Cambridge IGCSE

Cambridge International Examinations
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

8381579826

CO-ORDINATED SCIENCES **0654/31**

Paper 3 (Extended) **October/November 2015**

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, graphs, tables or rough working.
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.

This document consists of **30** printed pages and **2** blank pages.

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CAMBRIDGE
International Examinations

[Turn over

1 **(a)** In the Periodic Table the elements are organised into groups and periods. A copy of the Periodic Table is shown on page 32.

(i) State the total number of elements in the **period** that includes nitrogen, N.

.... [1]

(ii) Fig. 1.1 shows the electron arrangement and the number of protons in one atom of nitrogen.

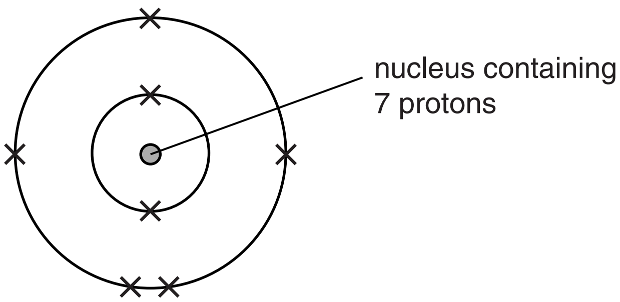


Fig. 1.1

Name the other type of sub-atomic particle contained in this nucleus.

.... [1]

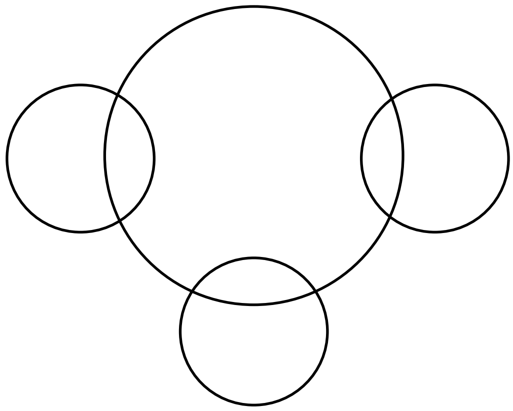
(iii) Draw a diagram, similar to Fig. 1.1, to show an atom of the element phosphorus, P.

[2]

(b) Hydrogen, proton number 1, combines with nitrogen to produce the covalent compound ammonia, NH_3.

Complete the covalent bonding diagram of one molecule of ammonia to show

- the chemical symbols of each atom,
- how the outer electrons of each atom are arranged.



[2]

(c) Ammonia is made in industry by reacting nitrogen and hydrogen together on the surface of a solid material containing iron.

A simplified diagram of the process is shown in Fig. 1.2.

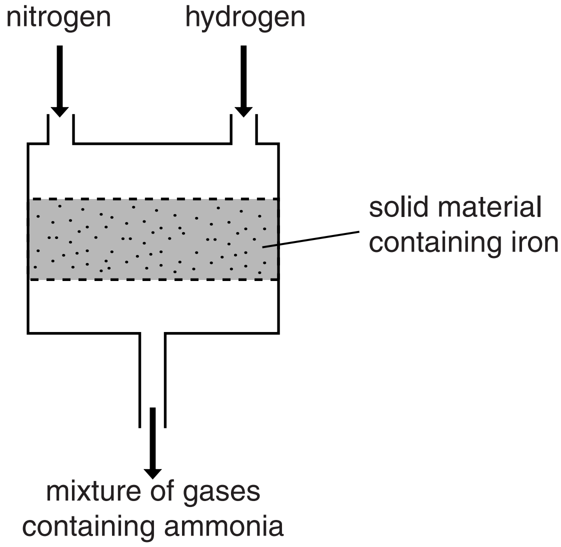


Fig. 1.2

(i) State the name of the industrial process shown in Fig. 1.2.

.... [1]

(ii) Hydrogen gas for the process is produced by reacting methane, CH_4, with steam, H_2O.

In this reaction, each molecule of methane reacts with **one** of the molecules in steam. The reaction produces **three** molecules of hydrogen.

Deduce the balanced symbol equation for this reaction.

.... [3]

(iii) State the purpose of the solid material containing iron that is used in the process shown in Fig. 1.2.

