Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

3726575367

CO-ORDINATED SCIENCES **0654/41**

Paper 4 Theory (Extended) **May/June 2024**

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.

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 (PB/CB) 331166/2

1 **(a)** Fig. 1.1 is a diagram of the female reproductive system in humans.

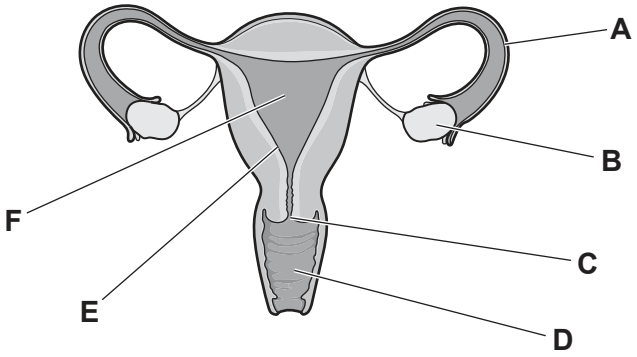

Fig. 1.1

State which letter in Fig. 1.1 identifies where:

meiosis occurs .....

fertilisation occurs .....

implantation occurs. .....

[3]

(b) Fig. 1.2 is a diagram showing some of the processes involved in the formation of a human embryo.

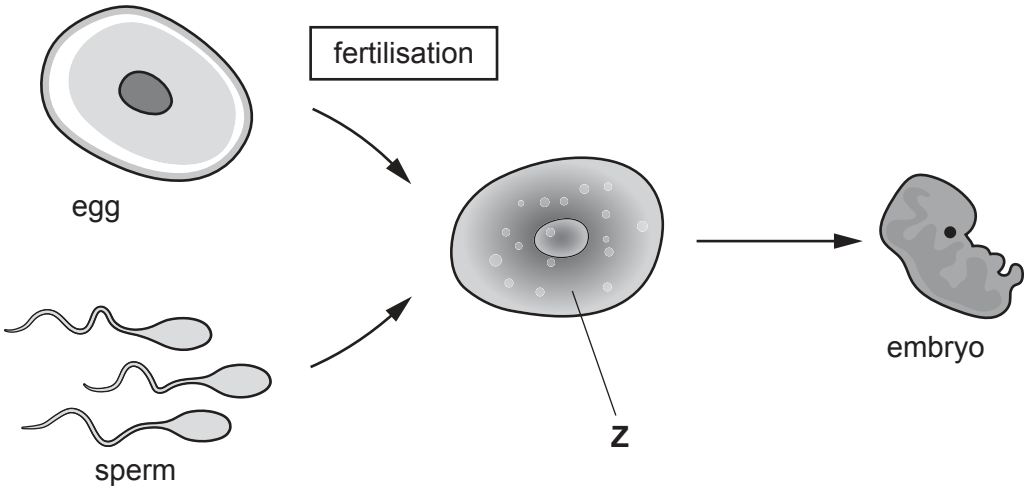

Fig. 1.2

(i) State the number and describe the arrangement of chromosomes in cell **Z** in Fig. 1.2.

number of chromosomes .....

arrangement of chromosomes .....

[2]

(ii) State the sex chromosomes in human females.

..... [1]

(iii) State the name of the adaptive feature of egg cells that changes after fertilisation to prevent entry of more than one sperm.

..... [1]

(c) State **one** function of the amniotic fluid.

.....

..... [1]

(d) Tick (✓) **all** the boxes that show correct statements about the placenta.

Carbon dioxide diffuses from the mother's blood in the placenta to the fetus.	
The blood of the fetus and the blood of the mother mix in the placenta.	
The mother provides the fetus with excretory products from the placenta.	
The placenta provides a barrier to toxins.	
The umbilical cord connects the fetus to the placenta.	

[2]

[Total: 10]

2 **(a)** Magnesium sulfate contains magnesium ions, Mg^{2+}, and sulfate ions, SO_4^{2-}.

(i) Determine the formula of magnesium sulfate.

formula = ... [1]

(ii) Explain why solid magnesium sulfate cannot conduct electricity but solid magnesium can conduct electricity.

.....

.....

.....

.....

.....

..... [3]

(b) Magnesium reacts with hydrochloric acid, HCl.

Magnesium chloride, $MgCl_2$, and hydrogen gas are made.

(i) Describe the test for hydrogen gas and the observation for a positive result.

test .....

observation .....
[2]

(ii) Calculate the mass of magnesium chloride made when 1.2 g of magnesium reacts with excess hydrochloric acid.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$

[A_r: Cl, 35.5; H, 1; Mg, 24]

mass of magnesium chloride = ... g [2]

(iii) The ionic equation for this reaction is shown.

$$Mg + 2H^+ \rightarrow Mg^{2+} + H_2$$

Explain why this reaction is described as a **redox** reaction.

