Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME

CENTRE NUMBER

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* 3 9 3 9 0 4 2 5 8 2 *

CO-ORDINATED SCIENCES **0654/41**

Paper 4 Theory (Extended) **May/June 2023**

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 **32** pages. Any blank pages are indicated.

1 **(a)** Fig. 1.1 is a diagram of a cross-section of skin.

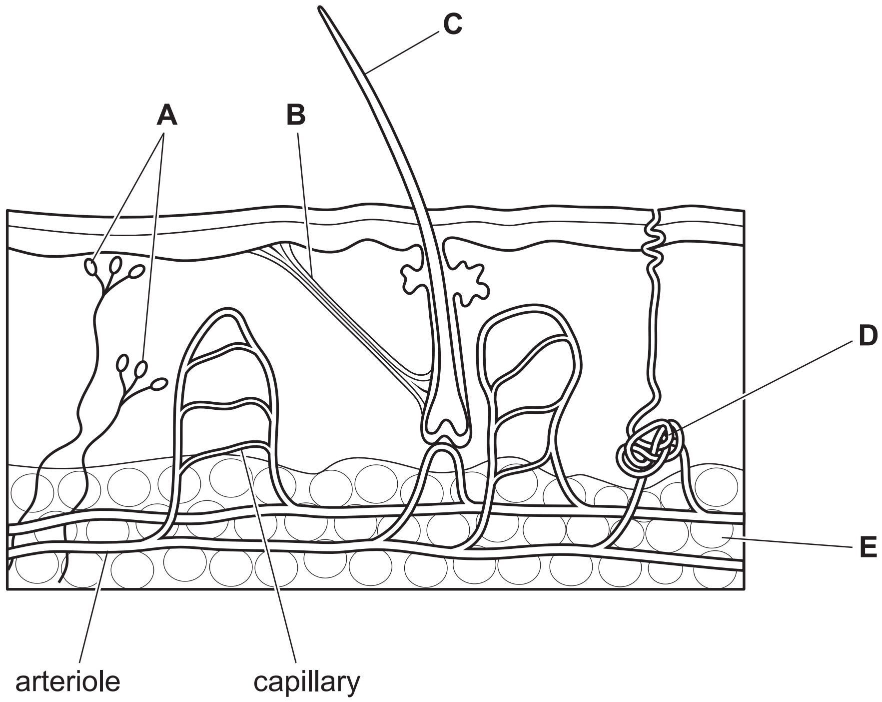

Fig. 1.1

(i) State the letter in Fig. 1.1 that identifies a part:

of the peripheral nervous system ....

that produces sweat ....

that requires energy for contraction. ....

[3]

(ii) Describe how the blood vessels labelled in Fig. 1.1 try to maintain a constant internal body temperature if internal body temperature **increases**.

....

....

....

....

....

....

.... [3]

(iii) State the term used to describe the homeostatic mechanism used to control internal body temperature.

.... [1]

(b) The control of glucose concentration in the blood is an example of homeostasis.

(i) State the name of the hormone that reduces the concentration of glucose in the blood.

.... [1]

(ii) State the type of organs that produce hormones.

.... [1]

(c) Stimuli cause the body to make responses.

(i) State the name of the organ that detects the change in temperature of the blood.

.... [1]

(ii) State the name of the characteristic of living organisms that describes the detection and response to stimuli.

.... [1]

[Total: 11]

2 **(a)** **(i)** Fig. 2.1 shows the three states of matter.

Complete the labels on Fig. 2.1.

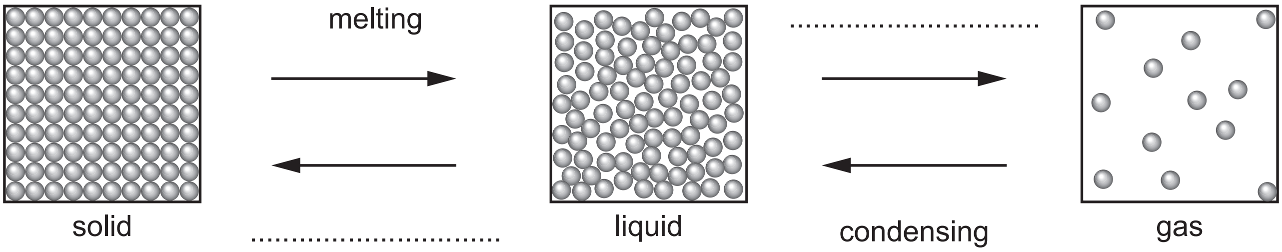

Fig. 2.1

[2]

(ii) Describe what happens to the kinetic energy of the particles in a gas when it is heated.

.... [1]

(b) A scientist analyses a food colouring **X**.

The scientist also analyses four dyes **A**, **B**, **C**, and **D**.

Fig. 2.2 shows the chromatogram produced.

