Cambridge Assessment International Education

# Cambridge IGCSE™

CANDIDATE NAME

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**CO-ORDINATED SCIENCES** **0654/42**

Paper 4 Theory (Extended) **February/March 2025**

**2 hours**

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 120.
- 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 **28** pages. Any blank pages are indicated.

DC (DE/SG) 343245/5


[Turn over

**1** **(a)** Fig. 1.1 shows a cross-section through a leaf.

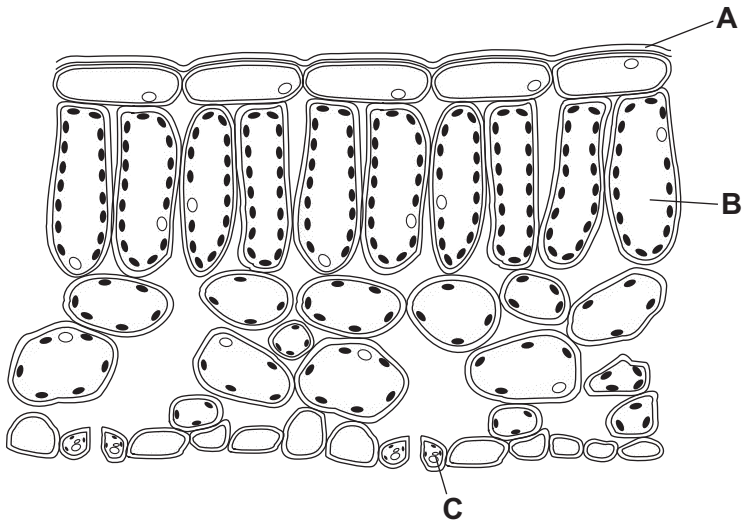


**Fig. 1.1**

State how the part labelled **A**, and cells **B** and **C** in Fig. 1.1 are adapted to help a leaf to photosynthesise.

part **A** .....

cell **B** .....

cell **C** .....

[3]

**(b)** **(i)** A student investigates the effect of changing the light intensity on the rate of photosynthesis in an aquatic plant.

Fig. 1.2 shows the apparatus that the student uses.

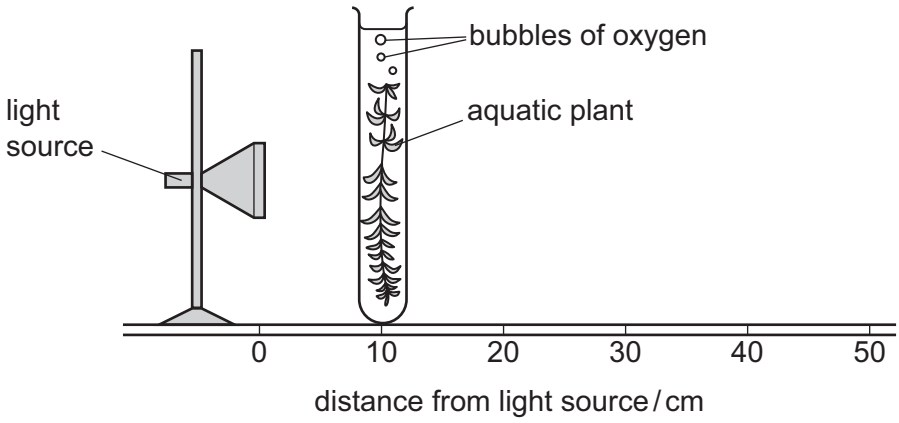


**Fig. 1.2**

Table 1.1 shows the results.

**Table 1.1**

| distance of light source from aquatic plant / cm | number of bubbles of oxygen produced in 1 minute |
|---|---|
| 10 | 60 |
| 20 | 35 |
| 30 | 15 |
| 40 | 2 |

Describe and explain the student's results.

.....

.....

.....

.....

..... [3]

**(ii)** Photosynthesis is an enzyme-controlled reaction.

When the student moves the light source from 20 cm to 10 cm they observe that the temperature of the water increases by 3 °C.

Explain the effect of this temperature increase on the rate of photosynthesis.

.....

.....

.....

..... [2]

**(c)** Glucose from photosynthesis is converted into sucrose.

The sucrose is transported from the source to the sink.

