Cambridge Assessment International Education

# Cambridge IGCSE™

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| CANDIDATE NAME | | | | | | | | | |
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*1120006290*

**CHEMISTRY** **0620/31**

Paper 3 Theory (Core) **May/June 2024**

**1 hour 15 minutes**

You must answer on the question paper.

No additional materials are needed.

**INSTRUCTIONS**

- 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.

**INFORMATION**

- 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.



**[Turn over**

**1** Fig. 1.1 shows the structures of seven substances, **A**, **B**, **C**, **D**, **E**, **F** and **G**.

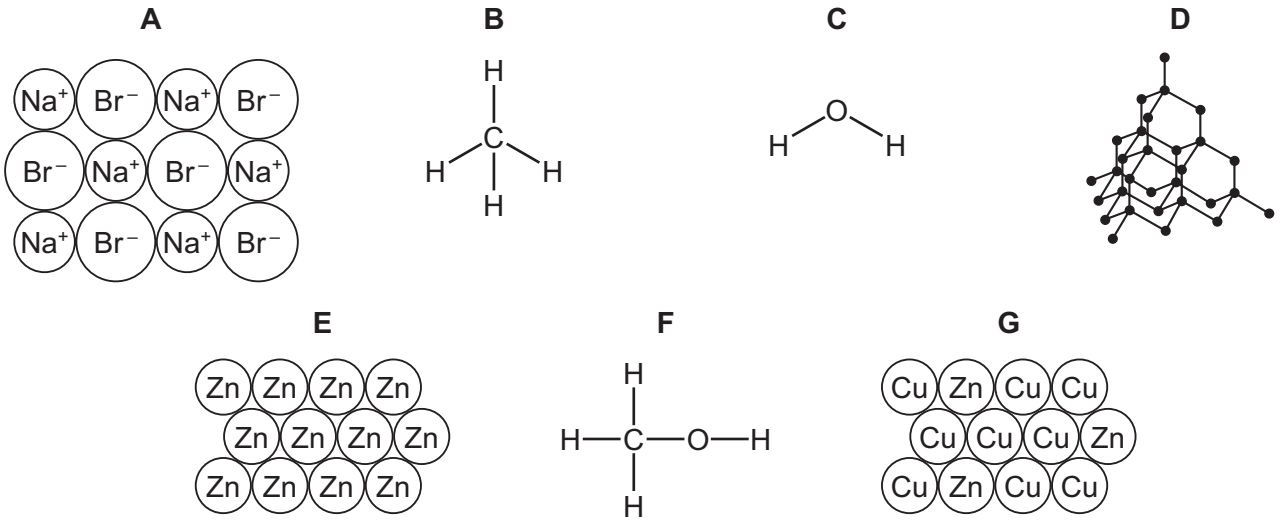



**Fig. 1.1**

**(a)** Answer the following questions using only the structures in Fig. 1.1.
Each structure may be used once, more than once or not at all.

State which structure represents:

**(i)** an alloy

..... [1]

**(ii)** a substance that only conducts electricity when molten or in aqueous solution

..... [1]

**(iii)** a giant covalent structure

..... [1]

**(iv)** a compound that is a product formed in a hydrogen–oxygen fuel cell

..... [1]

**(v)** a compound with a high melting point

..... [1]

**(vi)** a gas that is responsible for increased global warming.

..... [1]

**(b)** Complete Fig. 1.2 to show the dot-and-cross diagram for structure **C**.
Show the outer shell electrons only.

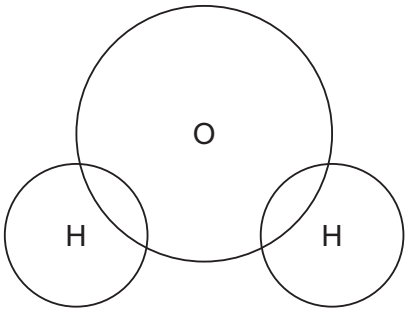



**Fig. 1.2**

[2]

[Total: 8]

**2** **(a)** Table 2.1 shows the percentages by mass of the elements present in the human body.

**Table 2.1**

| element | percentage by mass of element |
|---|---|
| calcium | 1.50 |
| carbon | 18.00 |
| chlorine | 0.15 |
| hydrogen | 10.00 |
| magnesium | 0.05 |
| nitrogen | 3.00 |
| oxygen | 65.00 |
| phosphorus | 1.00 |
| potassium | 0.35 |
| sodium | 0.15 |
| sulfur | 0.25 |
| other elements | 0.55 |

Answer these questions using information from Table 2.1.

