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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.

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

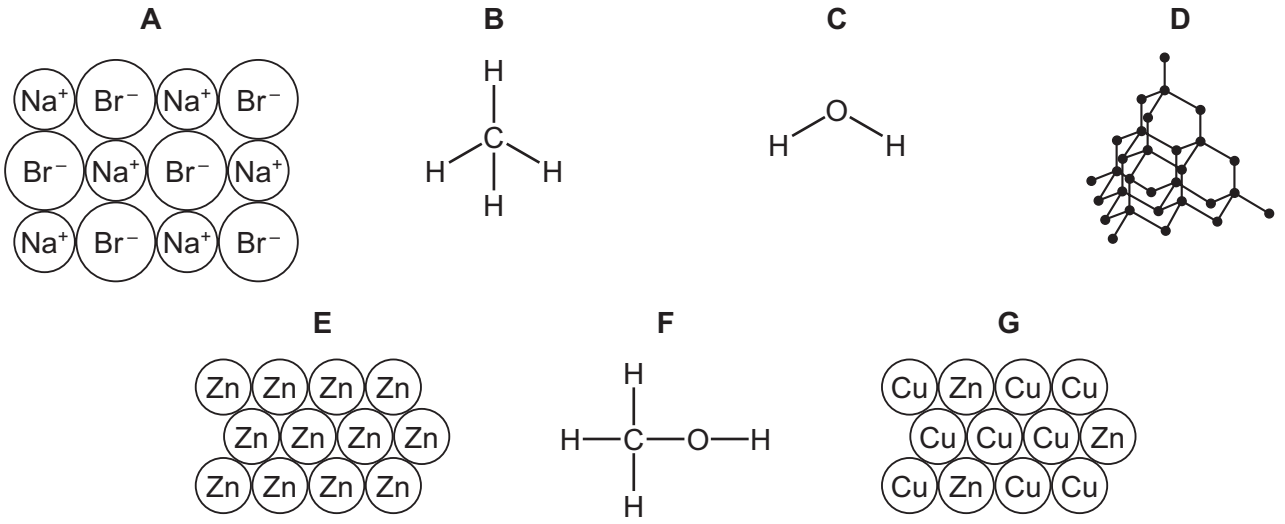

Fig. 1.1

(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]

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

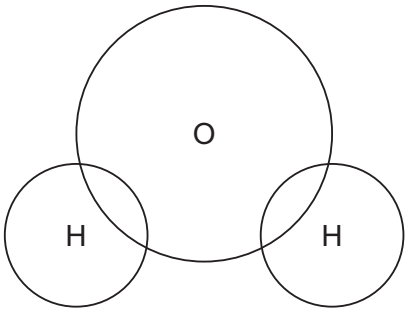

Fig. 1.2

[2]

[Total: 8]

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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]

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(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]

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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.

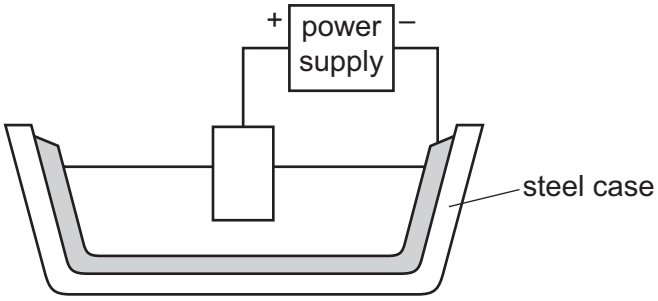

Fig. 3.1

(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]

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(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]

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

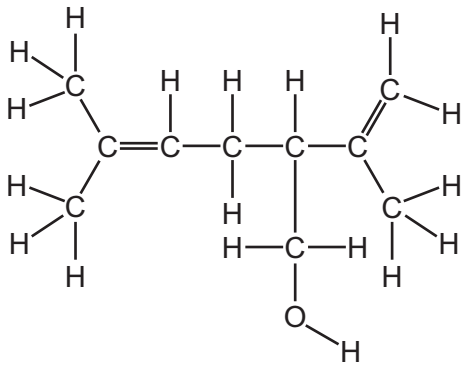

Fig. 4.1

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.

