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9352363892

PHYSICAL SCIENCE **0652/41**

Paper 4 Theory (Extended) **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. Any blank pages are indicated.

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1 **(a)** Fig. 1.1 shows the symbols of the elements in Period 2 of the Periodic Table.

Li	Be	B	C	N	O	F	Ne

Fig. 1.1

Use the symbols to answer the questions that follow.

Each symbol may be used once, more than once or not all.

State which element:

(i) is an unreactive gas

..... [1]

(ii) is in a group known as the alkali metals

..... [1]

(iii) forms a stable ion with a 1– charge

..... [1]

(iv) is used in the blast furnace in the extraction of iron from its ore

..... [1]

(v) forms a diatomic molecule with a triple covalent bond

..... [1]

(vi) forms a macromolecule and is used in cutting tools.

..... [1]

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(b) Methanol, CH_3OH, is a covalent compound.

Complete Fig. 1.2 to show the dot-and-cross diagram for a molecule of CH_3OH.

Show outer-shell electrons only.

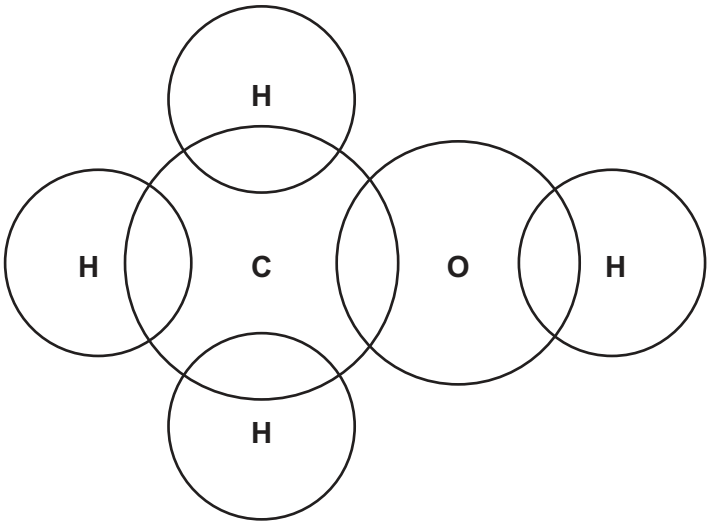


Fig. 1.2

[2]

[Total: 8]

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2 One drop of water falls from a tap at time $t = 0.0\,s$.

The distance of the drop from the tap is measured at four different times.

The speed of the drop is calculated at each of these times.

Table 2.1 shows the motion of the drop at each of these times.

Table 2.1

position of drop	time t from when drop starts to fall / s	distance of drop from tap / m	speed of drop at time t / m / s
	0.0	0.0	0.00
	0.1	0.046	0.92
	0.2	0.18	1.84
	0.3	0.41	2.76

(a) (i) Calculate the **average** speed of the drop during the first 0.1 s after it falls from the tap.

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

(ii) At $t = 0.1\,s$ the speed of the drop is 0.92 m / s.

Explain why your answer to **(a)(i)** is less than 0.92 m / s.

.....

..... [1]

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(b) Calculate the acceleration of the drop between $t = 0.1\,s$ and $t = 0.3\,s$.

acceleration = ...m/s^2 [3]

(c) Drops of water in rain reach a maximum speed as they fall.

They do **not** continue to accelerate.

Explain, in terms of forces, why the drops do **not** continue to accelerate as they fall.

.....

.....

.....

..... [2]

[Total: 8]

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3 **(a)** A sample of 0.35 g of copper(II) sulfate is dissolved in water and reacts with an excess of aqueous barium chloride. A precipitate of barium sulfate forms.

(i) Complete the symbol equation for the reaction by adding the state symbols.

$CuSO_4$(.....) + $BaCl_2$(.....) → $BaSO_4$(.....) + $CuCl_2$(aq)

[1]

(ii) State the type of reaction that takes place.

..... [1]

(iii) Calculate the mass of $BaSO_4$ produced from 0.35 g of $CuSO_4$.

[A_r: Ba, 137; Cu, 64; S, 32; O, 16]

Use the following steps.

- Determine the relative molecular mass, M_r, of $CuSO_4$.