.... [1]

2 Fig. 2.1 shows a plant cell from a leaf.

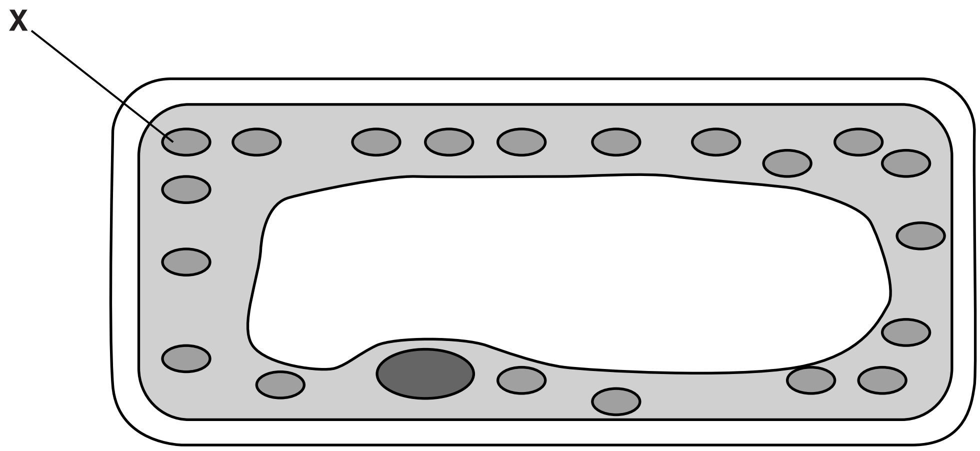


Fig. 2.1

(a) Name the part of the cell labelled **X**.

.... [1]

(b) State the energy transformation that occurs at **X** when the leaf is photosynthesising.

.... energy to .... energy [2]

(c) **(i)** Explain why a living leaf cell of this type

- produces oxygen in bright light, ...

....

....

- produces carbon dioxide in the dark, ...

....

....

- may produce neither oxygen nor carbon dioxide in dim light. ....

....

....

[3]

(ii) Explain why photosynthesis does not occur in xylem in the leaves.

....

.... [1]

3 A skier moves across the snow.

(a) The skier notices that some of the snow and ice is melting into water.

Ice is a solid and water is a liquid.

Fig. 3.1 shows three different ways in which particles may be arranged in substances.

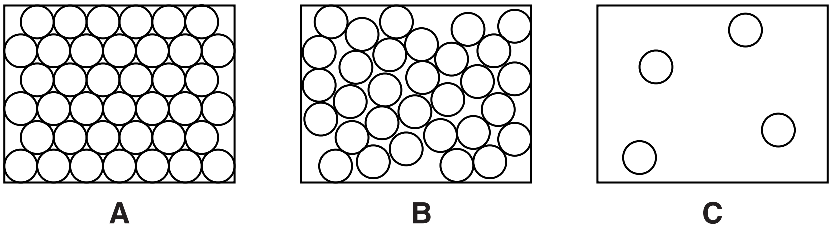


Fig. 3.1

State which diagram best represents the way particles are arranged in a liquid.

Explain your answer.

diagram ....

explanation ....

.... [1]

(b) The skier notices that some of the water evaporates.

(i) Outline **one** way in which the water could be made to evaporate faster.

....

.... [1]

(ii) The water evaporates but does not boil.

State **two** ways in which boiling differs from evaporation.

1 ....

....

2 ....

.... [2]

(c) The skier is staying in a remote ski lodge. The ski lodge receives 18 kW of electrical power from a 220 V supply.

(i) Calculate the electrical energy supplied to the ski lodge in one hour.

State the formula that you use and show your working.

formula

working

energy = ... [2]

(ii) The power supply to the ski lodge is from a nearby step-down transformer that is connected to long distance transmission cables. The voltage of the transmission cables is very much higher than 220 V.

Explain why the energy losses in the transmission cables are lower when the voltage is high.

....

....

.... [2]

(iii) State what is meant by a *step-down* transformer.

....

.... [1]

4 **(a)** Define the term *mutation*.

....

....[1]

(b) Fig. 4.1 shows some fruit flies. Fruit flies are insects that feed on fruit.

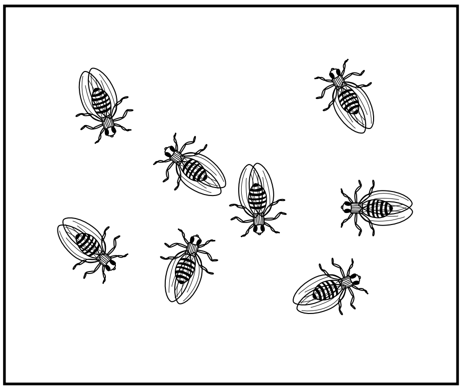


Fig. 4.1

Some fruit flies were exposed to a chemical that causes mutations. Later, when these fruit flies reproduced, some of their offspring had unusually small wings, as shown in Fig. 4.2.