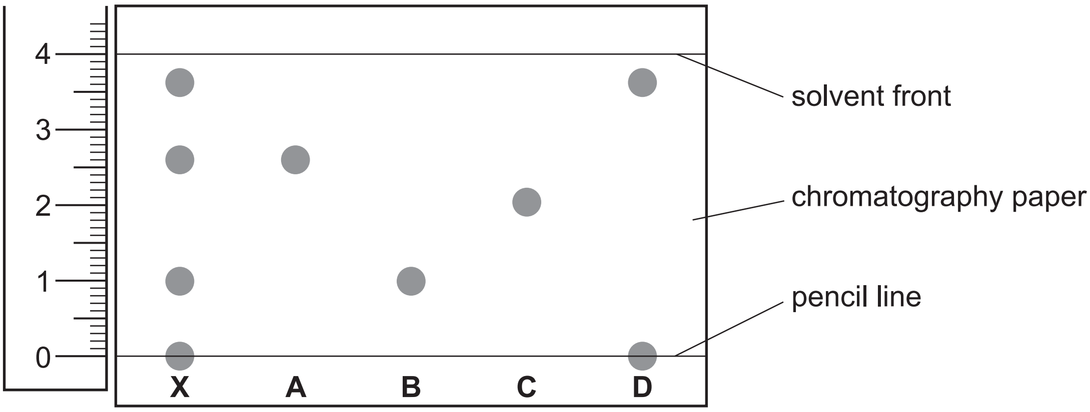

Fig. 2.2

(i) State why the start line is drawn using pencil instead of ink.

....

.... [1]

(ii) Identify which of the dyes, **A**, **B**, **C** and **D**, are in the food colouring **X**.

.... [2]

(iii) One of the substances in dye **D** remains on the pencil line.

Explain why.

.... [1]

(iv) Use Fig. 2.2 to calculate the R_f value for dye **A**.

R_f value = ... [2]

(c) Table 2.1 shows the melting points of tin, silver and the alloy solder.

Table 2.1

substance	melting point / °C
tin	232
silver	962
solder	220–229

Explain how the melting points show that solder is a mixture, but tin and silver are not.

....

....

.... [2]

[Total: 11]

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3 An Olympic triathlon event consists of a 1500 m swim, a 40 km cycle ride and a 10 km run.

(a) Fig. 3.1 shows an athlete swimming at a constant speed.

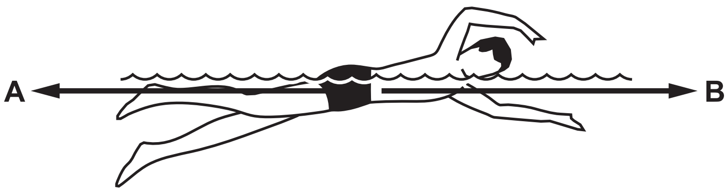

Fig. 3.1

(i) Describe how the size of force **A** compares with the size of force **B**.

....

.... [1]

(ii) The athlete has a weight of 750 N and moves with a kinetic energy of 13.5 J.

Calculate the speed of the athlete.

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

speed = ... m / s [2]

(b) Fig. 3.2 shows a speed–time graph for the start of the cycle ride.

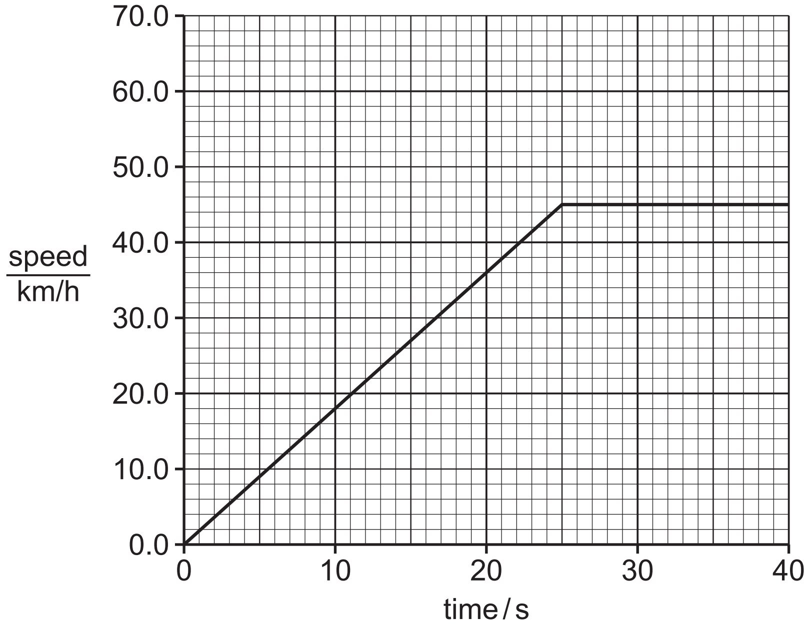

Fig. 3.2

(i) Show that the maximum speed of the athlete during the first 40 seconds of the cycle ride is 12.5 m/s.

