



CANDIDATE
NAME

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CENTRE
NUMBER

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CANDIDATE
NUMBER

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0654/41

October/November 2022

2 hours

No additional materials are needed.

- 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.

- 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.

- 1 (a) Fig. 1.1 is a diagram of the male reproductive system in humans.

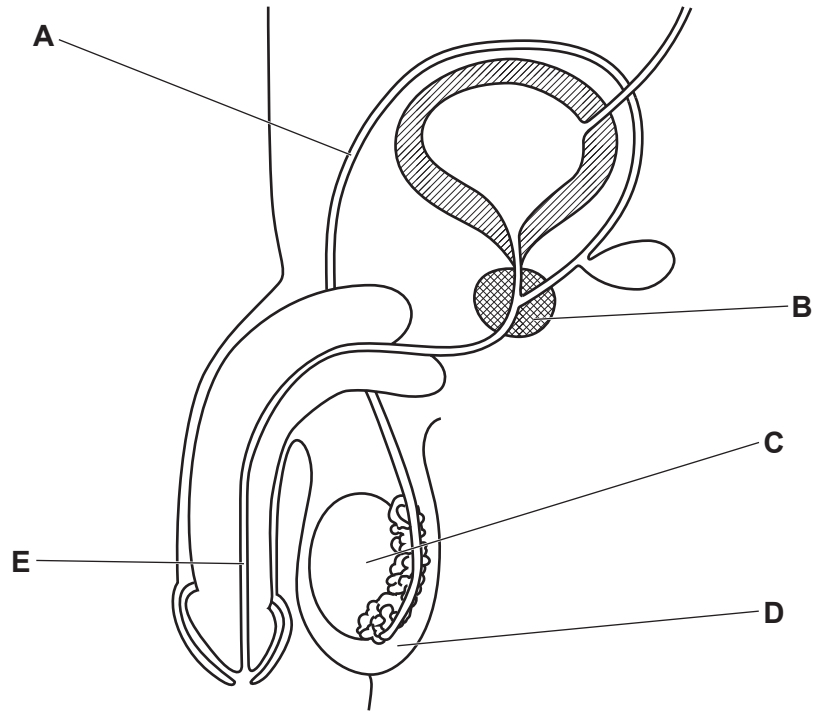


Fig. 1.1

State the letter from Fig. 1.1 that represents the part:

- where meiosis occurs
 which secretes fluid for sperm to swim in
 which carries urine
 which produces sperm.

[4]

- (b) Fig. 1.2 is a drawing of a sperm cell.

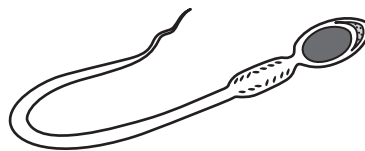


Fig. 1.2

Label Fig. 1.2 to identify **two** features of sperm that adapt it for reproduction.

[2]

- (c) Describe the difference between the arrangement of chromosomes found in the nuclei of sperm and those in a zygote.

.....
 [1]

- (d) Sperm and egg cells are specialised for their function of reproduction.

The boxes on the left show some other specialised cells.

The boxes on the right show some functions.

Draw lines to link each specialised cell with its function.

ciliated

palisade mesophyll

root hair

absorption

movement of mucus

photosynthesis

transport of oxygen

[3]

[Total: 10]

2 Alkanes are a type of hydrocarbon.

(a) State what is meant by a hydrocarbon.

.....
 [2]

(b) Table 2.1 shows some information about some alkanes.

Table 2.1

alkane	molecular formula	energy released when 1 g of alkane is completely burned / kJ
methane	CH ₄	55.6
butane	C ₄ H ₁₀	51.7
octane	C ₈ H ₁₈	48.0
eicosane	C ₂₀ H ₄₂	46.4

The general formula for the alkanes is C_nH_{2n+2}, where **n** is the number of carbon atoms in the molecule.

(i) When **n** increases, the amount of energy released changes.
 State how the amount of energy released changes.

..... [1]

(ii) Tetradecane is an alkane with 14 carbon atoms.

Write the **molecular formula** for tetradecane.

molecular formula = [1]

(iii) Decene is not an alkane. It has the molecular formula C₁₀H₂₀.

Use the general formula C_nH_{2n+2} to show that decene is **not** an alkane.

.....
 [1]

(c) Butane, C₄H₁₀, burns completely in air.

Carbon dioxide and water are made.

Construct the balanced symbol equation for this reaction.

..... [2]

- (d) (i) Burning butane is an exothermic reaction.

State what is meant by an exothermic reaction.

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

- (ii) Use the axes shown in Fig. 2.1 to draw and label the energy level diagram for this reaction.

Label:

- the energy of the reactants and the products
- the energy change in the reaction
- the activation energy of the reaction.

