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CANDIDATE NAME

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6322286772 2

CO-ORDINATED SCIENCES **0654/43**

Paper 4 Theory (Extended) **May/June 2026**

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. Do **not** use correction fluid or tape.
- 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.

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1 Figure 1.1 shows a food chain from a pond.

algae ⟶ mosquito larva ⟶ dragonfly larva ⟶ fish

Figure 1.1

(a) Draw straight lines from each organism to **all** the terms which describe that organism.

Use the information from Figure 1.1.

organism	term
algae	decomposer
mosquito larva	herbivore
dragonfly larva	producer
fish	secondary consumer
	carnivore

[3]

(b) A scientist wants to find the number of different species living in the pond.

(i) State the term that describes the number of different species living in an area.

..... [1]

(ii) The scientist takes four samples from different areas of the pond.

Table 1.1 shows the number of different species in each sample.

Table 1.1

sample	number of different species
1	191
2	143
3	171
4	154

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The scientist uses the data collected to monitor the number of different species in the pond over time.

To do this, they calculate the average (mean) number of different species and compare this with data from the previous year.

In the previous year, the average (mean) number was 180.

Use the data in Table 1.1 to calculate the average (mean) number of different species found in the pond samples.

State the conclusion made by the scientist.

average = ...

conclusion .....

.....

[2]

(c) Pollution containing nitrates enters the pond.

This causes the algae to reproduce rapidly.

(i) The algae reproduce by mitosis.

Describe what is meant by mitosis.

.....

.....

..... [2]

(ii) The algae photosynthesise.

State the word equation for photosynthesis.

..... [2]

[Total: 10]

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2 **(a)** Figure 2.1 shows a diagram of the heart.

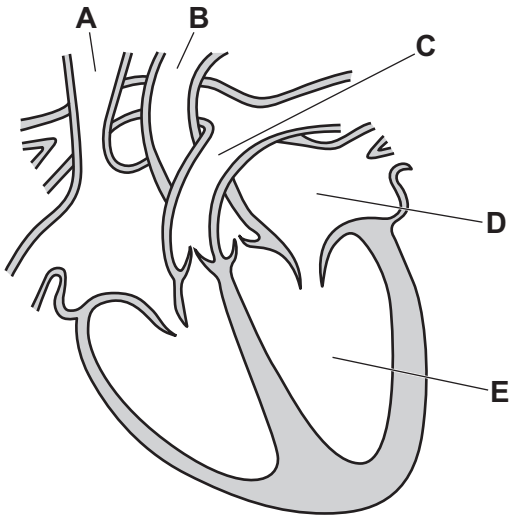


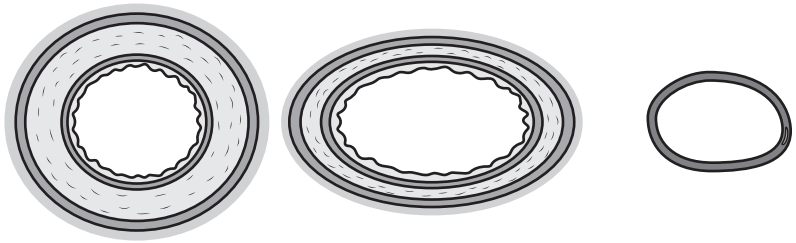
Figure 2.1

Using letters **A**–**E** from Figure 2.1, identify:

the left ventricle .....

the pulmonary artery. .....
[2]

(b) Figure 2.2 shows cross-sections of different types of blood vessels.



artery vein capillary

Figure 2.2

(i) Describe how the structure of **arteries** and **veins** is related to the pressure of blood they transport.

.....

.....

.....

.....

.....

..... [3]

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(ii) State the function of capillaries and describe how the structure of capillaries is related to their function.

function .....

.....

explanation .....

.....

[2]

(c) Figure 2.3 is a photomicrograph of the cells in blood.