.....

.....

..... [2]

[Total: 10]

3 Fig. 3.1 shows apparatus called a ripple tank.

This is used to investigate water waves.

An electric motor causes the board to vibrate.

At a constant speed of rotation, the motor produces waves at a constant rate.

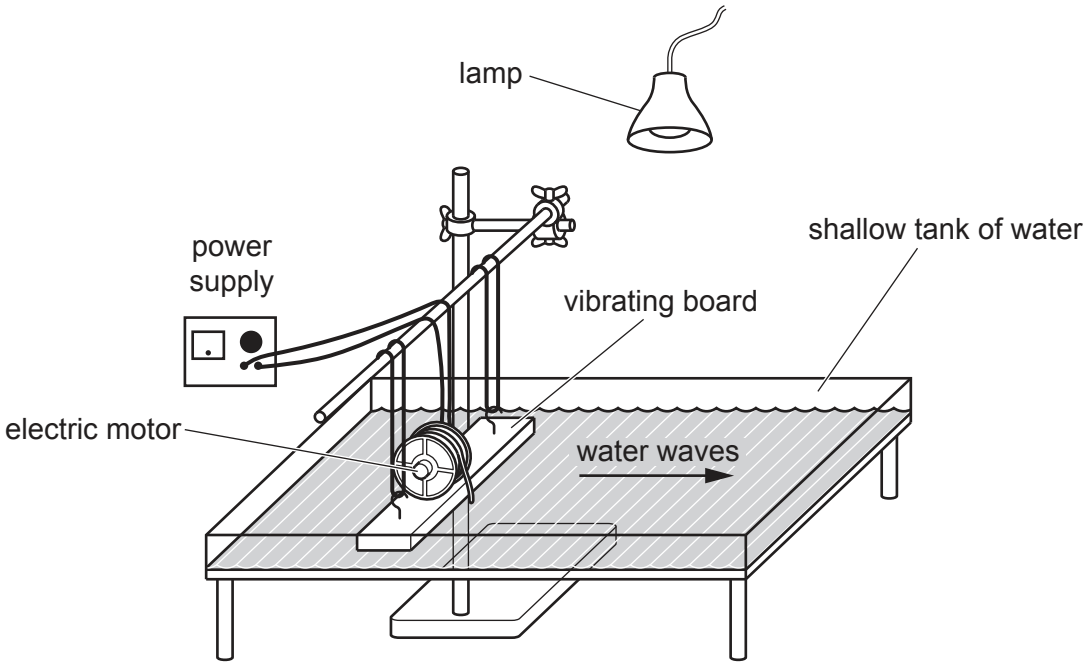

Fig. 3.1

(a) The electric motor causes the vibrating board to move up and down at a known frequency.

This produces water waves with the same frequency.

(i) State the meaning of the term frequency.

.....

..... [1]

(ii) The ripple tank produces waves with a frequency of 5.0 Hz which travel at a speed of 0.20 m / s.

Calculate the wavelength of the water waves.

wavelength = ... m [2]

(iii) Describe how the diffraction of water waves is demonstrated using a ripple tank.

Include a description of what is observed.

You may draw a diagram to help with your answer.

.....

.....

..... [2]

(b) The ripple tank uses a simple d.c. motor.

Complete the sentences to explain how the motor rotates.

The current-carrying coil experiences a force because it is in a ..... field.

The force on one side of the coil is upwards and the force on the other side of the coil is ....., causing a turning effect.

[2]

(c) The ripple tank uses a filament lamp during the demonstration.

(i) Draw the circuit symbol for a filament lamp.

[1]

(ii) The potential difference across the filament lamp is 12 V.

During the demonstration, the filament lamp uses 24 000 J of electrical energy.

Calculate how much charge passes through the filament lamp during the demonstration.

State the unit of your answer.

charge = ... unit ..... [4]

[Total: 12]

4 **(a)** A student investigates the effect of temperature on the rate of transpiration.

Transpiration is estimated by recording the loss in mass.

The student keeps one plant at 20 °C and one plant at 40 °C.

The student records the mass of each plant every day for 5 days.

Fig. 4.1 shows the apparatus the student uses.