[1]

(ii) Calculate the acceleration of the athlete during the first 25 seconds of the cycle ride.

Give your answer in m/s^2.

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

(iii) Calculate the distance covered by the athlete during the first 35 seconds of the cycle ride.

distance = ... m [2]

(iv) Fig. 3.3 shows the pedal of the bicycle as the athlete pedals.

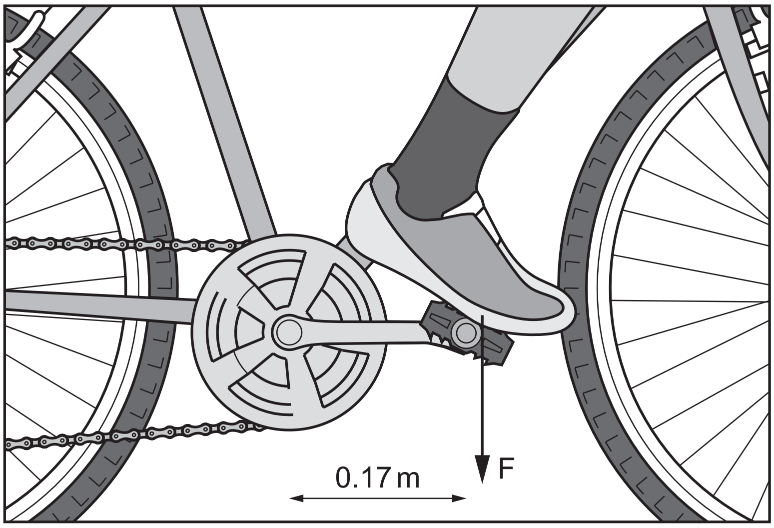

Fig. 3.3

The moment of the force applied by the athlete is 35.7 N m.

Use Fig. 3.3 to calculate the force exerted by the athlete on the pedal.

force = ... N [2]

(c) During the run, the athlete starts to sweat.

Explain, in terms of the motion and energy of water molecules, how sweating cools the athlete's skin.

....

....

....

....

....

.... [3]

[Total: 13]

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4 **(a)** Oxygen is one of the products of photosynthesis.

Complete the balanced symbol equation for photosynthesis.

$$\ldots\ldots\ldots\ldots + \ldots\ldots\ldots\ldots \xrightarrow[\text{chlorophyll}]{\text{light}} \ldots\ldots\ldots\ldots + 6O_2$$

[2]

(b) Complete the energy transfer that takes place using chlorophyll.

.... energy $\rightarrow$ .... energy [2]

(c) State the name of the cells in a leaf that contain the highest concentration of chlorophyll.

.... [1]

(d) A student investigates the effect of light intensity on the rate of photosynthesis.

Fig. 4.1 shows the apparatus she uses.

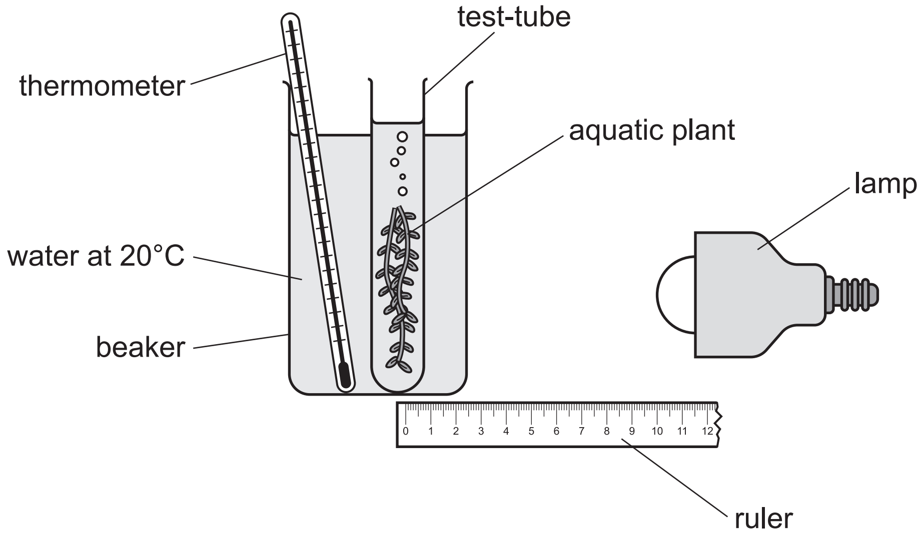

Fig. 4.1

The student:

- places the lamp at 10 cm from the aquatic plant
- counts the number of oxygen bubbles released in 2 minutes
- repeats this two more times and calculates a mean
- repeats the process with the lamp at different distances from the aquatic plant.

Table 4.1 shows the results.

The number of oxygen bubbles released indicates the rate of photosynthesis.