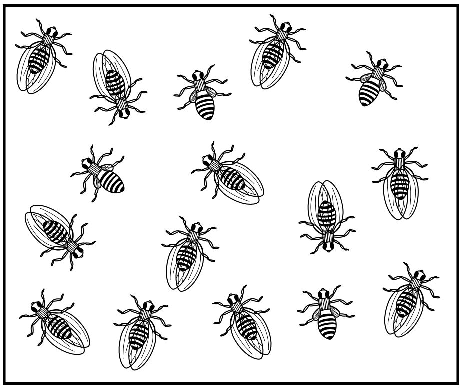


Fig. 4.2

(i) Explain, in terms of mutations, why some of the offspring had unusually small wings after their parents had been exposed to the chemical.

....

....

.... [2]

(ii) State **one** other way in which mutations can be caused, other than by exposure to chemicals.

.... [1]

(iii) Flies with small wings are less well suited to their environment than normal-winged flies. Suggest a reason for this.

....

.... [1]

(c) Use the words in the list to complete the sentences about the fruit flies described in part **(b)**. You may use each word once, more than once, or not at all.

adapted **alleles** **die** **eggs** **integrated**

resources **selection** **survive**

Fruit flies with small wings are less well .... to their

surroundings, and so are less likely to .... than normal flies.

This means that they are unlikely to pass on their .... to the next

generation. This is natural ....

[4]

5 **(a)** A colourless gas contained in a flask is either propane or propene.

(i) The gas is shaken with bromine solution.

Describe the observation, if any, that would be made if the gas is

- propane, ...

....

- propene. ....

.... [2]

(ii) Describe **one** difference between the structures of propane and propene molecules.

....

.... [1]

(b) Ethanol, C_2H_6O, is produced from glucose, $C_6H_{12}O_6$, in a fermentation reaction.

The balanced equation below shows the conversion of glucose to ethanol.

$$C_6H_{12}O_6(aq) \longrightarrow 2\ C_2H_6O(aq) + 2\ CO_2(g)$$

The fermentation reaction starts when yeast is added to the aqueous solution of glucose.

Fig. 5.1 shows apparatus that can be used for the reaction.

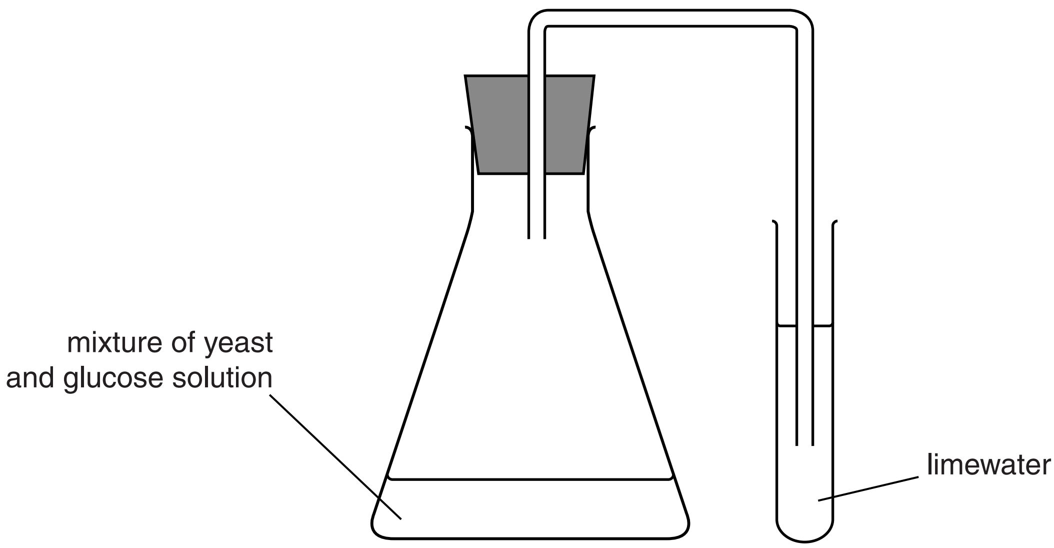


Fig. 5.1

(i) Describe how and explain why the appearance of the limewater changes during the fermentation reaction.

change ....

explanation ....

