

|  |
|--|
|  |
|--|

|  |  |  |  |  |
|--|--|--|--|--|
|  |  |  |  |  |
|--|--|--|--|--|

|  |  |  |  |
|--|--|--|--|
|  |  |  |  |
|--|--|--|--|

0620/23

**May/June 2013**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

## READ THESE INSTRUCTIONS FIRST

Write your Centre number, candidate number and name in the spaces at the top of this page.

Write in dark blue or black pen.

You may need to use a pencil for any diagrams, graphs or rough working.

Do not use staples, paper clips, highlighters, glue or correction fluid.

DO **NOT** WRITE IN ANY BARCODES.

Answer **all** questions.

Electronic calculators may be used.

A copy of the Periodic Table is printed on page 16.

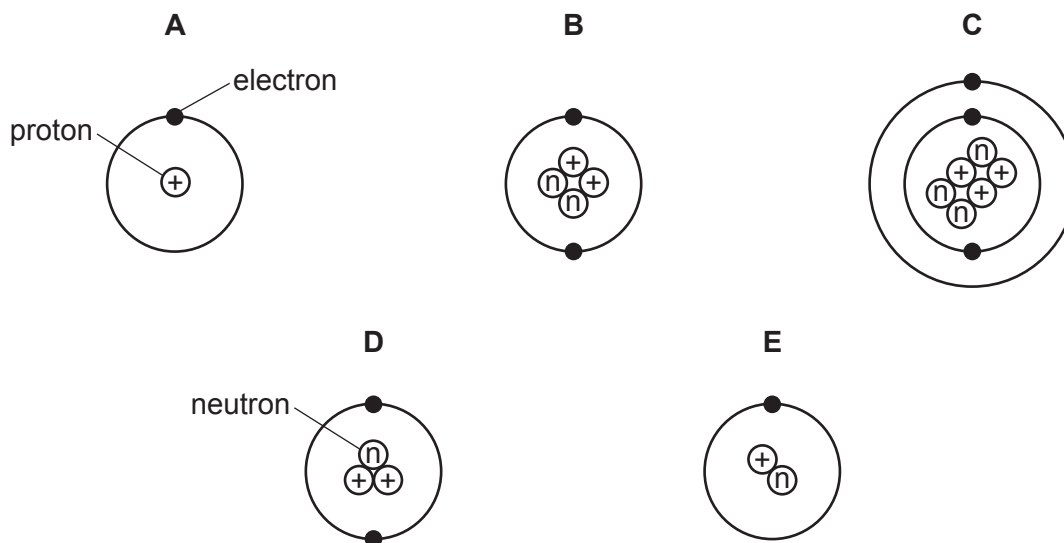
You may lose marks if you do not show your working or if you do not use appropriate units.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **14** printed pages and **2** blank pages.

- 1 The structures of five atoms, **A**, **B**, **C**, **D** and **E**, are shown below.



- (a) Answer the following questions about these structures. Each structure can be used once, more than once or not at all.

(i) Which **two** structures are hydrogen atoms? ..... and .....

(ii) Which structure represents an atom of a metal? .....

(iii) Which structure has a proton (atomic) number of 3? .....

(iv) Which structure has two neutrons in its nucleus? ..... [5]

- (b) The structure of carbon-12 can be written  $^{12}_6\text{C}$ .

Write the structure of atom **D** in a similar way.

[1]

- (c) Complete the following sentences about isotopes using words from the list below.

|          |         |             |           |
|----------|---------|-------------|-----------|
| atoms    | energy  | iron        | molecules |
| neutrons | protons | radioactive | stable    |

Isotopes are atoms of the same element with the same number of .....  
and different numbers of ..... . Some isotopes such as uranium-235 are  
..... . Uranium-235 can be used as a source of ..... [4]

[Total: 10]

2 The table shows some physical properties of the Group VII elements.

For  
Examiner's  
Use

| halogen  | melting point / °C | boiling point / °C | atomic radius / nanometres | colour      |
|----------|--------------------|--------------------|----------------------------|-------------|
| fluorine | -220               | -188               |                            | pale yellow |
| chlorine | -101               | -35                | 0.099                      |             |
| bromine  | -7                 | +59                | 0.114                      | red-brown   |
| iodine   | +114               | +184               | 0.133                      | grey-black  |

(a) Use the information in the table to explain why

(i) chlorine is a gas at room temperature, ..... [1]

(ii) bromine is a liquid at room temperature. .... [1]

(b) Describe the trend in atomic radius going down the group from chlorine to iodine.

