Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

CO-ORDINATED SCIENCES **0654/31**

Paper 3 (Extended) **October/November 2016**

2 hours

Candidates answer on the Question Paper.

No Additional Materials are required.

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.

1 Scientists can estimate the concentration of carbon dioxide in the Earth's atmosphere in past centuries. They drill into the thick ice near the poles to remove samples of ice that contain trapped air.

The ice is thousands of years old, with the oldest ice at the deepest levels. They sample at different levels and measure the concentration of carbon dioxide in the trapped air.

(a) Table 1.1 shows some results.

Table 1.1

year	carbon dioxide concentration /%
1000	0.0280
1200	0.0275
1400	0.0280
1600	0.0270
1800	0.0280
2000	0.0345

(i) In the year 2000, the carbon dioxide concentration in the trapped air was 0.0345%.

State the **two** gases that make up most of the rest of the atmosphere.

1 .....

2 .....

[2]

(ii) Using the information in Table 1.1, describe how the carbon dioxide concentration in the Earth's atmosphere changed between the year 1000 and the year 2000.

.....

.....

.....

.....[3]

(b) Name a **biological** process that

(i) releases carbon dioxide into the atmosphere,

.....[1]

(ii) removes carbon dioxide from the atmosphere.

.....[1]

(c) Suggest **two** reasons why the carbon dioxide concentration in the Earth's atmosphere changed between 1800 and 2000 as shown in Table 1.1.

1 .....

2 .....

[2]

(d) A scientist suggested that, when air gets trapped in the ice, its carbon dioxide concentration might change.

Suggest what measurements could be taken to check whether this happens.

.....

.....

.....[2]

(e) Explain how an increase in carbon dioxide concentration in the Earth's atmosphere could cause global warming.

.....

.....

.....

.....[2]

[Turn over

2 Five test-tubes containing different substances are labelled **A**, **B**, **C**, **D** and **E** as shown in Fig. 2.1. Dilute sulfuric acid is added to each of the five substances.

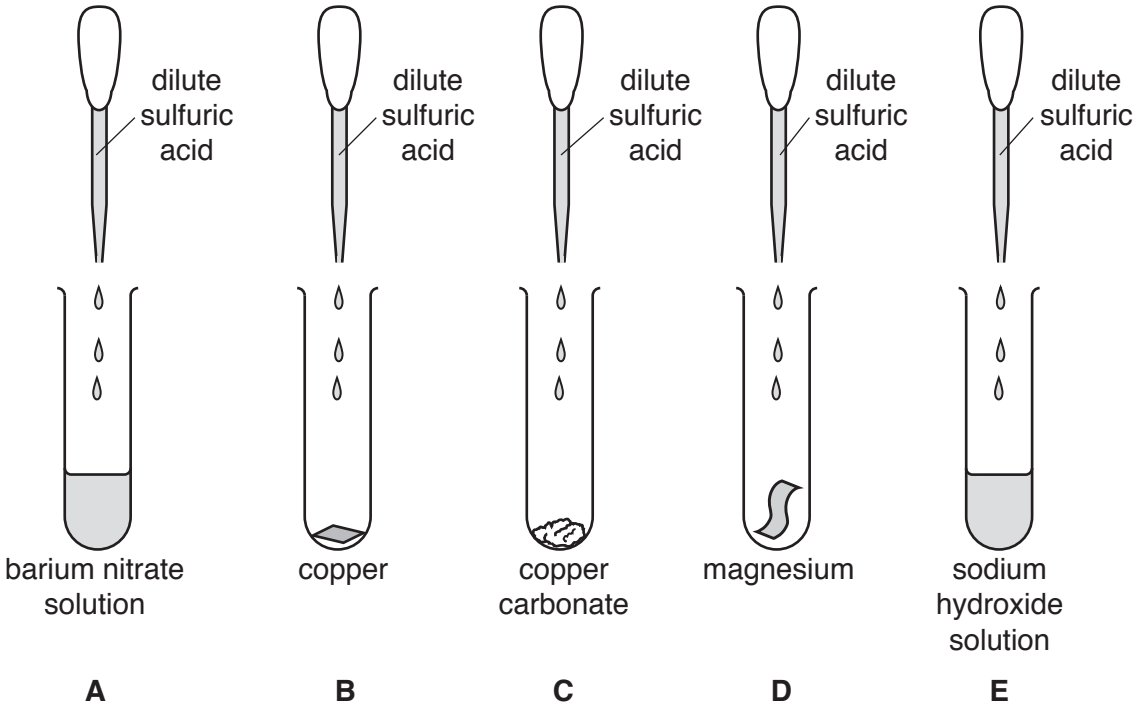


Fig. 2.1

(a) (i) Suggest the letter of the test-tube containing a substance that releases a gaseous **element** when the dilute sulfuric acid is added.

Name the gaseous element.

test-tube .....

gaseous element .....[1]

(ii) Suggest the letter of the test-tube containing a substance that releases a gaseous **compound** when the dilute sulfuric acid is added.

Name the gaseous compound.

test-tube .....

gaseous compound .....[1]

(iii) Suggest the letter of the test-tube containing a substance in which there is no chemical change.

Explain your answer in terms of the reactivity series.

test-tube .....

explanation .....

.....[1]

(iv) Dilute sulfuric acid contains sulfate ions.

Suggest the letter of the test-tube containing a substance that produces a white precipitate.

State the name of the precipitate.

test-tube .....

white precipitate .....[1]

(b) Sulfuric acid is made industrially in the Contact process.

Vanadium oxide acts as a catalyst in this process.

