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COMBINED SCIENCE **0653/41**

Paper 4 Theory (Extended) **May/June 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.
- Take the weight of 1.0 kg to be 9.8 N (acceleration of free fall = 9.8 m / s^2).

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 **24** pages. Any blank pages are indicated.

1 **(a)** Fats are broken down in the small intestine by chemical digestion.

(i) State the name of the enzyme that breaks down fats.

..... [1]

(ii) (Circle) **one** product of fat digestion.

amino acid **cellulose** **glycerol** **glycogen**

[1]

(b) One risk factor for coronary heart disease is a diet high in fats.

The graph in Fig. 1.1 shows the number of deaths from heart disease for one country between 1920 and 2020.

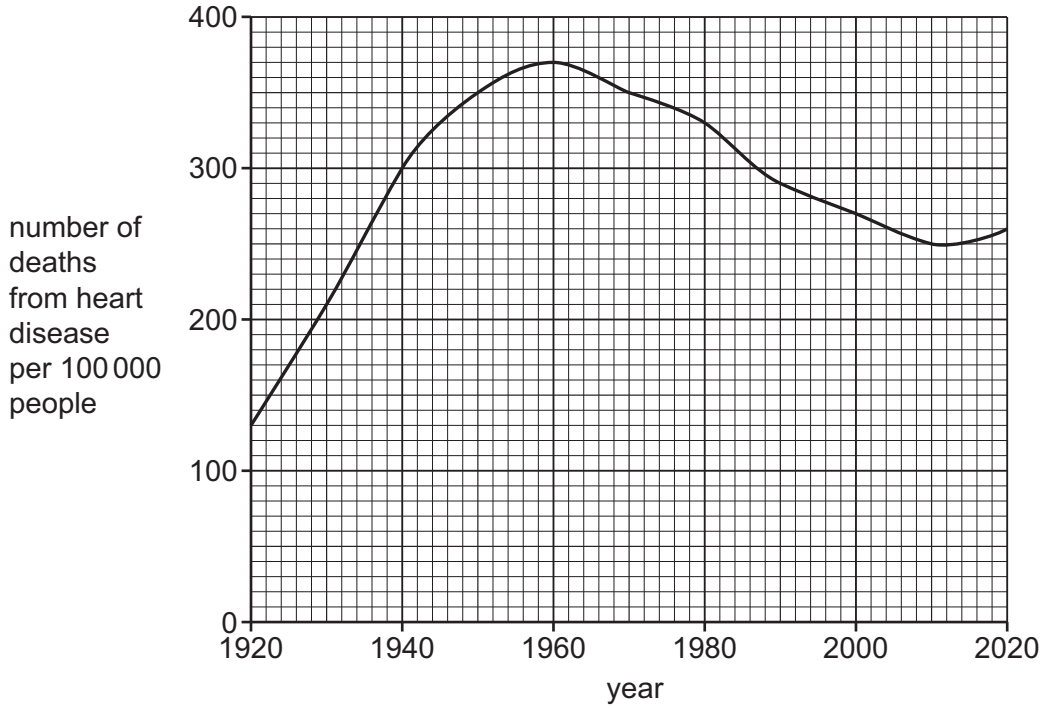

Fig. 1.1

(i) Describe the trend in the number of deaths from heart disease between 1920 and 1960 shown in Fig. 1.1.

..... [1]

(ii) Calculate the percentage increase between the lowest number of deaths and the highest number of deaths shown in Fig. 1.1.

lowest number of deaths = ...

highest number of deaths = ...

percentage increase = ...
[3]

(c) Digested food molecules are absorbed into the blood from the small intestine by active transport and diffusion.

Compare active transport and diffusion of molecules.

.....

.....

.....

..... [2]

[Total: 8]

2 **(a)** Fig. 2.1 is a photograph of a wind-pollinated flower.

