



# Cambridge IGCSE™

## CHEMISTRY

Paper 1 Multiple Choice (Core)

0620/12

May/June 2024

45 minutes

You must answer on the multiple choice answer sheet.

You will need: Multiple choice answer sheet  
Soft clean eraser  
Soft pencil (type B or HB is recommended)

## INSTRUCTIONS

- There are **forty** questions on this paper. Answer **all** questions.
- For each question there are four possible answers **A**, **B**, **C** and **D**. Choose the **one** you consider correct and record your choice in soft pencil on the multiple choice answer sheet.
- Follow the instructions on the multiple choice answer sheet.
- Write in soft pencil.
- Write your name, centre number and candidate number on the multiple choice answer sheet in the spaces provided unless this has been done for you.
- Do **not** use correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.

## INFORMATION

- The total mark for this paper is 40.
- Each correct answer will score one mark.
- Any rough working should be done on this question paper.
- The Periodic Table is printed in the question paper.

This document has **16** pages. Any blank pages are indicated.



1 Which statement about gases is correct?

- A Gases are difficult to compress when pressure is applied.
- B The particles in gases are close together.
- C The particles in gases have a random arrangement.
- D The particles in gases move slowly past each other.

2 A sample of argon gas is heated in a closed container.

Which row describes what happens to the pressure and the size of the argon atoms?

|   | pressure  | size           |
|---|-----------|----------------|
| A | decreases | increases      |
| B | decreases | stays the same |
| C | increases | increases      |
| D | increases | stays the same |

3 Which statement is correct?

- A Air is a mixture of gaseous elements only.
- B Alloys are formed when a metal is ionically bonded to other elements.
- C Carbon dioxide is a mixture of carbon and oxygen.
- D Potassium bromide is an ionic compound.

4 Which row identifies methods of testing the purity of a compound?

|   | melting point | boiling point | chromatography |
|---|---------------|---------------|----------------|
| A | ✓             | ✓             | ✓              |
| B | ✓             | x             | x              |
| C | ✓             | ✓             | x              |
| D | x             | ✓             | ✓              |

- 5 Which row shows the number of protons, neutrons and electrons in the ion  $^{18}_8\text{O}^{2-}$ ?

|          | protons | neutrons | electrons |
|----------|---------|----------|-----------|
| <b>A</b> | 10      | 8        | 8         |
| <b>B</b> | 8       | 10       | 8         |
| <b>C</b> | 10      | 8        | 10        |
| <b>D</b> | 8       | 10       | 10        |

- 6 Isotopes of the same element have some features that are the same and some that are different.

Which row shows the features that are the same and those that are different?

|          | nucleon number | proton number | number of outer shell electrons |
|----------|----------------|---------------|---------------------------------|
| <b>A</b> | ✓              | ✓             | ✗                               |
| <b>B</b> | ✗              | ✓             | ✓                               |
| <b>C</b> | ✓              | ✗             | ✗                               |
| <b>D</b> | ✗              | ✗             | ✓                               |

key

✓ = same

✗ = different

- 7 The electronic configurations of four atoms, W, X, Y and Z, are shown.

| atom | electronic configuration |
|------|--------------------------|
| W    | 2                        |
| X    | 2,6                      |
| Y    | 2,8,2                    |
| Z    | 2,8,6                    |

Which atoms form an ion with a charge of 2– when they react?

- A** W and Y      **B** W only      **C** X and Z      **D** Y only

8 Which statement about bonding is correct?

- A All the atoms in CH<sub>4</sub>, NH<sub>3</sub> and H<sub>2</sub>O molecules have noble gas electronic configurations.
- B Calcium chloride is a covalent molecule.
- C Group I metals gain electrons when they bond with Group VII elements.
- D Oxide ions in calcium oxide are positively charged.

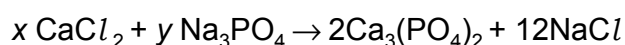
9 Which statement about diamond is correct?

- A It is a giant covalent structure consisting of carbon atoms and each atom is bonded to four other atoms.
- B It is a giant covalent structure consisting of flat sheets of carbon atoms.
- C It is a structure held together by ionic bonds and each ion is bonded to four other ions.
- D It is a structure held together by ionic bonds and each ion is bonded to three other ions.