Table 4.1

distance of lamp from aquatic plant / cm	number of oxygen bubbles released in 2 minutes			
	test 1	test 2	test 3	mean
10	78	77	80	78
20	31	33	32	32
30	14	15	17	
40	5	6	5	5
50	5	5	5	5

(i) Calculate the mean number of oxygen bubbles released when the lamp is 30 cm from the aquatic plant.

Give your answer to the nearest whole number.

Write your answer in Table 4.1.

[2]

(ii) Describe the effect of light intensity on the rate of photosynthesis using the data in Table 4.1.

....

....

....

.... [2]

(iii) The aquatic plant releases less oxygen into the water than it produces during photosynthesis.

Suggest **one** reason for this difference.

....

.... [1]

[Total: 10]

5 **(a)** Fig. 5.1 shows a diagram of a lithium atom.

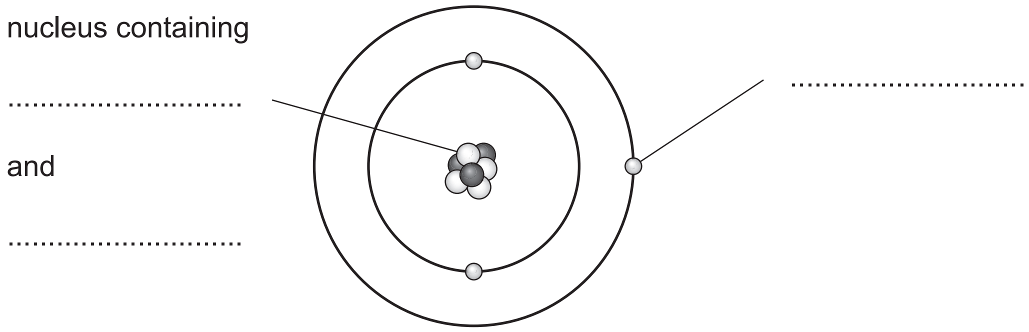

Fig. 5.1

(i) Complete the labels on Fig. 5.1. [3]

(ii) State the electronic structure of a lithium atom.

.... [1]

(b) **(i)** A lithium atom bonds with a chlorine atom by ionic bonding.

Fig. 5.2 shows the formation of a lithium ion, Li^+, from a lithium atom.

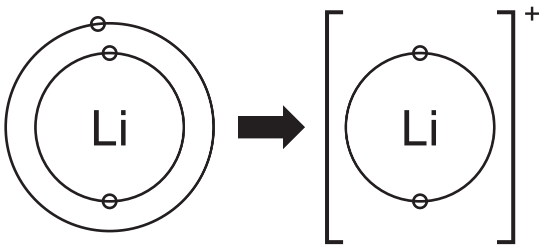

Fig. 5.2

Draw a similar diagram to show the formation of a chloride ion, Cl^-, from a chlorine atom.

[2]

(ii) Ionic compounds, such as lithium chloride, have a **lattice structure**.

Describe the lattice structure of ionic compounds.

You may include a labelled diagram if you wish.

....

....

.... [2]

(c) (i) Carbon has three naturally occurring isotopes: carbon-12, carbon-13 and carbon-14.

Complete Table 5.1 to show the numbers of protons, neutrons and electrons in an atom of each isotope.

Table 5.1

isotope	protons	neutrons	electrons
carbon-12	6	6	6
carbon-13	....	....	6
carbon-14	....	8	....

[2]

(ii) Explain, in terms of particles, why these isotopes have the same chemical properties.

....

.... [1]

[Total: 11]

6 Fig. 6.1 shows a boiler that uses combustion of natural gas to heat water.

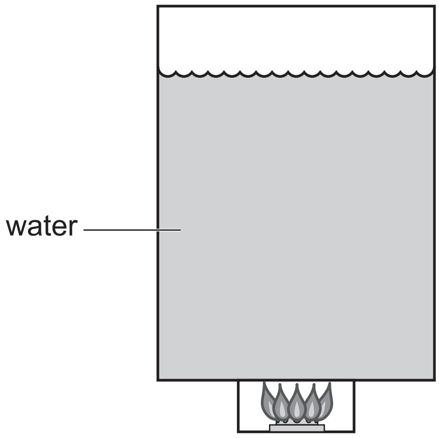

Fig. 6.1

(a) Natural gas is a non-renewable energy source.

Describe **one** environmental impact of using natural gas in this way.

....

.... [1]

(b) The boiler has an efficiency of 90%.

The combustion of natural gas provides an input energy of 1.50 kJ.

Calculate the useful energy output from the boiler.

useful energy output = ... kJ [2]

(c) Thermal energy is transferred through the water in the boiler by convection.

Describe the process of convection in terms of density changes.

....

....

....

.... [2]

(d) Light from the gas flame has a wavelength of 4.6×10^{-7} m.

(i) Calculate the frequency of the light from the flame.

frequency = ... Hz [3]

(ii) The light from the flame is a transverse wave.