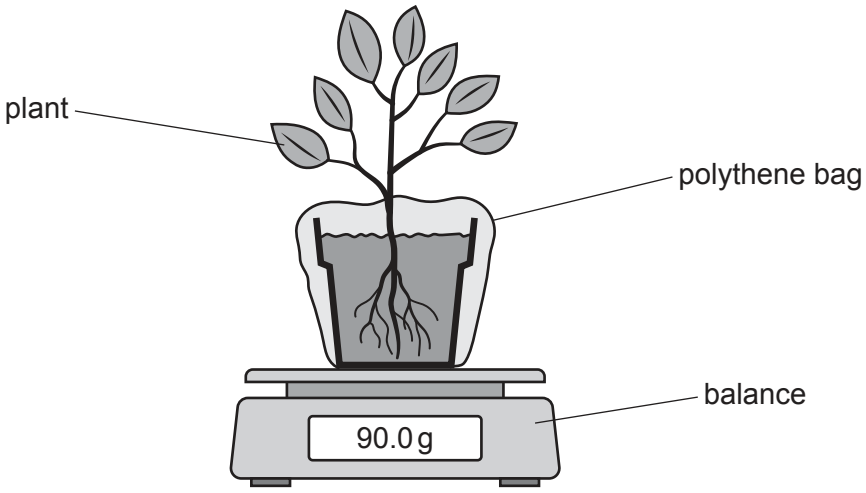

Fig. 4.1

Fig. 4.2 is a graph of the results.

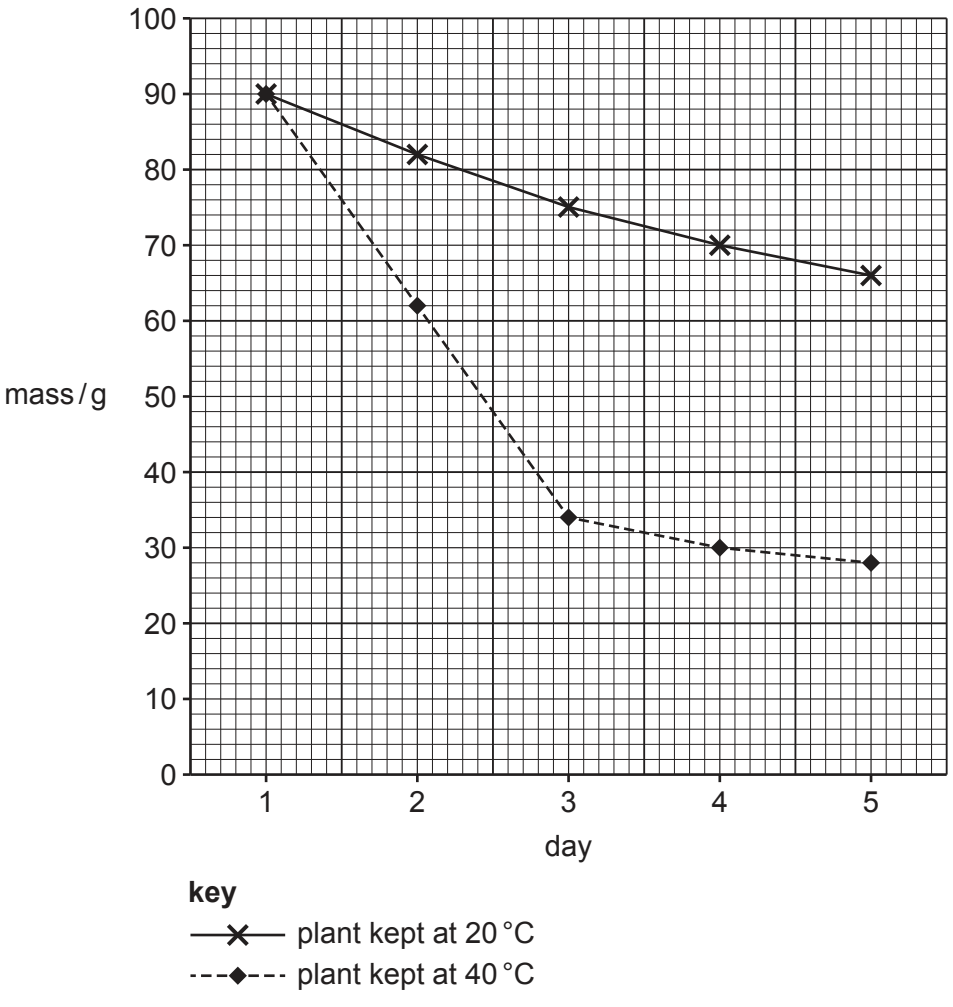

Fig. 4.2

(i) Complete the sentences to describe and explain the results shown in Fig. 4.2.

The mass of the plant kept at 40 °C decreased in mass by

..... g between day 1 and day 5.

As temperature increases, the water molecules gain more

..... energy.

This increases the rate of evaporation from the surfaces of the

..... cells.