..... [1]

(c) Suggest a value for the atomic radius of fluorine.

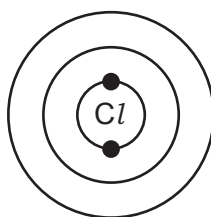
..... [1]

(d) Describe the colour of chlorine.

..... [1]

(e) A chlorine atom has 17 electrons.

Complete the following structure to show how the electrons are arranged.



[2]

(f) Chlorine reacts with potassium bromide to form potassium chloride and bromine.

(i) Complete the symbol equation for this reaction.



[2]

(ii) Explain why iodine does **not** react with potassium bromide.

..... [1]

[Total: 10]

3 Aluminium and gallium are in Group III of the Periodic Table.

(a) The heat from your hand is sufficient to melt gallium.  
Describe the change in state from solid to liquid in terms of the kinetic particle theory.  
In your answer include

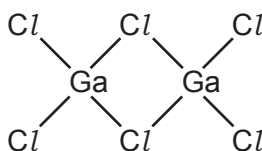
- the difference in arrangement and closeness of the particles in a solid and a liquid,
- the difference in the motion of the particles in a solid and a liquid.

.....  
.....  
.....  
.....  
..... [5]

(b) Gallium is a metal. Describe **three** physical properties of gallium which are typical of most metals.

1. ....
2. ....
3. .... [3]

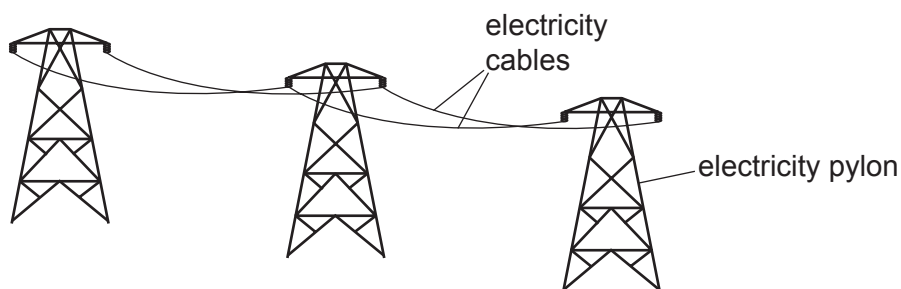
(c) When it is a gas, gallium(III) chloride has the structure shown below.



Write the molecular formula for gallium(III) chloride.

..... [1]

- (d) Aluminium is used to make high voltage electricity cables.



The table shows some properties of four metals which could be used for overhead power cables.

| metal     | relative strength | density in $\text{g/cm}^3$ | relative electrical conductivity | price \$ per tonne |
|-----------|-------------------|----------------------------|----------------------------------|--------------------|
| aluminium | 9                 | 2.70                       | 0.4                              | 2120               |
| copper    | 30                | 8.92                       | 0.7                              | 9600               |
| tungsten  | 100               | 19.35                      | 0.2                              | 450                |
| steel     | 50                | 7.86                       | 0.1                              | 700                |

- (i) Suggest why aluminium, rather than tungsten, is used in overhead power cables?

..... [1]

- (ii) Suggest why steel, rather than copper, is used as a core for overhead power cables.

..... [1]

- (iii) Give **two** reasons why aluminium is used for overhead power cables rather than copper.

1. ....

2. .... [2]

- (e) State **one** use of aluminium other than as an electrical conductor.

..... [1]

[Total: 14]

4 Impure water needs to be treated if it is to be used in the home.

(a) (i) Explain why filtration and chlorination are used in the water treatment process.

.....  
 .....  
 ..... [2]

(ii) State **one** use of water in the home.

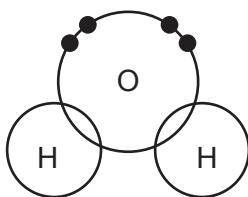
..... [1]

(b) Describe a chemical test for water.

test .....

result ..... [2]

(c) (i) Complete the diagram below to show the electron arrangement in a water molecule.



[1]

(ii) Is the bonding in water covalent or ionic?  
 Give a reason for your answer.