(i) The chemical symbol for vanadium is shown.

$$^{51}_{23}V$$

State

- the number of neutrons in the nucleus of this atom, ...
- the number of electrons in a vanadium atom. .....

[2]

(ii) State the name of the collection of metals in the Periodic Table to which vanadium belongs.

.....[1]

[Turn over

(iii) Fig. 2.2 shows part of the Contact process.

Boxes **X** and **Y** contain diagrams that represent the molecules involved in an oxidation reaction catalysed by vanadium oxide.

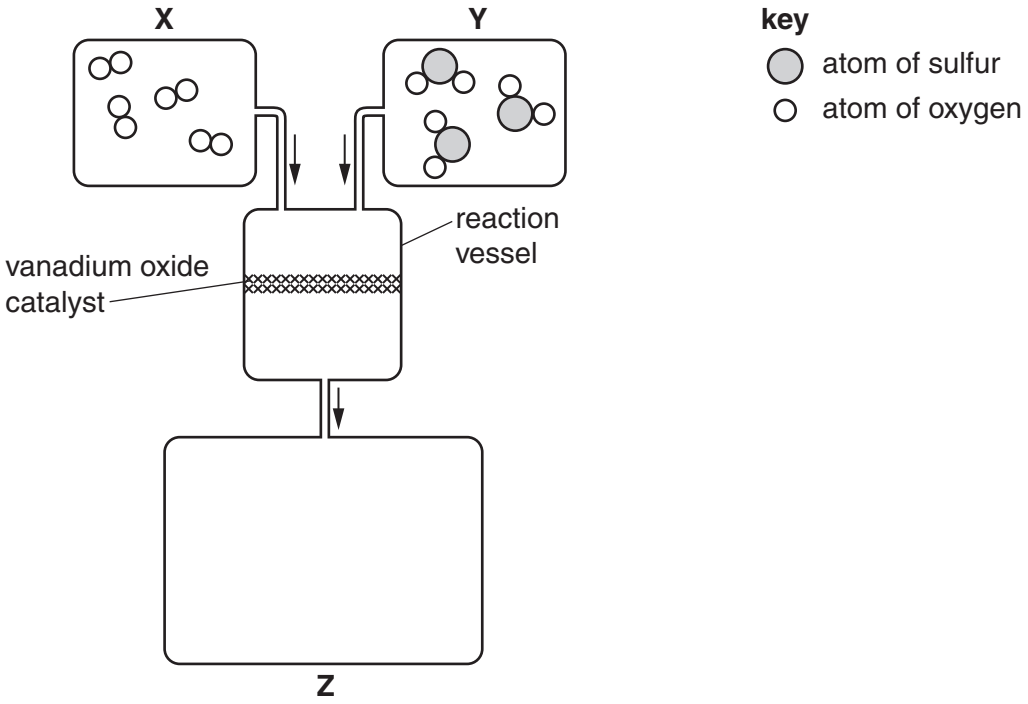


Fig. 2.2

In box **Z** in Fig. 2.2, draw **one** molecule to represent the product of the oxidation reaction. Use the key to draw the atoms of the molecule. [1]

(iv) Write a balanced chemical equation for the oxidation reaction that occurs in the reaction vessel to produce the product in box **Z**.

.....[2]

3 **(a)** Three identical kettles have each been filled with the same volume of water at 25 °C.

Fig. 3.1 shows the three kettles a few minutes later.

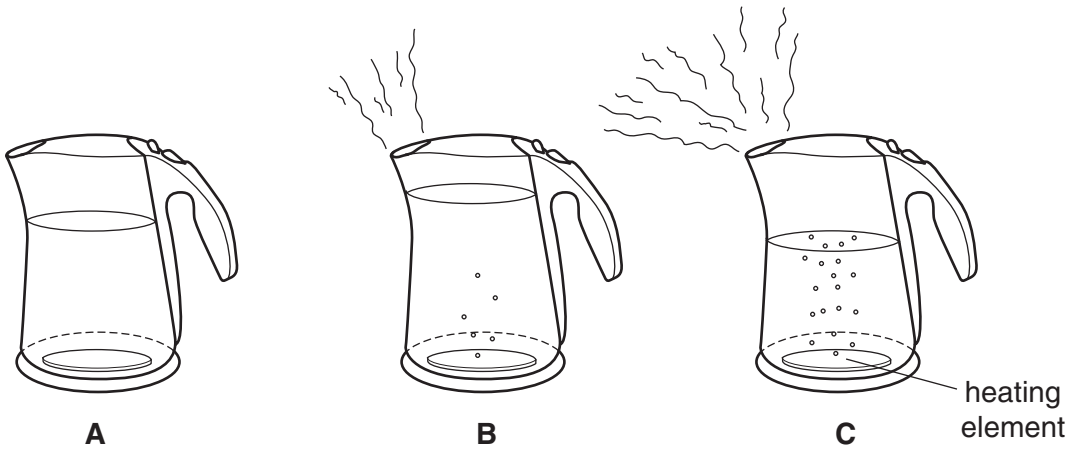


Fig. 3.1

Kettle **A** contains water that remains at 25 °C.

Kettle **B** contains water that is just starting to boil at 100 °C.

Kettle **C** contains water that has been boiling for a few minutes but is still at 100 °C.

(i) Explain why the water volume in kettle **B** is now different to that in kettle **C**.

.....

.....[1]

(ii) Explain why energy is required to boil the water in kettle **C** even though the temperature remains at 100 °C.

.....

.....

.....[1]

(iii) Describe **two** differences between evaporation and boiling.

1 .....

.....

2 .....

.....

[2]

[Turn over

(iv) When the water boils, some becomes water vapour in the air.