Describe what is meant by a:

source .....

.....

sink .....

.....

[2]

**(d)** In non-aquatic plants, water moves to the leaf from the soil.

Tick (✓) the box that outlines the pathway taken by the water.

root hair cells → root cortex cells → mesophyll cells → xylem ☐

root hair cells → root cortex cells → xylem → mesophyll cells ☐

root cortex cells → root hair cells → xylem → mesophyll cells ☐

root cortex cells → root hair cells → mesophyll cells → xylem ☐

[1]

[Total: 11]

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**2** **(a)** Water moves into plant cells by osmosis.

Fig. 2.1 shows apparatus used to demonstrate osmosis.

The glass container has one membrane which is partially permeable.

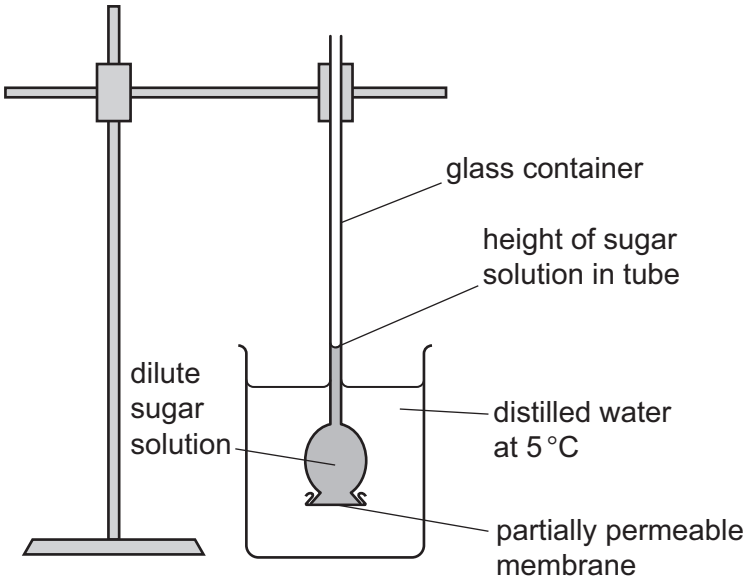


**Fig. 2.1**

The dilute sugar solution is replaced with the same volume of a more concentrated sugar solution.

After three hours the height of the sugar solution in the tube has increased.

Explain why the height of the sugar solution has increased.

Include ideas about water potential in your answer.

.....

.....

.....

.....

..... [2]

**(b)** Active transport is also used to move substances into plant cells.

**(i)** Define active transport.

.....

.....

.....

..... [2]

**(ii)** Nitrate ions are moved into plant cells by active transport.

The rate of nitrate uptake is measured in root hair cells both in the presence and absence of oxygen.

Table 2.1 shows the results.

**Table 2.1**

| condition | rate of nitrate ion uptake / arbitrary units |
|---|---|
| oxygen present in root hair cells | 50 |
| oxygen absent in root hair cells | 0 |

Explain the results from Table 2.1.

.....

.....

.....

.....

.....

..... [3]

**(iii)** State the function of nitrate ions in plants.

.....

..... [1]

**(c) (i)** Humans take in oxygen from the air in the lungs.

Name the blood vessel that takes deoxygenated blood to the lungs from the heart.

..... [1]

**(ii)** Alveoli are the gas exchange surface in humans.

Describe **two** features of the gas exchange surface in humans.

1 .....

.....

2 .....

.....

[2]

[Total: 11]

**3 (a) (i)** Fig. 3.1 shows a violet plant bought from a shop.

**Fig. 3.1**

Many violet plants are produced by asexual reproduction.

State **two** advantages of growing violet plants by asexual reproduction.

1 .....

.....

2 .....

.....

[2]

**(ii)** Violet plants also reproduce by sexual reproduction.

Complete the sentence about sexual reproduction in plants.

Choose words from the list.

**division fertile fusion**

**seed zygote**

Sexual reproduction is the process involving the .....

of nuclei of two gametes to form the ..... .