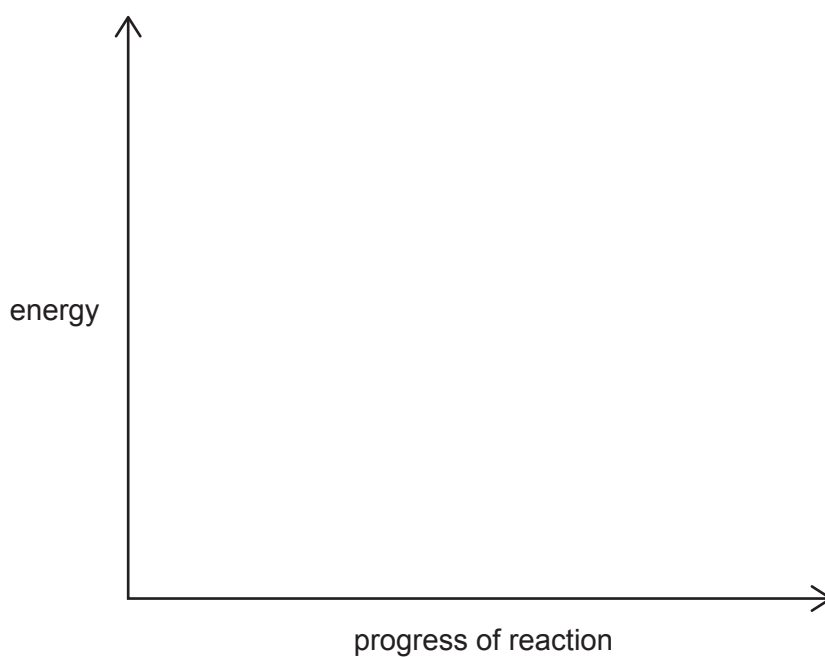


Fig. 2.1

[3]

[Total: 11]

3 Fig. 3.1 shows a crane lifting a wooden crate.

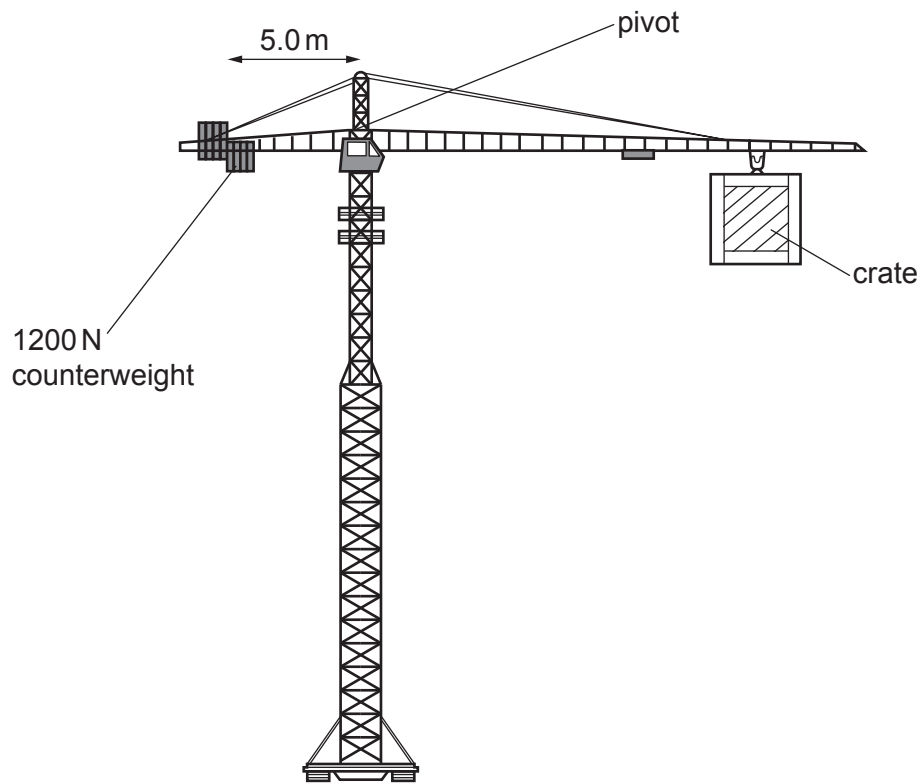


Fig. 3.1

(a) The crane is in equilibrium.

(i) The 1200 N counterweight is 5.0 m away from the pivot.

Calculate the moment of the counterweight about the pivot.

moment = Nm [2]

(ii) Determine the moment of the crate about the pivot.

moment = Nm [1]

- (b) The crate gains 105 kJ of gravitational potential energy as it is lifted through a height of 42 m.

Calculate the mass of the crate.

The gravitational field strength, g , is 10 N/kg.

mass = kg [2]

- (c) The crane uses an electric motor.
Fig. 3.2 shows a simple d.c. motor.

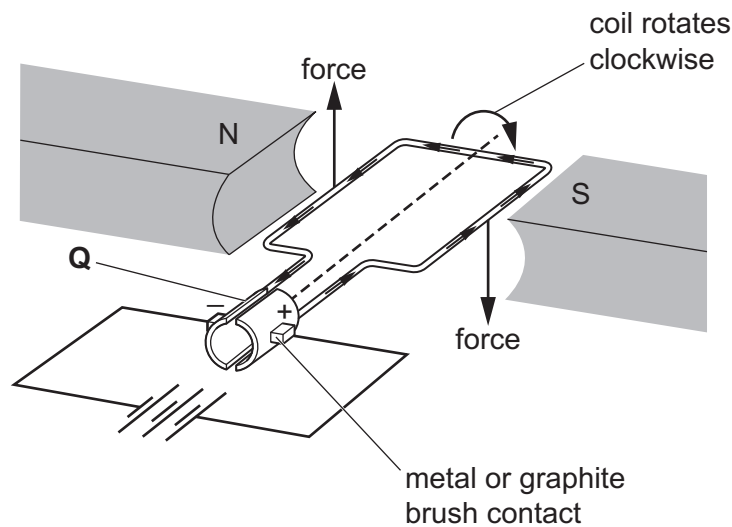


Fig. 3.2

- (i) State the name of the component labelled **Q** in Fig. 3.2.
..... [1]
- (ii) Draw an arrow on Fig. 3.2 to show the direction of the magnetic field. [1]
- (iii) State **two** ways to increase the speed at which the coil rotates.
1
.....
2
..... [2]

[Total: 9]

- 4 (a) A seed germinates.

