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**COMBINED SCIENCE**

**0653/31**

Paper 3 (Extended)

**October/November 2016**

**1 hour 15 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

**DO NOT WRITE IN ANY BARCODES.**

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

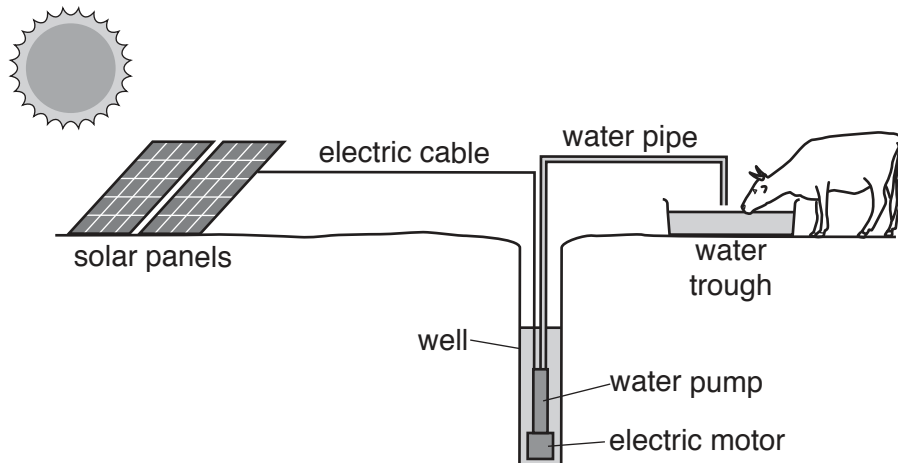
A copy of the Periodic Table is printed on page 24.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

This document consists of **23** printed pages and **1** blank page.

- 1 Fig. 1.1 shows a solar-powered pump used to fill a water trough from a well on a farm. Animals in a field on the farm drink from the trough.



**Fig. 1.1**

The solar panels use sunlight to generate electricity.  
 The motor uses the electricity to drive the pump.  
 The pump moves water from the well to the water trough.

- (a) (i) Complete the sequence of energy transformations that takes place as the water pipe is filled when the pump is switched on.

from ..... energy

to ..... *electrical* ..... energy

to ..... energy

to ..... *potential* ..... energy

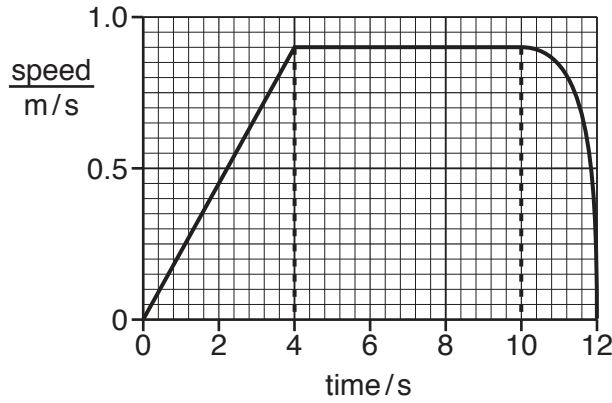
[2]

- (ii) The pipe from the pump to the trough is 9 m long. When the pump starts, it takes 12 s for water to move from the well to the trough.

Calculate the average speed of the water through the pipe.

speed = ..... m/s [1]

- (b) Fig. 1.2 shows a speed/time graph for one water molecule as it moves from the well through the pipe to the trough.



**Fig. 1.2**

- (i) State the maximum speed of the water molecule through the pipe.

speed = ..... m/s [1]

- (ii) Use Fig. 1.2 to describe how the motion of the molecule between 0s and 4s differs from its motion between 10s and 12s.

.....  
 .....  
 .....  
 ..... [2]

- (c) The water level in the well is 6 m below the water in the trough.

- (i) Calculate the work done in raising 10 kg of water from the well to the trough. (gravitational field strength,  $g = 10 \text{ N/kg}$ )

State any formula you use and show your working.

formula

working

work done = ..... J [2]

- (ii) When the pump is working steadily, it takes 2 minutes to pump 10 kg of water from the well into the trough.