There is also an increase in the rate of diffusion of .....

through the ..... into the atmosphere.

[5]

(ii) State how an increase in humidity would affect the results shown in Fig. 4.2.

.....

..... [1]

(b) Water is transported to the leaves by xylem.

(i) State how the water molecules are held together in the xylem.

..... [1]

(ii) State **one** other function of xylem, apart from transport.

..... [1]

(iii) State the name of **one** other transport tissue in plants.

..... [1]

[Total: 9]

5 **(a)** Fig. 5.1 shows part of the structure of lithium chloride.

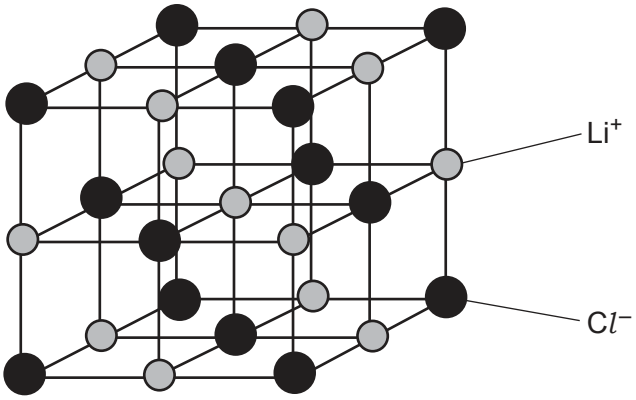

Fig. 5.1

(i) Deduce the formula of lithium chloride.

formula = ... [1]

(ii) Lithium chloride has a high melting point of 605 °C.

Explain why lithium chloride has a high melting point.

.....

.....

..... [2]

(b) Fig. 5.2 shows part of the structure of graphite.

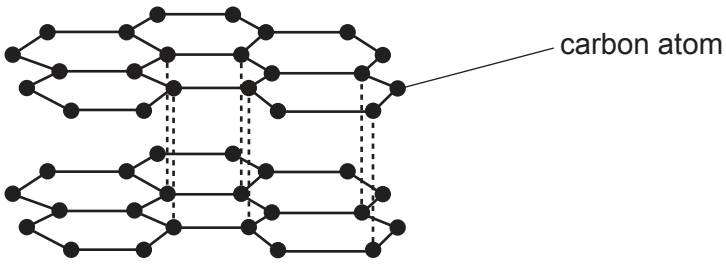

Fig. 5.2

(i) Describe the structure of graphite.

.....

.....

..... [2]

(ii) Explain why graphite is used as a lubricant.

Use ideas about structure and bonding.

.....

.....

..... [2]

(c) Mercury is a liquid at room temperature, 25 °C.

(i) Tick (✓) the row in Table 5.1 which shows the melting point and boiling point of mercury.

Table 5.1

melting point / °C	boiling point / °C	(✓)
–357	–39	
–57	9	
–39	357	
39	357	

[1]

(ii) Mercury has a proton number (atomic number) of 80 and a nucleon number (mass number) of 201.

Complete Table 5.2 for an atom of mercury.

Table 5.2

protons	80
neutrons	……..
electrons	……..

[2]

[Total: 10]

6 Fig. 6.1 shows a canister filled with liquid chlorine under pressure.

When the chlorine is released from the canister, it turns into a gas.

Fig. 6.1

(a) (i) Describe the arrangement and separation of molecules in a liquid and molecules in a gas.

arrangement

liquid .....

gas .....

separation

liquid .....

gas .....

[2]

(ii) Compare the motion of molecules in a liquid to the motion of molecules in a gas.

motion

liquid .....

gas .....

[1]

(b) A sample of chlorine gas contains two isotopes, chlorine-35 and chlorine-37.

(i) Describe **one** similarity and **one** difference in the composition of a nucleus of chlorine-35 and a nucleus of chlorine-37.

similarity .....

difference .....

[2]

(ii) Another isotope of chlorine is chlorine-36 which is unstable.

Fig. 6.2 shows how the number of undecayed nuclei in a sample changes over time.