.... [2]

(ii) Calculate the relative molecular mass of glucose, $C_6H_{12}O_6$.

Show your working.

relative molecular mass = ... [1]

(iii) Calculate the mass of glucose that has to be dissolved in $5.0\,dm^3$ of water to produce a solution whose concentration is $3.5\,mol/dm^3$.

Show your working.

mass of glucose = ...g [2]

(c) **(i)** Name the element present in **all** amino acids but **not** in ethanol.

.... [1]

(ii) Many different amino acids exist in nature.

Name the compound that is formed when amino acids link together in a condensation polymerisation reaction.

.... [1]

6 (a) Fig. 6.1 shows an endoscope being used to observe the inside of a patient's stomach.

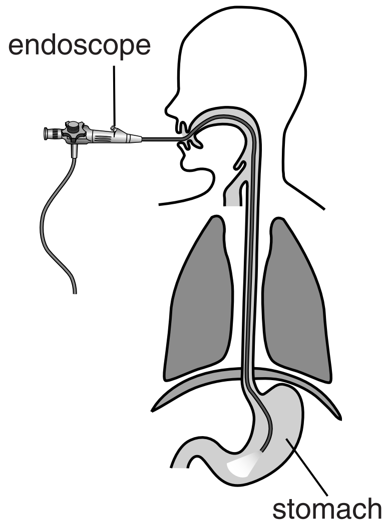


Fig. 6.1

Light passes through the endoscope to the stomach along optical fibres.

Describe how light passes along optical fibres.

Use the terms *total internal reflection* and *critical angle* in your answer.

....

....

....

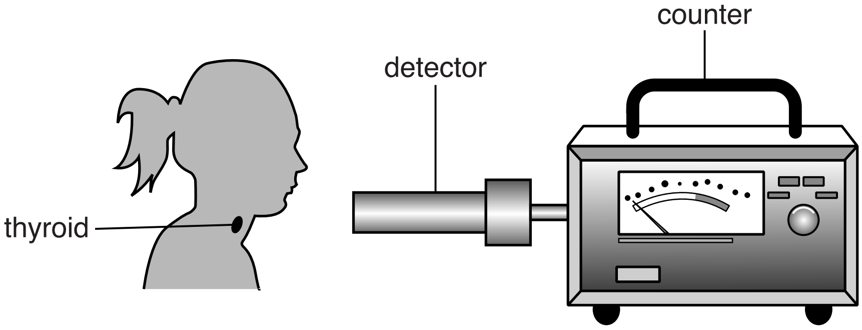
....

.... [2]

(b) The radioactive isotope iodine-123 is used by a doctor to examine the thyroid gland of a patient.

The patient takes a pill containing iodine-123, which is absorbed by the thyroid gland.

Iodine-123 emits γ-radiation which is detected outside the body.



(i) Explain why the doctor uses an isotope emitting γ-radiation to examine the thyroid gland rather than an isotope emitting α-radiation or β-radiation.

....

.... [1]

(ii) Iodine-123 has a half-life of 13 hours. A sample of this isotope has an activity of 800 counts per minute.

Write down the time taken for the activity to fall to 400 counts per minute.

.... hours [1]

(iii) Calculate the activity after 52 hours.

Show your working.

activity = ... counts per minute [2]

7 Fig. 7.1 shows the human nervous system.

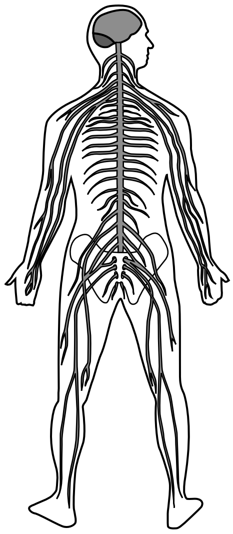


Fig. 7.1

(a) On Fig. 7.1, draw an arrow ending on any part of the peripheral nervous system. [1]

(b) A boy touches a hot plate, and quickly withdraws his hand.

(i) This is an example of a reflex action. State what is meant by a *reflex action*.

....

....

.... [2]

(ii) Describe how the peripheral nervous system is involved in this action.

....

....

.... [2]

(c) Describe how the nervous system usually differs from the hormonal control system in terms of

(i) the length of time that a response lasts, ...

.... [1]

(ii) the way in which information travels through the body. ....

....

.... [2]

8 **(a)** The bodywork of a car is often made of steel. If the bodywork has been damaged, the surface is repaired with a plastic filler.

