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## 0620/32

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 compounds is shown.

ammonia  
carbon dioxide  
carbon monoxide  
cobalt(II) chloride  
ethane  
ethene  
glucose  
methane  
potassium sulfate  
sodium phosphate  
sulfur dioxide

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

Give the name of the compound that:

(a) is an unsaturated hydrocarbon

..... [1]

(b) leads to the deoxygenation of water in rivers

..... [1]

(c) is a gas which turns damp red litmus paper blue

..... [1]

(d) is the main constituent of natural gas

..... [1]

(e) is a product of photosynthesis

..... [1]

(f) is a compound of a transition element.

..... [1]

[Total: 6]

2 Petroleum is a mixture of hydrocarbons.

(a) Describe **two** characteristics of a mixture.

1 .....

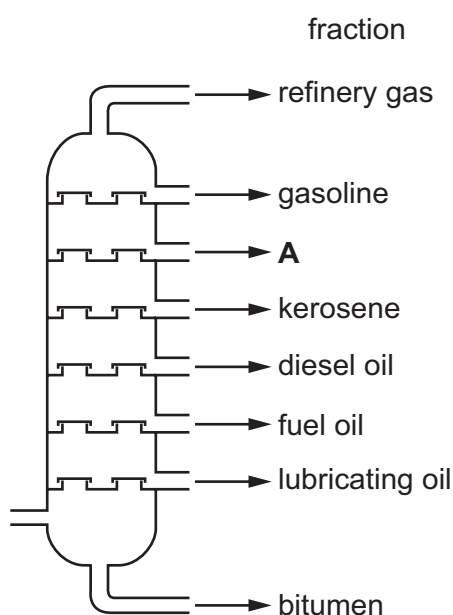
.....

2 .....

.....

[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 lowest volatility collects. [1]

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

..... [1]

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

..... [1]

(iv) State **one** use of the fuel oil 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 | 2.5                                                               | 12.0         | 19.6               | 28.0         | 30.0           |
| 2020 | 2.0                                                               | 13.5         | 21.8               | 30.1         | 21.7           |
| 2021 | 1.8                                                               | 14.8         | 18.5               | 27.5         | 23.8           |
| 2022 | 1.6                                                               | 16.0         | 22.7               | 26.2         | 25.0           |

- (i) Name the oxide pollutant that has the highest concentration in 2021.

..... [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 particulates in a  $250 \text{ cm}^3$  sample of polluted air in 2019.

mass = ..... ng [1]

- (b) (i) State **one** adverse effect of particulates on health.

..... [1]

- (ii) Particulates are formed by the incomplete combustion of hydrocarbons.

State the meaning of the term incomplete combustion.

.....  
 ..... [1]

- (c) (i) Oxides of nitrogen contribute to acid rain.

Choose from the list the pH value for an acidic solution.

Draw a circle around your chosen answer.

pH5                  pH7                  pH9                  pH13                  [1]

- (ii) Complete the sentence about removing oxides of nitrogen from car exhausts by choosing **two** words from the list.

agent                  catalytic                  compound                  converter  
distillation                  filter                  oxidising                  pump

The emission of oxides of nitrogen from car exhausts is reduced by using a

..... [1]

- (iii) Oxides of nitrogen can be formed by the action of bacteria on nitrates.

Name the aqueous solution and the metal used in the test for nitrate ions.

aqueous solution .....

metal ..... [2]

- (d) Nitrogen dioxide decomposes when heated. Nitric oxide and oxygen are produced.

- (i) Complete the symbol equation for this reaction.



- (ii) State the meaning of the symbol ⇌.

..... [1]

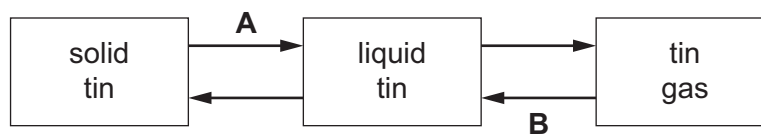
[Total: 12]

4 Tin is a solid at room temperature.

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

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

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



**Fig. 4.1**

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

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

(c) Describe solid and liquid tin in terms of the separation and motion of the particles.

solid tin

separation .....

.....

motion .....

.....

liquid tin

separation .....

.....

motion .....

.....

[4]

**(d)** A sealed gas syringe contains  $80\text{ cm}^3$  of carbon dioxide gas.

State how decreasing the temperature affects the volume of carbon dioxide gas in the gas syringe when the pressure remains constant.