..... [1]

(d) Pure water is neutral. Which one of these pH values is neutral?  
 Put a ring around the correct answer.

pH 0      pH 6      pH 7      pH 9      pH 13

[1]

(e) Water reacts with sodium. The products are sodium hydroxide and hydrogen.  
 Write a word equation for this reaction.

[1]

[Total: 9]

5 Energy is given out when fuels burn.

(a) State the name given to a chemical reaction which releases energy.

..... [1]

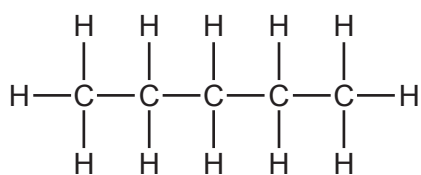
(b) Hydrogen can be used as a fuel.

Complete the symbol equation for the burning of hydrogen in oxygen.

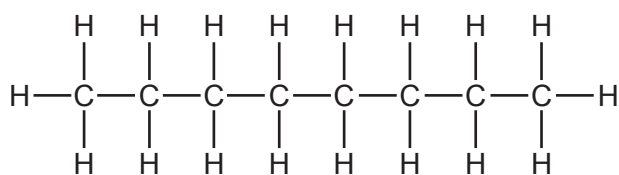


(c) Gasoline is a mixture of hydrocarbons containing between 5 and 10 carbon atoms.  
Four of these hydrocarbons are shown below.

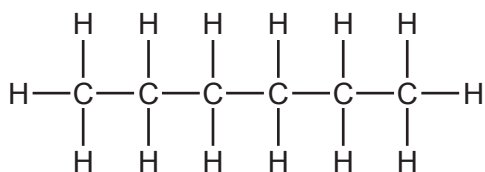
**A**



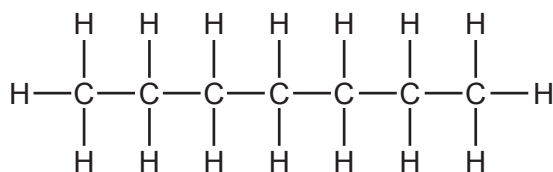
**B**



**C**



**D**



(i) Which **one** of these structures, **A**, **B**, **C** or **D**, has the highest relative molecular mass?

You are not expected to do any calculations.

..... [1]

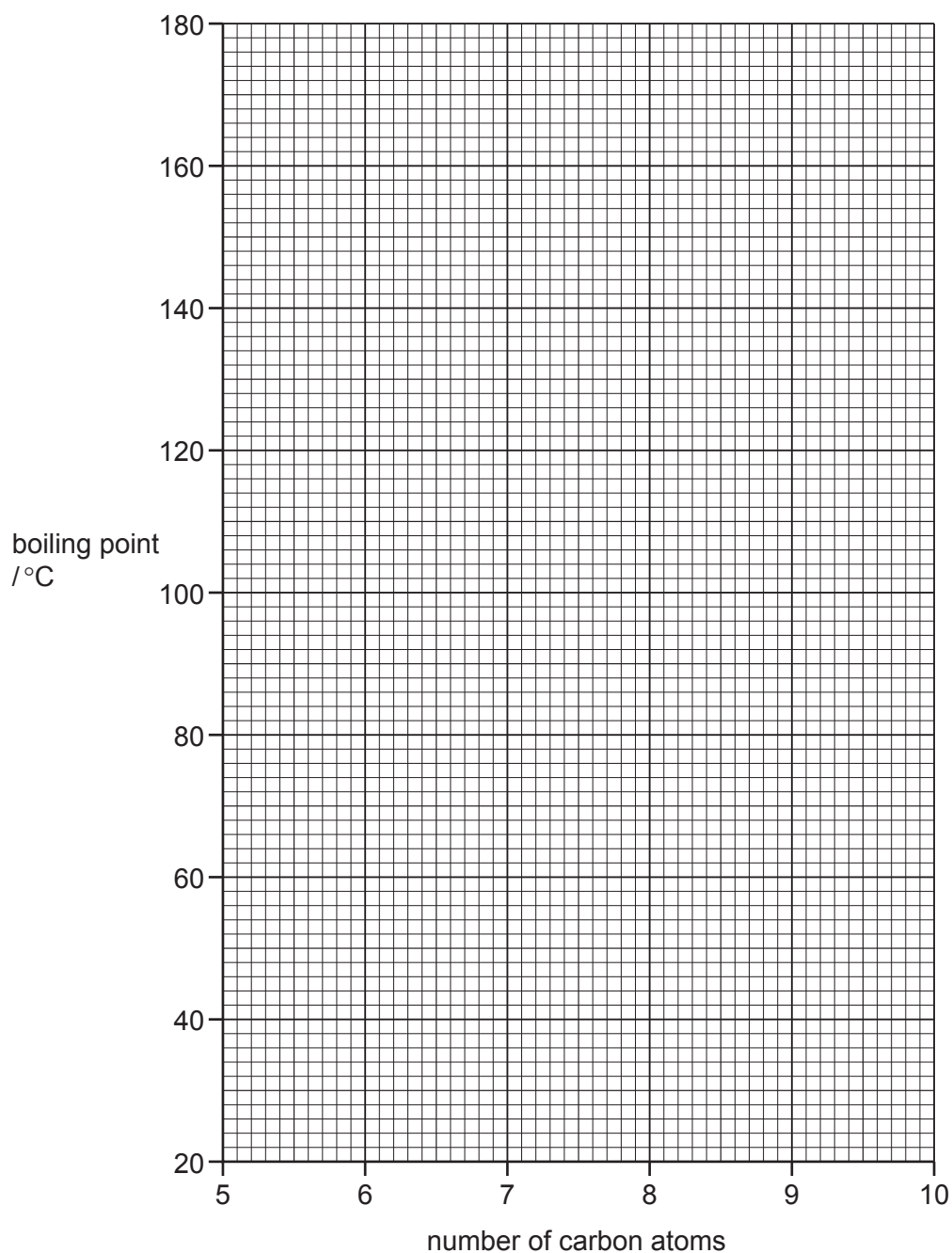
(ii) Give **one** use of gasoline.