M_r = ...

- Use the equation for the reaction to determine the stoichiometric ratio of $CuSO_4$: $BaSO_4$.

ratio = ... : .....

- Calculate the mass of $BaSO_4$ produced from 0.35 g of $CuSO_4$.

mass of $BaSO_4$ = ... g

[3]

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(b) Hydrated copper(II) sulfate crystals are blue.

Describe how hydration is reversed and state the observation.

description .....

.....

observation .....

[2]

(c) Copper is a transition element.

Transition elements often act as catalysts.

Fig. 3.1 shows the volume of a gas produced in a reaction when a catalyst is **not** used.

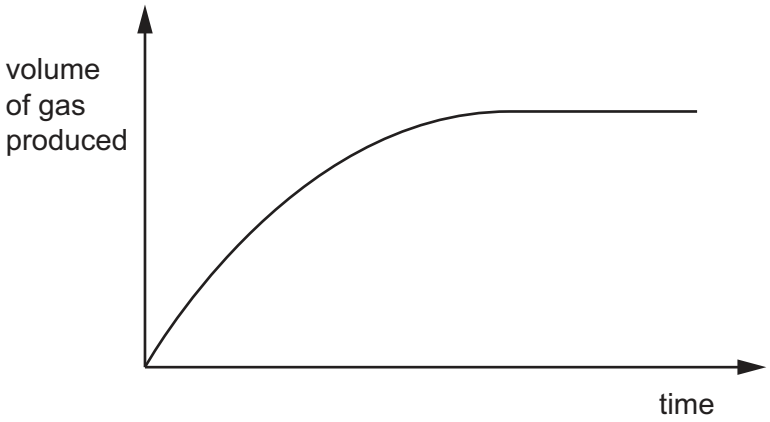


Fig. 3.1

Draw on Fig. 3.1 the graph of the volume of gas produced when a catalyst is used.

All other conditions are kept the same. [2]

[Total: 9]

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4 **(a)** A student measures the diameter of a metal wire using a ruler and a magnifying glass.

Fig. 4.1 shows the ruler and the wire as the student sees it through the magnifying glass.

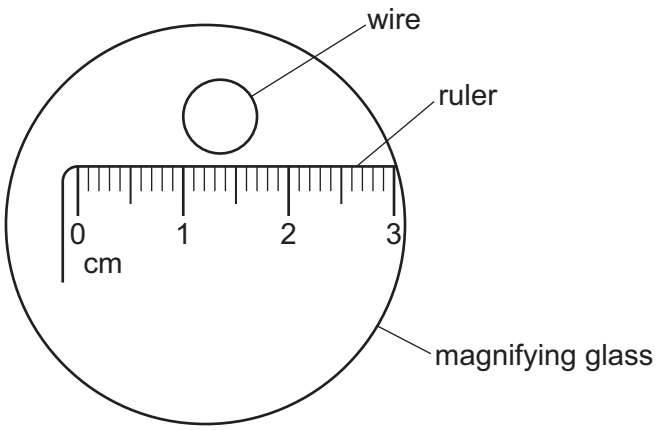


Fig. 4.1

Use Fig. 4.1 to determine the diameter of the wire in cm.

diameter of the wire = ... cm [1]

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(b) Fig. 4.2 is part of a ray diagram. It shows how the image of the wire is formed by the magnifying glass. The vertical arrow represents the wire.

