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CHEMISTRY **0620/33**

Paper 3 Theory (Core) **October/November 2025**

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.

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1 Fig. 1.1 shows part of the Periodic Table.

I	II											III	IV	V	VI	VII	VIII
							H										He
Li													C	N	O		Ne
Na												Al			S		
	Ca						Fe				Zn					Br	
																I	
										Au							

Fig. 1.1

Answer the following questions using only the symbols of the elements in Fig. 1.1.
Each symbol may be used once, more than once or not at all.

Give the symbol of the element that:

(a) is used in food containers because of its resistance to corrosion

..... [1]

(b) is a metal that does **not** react with water, dilute acids or oxygen

..... [1]

(c) reacts with hydrogen in a fuel cell

..... [1]

(d) is bonded to hydrogen in methane.

..... [1]

[Total: 4]

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2 The symbol for an atom of xenon is shown.

$$^{131}_{54}Xe$$

(a) Complete Table 2.1 to show the number of neutrons and nucleons in one atom of $^{131}_{54}Xe$.

Table 2.1

number of neutrons	
number of nucleons	

[2]

(b) Xenon is a gas at room temperature and pressure.

A sample of xenon is placed in a sealed syringe with a freely moving plunger.

Complete Table 2.2 to show the effect, if any, on the volume of xenon when:

- the temperature of the xenon is decreased
- the pressure of the xenon is decreased.

Use the words **increases**, **decreases** or **no change** in your answer.

Table 2.2

change	effect on the volume of xenon
temperature is decreased	
pressure is decreased	

[2]

(c) When xenon is cooled, it becomes a solid.

Describe the arrangement and motion of the particles in solid xenon.

particle arrangement .....

.....

particle motion .....

.....

[2]

[Total: 6]

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3 **(a)** Table 3.1 shows the masses of ions, in mg, present in a 600 cm^3 sample of contaminated water.

Table 3.1

name of ion	formula of ion	mass of ion in 600 cm^3 of contaminated water / mg
calcium	Ca^{2+}	7.3
hydrogencarbonate	HCO_3^-	11.2
iodide	I^-	25.0
magnesium	Mg^{2+}	6.2
nitrate	NO_3^-	0.3
	PO_4^{3-}	0.1
potassium	K^+	0.1
sodium	Na^+	2.7
sulfate	SO_4^{2-}	9.0

Answer these questions using the information from Table 3.1.

(i) Name the positive ion that has the highest concentration.

..... [1]

(ii) State the name of the PO_4^{3-} ion.

..... [1]

(iii) Describe a test to identify the presence of nitrate ions, NO_3^-, in a sample of water.

test .....

.....

test result .....

[2]

(iv) Calculate the mass of sodium ions, Na^+, in 200 cm^3 of the contaminated water.

mass = ... mg [1]

(v) A higher concentration of nitrate ions in river water can cause deoxygenation.

State a source of a higher concentration of nitrate ions in river water.

..... [1]

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(b) A sample of water is taken from a river. The sample contains some insoluble substances.

State **one** method of removing the insoluble substances from the water.

..... [1]

(c) **(i)** The water contains harmful microbes.

Suggest a source of the microbes in the water.

..... [1]

(ii) State how the water is treated so that the microbes do **not** cause harm to people.

..... [1]

(d) Before the treatment in **(c)(ii)**, the water has a bad taste and odour.

State the name of a substance that is added to remove the bad taste and odour from the water.

..... [1]

[Total: 10]

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4 **(a)** Compound **B** is a molecule found in a plant called basil.

Fig. 4.1 shows the displayed formula of a molecule of compound **B**.

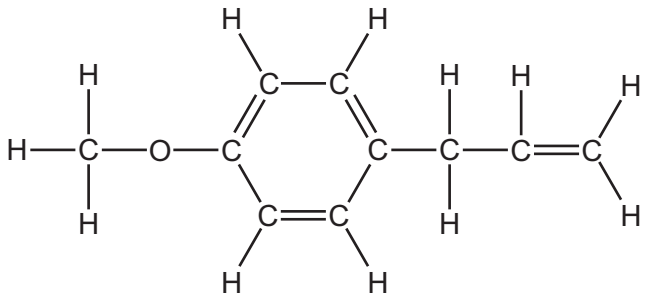


Fig. 4.1

Deduce the molecular formula of compound **B** to show the number of atoms of carbon, hydrogen and oxygen.

..... [1]

(b) On Fig. 4.1, draw a circle around **one** part of the molecule which shows that the molecule is unsaturated. [1]

(c) A different molecule found in plants has the molecular formula $C_9H_{10}O_3$.