A car mechanic can use a magnet to find out if parts of the bodywork have been filled with plastic filler.

He tests two areas of the car by placing a magnet near the surface. This is shown in Fig. 8.1.

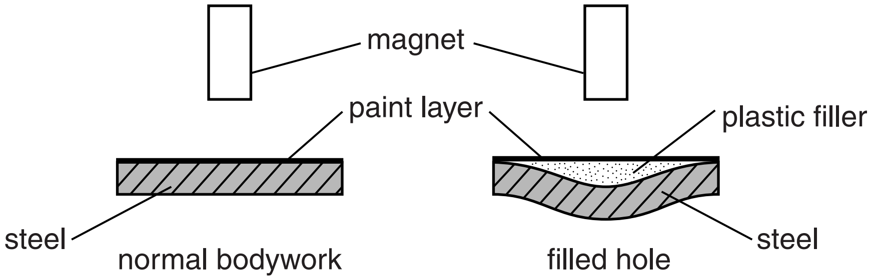


Fig. 8.1

(i) Explain how the magnet helps the mechanic to tell the difference between the normal bodywork and the filled hole.

....

.... [1]

(ii) Some cars have bodywork made from aluminium.

State whether the method you described in **(a)(i)** would work.

Explain your answer.

....

.... [1]

(b) A car has two headlights. The lamp inside each headlight is connected in parallel with the other lamp across a 12 V battery.

The resistance of each lamp is 2.5 Ω.

(i) Calculate the current passing through each lamp.

State the formula that you use and show your working. State the unit of your answer.

formula

working

current = ... unit .... [3]

(ii) The current that you calculated in **(b)(i)** flows through both lamps for 1 minute.

Calculate the total charge that flows through the two lamps.

State the formula that you use and show your working.

formula

working

charge = ... C [2]

(iii) Calculate the combined resistance of the two lamps connected in parallel.

State the formula that you use and show your working.

formula

working

resistance = ... Ω [2]

(c) The car radiator contains 4 dm^3 of water.

The mass of 1 dm^3 of water is 1 kg.

The specific heat capacity of water is 4200 J / kg °C.

Calculate the number of joules of energy needed to raise the temperature of the water from 10 °C to 90 °C.

State the formula that you use and show your working.

formula

working

energy = ... J [2]

9 Fig. 9.1 shows the industrial method used to obtain aluminium.

In this method an electric current is passed through a molten electrolyte which contains aluminium oxide.

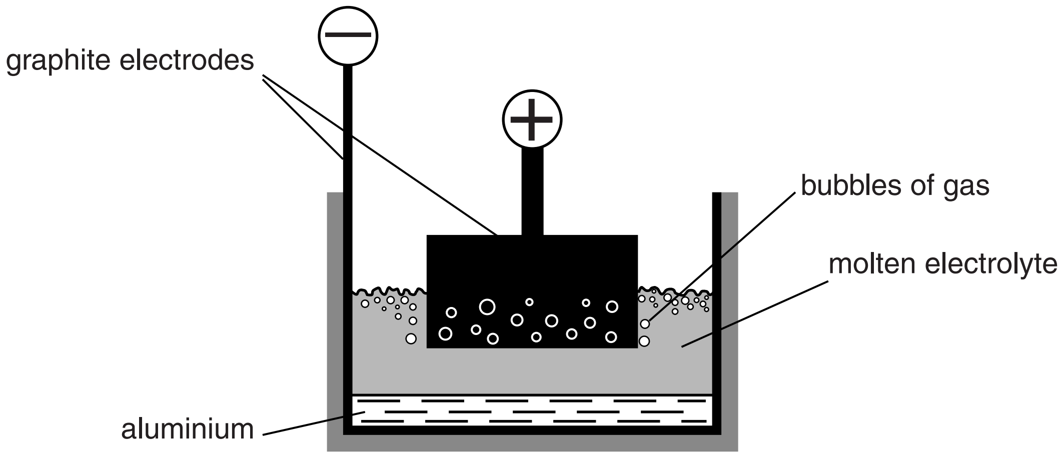


Fig. 9.1

(a) Name the process shown in Fig. 9.1.

.... [1]

(b) Aluminium ions move towards the negative electrode where they are converted to aluminium atoms.

Aluminium **ions** have the electron configuration, 2,8.

(i) Explain why aluminium **ions** move towards the negative electrode.

....