..... [1]

[Total: 9]

5 This question is about metals.

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

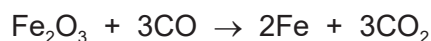
**Table 5.1**

| 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                                     |                                        |
| sodium    | 98                     |                        | 23.7                                     | bubbles form rapidly<br>but no flame   |
| potassium | 63                     | 760                    | 45.4                                     | bubbles form rapidly<br>and flame seen |
| rubidium  | 39                     | 686                    |                                          | explodes                               |

Use the information in Table 5.1 to predict:

- (i) the boiling point of sodium ..... [1]
- (ii) the atomic volume of rubidium ..... [1]
- (iii) the observations when lithium reacts with water .....  
..... [1]
- (iv) the physical state of lithium 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, Fe<sub>2</sub>O<sub>3</sub>, with carbon monoxide.



- (i) Explain how this equation shows that iron(III) oxide is reduced.  
.....  
..... [1]

- (ii) Choose the phrase which describes the meaning of (III) in iron(III) oxide.

Tick (✓) **one** box.

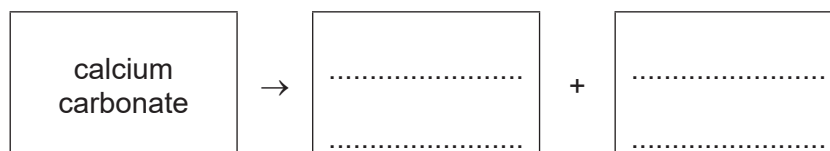
- |                                                             |                          |
|-------------------------------------------------------------|--------------------------|
| the number of oxygen atoms in iron(III) oxide               | <input type="checkbox"/> |
| the oxidation number of iron in iron(III) oxide             | <input type="checkbox"/> |
| the number of CO molecules which react with iron(III) oxide | <input type="checkbox"/> |
| the number of electrons in one atom of iron                 | <input type="checkbox"/> |

[1]

- (iii) Calcium carbonate is added to the blast furnace.

The calcium carbonate undergoes thermal decomposition.

Complete the word equation for the thermal decomposition of calcium carbonate.



[2]

- (c) Stainless steel is an alloy.

- (i) Choose the diagram, **A**, **B**, **C** or **D**, in Fig. 5.1 that best shows the structure of an alloy.

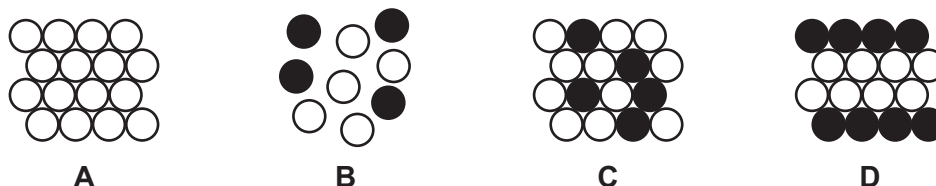


Fig. 5.1

diagram ..... [1]

- (ii) Give **one** reason for using stainless steel instead of pure iron for cutlery.

..... [1]

(d) Table 5.2 gives the observations when four different metals react with dilute hydrochloric acid.

**Table 5.2**

| metal     | observations              |
|-----------|---------------------------|
| iron      | bubbles form slowly       |
| mercury   | no bubbles seen           |
| strontium | bubbles form very quickly |
| tin       | bubbles form very slowly  |

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 A student investigates the reaction of large pieces of magnesium with dilute hydrochloric acid at 20°C. The magnesium is in excess.