Use your answer to (i) to calculate the output power of the pump.

State any formula you use and show your working.

formula

working

power = ..... W [2]

**Please turn over for Question 2.**

2 An atom of sodium has the symbol shown.



(a) Deduce the number of neutrons and the number of electrons in an atom of sodium.

neutrons .....

electrons .....

[2]

(b) State the electronic structure of the sodium atom.

.....

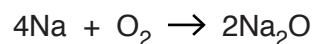
[1]

(c) Describe the relationship between the electronic structure of the sodium atom and the number of its group in the Periodic Table.

.....

.....[1]

(d) The equation for the reaction between sodium and oxygen is



(i) Describe, in terms of electrons, the formation of a sodium ion from a sodium atom.

.....[1]

(ii) Use the Periodic Table on page 24 to identify the element which has atoms with the same electronic structure as a sodium ion.

.....[1]

- (e) All of the Group I metals are solid at 20 °C.

Table 2.1 shows the melting points of some of the Group I metals.

**Table 2.1**

metal	melting point/°C
Li	
Na	98
K	64
Rb	39
Cs	

Complete Table 2.1 by suggesting the melting points of lithium, Li, and caesium, Cs. [2]

- (f) Solid sodium chloride, NaCl, contains sodium ions, Na<sup>+</sup>, and chloride ions, Cl<sup>-</sup>.

**observations**

1. Sodium ions cannot be separated from chloride ions in solid sodium chloride by any simple separation method.
2. An aqueous solution of sodium chloride can be separated into sodium chloride and water by the process of evaporation.

Explain these observations.

observation 1 .....

.....

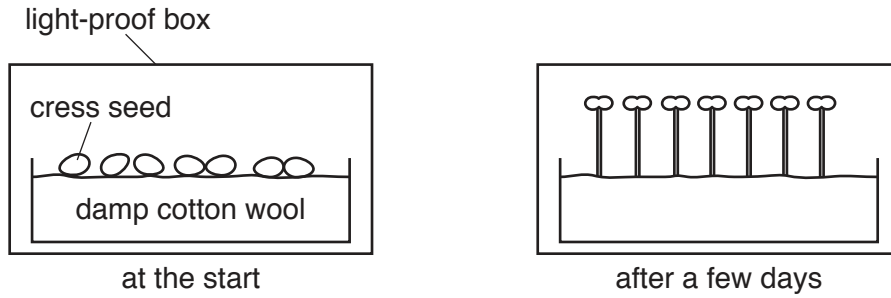
.....

observation 2 .....

.....

.....[2]

- 3 Some cress seeds are placed on damp cotton wool in a dish. They are left to germinate in a light-proof box for a few days.



**Fig. 3.1**

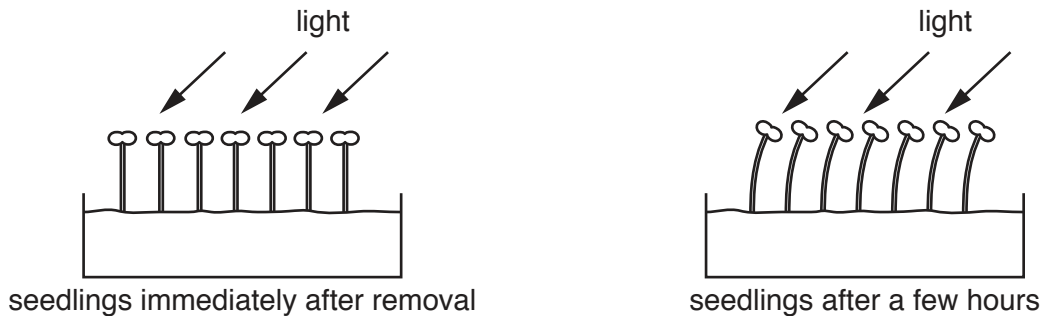
- (a) Fig. 3.1 shows that the seedlings grow directly upwards.

Name this response.

.....[1]

- (b) The dish of seedlings is removed from the box and lit from one side.

