

CANDIDATE  
NAME

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**CO-ORDINATED SCIENCES**

**0654/42**

Paper 4 (Extended)

**October/November 2017**

**2 hours**

Candidates answer on the Question Paper.

No Additional Materials are required.

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**READ THESE INSTRUCTIONS FIRST**

Write your Centre number, candidate number and name on all the work you hand in.

Write in dark blue or black pen.

You may use an HB pencil for any diagrams or graphs.

Do not use staples, paper clips, glue or correction fluid.

**DO NOT WRITE IN ANY BARCODES.**

Answer **all** questions.

Electronic calculators may be used.

You may lose marks if you do not show your working or if you do not use appropriate units.

A copy of the Periodic Table is printed on page 32.

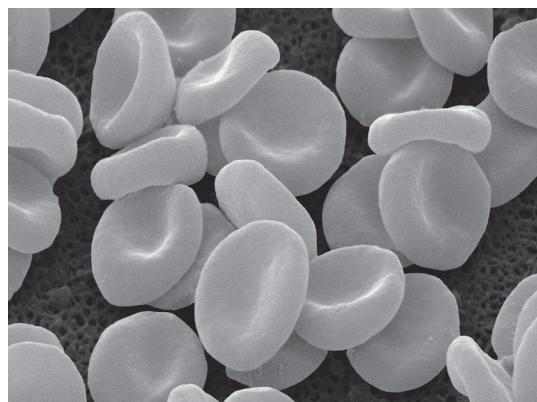
At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [ ] at the end of each question or part question.

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This document consists of **31** printed pages and **1** blank page.

- 1 Fig. 1.1 is a photograph of red blood cells in the human body taken with an electron microscope.



**Fig. 1.1**

- (a) (i) State the main role of red blood cells in the human body.

..... [1]

- (ii) Describe **one** way in which red blood cells are adapted for this role.

.....

..... [1]

- (b) Red blood cells are one of the components of blood.

Name **two other** main components of blood.

1 .....

2 .....

[1]

- (c) Fig. 1.2 shows a photograph of a normal red blood cell, and a red blood cell that has shrunk and changed shape.

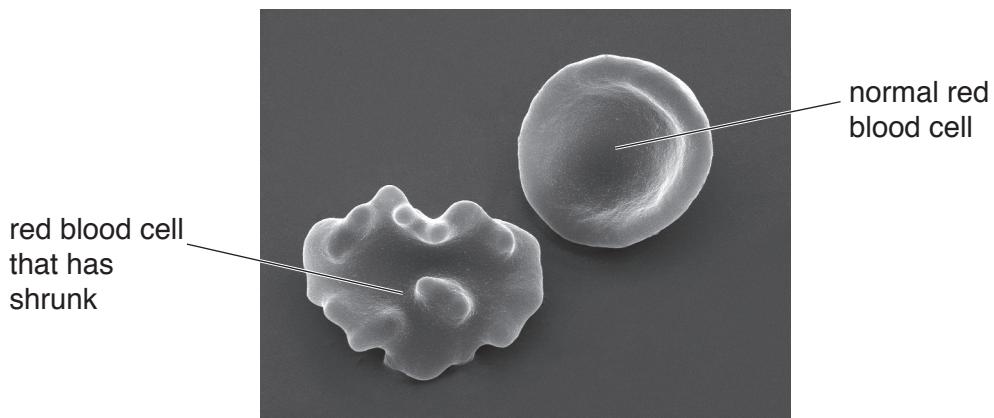


Fig. 1.2

- (i) Explain why isolated red blood cells shrink and change shape when placed in a concentrated salt solution.

.....  
.....  
.....  
.....  
.....

[3]

- (ii) Suggest **and** explain what would happen to the appearance of a normal red blood cell if it was placed in water.

.....  
.....  
.....

[2]

- 2 (a) The Periodic Table includes the five metals listed.

copper, Cu

iron, Fe

lithium, Li

potassium, K

sodium, Na

- (i) State which **three** of these metals are made of atoms that

have one electron in their outer shell,

..... and ..... and .....

are in the same period of the Periodic Table.

..... and ..... and .....

[2]

- (ii) Place the five metals in decreasing order of reactivity.

..... (most reactive)

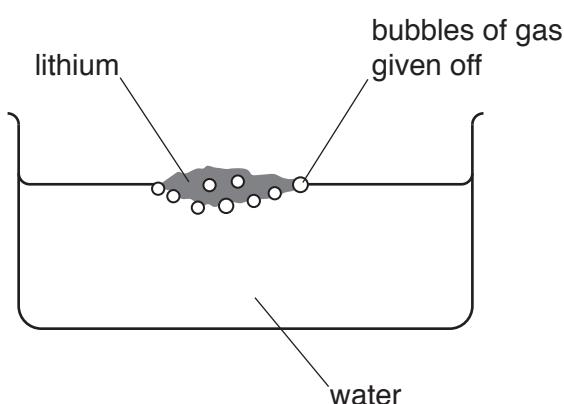
.....

.....

..... (least reactive)

[2]

- (b) Fig. 2.1 shows lithium reacting with water.



**Fig. 2.1**

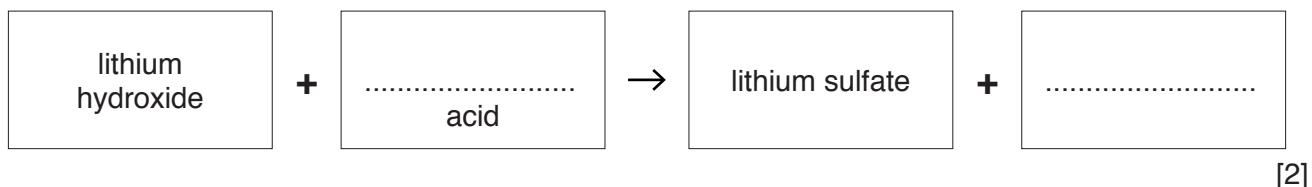
- (i) Name the gas given off in this reaction.

..... [1]

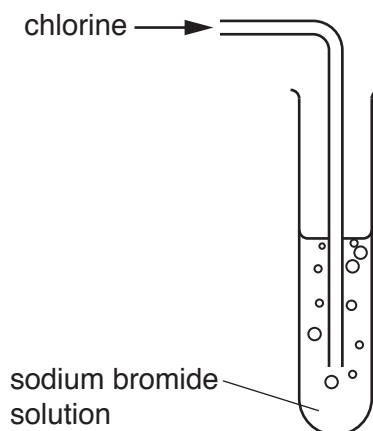
- (ii) This reaction also produces an alkaline solution of lithium hydroxide.

When lithium hydroxide is neutralised by an acid, the salt lithium sulfate is produced.

Complete the **word** equation for this neutralisation reaction.



- (c) Chlorine,  $Cl_2$ , reacts with sodium bromide solution, NaBr, to form bromine and sodium chloride as shown in Fig. 2.2.