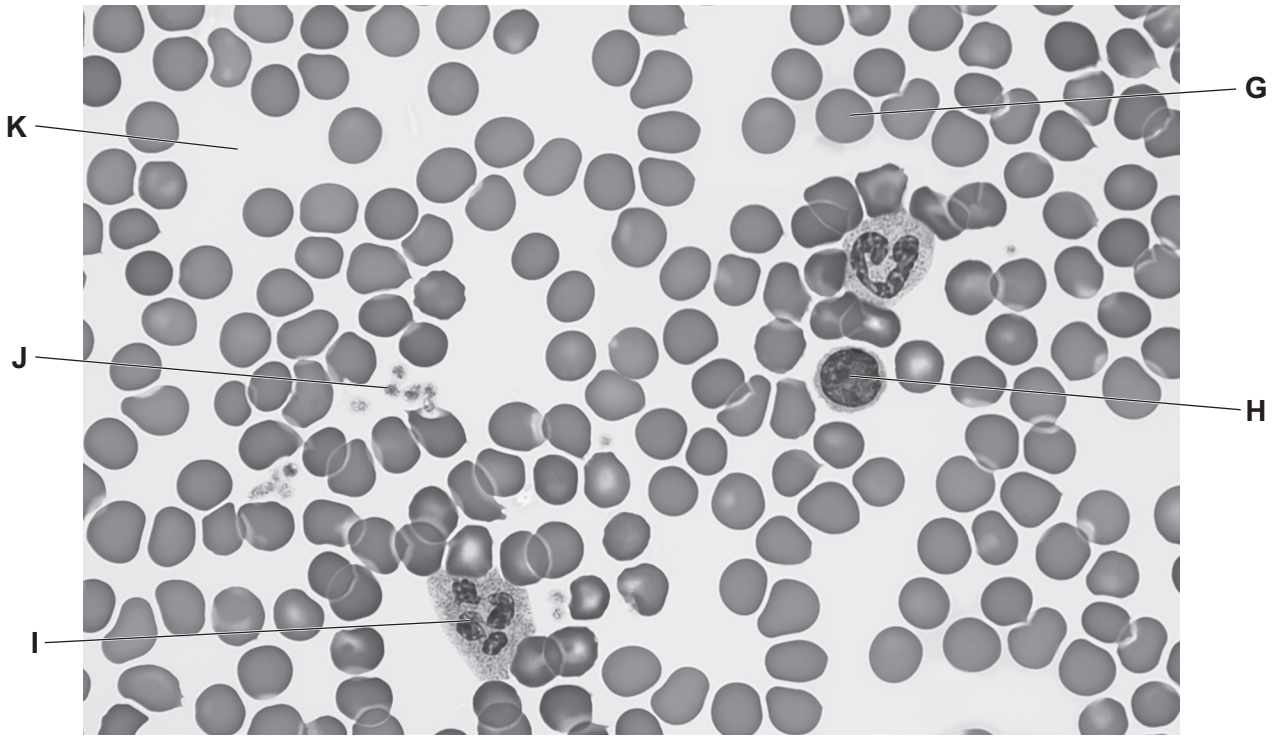

Figure 2.3

Using letters **G**–**K** from Figure 2.3, identify:

a red blood cell .....

a lymphocyte .....

a cell which engulfs pathogens. .....

[3]

[Total: 10]

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3 Water moves through a plant from the roots to the leaves.

(a) Water enters the roots by osmosis.

Describe osmosis.

Use ideas about water potential.

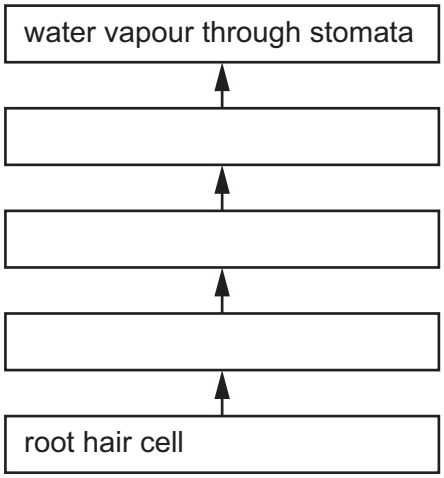
.....

.....

..... [2]

(b) Water moves from cells in the root through the stem to the leaf.

Complete the flow chart to show the movement of water through the cells in a plant.