Complete Table 4.1 to calculate the relative molecular mass of $C_9H_{10}O_3$.

Table 4.1

type of atom	number of atoms	relative atomic mass	
carbon	9	12	9 × 12 = 108
hydrogen		1	
oxygen		16	

relative molecular mass = ... [2]

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(d) Fig. 4.2 shows the names of some of the fractions obtained from petroleum using a fractionating column.

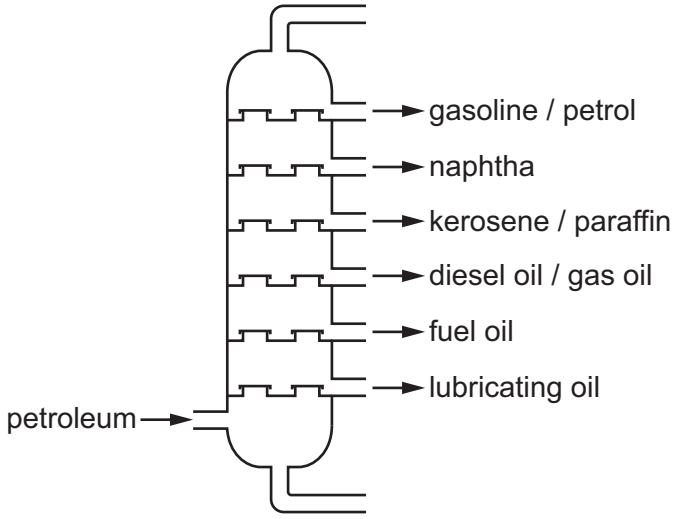


Fig. 4.2

Using only the fractions shown in Fig. 4.2, name the fraction which contains compounds that:

(i) have the highest boiling point

..... [1]

(ii) have the shortest chain length

..... [1]

(iii) are used to make waxes and polishes.

..... [1]

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(e) Table 4.2 shows some properties of alcohols.

Table 4.2

name	formula	melting point / °C	boiling point / °C
hexanol	$C_6H_{13}OH$	–45	157
heptanol	$C_7H_{15}OH$	–35	176
octanol		–16	195
nonanol	$C_9H_{19}OH$		214
decanol	$C_{10}H_{21}OH$	7	233

(i) The compounds in Table 4.2 are members of the alcohol homologous series.

State what is meant by the term homologous series.

.....

..... [1]

(ii) A molecule of octanol has eight carbon atoms.

Use the information in Table 4.2 to deduce the formula of octanol.

..... [1]

(iii) Use the information in Table 4.2 to predict the melting point of nonanol.

..... [1]

(f) **(i)** Hexanol is a fuel. In excess oxygen, hexanol undergoes complete combustion to produce water and one other product.

Identify this other product.

..... [1]

(ii) State the colour change observed when water is added to anhydrous copper(II) sulfate.

from white to .....

[1]

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(g) Ethanol can be manufactured by fermentation.

Name the reactant, and state **two** conditions needed for the fermentation of ethanol.

reactant .....

condition 1 .....

condition 2 .....

[3]

(h) Ethanol can be converted into ethanoic acid.

Draw the displayed formula of ethanoic acid. Show all the atoms and all the bonds.

[2]

[Total: 17]

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5 This question is about elements in different groups of the Periodic Table and their compounds.

(a) Silicon is in Group IV of the Periodic Table.

Explain why silicon is placed in Group IV.
Give your answer in terms of electronic configuration.

..... [1]

(b) Tin is also in Group IV of the Periodic Table.

Table 5.1 shows the melting point and the boiling point of tin.

Table 5.1

melting point / °C	232
boiling point / °C	2602

Use Table 5.1 to deduce the physical state of tin at 175 °C.

Give a reason for your answer.

physical state .....

reason .....

.....
[2]

(c) Iodine is in Group VII of the Periodic Table.

Give the colour and state of iodine at room temperature and pressure.

colour .....

state .....
[2]

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(d) When a sample of calcium is added to a large container of cold water, a chemical reaction occurs.

(i) Describe what is observed when calcium is added to water.

.....

.....

.....

..... [2]

(ii) Complete the word equation for the reaction of calcium with water.

calcium	+	water	→	....	+	.....

[2]

(e) Dilute nitric acid is poured into a conical flask.

(i) Choose the pH value of dilute nitric acid.

Draw a circle around your chosen answer.

pH 1 **pH 7** **pH 9** **pH 13**

[1]

(ii) Complete the equation for the neutralisation of an acid to produce water.

