

CANDIDATE  
NAME

CENTRE  
NUMBER

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NUMBER

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**CO-ORDINATED SCIENCES**

**0654/41**

Paper 4 (Extended)

**May/June 2017**

**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 28.

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.

This document consists of **28** printed pages.

1 Fig. 1.1 shows a 36-week-old growing baby (fetus) in the uterus.

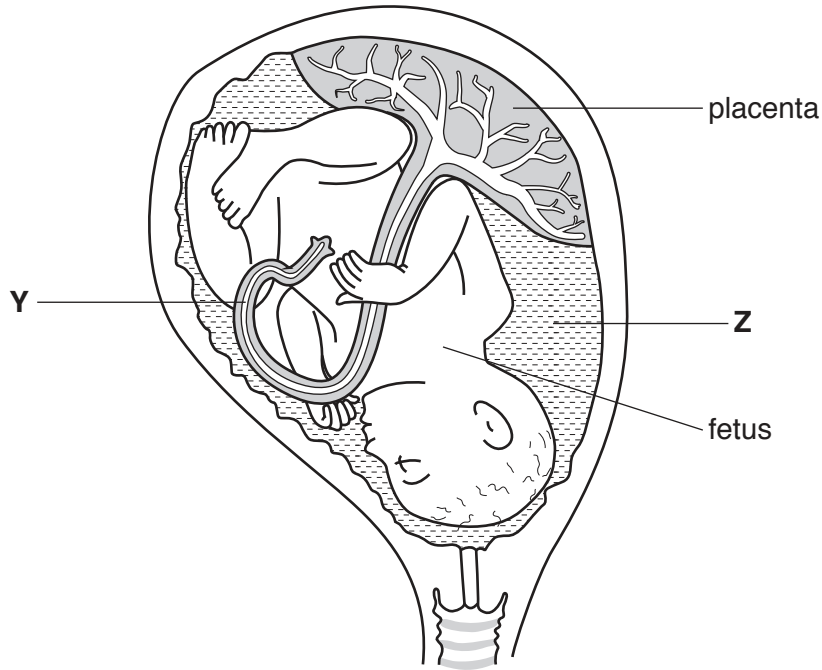


Fig. 1.1

(a) (i) Name the parts labelled Y and Z.

Y .....

Z .....

[2]

(ii) State **one** function of the part labelled Z.

.....

..... [1]

(iii) Describe the role of the blood vessels in Y in the exchange of materials between the mother and the fetus.

.....

.....

..... [2]

(b) *Placenta praevia* is a condition during pregnancy where the placenta can cover the cervix.

(i) Draw an **X** on the diagram to show the position of the placenta in a mother that has *placenta praevia*. [1]

(ii) Suggest a complication that might occur as a result of *placenta praevia* during childbirth.

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

2 (a) A student plans an experiment to calculate the specific heat capacity of water by heating some water in a kettle.

- She measures 1.2 kg of water into an electric kettle.
- The initial temperature of the water is 18 °C.
- She switches on the kettle and heats the water for 60 seconds.
- The final temperature of the water is 49 °C.
- The energy given to the water by the kettle in 60 seconds is 156 000 J.

(i) Calculate the specific heat capacity of water.

State the formula you use and show your working.

formula

working

specific heat capacity = ..... J/kg °C [3]

(ii) The kettle is supplied with 3000 joules of energy each second.

The water in the kettle only gains 2600 joules of thermal energy each second.

Calculate the efficiency of the kettle.

State the formula you use and show your working.

formula

working

efficiency = .....% [2]

(b) A kettle is switched on and the water reaches its boiling point. It starts to boil and the kettle remains switched on.

Explain in terms of molecules what happens to the thermal energy supplied after the water starts to boil.

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

3 (a) Nitrogen combines with different elements to make ammonia and nitrogen oxides.

- (i) Describe **one** way that nitrogen oxides are formed and **one** effect these can have on the environment.

formation .....

.....

effect .....

.....

[2]

- (ii) Name the industrial process that is used to combine nitrogen and hydrogen to make ammonia.

.....[1]

- (iii) Hydrogen,  $H_2$ , is produced by reacting methane,  $CH_4$ , with steam,  $H_2O(g)$ . The reaction also produces the gas carbon monoxide,  $CO$ .

Construct the **balanced symbolic** equation, including all state symbols, for this reaction.

.....[2]

(b) Molecules of nitrogen gas,  $N_2$ , are not very reactive.

(i) Fig. 3.1 shows the outer electrons in a nitrogen atom.

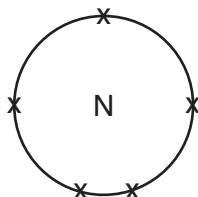


Fig. 3.1

Complete the bonding diagram in Fig. 3.2 to show how all of the outer electrons in a nitrogen molecule are arranged.

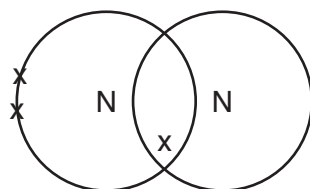


Fig. 3.2

[2]

(ii) Suggest why nitrogen molecules are **not** very reactive.

.....

.....

.....[2]

(c) Hydrazine has the chemical formula  $N_2H_4$ .

Hydrazine decomposes as shown in the equation below.



(i) Show that the relative molecular mass of hydrazine is 32.