[3]

(c) A student investigates the effect of wind speed on transpiration rate in a leafy shoot.

Figure 3.1 shows the equipment the student uses to measure water uptake.

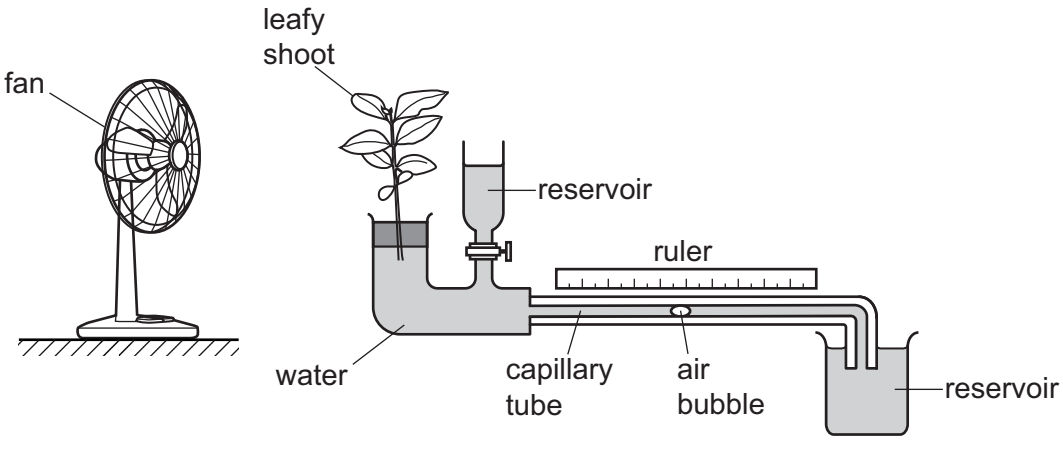


Figure 3.1

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(i) The student uses the fan at four different wind speeds.

The student records the distance moved by the air bubble in 5 minutes for each wind speed.

Table 3.1 shows the results.

Table 3.1

wind speed / m/s	distance moved by air bubble / mm	rate of water uptake / mm/min
0	2	0.4
2	12	2.4
4	20	4.0
6	35	

Calculate the rate of water uptake by the shoot when the wind speed is 6 m/s.

rate of water uptake = ... mm/min [1]

(ii) The rate of water uptake is approximately equal to the rate of transpiration.

Describe and explain the trend in water uptake shown in Table 3.1.

.....

.....

.....

.....

..... [3]

(iii) The student repeats the experiment on a hotter day.

Predict the effect on the rate of water uptake.

Explain your answer.

.....

.....

..... [2]

[Total: 11]

4 Anaerobic respiration happens in muscles during vigorous exercise.

(a) Complete the sentence to describe anaerobic respiration.

Anaerobic respiration is the chemical reactions in cells that break

down ..... molecules to release .....

for muscle contraction, without using oxygen.

[2]

(b) Anaerobic respiration does **not** use oxygen.

Aerobic respiration does use oxygen.

State **two** other differences between anaerobic respiration and aerobic respiration in humans.

1 .....

.....

2 .....

.....

[2]

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(c) Aerobic respiration is one of many metabolic reactions.

All metabolic reactions use enzymes.

(i) Describe the main stages in an enzyme-catalysed reaction.

.....

.....

.....

..... [2]

(ii) State why each metabolic reaction needs a different enzyme.

.....

..... [1]

(iii) Metabolic reactions are either anabolic or catabolic.

Anabolic reactions combine molecules.

Catabolic reactions break down molecules.

Complete Table 4.1 to describe **two** catabolic reactions.

Table 4.1

reaction	enzyme	substrate(s)	product(s)
1			
2			

[2]

[Total: 9]

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5 **(a)** Anhydrous copper(II) sulfate, $CuSO_4$, can be used to test for water.

(i) Anhydrous copper(II) sulfate is a white solid.

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

white to ..... [1]

(ii) The equation for the reaction that takes place is shown.

$$CuSO_4 + xH_2O \rightarrow CuSO_4.xH_2O$$

The relative molecular mass, M_r, of the product, $CuSO_4.xH_2O$, is 250.