Fig. 3.2 shows what happens.



**Fig. 3.2**

Explain in detail how hormones in the seedlings cause the response shown in Fig. 3.2. You may use a diagram to illustrate your answer.

.....

.....

.....

.....

.....

.....[3]



(c) A student thinks that the germination of seeds might be affected by acid rain.

The student has five dishes each containing 20 seeds. He waters them with solutions that have a range of pH values.

Table 3.1 shows the results after a few days.

**Table 3.1**

pH of solution	number of seeds that germinate
3	1
4	3
5	3
6	14
7	16

(i) Describe the effect of pH on the germination of the seeds.

.....  
.....  
.....  
.....  
.....[2]

(ii) Explain why the germination of seeds is affected by pH.

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

(iii) The pH of acid rain is usually between pH 4 and 5.

Calculate the percentage germination in this pH range.

answer = ..... % [1]

(d) (i) Describe how the activities of humans cause acid rain.

.....  
.....  
.....  
.....  
.....[2]

(ii) Suggest how acid rain affects the productivity of farms which grow crops.

Explain your answer.

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

**Please turn over for Question 4.**

4 There is a water trough in a field for animals to drink from. On a hot day, the level of the water in the trough drops even when there are no animals drinking from it.

(a) (i) Explain in terms of the energy and movement of water molecules why the level of water goes down in the trough on a hot day.

.....  
 .....  
 .....  
 .....  
 .....  
 .....  
 ..... [3]

(ii) The thermal energy causing the process in (i) is provided by the Sun.

Suggest one way in which the loss of water from the trough could be reduced without placing a lid on the trough.

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

(b) Fig. 4.1 shows the farmer looking at a stick lying in the water trough.

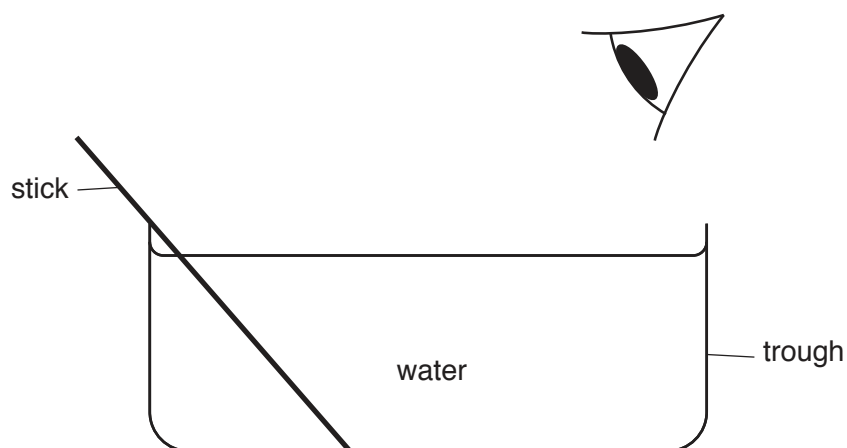


Fig. 4.1

The farmer says that the stick looks bent where it goes into the water.

(i) Name the property of light that causes the stick to look bent.

..... [1]

(ii) On Fig. 4.1, draw a ray diagram using two rays from the bottom of the stick to show why the stick appears bent when the farmer looks at it from the side. [3]



5 (a) Iron is extracted in the blast furnace, as shown in Fig. 5.1.