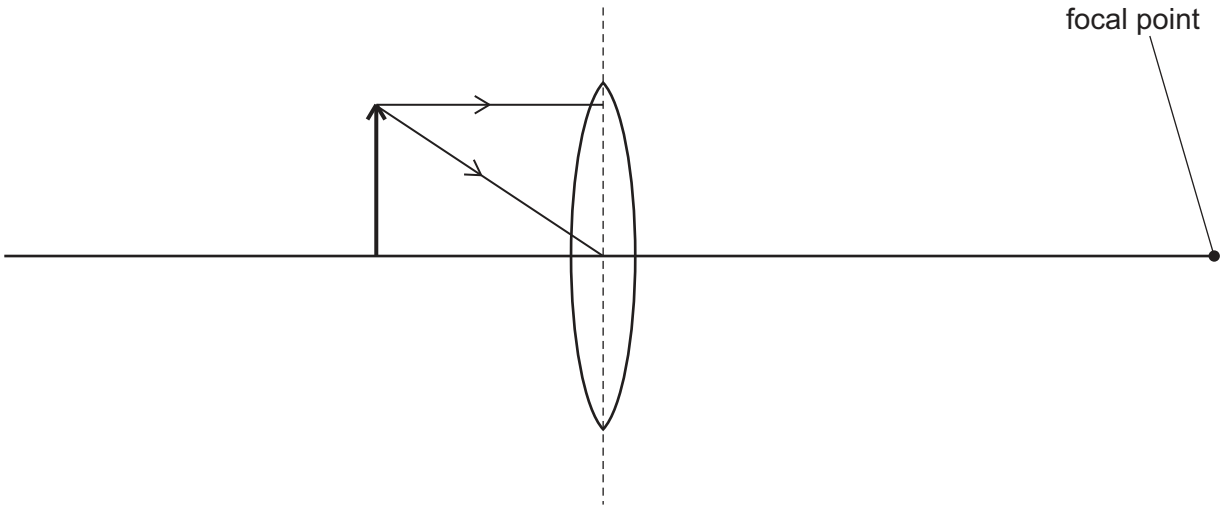


Fig. 4.2

(i) Complete the ray diagram in Fig. 4.2 to show the position of the image formed. [3]

(ii) The image formed by the magnifying glass in Fig. 4.2 is enlarged.

State **two** other features which describe the nature of the image.

1 .....

2 .....

[1]

(c) Suggest a suitable instrument to measure the diameter of a very thin metal wire.

..... [1]

(d) The mass of a metal wire is 17.3 g.

The volume of the metal wire is 1.9 cm^3.

Calculate the density of the metal.

Give a suitable unit for your answer.

density = ... unit ..... [3]

[Total: 9]

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5 **(a)** Sulfur dioxide, SO_2, is a pollutant in air.

(i) Explain why emissions of sulfur dioxide have increased in the last 100 years.

.....

..... [1]

(ii) Describe how flue gas desulfurisation reduces the emissions of sulfur dioxide.

.....

.....

.....

..... [2]

(iii) State **one** environmental impact of sulfur dioxide in the air.

..... [1]

(b) The equation shows a reaction of sulfur dioxide.

$$SO_2 + Cl_2 + 2H_2O \rightarrow H_2SO_4 + 2HCl$$

Describe how the equation shows sulfur dioxide is a reducing agent.

..... [1]

(c) Fig. 5.1 shows the structure of a compound of sulfur.

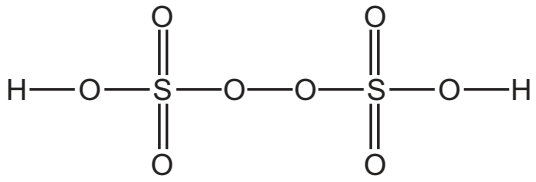


Fig. 5.1

Determine the formula for this compound of sulfur.

..... [1]

[Total: 6]

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6 Fig. 6.1 shows a child's electric scooter.

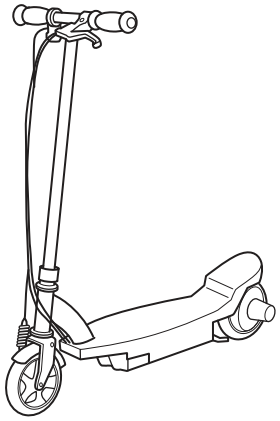


Fig. 6.1

(a) The child uses the scooter for 10 minutes.

The battery of the scooter has an electromotive force (e.m.f.) of 18 V.

The power of the motor in the scooter is 90 W.

(i) Calculate the energy transferred by the battery in 10 minutes.

energy = ... J [2]

(ii) Calculate the current in the motor.

current = ... A [2]

(b) The total energy input to the battery is 1200 J as the battery is charged.

The fully charged battery transfers 1000 J of energy to the motor.

Calculate the efficiency of the battery.

Give your answer to 2 significant figures.

efficiency = ... % [2]

[Total: 6]

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7 Alkenes are unsaturated hydrocarbons.

(a) Describe the meaning of unsaturated.