The relative molecular mass, M_r, of $CuSO_4$ is 160.

Calculate the value of x.

[A_r: H, 1; O, 16]

x = ... [3]

(b) Water is treated to make it safe to use as domestic water.

Figure 5.1 shows the stages in the water treatment.

Complete the stages in Figure 5.1.

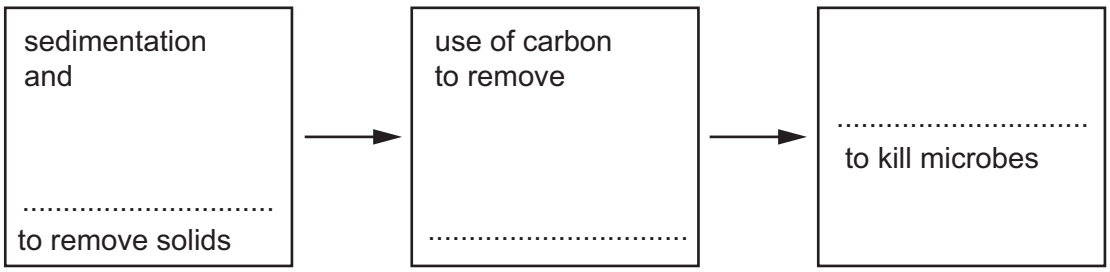

Figure 5.1

[3]

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(c) Two isotopes of the element carbon are $^{12}_{6}C$ and $^{13}_{6}C$.

Compare the atomic structure of these two isotopes.

similarity .....

.....

difference .....

.....

[2]

(d) It does **not** matter which isotope of carbon is used in water treatment.

This is because the isotopes have the same chemical properties.

Explain why the isotopes have the same chemical properties.

.....

.....

..... [2]

[Total: 11]

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6 The reaction between hydrogen and oxygen **releases** thermal energy to the surroundings.

(a) State the name given to the type of reaction that releases thermal energy.

..... [1]

(b) A student draws a reaction pathway diagram for the reaction between hydrogen and oxygen.

Figure 6.1 shows the diagram.

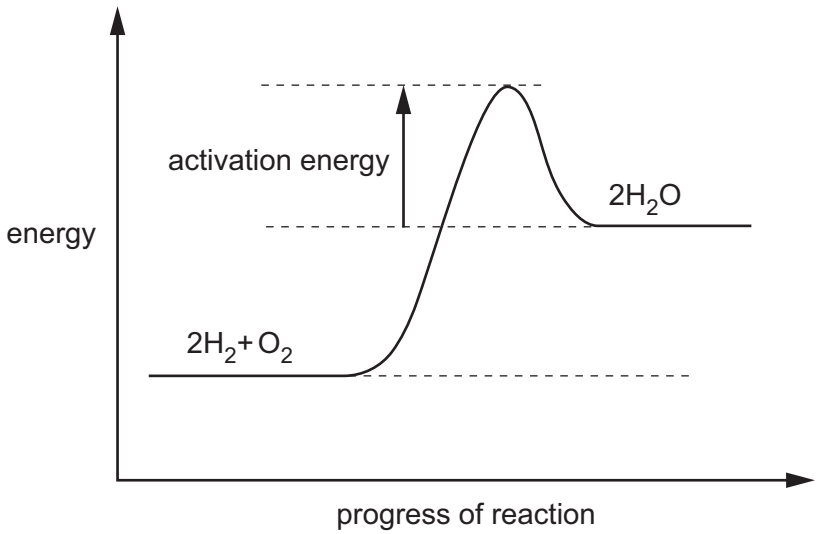

Figure 6.1

There are **two** mistakes shown on this diagram.

Describe the **two** mistakes.

1 .....

.....

2 .....

.....

[2]

(c) Hydrogen–oxygen fuel cells are used to power electric engines in some vehicles.

State **one advantage** and **one disadvantage** of a hydrogen–oxygen fuel cell compared to a gasoline/petrol engine.

advantage .....

.....

disadvantage .....

.....

[2]

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(d) A vehicle powered by a hydrogen–oxygen fuel cell needs 0.55 kg of hydrogen, H_2, to travel 100 km.