[ $A_r$  : N, 14 ; H, 1]

[1]

- (ii) Complete the following steps to calculate the volume of ammonia produced when 192 g of hydrazine decompose.

Show your working in each step.

**Step 1**

Calculate the number of moles in 192 g of hydrazine.

moles of hydrazine = .....

**Step 2**

Calculate the number of moles of ammonia produced.

moles of ammonia = .....

**Step 3**

Calculate the volume of ammonia produced in  $\text{dm}^3$ .

Assume that one mole of ammonia occupies  $24 \text{ dm}^3$ .

volume of ammonia = .....  $\text{dm}^3$   
[3]

4 Fig. 4.1 shows the activity of three enzymes, **A**, **B** and **C**, at different pHs.

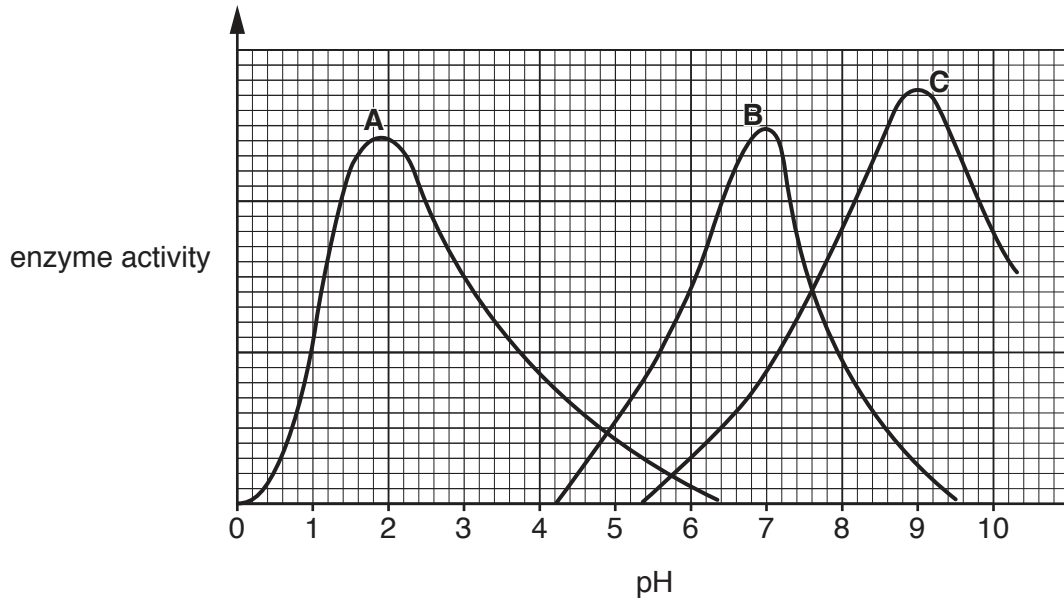


Fig. 4.1

- (a) (i) State the optimum pH for enzyme **C**.  
 ..... [1]
- (ii) Explain why enzyme **C** shows no activity below pH5.  
 .....  
 ..... [1]
- (iii) Name **one** factor other than pH that affects enzyme activity.  
 ..... [1]
- (b) The enzymes shown in Fig. 4.1 are digestive enzymes.  
 Define the term *digestion*.  
 .....  
 .....  
 ..... [3]
- (c) The environment in the stomach is strongly acidic.  
 State and explain which enzyme is most likely to be protease.  
 enzyme .....  
 explanation .....  
 ..... [2]



5 Plants need to use several substances in order to photosynthesise.

(a) Write the balanced **symbol** equation for photosynthesis.

.....[2]

(b) Plants also need mineral ions in order to function efficiently.

Describe how the appearance of a plant deficient in nitrate ions would differ from that of a healthy plant.

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

(c) Nitrate fertilisers can be applied to the soil. Nitrate ions are taken into the plant and transported with water through the plant.

(i) Describe how water and mineral ions are moved from the roots to the leaves in plants.

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

(ii) Suggest how an increase in humidity affects the movement of water and ions through the plant. Explain your answer.

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

(d) When nitrate fertilisers are used in excess, they can be washed into lakes and rivers.

Describe **and** explain the effects of excess nitrates on lakes and rivers.

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

6 (a) Petroleum is a black liquid.

It is a source of hydrocarbons.

Fig. 6.1 shows apparatus used to investigate petroleum.