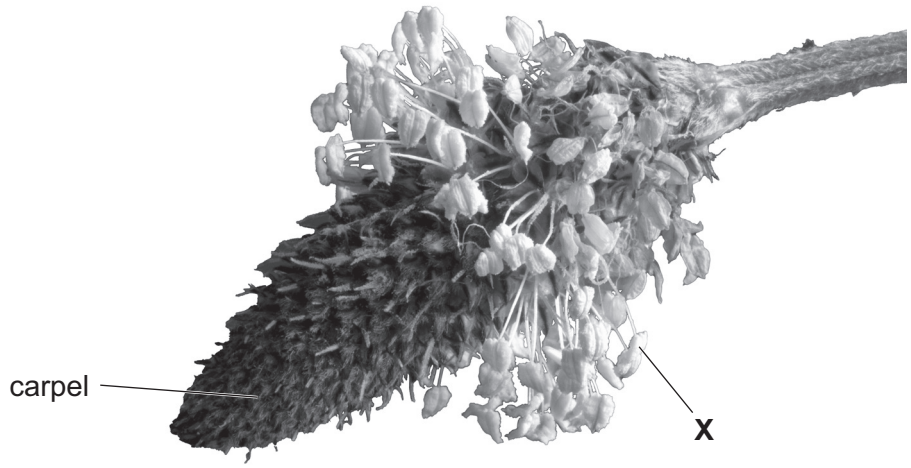

Fig. 2.1

(i) Identify the part labelled **X** on Fig. 2.1.

..... [1]

(ii) Describe how the flower in Fig. 2.1 is pollinated by the wind.

.....

.....

..... [2]

(b) Flowers produce seeds. Germination of seeds uses enzymes.

The graph in Fig. 2.2 shows the effect of pH on an enzyme.

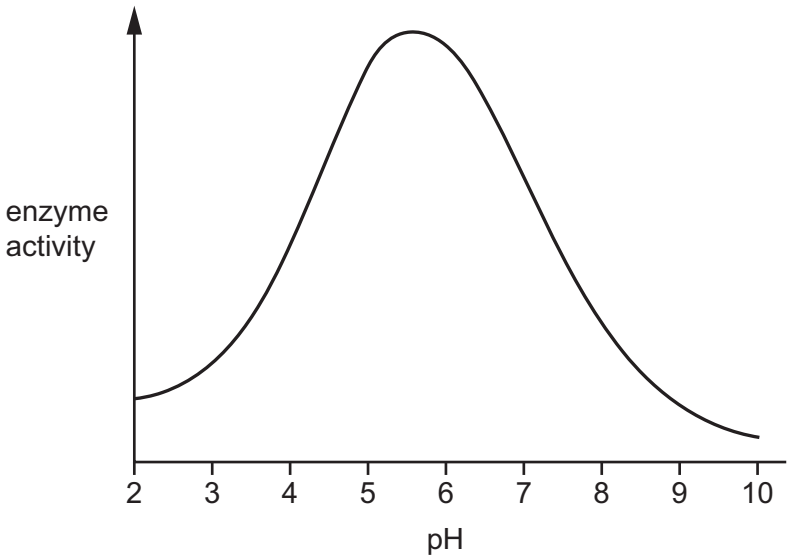

Fig. 2.2

Explain the effect of pH 10 on the enzyme in Fig. 2.2.

.....

.....

.....

.....

..... [3]

(c) A student investigates the germination of seeds.
Seeds produce carbon dioxide when they germinate.

Hydrogencarbonate indicator is a red solution in atmospheric carbon dioxide concentrations. In higher concentrations of carbon dioxide, the indicator turns yellow.

The student prepares the three test-tubes shown in Fig. 2.3.