**Fig. 2.2**

- (i) State the change in appearance when chlorine reacts with colourless sodium bromide solution.

..... [1]

- (ii) Construct the **balanced symbolic** equation for the reaction between chlorine and sodium bromide.

..... [2]

3 (a) A student is listening to music on her computer using headphones.

(i) State the useful energy transformation that happens in the headphones.

from ..... energy to ..... energy [1]

(ii) Fig. 3.1 shows the heat sink on a computer chip.

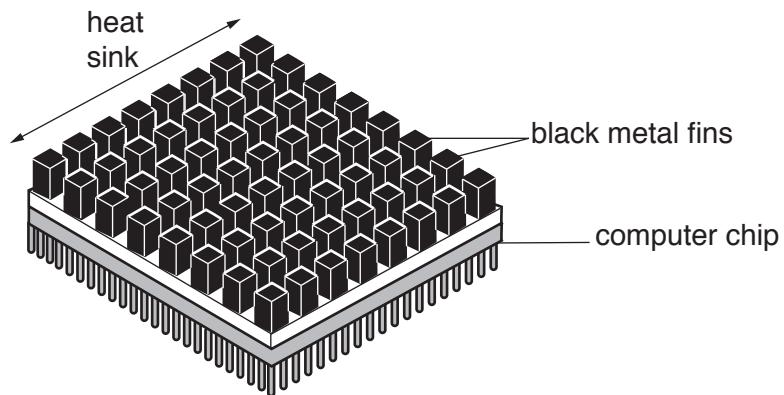


Fig. 3.1

The heat sink allows unwanted thermal energy to be transferred away from the chip.

Suggest **two** features of the heat sink that allow thermal energy to be transferred away from the chip.

Explain why each feature transfers thermal energy efficiently.

feature 1 .....

because .....

.....  
feature 2 .....

because .....

[2]

- (b) The student watches her teacher set up a radiation detector in the school science laboratory.

A sealed radioactive source, strontium-90, is placed on the bench next to the radiation detector.

Strontium-90 emits  $\beta$ -particles. A small count rate is measured.

- (i) When the teacher repeats the experiment a few minutes later, the count rate measured is slightly higher.

Suggest **one** reason for this.

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

- (ii) Strontium-90 decays by beta ( $\beta$ ) emission to produce an isotope of yttrium.

Use the correct nuclide notation to complete the symbol equation for this decay process.



[3]

- (c) The teacher asks the student to test one of the springs from a chair. Fig. 3.2 shows the chair.

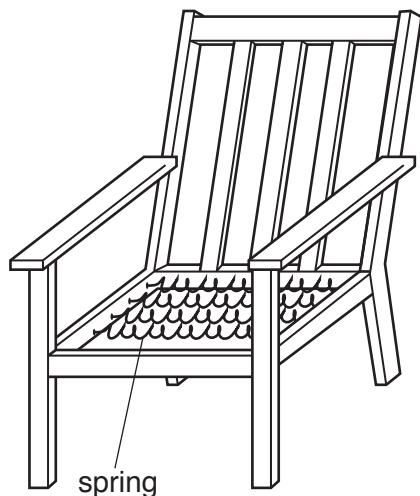


Fig. 3.2

The student measures the extension of the spring for different stretching forces.

She plots the graph shown in Fig. 3.3.

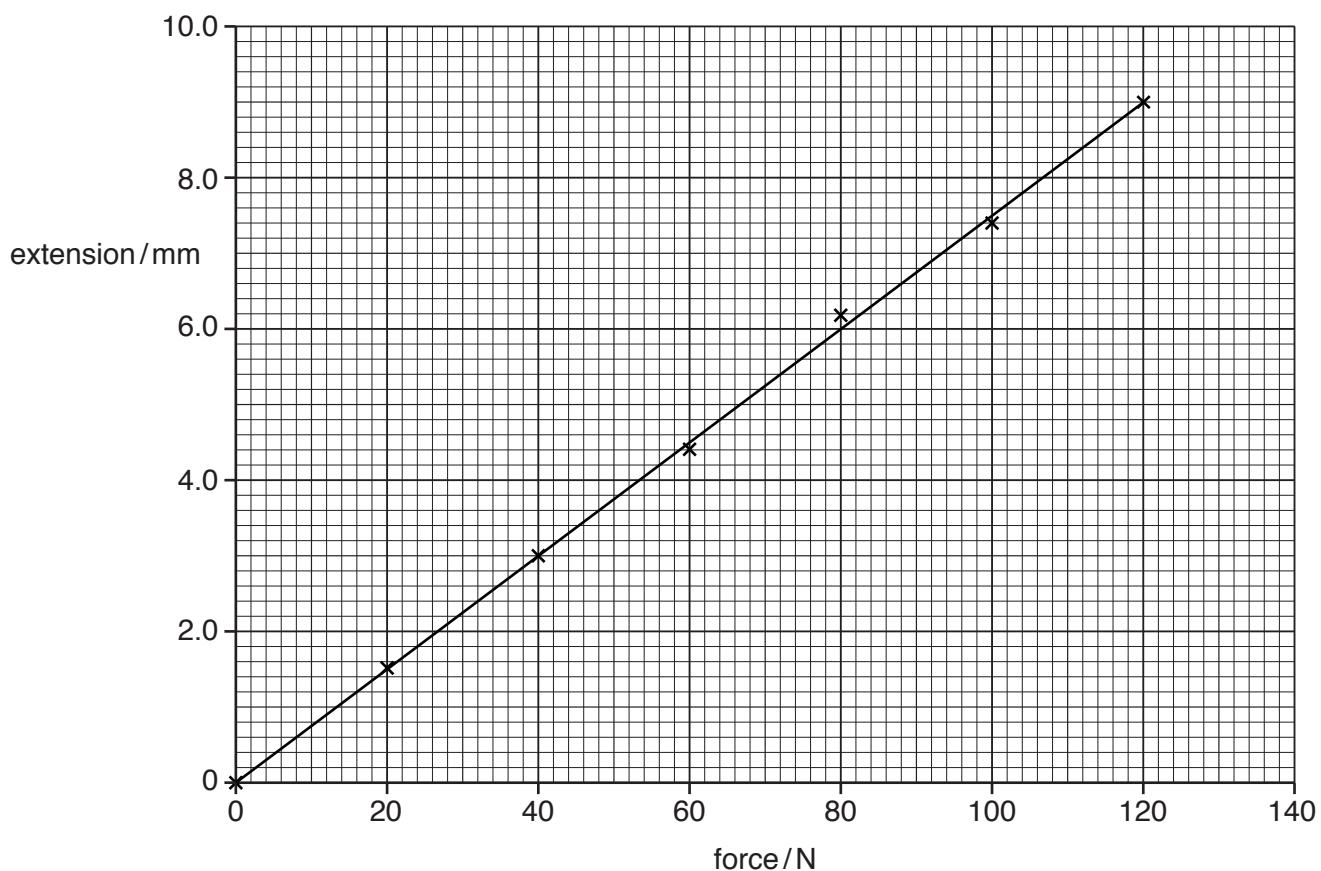


Fig. 3.3

- (i) The force changes the shape of the spring.