Complete the sentences to describe the differences between a transverse wave and a longitudinal wave.

Transverse waves are produced by vibrations acting .... to the direction of energy transfer.

Longitudinal waves are produced by vibrations acting .... to the direction of energy transfer.

An example of a longitudinal wave is a .... wave.

[2]

[Total: 10]

7 (a) Fig. 7.1 is a diagram showing the development of a strain of antibiotic resistant bacteria.

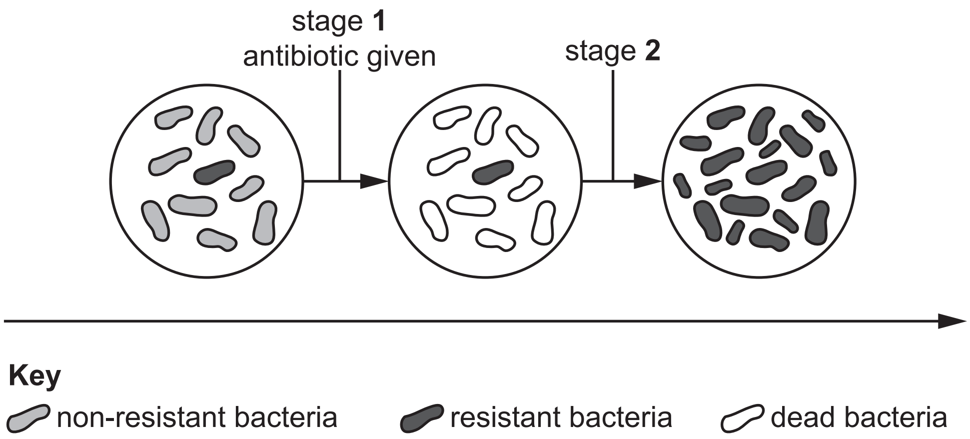

Fig. 7.1

(i) Describe what happens to the bacteria during stage **1** in Fig. 7.1.

....

....

.... [2]

(ii) Describe what happens to the bacteria during stage **2** in Fig. 7.1.

....

....

.... [2]

(iii) State the name of the process that results in antibiotic resistance shown in Fig. 7.1.

.... [1]

(b) Antibiotic resistance initially occurs due to a mutation.

Some chemicals can cause mutation.

(i) Define the term mutation.

....

.... [1]

(ii) State the type of radiation that increases the rate of mutation.

.... [1]

(c) Components of blood are responsible for protecting the body from disease-causing organisms including some strains of bacteria.

State the name of the component of blood responsible for:

antibody production ....

blood clotting. ....
[2]

[Total: 9]

8 A student investigates the rate of reaction between dilute hydrochloric acid, HCl, and magnesium, as shown in Fig. 8.1.

Magnesium chloride, $MgCl_2$, and hydrogen gas, H_2, are made.

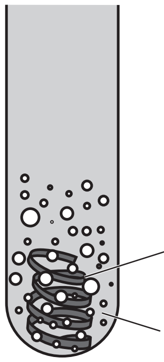

Fig. 8.1

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

.... [2]

(b) The student repeats the experiment with five different temperatures of the dilute hydrochloric acid.

The same volume and concentration of hydrochloric acid and the same mass of magnesium ribbon are used in each experiment.

She measures the time for the magnesium to completely react at each temperature.

Table 8.1 shows her results.

Table 8.1

temperature / °C	time / s
20	119
25	76
30	60
35	39
40	31

(i) The reaction gets faster as the temperature increases.

Explain how you can tell this from Table 8.1.

.... [1]

(ii) Tick (✓) **two** reasons in Table 8.2 which explain why reactions get faster as the temperature increases.

Table 8.2

reason	tick (✓)
particles are closer together	
particles collide more often	
particles have less energy	
particles have a larger surface area	
particles move faster	

[2]

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

Use the axes shown in Fig. 8.2 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.

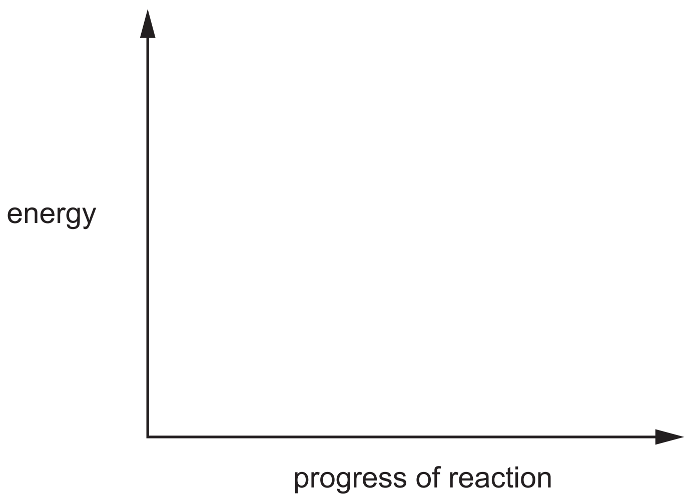

Fig. 8.2

[3]

(d) Zinc reacts with sulfuric acid, H_2SO_4, to make zinc sulfate, $ZnSO_4$, and hydrogen gas.

$$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$$

3.35 g of zinc reacts with excess dilute sulfuric acid to make 0.1 g of hydrogen gas.