[2]

**(b) (i)** Fig. 3.2 shows a wind-pollinated flower.

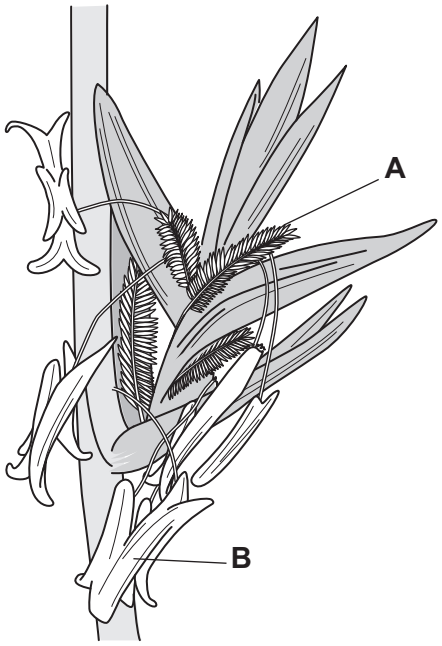


**Fig. 3.2**

State the function of structure **A** and structure **B** as shown in Fig. 3.2.

Structure **A** .....

Structure **B** .....

[2]

**(ii)** Describe how structure **B** in Fig. 3.2 would be different in an insect-pollinated flower.

.....

.....

..... [1]

**(c) (i)** The root hair cells of a species of violet plant contain 30 chromosomes.

State the number of chromosomes in:

a leaf cell of a violet plant .....

an ovule of a violet plant. .....

[2]

**(ii)** Flowers produce gametes.

Name the process that leads to the formation of gametes.

..... [1]

[Total: 10]

**4** **(a)** Blood plasma transports blood cells and platelets.

Name two other substances transported by blood plasma.

1 .....

2 .....

[2]

**(b)** Fig. 4.1 shows some blood cells seen using a light microscope.

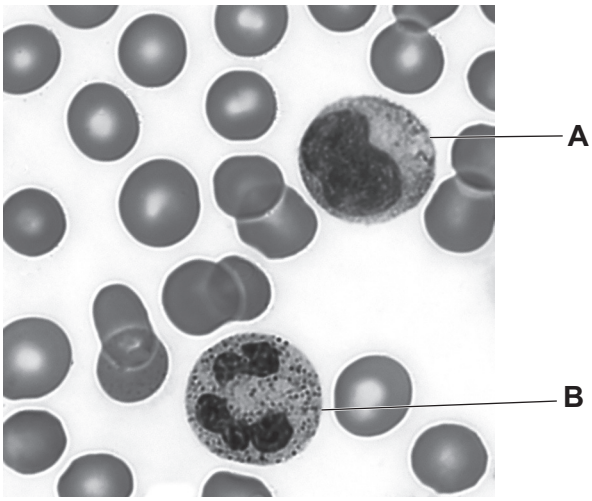


**Fig. 4.1**

State the names and functions of the types of white blood cells labelled **A** and **B** in Fig. 4.1.

blood cell **A** name .....

function .....

.....

blood cell **B** name .....

function .....

.....

[4]

**(c)** Platelets are another component of the blood.

Describe how platelets prevent infection when the skin is cut.

.....

.....

..... [2]

[Total: 8]

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**5** Fig. 5.1 shows the electronic configuration of an aluminium atom.

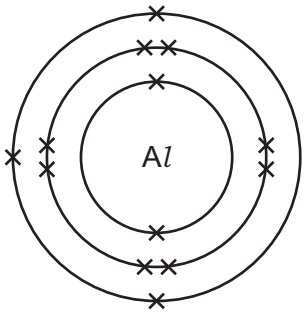


**Fig. 5.1**

**(a)** Describe how Fig. 5.1 shows that aluminium is in period 3 of the Periodic Table.

..... [1]

**(b)** An aluminium atom, Al, forms an aluminium ion, $Al^{3+}$.

Describe, in terms of electrons, how an aluminium ion is formed.

.....

..... [2]

**(c)** Aluminium reacts with chlorine to make aluminium chloride.

Aluminium chloride is an ionic compound.

**(i)** Complete the sentence about ionic bonds.

An ionic bond is a ..... electrostatic attraction between

..... charged ions.

[2]

**(ii)** Tick (✓) the correct property of ionic compounds.

generally insoluble in water ☐

good electrical conductivity when solid ☐

high melting point ☐

[1]

**(d)** Aluminium and chlorine are elements.

Aluminium chloride is a compound.