Calculate the volume occupied by 0.55 kg of hydrogen gas at room temperature and pressure (r.t.p.).

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

[M_r: H_2, 2]

volume = ... dm^3 [3]

(e) The hydrogen gas needed to power the vehicle must be carried on board. This uses storage space.

Figure 6.2 shows the relative separation of the particles in hydrogen gas.

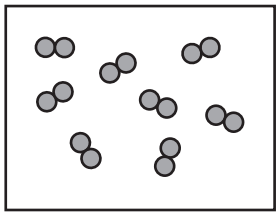

Figure 6.2

Suggest **one** way the volume of stored hydrogen gas can be reduced.

.....

..... [1]

(f) Complete the dot-and-cross diagram in Figure 6.3 to show the bonding in oxygen, O_2.

Only show the outer-shell electrons.

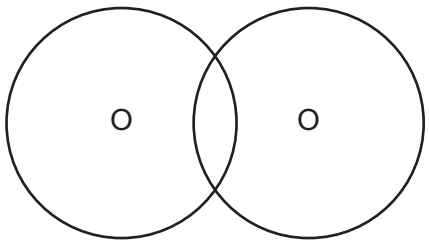

Figure 6.3

[2]

[Total: 11]

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7 A student investigates the rate of the reaction between zinc and excess dilute hydrochloric acid, HC*l*.

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

..... [2]

(b) The student measures the total volume of gas given off every 20 seconds.

Figure 7.1 shows a graph of the results.

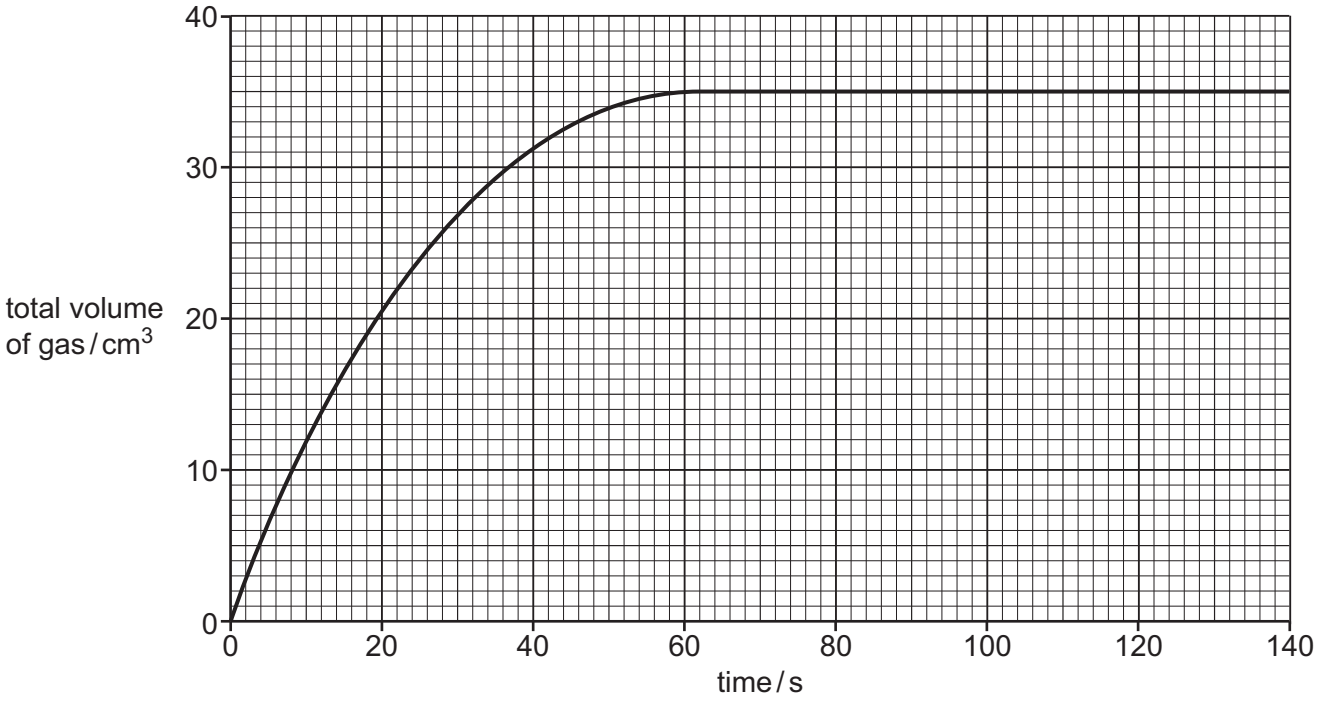

Figure 7.1

(i) Calculate the mean rate of reaction between time = 0 and time = 60 s.