State **two** environmental conditions needed for germination.

1

2

[2]

- (b) A plant is kept in the **dark** to grow.

Fig. 4.1 shows the growth of the plant shoot.

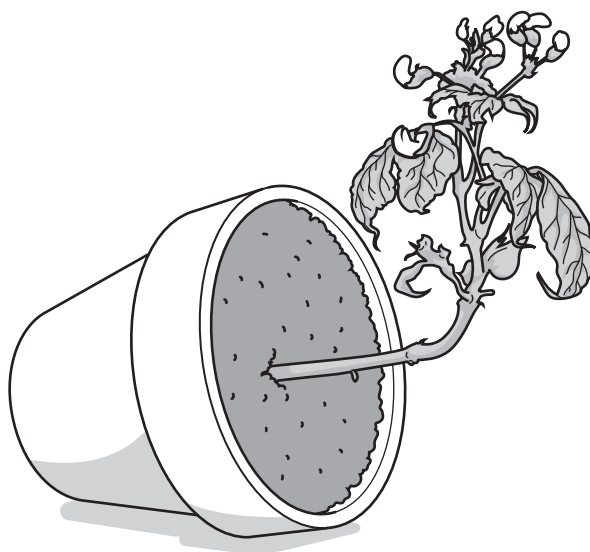


Fig. 4.1

- (i) State the name of the tropic response shown in Fig. 4.1.

..... [1]

- (ii) Complete the sentences to explain the mechanism of this growth response.

A plant hormone called is made in the shoot tip and moves through the plant.

The hormone collects on the side of the shoot.

This stimulates growth causing cell

The shoot grows away from the direction of

[4]

(c) Plants photosynthesise.

(i) State the balanced symbol equation for photosynthesis.

..... [2]

(ii) Explain why chlorophyll is needed for photosynthesis.

.....

.....

..... [2]

[Total: 11]

- 5 (a) Fig. 5.1 shows the arrangement of particles in a **liquid**.

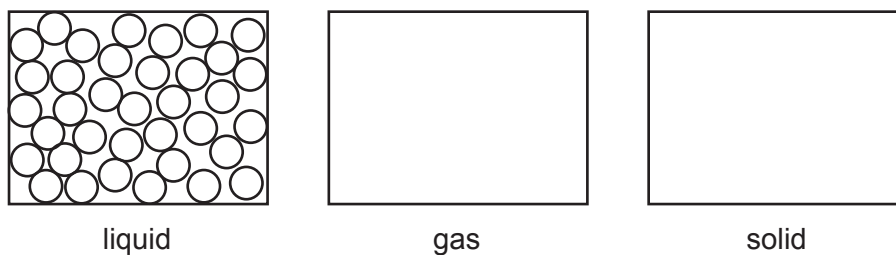


Fig. 5.1

Complete Fig. 5.1 to show the arrangement of the particles in a gas and in a solid.

[2]

- (b) (i) Liquid water boils at 100 °C to form steam.

Describe what happens to the water particles during this change of state.

Include:

- how the arrangement of the particles changes
- how the movement of the particles changes.

arrangement

.....

movement

.....

[2]

- (ii) Fig. 5.2 shows the bonds between the atoms and the forces between the molecules in water.

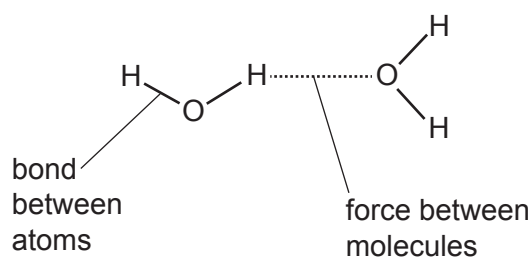


Fig. 5.2

When water boils, the forces between the molecules are broken.

Explain why the bonds between atoms are **not** broken.

.....

..... [1]

- (iii) Draw a dot-and-cross diagram to show the bonding in water, H_2O .

Show only the outer shell electrons.

[2]

- (c) (i) Water reacts with magnesium metal. The reaction is very slow.

The reaction is faster if **hot** water is used.

Explain why. Use ideas about collisions between particles.

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

- (ii) The reaction between water and magnesium is faster if **powdered** magnesium is used instead of strips of magnesium.

Explain why. Use ideas about collisions between particles.

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

[Total: 11]

- 6 Fig. 6.1 shows a man paddling a canoe on a lake. The arrows show the horizontal forces acting on the canoe.