State **one other** effect that a force can have on a body.

..... [1]

- (ii) Use Fig. 3.3 to predict the force needed to give an extension of 10.0 mm.

..... N [1]

- (iii) State the assumption you have made to make your prediction in (ii).

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

- 4 MRSA is a bacterium that causes infection and has become resistant to many antibiotics.

Samples of MRSA bacteria are tested each year to see what percentage of the bacteria population is resistant to antibiotics.

The results are shown in Fig. 4.1.

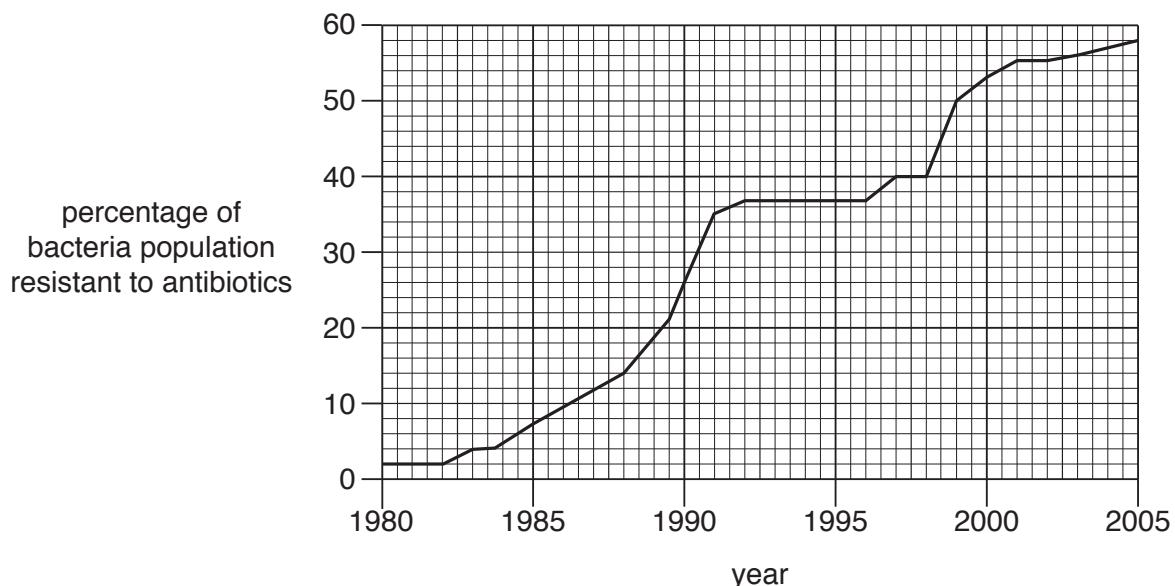


Fig. 4.1

- (a) Describe the results shown in Fig. 4.1.

.....  
.....  
.....

[2]

- (b) Antibiotic resistance first appeared in strains of bacteria due to a mutation.

Define the term *mutation*.

.....

[1]

- (c) Eventually, the majority of the population of MRSA bacteria will become resistant to antibiotics.

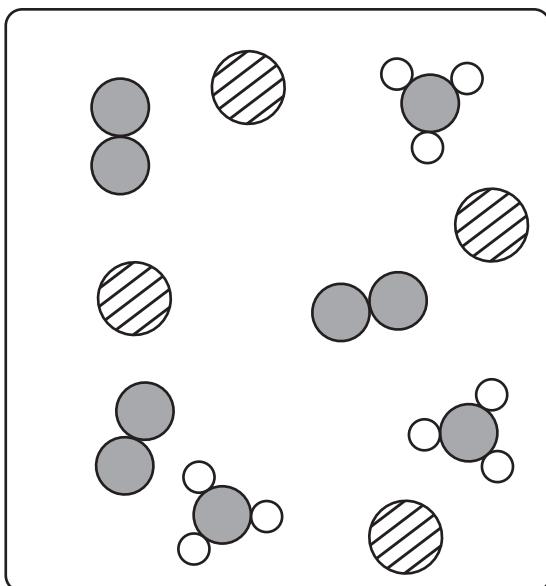
Explain how the majority of the population will become resistant to antibiotics.

.....  
.....  
.....  
.....  
.....

[3]

- 5 (a) Fig. 5.1 represents some particles in a mixture of gases.

Atoms of only three elements are shown.



**Fig. 5.1**

- (i) On Fig. 5.1, use a label line and the letter **L** to indicate a particle that could be of an element in Group VIII of the Periodic Table.

Explain your choice of particle.

.....

[1]

- (ii) On Fig. 5.1, use a label line and the letter **M** to indicate a molecule of a compound.

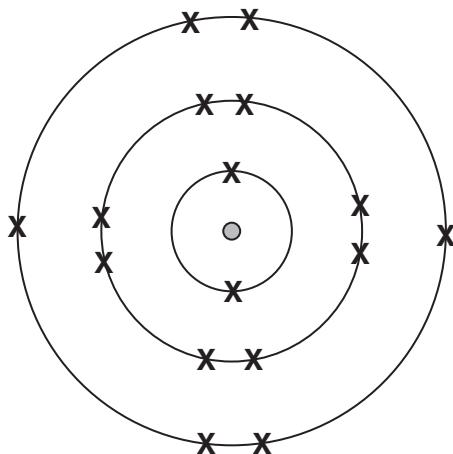
Explain your choice of particle.

.....

[1]

- (b) Sulfur reacts with magnesium to form the solid compound magnesium sulfide, MgS.

Fig. 5.2 shows the electronic structure of a sulfur atom.