State symbols are not required.

$$H^+ + \text{.....} \rightarrow H_2O$$

[1]

(iii) A few drops of methyl orange indicator are added to the flask containing dilute nitric acid.

Solid lithium carbonate is slowly added to the flask until the indicator changes colour.

State the colour change of the methyl orange indicator as the lithium carbonate is added to the dilute nitric acid in the flask.

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

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(f) Lithium carbonate reacts with dilute nitric acid to form aqueous lithium nitrate.

Describe a test to show that Li^+ ions are present in the solution.

test .....

observations .....

[2]

(g) Chlorine is in Group VII of the Periodic Table.

Chlorine reacts with lithium to form the ionic compound lithium chloride.

Complete the dot-and-cross diagram in Fig. 5.1 for lithium chloride to show:

- the electronic configuration for each ion
- the charge on each ion.

Use crosses to represent the electrons of lithium.

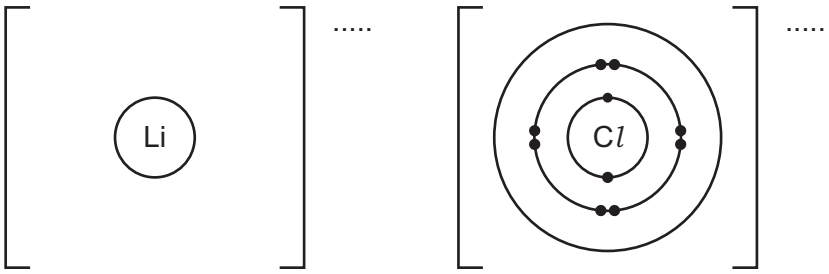


Fig. 5.1

[3]

[Total: 18]

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Question 6 starts on the next page.

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6 This question is about metals.

(a) Iron is extracted from its ore using carbon in a blast furnace.

When calcium carbonate is heated strongly in the blast furnace, it forms calcium oxide and carbon dioxide.

$$CaCO_3 \rightarrow CaO + CO_2$$

(i) State the type of reaction that occurs when calcium carbonate is heated strongly.

..... [1]

(ii) State whether calcium oxide is an acidic oxide or a basic oxide.

Explain your answer.

.....

..... [1]

(iii) Name the gas removed by calcium oxide in flue gas desulfurisation.

..... [1]

(b) Zinc is also extracted from its ore using carbon.

(i) The equation for the extraction of zinc from zinc oxide is shown.

$$2ZnO + C \rightarrow 2Zn + CO_2$$

Explain how this equation shows that zinc oxide is reduced.

.....

..... [1]

(ii) Brass is an alloy that contains zinc.

Name the **other** metal in brass.

..... [1]

(iii) Suggest **two** reasons why brass is used to make water taps rather than pure zinc.

1 .....

2 .....

[2]

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(c) The extraction of zinc from its ore produces atmospheric sulfur dioxide and carbon dioxide.

(i) State the adverse effect that increased levels of sulfur dioxide have on the environment.

..... [1]

(ii) Increased levels of carbon dioxide in the atmosphere can lead to increased global warming.

State **one** strategy which would help to remove carbon dioxide that is already in the atmosphere.

..... [1]

(d) Table 6.1 shows the observations when four different metals are added separately to dilute hydrochloric acid.

Table 6.1

metal	observations
Fe	a few bubbles of gas given off very slowly and the temperature of the mixture increases very slowly
W	no bubbles of gas given off and no temperature increase of the mixture
Ba	many bubbles of gas given off very quickly and the temperature of the mixture increases rapidly
Mg	bubbles of gas given off quickly and the temperature of the mixture increases slowly

Put the four metals in order of their reactivity.
Put the least reactive metal first.

least reactive ⟶ most reactive

[2]

[Total: 11]

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7 Fig. 7.1 shows the apparatus used to electroplate a nickel object with copper.

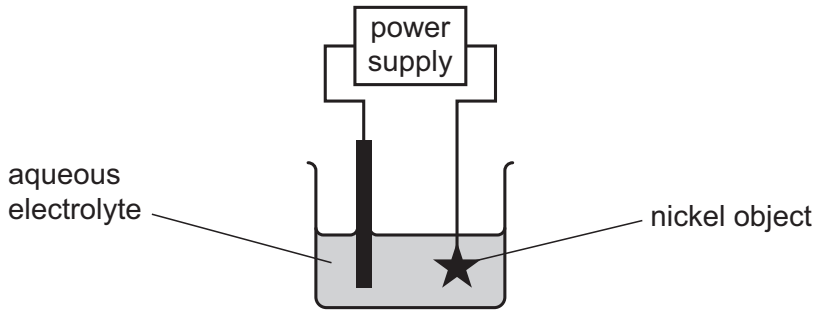


Fig. 7.1

(a) Label the anode in Fig. 7.1. [1]

(b) Name a suitable aqueous electrolyte for the electroplating in Fig. 7.1.