Fig. 3.2 shows the arrangement of particles in a gas, liquid and solid.

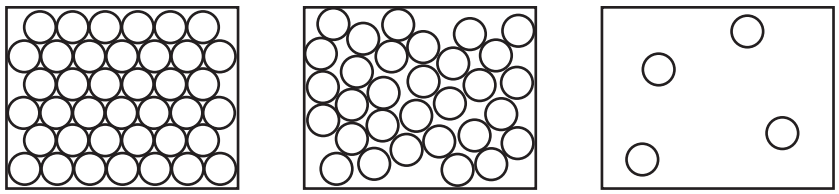


Fig. 3.2

State and explain which diagram, **A**, **B** or **C**, best represents:

water at 25 °C, ...

explanation .....

.....

water vapour. .....

explanation .....

.....

[2]

(b) Explain why the electric kettles shown in Fig. 3.1 have the heating element at the bottom of the kettle.

.....

.....

.....[2]

(c) A kettle rated at 2000 W is connected to a 250 V supply.

Show that the current in the heating element is 8 A.

State the formula you use and show your working.

formula

working

[2]

4 A gardener increases the number of trees by taking cuttings. The gardener cuts off part of a stem (the cutting) and places it in water, as shown in Fig. 4.1.

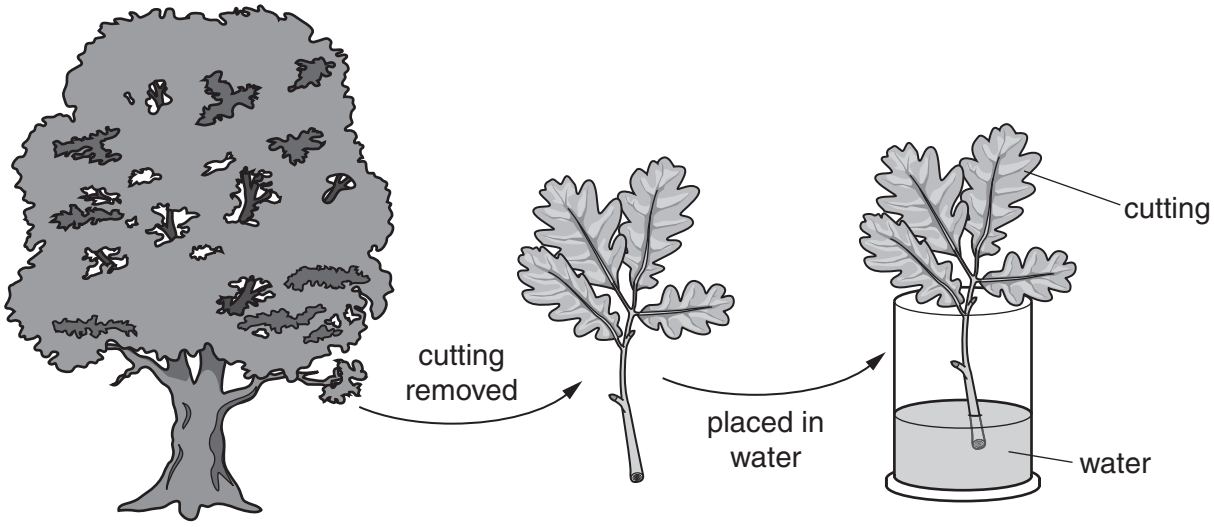


Fig. 4.1

The cutting develops roots as shown in Fig. 4.2. The gardener then plants the cutting in the ground.

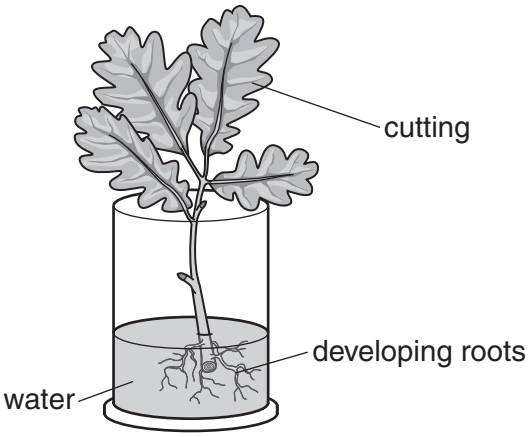


Fig. 4.2

(a) Name the type of cell division by which the roots are produced.

..... [1]

(b) Suggest how the cutting will compare to the parent tree in

(i) its genotype,

.....

.....[1]

(ii) its overall appearance once it is fully grown.

.....

.....[1]

(c) Before the roots develop on a cutting, the gardener encloses the cutting in a plastic bag, as shown in Fig. 4.3.

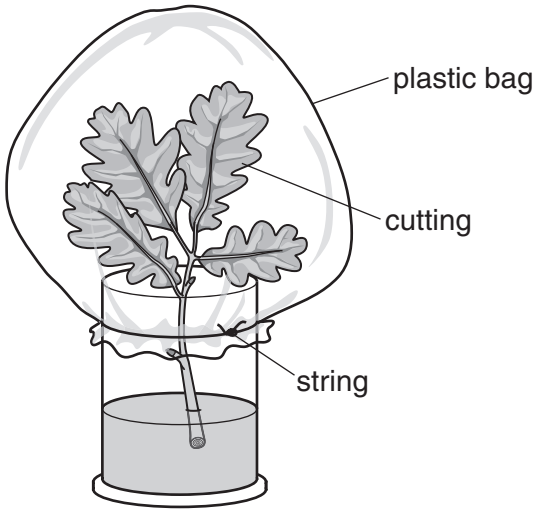


Fig. 4.3

Suggest why the gardener places the plastic bag over the cutting before the roots develop.