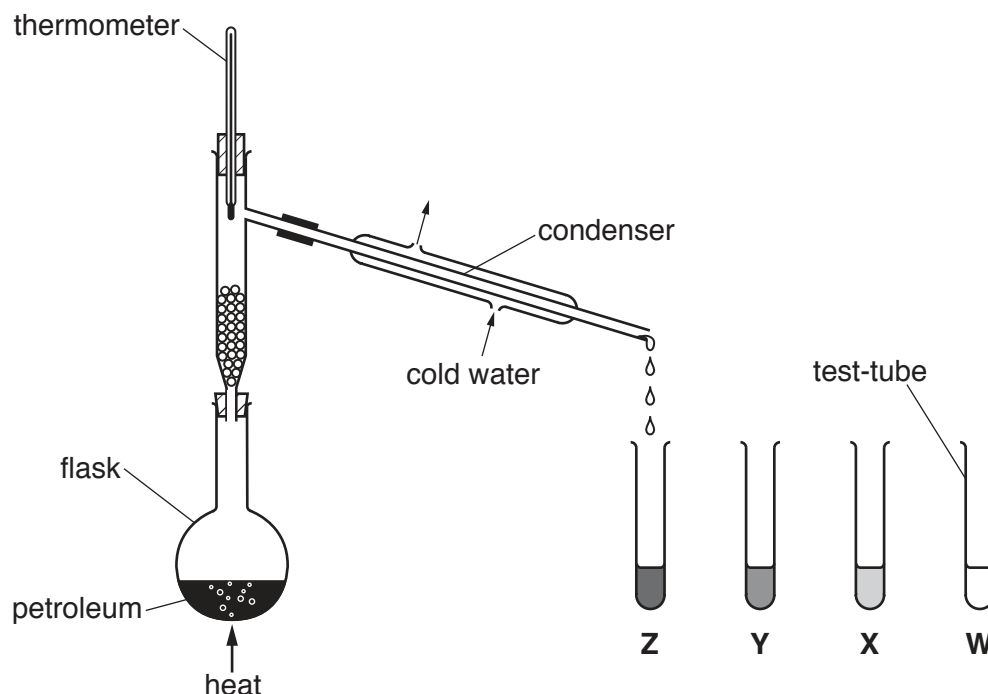


Fig. 6.1

When the petroleum boils, vapour rises and then condenses in the condenser.

The thermometer measures the range of boiling temperature of the liquids that collect in the test-tubes.

The ranges of boiling temperature ( $^{\circ}\text{C}$ ) of the four liquids, **W**, **X**, **Y** and **Z** are shown below.

<b>W</b>	20	to	70
<b>X</b>	70	to	120
<b>Y</b>	120	to	170
<b>Z</b>	170	to	240

(i) Name the process shown in Fig. 6.1.

.....[1]

- (ii) Explain, in terms of molecular properties, why the boiling temperature increases from liquid **W** to liquid **Z**.

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

- (iii) A student suggests that liquids **W**, **X**, **Y** and **Z** are four pure compounds.

Explain why the boiling temperature data for each liquid show that the student is mistaken.

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

- (b) (i) Complete Fig. 6.2 to show a molecule of the **saturated** hydrocarbon that contains four carbon atoms.

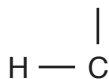


Fig. 6.2

[2]

- (ii) Methane and hexane are hydrocarbons in the same homologous series.

Suggest **one** similarity in the properties of methane and hexane.

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

7 (a) Fig. 7.1 shows a speed-time graph for a car over a period of 50 seconds.

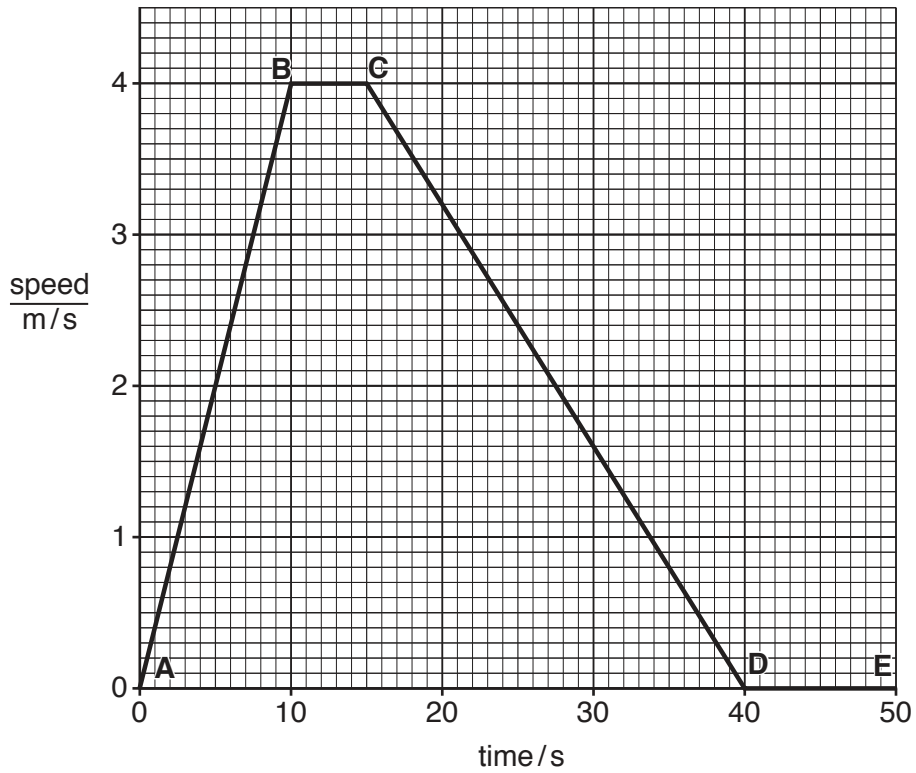


Fig. 7.1

(i) State the maximum speed reached by the car.

..... m/s

[1]

(ii) Calculate the total distance travelled by the car.

Show your working.

distance = ..... m [2]

(iii) Show that the acceleration of the car during the first ten seconds is  $0.4 \text{ m/s}^2$ .

[1]

- (iv) The mass of the car is 950 kg. Calculate the force needed to produce an acceleration of  $0.4 \text{ m/s}^2$ .

