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## 0620/33

October/November 2023

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

- The total mark for this paper is 80.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **20** pages. Any blank pages are indicated.

1 A list of substances is shown.

ammonia  
calcium oxide  
carbon monoxide  
cobalt(II) chloride  
ethane  
ethanol  
ethene  
oxygen  
potassium oxide  
sodium sulfate  
sulfuric acid  
water

Answer the following questions using only the substances from the list.  
Each substance may be used once, more than once or not at all.

Give the name of the substance that:

(a) is a product of photosynthesis

..... [1]

(b) is a member of the alkene homologous series

..... [1]

(c) has an ion with a charge of 1–

..... [1]

(d) is used to remove sulfur dioxide in flue gas desulfurisation

..... [1]

(e) is the product formed in a hydrogen–oxygen fuel cell

..... [1]

(f) is used to test for water.

..... [1]

[Total: 6]

2 Hydrocarbons are compounds of carbon and hydrogen.

(a) State the meaning of the term compound.

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

(b) Fig. 2.1 shows a fractionating column for separating petroleum into different hydrocarbon fractions.

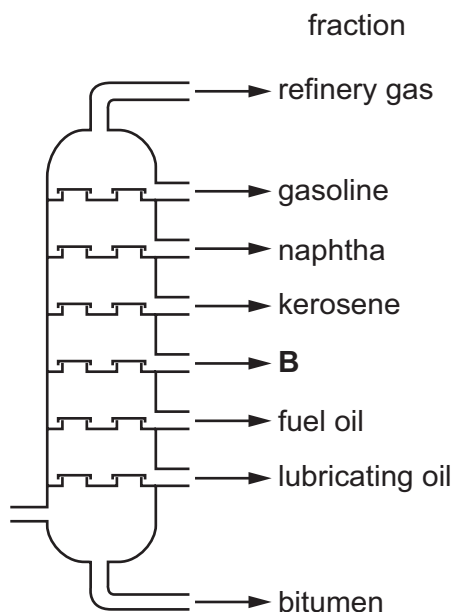


Fig. 2.1

(i) On Fig. 2.1, draw an **X** inside the column to show where the hydrocarbon with the highest boiling point collects. [1]

(ii) Name the fraction labelled **B** in Fig. 2.1.

..... [1]

(iii) State the name of the fraction which has hydrocarbons with the shortest chain length.

..... [1]

(iv) State **one** use of the naphtha fraction.

..... [1]

[Total: 6]

- 3 (a) Table 3.1 shows the average concentrations, in  $\text{ng} / 1000 \text{ cm}^3$ , of air pollutants in four different years.

Table 3.1

| year | concentration of air pollutant in $\text{ng} / 1000 \text{ cm}^3$ |              |                    |              |                |
|------|-------------------------------------------------------------------|--------------|--------------------|--------------|----------------|
|      | carbon monoxide                                                   | hydrocarbons | oxides of nitrogen | particulates | sulfur dioxide |
| 2019 | 5.3                                                               | 22.0         | 15.6               | 19.0         | 20.0           |
| 2020 | 4.1                                                               | 13.5         | 14.8               | 20.1         | 18.2           |
| 2021 | 5.8                                                               | 14.8         | 22.7               | 23.5         | 16.2           |
| 2022 | 2.6                                                               | 18.0         | 10.9               | 26.2         | 14.0           |

- (i) Name the pollutant which has the highest concentration in 2019.

..... [1]

- (ii) Name the pollutant that shows a continuous decrease in concentration from 2019 to 2022.

..... [1]

- (iii) Calculate the average mass, in ng, of hydrocarbons in a  $200 \text{ cm}^3$  sample of polluted air in 2019.

mass = ..... ng [1]

- (b) (i) State **one** source of oxides of nitrogen in the air.

..... [1]

- (ii) Oxides of nitrogen contribute to acid rain.

Give one **other** effect of oxides of nitrogen in the air.

..... [1]

- (iii) Unpolluted water has a neutral pH.

Choose from the list the pH value of a neutral substance.