.....

.....

.....[2]

(d) As the cutting grows, it needs nitrate ions and magnesium ions for healthy growth.

Describe the effect on the cutting of

(i) a deficiency of nitrate ions,

.....

.....[1]

(ii) a deficiency of magnesium ions.

.....

.....[1]

5 A student studies the relative reactivity of four metals.

She adds small pieces of different metals to solutions of metal salts.

The metals and solutions she uses, together with her results, are shown in Table 5.1.

Table 5.1

	zinc sulfate solution	copper sulfate solution	silver nitrate solution	metal **M** salt solution
zinc		✓	✓	✓
copper	✗		✓	✗
silver	✗	✗		✗
metal **M**	✗	✓	✓	

key ✓ shows that a metal displacement reaction occurs
✗ shows that a reaction does not occur

(a) (i) Zinc reacts with copper sulfate solution because zinc is more reactive than copper.

Describe and explain **one** change of colour which is observed when zinc and copper sulfate solution react.

observation .....

.....

explanation .....

.....

[2]

(ii) Use the results in Table 5.1 and the Periodic Table to suggest the proton number of metal **M** from the list.

11 20 26

Explain your answer.

proton number of metal **M** .....

explanation .....

.....

.....

.....

[2]

(b) The reaction between zinc and silver nitrate solution is shown by the balanced ionic equation.

$$Zn(s) + 2Ag^{+}(aq) \rightarrow Zn^{2+}(aq) + 2Ag(s)$$

(i) State the meaning of the state symbol *(aq)*.

.....[1]

(ii) Use the information in the ionic equation to explain why the reaction between zinc atoms and silver ions is an example of a redox reaction.

.....

.....

.....

.....[2]

(c) In another experiment, shown in Fig. 5.1, the student adds magnesium ribbon to excess copper sulfate solution.

She measures the temperature of the solution for ten minutes.

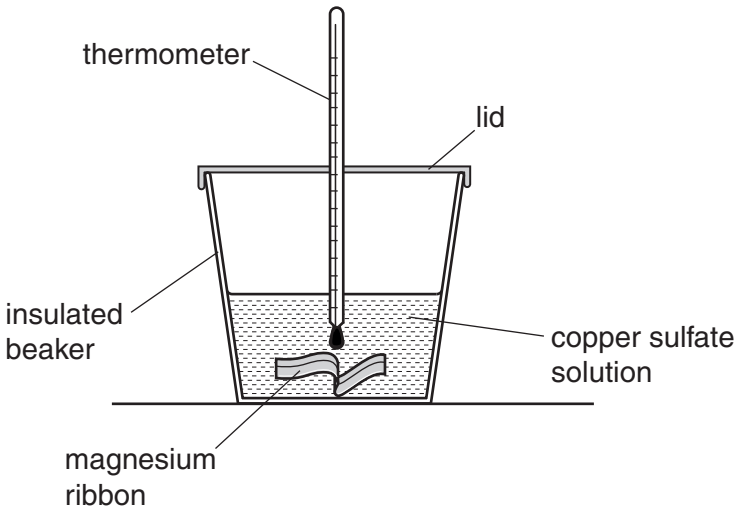


Fig. 5.1

Fig. 5.2 shows a graph of her results.

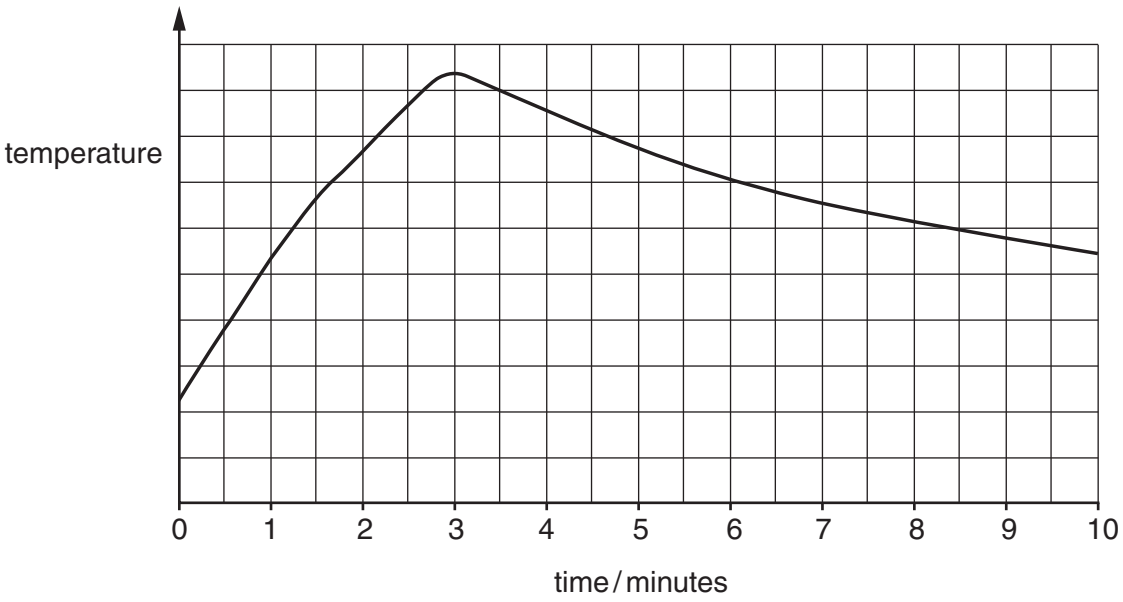


Fig. 5.2

Complete the sentences below using suitable words.