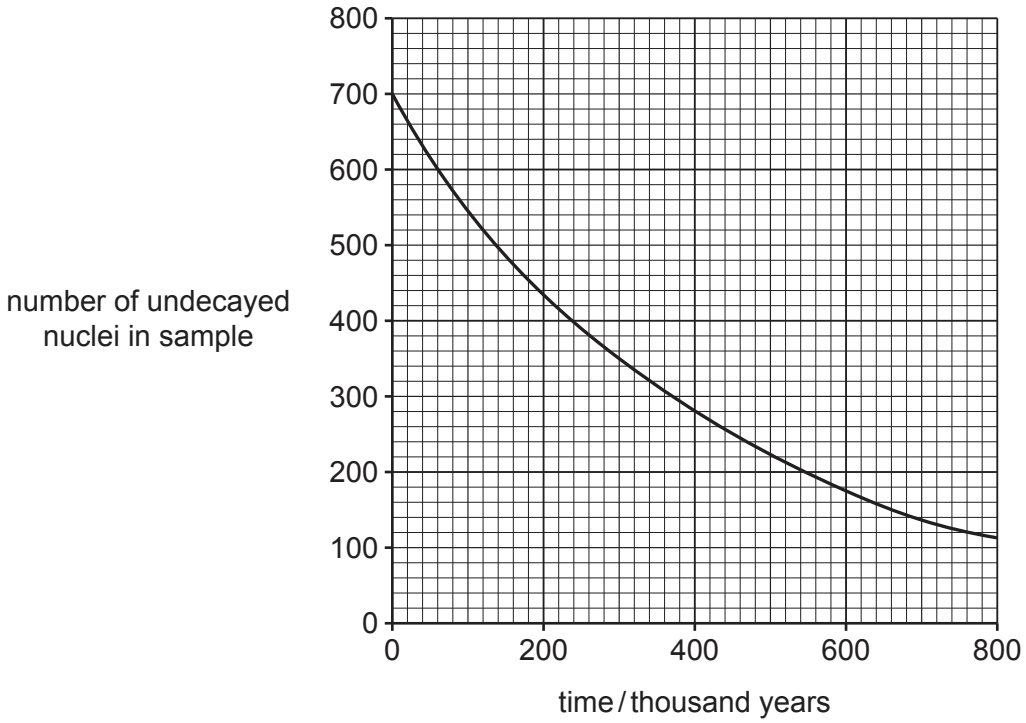

Fig. 6.2

Use Fig. 6.2 to determine the half-life of chlorine-36.

half-life = ... thousand years [1]

(iii) Chlorine-36 decays to produce an isotope of argon.

Use the correct nuclide notation to complete the decay equation.

$$^{36}_{17}Cl \rightarrow {}^{.....}_{18}Ar + {}^{.....}_{.....}{.....}$$

[2]

(c) The canister holds 0.020 m^3 of liquid chlorine when it is full.

When the canister is full of liquid chlorine, the total mass of the canister and the liquid chlorine is 13 kg.

The density of liquid chlorine is 570 kg / m^3.

Calculate the mass of the canister when it is empty.

mass of empty canister = ... kg [3]

[Total: 11]

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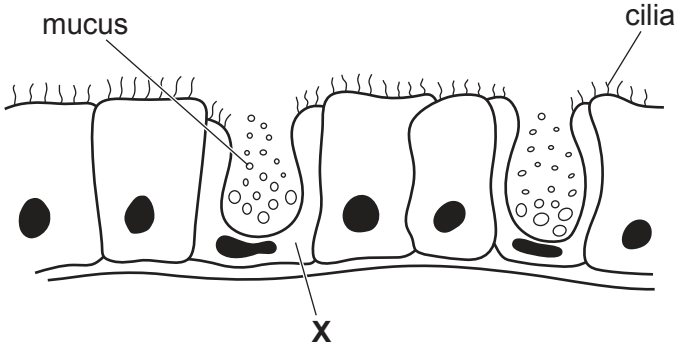
7 **(a)** Fig. 7.1 is a diagram showing the difference in the cells lining the gas exchange system of a person that smokes tobacco and a person that does not smoke tobacco.

cells in the bronchi of a person that smokes tobacco



cells in the bronchi of a person that does not smoke tobacco

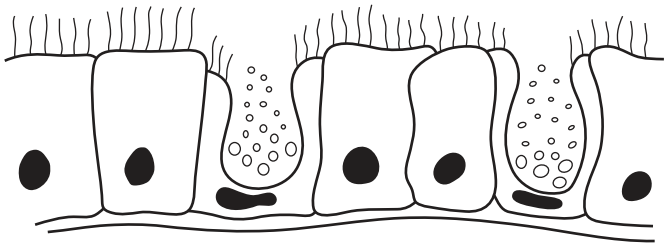


Fig. 7.1

(i) Use the information in Fig. 7.1 to explain why tobacco smokers are more likely to get lung infections.

.....

.....

.....

.....

.....

.....

..... [3]

(ii) Identify the name of the cell labelled **X** in Fig. 7.1.

..... [1]

(b) Smoking causes cancer.

(i) State the names of **two** other diseases caused by smoking.

1 .....

2 .....
[2]

(ii) State the component of tobacco smoke that causes cancer.

..... [1]

(iii) Cancer is the result of a mutation in cells.