.....

..... [1]

(b) The general formula for an alkene is C_nH_{2n}.

Determine the formula for an alkene with 9 carbon atoms.

..... [1]

(c) Alkenes can be obtained from larger alkane molecules by cracking.

State **two** conditions required for cracking.

1 .....

2 .....
[2]

(d) Ethene is an alkene.

Ethene reacts with bromine.

(i) State the type of reaction.

..... [1]

(ii) Name the product of the reaction.

..... [1]

(e) Ethene reacts with steam to form ethanol.

Describe one **other** way ethanol can be produced.

In your answer include:

- the name of the process
- the reactants
- the conditions.

name of the process .....

reactants .....

.....

conditions .....

.....
[3]

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(f) Write the word equation for the complete combustion of ethanol.

..... [1]

(g) Complete the sentences about the use of ethanol.

Ethanol is used to dissolve solids. The ethanol is acting as a ..... .

Ethanol releases heat when it is combusted. The ethanol is acting as a ..... .
[2]

[Total: 12]

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8 **(a)** Fig. 8.1 shows a coil of wire connected to a voltmeter.

A student steadily moves a bar magnet towards the coil and then immediately moves the magnet away from the coil.

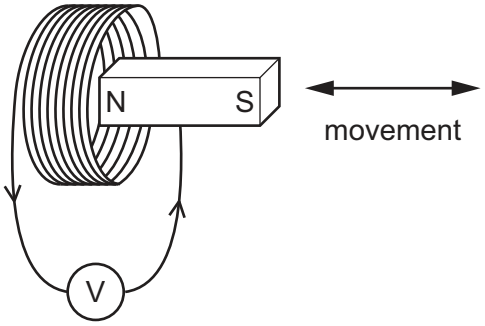


Fig. 8.1

The maximum magnitude of the induced electromotive force (e.m.f.) is 12 mV.

The student makes **one** change and repeats the experiment.

After this change the maximum magnitude of the induced e.m.f. is 4 mV.

Describe the change the student makes to the experiment.

.....

..... [1]

(b) Fig. 8.2 shows a simple a.c. generator.

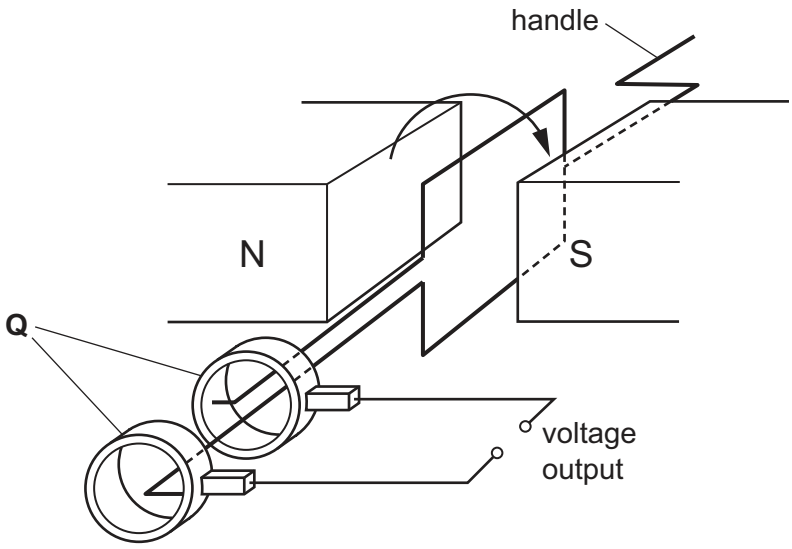


Fig. 8.2

(i) Name the parts of the generator labelled **Q**.

..... [1]

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(ii) The coil is completely rotated twice at a constant speed.

The maximum reading on the voltmeter is 6 V.

Sketch, on the grid in Fig. 8.3, a graph of the voltage output against time for two complete rotations of the coil.

The start of the graph has been done for you.