During the first three minutes of the experiment the temperature rises. The speed of the particles in the solution ..... .

The temperature rises because the reaction is .....

and ..... energy is transferred into thermal energy.

[3]

6 Fig. 6.1 shows a train.

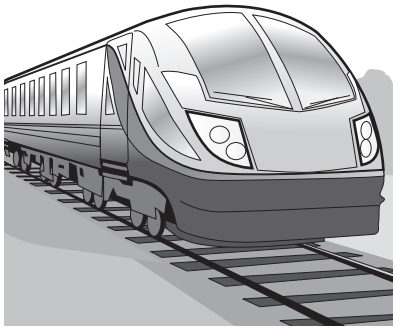
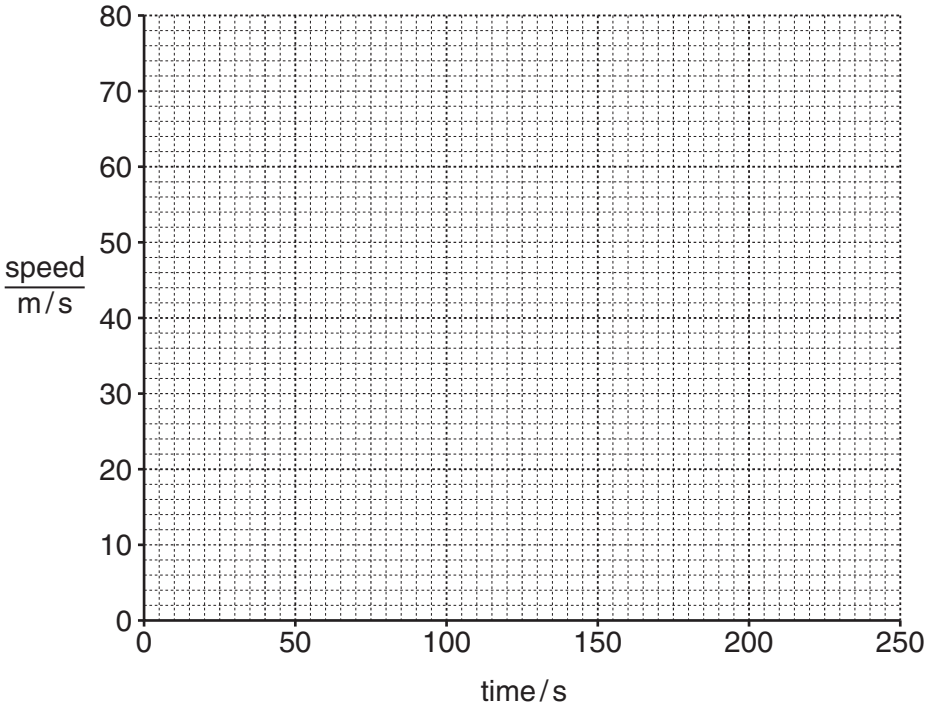


Fig. 6.1

The train starts from rest and accelerates with constant acceleration. The train reaches 45 m/s after 60 seconds.

The train then continues at this constant speed for 150 seconds.

(a) (i) On the grid below sketch a speed/time graph for the train.



[2]

(ii) Describe how you could calculate the distance travelled by the train from the speed/time graph.

.....

.....[1]

(b) The train has a mass of 6.0×10^5 kg.

Calculate the kinetic energy of the train 120 seconds after the train starts from rest.

State the formula you use and show your working.

formula

working

kinetic energy = ... J [3]

(c) During one part of the journey the train accelerates at $0.75\,m/s^2$.

Calculate the force required to cause this acceleration.

State the formula you use and show your working.

formula

working

force = ... N [2]

[Turn over

7 **(a)** Use the terms in the list to complete the sentences about homeostasis.

Each term may be used once, more than once, or not at all.

against **away from** **concentration** **environment**

negative **positive** **temperature** **towards** **within**

Homeostasis is defined as the maintenance of a constant internal

..... .

Homeostasis depends on ..... feedback, where a change

..... a set point causes a change .....

the set point.

[3]

(b) Fig. 7.1 shows how the glucose concentration of a person's blood changes over a period of three hours during the middle of the day.