Define the term mutation.

.....

..... [1]

(c) Alveoli are the gas exchange surface in humans.

Gases are exchanged by the process of diffusion.

Explain the advantage, in terms of diffusion, of the alveoli being thin and well ventilated.

thin .....

.....

well ventilated .....

.....
[2]

(d) State the names of **two** parts of the gas exchange system, that air passes through, between the mouth and the alveoli.

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

[Total: 12]

8 **(a)** A student investigates the reactivity of four metals **W**, **X**, **Y** and **Z**.

They react the same sized piece of each metal with excess dilute hydrochloric acid.

Table 8.1 shows their observations.

Table 8.1

metal	observations
W	fizzed rapidly with almost half of the metal left after two minutes
X	fizzed rapidly and most of the metal had reacted after two minutes
Y	some fizzing and the metal looked unchanged after two minutes
Z	fizzed very rapidly and no metal was left after two minutes

Use the observations in Table 8.1 to list the metals in order of reactivity.

..... most reactive

.....

.....

..... least reactive

[2]

(b) Fig. 8.1 shows the reactivity series of some metals.

The element carbon is also included in the list.

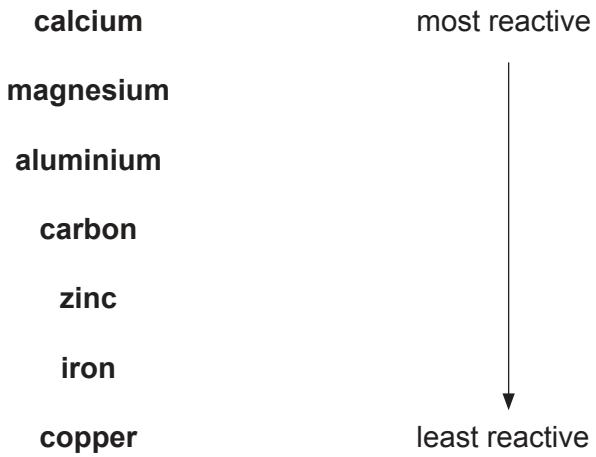


Fig. 8.1

(i) Aluminium is extracted from the ore bauxite by electrolysis.

Use Fig. 8.1 to state and explain how copper is extracted from copper ore.

.....

.....

..... [2]

(ii) Calcium is more reactive than magnesium.

Suggest why.

.....

..... [1]

(iii) Iron objects can be protected from rusting by coating them with zinc.

This is called sacrificial protection.

Use Fig. 8.1 to explain how sacrificial protection with zinc stops iron from rusting.

.....

.....

..... [2]

(c) Iron is more reactive than copper.

Iron metal reacts with aqueous copper chloride, $CuCl_2$.

Iron(II) chloride is made.

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

..... [2]

(ii) State the name of this type of reaction.

Choose from the list.

addition
displacement
neutralisation
thermal decomposition

..... [1]

(d) Aluminium is more reactive than iron but is more resistant to corrosion than iron.

Explain why.

.....

.....

..... [2]

[Total: 12]

9 Fig. 9.1 shows a skydiver before the parachute opens.

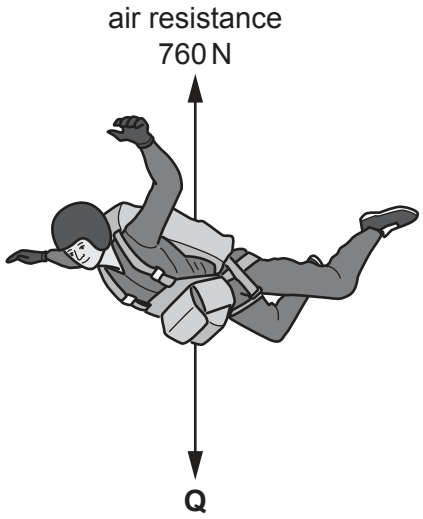


Fig. 9.1

(a) The skydiver has a mass of 84 kg.

(i) State the name of the force labelled **Q**.

..... [1]

(ii) Calculate the size of the force labelled **Q**.

The gravitational field strength g = 10 N / kg.

force **Q** = ... N [1]

(iii) The air resistance force at one point during the skydiver's journey is 760 N.

Use your answer to **(a)(ii)** to calculate the acceleration of the skydiver when the air resistance force is 760 N.

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

(b) Fig. 9.2 shows a speed–time graph for the skydiver's journey.