Draw a circle around your chosen answer.

pH 1      pH 6      pH 7      pH 14

[1]

(c) Nitrogen dioxide is an acidic oxide.

Choose an oxide from the list which is also an acidic oxide.

Tick (✓) **one** box.

|                     |                          |
|---------------------|--------------------------|
| copper(II) oxide    | <input type="checkbox"/> |
| magnesium oxide     | <input type="checkbox"/> |
| phosphorus(V) oxide | <input type="checkbox"/> |
| sodium oxide        | <input type="checkbox"/> |

[1]

(d) Sulfur dioxide reacts with oxygen to produce sulfur trioxide.

(i) Complete the symbol equation for this reaction.



(ii) State the meaning of the symbol  $\rightleftharpoons$ .

..... [1]

(iii) Sulfur trioxide reacts with calcium oxide to produce calcium sulfate.

Describe a test for sulfate ions.

test .....

observations .....

[2]

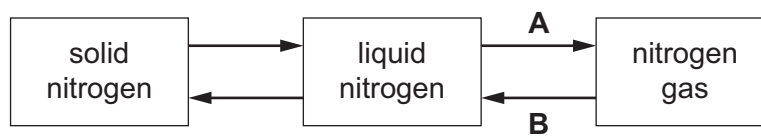
[Total: 12]

4 Nitrogen is a gas at room temperature.

(a) State **two** general properties of a gas.

- 1 .....
- .....
- 2 .....
- .....
- [2]

(b) Fig. 4.1 shows the physical states of nitrogen.



**Fig. 4.1**

Name the changes of physical states **A** and **B**.

- A** .....
- B** .....
- [2]

(c) Describe solid nitrogen and nitrogen gas in terms of the arrangement and separation of the particles.

solid nitrogen

arrangement .....

.....

separation .....

.....

nitrogen gas

arrangement .....

.....

separation .....

.....

[4]

- (d) A sealed gas syringe contains  $80\text{ cm}^3$  of nitrogen gas.

State how increasing the pressure affects the volume of nitrogen gas in the gas syringe when the temperature remains constant.

..... [1]

[Total: 9]

5 This question is about metals.

(a) Table 5.1 shows some properties of the Group I metals.

**Table 5.1**

| metal     | melting point<br>in °C | boiling point<br>in °C | atomic volume<br>in cm <sup>3</sup> /mol | observations on<br>reaction with water      |
|-----------|------------------------|------------------------|------------------------------------------|---------------------------------------------|
| lithium   | 181                    | 1342                   | 12.9                                     | bubbles form slowly<br>but no flame         |
| sodium    | 98                     | 883                    | 23.7                                     |                                             |
| potassium | 63                     | 760                    |                                          | bubbles form very<br>rapidly and flame seen |
| rubidium  |                        | 686                    | 55.8                                     | explodes                                    |

Use the information in Table 5.1 to predict:

- (i) the melting point of rubidium ..... [1]
- (ii) the atomic volume of potassium ..... [1]
- (iii) the observations when sodium reacts with water .....  
..... [1]
- (iv) the physical state of sodium at 1300 °C. Give a reason for your answer.
- physical state .....
- reason .....
- ..... [2]

**(b)** Iron is extracted in a blast furnace by reduction of iron(III) oxide.

**(i)** In the first step, carbon burns in air to form carbon dioxide.

State the percentage of oxygen in clean, dry air.

..... [1]

**(ii)** In the second step, carbon monoxide is produced by the reaction of carbon dioxide with carbon.



Choose the correct statement about this reaction.

Tick (✓) **one** box.

- |                                                          |                          |
|----------------------------------------------------------|--------------------------|
| the carbon dioxide is oxidised and the carbon is reduced | <input type="checkbox"/> |
| both carbon dioxide and carbon are oxidised              | <input type="checkbox"/> |
| the carbon dioxide is reduced and the carbon is oxidised | <input type="checkbox"/> |
| both carbon dioxide and carbon are reduced               | <input type="checkbox"/> |

[1]

**(iii)** In the third step, iron(III) oxide is reduced by carbon monoxide.  
The reaction is exothermic.

State the meaning of the term exothermic.