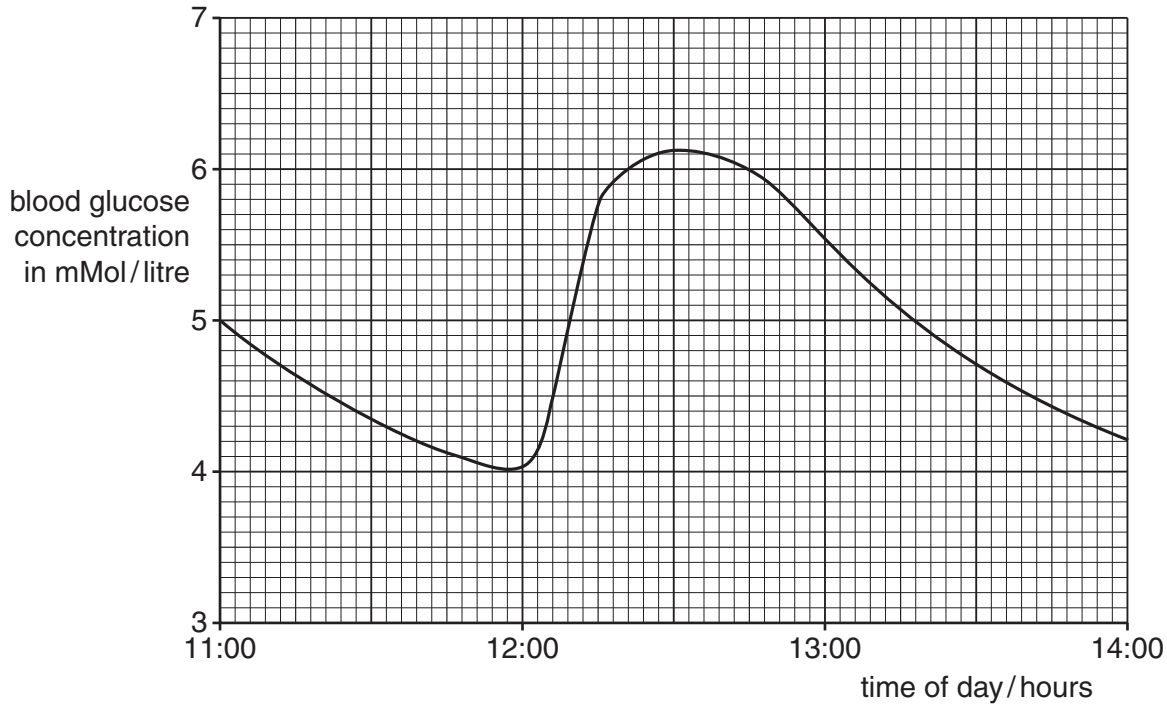


Fig. 7.1

(i) State the time at which the person's blood glucose concentration is highest.

..... [1]

(ii) Suggest why the person's blood glucose concentration rises immediately after the first hour.

.....[1]

(iii) Suggest **two** processes in the cells of the body that may cause the glucose concentration to **decrease**.

1 .....

2 .....

[2]

(c) Describe the role of the liver in the control of the glucose concentration in blood.

.....

.....

.....

.....

.....[3]

8 **(a)** Fig. 8.1 represents the electron arrangement in an atom of sulfur.

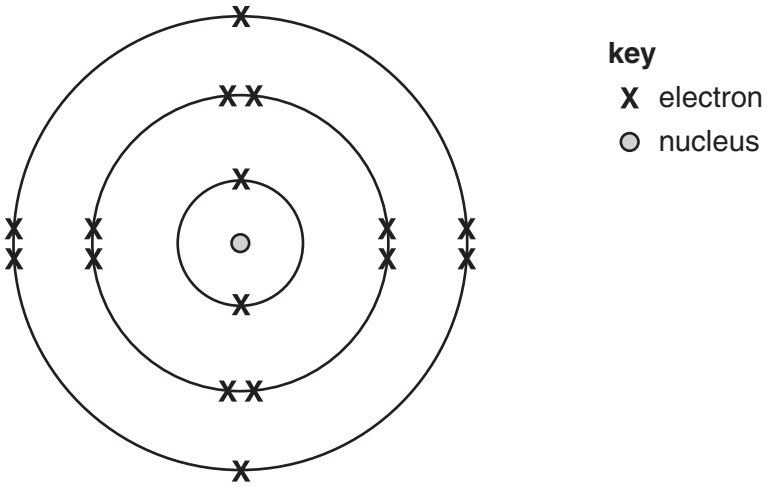


Fig. 8.1

(i) State the charge of the **ion** that forms from a sulfur atom.

Explain this charge in terms of the number of protons and the number of electrons.

charge .....

explanation .....

.....

.....

[3]

(ii) Zinc is extracted from rocks containing zinc sulfide, ZnS.

Use this formula and your answer to **(a)(i)** to predict and explain the charge of an **ion** of zinc.

charge .....

explanation .....

.....

.....

[2]

(b) Zinc is produced by the electrolysis of a concentrated solution of zinc sulfate.

Fig. 8.2 shows the apparatus used to produce zinc by this method.

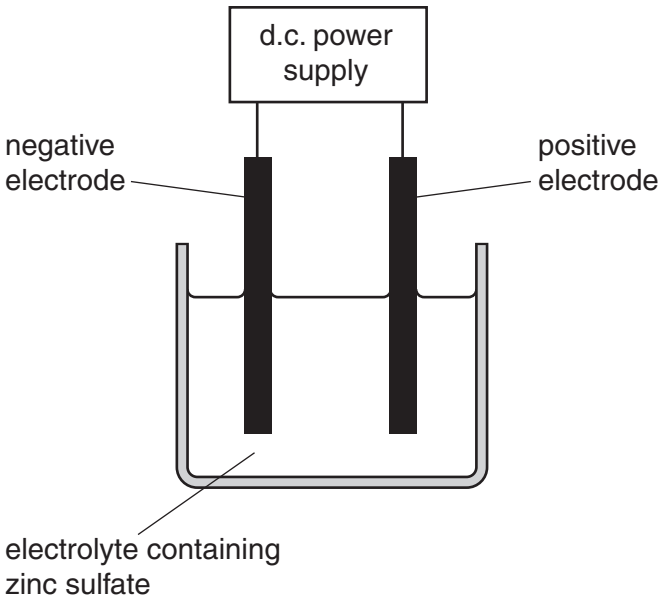


Fig. 8.2

During electrolysis, the cathode becomes covered by a layer of zinc atoms.

Describe why zinc atoms form on the cathode.

.....

.....

.....[2]

(c) A layer of zinc on the surface of a steel object prevents the object from rusting.

(i) State the word that is used to describe steel that is protected from rusting by a layer of zinc.

..... [1]

(ii) Explain why a layer of zinc will continue to protect steel from rusting even when the zinc layer is damaged to expose the steel.

.....

.....

.....[2]

[Turn over

(d) Brass is an alloy of zinc and copper.

Many types of brass are less malleable than zinc or copper.

State the meaning of the term *malleable*.

.....