**(i)** Name the non-metallic element in Table 2.1 that has the lowest percentage by mass.

..... [1]

**(ii)** Name an element in Table 2.1 that is in Period 4 of the Periodic Table.

..... [1]

**(b)** Some medicines contain a compound made of $Mg^{2+}$ ions and $OH^-$ ions.

Name the compound made of $Mg^{2+}$ ions and $OH^-$ ions.

..... [1]

**(c)** Describe the observations when aqueous sodium hydroxide is added dropwise to a solution containing calcium ions until the sodium hydroxide is in excess.

observations with dropwise addition of sodium hydroxide

.....

observations with excess sodium hydroxide

.....
[2]

**(d)** Name a calcium salt that is soluble in water.

..... [1]

**(e)** Table 2.2 shows some properties of the Group I metals.

**Table 2.2**

| metal | melting point / °C | observations on reaction with water |
|---|---|---|
| lithium | 181 | |
| sodium | 98 | bubbles form rapidly but no flame |
| potassium | | bubbles form very rapidly and flame |
| rubidium | 39 | explodes |

Use the information in Table 2.2 to predict:

- the melting point of potassium

.....

- the observations when lithium reacts with water.

.....

[2]

**(f)** State how the density of the Group I elements changes down the group.

..... [1]

**(g)** Sodium reacts with water to produce sodium hydroxide and a gas which pops with a lighted splint.

Complete the symbol equation for this reaction.

$$.....Na + 2H_2O \rightarrow 2NaOH + .....$$ [2]

[Total: 11]



**[Turn over**

**3** Aluminium is extracted by electrolysis of its purified ore.

**(a)** Name the main ore of aluminium.

..... [1]

**(b)** Fig. 3.1 shows the apparatus used in the extraction of aluminium.

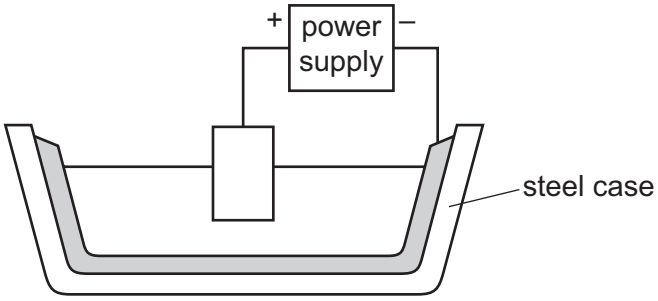



**Fig. 3.1**

**(i)** Label the cathode in Fig. 3.1. [1]

**(ii)** The electrolyte contains molten aluminium oxide.

State the product formed at each electrode.

positive electrode .....

negative electrode .....
[2]

**(c)** State **two** physical properties that explain why aluminium is used in overhead electrical cables.

1 .....

2 .....
[2]

**(d)** Aluminium ore is purified by reacting it with sodium hydroxide.
Sodium hydroxide is an alkali.

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

..... [1]

**(ii)** Describe how to find the pH of a dilute solution of sodium hydroxide using universal indicator paper.

.....

..... [2]

**(iii)** A dilute solution of sodium hydroxide is added to a solution of methyl orange in acid until the sodium hydroxide is in excess.

State the colour change of the methyl orange.

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

[Total: 11]

**4** **(a)** Fig. 4.1 shows the displayed formula of a compound extracted from a plant.

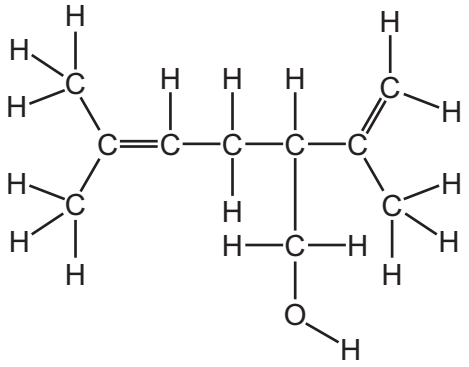


**Fig. 4.1**

On Fig. 4.1, draw a circle around **one** functional group that makes this compound unsaturated. [1]

**(b)** A student extracts mixtures of coloured compounds from four different plants, **Q**, **R**, **S** and **T**.

Fig. 4.2 shows the results of chromatography of these mixtures using an organic solvent.