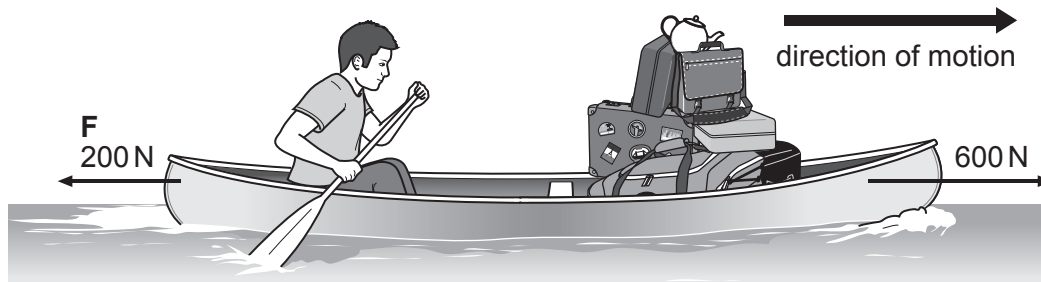


Fig. 6.1

- (a) (i) State the cause of the force labelled **F** on Fig. 6.1.

..... [1]

- (ii) The combined mass of the man and the canoe and his luggage is 100 kg.

Calculate the acceleration of the canoe.

acceleration = m/s^2 [3]

- (b) Water waves travel across the surface of the lake.

- (i) The man counts 15 wavefronts passing a point in 1 minute.

Calculate the frequency of the waves in Hz.

frequency = Hz [1]

- (ii) The wavelength of the water waves is 0.6 m.

Use your answer to **6(b)(i)** to calculate the speed of the water waves.

speed = m/s [2]

- (iii) Fig. 6.2 shows the wavefronts of the water waves moving towards two rocks. The water waves will diffract as they travel between the two rocks.

Complete Fig. 6.2 to show how the water waves are diffracted.

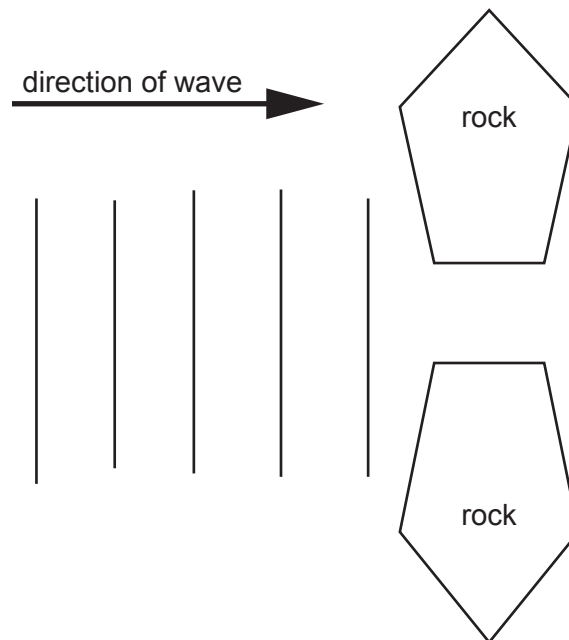


Fig. 6.2

[1]

- (c) The man uses a solar panel to charge his mobile phone.
The solar panel uses energy from the Sun to generate electricity.

State the name of the process in the Sun that releases energy.

..... [1]

[Total: 9]

- 7 (a) Fig. 7.1 is a photograph of a person with a deficiency disease that has affected their bone growth.



Fig. 7.1

- (i) State the name of the vitamin the person in Fig. 7.1 is deficient in.

..... [1]

- (ii) Taking vitamin supplements can prevent the deficiency disease shown in Fig. 7.1.

Suggest **two** other ways to prevent the effects seen in Fig. 7.1.

1

2

[2]

- (b) Kwashiorkor is a deficiency disease caused by a lack of protein in the diet.

Table 7.1 shows the ages of children admitted to a hospital with kwashiorkor disease.

Table 7.1

age group	number of children
4 and under	88
over 4	7
Total	95

- (i) Use Table 7.1 to calculate the percentage of children of age 4 and under with kwashiorkor disease admitted to the hospital.

Give your answer to the nearest whole number.

.....% [2]

- (ii) The recommended daily intake of protein per kg of body mass for a child is greater than that of an adult.

State why.

.....
 [1]

- (c) State the name of **one** other deficiency disease caused by protein-energy malnutrition.

..... [1]

- (d) State the names of the **four** elements that all proteins contain.

.....
 [2]

- (e) State the name of the enzyme that breaks down proteins.

..... [1]

[Total: 10]

- 8 Some cars use petrol as a fuel. Some cars use diesel as a fuel.

Table 8.1 shows the mass of pollutant made when 1 kg of petrol or 1 kg of diesel is burnt in a car engine.

Table 8.1

pollutant	mass of pollutant/g	
	car using petrol	car using diesel
black smoke	18	0.6
carbon monoxide	236	10
nitrogen monoxide	59	29
sulfur dioxide	3.8	0.9

- (a) (i) Car **A** uses 5 kg of petrol fuel for a journey.

Car **B** uses 8 kg of diesel fuel for the same journey.

State which car, **A** or **B**, makes the most **nitrogen monoxide**.

Explain your answer.

Car makes most nitrogen monoxide.

explanation

..... [1]

- (ii) The nitrogen monoxide, NO, made inside the car engine is removed by a catalytic converter.

The nitrogen monoxide is turned into nitrogen gas and oxygen gas.

Construct the balanced symbol equation for this reaction.

..... [2]

- (iii) Sulfur dioxide is a pollutant that causes acid rain.

Sulfur dioxide is not removed from car emissions by a catalytic converter.

Describe **one** way that emissions of sulfur dioxide by cars can be reduced.

.....