Calculate the volume occupied by 0.1 g of hydrogen gas.

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

volume of hydrogen gas = ... dm^3 [3]

[Total: 11]

9 A student investigates how the resistance of a wire changes with length.

Fig. 9.1 shows the equipment she uses.

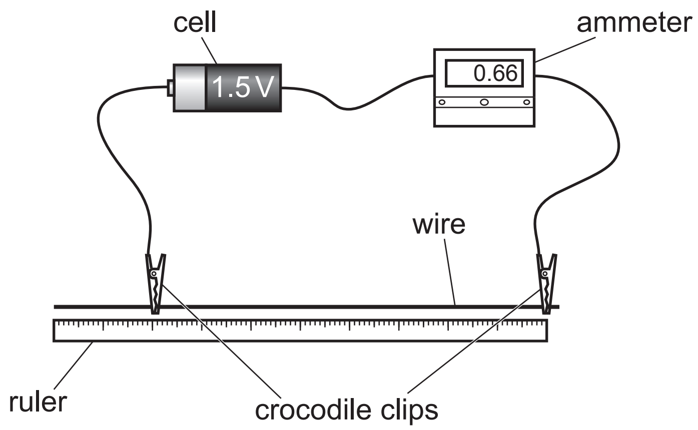

Fig. 9.1

(a) The student moves the crocodile clips to change the length of the wire.

She measures this length with the ruler and uses the ammeter reading to calculate the resistance of the wire.

When the wire is made longer, the reading on the ammeter decreases.

Explain why the reading on the ammeter decreases.

....

....

....

.... [2]

(b) Fig. 9.2 shows a length of wire connected in series with another component labelled **X**.

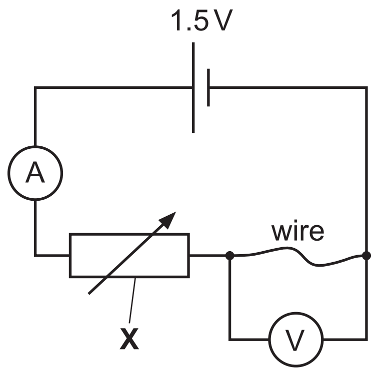

Fig. 9.2

(i) State the name of the component labelled **X** in Fig. 9.2.

.... [1]

(ii) The student uses the component labelled **X** to vary the potential difference across the length of wire.

The student records the potential difference across the wire and the current in the wire.

Fig. 9.3 shows her results.

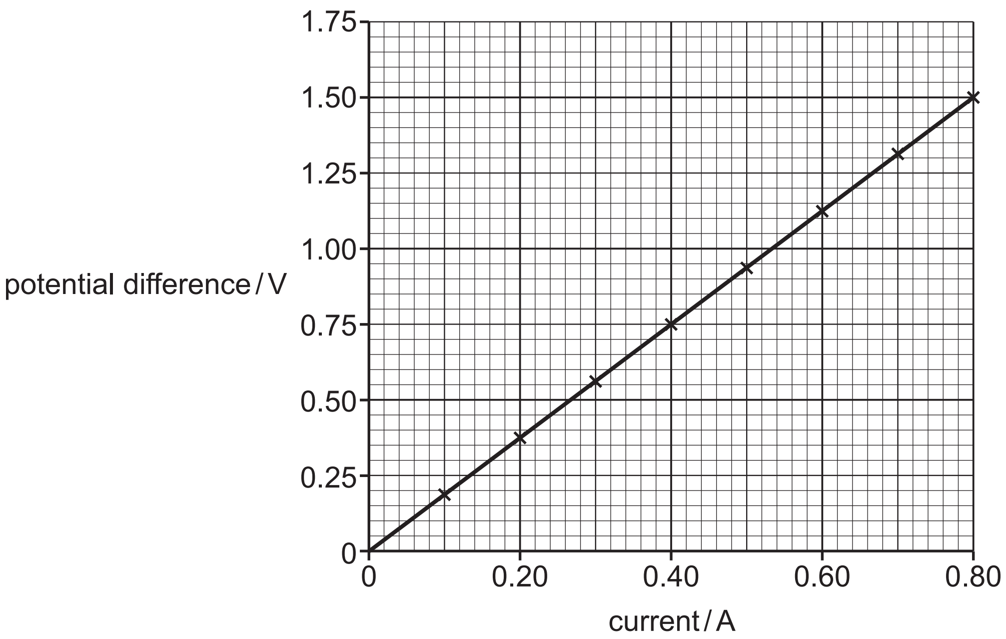

Fig. 9.3

Use Fig. 9.3 to determine the resistance of the wire.

resistance = ... Ω [2]

(c) The student chooses to use a maximum electromotive force (e.m.f.) of 1.5 V.