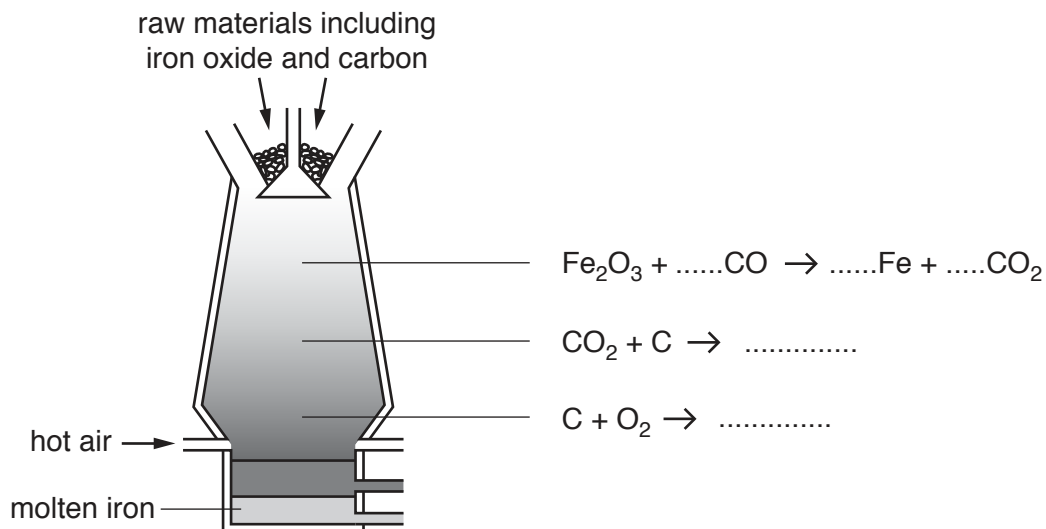


Fig. 5.1

(i) Complete and balance the equations in Fig. 5.1. [3]

(ii) The three equations in Fig. 5.1 represent redox reactions.

Identify **one** substance in these equations which is reduced.  
Explain your answer briefly.

substance .....

explanation .....

.....[2]

(b) Aluminium is extracted from aluminium oxide,  $\text{Al}_2\text{O}_3$ , by the process of electrolysis, as shown in Fig. 5.2.

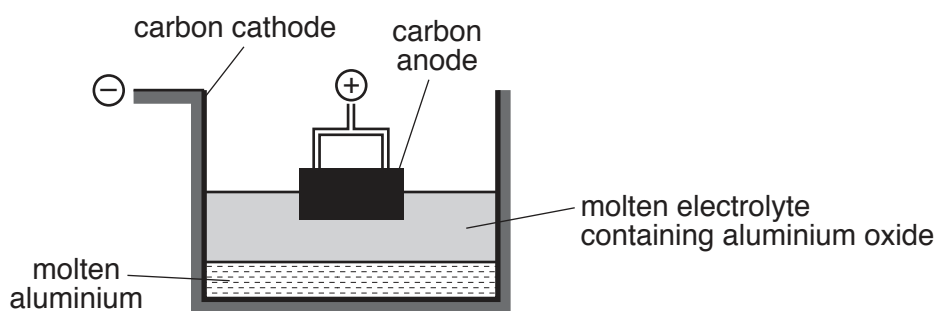


Fig. 5.2

(i) Suggest why aluminium cannot be extracted from aluminium oxide by heating with carbon in a blast furnace.

.....

.....[1]

(ii) The electrolysis of aluminium oxide does not occur if it is solid.

Explain, in terms of the ions present, why the electrolyte must be molten.

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

(iii) Describe briefly, in terms of electrons, what happens to the aluminium ions,  $Al^{3+}$ , and the oxide ions,  $O^{2-}$ , when aluminium and oxygen are formed during electrolysis.

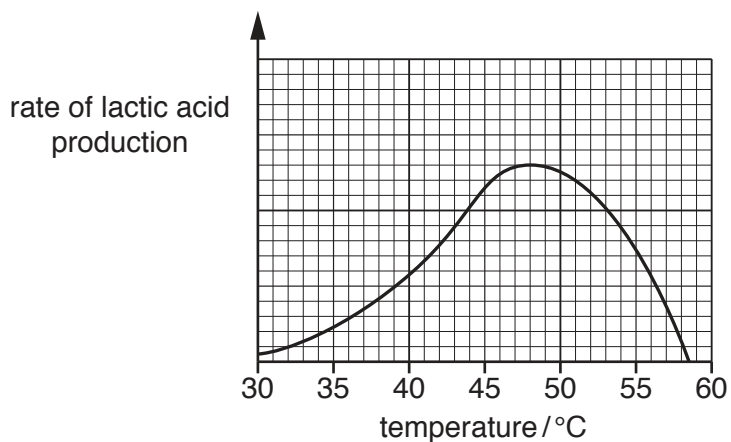
aluminium ions .....  
.....  
oxide ions .....  
.....[1]

(c) (i) Suggest why aluminium alloys, rather than iron alloys, are used in aircraft construction.  
.....[1]

(ii) Suggest why aluminium alloys, rather than pure aluminium, are used in aircraft construction.  
.....[1]

- 6 (a) Microorganisms are added to milk to make yoghurt. They use the nutrients in the milk to make lactic acid. The lactic acid causes the milk to thicken.

