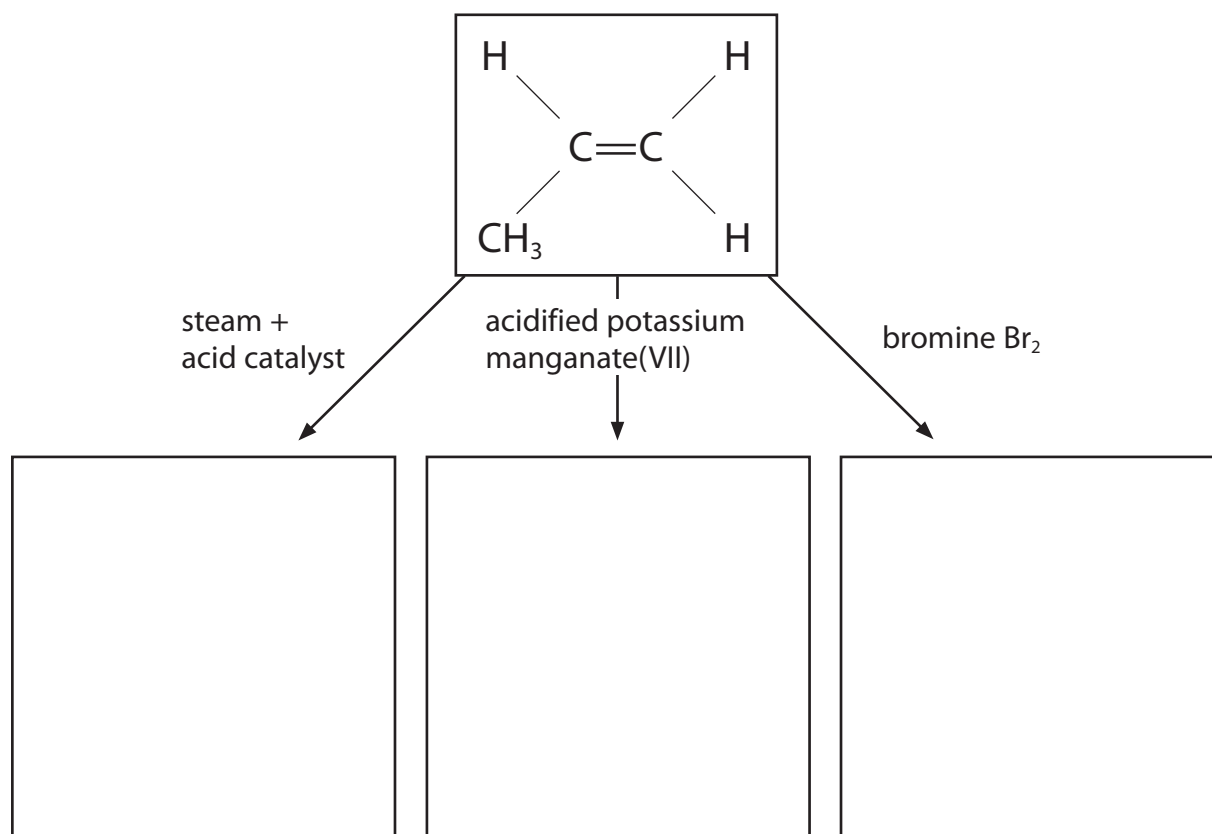
Alkenes contain a carbon to carbon double bond that consists of a  $\sigma$  bond and a  $\pi$  bond.

- (a) Complete the diagram to show the areas of electron density for each bond. Label the  $\sigma$  bond and the  $\pi$  bond.

(2)



- (b) Propene,  $C_3H_6$ , is an alkene. The reagents needed for three reactions of propene are shown.



- (i) In each box, draw the structure of the organic product of the reaction.

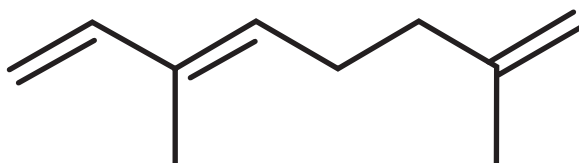
(3)

(ii) Propene also reacts with hydrogen bromide, HBr.

Give the mechanism for this reaction to form the **major** product.  
Include curly arrows, and relevant lone pairs and dipoles.

(3)

(c) Alpha-ocimene contains three carbon to carbon double bonds. It is found in plants and has a sweet smell. The skeletal formula of alpha-ocimene is shown.

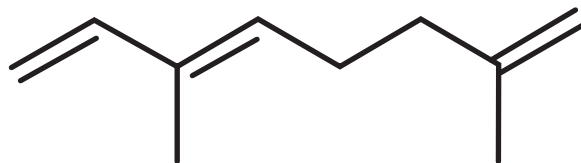


(i) Give the molecular formula of alpha-ocimene.