State the meaning of the term electromotive force (e.m.f.).

....

.... [2]

(d) On Fig. 9.4, draw the shape and direction of the magnetic field around the current-carrying wire.

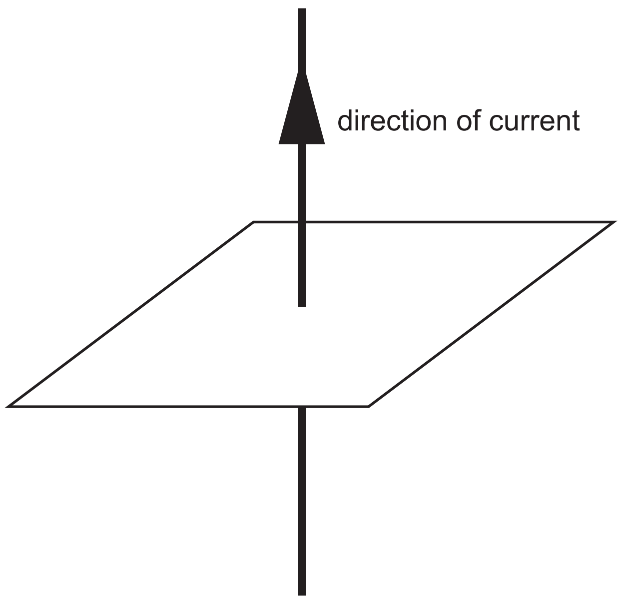

Fig. 9.4

[2]

[Total: 9]

10 Fig. 10.1 shows two red blood cells after they have been immersed in different solutions for an hour.

Cell **A** was immersed in a concentrated salt solution.

Cell **B** was immersed in blood plasma.

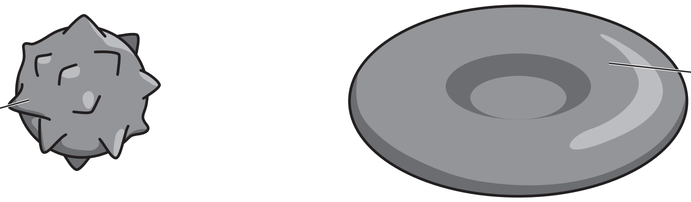

Fig. 10.1

(a) Complete the sentences to explain the appearance of cell **A** in Fig. 10.1.

The concentrated salt solution has a lower .... than cell **A**.

Water crosses the .... and leaves the cell by osmosis.

Water molecules move from a more .... solution to a more

.... solution.

[3]

(b) Immersion of cell **A** in concentrated salt solution changes the shape of the cell.

Suggest how this change in shape affects the function of red blood cells in the body.

....

....

....

.... [2]

(c) Concentration gradients affect the rate of osmosis.

Suggest two other factors that affect the rate of osmosis.

1 ....

2 ....

[2]

(d) Plant cells have additional cell structures that are not present in animal cells.

(i) State the names of two cell structures present in plant cells but **not** in animal cells.

1 ....

2 ....
[2]

(ii) State the name of the type of plant cell that is specialised for absorption of water.

.... [1]

[Total: 10]

11 Look at the structures of the carbon compounds shown in Fig. 11.1.

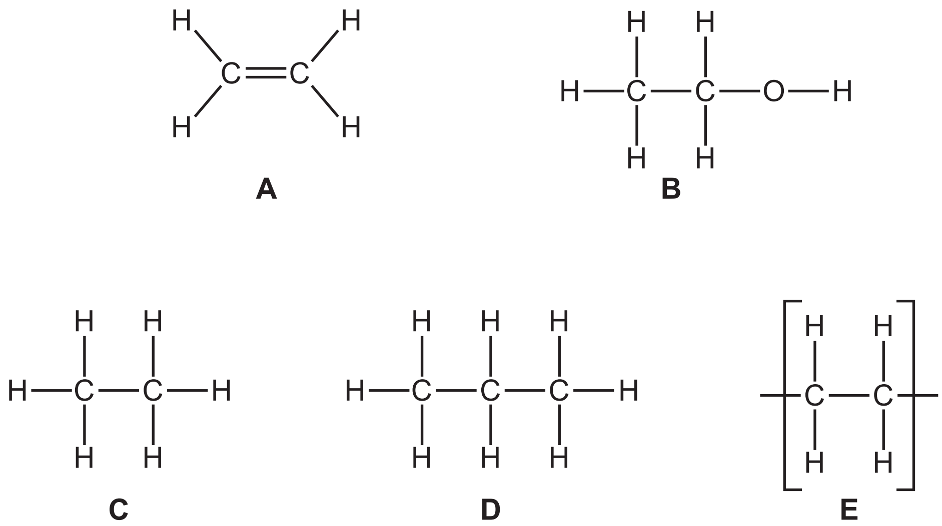

Fig. 11.1

(a) **(i)** State which compound is made by the catalytic addition of steam to compound **A**.