..... [1]

- (b) A petrol car makes 236 g of carbon monoxide gas when 1 kg of petrol is burnt.

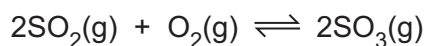
Calculate the volume occupied by 236 g of carbon monoxide gas.

The molar gas volume at room temperature and pressure is 24 dm^3 .

Show your working.

volume = dm^3 [3]

- (c) Sulfur dioxide is used in the manufacture of sulfuric acid in the Contact process.



Describe **two** conditions used for this reversible reaction.

1

2 [2]

[Total: 9]

- 9 A student investigates the effect of changing temperature on the current through a thermistor. The student connects a cell, an NTC thermistor, an ammeter and a switch in series.

(a) On Fig. 9.1, complete the circuit diagram to show the circuit used by the student.



Fig. 9.1

[2]

(b) The graph in Fig. 9.2 shows the results obtained by the student.

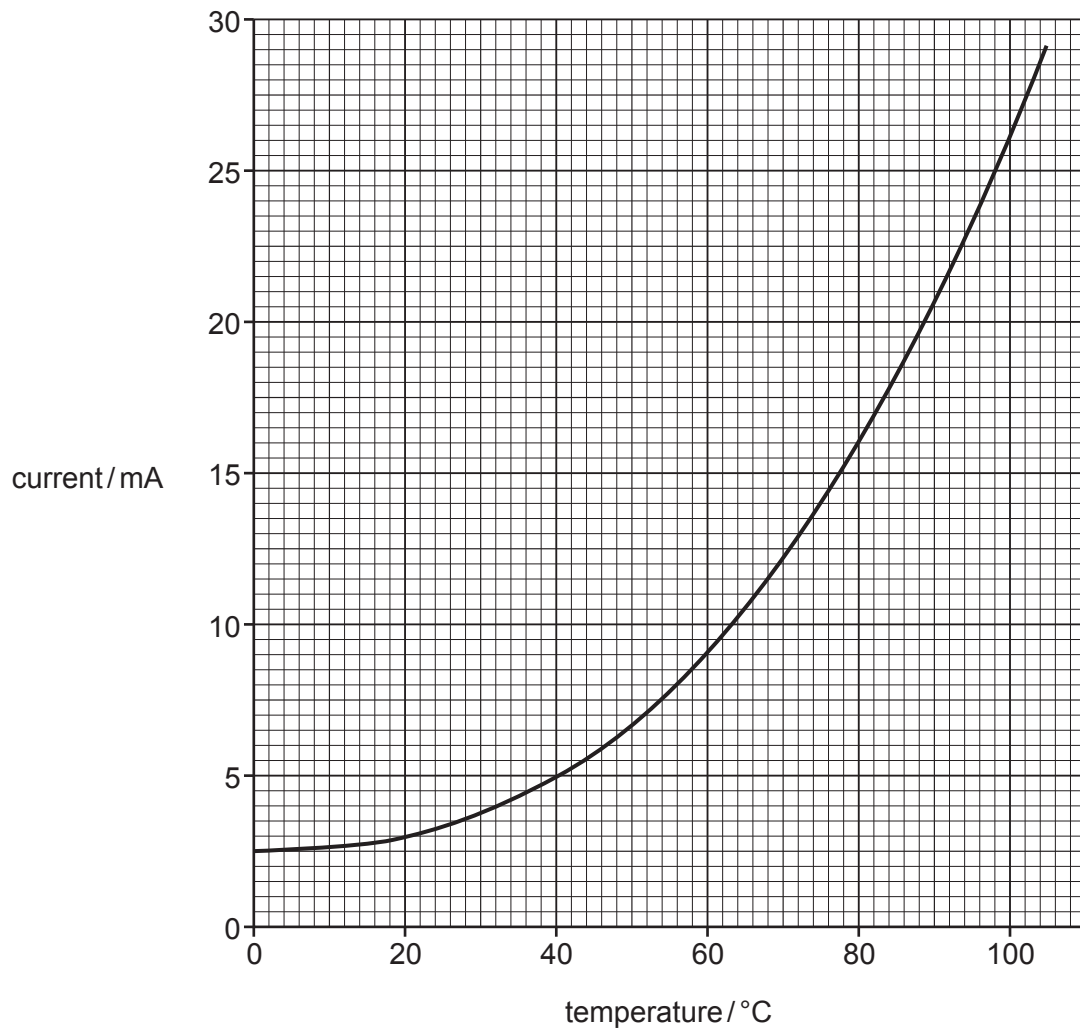


Fig. 9.2

The temperature of the thermistor is 40 °C.

Calculate the time it takes for 1.0 C of charge to flow through the thermistor.

time = s [3]

- (c) The student uses a liquid-in-glass thermometer to measure temperature.

Fig. 9.3 shows the structure of a liquid-in-glass thermometer.

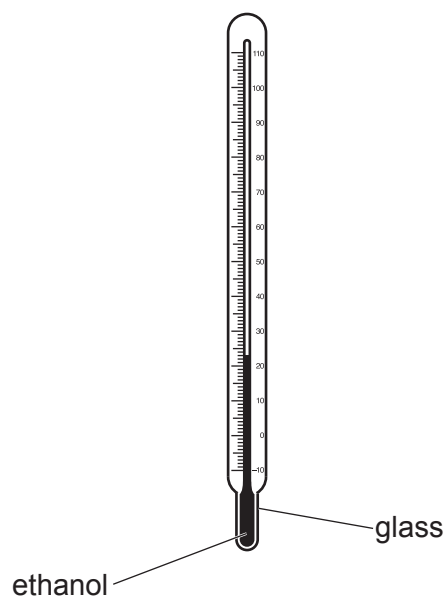


Fig. 9.3

- (i) Thermal energy is transferred through the glass to the ethanol.