10 Which row shows the correct formulae of lead(II) bromide and butane?

|   | lead(II) bromide   | butane                         |
|---|--------------------|--------------------------------|
| A | PbBr <sub>2</sub>  | C <sub>4</sub> H <sub>8</sub>  |
| B | PbBr <sub>2</sub>  | C <sub>4</sub> H <sub>10</sub> |
| C | Pb <sub>2</sub> Br | C <sub>4</sub> H <sub>8</sub>  |
| D | Pb <sub>2</sub> Br | C <sub>4</sub> H <sub>10</sub> |

11 Calcium phosphate forms when calcium chloride and sodium phosphate solutions react together.



Which values of  $x$  and  $y$  balance the equation?

|   | $x$ | $y$ |
|---|-----|-----|
| A | 2   | 2   |
| B | 3   | 4   |
| C | 6   | 3   |
| D | 6   | 4   |

**12** What is the definition of relative molecular mass,  $M_r$ ?

- A** It is the average mass of the isotopes in a compound.
- B** It is the sum of the atomic numbers in a compound.
- C** It is the sum of the relative atomic masses in a compound.
- D** It is the total number of atoms in a compound.

**13** In an experiment, a molten compound is broken down using electricity.

Which row identifies the negative electrode and the general name for the molten compound being broken down?

|          | negative electrode | general name for the molten compound |
|----------|--------------------|--------------------------------------|
| <b>A</b> | anode              | electrolysis                         |
| <b>B</b> | anode              | electrolyte                          |
| <b>C</b> | cathode            | electrolyte                          |
| <b>D</b> | cathode            | electrolysis                         |

**14** Hydrogen–oxygen fuel cells can be used to power vehicles.

What is produced by the fuel cells?

- 1 carbon dioxide
- 2 electricity
- 3 water

**A** 1, 2 and 3      **B** 1 and 2 only      **C** 1 and 3 only      **D** 2 and 3 only

**15** Three reactions are described.

- 1 An acid is added to substance H. Rapid fizzing happens and the temperature decreases.
- 2 When substance J is ignited, it produces large quantities of heat.
- 3 Substance K reacts slowly with air and becomes warmer.

Which reactions are endothermic?

**A** 1, 2 and 3      **B** 1 and 2 only      **C** 1 only      **D** 2 and 3 only

16 Which of the processes produces a physical change?

- A thermal decomposition of calcium carbonate
- B addition of sodium chloride to water
- C addition of magnesium to hydrochloric acid
- D combustion of sodium

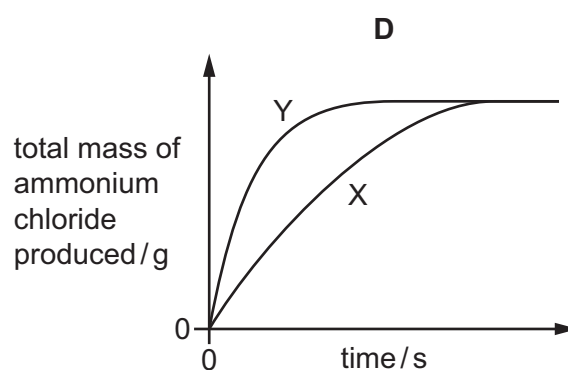
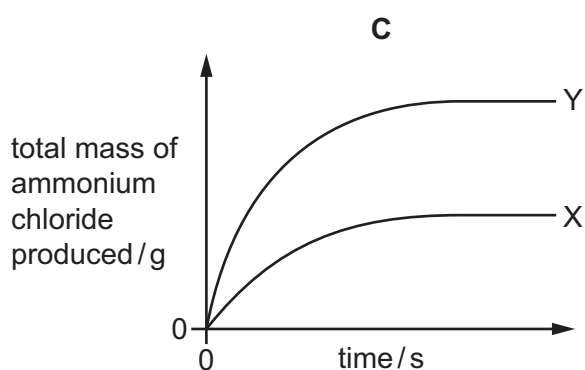
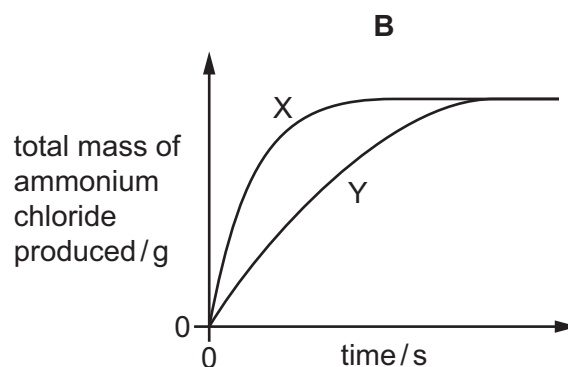
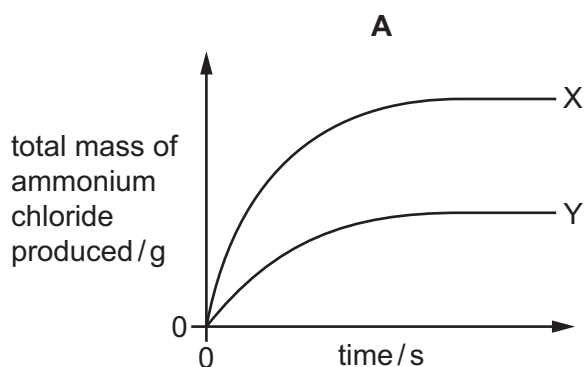
17 A known mass of gaseous ammonia and excess gaseous hydrogen chloride react together to make solid ammonium chloride.