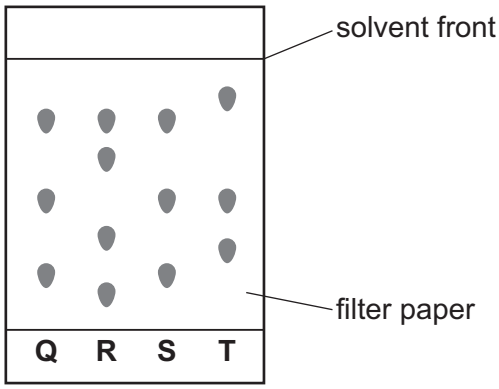



**Fig. 4.2**

**(i)** Deduce which plant, **Q**, **R**, **S** or **T**, contains the greatest number of coloured compounds.

..... [1]

**(ii)** Deduce which **two** plants, **Q**, **R**, **S** or **T**, contain exactly the same coloured compounds.

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

**(iii)** State the meaning of the term solvent.

..... [1]

**(c) (i)** Plants produce glucose and oxygen by photosynthesis.

Complete the word equation for photosynthesis.

| | | | | | | |
|---|---|---|---|---|---|---|
| ..... ..... | + | ..... | → | glucose | + | oxygen |

[2]

**(ii)** Name one **other** substance that is essential for photosynthesis.

..... [1]

[Total: 7]

**5** **(a)** An atom of carbon is represented by the symbol shown.

$$^{14}_{6}C$$

Describe this atom of carbon in terms of:

- the position of the electrons, neutrons and protons in this atom

.....

.....

.....

- the number of neutrons and number of protons

.....

.....

- the electronic configuration.

.....

[5]

**(b)** **(i)** Complete the symbol equation for the incomplete combustion of carbon to produce carbon monoxide.

$$.....C + O_2 \rightarrow .....CO$$ [2]

**(ii)** State **one** adverse effect of carbon monoxide.

..... [1]

**(c)** Fig. 5.1 shows the displayed formula of chromium carbonyl.

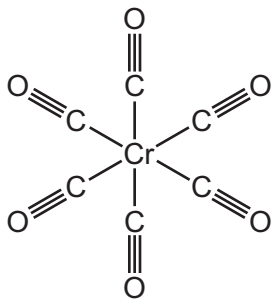



**Fig. 5.1**

Deduce the molecular formula of chromium carbonyl.

..... [1]

**(d)** Another compound of chromium has the formula $Na_2Cr_2C_{10}O_{10}$.

Complete Table 5.1 to calculate the relative molecular mass of $Na_2Cr_2C_{10}O_{10}$.

**Table 5.1**

| type of atom | number of atoms | relative atomic mass | |
|---|---|---|---|
| sodium | 2 | 23 | $2 \times 23 = 46$ |
| chromium | | 52 | |
| carbon | | 12 | |
| oxygen | | 16 | |

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

**(e)** Chromium can be produced by heating chromium(III) oxide, $Cr_2O_3$, with carbon.

$$Cr_2O_3 + 3C \rightarrow 2Cr + 3CO$$

Describe how this equation shows that chromium(III) oxide is reduced.

.....

..... [1]

[Total: 12]



**[Turn over**

**6** Large pieces of solid sulfur burn in excess oxygen to produce sulfur dioxide gas.

**(a)** Complete the equation by adding the missing state symbol.

$$S(.....) + O_2(g) \rightarrow SO_2(g)$$ [1]