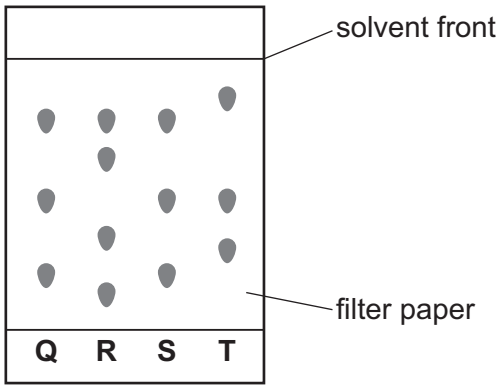

Fig. 4.2

(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]

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(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]

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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.

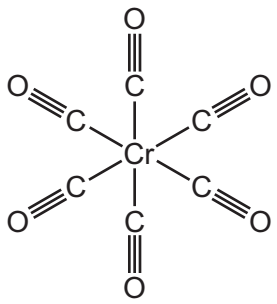

Fig. 5.1

Deduce the molecular formula of chromium carbonyl.

..... [1]

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(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]

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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.

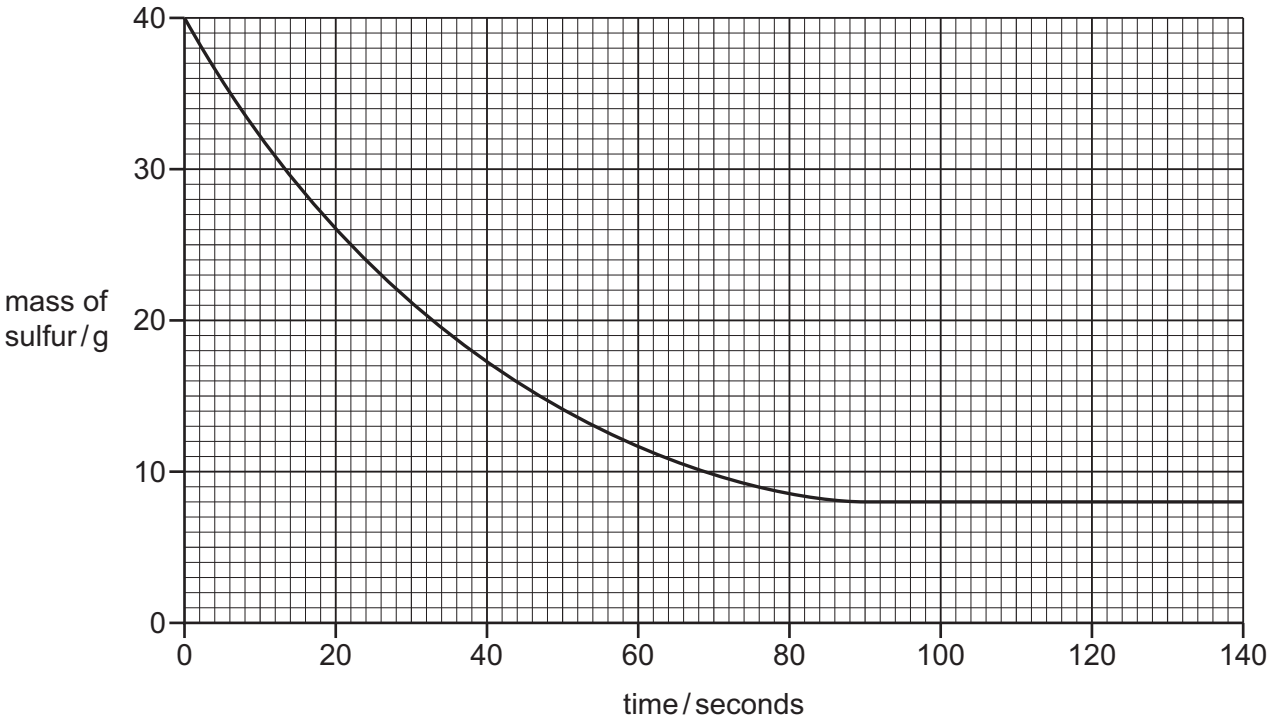

Fig. 6.1

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]

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(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]

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(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.