Line X shows the total mass of ammonium chloride produced over time.

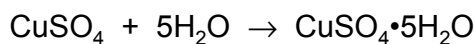
The reaction is repeated at a higher pressure. All other conditions are kept the same.

Line Y shows the total mass of ammonium chloride produced over time at the higher pressure.

Which diagram is correct?

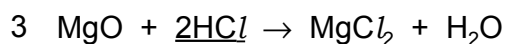
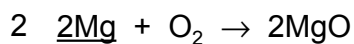
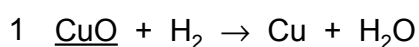


- 18 The equation for the hydration of anhydrous copper(II) sulfate is shown.



Which colour change is observed in this reaction?

- A blue to white  
 B white to blue  
 C pink to blue  
 D blue to pink
- 19 Which of the reactions show the underlined substance being reduced?



- A 1 and 2      B 1 only      C 2 and 3      D 3 only
- 20 Four different solutions are separately tested with blue litmus and with methyl orange.

Each solution is known to be either acidic or alkaline. The results are shown.

| solution | result with blue litmus | result with methyl orange |
|----------|-------------------------|---------------------------|
| 1        | red                     | red                       |
| 2        | red                     | yellow                    |
| 3        | blue                    | yellow                    |
| 4        | blue                    | yellow                    |

Which statement is correct?

- A Solutions 1 and 4 are acidic.  
 B Solutions 1 and 2 are alkaline.  
 C Solutions 3 and 4 are acidic.  
 D Solutions 3 and 4 are alkaline.

**21** Which statement about sulfur dioxide or calcium oxide is correct?

- A** Calcium oxide is an acid.
- B** Calcium oxide turns thymolphthalein yellow.
- C** Sulfur dioxide is a base.
- D** Sulfur dioxide turns thymolphthalein colourless.

**22** Which substances can be used to make pure crystals of sodium sulfate?

- A** potassium sulfate and sodium hydroxide  
**B** sodium carbonate and sulfuric acid  
**C** sodium nitrate and magnesium sulfate  
**D** sulfuric acid and sodium chloride

**23** Which statements describe changes that occur from left to right across a period of the Periodic Table?

- 1 The atomic number of the elements increases.
- 2 The metallic character of the elements decreases.
- 3 The physical state of the elements changes from gas to solid.

- A** 2 only      **B** 1 and 2      **C** 1 and 3      **D** 2 and 3

**24** Part of the Periodic Table is shown.

Which element is the **most** reactive non-metal?

A simplified periodic table grid is shown, consisting of a 4x16 grid of squares. The grid is divided into four main sections by a gap in the middle. The top row contains a single square in the 10th column. The second row contains two squares in the first and second columns, and a single square in the 16th column. The third row contains a square in the first column and a square in the 15th column. The fourth row contains a square in the 10th column. The elements are labeled as follows: A is in the first column, second row; B is in the 10th column, third row; C is in the 16th column, second row; and D is in the 15th column, third row.