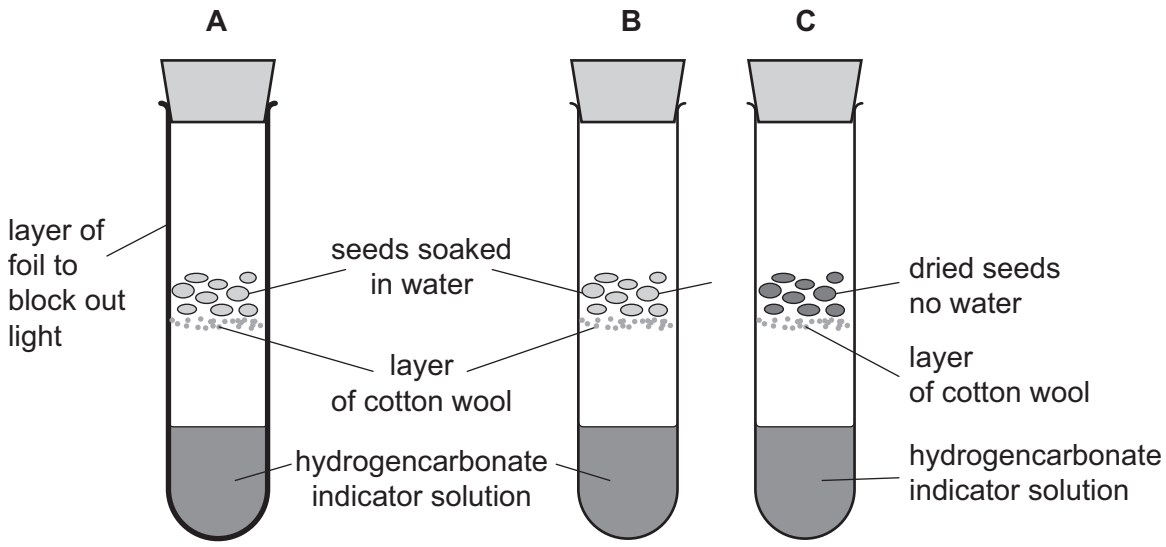

Fig. 2.3

After 24 hours, the student records the colour of the hydrogencarbonate indicator solution in each test-tube.

Table 2.1 shows the results.

Table 2.1

test-tube	conditions	colour of hydrogencarbonate indicator solution	
		at start	after 24 hours
A	dark and water	red	yellow
B	light and water	red	yellow
C	light and **no** water	red	red

(i) Explain the results for test-tube **A** and test-tube **C**.

test-tube **A** .....

.....

test-tube **C** .....

.....

[2]

(ii) During germination, energy is released from stored carbohydrates in the seeds.

Complete the sentences about this process.

Energy is released from the carbohydrates by the process of aerobic

…… .

This is a chemical reaction in cells that uses …….. gas to break down glucose.

The chemical formula for glucose is …… .

[3]

[Total: 11]

3 **(a)** Fig. 3.1 is a diagram showing a cross-section of a bacterial cell.

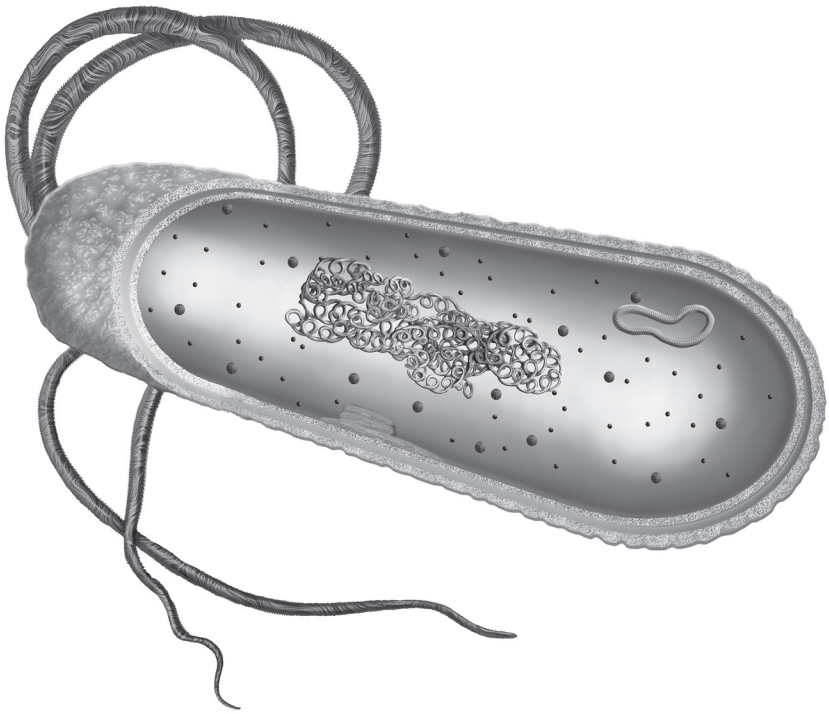

Fig. 3.1

(i) Draw a label line and the letter **P** to identify a plasmid in Fig. 3.1. [1]

(ii) Plasmids are one structure found in bacterial cells that are **not** found in plant cells.