mean rate of reaction = ... cm^3 / s [2]

(ii) The student repeats the experiment using more concentrated hydrochloric acid.

On Figure 7.1, draw a line to show the student's results. [2]

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(c) The reaction between zinc and hydrochloric acid is faster if **smaller** pieces of zinc are used.

Use collision theory to explain why.

.....

.....

..... [2]

(d) Zinc is in the same period of the Periodic Table as iron.

Iron is a transition metal.

(i) State **one** property of transition metals.

Tick (✓) **one** box.

non-malleable	☐
only form white compounds	☐
high density	☐
low melting point	☐

[1]

(ii) Transition metals often act as catalysts.

State what is meant by a catalyst.

.....

.....

..... [2]

[Total: 11]

8 A student investigates the reactivity of four different metals, **A**, **B**, **C** and **D**.

The student adds a piece of each metal to an aqueous solution of each metal sulfate.

(a) (i) State the observation that shows that a reaction takes place.

Tick (✓) **one** box.

colour change ☐

metal sinks ☐

no bubbling ☐

no temperature change ☐

[1]

(ii) Table 8.1 shows the student's results.

Table 8.1

	aqueous metal sulfate			
metal	**A sulfate**	**B sulfate**	**C sulfate**	**D sulfate**
A	✗	✗	✓	✗
B	✓	✗	✓	✗
C	✗	✗	✗	✗
D	✓	✓	✓	✗

✓ means a reaction takes place

✗ means a reaction does **not** take place

Write the four different metals, **A**, **B**, **C** and **D**, in order of reactivity.

..... most reactive

.....

.....

..... least reactive

[2]

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(b) Magnesium metal reacts with aqueous copper(II) sulfate.

$$Mg + CuSO_4 \rightarrow MgSO_4 + Cu$$

The reaction can be shown as two ionic half-equations.

$Mg \rightarrow Mg^{2+} + 2e^-$ and $Cu^{2+} + 2e^- \rightarrow Cu$

Describe how the two ionic half-equations show that both oxidation and reduction happen.

.....

.....

..... [2]

(c) Aqueous copper(II) sulfate is electrolysed using graphite electrodes.

Figure 8.1 shows the electrolysis experiment.

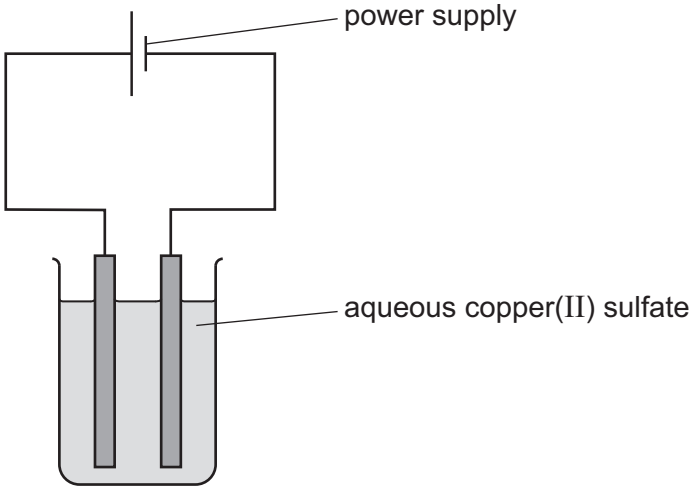

Figure 8.1

State the product formed at each electrode in the experiment.

anode .....

cathode .....

[2]

[Total: 7]

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9 **(a)** **(i)** Explain why metals are good electrical conductors.

.....

..... [1]

(ii) On Figure 9.1, draw an arrow to show the direction of the flow of electrons in this circuit.