State the formula you use and show your working.

formula

working

force = ..... N [2]

- (b) The temperature of the air in car tyres increases during a journey.

- (i) Describe what happens to the motion of the air particles as the air warms up.

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

- (ii) When the temperature of the air in the tyres increases, the pressure in the tyres increases.

Explain in terms of the motion of the air particles why the pressure increases.

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

(c) Relays are needed in many electrical circuits used in machines.

Fig. 7.2 shows a simple relay circuit.

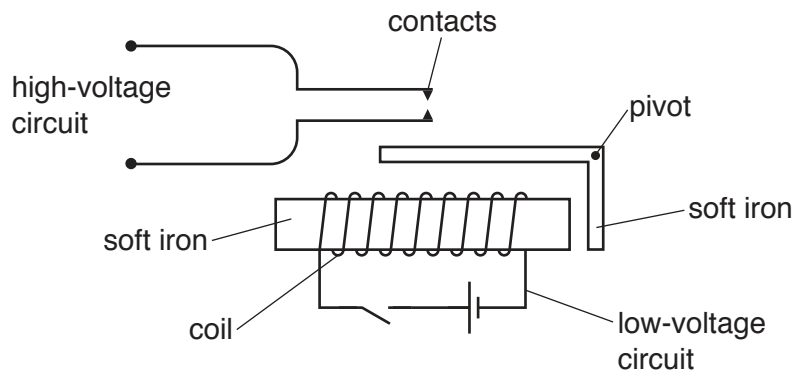


Fig. 7.2

(i) Describe how a small current flowing in a low-voltage circuit is able to turn on the high-voltage circuit.

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

(ii) Suggest how the use of a relay in a high-voltage circuit protects the person operating a machine.

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

8 The pupil reflex to light is an example of a reflex action.

(a) The letters below represent different parts of a reflex action pathway.

- A CNS (central nervous system)
- B effector
- C motor neurone
- D receptor
- E sensory neurone

(i) Put the letters in the correct order to show the reflex action pathway. Two have been done for you.

<b>D</b>		<b>A</b>		
----------	--	----------	--	--

[1]

(ii) Suggest why the nerve impulses travel to the brain rather than to the spinal cord during the pupil reflex.

.....

.....[1]

(b) The size of the pupil in the eye changes in response to light.

This is an example of a reflex action.

Fig. 8.1 shows a photograph of an eye in bright light conditions.



Fig. 8.1

(i) Describe and explain the changes to the eye that occur when a person goes from bright light back to normal light conditions.

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

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

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

(c) Nocturnal animals are active at night.

Suggest **one** way that the eyes of nocturnal animals may differ from animals that are active during the day.

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



9 Magnesium is an element in Group II of the Periodic Table.

(a) (i) An atom of magnesium has a mass (nucleon) number of 26.

State the names and numbers of particles contained in the nucleus of this magnesium atom.

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

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

.....[1]

(b) Fig.9.1 shows apparatus that a student uses to investigate the energy change when magnesium reacts with dilute hydrochloric acid.

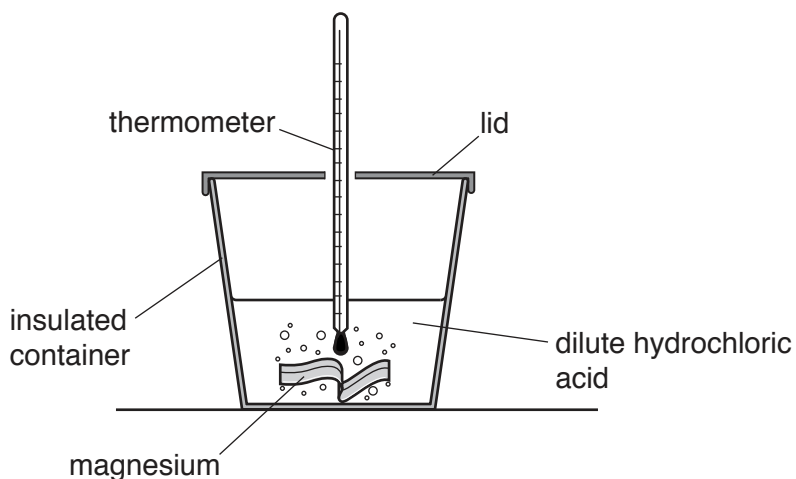


Fig. 9.1

Fig. 9.2 shows a graph of the temperature measurements the student obtains during the investigation.

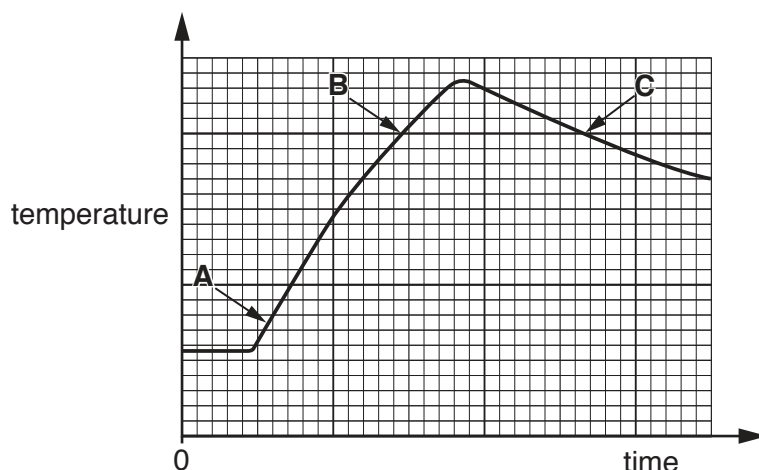


Fig. 9.2

(i) Name the gas released in the reaction.