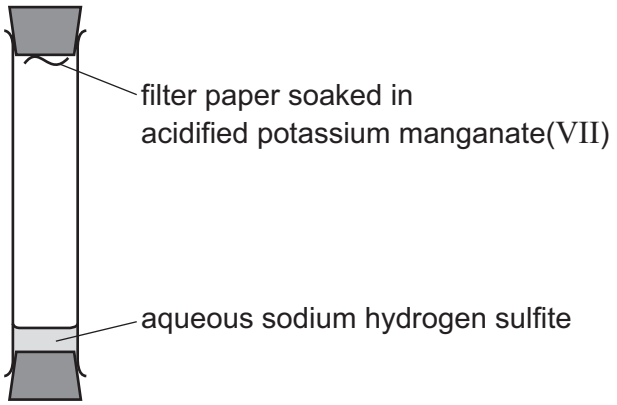

Fig. 6.2

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]

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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.

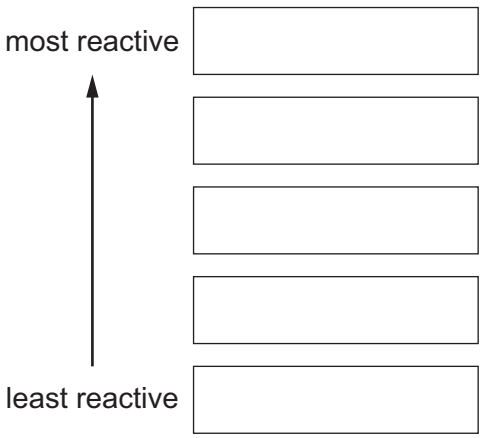
Rusting can be prevented by painting or .....

..... [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]

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

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

[2]

[Total: 11]

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

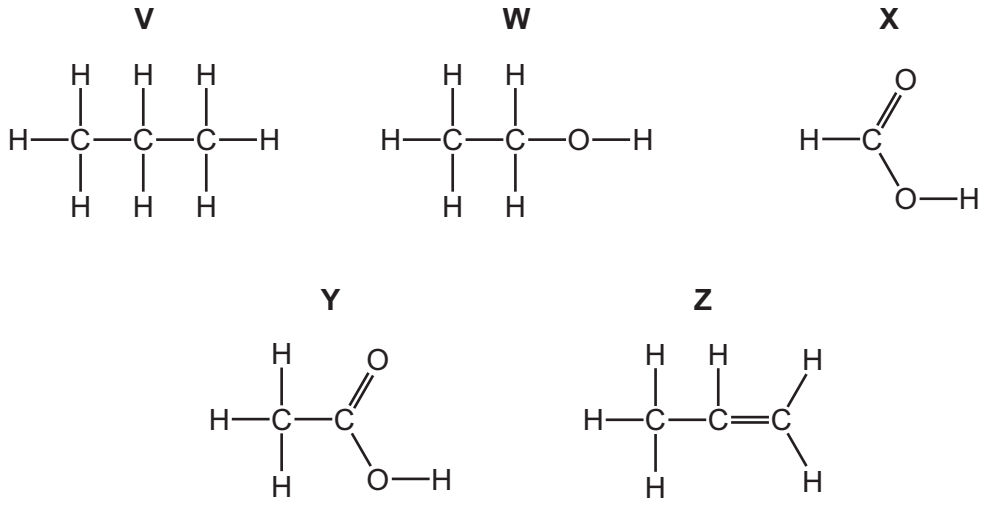

Fig. 8.1

(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.).

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