.....

..... [2]

**(c)** Calcium carbonate is added to the blast furnace.  
The calcium carbonate breaks down as shown.



**(i)** Name the type of chemical reaction that takes place.

..... [1]

**(ii)** Complete this sentence about the calcium oxide that is produced in the blast furnace.

Calcium oxide reacts with impurities in the iron ore to form ..... [1]

(d) Table 5.2 gives the observations when four different metals react with air.

**Table 5.2**

| metal    | observations                                  |
|----------|-----------------------------------------------|
| cerium   | forms an oxide layer slowly without heating   |
| copper   | forms an oxide layer only when heated         |
| gold     | does not form an oxide layer even when heated |
| rubidium | forms an oxide layer quickly without heating  |

Put the four metals in order of their reactivity.

Put the least reactive metal first.

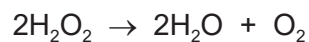
least reactive            most reactive

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

[2]

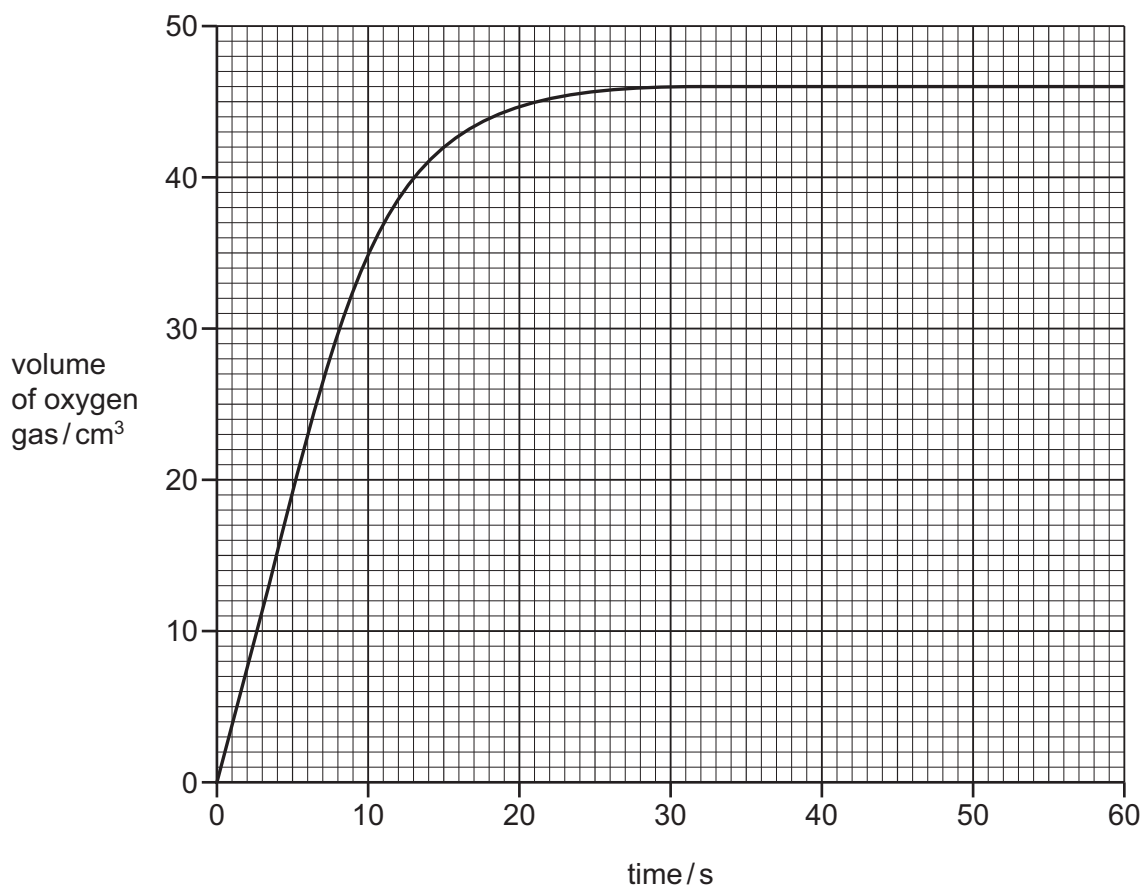
[Total: 13]

- 6 Hydrogen peroxide,  $\text{H}_2\text{O}_2$ , breaks down slowly at  $40^\circ\text{C}$  to produce oxygen gas and water.