(1)

- (ii) On the skeletal formula, draw a circle around the part of the molecule that gives rise to the geometric isomerism of alpha-ocimene.

(1)



- (iii) Draw the **skeletal** formula of the other geometric isomer of alpha-ocimene.

(1)

- (iv) In an experiment, 0.050 mol of alpha-ocimene reacted with 3.6 dm<sup>3</sup> of hydrogen, H<sub>2</sub>, in the presence of a catalyst.

Deduce the structure of the product of this reaction.  
You **must** show your working.

[Molar volume of H<sub>2</sub> = 24 dm<sup>3</sup> mol<sup>-1</sup>]

(3)

Calculation

Structure

(Total for Question 21 = 14 marks)

**22** This question is about the bonding in the elements of Period 3 in the Periodic Table.

The melting temperatures of the Period 3 elements are shown in the table.

| Element                  | Na | Mg  | Al  | Si   | P  | S   | Cl   | Ar   |
|--------------------------|----|-----|-----|------|----|-----|------|------|
| Melting temperature / °C | 98 | 650 | 660 | 1423 | 44 | 120 | -101 | -189 |

(a) Sodium, magnesium and aluminium are metals.

(i) State what is meant by metallic bonding.

(1)

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(ii) Melting temperature depends on the strength of metallic bonding.

Explain why the metallic bonding in magnesium is much stronger than that in sodium.

(3)

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- (b) (i) In the elements silicon, phosphorus, sulfur and chlorine, the atoms are joined by covalent bonds.

Describe the attraction between the atoms in a covalent bond.

(1)

- (ii) Explain why the melting temperature of silicon is much higher than that of phosphorus, by referring to their structures.

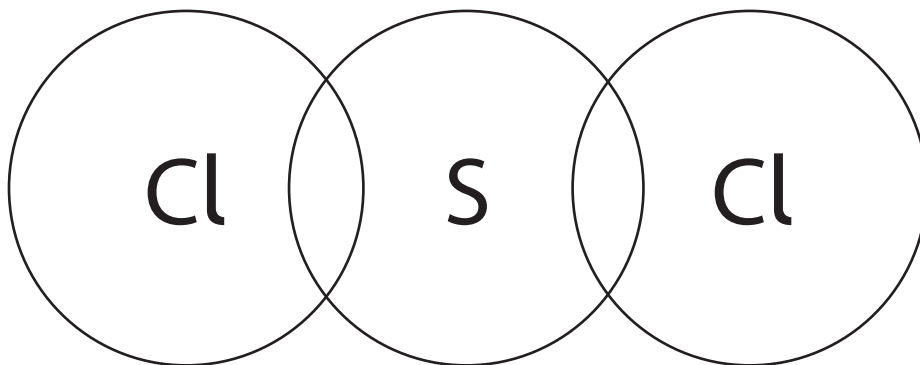
(3)



(c) Sulfur reacts with chlorine to form sulfur dichloride,  $\text{SCl}_2$ .

- (i) Complete the dot-and-cross diagram of a molecule of sulfur dichloride.  
Use dots (•) for the chlorine electrons and crosses (x) for the sulfur electrons.  
Show the outer shell electrons only.

(2)



- (ii) Suggest a value for the  $\text{Cl—S—Cl}$  bond angle. Justify your answer.

(3)

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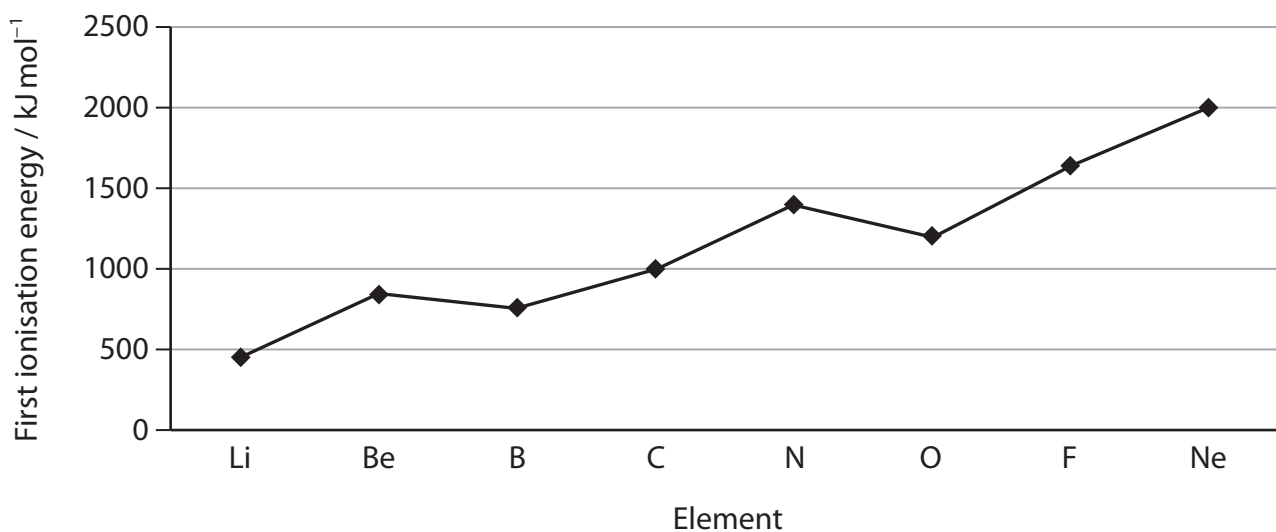
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(Total for Question 22 = 13 marks)