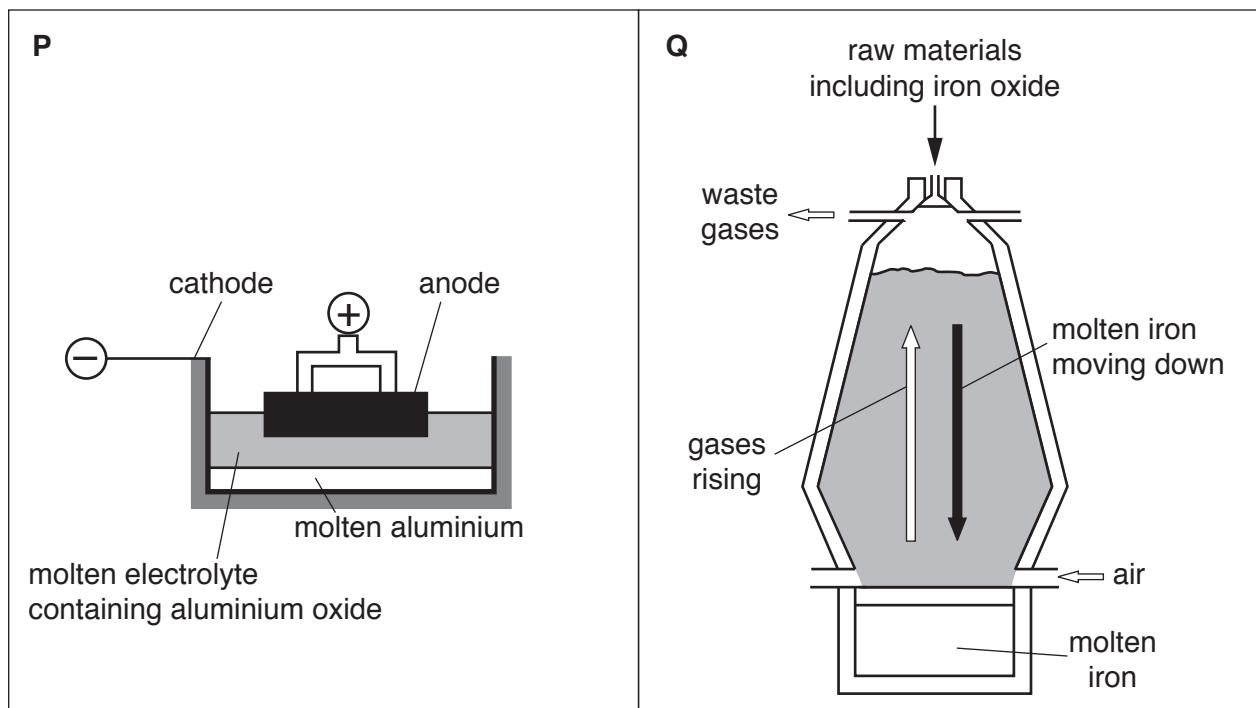


**Fig. 5.2**

Describe the formation of chemical bonds when magnesium reacts with sulfur to produce magnesium sulfide.

You may draw a diagram if it helps you to answer this question.

- (c) Fig. 5.3 shows two industrial processes, **P** and **Q**, that are used in the extraction of metals from their ores.



**Fig. 5.3**

- (i) Name process **P**.

..... [1]

- (ii) Describe how an aluminium ion,  $\text{Al}^{3+}$ , is reduced to form an aluminium atom in process **P**.

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

- (iii) In process **Q**, a redox reaction occurs between iron oxide and a gas.

Name this gas.

..... [1]

- 6 (a) Fig. 6.1 shows the information label found on the back of a microwave oven.

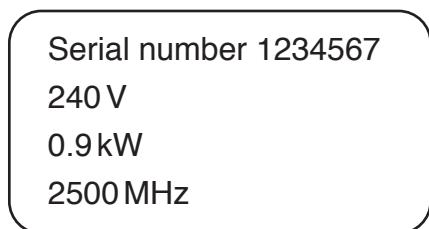


Fig. 6.1

- (i) State the frequency of the microwaves used in the oven.

.....

[1]

- (ii) State the power of the oven.

.....

[1]

- (b) Infra-red radiation may also be used to heat food.

State whether, compared with microwave radiation, infra-red radiation has a higher, lower or the same value of

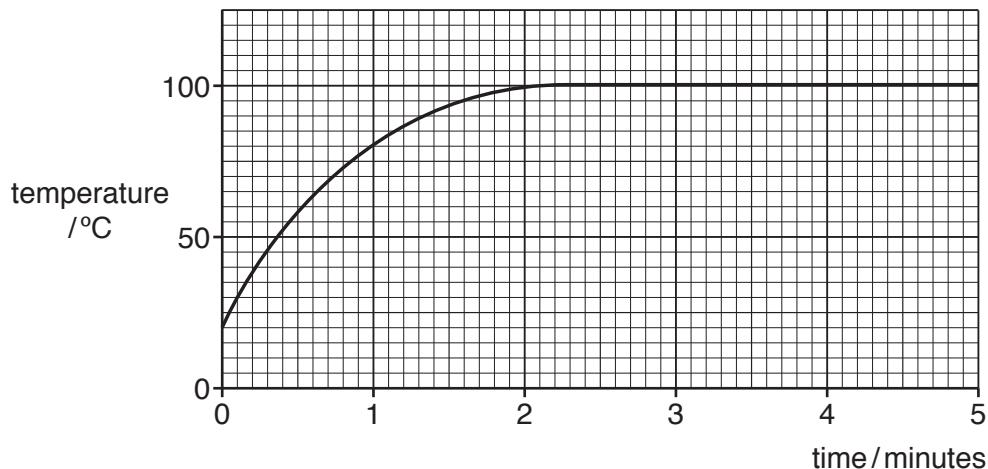
wavelength, .....

speed in a vacuum. ....

[1]

- (c) Some water is heated in the microwave oven for five minutes.

Fig. 6.2 shows how the temperature of the water changes with time.



**Fig. 6.2**

- (i) Describe what happens to the water molecules during the first two minutes.

.....  
.....

[1]

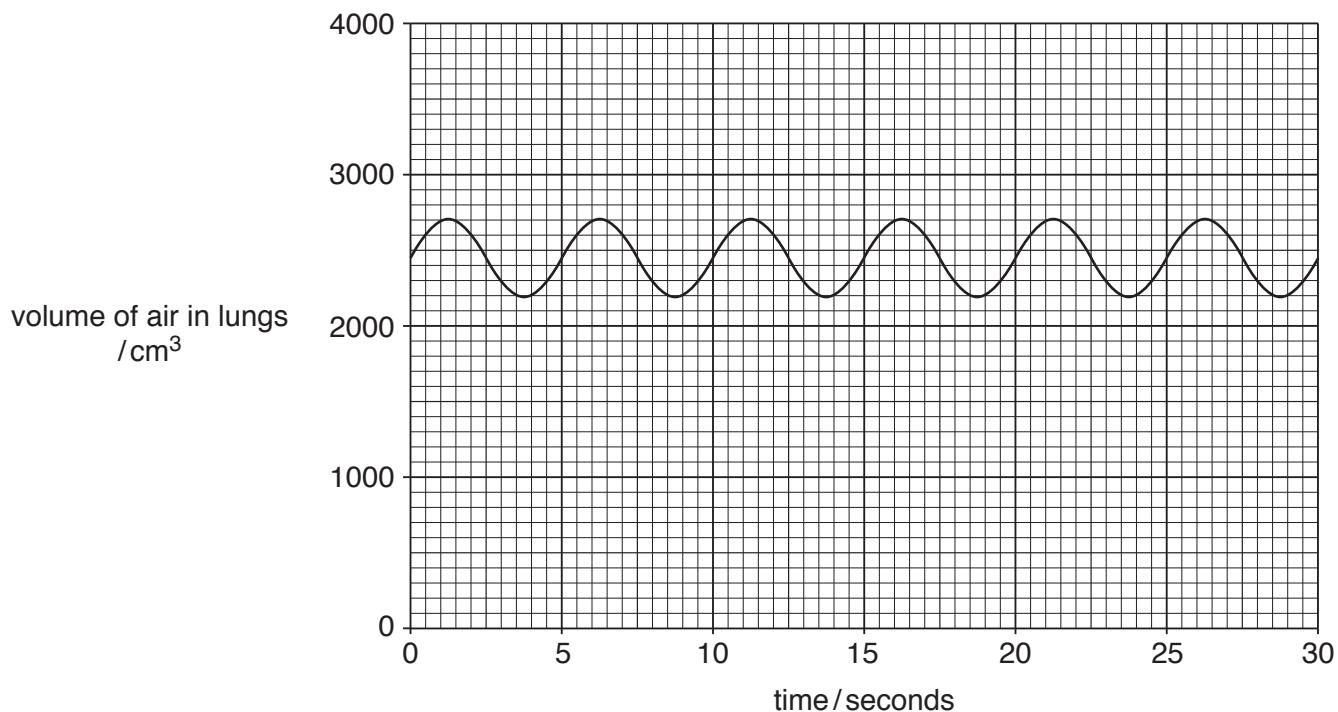
- (ii) Explain, in terms of molecules, why the temperature of the water remains unchanged between two and five minutes.