Choose from **B**, **C**, **D** or **E**.

.... [1]

(ii) State which compound is made when compound **A** reacts with hydrogen gas, H_2.

Choose from **B**, **C**, **D** or **E**.

.... [1]

(iii) State which compound reacts with bromine to form $C_2H_4Br_2$.

Choose from **A**, **B**, **C**, **D** or **E**.

.... [1]

(iv) State which compound forms compound **E** in an addition polymerisation reaction.

Choose from **A**, **B**, **C** or **D**.

.... [1]

(b) Fig. 11.2 represents the formation of the polymer nylon from two monomers, **X** and **Y**.

Nylon is made in a **condensation polymerisation** reaction.

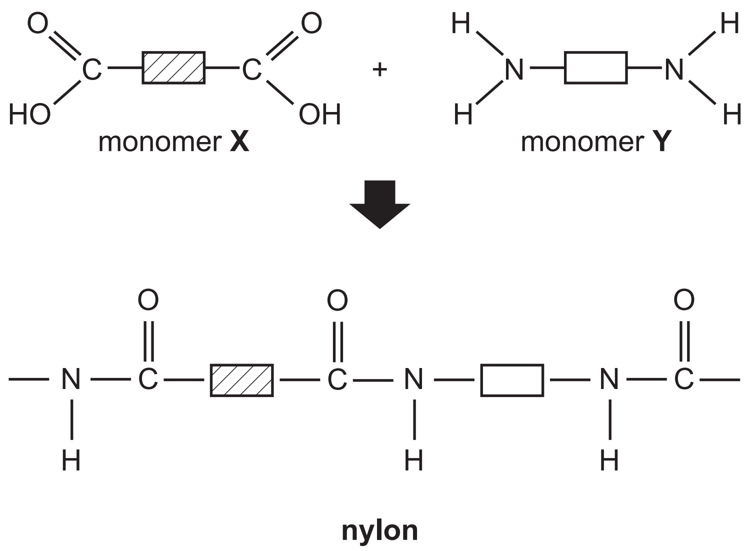

Fig. 11.2

Describe how monomer **X** and monomer **Y** react together to make nylon.

Use the information in Fig. 11.2 in your answer.

....

....

....

....

.... [3]

[Total: 7]

12 A student investigates the penetrating abilities of ionising radiation.

Fig. 12.1 shows the equipment used by the student.

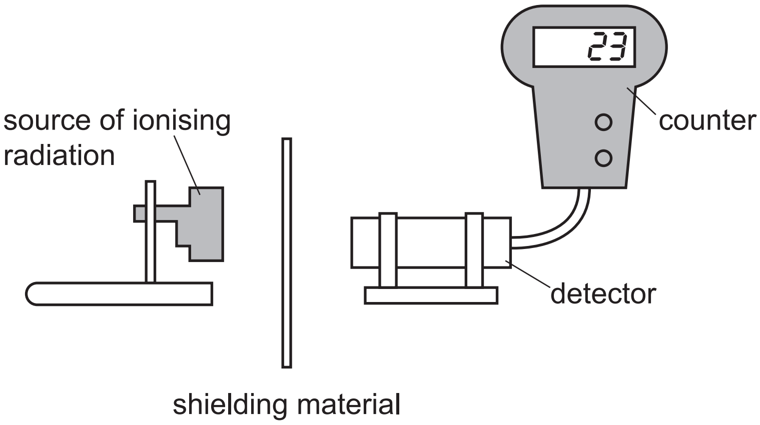

Fig. 12.1

(a) The student places different shielding materials between the source and the detector and uses the counter to record the number of counts in 1 minute.

Table 12.1 shows the student's results.

Table 12.1

shielding material	counts in 1 minute
no material (air only)	2560
paper	2555
thin aluminium	23
thick aluminium	24
thin lead	22
thick lead	17

(i) Use Table 12.1 to state **and** explain which type of ionising radiation is emitted by the source.

type of ionising radiation ....

explanation ....

....

....

....

.... [3]

(ii) The source used in Fig. 12.1 has a half-life of 29 years.

Calculate the time it will take for the activity of the source to drop to 12.5% of the original value.

time = ... years [2]

(b) The lead used in the student's investigation is a solid.

The melting point of lead is 327 °C. When lead melts, it turns from a solid into a liquid.

Describe the changes in the forces between particles when a solid melts.

....

.... [1]

(c) The density of liquid lead is 10.6 g / cm^3.

A sample of liquid lead has a mass of 37.1 g.

Calculate the volume of the sample of liquid lead.

volume = ... cm^3 [2]

[Total: 8]

The Periodic Table of Elements

Key

atomic number atomic symbol name relative atomic mass

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 –

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.).