Describe how thermal energy is transferred through glass.

.....

.....

..... [2]

- (ii) The ethanol in the thermometer expands as the temperature increases.

Explain why the ethanol expands as the temperature increases in terms of the motion and arrangement of molecules.

.....

.....

.....

..... [2]

- (iii) The volume of the ethanol in the thermometer at 25 °C is 2.00 cm³ and the density of the ethanol is 0.78 g/cm³.

When the thermometer is cooled to 3 °C, the volume decreases to 1.95 cm³.

Calculate the density of the ethanol at 3 °C.

density of ethanol = g/cm³ [3]

[Total: 12]

10 (a) Fig. 10.1 is a diagram of a cross-section through skin.

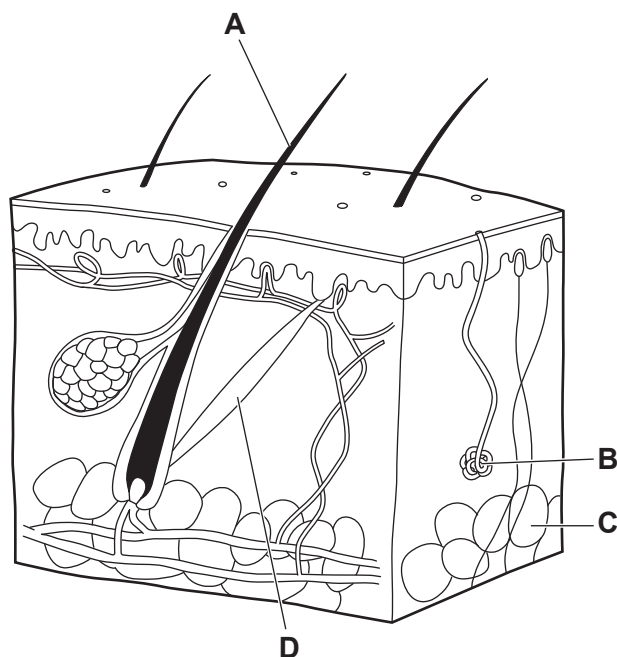


Fig. 10.1

Table 10.1 shows the names and functions of some of the parts labelled **A–D** in Fig. 10.1.

Complete Table 10.1.

Table 10.1

name of part	letter in Fig. 10.1	function
		provide insulation
hair erector muscle		
	B	

[3]

(b) Describe the role of **arterioles** in reducing body temperature when the body gets too hot.

.....

.....

.....

.....

.....

[3]

(c) The control of internal body temperature is an example of negative feedback.

(i) Explain what is meant by the term negative feedback.

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

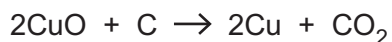
(ii) State **one** other example of negative feedback.

..... [1]

[Total: 9]

- 11 (a) Copper oxide, CuO, is heated with carbon, C.

Copper, Cu, and carbon dioxide, CO₂, are made as shown in the equation:



This reaction is an example of reduction.

Use the equation to explain what reduction means.

.....
 [1]

- (b) The copper made from copper oxide is not pure.

A student purifies the impure copper using electrolysis.

Fig. 11.1 shows the apparatus the student uses.

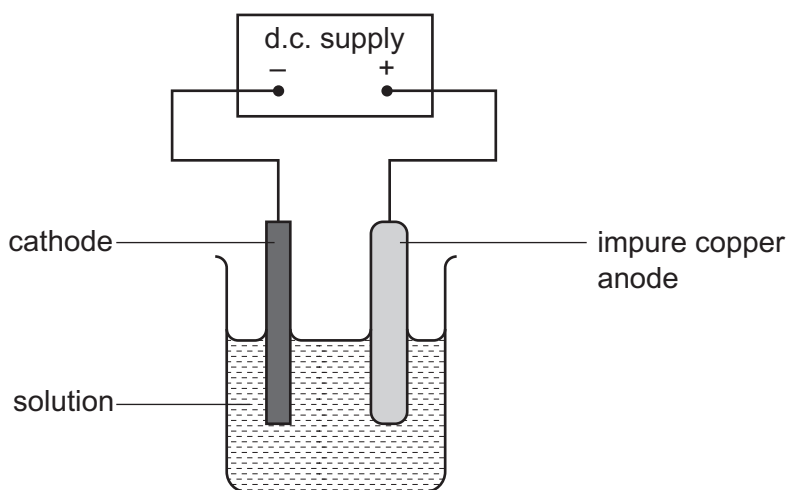


Fig. 11.1

- (i) State the name of the electrolyte solution the student uses.

..... [1]

- (ii) The student uses impure copper as the anode.

State what the student uses as the cathode.

..... [1]

- (c) Copper atoms are formed from copper ions, Cu²⁺, at the cathode.

Construct the balanced ionic half-equation for this reaction.

Use the symbol e⁻ for an electron.

..... [2]

- (d) Aluminium is a metal that is extracted by electrolysis.