- 25** An alloy contains aluminium, copper, magnesium, manganese, silver and zirconium.

Which row identifies the number of transition elements in the alloy and the relative density of the transition elements compared to sodium?

|          | number of transition elements in the alloy | relative density of transition elements compared to sodium |
|----------|--------------------------------------------|------------------------------------------------------------|
| <b>A</b> | 4                                          | higher                                                     |
| <b>B</b> | 4                                          | lower                                                      |
| <b>C</b> | 5                                          | higher                                                     |
| <b>D</b> | 5                                          | lower                                                      |

- 26** Which statement about the halogens and their compounds is correct?

- A** The colour of the element gets lighter going down Group VII.
- B** The elements get less dense going down Group VII.
- C** When chlorine is added to sodium iodide solution, iodine is formed.
- D** When iodine is added to sodium bromide solution, bromine is formed.

- 27** Which row describes an element in Group VIII of the Periodic Table?

|          | boiling point / °C | structure |
|----------|--------------------|-----------|
| <b>A</b> | -107               | diatomic  |
| <b>B</b> | -107               | monatomic |
| <b>C</b> | 107                | diatomic  |
| <b>D</b> | 107                | monatomic |

- 28** Magnesium reacts with dilute hydrochloric acid.

Which gas is given off in this reaction?

- A** carbon dioxide
- B** chlorine
- C** hydrogen
- D** oxygen

29 Which statement about aluminium is correct?

- A Aluminium is easy to extract from its ore because it is near the bottom of the reactivity series.
- B Aluminium is formed when aluminium oxide is heated with carbon.
- C Bauxite is an important ore of aluminium.
- D Hematite is an important ore of aluminium.

30 Which statement shows that a liquid is pure water?

- A It boils at 100 °C.
- B It has a pH value of 7.
- C It turns blue cobalt(II) chloride pink.
- D It turns white copper(II) sulfate blue.

31 Which compound can be added to ammonium sulfate to make an NPK fertiliser?

- A  $(\text{NH}_4)_3\text{PO}_4$
- B  $\text{KNO}_3$
- C  $\text{K}_3\text{PO}_4$
- D  $\text{CO}(\text{NH}_2)_2$

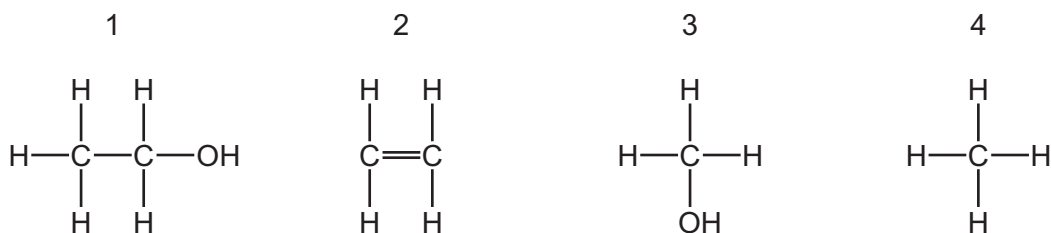
32 Four gases found in air are listed.

- 1 carbon dioxide
- 2 carbon monoxide
- 3 methane
- 4 sulfur dioxide

Which gases lead directly to global warming when their concentrations are increased?

- A 1 and 3      B 1 and 4      C 2 and 3      D 2 and 4

33 The structures of four organic compounds are shown.



Which compounds are members of the same homologous series?

- A** 1, 2 and 3      **B** 1 and 2 only      **C** 1 and 3 only      **D** 3 and 4

34 Which of the statements about propene are correct?

- 1 Propene contains only single bonds.
- 2 Propene decolourises aqueous bromine.
- 3 Propene is obtained by cracking large alkanes.
- 4 Propene is a hydrocarbon.

- A** 1, 3 and 4      **B** 1 only      **C** 2, 3 and 4      **D** 2 and 4 only

35 Petroleum is a mixture.

Which method is used to separate petroleum into its components?

- A** chromatography  
**B** cracking  
**C** filtration  
**D** fractional distillation

36 The equation for a reaction that produces ethanol is shown.



Which type of reaction does the equation represent?