Fig. 6.1 shows how the lactic acid production of a microorganism varies with temperature.



**Fig. 6.1**

- (i) State the optimum temperature for lactic acid production by this microorganism.

.....[1]

- (ii) Describe evidence from Fig. 6.1 that shows that lactic acid production depends on enzyme action in the microorganism.

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

- (b) Yoghurt can be made from different types of milk.

Table 6.1 shows some of the substances found in two different types of milk.

**Table 6.1**

substance	milk A/g per 100 cm <sup>3</sup>	milk B/g per 100 cm <sup>3</sup>
protein	3.4	7.2
fat	3.6	0.1
carbohydrate	4.7	4.9
calcium (mineral salt)	0.1	0.1
fibre	none	none



- (i) Milk **B** contains more protein than milk **A**.

State why the body needs protein.

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

- (ii) A balanced diet contains five nutrient groups, as well as fibre and water.

Name the nutrient group, present in milk, which is **not** listed in Table 6.1.

.....

Describe the importance of including this nutrient group in a balanced diet.

.....  
.....  
.....  
.....  
.....[2]

- (iii) Suggest which type of milk, **A** or **B**, would be a healthy choice for someone who does not wish to develop coronary heart disease.

Explain your answer.

type of milk .....

explanation .....

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

- (c) Sometimes fresh fruit is added to yoghurt in the final stages of manufacture. This improves the yoghurt by adding fibre.

Explain the importance of fibre in the diet.

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

7 Fig. 7.1 shows a circuit diagram for a solar-powered electric motor.

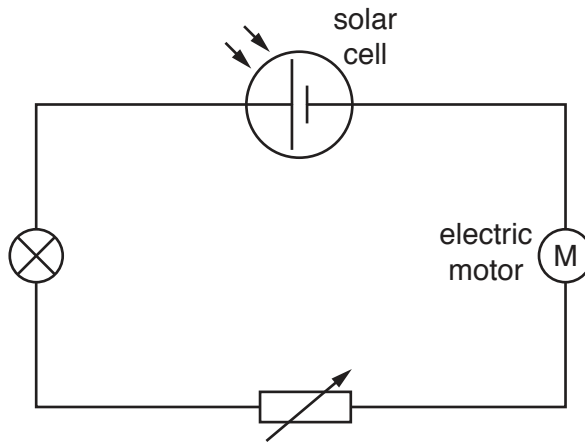


Fig. 7.1

(a) When the motor is turning, the potential difference (p.d.) across the motor is 1.5 V, across the lamp is 0.5 V, and across the variable resistor is 0.6 V.

(i) Calculate the p.d. across the solar cell.

p.d. across cell = ..... V [1]

(ii) The current in the circuit is 0.3 A.

Calculate the resistance of the lamp in the circuit.

State the formula you use and show your working.

formula

working

resistance = .....  $\Omega$  [2]

(iii) Calculate the power output of the solar cell.

State any formula you use and show your working.

formula

working

power = ..... W [2]

(b) The purpose of the lamp in the circuit in Fig. 7.1 is to indicate that the motor is working.

Explain why the lamp is connected in series and not in parallel with the motor.

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

- 8 Fig. 8.1 shows fractional distillation and catalytic cracking at an oil refinery.