Describe the difference between an element and a compound.

element .....

.....

compound .....

.....

[2]

**(e)** Explain why $^{37}_{17}Cl$ and $^{35}_{17}Cl$ are isotopes of the element chlorine.

.....

.....

..... [2]

[Total: 10]

**6** Magnesium reacts with dilute hydrochloric acid.

Magnesium chloride and hydrogen gas are made.

**(a)** Construct the balanced symbol equation for this reaction.

..... [2]

**(b)** Five students investigate the rate of the reaction between magnesium and dilute hydrochloric acid.

They each have a test tube containing 1.0 g magnesium and 10 $cm^3$ of dilute hydrochloric acid.

They drop the magnesium into the dilute hydrochloric acid and time how long it takes for the reaction to stop.

Table 6.1 shows their results.

**Table 6.1**

| student | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| time / s | 242 | 256 | 202 | 300 | 270 |

**(i)** State which student's reaction is the fastest.

student ..... [1]

**(ii)** Each student had 1.0 g of different sized pieces of magnesium.

State which student had the pieces of magnesium with the smallest surface area.

student ..... [1]

**(c)** Student 1 repeats their experiment at a lower temperature.

The reaction is slower.

Explain why the reaction is slower, using collision theory.

.....

.....

.....

..... [3]

**(d)** The reaction between magnesium and dilute hydrochloric acid is exothermic.

Fig. 6.1 shows the reaction pathway diagram for the reaction.

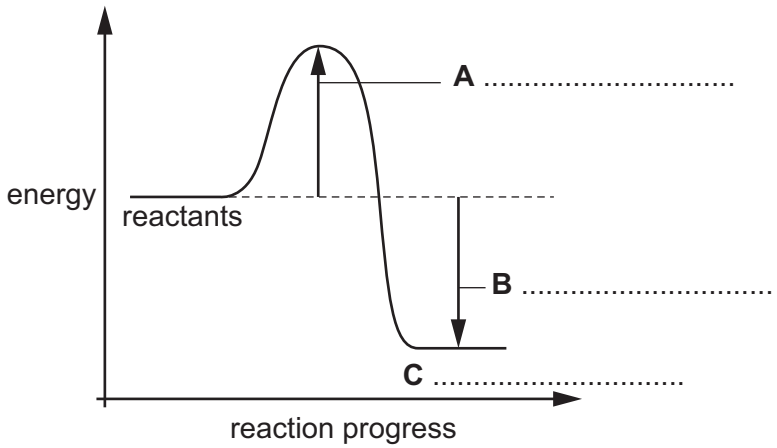


**Fig. 6.1**

Complete the labels, **A**, **B** and **C**, on Fig. 6.1. [3]

[Total: 10]

**7** The alkenes are a family of similar compounds with similar chemical properties.

**(a)** State the term used to describe a family of similar compounds with similar chemical properties.

..... [1]

**(b)** **(i)** Butene, $C_4H_8$, reacts with bromine.

State what would be observed in the reaction.

.....

..... [2]

**(ii)** The equation for the reaction is

$$C_4H_8 + Br_2 \rightarrow C_4H_8Br_2$$

State what type of reaction this is.

Choose your answer from the list.

**addition**

**combustion**

**cracking**

**polymerisation**

answer ..... [1]

**(c)** Butene also reacts with hydrogen to form butane, $C_4H_{10}$.

$$C_4H_8 + H_2 \rightarrow C_4H_{10}$$

Calculate the maximum mass of butane that can be made from 1.68 kg of butene.

[$A_r$: C, 12; H, 1]

mass of butane = ..... kg [3]

**(d)** Fig. 7.1 shows the structural formula of but-1-ene.

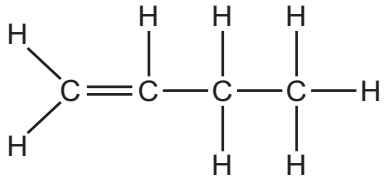

**Fig. 7.1**

Draw the structural formula of but-2-ene.