- A** addition  
**B** combustion  
**C** fermentation  
**D** polymerisation

**37** Four statements about ethene or poly(ethene) are listed.

- 1 Poly(ethene) is produced by an addition reaction.
- 2 Ethene is a monomer.
- 3 Poly(ethene) is a monomer.
- 4 Poly(ethene) decolourises aqueous bromine.

Which statements are correct?

- A** 1 and 2      **B** 1 and 3      **C** 2 and 4      **D** 3 and 4

**38** Sea water contains dissolved sodium chloride.

Which method is used to obtain pure water from sea water?

- A** chromatography  
**B** distillation  
**C** evaporation  
**D** filtration

**39** Which piece of apparatus is used to measure exactly  $21.4\text{ cm}^3$  of water?

- A** a  $25\text{ cm}^3$  beaker  
**B** a  $25\text{ cm}^3$  pipette  
**C** a  $50\text{ cm}^3$  burette  
**D** a  $50\text{ cm}^3$  measuring cylinder

**40** An aqueous solution of compound M is tested.

The results are shown.

- a lilac colour in a flame test
- a white precipitate when tested with acidified barium nitrate

What is compound M?

- A** copper(II) chloride  
**B** copper(II) sulfate  
**C** potassium carbonate  
**D** potassium sulfate



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The Periodic Table of Elements

| Group                      |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|----------------------------|-----------------------------|---------------------------------------------------------------------------------------------|---------------------------------|-----------------------------|------------------------------|-----------------------------|------------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|------------------------------|-----------------------------|------------------------|------------------------|------|------------------------|
| I                          | II                          |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               | III                         | IV                          | V                           | VI                            | VII                          | VIII                        |                        |                        |      |                        |
| 3<br>Li<br>lithium<br>7    | 4<br>Be<br>beryllium<br>9   | <div>Key</div> <div>atomic number<br/>atomic symbol<br/>name<br/>relative atomic mass</div> |                                 |                             |                              |                             |                              |                              |                                |                               |                               | 1<br>H<br>hydrogen<br>1     | 5<br>B<br>boron<br>11       | 6<br>C<br>carbon<br>12      | 7<br>N<br>nitrogen<br>14      | 8<br>O<br>oxygen<br>16       | 9<br>F<br>fluorine<br>19    | 10<br>Ne<br>neon<br>20 | VIII                   |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
| 11<br>Na<br>sodium<br>23   | 12<br>Mg<br>magnesium<br>24 |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               | 13<br>Al<br>aluminium<br>27 | 14<br>Si<br>silicon<br>28   | 15<br>P<br>phosphorus<br>31 | 16<br>S<br>sulfur<br>32       | 17<br>Cl<br>chlorine<br>35.5 | 18<br>Ar<br>argon<br>40     | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
| 19<br>K<br>potassium<br>39 | 20<br>Ca<br>calcium<br>40   | 21<br>Sc<br>scandium<br>45                                                                  | 22<br>Ti<br>titanium<br>48      | 23<br>V<br>vanadium<br>51   | 24<br>Cr<br>chromium<br>52   | 25<br>Mn<br>manganese<br>55 | 26<br>Fe<br>iron<br>56       | 27<br>Co<br>cobalt<br>59     | 28<br>Ni<br>nickel<br>59       | 29<br>Cu<br>copper<br>64      | 30<br>Zn<br>zinc<br>65        | 31<br>Ga<br>gallium<br>70   | 32<br>Ge<br>germanium<br>73 | 33<br>As<br>arsenic<br>75   | 34<br>Se<br>selenium<br>79    | 35<br>Br<br>bromine<br>80    | 36<br>Kr<br>krypton<br>84   |                        |                        | VIII | 2<br>He<br>helium<br>4 |
| 37<br>Rb<br>rubidium<br>85 | 38<br>Sr<br>strontium<br>88 | 39<br>Y<br>yttrium<br>89                                                                    | 40<br>Zr<br>zirconium<br>91     | 41<br>Nb<br>niobium<br>93   | 42<br>Mo<br>molybdenum<br>96 | 43<br>Tc<br>technetium<br>— | 44<br>Ru<br>ruthenium<br>101 | 45<br>Rh<br>rhodium<br>103   | 46<br>Pd<br>palladium<br>106   | 47<br>Ag<br>silver<br>108     | 48<br>Cd<br>cadmium<br>112    | 49<br>In<br>indium<br>115   | 50<br>Sn<br>tin<br>119      | 51<br>Sb<br>antimony<br>122 | 52<br>Te<br>tellurium<br>128  | 53<br>I<br>iodine<br>127     | 54<br>Xe<br>xenon<br>131    | VII                    | 2<br>He<br>helium<br>4 |      |                        |
| 55<br>Cs<br>caesium<br>133 | 56<br>Ba<br>barium<br>137   | 57–71<br>lanthanoids                                                                        | 72<br>Hf<br>hafnium<br>178      | 73<br>Ta<br>tantalum<br>181 | 74<br>W<br>tungsten<br>184   | 75<br>Re<br>rhenium<br>186  | 76<br>Os<br>osmium<br>190    | 77<br>Ir<br>iridium<br>192   | 78<br>Pt<br>platinum<br>195    | 79<br>Au<br>gold<br>197       | 80<br>Hg<br>mercury<br>201    | 81<br>Tl<br>thallium<br>204 | 82<br>Pb<br>lead<br>207     | 83<br>Bi<br>bismuth<br>209  | 84<br>Po<br>polonium<br>—     | 85<br>At<br>astatine<br>—    | 86<br>Rn<br>radon<br>—      |                        |                        |      |                        |
| 87<br>Fr<br>francium<br>—  | 88<br>Ra<br>radium<br>—     | 89–103<br>actinoids                                                                         | 104<br>Rf<br>rutherfordium<br>— | 105<br>Db<br>dubnium<br>—   | 106<br>Sg<br>seaborgium<br>— | 107<br>Bh<br>bohrium<br>—   | 108<br>Hs<br>hassium<br>—    | 109<br>Mt<br>meitnerium<br>— | 110<br>Ds<br>darmstadtium<br>— | 111<br>Rg<br>roentgenium<br>— | 112<br>Cn<br>copernicium<br>— | 113<br>Nh<br>nihonium<br>—  | 114<br>Fl<br>flerovium<br>— | 115<br>Mc<br>moscovium<br>— | 116<br>Lv<br>livermorium<br>— | 117<br>Ts<br>tennessine<br>— | 118<br>Og<br>oganesson<br>— |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        | VII  | 2<br>He<br>helium<br>4 |
|                            |                             |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             | VII                    | 2<br>He<br>helium<br>4 |      |                        |
|                            | </                          |                                                                                             |                                 |                             |                              |                             |                              |                              |                                |                               |                               |                             |                             |                             |                               |                              |                             |                        |                        |      |                        |