..... [1]

- (d) The table shows the boiling points of the straight-chain hydrocarbons in the gasoline fraction.

|                        |    |    |   |     |     |     |
|------------------------|----|----|---|-----|-----|-----|
| number of carbon atoms | 5  | 6  | 7 | 8   | 9   | 10  |
| boiling point / °C     | 36 | 69 |   | 126 | 151 | 174 |

- (i) On the grid below, plot a graph to show how the boiling point changes with the number of carbon atoms in these hydrocarbons. Draw a smooth curve through the points.



[3]

- (ii) Use your graph to deduce the boiling point of the hydrocarbon with 7 carbon atoms.

boiling point ..... °C [1]

(e) The alkanes are a homologous series of hydrocarbons.

(i) What is meant by the term *homologous series*?

.....  
..... [2]

(ii) Alkanes can be cracked to form alkenes and smaller alkanes.  
State the conditions needed for cracking.

.....  
..... [2]

[Total: 13]

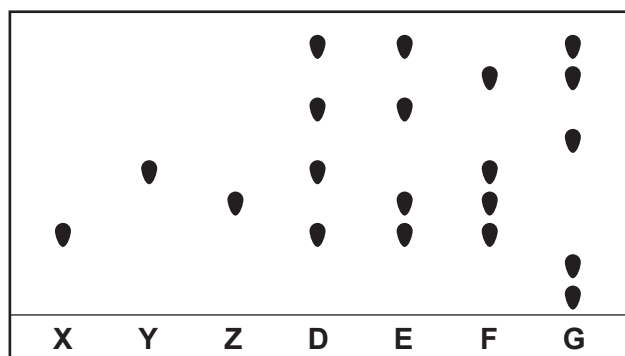
6 Inks are mixtures of different dyes.

- (a) A student used paper chromatography to separate the dyes in a particular ink. Describe how paper chromatography is carried out. You may draw a diagram to help explain your answer.  
In your description include

- the apparatus you would use,
- how chromatography is carried out.

.....  
 .....  
 .....  
 ..... [4]

- (b) The chromatogram below shows the results of a chromatography experiment. **X**, **Y** and **Z** are pure dyes containing only one compound. The dyes present in four different inks, **D**, **E**, **F** and **G** are also shown.



- (i) Which ink, **D**, **E**, **F** or **G**, contains all the dyes **X**, **Y** and **Z**?

..... [1]

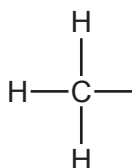
- (ii) Which ink, **D**, **E**, **F** or **G**, does **not** contain any of the dyes **X**, **Y** and **Z**?