.....  
.....  
.....

[2]

- 7 The breathing rate of a student at rest is measured by measuring the volume of air in the lungs during inhalation and exhalation.

The results are shown in Fig. 7.1.



**Fig. 7.1**

- (a) The breathing rate of the student was measured again during intense exercise.

Describe how the graph line differs during intense exercise.

.....  
.....  
.....

[2]

- (b) Describe **and** explain the difference in breathing between rest and intense exercise.
- .....  
.....  
.....

[2]

- (c) Describe **and** explain why the student's pulse rate changes during intense exercise.
- .....  
.....  
.....

[2]

- (d) After some time of intense exercise the student develops pain, called cramp, in the leg muscles.

- (i) Describe what happens to cause cramp.

.....  
.....  
.....

[2]

- (ii) Explain why the student's breathing does **not** return to normal immediately after intense exercise.

.....  
.....

[1]

- 8 (a) For each compound shown, predict whether it reacts with water to produce an acidic, an alkaline or a neutral solution.

potassium oxide,  $K_2O$  .....

calcium oxide,  $CaO$  .....

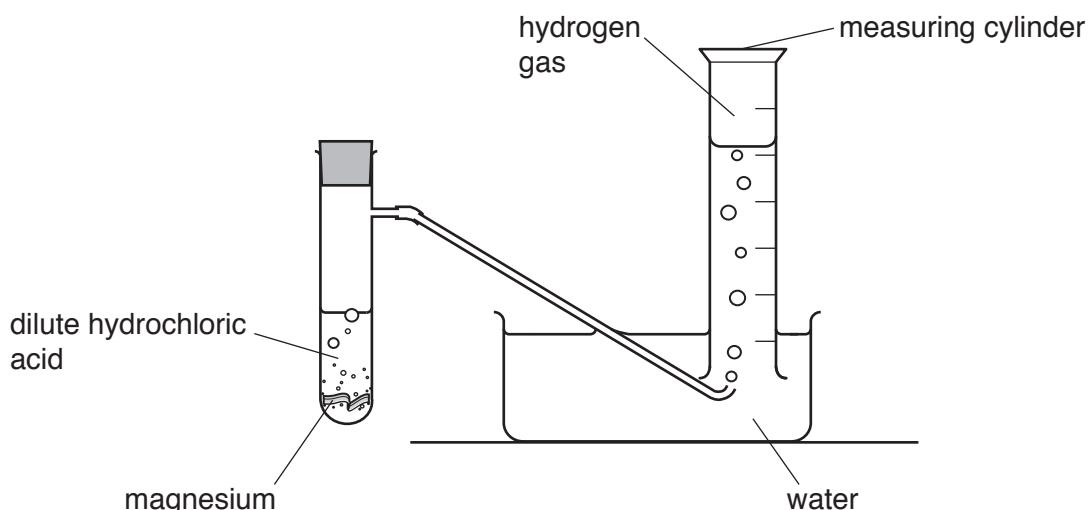
carbon dioxide,  $CO_2$  .....

nitrogen dioxide,  $NO_2$  .....

[2]

- (b) When magnesium reacts with **excess** dilute hydrochloric acid, hydrogen gas is produced.

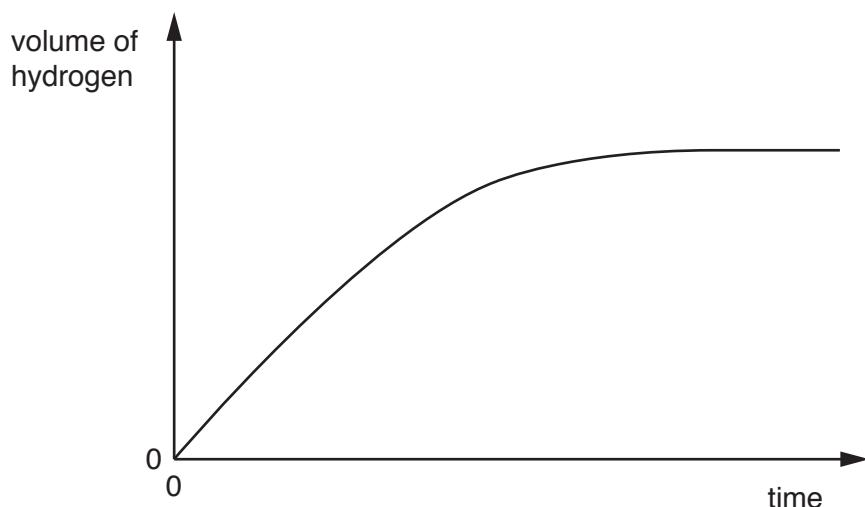
Fig. 8.1 shows apparatus a student uses to investigate this reaction.



**Fig. 8.1**

She measures the volume of gas in the measuring cylinder at regular intervals after the start of the reaction.

A sketch graph of her results is shown in Fig. 8.2.



**Fig. 8.2**

- (i) Predict how the concentration of the hydrochloric acid changes, if at all, during the reaction.

..... [1]

- (ii) Describe **and** explain the shape of the graph in Fig. 8.2 in terms of the rate of reaction.

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

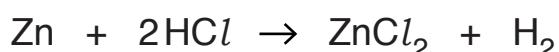
- (iii) The student repeats the experiment.

She uses hydrochloric acid that has a **higher** concentration.

She keeps all of the other variables the same.

On Fig. 8.2, sketch a graph to show the results that the student obtains from her second experiment. [2]

- (c) The balanced equation for the reaction between zinc and dilute hydrochloric acid is shown.



Complete the steps in the calculation to find the volume of hydrogen gas that is produced when 2.6 g of zinc reacts completely in excess dilute hydrochloric acid.

Show your working.

**Step 1**

Calculate the number of moles in 2.6 g of zinc.