**23** This question is about the ionisation energies of the elements in Period 2 of the Periodic Table.

(a) The first ionisation energies of the Period 2 elements are shown.



(i) Give an equation that represents the first ionisation energy of lithium. Include state symbols.

(1)

(ii) Explain why there is a general increase in the first ionisation energy across the period.

(2)

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(iii) Explain why the first ionisation energy of oxygen is lower than that of nitrogen.

(2)

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(b) All the successive ionisation energies of nitrogen are shown in the table.

| Ionisation number                        | 1    | 2    | 3    | 4    | 5    | 6      | 7      |
|------------------------------------------|------|------|------|------|------|--------|--------|
| Ionisation energy / $\text{kJ mol}^{-1}$ | 1402 | 2856 | 4578 | 7475 | 9445 | 53 267 | 64 360 |

Explain the trend in the successive ionisation energies of nitrogen.

(2)

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**(Total for Question 23 = 7 marks)**



**24** A 0.210 g sample of a volatile organic liquid **C** is injected into a gas syringe and heated in an oven.

At 100 kPa and 358 K, the syringe contains 72.5 cm<sup>3</sup> of gas.

(a) Calculate the molar mass of **C**.

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

(4)

(b) The organic liquid **C** is a hydrocarbon.

Give a possible name or formula for **C**, using your answer in (a).

(1)

(Total for Question 24 = 5 marks)

**TOTAL FOR SECTION B = 60 MARKS**

**TOTAL FOR PAPER = 80 MARKS**



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# The Periodic Table of Elements

[illegible]

Elements with atomic numbers 112-116 have been reported but not fully authenticated

|                     |     |           |              |     |
|---------------------|-----|-----------|--------------|-----|
| * Lanthanide series | 140 | <b>Ce</b> | cerium       | 58  |
|                     | 141 | <b>Pr</b> | praseodymium | 59  |
|                     | 144 | <b>Nd</b> | neodymium    | 60  |
|                     | 147 | <b>Pm</b> | promethium   | 61  |
|                     | 150 | <b>Sm</b> | samarium     | 62  |
|                     | 152 | <b>Eu</b> | europium     | 63  |
|                     | 157 | <b>Gd</b> | gadolinium   | 64  |
|                     | 159 | <b>Tb</b> | terbium      | 65  |
|                     | 163 | <b>Dy</b> | dysprosium   | 66  |
|                     | 165 | <b>Ho</b> | holmium      | 67  |
|                     | 167 | <b>Er</b> | erbium       | 68  |
|                     | 169 | <b>Tm</b> | thulium      | 69  |
|                     | 173 | <b>Yb</b> | ytterbium    | 70  |
|                     | 175 | <b>Lu</b> | lutetium     | 71  |
| * Actinide series   | 232 | <b>Th</b> | thorium      | 90  |
|                     | 231 | <b>Pa</b> | protactinium | 91  |
|                     | 238 | <b>U</b>  | uranium      | 92  |
|                     | 237 | <b>Np</b> | neptunium    | 93  |
|                     | 242 | <b>Pu</b> | plutonium    | 94  |
|                     | 243 | <b>Am</b> | americium    | 95  |
|                     | 247 | <b>Cm</b> | curium       | 96  |
|                     | 245 | <b>Bk</b> | berkelium    | 97  |
|                     | 251 | <b>Cf</b> | californium  | 98  |
|                     | 254 | <b>Es</b> | einsteinium  | 99  |
|                     | 253 | <b>Fm</b> | fermium      | 100 |
|                     | 256 | <b>Md</b> | moscovium    | 101 |
|                     | 254 | <b>No</b> | nobelium     | 102 |
|                     | 257 | <b>Lr</b> | lawrencium   | 103 |

\* Lanthanide series

\* Actinide series

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