.....[1]

9 **(a)** A nuclear power station uses the energy from nuclear fission to generate electricity. Plutonium-239 can be used in nuclear fission.

(i) Describe the difference between nuclear fission and nuclear fusion.

.....

.....

.....[1]

(ii) Plutonium-239, $^{239}_{94}Pu$, decays by alpha (α) emission to produce an isotope of uranium.

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

$^{239}_{94}Pu \rightarrow$ ..... + ...

[3]

(b) The voltage in a power station is increased using a transformer before transmitting electrical power.

(i) Explain the benefit of transmitting electrical power at a high voltage.

.....

.....

.....[1]

[Turn over

(ii) Fig. 9.1 shows a simple transformer.

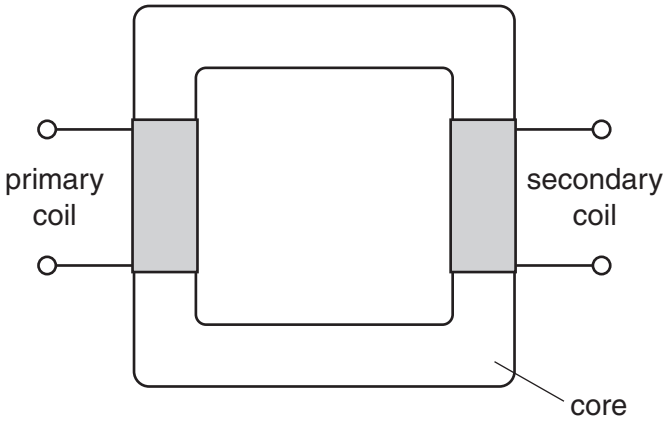


Fig. 9.1

The transformer increases the voltage from 25 000 V to 600 000 V. The number of turns in the primary coil is 5000.

Calculate the number of turns in the secondary coil.

State the formula you use and show your working.

formula

working

number of turns = ... [3]

(c) An overhead power cable transmits electrical power from the power station to a town 10 km away. The resistance of the cable is 6.5 Ω.

(i) Predict the resistance of a cable which has twice the cross-sectional area.

resistance = ... Ω [2]

(ii) State **one** way of changing the resistance of the cable, other than changing its cross-sectional area.

.....[1]

(iii) Apart from the increased cost, suggest and explain **one** negative effect of doubling the cross-sectional area of the cable.

.....

.....

.....[2]

10 **(a)** Fig. 10.1 shows a fetus developing in the uterus.

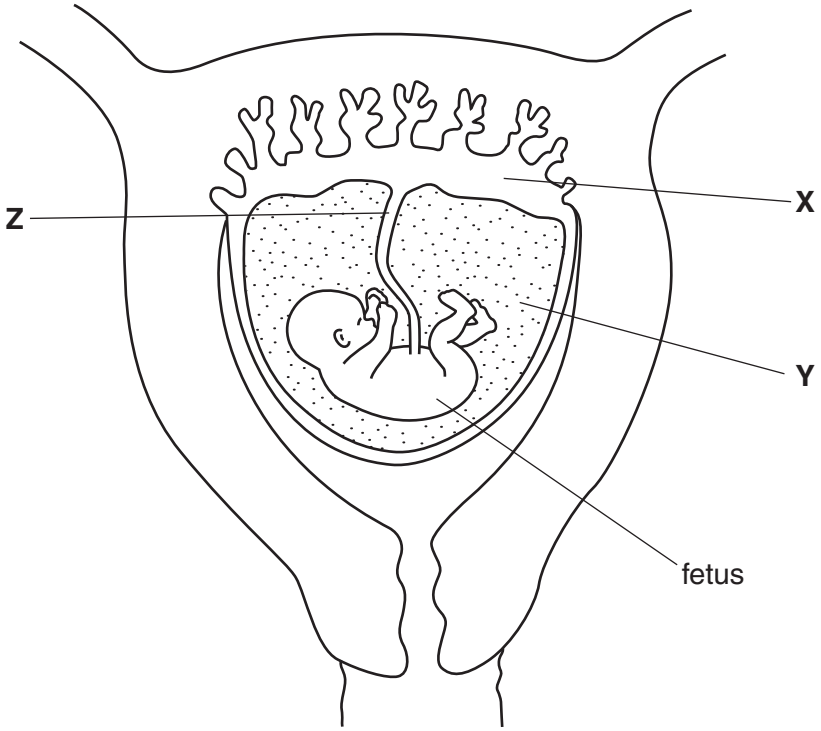


Fig. 10.1

(i) Name the parts labelled **X**, **Y** and **Z**.

X .....

Y .....

Z .....

[3]

(ii) State the function of part **Y**.

.....

.....[1]

(iii) Describe how the blood flowing away from the fetus in part **Z** differs in composition from that flowing towards the fetus.

.....

.....

.....

.....[3]

(b) After a baby is born, the mother can feed her baby by breast-feeding or by bottle-feeding.

(i) Describe **two** benefits of breast-feeding.

1 .....

.....

2 .....

.....
[2]

(ii) Describe **one** benefit of bottle-feeding.

.....