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

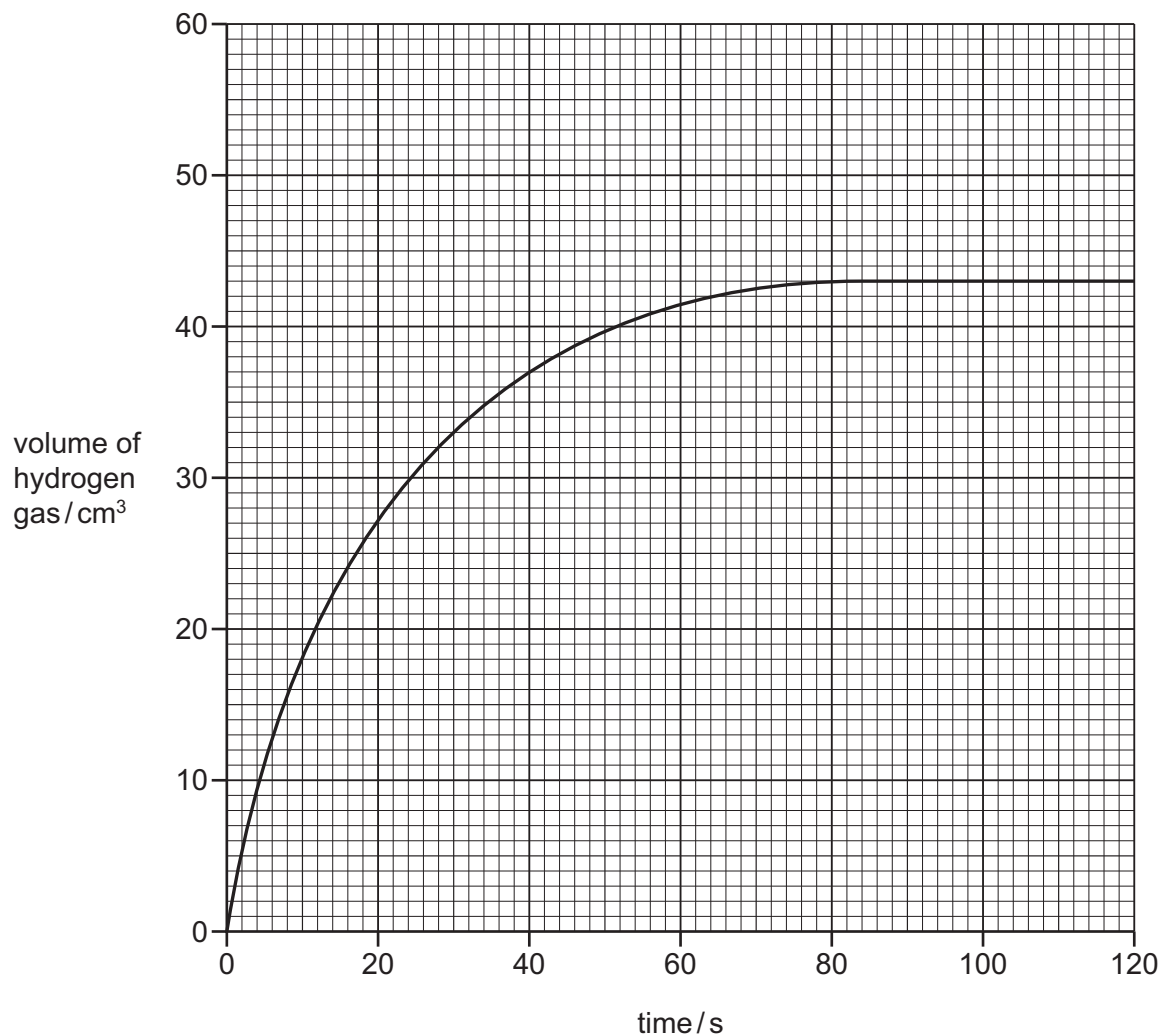


Fig. 6.1

- (i) Deduce the volume of hydrogen gas released after 30 seconds.

volume of hydrogen = ..... cm³ [1]

- (ii) The student repeats the experiment using smaller pieces of magnesium. The mass of magnesium used remains the same. The magnesium is still in excess.

All other conditions stay the same.

Draw a line on the grid in Fig. 6.1 to show the volume of hydrogen gas released when smaller pieces of magnesium are used. [2]

- (b) (i) The student repeats the experiment at a higher temperature of 35 °C.

All other conditions stay the same.

Describe how the rate of reaction differs when a temperature of 35 °C is used.

..... [1]

- (ii) The student repeats the experiment using a lower concentration of acid.

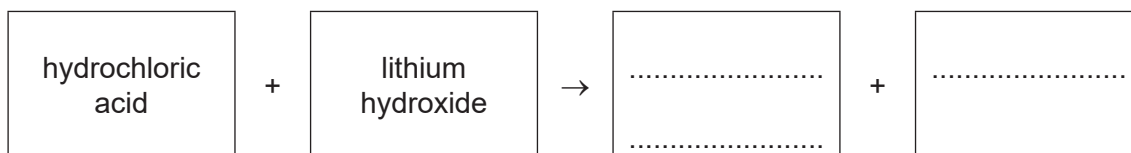
All other conditions stay the same.

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

..... [1]

- (c) Hydrochloric acid reacts with lithium hydroxide.

- (i) Complete the word equation for this reaction.