..... [1]

(ii) Predict **two** ways in which the composition of the reaction mixture inside the insulated container changes during the reaction.

1 .....

2 .....

[2]

(iii) Use Fig.9.2 to compare the average kinetic energies of the particles in the reaction mixture

at points **A** and **B**, .....

.....

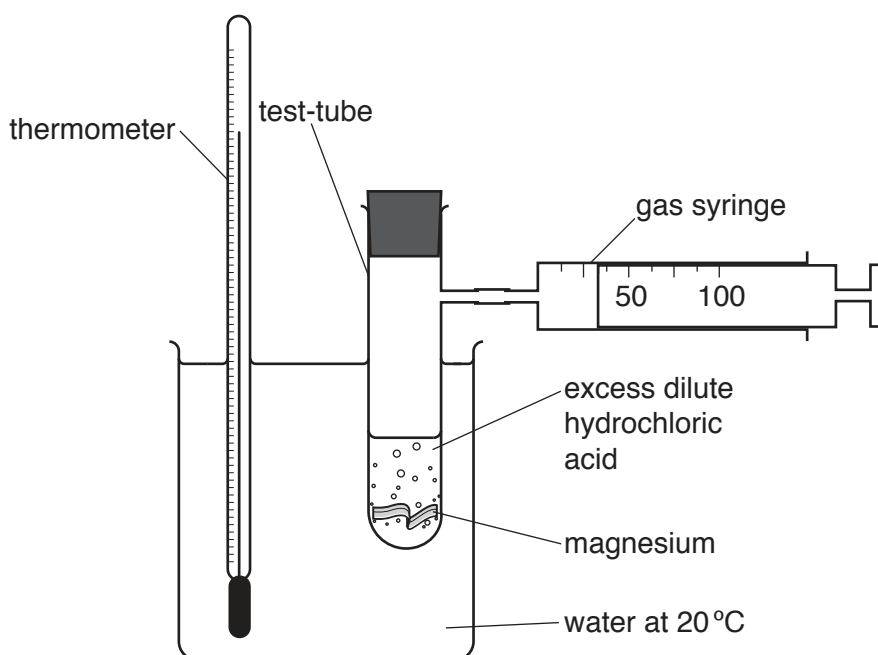
at points **B** and **C**. .....

.....

[1]

- (c) The student then investigates how the concentration of acid affects the rate of reaction between magnesium and dilute hydrochloric acid.

Fig. 9.3 shows the apparatus he uses.



**Fig. 9.3**

- (i) The student repeats this experiment several times using different concentrations of acid.

Explain why the test-tube in Fig. 9.3 is placed in a large volume of water at 20 °C.

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

- (ii) State and explain, in terms of collisions between reacting particles, the effect of an increase in acid concentration on the rate of reaction.

effect .....

explanation .....

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

- 10 A student investigates the respiration rate of germinating seeds using the apparatus shown in Fig. 10.1.

The soda lime removes any carbon dioxide produced by the seeds. The red liquid moves to the left as the oxygen is used by respiration of the seeds. The rate of respiration can be measured by calculating the distance moved by the liquid in a certain time period.

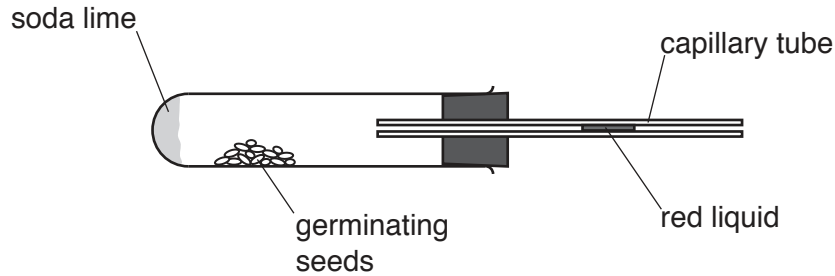


Fig. 10.1

- (a) The seeds use oxygen from the air in the test-tube.

State **two** other conditions necessary for the germination of seeds.

- 1 .....
- 2 ..... [1]

- (b) Name **one** other raw material, apart from oxygen, needed for respiration.

..... [1]

- (c) State **and** explain the effect that an increase in the number of seeds would have on the position of the red liquid.

.....

.....

.....

..... [3]

- (d) The investigation is repeated with seeds that have been boiled.

State **and** explain the effect of boiling the seeds on the position of the red liquid.

.....

.....

.....

..... [3]

11 (a) A small quantity of radioactive material is taken from a nuclear reactor.

Describe how a scientist could prove that the material is releasing  $\gamma$ -rays but not  $\alpha$ -particles or  $\beta$ -particles.

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

(b) The nuclear fuel used in a power station is plutonium-239.

$^{239}_{94}\text{Pu}$  decays by  $\alpha$ -emission to produce an isotope of uranium.

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



(c) The electricity produced in a nuclear power station is transferred from the power station to a nearby town using overhead power cables.