[2]

[Total: 9]

**8** Fig. 8.1 shows the electrolysis of aqueous copper sulfate using graphite electrodes.

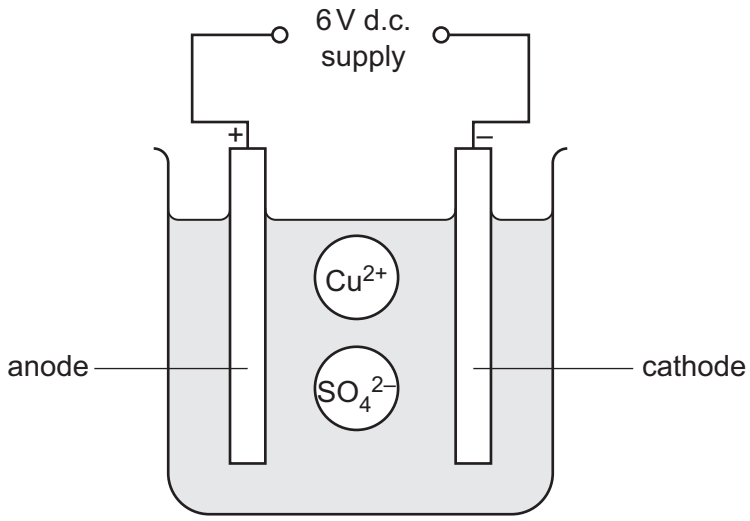


**Fig. 8.1**

**(a)** Draw arrows on Fig. 8.1 to show the direction of movement of the ions. [1]

**(b)** Aqueous copper sulfate also contains hydrogen ions, $H^+$, and hydroxide ions, $OH^-$.

**(i)** State the name of the product formed at the anode.

..... [1]

**(ii)** Describe what would be observed at the anode.

..... [1]

**(c)** Write the ionic half-equation for the reaction of copper ions, $Cu^{2+}$, to form copper, Cu.

..... [2]

**(d)** The electrodes in the experiment are made of graphite.

State two reasons why graphite is used for the electrodes.

Explain your answer using ideas about structure and bonding.

1 .....

2 .....

explanation .....

..... [3]

**(e)** Graphite is a form of the element carbon.

Carbon reacts with oxygen to form carbon dioxide, $CO_2$.

Complete the dot-and-cross diagram in Fig. 8.2 to show the bonding in carbon dioxide.

Only show the outer-shell electrons.

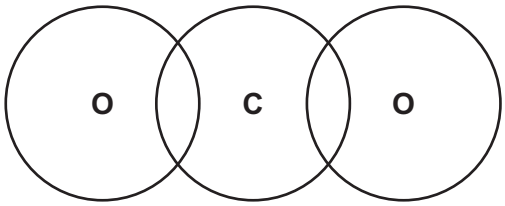


**Fig. 8.2**

[2]

**(f)** Methane is another gas that contains the element carbon.

Methane has a low boiling point.

Explain why.

.....

..... [1]

[Total: 11]