[2]

- (ii) Choose from the list the word that best describes this reaction.

Draw a circle around your chosen answer.

**addition**      **decomposition**      **neutralisation**      **oxidation** [1]

- (iii) State the colour of a solution of thymolphthalein dissolved in aqueous sodium hydroxide.

..... [1]

[Total: 9]

- 7 (a) Fig. 7.1 shows the displayed formula of fumaric acid.

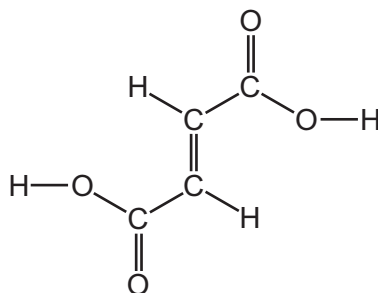


Fig. 7.1

- (i) On Fig. 7.1, draw a circle around **one** carboxylic acid functional group. [1]

- (ii) Deduce the molecular formula of fumaric acid.

..... [1]

- (iii) Fumaric acid is a colourless compound.

Describe the colour change when excess fumaric acid is added to aqueous bromine.

from ..... to ..... [2]

- (b) Fumaric acid can be oxidised to produce a compound with the molecular formula  $C_4H_6O_6$ .

Complete Table 7.1 to calculate the relative molecular mass of  $C_4H_6O_6$ .

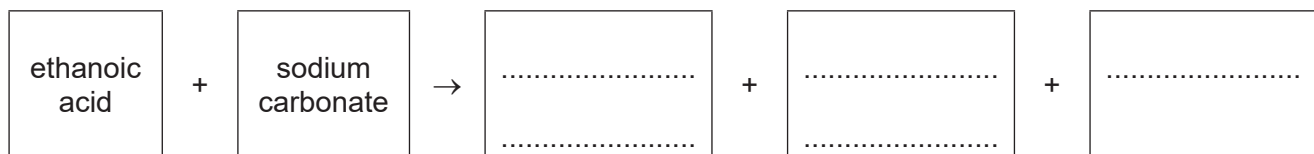
Table 7.1

| atom     | number of atoms | relative atomic mass |                    |
|----------|-----------------|----------------------|--------------------|
| carbon   | 4               | 12                   | $4 \times 12 = 48$ |
| hydrogen |                 | 1                    |                    |
| oxygen   |                 | 16                   |                    |

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

(c) Ethanoic acid is a carboxylic acid.

Complete the word equation for the reaction of ethanoic acid with sodium carbonate.



[3]

(d) Ethanoic acid can be produced by the oxidation of ethanol.

(i) State **one** use of ethanol.

..... [1]

(ii) Ethanol, C<sub>2</sub>H<sub>5</sub>OH, is an alcohol.

Choose from the list the general formula for the alcohol homologous series.

Draw a circle around your chosen answer.

$C_nH_nOH$        $C_nH_{2n+1}OH$        $C_nH_{2n+2}OH$        $C_{2n}H_{2n}OH$ 
[1]

(iii) Ethanol can be manufactured by the addition of steam to ethene.

State **two** conditions for this reaction.

1 .....

2 .....

[2]

[Total: 13]

8 Zinc chloride is an ionic compound.

(a) Ionic compounds are good electrical conductors when molten or in aqueous solution.

Describe one **other** physical property of ionic compounds.

..... [1]

(b) Complete Fig. 8.1 to show:

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

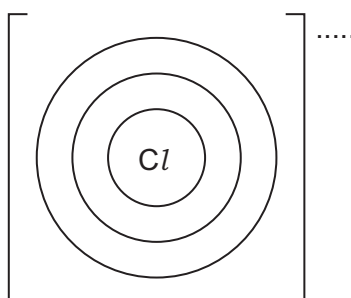


Fig. 8.1

[2]

(c) (i) Deduce the number of protons and neutrons in the zinc ion shown.



number of protons .....

number of neutrons .....

[2]

(ii) Complete this sentence about positive ions.

Positive ions are known as ..... [1]

(d) Molten zinc chloride is electrolysed using graphite electrodes.

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]

(e) Graphite electrodes conduct electricity.

(i) State one **other** property that the electrode should have.

..... [1]

(ii) Choose the correct statement about the structure and bonding in graphite.

Tick (✓) **one** box.

simple ionic

☐

simple covalent

☐

giant ionic

☐

giant covalent

☐

[1]

(iii) State **one** use of graphite other than as an electrode.

..... [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.).