..... [1]

(c) Fig. 7.2 shows the apparatus used to electrolyse molten lead(II) bromide using inert electrodes.

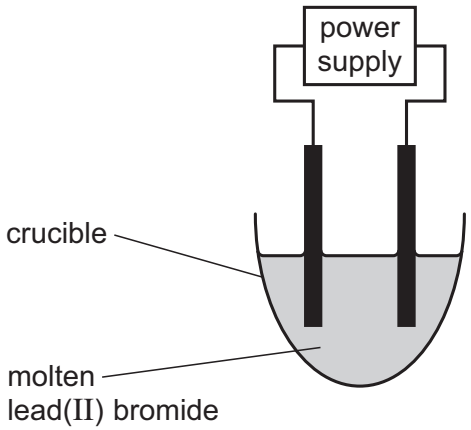


Fig. 7.2

State the colour of the gas produced at the anode in this electrolysis.

..... [1]

(d) State whether the electrolysis of molten lead(II) bromide produces a physical or chemical change.

Explain your answer.

type of change .....

explanation .....

.....

[1]

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(e) Cobalt is a metal that reacts slowly with a dilute acid to produce cobalt(II) ethanoate and hydrogen.

(i) Name the dilute acid.

..... [1]

(ii) Describe a test for hydrogen.

test .....

observations .....

[1]

(f) Cobalt(II) chloride, $CoCl_2$, exists in different forms.

Draw **one** line from each form of cobalt(II) chloride to its description.

form of cobalt(II) chloride	description
hydrated $CoCl_2$	solid $CoCl_2$ containing no water
aqueous $CoCl_2$	solid $CoCl_2$ chemically combined with water
anhydrous $CoCl_2$	$CoCl_2$ dissolved in water

[2]

[Total: 8]

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8 Excess dilute citric acid, $C_6H_8O_7$, is added to aqueous sodium hydrogencarbonate to form aqueous sodium citrate, $Na_3C_6H_5O_7$, carbon dioxide and water.

$$C_6H_8O_7(aq) + 3NaHCO_3(aq) \rightarrow Na_3C_6H_5O_7(aq) + 3CO_2(g) + 3H_2O(l)$$

(a) Give the meaning of the symbol (l) in the equation.

..... [1]

(b) Fig. 8.1 shows the total volume of carbon dioxide gas, CO_2, produced as the reaction proceeds.