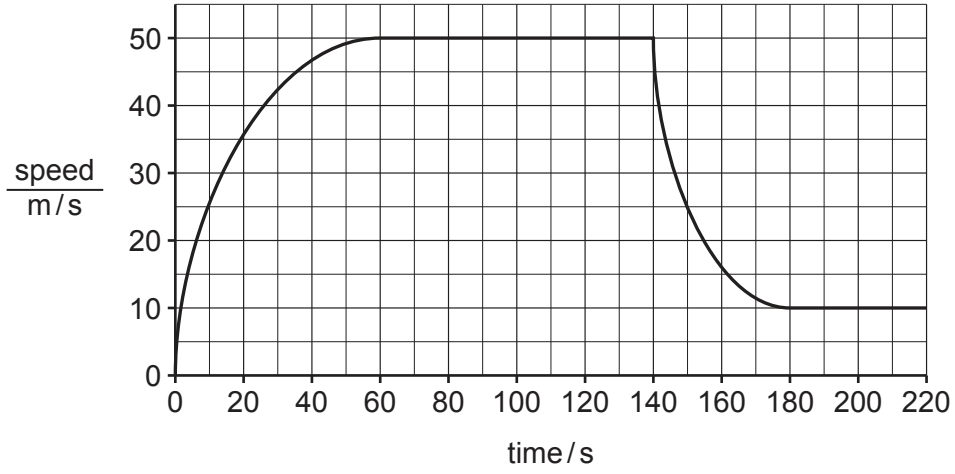


Fig. 9.2

The parachute is opened after 140 s.

Explain, in terms of motion and forces, the shape of the speed–time graph after the parachute is opened.

from 140 s to 180 s .....

.....

.....

after 180 s .....

.....

.....

[4]

(c) The skydiver falls from a height of 7500 m.

Show that the loss in gravitational potential energy when the skydiver reaches the ground is 6.3 MJ.

The gravitational field strength g = 10 N / kg.

[1]

[Total: 10]

10 **(a)** Fig. 10.1 is a diagram of part of the carbon cycle.

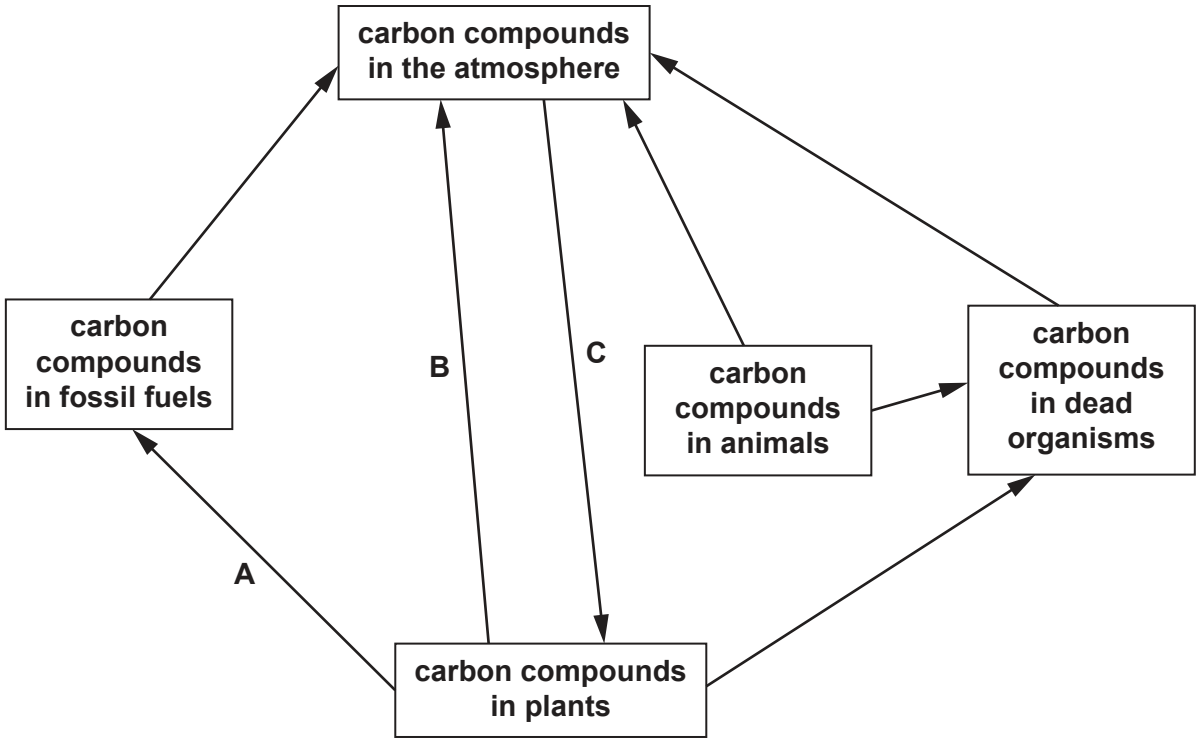


Fig. 10.1

(i) State the name of process **A** in Fig. 10.1.