.....[1]

[Turn over

11 Fig. 11.1 shows apparatus used to investigate the compounds produced when ethanol burns.

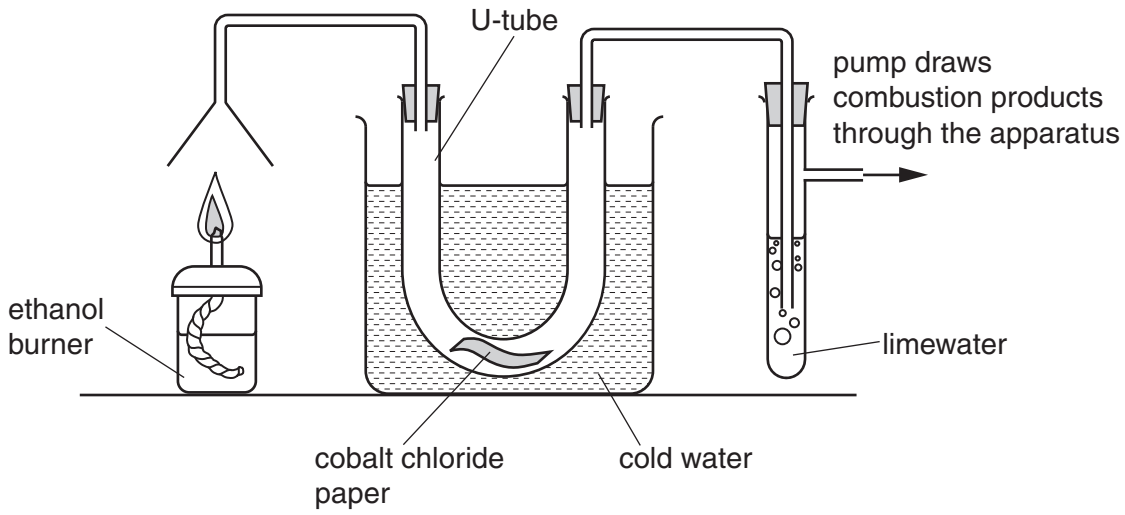


Fig. 11.1

(a) Before the ethanol burner is lit, the cobalt chloride paper is blue and the limewater is colourless.

Predict and explain the changes in appearance of the cobalt chloride paper and the limewater shortly after the burner is lit.

cobalt chloride paper .....

explanation .....

limewater .....

explanation .....

[4]

(b) Name **two** substances that react together in an addition reaction to produce ethanol.

1 .....

2 .....

[1]

(c) The formula of ethanol is C_2H_6O.

(i) Show that the relative molecular mass of ethanol is 46.

[1]

(ii) Calculate the mass of ethanol contained in 250 cm^3 of an aqueous solution that has a concentration of 0.5 mol/dm^3.

Show your working and give the unit.

mass of ethanol = ... unit = ... [3]

12 **(a)** A star emits γ-rays and visible light.

γ-rays and visible light are parts of the electromagnetic spectrum.

(i) Place γ-rays and visible light in their correct positions in the incomplete electromagnetic spectrum shown in Fig. 12.1. [1]

	X-rays			infra-red waves	microwaves	

Fig. 12.1

(ii) State why it takes the same time for γ-rays and visible light to travel from the star to the Earth.

.....

.....

.....[1]

(iii) The γ-rays are more dangerous than visible light to an observer on a space station.

Explain why.

.....

.....[1]

(b) Below are four terms used to describe a wave. Draw a line from each term to its definition.

term	**definition**
amplitude	how far the wave travels in one second
frequency	the distance from any point on one wave to the same point on the next wave
speed	the distance from the centre of a wave to the top or to the bottom of the wave
wavelength	the number of waves passing a fixed point in one second

[2]

(c) Telescopes used to observe stars contain mirrors.

Fig. 12.2 shows two rays of light from an object **O** striking a mirror.

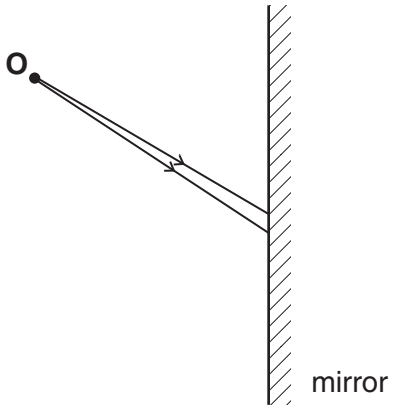


Fig. 12.2

(i) Draw the reflected rays. [1]

(ii) Extend the lines of the reflected rays behind the mirror to show the position of the image. Label the image **I**.

[1]

(d) Telescopes also contain lenses.

Rays of light from a distant star pass through the lens shown in Fig. 12.3.

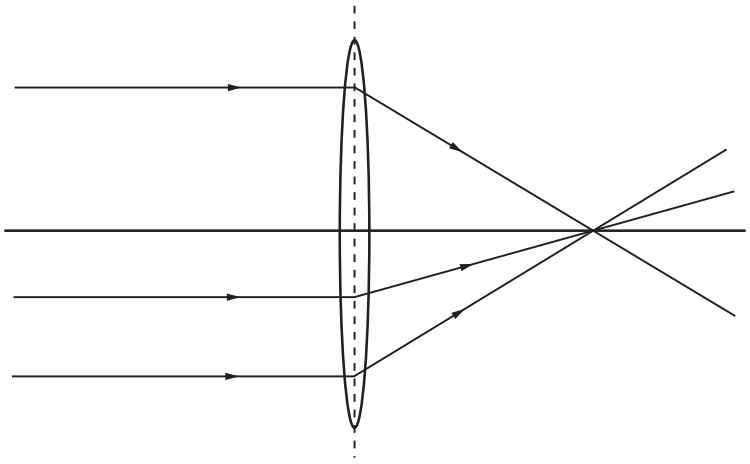


Fig. 12.3

(i) On Fig. 12.3, use a double-headed arrow (◄►) to indicate the focal length of the lens. [1]

(ii) As light passes through the lens, the direction of the light is changed.

State the name of this process.

..... [1]

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 –		114 Fl flerovium –		116 Lv livermorium –		

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.)