Identify **two** structures visible in Fig. 3.1 that **are also** found in plant cells.

1 .....

2 .....

[2]

(b) Some bacteria are pathogens that infect the human body.

(i) Bacterial infections are treated with antibiotics.

Explain why antibiotics should only be used when essential.

.....

.....

..... [2]

(ii) The body can develop active immunity after infection by some bacteria.

Describe what is meant by active immunity.

.....

.....

..... [1]

(c) Some bacteria gain energy from waste organic material in sewage.

(i) Name the type of organism that gains energy from waste organic material.

..... [1]

(ii) Sewage treatment is one way to control the spread of disease.

State **one** other way to control the spread of disease.

.....

..... [1]

[Total: 8]

4 Iron is a metal.

(a) Fig. 4.1 shows the three physical states of iron.

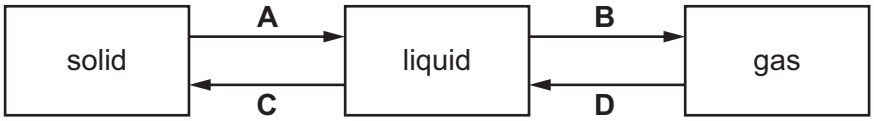

Fig. 4.1

Name the state changes shown by arrows **B** and **C**.

B .....

C .....

[2]

(b) Describe how the arrangement and movement of particles change when solid iron becomes a liquid.

Use ideas about kinetic particle theory in your answer.

.....

.....

.....

..... [2]

(c) Stainless steel is an alloy of iron.

(i) Name **one** of the other elements in stainless steel.

..... [1]

(ii) Explain in terms of structure why stainless steel is harder and stronger than iron.

.....

.....

.....

..... [2]

(d) Iron is extracted from iron(III) oxide in the blast furnace.

Iron(III) oxide reacts with carbon monoxide to form iron.

The equation for the reaction is shown.

$$Fe_2O_3 + 3CO \rightarrow 2Fe + 3CO_2$$

Explain how the equation shows the iron(III) oxide is reduced.

.....

..... [1]

[Total: 8]

5 **(a)** Table 5.1 shows properties of some halogens at room temperature (25 °C) and pressure.

Table 5.1

halogen	melting point / °C	state	colour
fluorine	–220	gas	pale yellow
chlorine	–101	gas	pale yellow-green
bromine		liquid	
iodine	+114	solid	grey-black
astatine	+302		black

(i) State the colour of bromine at room temperature and pressure.

.....[1]

(ii) Predict the:

- melting point of bromine .....
- physical state of astatine at room temperature and pressure. .....

[2]

(b) **(i)** State the type of chemical reaction when chlorine reacts with aqueous potassium bromide.

..... [1]

(ii) Write the word equation for the reaction of chlorine with aqueous potassium bromide.

..... [1]

(iii) Explain why chlorine does **not** react with aqueous potassium fluoride.

.....

..... [1]

(c) Iodine reacts with iron to form iron(III) iodide, FeI_3.

Complete the balanced symbol equation for this reaction.

..... + ... → ..... FeI_3

[1]

(d) Aqueous bromine is used to distinguish between saturated and unsaturated hydrocarbons.

(i) Circle the type of reaction when aqueous bromine reacts with an unsaturated hydrocarbon.

addition **combustion** **polymerisation** **sedimentation**

[1]

(ii) State the colour change when aqueous bromine is added to an **unsaturated** hydrocarbon.

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

[Total: 9]

6 This question is about ionic compounds.

(a) Dilute nitric acid and solid copper oxide react to form copper nitrate.

Copper oxide is an insoluble base and copper nitrate is a soluble salt.