Fig. 11.2 shows the apparatus that is used.

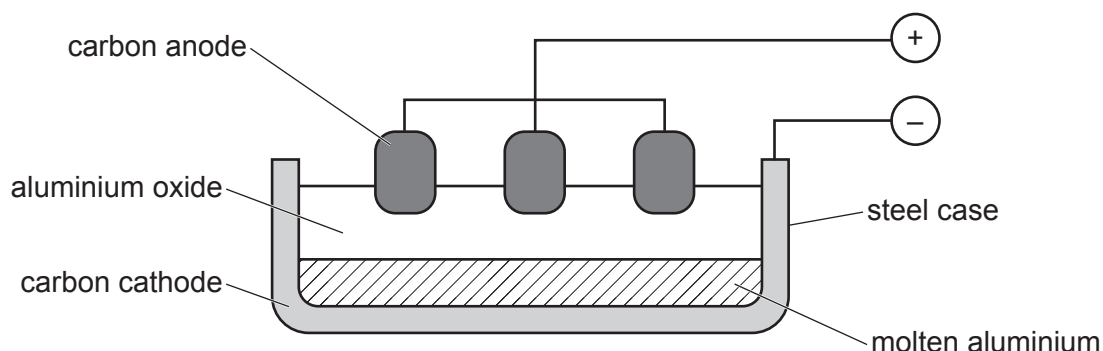


Fig. 11.2

The word equation for the electrolysis of aluminium oxide is:

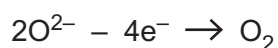


- (i) State what is made at the cathode.

..... [1]

- (ii) Oxide ions lose electrons to form oxygen molecules.

The ionic half-equation for the reaction is:

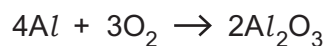


Electrons are lost during this process.

State the name of this type of reaction.

..... [1]

- (e) Aluminium reacts with oxygen to make aluminium oxide, Al_2O_3 .



Calculate the maximum mass of aluminium oxide that can be made from 1.35 g of aluminium.
Show your working.

mass of aluminium oxide = g [2]

[Total: 9]

12 α -particles, β -particles and γ -rays are all forms of ionising radiation.

(a) State **one** effect of ionising radiation on living things.

..... [1]

(b) The radioactive isotope uranium-238 decays into the isotope thorium-234 by emitting an α -particle.

Use the correct nuclide notation to complete the decay equation for uranium-238.

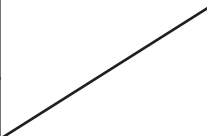


(c) Gamma radiation is part of the electromagnetic spectrum.

(i) State the speed of gamma radiation in a vacuum.

..... [1]

(ii) Draw lines to match each form of electromagnetic radiation to its use. One line has been drawn for you.

form of electromagnetic radiation		use
infrared		medicine and security
microwaves		radio and TV communications
radio waves		remote controls and intruder alarms
X-rays		satellite television and telephones

[2]

- (d) Visible light is also part of the electromagnetic spectrum.
Fig. 12.1 shows an object emitting visible light and a thin converging lens.

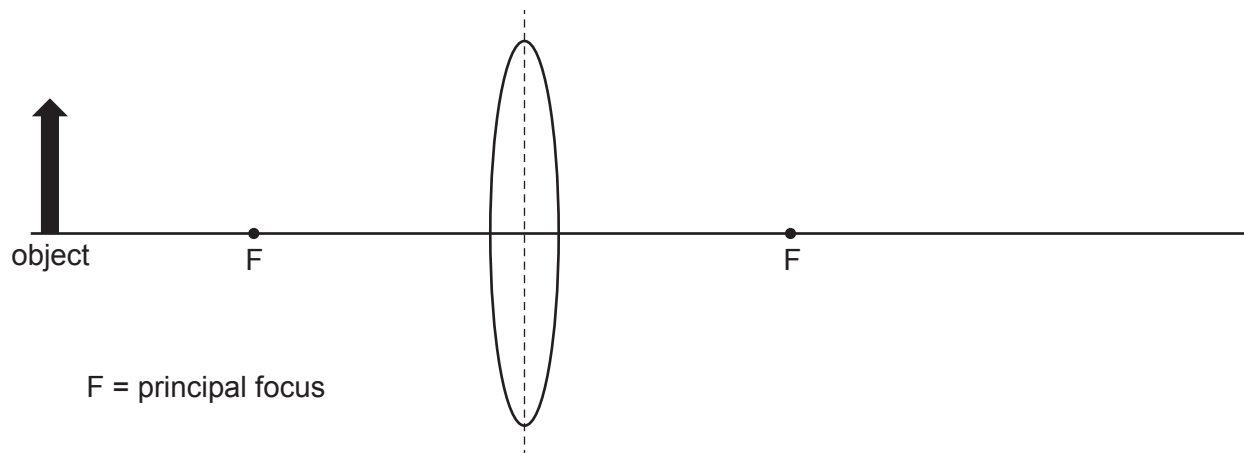


Fig. 12.1

- (i) Complete Fig. 12.1 to show how the rays of light from the object form an image. [3]
- (ii) The image formed is a **real** image.

State **one** difference between a real image and a virtual image.

.....