**(b)** Fig. 6.1 shows how the mass of sulfur changes as the reaction proceeds.

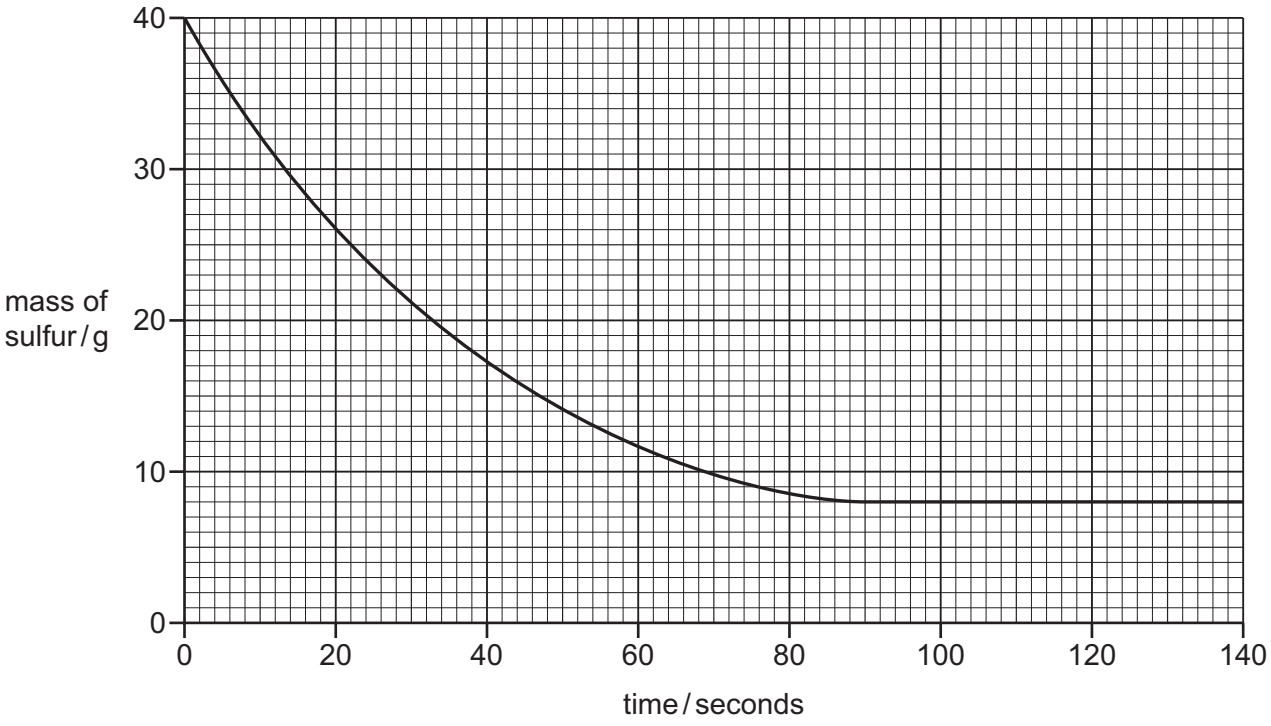



**Fig. 6.1**

Deduce the time taken for the reaction to finish.

..... [1]

**(c)** The experiment is repeated using powdered sulfur.

Describe the effect on the rate of reaction of using powdered sulfur rather than large pieces of sulfur.

..... [1]

**(d)** Sulfur dioxide reacts with oxygen in a closed container.

$$2SO_2(g) + O_2(g) \rightleftharpoons 2SO_3(g)$$

**(i)** Describe the effect, if any, each of the following has on the rate of this reaction.

All other conditions stay the same.

- The temperature is decreased.

.....

- The pressure of the gases is increased.

.....

[2]

**(ii)** Changing concentration changes the rate of a reaction.

Choose the correct unit of concentration from the list.

Draw a circle around your chosen answer.

**$dm^3$ / mol** **mol / dm** **mol / $dm^2$** **mol / $dm^3$** [1]

**(e)** Sulfur dioxide is an air pollutant.

**(i)** State **one** adverse effect of sulfur dioxide.

..... [1]

**(ii)** Emissions of sulfur dioxide can be reduced by using low-sulfur fossil fuels.

State one **other** way of reducing sulfur dioxide emissions from fossil fuels.

..... [1]



**[Turn over**

**(f)** Aqueous sodium hydrogen sulfite releases sulfur dioxide gas at room temperature.

Sulfur dioxide changes the colour of acidified potassium manganate(VII) from purple to colourless.

Fig. 6.2 shows a sealed tube with a small volume of aqueous sodium hydrogen sulfite at the bottom. A piece of filter paper soaked in acidified potassium manganate(VII) is attached to the top of the tube.

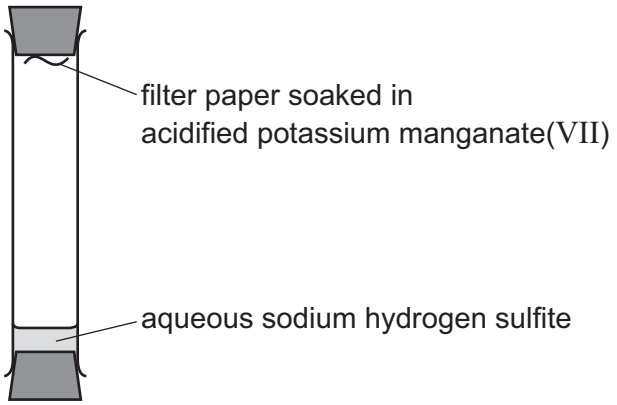



**Fig. 6.2**

The filter paper remains purple at first.
The filter paper becomes colourless after a short time.