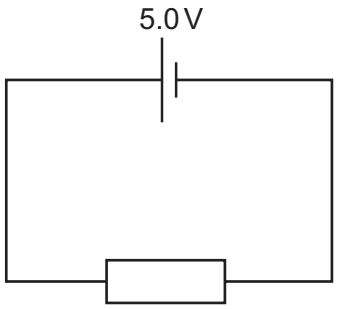

Figure 9.1

[1]

(iii) The cell in Figure 9.1 has a current of 0.85A.

Calculate the charge which passes through the resistor in 2.0 minutes.

charge = ... C [2]

(iv) A second resistor of identical resistance is added to the circuit shown in Figure 9.1 connected in parallel with the first resistor.

State and explain the change to the current in the cell.

.....

.....

..... [2]

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(b) (i) Describe the construction of a step-up transformer.

.....

.....

.....

..... [3]

(ii) A step-down transformer has a potential difference (p.d.) of 10 000 V across the primary coil.

The current in the primary coil is 80 A.

The p.d. is reduced to 230 V by the transformer.

Calculate the current in the secondary coil.

current = ... A [2]

(iii) State where, in the transmission of electricity, a step-down transformer is used.

..... [1]

[Total: 12]

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10 **(a)** Compare the relative ionising effects of alpha, beta and gamma radiation.

.....

..... [1]

(b) **(i)** Describe, in terms of particles, the change which occurs in the nucleus of an atom which undergoes beta decay.

.....

.....

..... [2]

(ii) Explain why beta radiation, rather than alpha or gamma radiation, is used for measuring and controlling the thickness of materials.

.....

.....

..... [1]

(c) The isotope americium-241 undergoes alpha decay.

Complete the decay equation to show this decay.

$$^{241}_{95}\text{Am} \rightarrow \overset{\cdots\cdots}{\underset{\cdots\cdots}{\cdots\cdots}}\text{Np} + \overset{\cdots\cdots}{\underset{\cdots\cdots}{\cdots\cdots}}\alpha$$

[2]

(d) **(i)** Describe how stable stars release energy.

.....

.....

..... [2]

(ii) The nearest star to the Sun is 4.2 light-years away.

Describe what is meant by one light-year.

.....

.....

..... [2]

[Total: 10]

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Turn over

11 **(a)** Figure 11.1 shows a velocity–time graph for a car.

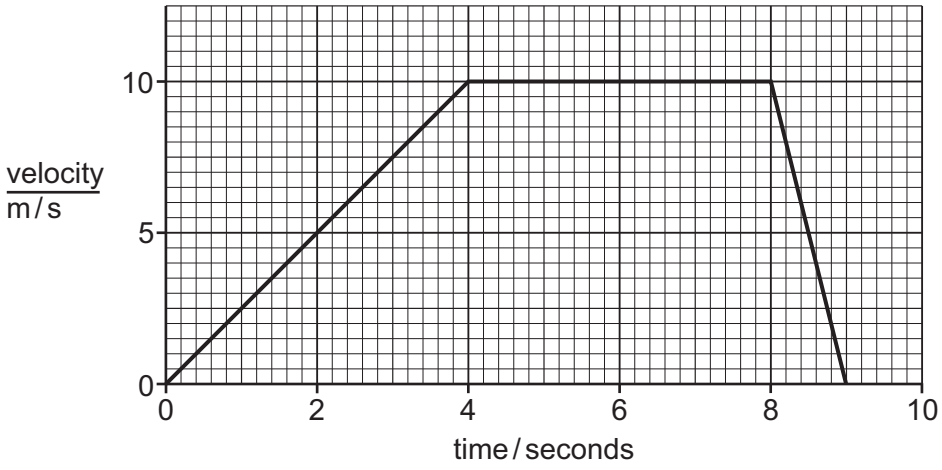

Figure 11.1

(i) Describe the motion of the car between time = 4 seconds and time = 8 seconds.

.....

..... [1]

(ii) Describe the motion of the car between time = 8 seconds and time = 9 seconds.

.....

..... [1]

(iii) Calculate the acceleration of the car at time = 2 seconds.