Describe how to produce pure, dry crystals of copper nitrate.

.....

.....

.....

.....

.....

.....

.....

..... [4]

(b) Sodium chloride is an ionic compound.

Complete the dot-and-cross diagram in Fig. 6.1 to show the outer-shell electrons for each ion in sodium chloride.

Include the charge on each ion.

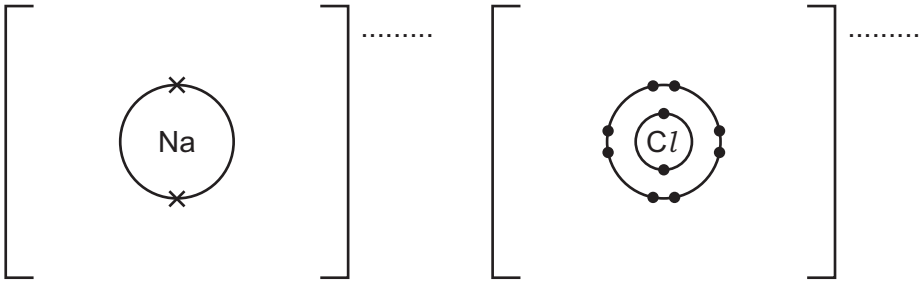

Fig. 6.1

[3]

(c) Describe the arrangement of ions in solid sodium chloride.

.....

.....

.....

..... [2]

[Total: 9]

7 Fig. 7.1 shows an electric car.

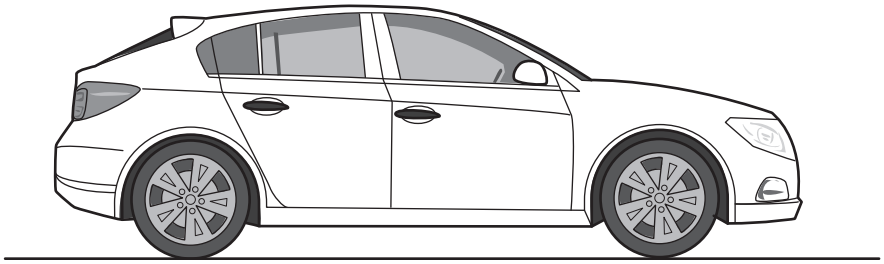

Fig. 7.1

The mass of the car is 2000 kg.

The speed of the car increases from 5.0 m / s to 23 m / s in a time of 4.0 s.

(a) (i) Complete Fig. 7.2 to show one energy transfer that occurs.

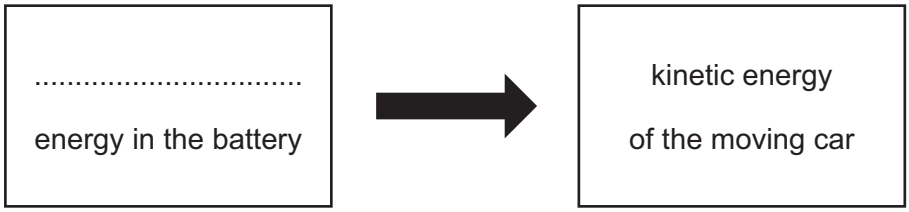

Fig. 7.2

[1]

(ii) State the equation used for calculating the efficiency of energy transfers.

..... [1]

(b) Show that the acceleration of the car is approximately 5 m / s^2.

[2]

(c) Calculate the resultant force acting on the car.

Include the unit in your answer.

force = ... unit ..... [3]

(d) Calculate the increase in the kinetic energy of the car.

increase in kinetic energy = ... J [2]

[Total: 9]