..... [1]

[Total: 10]

The Periodic Table of Elements

Group																	
I	II											III	IV	V	VI	VII	VIII
Key atomic number atomic symbol name relative atomic mass 1 H hydrogen 1 5 B boron 11 13 Al aluminium 27 31 Ga gallium 70 49 In indium 115 81 Tl thallium 204 114 Fl flerovium — 101 Ru ruthenium 101 44 Ru ruthenium 101 76 Os osmium 190 108 Hs hassium — 112 Cn copernicium — 26 Fe iron 56 56 Fe iron 56 76 Os osmium 190 108 Hs hassium — 112 Cn copernicium — 27 Co cobalt 59 59 Co cobalt 59 77 Ir iridium 192 109 Mt meitnerium — 111 Rg roentgenium — 28 Ni nickel 59 58 Ni nickel 58 78 Pt platinum 195 110 Ds darmstadtium — 112 Cn copernicium — 29 Cu copper 64 64 Cu copper 64 79 Au gold 197 111 Rg roentgenium — 114 Fl flerovium — 30 Zn zinc 65 65 Zn zinc 65 80 Hg mercury 201 112 Cn copernicium — 32 Ge germanium 73 73 Ge germanium 73 82 Pb lead 207 114 Fl flerovium — 33 As arsenic 75 75 As arsenic 75 83 Bi bismuth 209 116 Lv livermorium — 34 Se selenium 79 79 Se selenium 79 84 Po polonium — 116 Lv livermorium — 35 Br bromine 80 80 Br bromine 80 85 At astatine — 116 Lv livermorium — 36 Kr krypton 84 84 Kr krypton 84 86 Rn radon — 116 Lv livermorium — 37 Rb rubidium 85 85 Rb rubidium 85 87 Fr francium — 116 Lv livermorium — 38 Sr strontium 88 88 Sr strontium 88 88 Ra radium — 116 Lv livermorium — 39 Y yttrium 89 89 Y yttrium 89 89–103 actinoids 116 Lv livermorium — 40 Zr zirconium 91 91 Zr zirconium 91 104 Rf rutherfordium — 116 Lv livermorium — 41 Nb niobium 93 93 Nb niobium 93 105 Db dubnium — 116 Lv livermorium — 42 Mo molybdenum 96 96 Mo molybdenum 96 106 Sg seaborgium — 116 Lv livermorium — 43 Tc technetium — — Tc technetium — 107 Bh bohrium — 116 Lv livermorium — 44 Ru ruthenium 101 101 Ru ruthenium 101 108 Hs hassium — 116 Lv livermorium — 45 Rh rhodium 103 103 Rh rhodium 103 109 Mt meitnerium — 116 Lv livermorium — 46 Pd palladium 106 106 Pd palladium 106 110 Ds darmstadtium — 116 Lv livermorium — 47 Ag silver 108 108 Ag silver 108 111 Rg roentgenium — 116 Lv livermorium — 48 Cd cadmium 112 112 Cd cadmium 112 112 Cn copernicium — 116 Lv livermorium — 50 Sn tin 119 119 Sn tin 119 114 Fl flerovium — 116 Lv livermorium — 51 Sb antimony 122 122 Sb antimony 122 116 Lv livermorium — 116 Lv livermorium — 52 Te tellurium 128 128 Te tellurium 128 116 Lv livermorium — 116 Lv livermorium — 53 I iodine 127 127 I iodine 127 116 Lv livermorium — 116 Lv livermorium — 54 Xe xenon 131 131 Xe xenon 131 116 Lv livermorium — 116 Lv livermorium — 55 Cs caesium 133 133 Cs caesium 133 87 Fr francium — 116 Lv livermorium — 56 Ba barium 137 137 Ba barium 137 88 Ra radium — 116 Lv livermorium — 57–71 lanthanoids 89–103 actinoids 57 La lanthanum 139 139 La lanthanum 139 89 Ac actinium — 116 Lv livermorium — 58 Ce cerium 140 140 Ce cerium 140 90 Th thorium 232 116 Lv livermorium — 59 Pr praseodymium 141 141 Pr praseodymium 141 91 Pa protactinium 231 116 Lv livermorium — 60 Nd neodymium 144 144 Nd neodymium 144 92 U uranium 238 116 Lv livermorium — 61 Pm promethium — — Pm promethium — 93 Np neptunium — 116 Lv livermorium — 62 Sm samarium 150 150 Sm samarium 150 94 Pu plutonium — 116 Lv livermorium — 63 Eu europium 152 152 Eu europium 152 95 Am americium — 116 Lv livermorium — 64 Gd gadolinium 157 157 Gd gadolinium 157 96 Cm curium — 116 Lv livermorium — 65 Tb terbium 159 159 Tb terbium 159 97 Bk berkelium — 116 Lv livermorium — 66 Dy dysprosium 163 163 Dy dysprosium 163 98 Cf californium — 116 Lv livermorium — 67 Ho holmium 165 165 Ho holmium 165 99 Es einsteinium — 116 Lv livermorium — 68 Er erbium 167 167 Er erbium 167 100 Fm fermium — 116 Lv livermorium — 69 Tm thulium 169 169 Tm thulium 169 101 Md mendelevium — 116 Lv livermorium — 70 Yb ytterbium 173 173 Yb ytterbium 173 102 No nobelium — 116 Lv livermorium — 71 Lu lutetium 175 175 Lu lutetium 175 103 Lr lawrencium — 116 Lv livermorium — lanthanoids actinoids																	

The volume of one mole of any gas is 24 dm³ at room temperature and pressure (r.t.p.).