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

(b) At another time, the car is travelling at a velocity of 18 m / s.

The kinetic energy of the car is then 230 000 J.

Calculate the mass of the car.

mass = ... kg [2]

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(c) When the car is travelling at a constant velocity of 18 m / s, an object falls from the outside of the car.

(i) Describe and explain the **horizontal** motion of the object.

Refer to the forces acting on the object in your answer.

.....

.....

..... [2]

(ii) Describe and explain the **vertical** motion of the object.

Refer to the forces acting on the object in your answer.

.....

.....

..... [2]

[Total: 10]

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12 **(a)** Figure 12.1 shows a diagram of a wave.

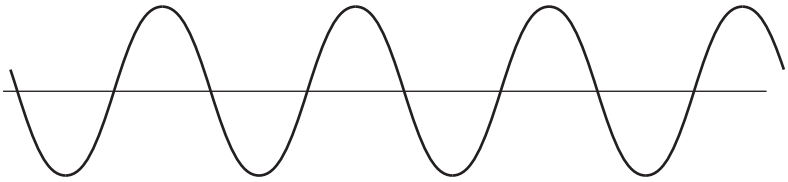

Figure 12.1

On Figure 12.1, use a double headed arrow (↔ or ↕) to show the amplitude of the wave. [1]

(b) Figure 12.2 shows part of an image formed in a plane mirror.

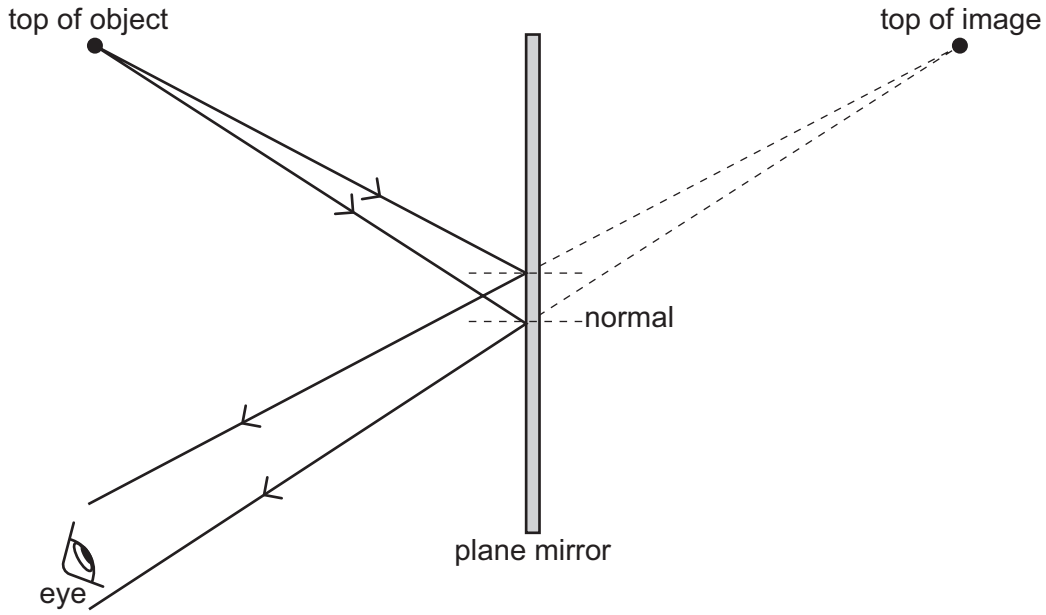

Figure 12.2

State **three** characteristics of the image.

1 .....

2 .....

3 .....

[3]

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(c) (i) A ray of light travelling in air is incident at an angle of 60° from the normal on a boundary with glass.

The ray enters the glass with an angle of refraction of 38°.

Calculate the refractive index of the glass.

refractive index = ... [2]

(ii) Another ray of light travelling in glass is incident at an angle of 20° from the normal on a boundary with air.

The ray enters the air with an angle of refraction of 29°.

The ray of light does **not** undergo total internal reflection.

Explain what change is made to the arrangement so that total internal reflection occurs.

.....

.....

..... [2]

[Total: 8]

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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.).

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