[ $A_r$ : Zn = 65]

number of moles = .....

**Step 2**

State the number of moles of hydrogen gas produced.

number of moles = .....

**Step 3**

Calculate the volume, **in cm<sup>3</sup>**, of hydrogen gas produced.

[molar gas volume = 24 dm<sup>3</sup>]

volume = ..... cm<sup>3</sup>  
[4]

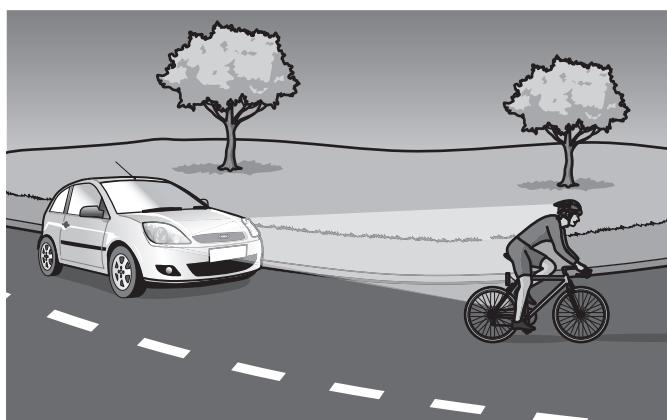
- 9 (a) A boy riding his bicycle is cooled by sweating.

Describe, in terms of molecules, how sweating cools his body by evaporation.

.....  
 .....  
 .....  
 .....

[3]

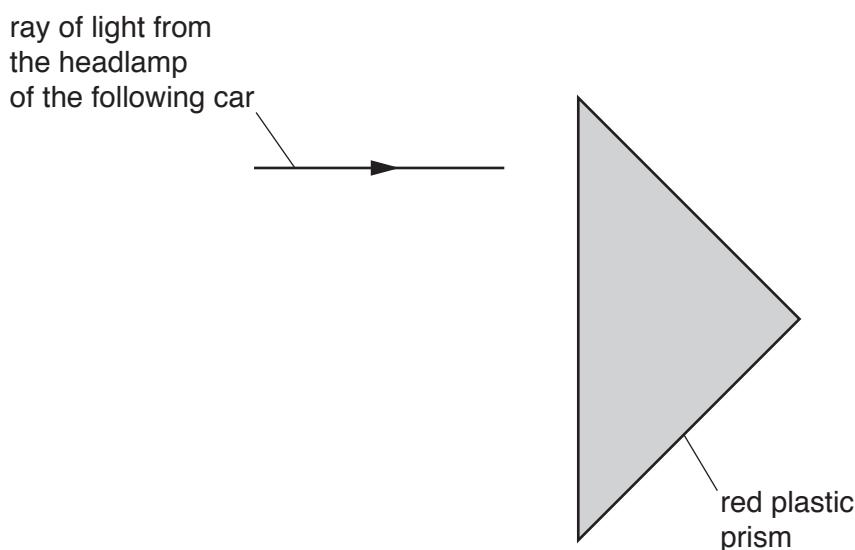
- (b) Fig. 9.1 shows a car behind a bicycle at night.



**Fig. 9.1**

A reflector on the back of the bicycle is made from many small red plastic prisms, one of which is shown in Fig. 9.2.

A ray of light from the headlamp of the car enters the prism.



**Fig. 9.2**

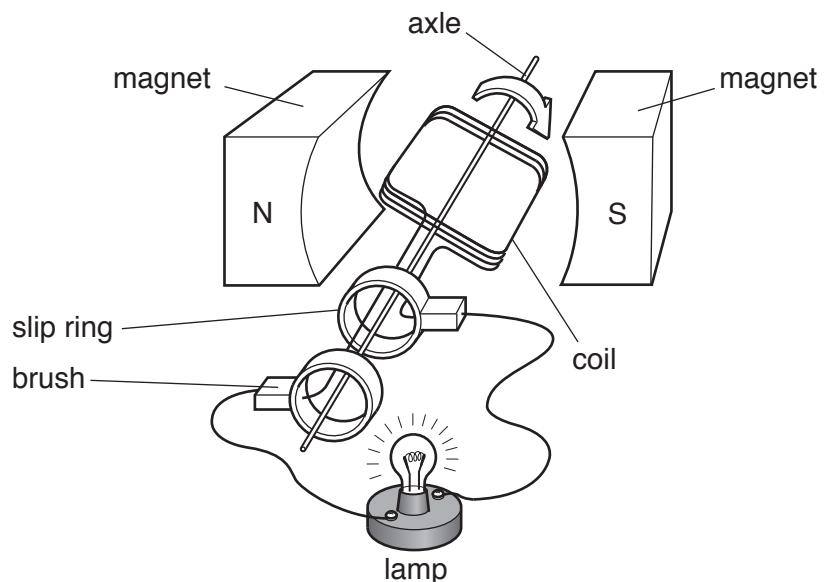
Total internal reflection occurs within the prism.

On Fig. 9.2, complete the path taken by the ray of light until it emerges from the prism. [2]

- (c) The bicycle has a lamp powered by a small generator.

The generator turns as the boy pedals and the lamp lights up.

Fig. 9.3 shows a simple version of the generator.



**Fig. 9.3**

Describe how the rotating coil causes the lamp to light.

.....

.....

.....

.....

.....

.....

[3]

- (d) The generator produces an alternating voltage.

Fig. 9.4 shows how the output voltage of the bicycle generator changes with time.

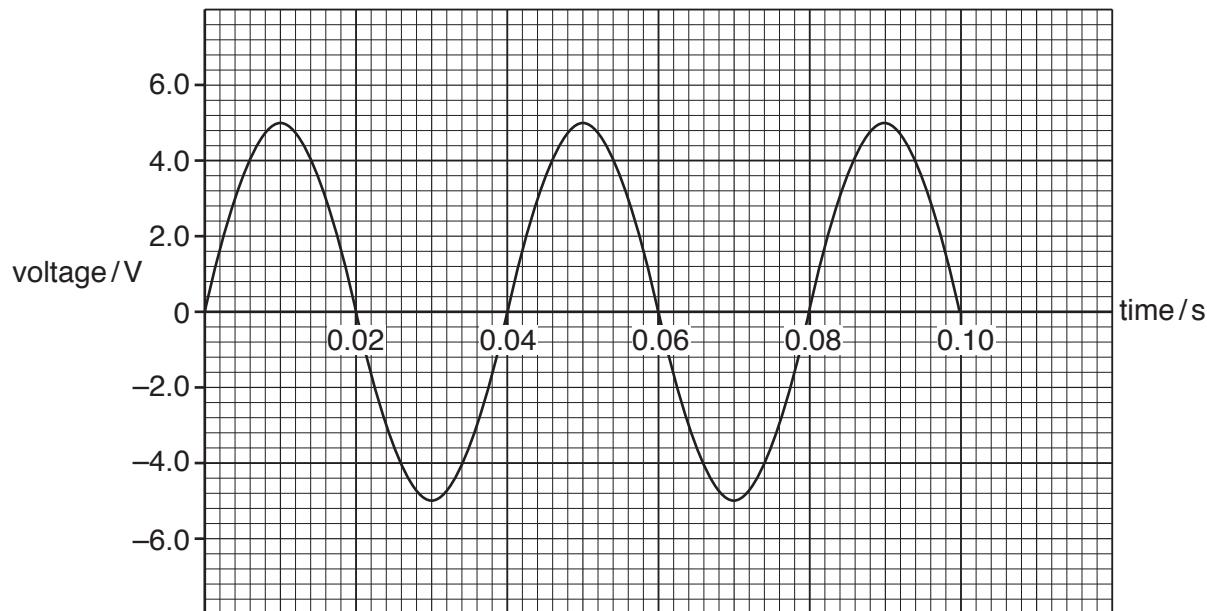


Fig. 9.4

- (i) Calculate the frequency of the alternating voltage.