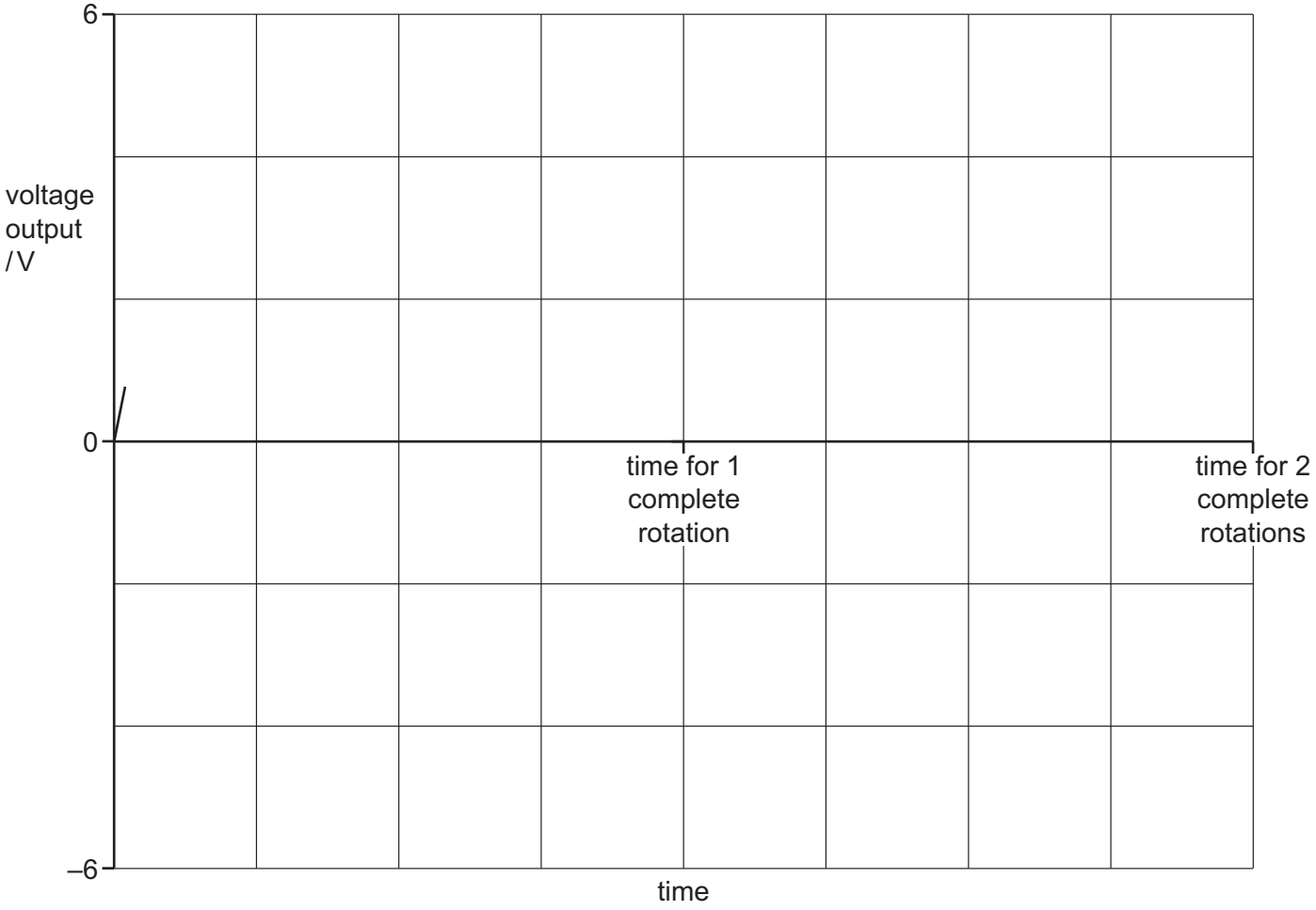


Fig. 8.3

[4]

[Total: 6]

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9 Some metals react with dilute hydrochloric acid.

(a) Put these metals in order of their reactivity with dilute hydrochloric acid.

calcium

copper

sodium

zinc

least reactive ⟶ most reactive

[2]

(b) Excess magnesium reacts with dilute hydrochloric acid.

(i) The magnesium forms a positive ion.

State the general name for a positive ion.

..... [1]

(ii) Name the gas produced during the reaction.

..... [1]

(iii) Predict the pH of the solution formed after the reaction.