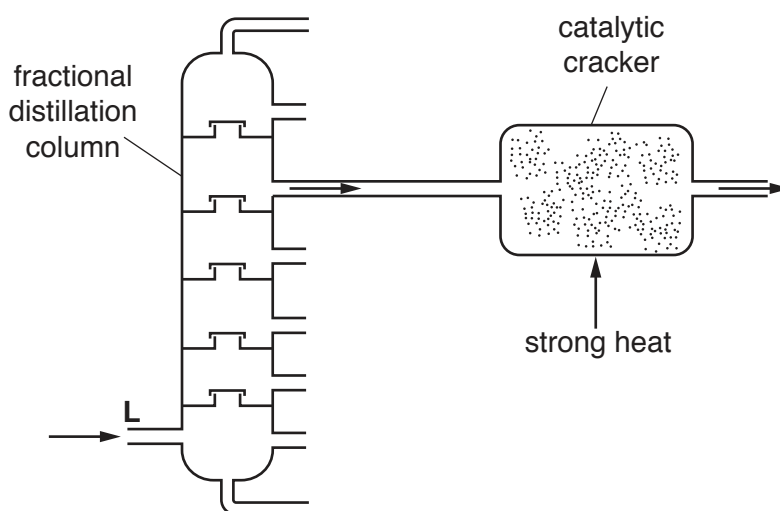
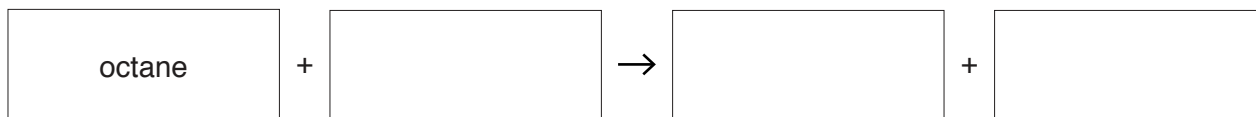


Fig. 8.1

- (a) (i) Name the raw material that enters the fractional distillation column at **L**.  
 .....[1]
- (ii) State the physical property which enables the different molecules to be separated during fractional distillation.  
 .....[1]
- (b) Cracking molecules of the hydrocarbon  $C_{20}H_{42}$  produces a mixture of compounds, as shown below.
- $$C_{20}H_{42} \rightarrow 3C_2H_4 + 2X + C_8H_{18}$$
- (i) Deduce the formula of compound **X**.  
 ..... [1]
- (ii) Name the compound with the formula  $C_2H_4$ .  
 .....[1]
- (iii) Describe a simple chemical test that can distinguish octane,  $C_8H_{18}$ , from  $C_2H_4$ .  
 Give the results for both compounds.
- test .....
- .....
- $C_8H_{18}$  result.....
- $C_2H_4$  result .....
- [2]

(c) Give the word equation for the complete combustion of octane.



[1]

Please turn over for Question 9.

9 Fig. 9.1 shows a fetus shortly before it is born.

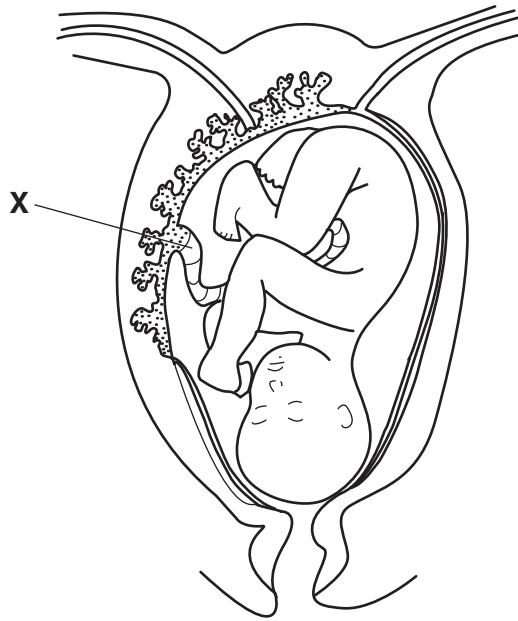


Fig. 9.1

(a) Complete the sentences below using the words or phrases provided.

You may use each word or phrase once, more than once or not at all.