Show your working.

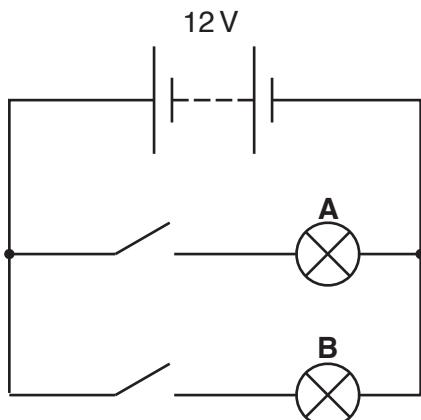
$$\text{frequency} = \dots \text{Hz} [1]$$

- (ii) State the amplitude of the alternating voltage.

$$\text{amplitude} = \dots \text{V} [1]$$

- (e) A different bicycle has a front lamp, **A**, and a rear lamp, **B**, powered by the same battery.

Fig. 9.5 shows how the lamps are connected.



**Fig. 9.5**

- (i) State the name given to this arrangement of lamps in a circuit.

..... [1]

- (ii) Lamp **A** has a resistance of  $5\Omega$ .

The battery has a voltage of 12V.

Calculate the current flowing through lamp **A** when the switch is closed.

State the formula you use and show your working.

formula

working

current = ..... A [2]

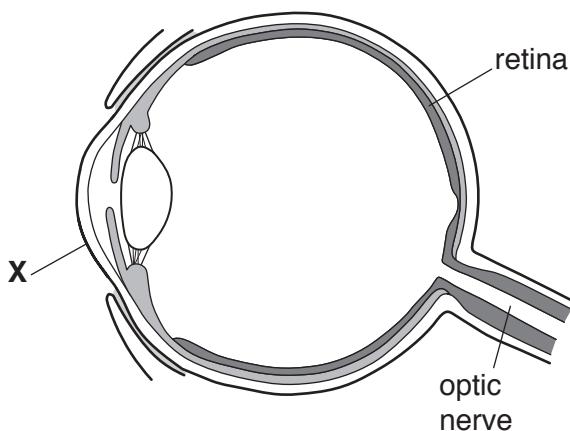
- (iii) Lamp **B** has a resistance of  $10\Omega$ .

Calculate the combined resistance of the two lamps in this circuit.

Show your working.

resistance = .....  $\Omega$  [2]

- 10 Fig. 10.1 is a diagram of a human eye.



**Fig. 10.1**

- (a) (i) Name the part labelled X on Fig. 10.1.

..... [1]

- (ii) Draw a label line to identify the iris on Fig. 10.1.

Label this C. [1]

- (b) The pupil response to light is an example of a reflex action.

- (i) Describe the changes that happen in the eye when a person goes from dark to light conditions.

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

- (ii) Explain why the pupil response is described as a reflex action.

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

- (iii) Identify the following parts which are involved during the pupil reflex of the eye.

receptor .....

coordinator .....

[2]

- (c) The pupil reflex is an example of nervous control.

Table 10.1 compares hormonal and nervous control systems in the body.

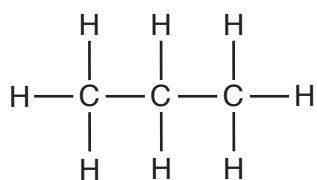
Complete Table 10.1 to show the differences between hormonal control and nervous control.

**Table 10.1**

feature	hormonal control	nervous control
method of transmission around the body	.....	along neurones
speed of transmission around the body	.....	.....
length of effect	.....	.....

[3]

- 11 (a) Fig. 11.1 shows the structure of a molecule of an alkane.



**Fig. 11.1**

- (i) Name this alkane.

..... [1]

- (ii) Complete Fig. 11.2 to show the structure of a molecule of the **alkene** that contains only three carbon atoms.



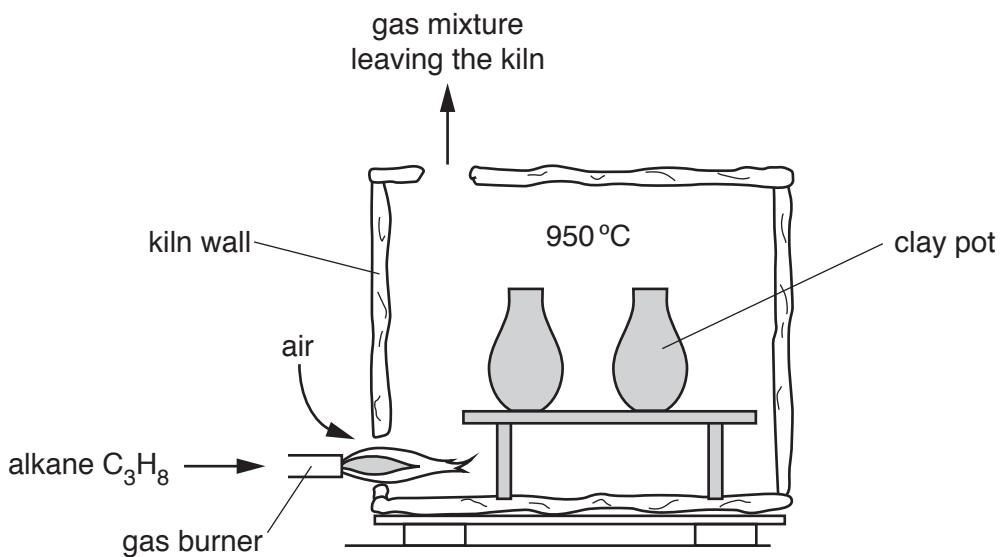
**Fig. 11.2**

[2]

- (b) Fig. 11.3 shows clay pots being heated strongly in a kiln.

The alkane,  $\text{C}_3\text{H}_8$ , is supplied to the gas burner.

Hot gases circulate through the kiln, heating the clay pots and then leaving through the top of the kiln.



**Fig. 11.3**

- (i) Explain why the gas mixture leaving the kiln contains nitrogen and argon.