lanthanoids

|                              |                            |                                 |                              |                             |                             |                             |                               |                            |                               |                              |                           |                               |                              |                              |
|------------------------------|----------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-------------------------------|------------------------------|---------------------------|-------------------------------|------------------------------|------------------------------|
| 57<br>La<br>lanthanum<br>139 | 58<br>Ce<br>cerium<br>140  | 59<br>Pr<br>praseodymium<br>141 | 60<br>Nd<br>neodymium<br>144 | 61<br>Pm<br>promethium<br>— | 62<br>Sm<br>samarium<br>150 | 63<br>Eu<br>europium<br>152 | 64<br>Gd<br>gadolinium<br>157 | 65<br>Tb<br>terbium<br>159 | 66<br>Dy<br>dysprosium<br>163 | 67<br>Ho<br>holmium<br>165   | 68<br>Er<br>erbium<br>167 | 69<br>Tm<br>thulium<br>169    | 70<br>Yb<br>ytterbium<br>173 | 71<br>Lu<br>lutetium<br>175  |
| 89<br>Ac<br>actinium<br>—    | 90<br>Th<br>thorium<br>232 | 91<br>Pa<br>protactinium<br>231 | 92<br>U<br>uranium<br>238    | 93<br>Np<br>neptunium<br>—  | 94<br>Pu<br>plutonium<br>—  | 95<br>Am<br>americium<br>—  | 96<br>Cm<br>curium<br>—       | 97<br>Bk<br>berkelium<br>— | 98<br>Cf<br>californium<br>—  | 99<br>Es<br>einsteinium<br>— | 100<br>Fm<br>fermium<br>— | 101<br>Md<br>mendelevium<br>— | 102<br>No<br>nobelium<br>—   | 103<br>Lr<br>lawrencium<br>— |

actinoids

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.).