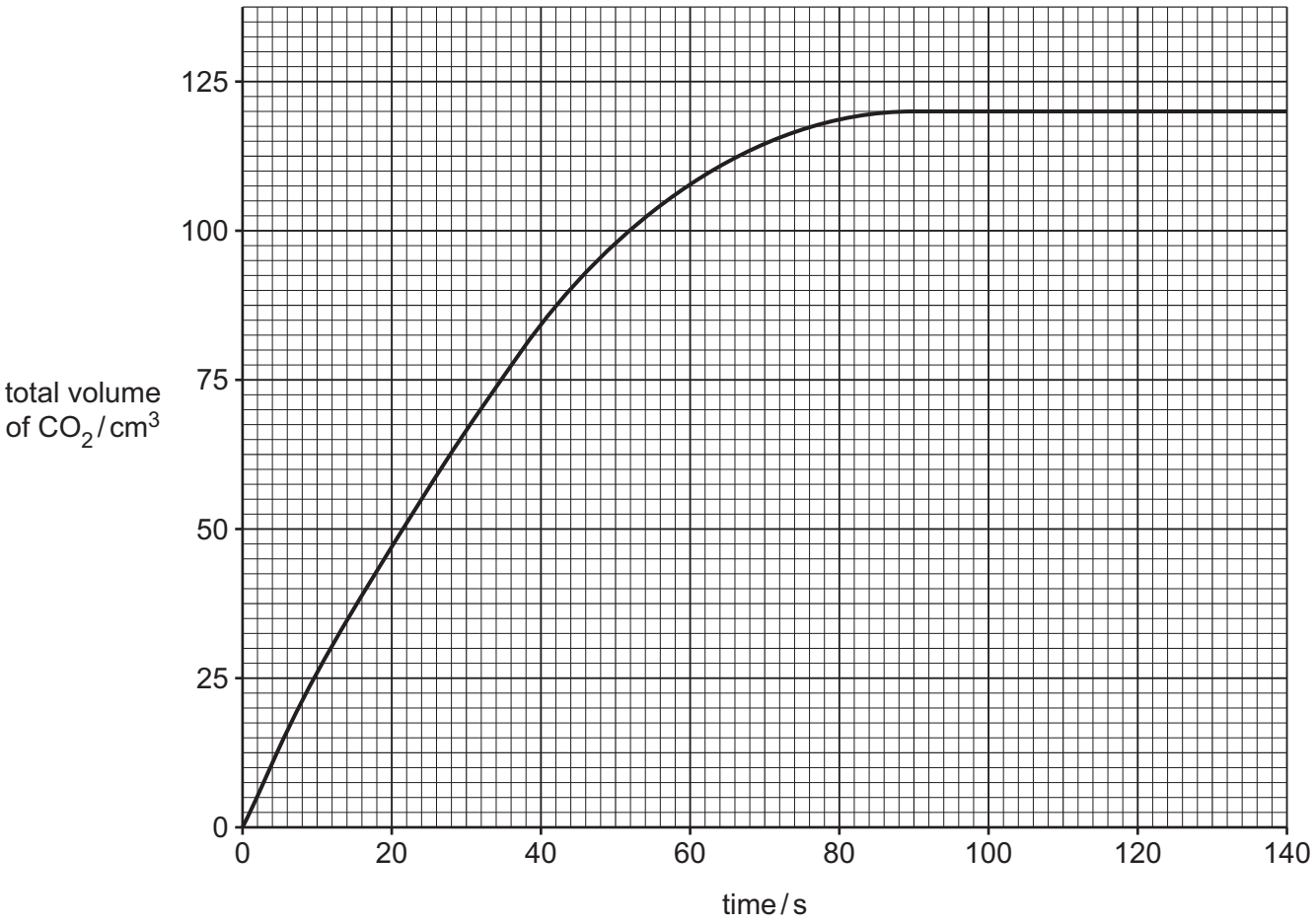


Fig. 8.1

Use Fig. 8.1 to determine the total volume of CO_2 produced at 24 s.

total volume of CO_2 at 24 s = ...cm^3 [1]

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(c) The reaction is repeated using excess citric acid of a lower concentration.

All other conditions stay the same.

State the effect, if any, on:

(i) the time taken for the reaction to finish

..... [1]

(ii) the total volume of CO_2 produced when the reaction is complete.

..... [1]

(d) Fig. 8.2 shows the reaction pathway diagram for the reaction of dilute citric acid with aqueous sodium hydrogencarbonate.

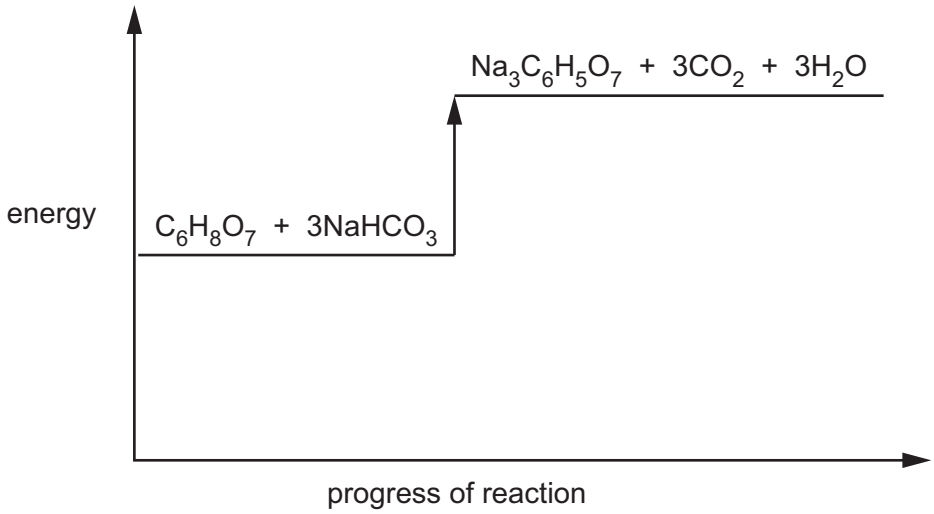


Fig. 8.2

Deduce the type of energy change shown in the diagram in Fig. 8.2.

Explain your answer.

.....

.....

.....

..... [2]

[Total: 6]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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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