.....  
.....  
.....

[2]

- (ii) State **two** gases that are produced by the combustion of  $\text{C}_3\text{H}_8$ .

1 .....

2 .....

[1]

- (c) Sometimes clay pots are covered with a glaze before they go into the kiln.

Glaze is a mixture of solid compounds that melt at high temperatures. It forms a coloured, shiny layer on the pots as they cool.

Four compounds found in a glaze are listed.

calcium carbonate,  $\text{CaCO}_3$

cobalt oxide,  $\text{CoO}$

copper oxide,  $\text{CuO}$

silicon dioxide,  $\text{SiO}_2$

- (i) Predict which **two** compounds produce colours in the glaze layer.

Explain your prediction.

compounds ..... and .....

explanation .....

[2]

- (ii) Explain, in terms of its structure, why silicon dioxide has a high melting point.

.....  
.....  
.....

[2]

- 12 (a) During car journeys, a car will often become electrostatically charged.

On a warm dry day, the potential difference between the driver and the car increases to 12000 V.

- (i) Explain what happens to cause the car to become charged.

.....  
.....  
.....

[2]

- (ii) The driver touches the car door and receives an electric shock.

0.030 J of energy is transferred between the driver and the car. The discharge current lasts for 0.36 milliseconds. The discharge current is the current which flows through the driver.

Calculate the power of the discharge.

State the formula you use and show your working.

formula

working

power = ..... W [2]

- (iii) Calculate the discharge current.

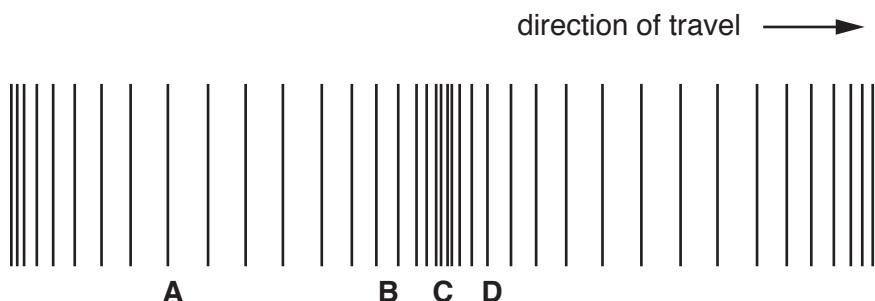
State the formula you use and show your working.

formula

working

current = ..... A [2]

- (b) Fig. 12.1 shows a sound wave travelling through the air from the car radio to the driver.



**Fig. 12.1**

Choose from the letters **A** to **D** to complete the sentences.

A compression in this sound wave is shown by letter .....

A rarefaction in this sound wave is shown by letter .....

[1]

- (c) Car wheels are usually made from steel. Some cars have aluminium alloy wheels.

Suggest a simple way to show that a wheel is **not** made from steel.

Explain your answer.

.....  
.....

[1]

- (d) The driver of the car thinks that he is travelling at 8 m/s.

He is unsure whether this is his speed or his velocity.

Describe the difference between the terms *speed* and *velocity*.

.....  
.....  
.....

[1]

- 13 Fig. 13.1 is a simplified diagram of the carbon cycle.

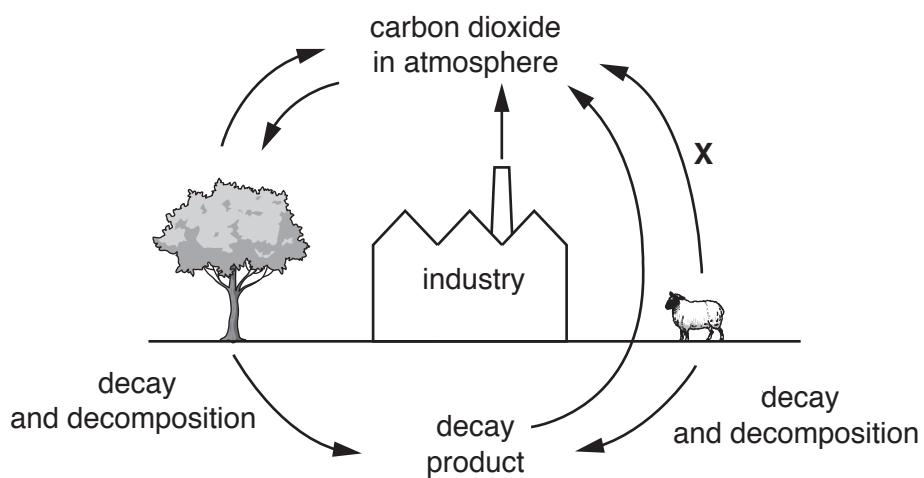


Fig. 13.1

- (a) Identify the process that takes place at X.

..... [1]

- (b) Name the type of organism that gets its energy from decaying matter.

..... [1]

- (c) Combustion of fossil fuels increases the carbon dioxide concentration in the atmosphere.

Explain how an increase in atmospheric carbon dioxide leads to global warming.

.....  
.....  
.....  
.....  
..... [3]

- (d) Deforestation prevents the removal of carbon dioxide from the atmosphere.

List **two other** effects of deforestation.

1 ..... [1]

2 ..... [1]

[2]



**The Periodic Table of Elements**

I		II		Group														
				1						2								
				Key														
3	Li	4	Be	atomic number name relative atomic mass	1	H hydrogen 1	B	C	N	O	F	Ne neon 20	He helium 4	10				
11	Na	12	Mg				boron 11	carbon 12	nitrogen 14	oxygen 16	fluorine 19							
19	K	20	Ca	21	Ti	V vanadium 51	Cr chromium 52	Mn manganese 55	Fe iron 56	Co cobalt 59	Ni nickel 59	Cu copper 64	Zn zinc 65	Ga gallium 70	30	31		
37	Rb	38	Sr	39	Y	Zr zirconium 91	Nb niobium 93	Mo molybdenum 96	Tc technetium –	Ru ruthenium 101	Rh rhodium 103	Pd palladium 106	Ag silver 108	Cd cadmium 112	In indium 115	Ge germanium 73	32	33
55	Cs	56	Ba	57–71	Hf hafnium 178	Ta tantalum 181	W tungsten 184	Re rhenium 186	Os osmium 190	Ir iridium 192	Pt platinum 195	Au gold 197	Hg mercury 201	Tl thallium 204	Sb antimony 119	51	52	
87	Fr	88	Ra	89–103	Rf actinoids –	Df rutherfordium –	Db dubnium –	Sg seaborgium –	Mt meitnerium –	Ds darmstadtium –	Rg roentgenium –	Cn copernicium –	Pb bismuth 209	Bi bismuth 207	Te tellurium 128	53	54	
															I iodine 127	Xe xenon 131		
																Rn radon –		

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	Pu plutonium –	94	Np neptunium –	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  $24\text{ dm}^3$  at room temperature and pressure (r.t.p.).