The resistance of a length of cable may be calculated using the equation shown.

$$\text{resistance} = \text{constant} \times \frac{\text{length}}{\text{cross-sectional area}}$$

One length of an overhead power cable has a resistance of  $7.0\Omega$ .

Predict the resistance of a cable that has half the diameter but is the same length.

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

(d) The power station uses generators to generate electricity. Fig. 11.1 shows a simple generator.

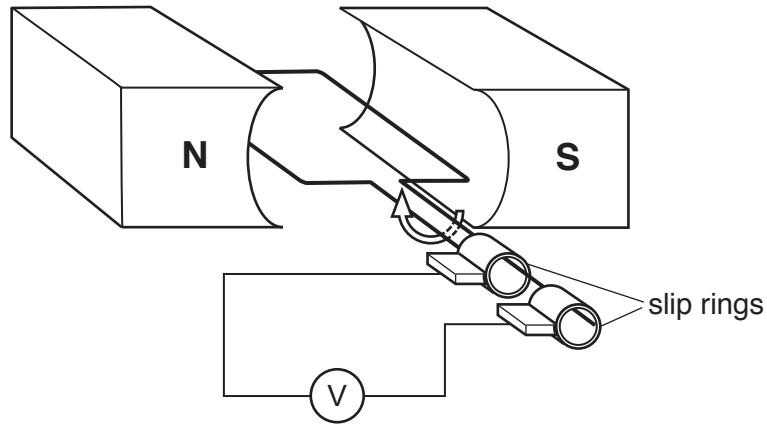


Fig. 11.1

A voltage is generated when a coil of wire is turned in a magnetic field.

The voltage is measured using a voltmeter connected across slip rings as shown in Fig. 11.1.

(i) On the grid in Fig. 11.2, sketch a graph of voltage output against time for the generator, when the coil is rotating at constant speed.

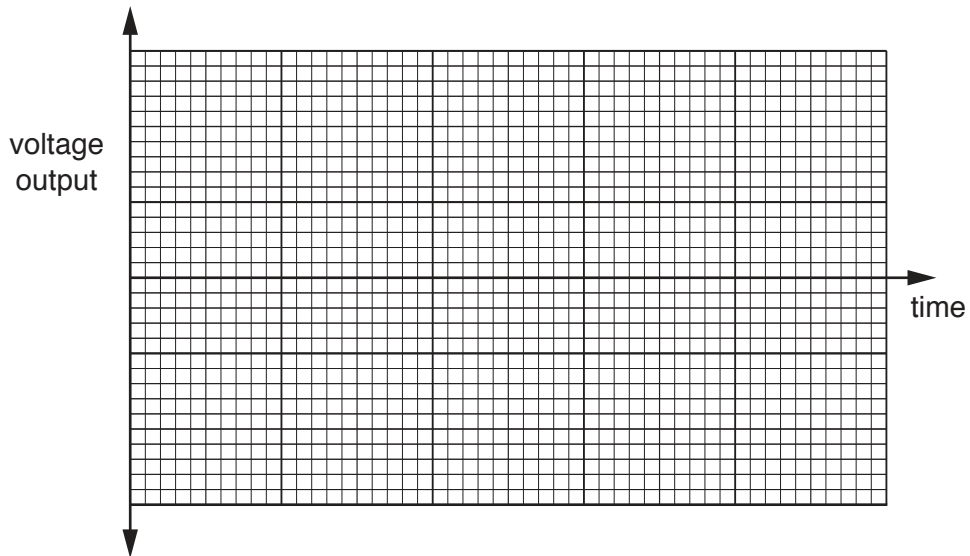


Fig. 11.2

(ii) State **one** way in which the size of the induced voltage can be increased. [2]

.....

..... [1]

(e) A generator is very noisy and emits sound waves which pass through the air. The speed of sound waves in air is 340 m/s. The frequency of the sound waves is 490 Hz.

(i) Calculate the wavelength of the sound waves.

State the formula you use and show your working.

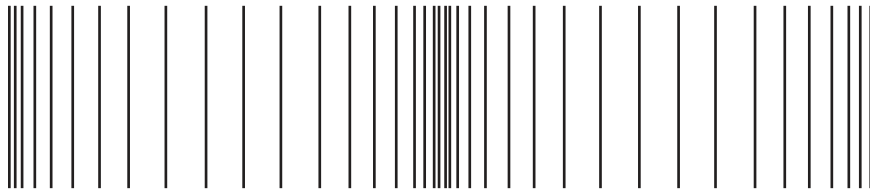
formula

working

wavelength = ..... m [2]

(ii) Fig. 11.3 represents a sound wave travelling through the air from the generator.

direction of travel →



**Fig. 11.3**

On Fig. 11.3, label a compression with the letter **C**. [1]

(iii) The generator turns faster and the frequency of the sound emitted increases.

Suggest how the distance between two compressions changes.

.....[1]

12 Fig. 12.1 shows sodium reacting with chlorine gas.

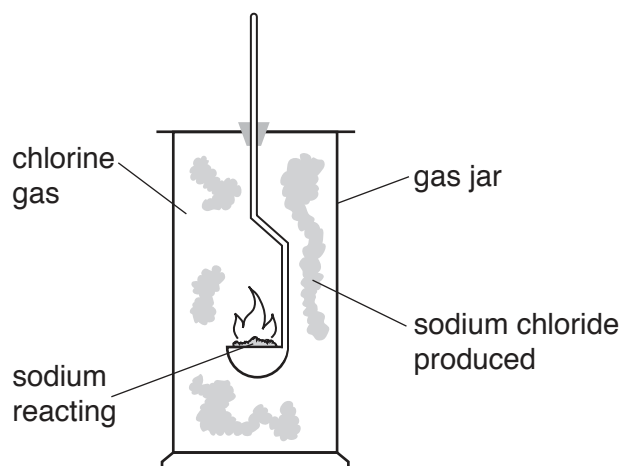


Fig. 12.1

(a) The symbol of a sodium ion is  $\text{Na}^+$ .