**9** **(a)** Circle two vector quantities.

**acceleration** **speed** **temperature** **time** **weight** [2]

**(b)** Fig. 9.1 shows the speed–time graph for a car travelling along a straight horizontal road.

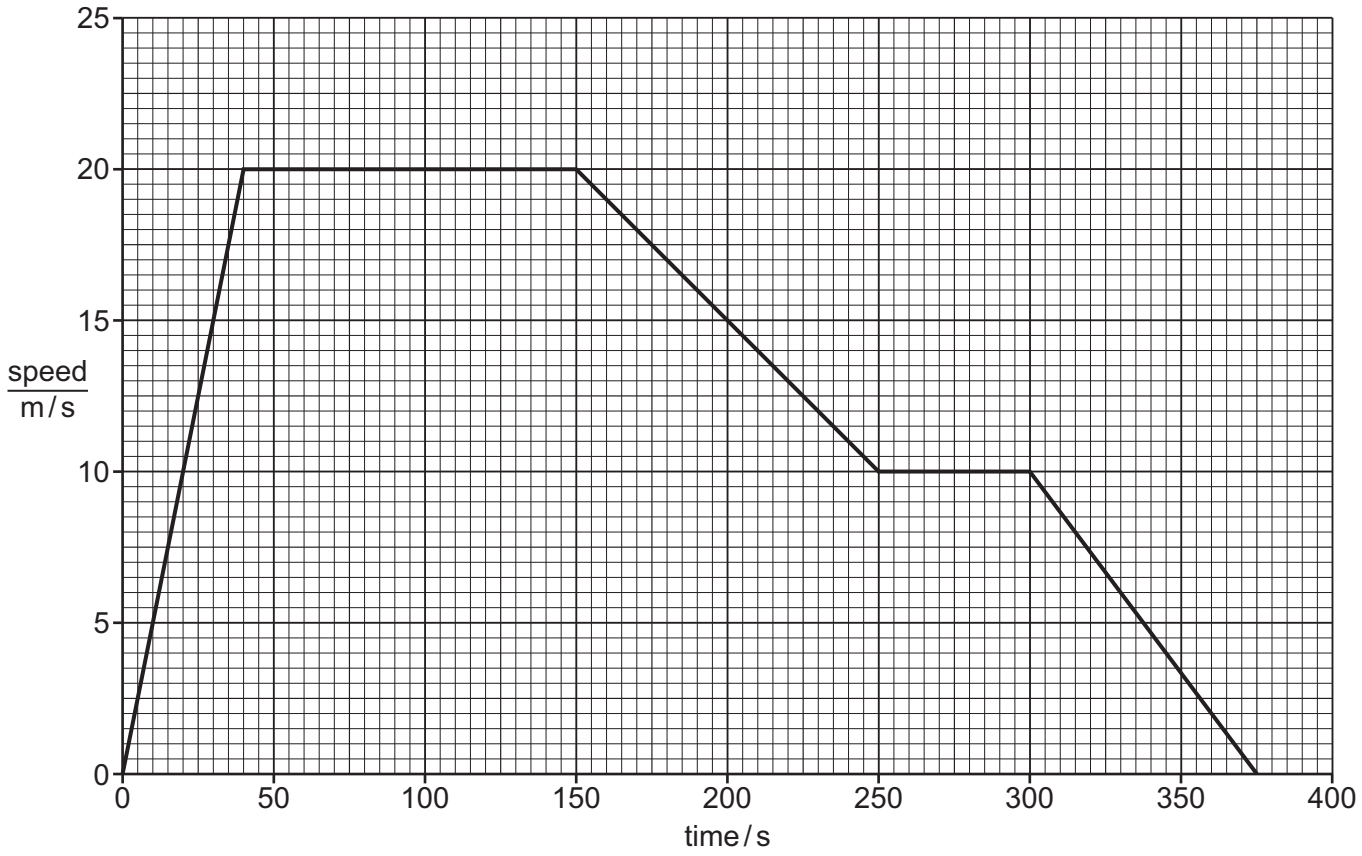


**Fig. 9.1**

**(i)** Describe the motion of the car between time = 250 s and time = 375 s.

.....

.....

..... [2]

**(ii)** Calculate the acceleration of the car in the first 40 s.

State the unit.

acceleration = ..... unit ..... [3]

**(c) (i)** Complete the sentence to describe the changes to the energy stores when the car accelerates.

The amount of energy in the ..... energy store decreases and

the amount of energy in the kinetic energy store ..... .

[2]

**(ii)** When the car is travelling at constant speed there are changes to the amount of energy stored in two energy stores.

State the name of the energy stores and describe these changes.

.....

.....

..... [1]

[Total: 10]