8 Fig. 8.1 shows the two tyres of a motorcycle.

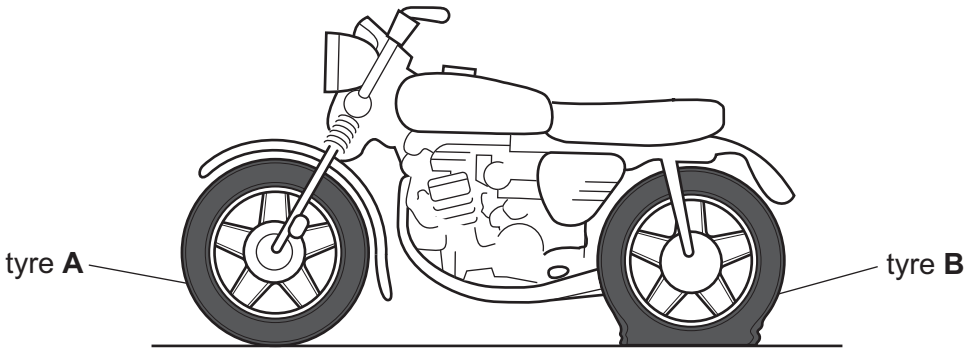

Fig. 8.1

Tyre **A** is full of air and is at the correct pressure.

Tyre **B** is flat and does **not** have enough air in it.

(a) The weight of the motorcycle is shared equally between the two tyres.

(i) Identify which tyre, **A** or **B**, exerts the greater pressure on the road.

Give a reason for your answer.

tyre ……..

reason .....

.....

[2]

(ii) Describe how the pressure inside tyre **A** is caused by the air particles inside the tyre.

.....

.....

..... [2]

(b) Each tyre has a pressure sensor that transmits an electromagnetic wave as a signal when the pressure is low.

Table 8.1 shows the approximate frequency ranges of the different regions of the electromagnetic spectrum.

Table 8.1

gamma radiation	X-rays	ultraviolet	visible light	infrared	micro-waves	radio waves
more than 1×10^{19} Hz	1×10^{16} Hz to 1×10^{19} Hz	8×10^{14} Hz to 1×10^{16} Hz	4×10^{14} Hz to 8×10^{14} Hz	1×10^{11} Hz to 4×10^{14} Hz	1×10^{9} Hz to 1×10^{11} Hz	less than 1×10^{9} Hz

The frequency of the transmitted wave is 3.5×10^{8} Hz.

(i) Use Table 8.1 to identify the region of the electromagnetic spectrum of this transmitted wave.

..... [1]

(ii) State the speed of electromagnetic waves in a vacuum.

speed = ... m/s [1]

(iii) Use your answer to **(b)(ii)** to calculate the wavelength of the transmitted wave.

wavelength = ... m [2]

[Total: 8]

9 Fig. 9.1 shows a circuit that contains an electric motor and a light-emitting diode (LED) connected to a direct current (d.c.) power supply.

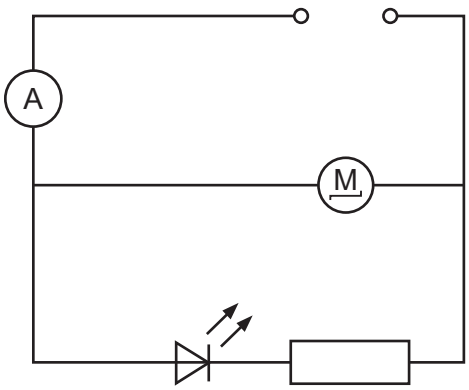

Fig. 9.1

(a) When the motor is switched on, the LED lights up.

(i) On Fig. 9.1, show the polarity of the terminals of the power supply using + and – signs.

Give a reason why the + and – signs must be the way you have shown.

.....

..... [1]

(ii) The power supply is 9.0 V.

The reading on the ammeter is 6.6 A.

The current in the LED is 0.30 A.

Calculate the resistance of the motor.

resistance = ... Ω [3]

(b) **(i)** State the name of the component with the electrical symbol shown.

…… [1]

(ii) Complete the sentence to define electromotive force (e.m.f.).

Electromotive force is the electrical …… done by a source in

moving a unit …… around a complete circuit.

[2]

(c) The circuit in Fig. 9.1 is used in a satellite.

(i) The satellite orbits the Earth at a distance of 15 000 km from the centre of the Earth.

The orbital speed of the satellite is 17 km / s.

Calculate the orbital period *T* of the satellite.

T = ... s [2]

(ii) The satellite is used to study the Universe.
State the approximate age of the Universe.

..... [1]

[Total: 10]

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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.).