The symbol of a chloride ion is  $\text{Cl}^-$ .

(i) Describe, in terms of electron movement, what happens when sodium and chlorine atoms combine.

.....

.....

.....[2]

(ii) Complete Fig. 12.2 to show the arrangement of the ions in solid sodium chloride.

Use symbols  $\text{Na}^+$  and  $\text{Cl}^-$  to label **all** of the particles in Fig. 12.2.

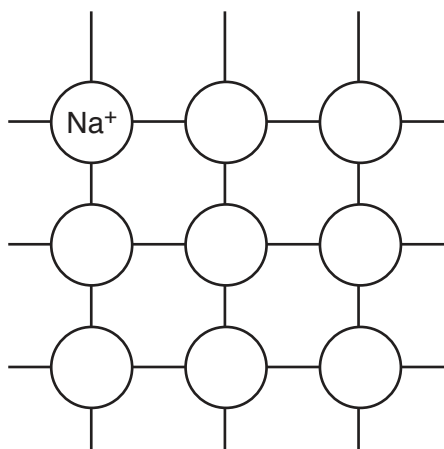


Fig. 12.2

[1]



(b) During electrolysis, an electric current passes through an electrolyte and causes compounds to break up into simpler substances.

(i) Complete Table 12.1 to show the products formed at the inert electrodes during the electrolysis of each electrolyte.

**Table 12.1**

electrolyte	cathode product	anode product
<b>aqueous</b> sodium chloride		
<b>molten</b> sodium chloride		

[2]

(ii) Explain why solid sodium chloride **cannot** be used as an electrolyte.

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

13 A student is climbing a mountain.

(a) During a storm, she sees lightning strike a tree in the distance. Several seconds later she hears the sound of the thunder caused by the lightning.

(i) Explain why she sees the lightning several seconds before she hears the thunder.

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

(ii) The base of the thunder cloud is negatively charged.

Fig. 13.1 shows the cloud above the ground.

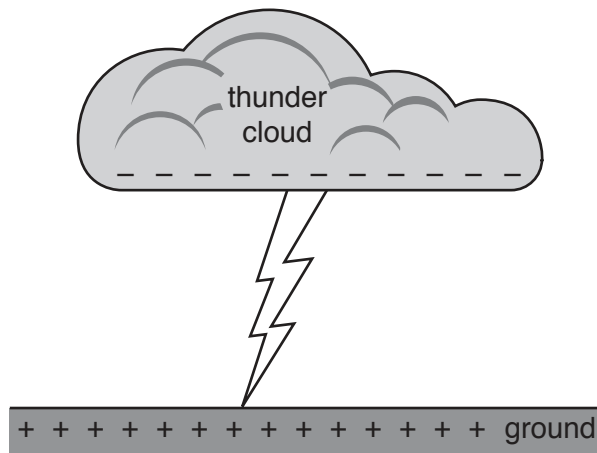


Fig. 13.1

In the space between the negative charge on the cloud and the positive charge on the ground, there is an electric field.

State what is meant by the term *electric field*.

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

(iii) A lightning flash occurs when the thunder cloud loses some of its charge to the ground.

One lightning flash discharges 1.21 C in 0.00011 s.

Calculate the average current that passes between the thunder cloud and the ground.

State the formula you use and show your working.

formula

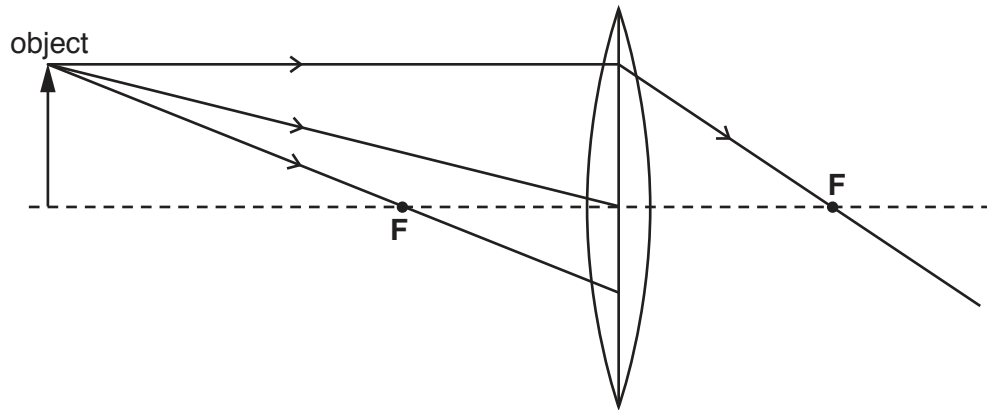
working

current = ..... A [2]

(b) The student uses a camera to take photographs when she reaches the top of the mountain.

The camera uses a converging lens.