A student investigates the breakdown of hydrogen peroxide at  $40^\circ\text{C}$  in the presence of a catalyst.

- (a) Fig. 6.1 shows the volume of oxygen gas released as the reaction proceeds.



**Fig. 6.1**

- (i) Deduce the volume of oxygen gas released after 15 seconds.

volume of oxygen = .....  $\text{cm}^3$  [1]

- (ii) The student repeats the experiment at  $20^\circ\text{C}$ .

All other conditions stay the same.

Draw a line on the grid in Fig. 6.1 to show how the volume of oxygen changes when a temperature of  $20^\circ\text{C}$  is used. [2]

- (b) (i)** The student repeats the experiment without a catalyst.

All other conditions stay the same.

Describe how the rate of reaction differs when no catalyst is used.

..... [1]

- (ii)** The student repeats the experiment using a lower concentration of hydrogen peroxide.

All other conditions stay the same.

Describe how the rate of reaction differs when a lower concentration of hydrogen peroxide is used.

..... [1]

- (c)** Hydrogen peroxide can act as a reducing agent in the presence of an alkali.

- (i)** State the meaning of the term alkali.

..... [1]

- (ii)** Give the formula of the ion that is present in all alkaline solutions.

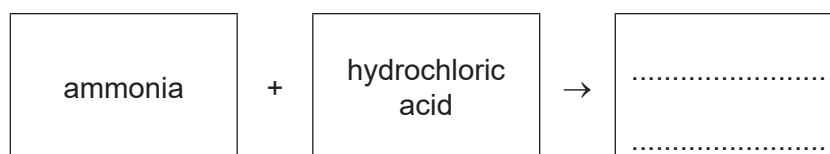
..... [1]

- (iii)** State the colour of methyl orange in an alkaline solution.

..... [1]

- (iv)** Aqueous ammonia is an alkali.

Complete the word equation for the reaction of aqueous ammonia with hydrochloric acid.

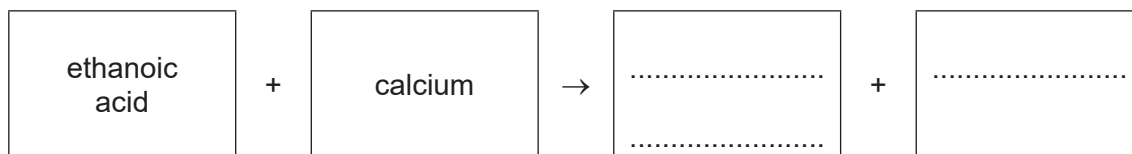


[1]

[Total: 9]

7 Ethanoic acid and methacrylic acid are both carboxylic acids.

(a) Complete the word equation for the reaction of ethanoic acid with calcium.



[2]

(b) Ethanoic acid can be reduced to ethanol.

(i) Name the homologous series that includes ethanol.

..... [1]

(ii) Ethanol can be manufactured by fermentation.

Describe **two** conditions needed for fermentation.

1 .....

2 .....

[2]

(c) Fig. 7.1 shows the displayed formula of methacrylic acid.

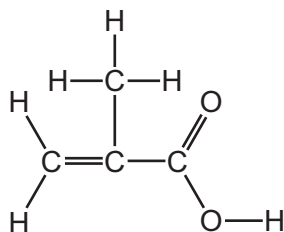


Fig. 7.1

(i) On Fig. 7.1, draw a circle around the functional group which reacts with aqueous bromine.

[1]

(ii) State the colour of aqueous bromine.

..... [1]

(iii) Deduce the molecular formula of methacrylic acid.

..... [1]

- (d) Methacrylic acid can be converted to methyl methacrylate.  
The molecular formula of methyl methacrylate is  $C_5H_8O_2$ .