..... [1]

- (iii) Which ink contains the greatest number of different dyes?

..... [1]

- (c) Some inks contain ethanoic acid.  
Complete the structure of ethanoic acid.

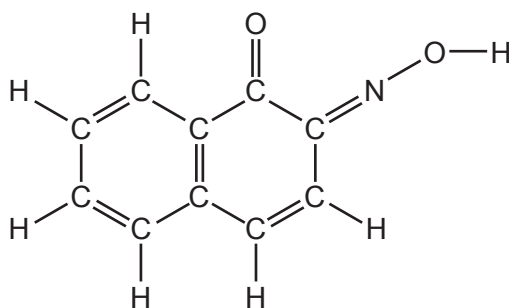


[1]

- (d) Ethanoic acid can be used as a solvent.  
What is the meaning of the term *solvent*?

..... [1]

- (e) The structure of a dye called Gambine R is shown below.



- (i) How many different types of atom are there in one molecule of Gambine R?

..... [1]

- (ii) How many carbon atoms are there in one molecule of Gambine R?

..... [1]

[Total: 11]

- 7 Hydrogen peroxide,  $\text{H}_2\text{O}_2$ , decomposes in the presence of an enzyme called peroxidase. The products of this reaction are water and oxygen.

(a) (i) What is meant by the term *enzyme*?

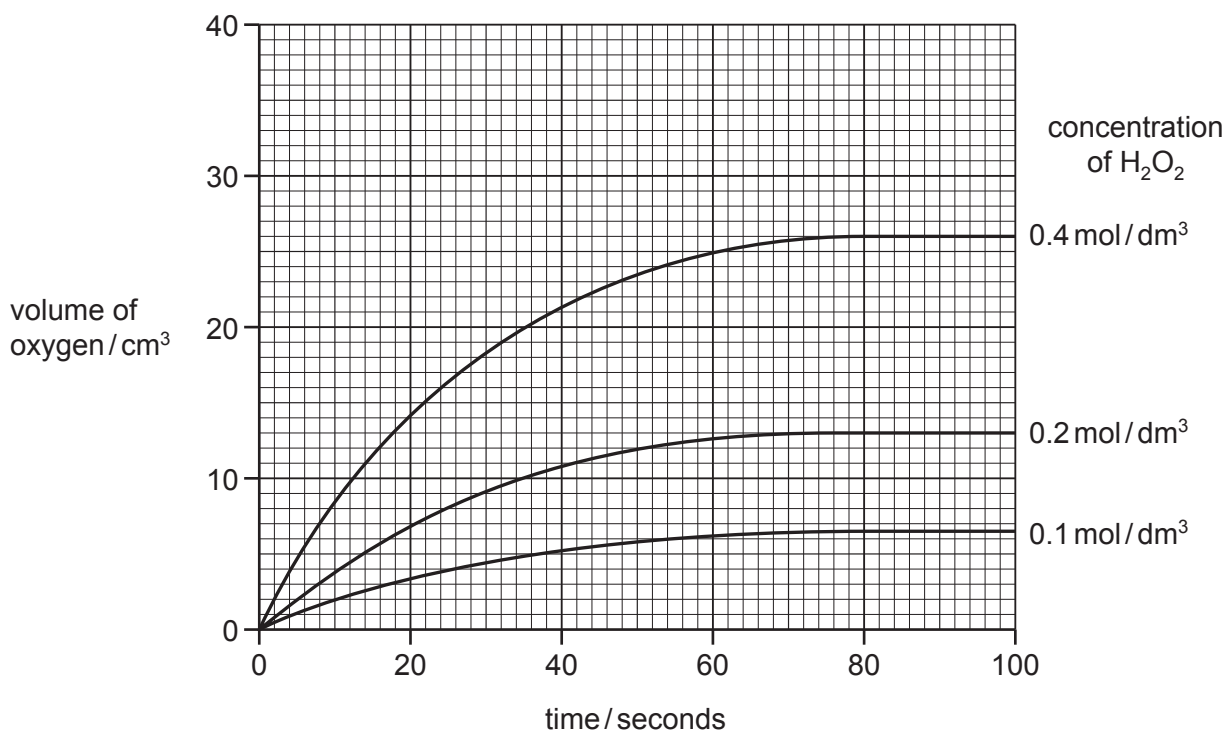
.....  
..... [2]

(ii) Complete the symbol equation for this reaction.