Fig. 13.2 shows an incomplete ray diagram for a converging lens forming an image.



**Fig. 13.2**

- (i) On Fig. 13.2, complete the ray diagram to show the three rays of light after they have passed through the lens. One ray has been drawn for you. [1]
- (ii) On Fig. 13.2, draw an arrow ↓ to show where the image is formed. [1]

## The Periodic Table of Elements

		Group																
I	II	III	IV	V	VI	VII	VIII											
3 <b>Li</b> lithium 7	4 <b>Be</b> beryllium 9	1 <b>H</b> hydrogen 1	5 <b>B</b> boron 11	6 <b>C</b> carbon 12	7 <b>N</b> nitrogen 14	8 <b>O</b> oxygen 16	9 <b>F</b> fluorine 19	10 <b>Ne</b> neon 20										
11 <b>Na</b> sodium 23	12 <b>Mg</b> magnesium 24	13 <b>Al</b> aluminium 27	14 <b>Si</b> silicon 28	15 <b>P</b> phosphorus 31	16 <b>S</b> sulfur 32	17 <b>Cl</b> chlorine 35.5	18 <b>Ar</b> argon 40											
19 <b>K</b> potassium 39	20 <b>Ca</b> calcium 40	21 <b>Sc</b> scandium 45	22 <b>Ti</b> titanium 48	23 <b>V</b> vanadium 51	24 <b>Cr</b> chromium 52	25 <b>Mn</b> manganese 55	26 <b>Fe</b> iron 56	27 <b>Co</b> cobalt 59	28 <b>Ni</b> nickel 59	29 <b>Cu</b> copper 64	30 <b>Zn</b> zinc 65	31 <b>Ga</b> gallium 70	32 <b>Ge</b> germanium 73	33 <b>As</b> arsenic 75	34 <b>Se</b> selenium 79	35 <b>Br</b> bromine 80	36 <b>Kr</b> krypton 84	
37 <b>Rb</b> rubidium 85	38 <b>Sr</b> strontium 88	39 <b>Y</b> yttrium 89	40 <b>Zr</b> zirconium 91	41 <b>Nb</b> niobium 93	42 <b>Mo</b> molybdenum 96	43 <b>Tc</b> technetium —	44 <b>Ru</b> ruthenium 101	45 <b>Rh</b> rhodium 103	46 <b>Pd</b> palladium 106	47 <b>Ag</b> silver 108	48 <b>Cd</b> cadmium 112	49 <b>In</b> indium 115	50 <b>Sn</b> tin 119	51 <b>Sb</b> antimony 122	52 <b>Te</b> tellurium 128	53 <b>I</b> iodine 127	54 <b>Xe</b> xenon 131	
55 <b>Cs</b> caesium 133	56 <b>Ba</b> barium 137	57–71 lanthanoids	72 <b>Hf</b> hafnium 178	73 <b>Ta</b> tantalum 181	74 <b>W</b> tungsten 184	75 <b>Re</b> rhenium 186	76 <b>Os</b> osmium 190	77 <b>Ir</b> iridium 192	78 <b>Pt</b> platinum 195	79 <b>Au</b> gold 197	80 <b>Hg</b> mercury 201	81 <b>Tl</b> thallium 204	82 <b>Pb</b> lead 207	83 <b>Bi</b> bismuth 209	84 <b>Po</b> polonium —	85 <b>At</b> astatine —	86 <b>Rn</b> radon —	
87 <b>Fr</b> francium —	88 <b>Ra</b> radium —	89–103 actinoids	104 <b>Rf</b> rutherfordium —	105 <b>Db</b> dubnium —	106 <b>Sg</b> seaborgium —	107 <b>Bh</b> bohrium —	108 <b>Hs</b> hassium —	109 <b>Mt</b> meitnerium —	110 <b>Ds</b> darmstadtium —	111 <b>Rg</b> roentgenium —	112 <b>Cn</b> copernicium —	114 <b>Fl</b> flerovium —	116 <b>Lv</b> livermorium —					
		57 <b>La</b> lanthanum 139	58 <b>Ce</b> cerium 140	59 <b>Pr</b> praseodymium 141	60 <b>Nd</b> neodymium 144	61 <b>Pm</b> promethium —	62 <b>Sm</b> samarium 150	63 <b>Eu</b> europium 152	64 <b>Gd</b> gadolinium 157	65 <b>Tb</b> terbium 159	66 <b>Dy</b> dysprosium 163	67 <b>Ho</b> holmium 165	68 <b>Er</b> erbium 167	69 <b>Tm</b> thulium 169	70 <b>Yb</b> ytterbium 173	71 <b>Lu</b> lutetium 175		
		89 <b>Ac</b> actinium	90 <b>Th</b> thorium 232	91 <b>Pa</b> protactinium 231	92 <b>U</b> uranium 238	93 <b>Np</b> neptunium —	94 <b>Pu</b> plutonium —	95 <b>Am</b> americium —	96 <b>Cm</b> curium —	97 <b>Bk</b> berkelium —	98 <b>Cf</b> californium —	99 <b>Es</b> einsteinium —	100 <b>Fm</b> fermium —	101 <b>Md</b> mendelevium —	102 <b>No</b> nobelium —	103 <b>Lr</b> lawrencium —		

## Key

atomic number  
atomic symbol  
name  
relative atomic mass

lanthanoids

actinoids

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