**10 (a)** Fig. 10.1 shows a simple d.c. motor.

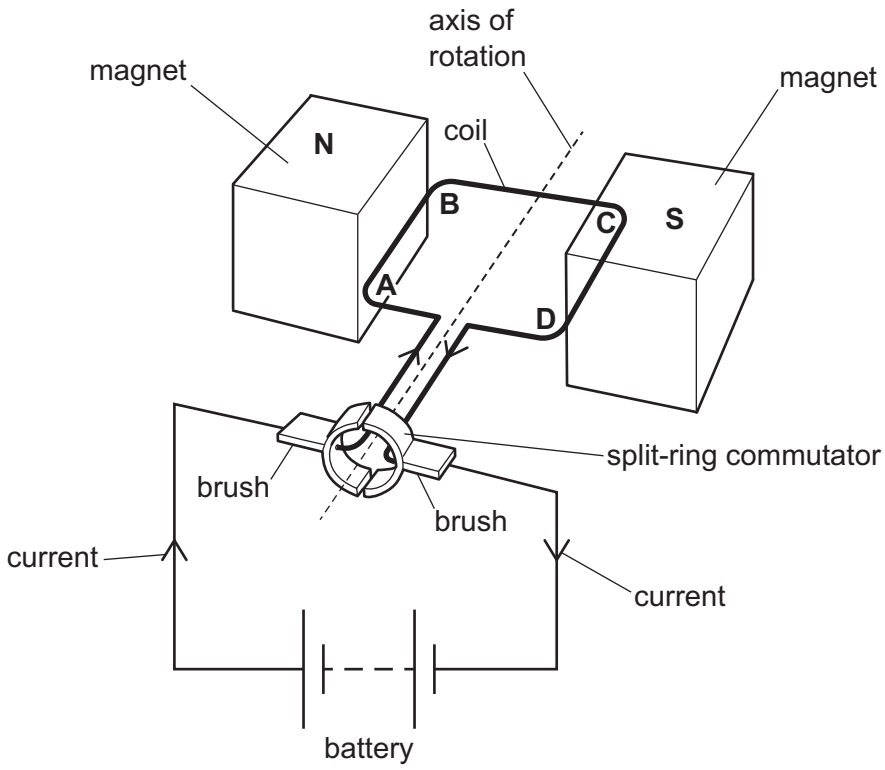


**Fig. 10.1**

**(i)** Explain why the side **AB** of the coil experiences a force when a current is in the coil.

.....

.....

..... [2]

**(ii)** Describe how forces on sides **AB** and **CD** cause a turning effect on the coil when a current is in the coil.

.....

.....

..... [2]

**(iii)** Describe how the split-ring commutator and brushes ensure the coil rotates continuously in the same direction.

.....

.....

..... [2]

**(b) (i)** Circle the component which is part of a basic transformer.

**cell** **permanent magnet** **soft-iron core** **straight wire** [1]

**(ii)** An ideal transformer has 2500 turns on the primary coil and 400 turns on the secondary coil.

There is a voltage of 230 V across the primary coil.

Calculate the voltage across the secondary coil.

voltage = ..... V [2]

**(iii)** The current in the secondary coil is 1.6 A.

Calculate the current in the primary coil.

current = ..... A [2]

**(iv)** State the assumption made in the calculation in **(b)(iii)**.

..... [1]

[Total: 12]

**11** **(a)** $^{90}_{38}Sr$ is a radioactive isotope. It undergoes beta decay with a half-life of 29 years.

**(i)** Complete the equation for this nuclear decay.

$$^{90}_{38}Sr \rightarrow \,^{\cdots\cdots}_{\cdots\cdots}Y + \,^{\cdots\cdots}_{\cdots\cdots}\beta$$

[3]

**(ii)** The mass of $^{90}_{38}Sr$ in a sample is 1.6 mg.

Calculate the mass of $^{90}_{38}Sr$ isotope remaining after 58 years.

mass ..... mg [1]

**(iii)** A $^{90}_{38}Sr$ source is used in a factory making aluminium foils.

Describe **three** ways in which workers are kept safe from the effects of the radiation.

1 .....

2 .....

3 .....

[3]

**(b)** Space vehicles used to explore the Moon can be powered by radioactive sources.

The Moon takes 27.3 days to orbit the Earth.

The mean distance from the Earth to the Moon is $3.84 \times 10^8$ m.

Calculate the mean orbital speed of the Moon around the Earth.

speed = ..... m/s [2]

[Total: 9]

**12 (a) (i)** Sound travels at different speeds in solids, liquids and gases.

Identify the state of matter in which sound travels:

the slowest .....

the fastest .....

[1]

**(ii)** Describe how sound travels through air.

.....

.....

.....

..... [3]

**(iii)** State the frequency range of human hearing.

..... [1]

**(b) (i)** State one use for ultraviolet radiation.

..... [1]

**(ii)** State one danger of ultraviolet radiation.

..... [1]

**(c)** An infrared wave has a frequency of $2.2 \times 10^{12}$ Hz.

The speed of light is $3.0 \times 10^{8}$ m/s.

Calculate the wavelength of the infrared wave.

wavelength = ..... m [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.).