Complete Table 7.1 to calculate the relative molecular mass of methyl methacrylate.

**Table 7.1**

| atom     | number of atoms | relative atomic mass |                    |
|----------|-----------------|----------------------|--------------------|
| carbon   | 5               | 12                   | $5 \times 12 = 60$ |
| hydrogen |                 | 1                    |                    |
| oxygen   |                 | 16                   |                    |

relative molecular mass = ..... [2]

- (e) Methyl methacrylate can be polymerised to produce a plastic.

Describe **two** environmental problems caused by plastics.

1 .....

2 ..... [2]

- (f) Poly(ethene) is a polymer.

Draw the displayed formula of the monomer used to make poly(ethene).

[1]

[Total: 13]

8 Potassium chloride is an ionic compound.

(a) Complete Fig. 8.1 to show:

- the electronic configuration of a potassium ion
- the charge on the ion.

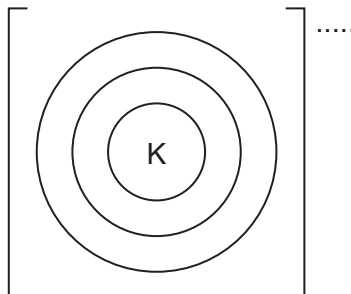


Fig. 8.1

[2]

(b) Deduce the number of protons and neutrons in the chloride ion shown.



number of protons .....

number of neutrons .....

[2]

(c) Molten potassium chloride is electrolysed using graphite electrodes.

(i) Define the term electrolysis.

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

(ii) State the names of the products at each electrode and give the observations at the positive electrode.

product at the negative electrode .....

product at the positive electrode .....

observations at the positive electrode  
 .....

[3]

(d) Graphite electrodes are inert.

Name one **other** inert electrode.

..... [1]

(e) Graphite and diamond are two forms of carbon.

Fig. 8.2 shows the structure of diamond.

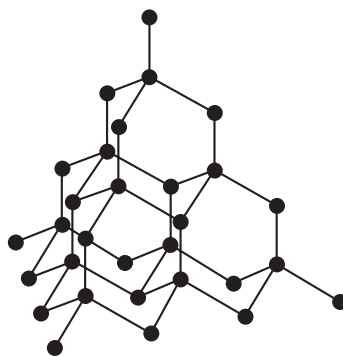


Fig. 8.2

(i) Name the type of bonding in diamond.

..... [1]

(ii) Use Fig. 8.2 to explain why diamond is used in cutting tools.

..... [1]

[Total: 12]

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The Periodic Table of Elements

| Group                                                                                       |                             |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               |                               |                             |                             |                              |                               |                              |                             |
|---------------------------------------------------------------------------------------------|-----------------------------|----------------------------|-----------------------------|---------------------------------|------------------------------|------------------------------|------------------------------|----------------------------|------------------------------|--------------------------------|-------------------------------|-------------------------------|-----------------------------|-----------------------------|------------------------------|-------------------------------|------------------------------|-----------------------------|
| I                                                                                           | II                          |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               | III                           | IV                          | V                           | VI                           | VII                           | VIII                         |                             |
| <div>Key</div> <div>atomic number<br/>atomic symbol<br/>name<br/>relative atomic mass</div> |                             |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               |                               |                             |                             |                              |                               |                              |                             |
| <div>1<br/>H<br/>hydrogen<br/>1</div>                                                       |                             |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               |                               |                             |                             |                              |                               |                              |                             |
| 3<br>Li<br>lithium<br>7                                                                     | 4<br>Be<br>beryllium<br>9   |                            |                             |                                 |                              |                              |                              |                            |                              |                                |                               | 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       |                             |
| 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      |                             |
| 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    |                             |
| 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     |                             |
| 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>— |

|             |                              |                            |                                 |                              |                             |                             |                             |                               |                            |                               |                              |                           |                               |                              |                              |
|-------------|------------------------------|----------------------------|---------------------------------|------------------------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|----------------------------|-------------------------------|------------------------------|---------------------------|-------------------------------|------------------------------|------------------------------|
| 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  |
| actinoids   | 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>— |

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