(b) A student followed the course of this reaction by measuring the volume of oxygen released over a period of time.

The diagram below shows some results that he obtained using hydrogen peroxide at three different concentrations.



(i) Describe how the concentration of hydrogen peroxide affects the rate of this reaction.

..... [1]

(ii) On the graph above, draw a line to show the course of the reaction when the starting concentration of hydrogen peroxide is  $0.3 \text{ mol/dm}^3$ . [2]

(iii) For the concentration of hydrogen peroxide of  $0.4 \text{ mol/dm}^3$ , deduce

- the volume of oxygen given off when the reaction is complete,

.....  $\text{cm}^3$

- the time it takes to produce  $14 \text{ cm}^3$  of oxygen.

..... seconds [2]

(c) In the presence of sulfuric acid, hydrogen peroxide reacts with iodide ions to form iodine and water. This involves the reduction of hydrogen peroxide.

(i) What is the meaning of the term *reduction*?

..... [1]

(ii) Complete the word equation for the reaction of sulfuric acid with calcium hydroxide.

sulfuric acid + calcium hydroxide → ..... + .....

..... [2]

(iii) Describe a test for iodide ions.

test .....

result ..... [2]

[Total: 13]





## DATA SHEET

### The Periodic Table of the Elements

| Group                    |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|--------------------------|-----------------------------|-------------------------|--|--|--|--|--|--|--|--|--|-----|----|---|----|-----|---|-----------------------------|-----------------------------|-----------------------------|------------------------------|------------------------------|---------------------------|-------------------|--|--|--|--|--|
| I                        | II                          |                         |  |  |  |  |  |  |  |  |  | III | IV | V | VI | VII | 0 |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
| 7<br>Li<br>Lithium<br>3  | 9<br>Be<br>Beryllium<br>4   | 1<br>H<br>Hydrogen<br>1 |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   | 4<br>He<br>Helium<br>2      |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
| 23<br>Na<br>Sodium<br>11 | 24<br>Mg<br>Magnesium<br>12 |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   | 11<br>B<br>Boron<br>5       | 12<br>C<br>Carbon<br>6      | 14<br>N<br>Nitrogen<br>7    | 16<br>O<br>Oxygen<br>8       | 19<br>F<br>Fluorine<br>9     | 20<br>Ne<br>Neon<br>10    |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   | 27<br>Al<br>Aluminium<br>13 | 28<br>Si<br>Silicon<br>14   | 31<br>P<br>Phosphorus<br>15 | 32<br>S<br>Sulfur<br>16      | 35.5<br>Cl<br>Chlorine<br>17 | 40<br>Ar<br>Argon<br>18   |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   | 70<br>Ga<br>Gallium<br>31   | 73<br>Ge<br>Germanium<br>32 | 75<br>As<br>Arsenic<br>33   | 79<br>Se<br>Selenium<br>34   | 80<br>Br<br>Bromine<br>35    | 84<br>Kr<br>Krypton<br>36 |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   | 115<br>In<br>Indium<br>49   | 119<br>Sn<br>Tin<br>50      | 122<br>Sb<br>Antimony<br>51 | 128<br>Te<br>Tellurium<br>52 | 127<br>I<br>Iodine<br>53     | 131<br>Xe<br>Xenon<br>54  |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   | 204<br>Tl<br>Thallium<br>81 | 207<br>Pb<br>Lead<br>82     | 209<br>Bi<br>Bismuth<br>83  |                              | Po<br>Polonium<br>84         | At<br>Astatine<br>85      | Rn<br>Radon<br>86 |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |
|                          |                             |                         |  |  |  |  |  |  |  |  |  |     |    |   |    |     |   |                             |                             |                             |                              |                              |                           |                   |  |  |  |  |  |

The volume of one mole of any gas is  $24 \text{ dm}^3$  at room temperature and pressure (r.t.p.).

Permission to reproduce items where third-party owned material protected by copyright is included has been sought and cleared where possible. Every reasonable effort has been made by the publisher (UCLES) to trace copyright holders, but if any items requiring clearance have unwittingly been included the publisher will be pleased to make amends at the earliest possible opportunity.

University of Cambridge International Examinations is part of the Cambridge Assessment Group. Cambridge Assessment is the brand name of University of Cambridge Local Examinations Syndicate (UCLES), which is itself a department of the University of Cambridge.