..... [1]

[Total: 5]

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10 This question is about radioactive decay.

(a) Carbon-14 decays to nitrogen-14 and emits a particle.

Complete the nuclear equation for this decay.

Include the symbol for the particle.

$$^{14}_{6}C \rightarrow {}^{14}_{\ldots\ldots}N + {}^{0}_{-1\ldots\ldots}$$

[2]

(b) Carbon-14 decays slowly with a half-life of approximately 5000 years.

A sample of carbon is placed in a detector.

Initially, 80 carbon-14 nuclei decay per minute.

Sketch, on the grid in Fig. 10.1, a graph to show how the number of carbon-14 nuclei that decay per minute changes during 20 000 years.

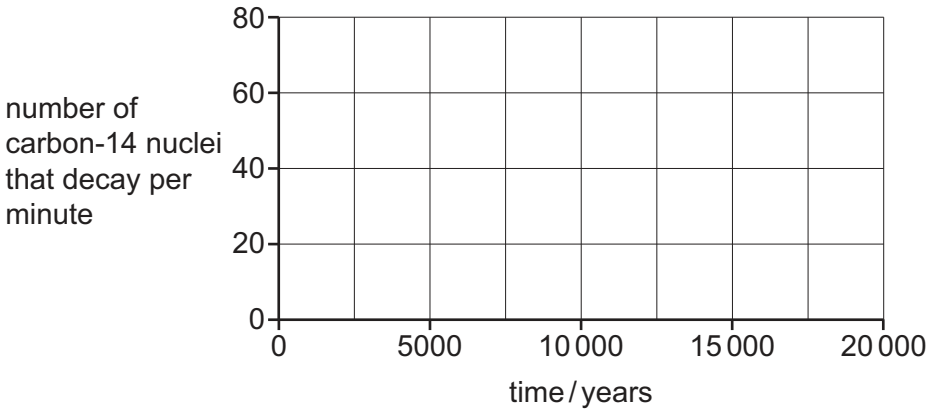


Fig. 10.1

[2]

[Total: 4]

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11 An automatic system opens a window when the air temperature increases.

The window is opened by a cylinder which contains wax and a piston connected to a rod.

Fig. 11.1 shows the automatic system.

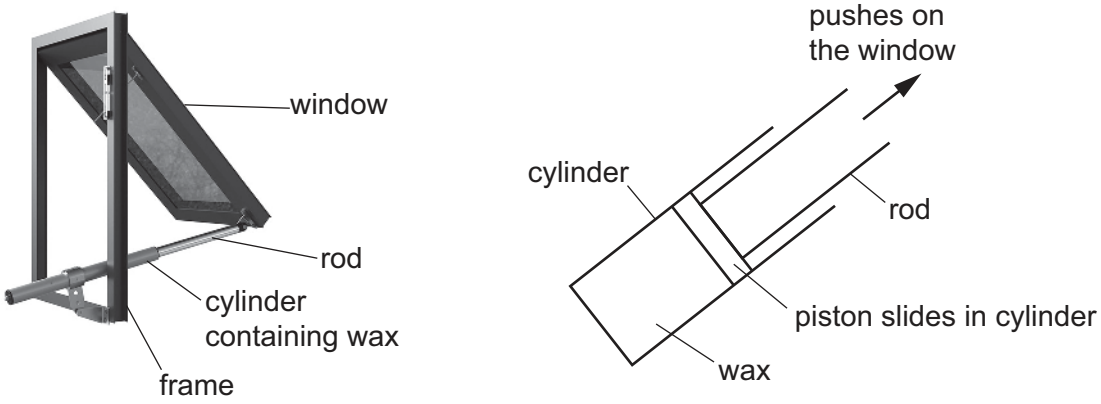


Fig. 11.1

(a) Explain why the rod moves and opens the window when the temperature increases.

.....

.....

.....

..... [2]

(b) Describe how the molecular structure of solid wax changes as the temperature of the wax increases.

.....

.....

.....

..... [2]

(c) The rod pushes on the window and causes the window to turn about a pivot.

(i) State what is meant by the moment of a force.

..... [1]

(ii) Explain how you calculate the moment of a force about a pivot.

.....

..... [2]

[Total: 7]

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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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