..... [1]

(ii) State the balanced chemical equation for process **B** in Fig. 10.1.

..... [2]

(iii) Draw an arrow on Fig. 10.1 to represent the process of feeding. [1]

(iv) State the name of the cell structure where process **C** in Fig. 10.1 occurs.

..... [1]

(b) Tick (✓) **all** the boxes which show factors that cause an **increase** in carbon dioxide concentration in the atmosphere.

A decrease in the combustion of fossil fuels.	
A decrease in the use of cars that use petroleum.	
An increase in natural habitats being converted to land for intensive cattle farming.	
An increase in land used for housing.	
An increase in tree planting.	

[2]

(c) Suggest **two** ways that deforestation causes extinction of animal species.

1 .....

.....

2 .....

.....

[2]

[Total: 9]

11 Electrolysis is the breakdown of an ionic compound by the passage of electricity.

(a) Complete the following sentences about the products of electrolysis.

Choose words from the list.

electrolytes
hydrogen
negative
neutral
non-metals
positive

During electrolysis of aqueous solutions, metals or ..... are formed at the cathode. The anode is the ..... electrode where ..... are formed. [3]

(b) Aqueous copper(II) sulfate can be electrolysed using copper electrodes or using carbon (graphite) electrodes.

(i) State the product formed at the **anode** when aqueous copper(II) sulfate is electrolysed using each type of electrode.

copper electrodes .....

carbon (graphite) electrodes .....
[2]

(ii) Fig. 11.1 shows the change in mass at the cathode when aqueous copper(II) sulfate is electrolysed using copper electrodes.

The investigation is done using different currents, each for the same length of time.

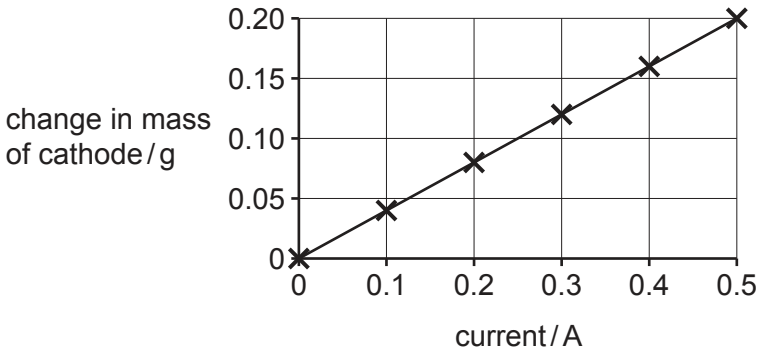


Fig. 11.1

Predict the change in mass of the **anode** when the current is 0.25A.

change in mass of anode = ... g [1]

(iii) Construct the ionic half-equation for the formation of the product at the **cathode** using **carbon (graphite)** electrodes.

..... [2]

[Total: 8]

12 A student is investigating electrical circuits.

(a) Fig. 12.1 shows a circuit made by the student.

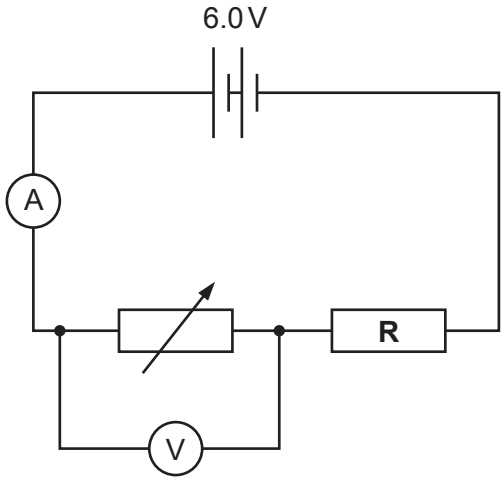


Fig. 12.1

(i) The ammeter in Fig. 12.1 reads 0.50 A.

The voltmeter in Fig. 12.1 reads 2.0 V.

Calculate the resistance of the resistor labelled **R** in Fig. 12.1.

resistance = ... Ω [3]

(ii) The student notices that resistor **R** gets hot if the circuit is left connected for too long.

Describe, in terms of current, how the student prevents resistor **R** from overheating using the circuit shown in Fig. 12.1.

.....

.....

..... [2]

(b) The student replaces the 6.0 V battery with a small solar cell.

The solar cell has an efficiency of 16%.

Calculate the power input to the solar cell when the solar cell provides 8.0 W of power to the circuit.

power input = ... W [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.).