Explain these results in terms of kinetic particle theory.

.....

.....

.....

..... [3]

[Total: 11]

**7** Iron is a metal. Iron has a high density, a high melting point and a high boiling point.

**(a)** State three **other** physical properties of iron.

1 .....

2 .....

3 .....

[3]

**(b) (i)** State the conditions needed for iron to rust.

.....

..... [2]

**(ii)** Rust is hydrated iron(III) oxide.

State if iron(III) oxide is an acidic or basic oxide.
Give a reason for your answer.

.....

..... [1]

**(iii)** Complete this sentence about methods of preventing rusting.

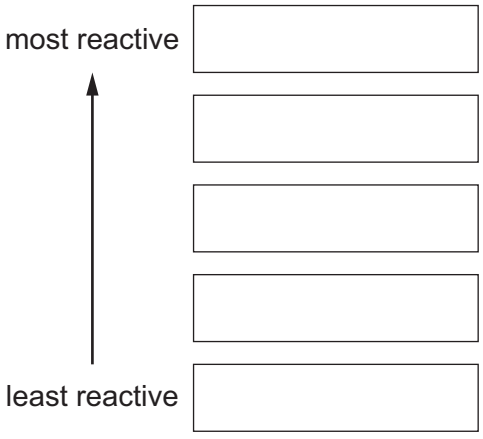
Rusting can be prevented by painting or .....

..... [1]

**(c)** The list shows five metals.

**calcium** **copper** **iron** **silver** **sodium**

Put these metals in order of their reactivity.
Put the most reactive metal at the top.




[2]

**(d)** Complete the word equation for the reaction of calcium carbonate with nitric acid.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| calcium carbonate | + | nitric acid | → | ..... ..... | + | water | + | ..... ..... |

[2]

[Total: 11]

**8** **(a)** Fig. 8.1 shows the displayed formulae of five organic compounds, **V**, **W**, **X**, **Y** and **Z**.

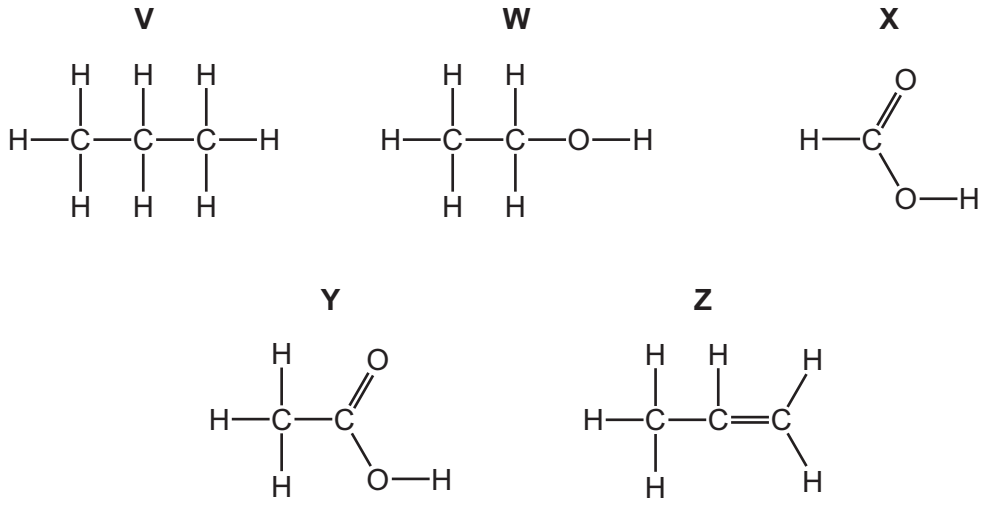



**Fig. 8.1**

**(i)** State which **two** of the compounds, **V**, **W**, **X**, **Y** and **Z**, are in the same homologous series.

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

**(ii)** Explain why compound **V** is an alkane.

.....

..... [2]

**(iii)** State the name of the homologous series to which compound **X** belongs.

..... [1]

**(b)** Ethanol can be manufactured by the catalytic addition of steam to ethene.

**(i)** State the temperature and pressure required for this reaction.

temperature ..... °C

pressure ..... atm

[2]

**(ii)** Name one **other** method of manufacturing ethanol.

..... [1]

**(c)** Describe how alkenes are manufactured from petroleum fractions.

.....

.....

..... [2]

[Total: 9]

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## The Periodic Table of Elements

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

**Key**

atomic number
atomic symbol
name
relative atomic mass

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

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