- amnion**      **an artery**      **a vein**      **carbon dioxide**  
**oxygen**      **placenta**      **umbilical cord**

Structure X is the ..... It contains  
 ..... which carries blood to the  
 ..... to collect ..... for the  
 growing fetus. [4]

(b) (i) Describe **two** ways in which HIV can be transmitted.

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

(ii) Describe how the immune system is affected by HIV/AIDS.

.....  
 .....  
 ..... [2]



## The Periodic Table of Elements

		Group															
I	II	III	IV	V	VI	VII	VIII										
3 <b>Li</b> lithium 7	4 <b>Be</b> beryllium 9	1 <b>H</b> hydrogen 1	5 <b>B</b> boron 11	6 <b>C</b> carbon 12	7 <b>N</b> nitrogen 14	8 <b>O</b> oxygen 16	9 <b>F</b> fluorine 19	10 <b>He</b> helium 4									
11 <b>Na</b> sodium 23	12 <b>Mg</b> magnesium 24	<div style="border: 1px solid black; padding: 5px; width: fit-content; margin: 0 auto;"> <b>Key</b>            atomic number            atomic symbol            name            relative atomic mass         </div>															
19 <b>K</b> potassium 39	20 <b>Ca</b> calcium 40	21 <b>Sc</b> scandium 45	22 <b>Ti</b> titanium 48	23 <b>V</b> vanadium 51	24 <b>Cr</b> chromium 52	25 <b>Mn</b> manganese 55	26 <b>Fe</b> iron 56	27 <b>Co</b> cobalt 59	28 <b>Ni</b> nickel 59	29 <b>Cu</b> copper 64	30 <b>Zn</b> zinc 65	31 <b>Ga</b> gallium 70	32 <b>Ge</b> germanium 73	33 <b>As</b> arsenic 75	34 <b>Se</b> selenium 79	35 <b>Br</b> bromine 80	36 <b>Kr</b> krypton 84
37 <b>Rb</b> rubidium 85	38 <b>Sr</b> strontium 88	39 <b>Y</b> yttrium 89	40 <b>Zr</b> zirconium 91	41 <b>Nb</b> niobium 93	42 <b>Mo</b> molybdenum 96	43 <b>Tc</b> technetium —	44 <b>Ru</b> ruthenium 101	45 <b>Rh</b> rhodium 103	46 <b>Pd</b> palladium 106	47 <b>Ag</b> silver 108	48 <b>Cd</b> cadmium 112	49 <b>In</b> indium 115	50 <b>Sn</b> tin 119	51 <b>Sb</b> antimony 122	52 <b>Te</b> tellurium 128	53 <b>I</b> iodine 127	54 <b>Xe</b> xenon 131
55 <b>Cs</b> caesium 133	56 <b>Ba</b> barium 137	57–71 lanthanoids	72 <b>Hf</b> hafnium 178	73 <b>Ta</b> tantalum 181	74 <b>W</b> tungsten 184	75 <b>Re</b> rhenium 186	76 <b>Os</b> osmium 190	77 <b>Ir</b> iridium 192	78 <b>Pt</b> platinum 195	79 <b>Au</b> gold 197	80 <b>Hg</b> mercury 201	81 <b>Tl</b> thallium 204	82 <b>Pb</b> lead 207	83 <b>Bi</b> bismuth 209	84 <b>Po</b> polonium —	85 <b>At</b> astatine —	86 <b>Rn</b> radon —
87 <b>Fr</b> francium —	88 <b>Ra</b> radium —	89–103 actinoids	104 <b>Rf</b> rutherfordium —	105 <b>Db</b> dubnium —	106 <b>Sg</b> seaborgium —	107 <b>Bh</b> bohrium —	108 <b>Hs</b> hassium —	109 <b>Mt</b> meitnerium —	110 <b>Ds</b> darmstadtium —	111 <b>Rg</b> roentgenium —	112 <b>Cn</b> copernicium —	114 <b>Fl</b> flerovium —	116 <b>Lv</b> livermorium —	—	—	—	—

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

The volume of one mole of any gas is 24 dm<sup>3</sup> at room temperature and pressure (r.t.p.)