.... [1]

(ii) Describe how aluminium ions are converted to aluminium atoms.

....

....

.... [2]

(c) Aluminium reacts with iron oxide to release iron.

The word equation for this reaction is

$$\text{aluminium} + \text{iron oxide} \longrightarrow \text{aluminium oxide} + \text{iron}$$

(i) The chemical formula of iron oxide is Fe_2O_3 and the formula of an oxide ion is O^{2-}.

Deduce the charge of the iron ions in iron oxide, Fe_2O_3.

Show your working.

charge of iron ion = ... [2]

(ii) Use the information above and your knowledge of the reactivity series to deduce whether or not aluminium reacts with copper oxide to release copper.

Explain your answer.

....

....

.... [2]

10 Some river animals can be used as 'indicator species'. This means that the presence of these species in a river indicates how polluted the water is.

Fig. 10.1 shows, for different pollution levels, the animals that are likely to be found in a river.

pollution level	species present at each pollution level
no pollution	← stonefly nymphs
↑	← mayfly larvae
	← caddis flies
	← freshwater shrimps
	← water lice
↓	← bloodworms
high pollution	← sludgeworms

Fig. 10.1

(a) From Fig. 10.1, name an animal whose presence indicates that a river is only slightly polluted.

.... [1]

(b) A farmer allowed fertiliser to pollute a river at one point.

Fig. 10.2 shows how the numbers of freshwater shrimps, mayfly larvae and sludgeworms changed along the stretch of the river where this pollution occurred.

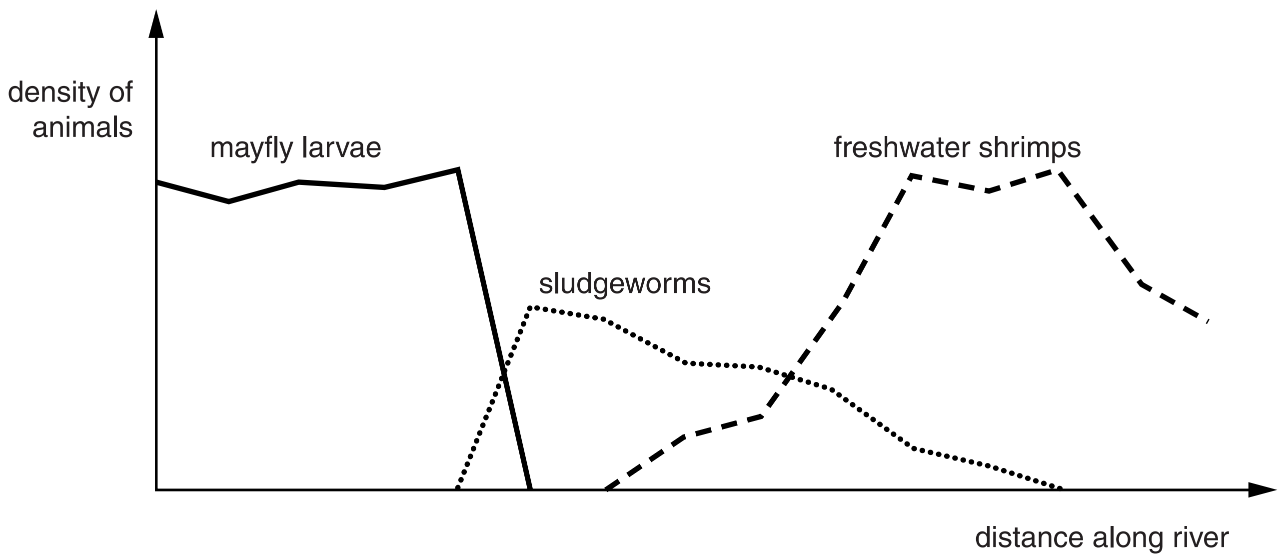


Fig. 10.2

(i) On Fig. 10.2, suggest a point at which the pollution occurred. Indicate this with an arrow. [1]

(ii) Suggest and explain why stonefly nymphs might be killed in a river polluted with

- sewage, ...

....

....

- chemical waste. ....

....

....
[3]

(c) Acid rain is another pollutant that can be harmful to animals in rivers.

(i) State what is meant by acid rain.

.... [1]

(ii) Suggest **two** different ways in which the incidence of acid rain could be reduced.

1 ....

2 .... [2]

11 **(a)** An elephant of mass 4000 kg moves at 0.4 m / s.

Calculate the kinetic energy of the elephant.

State the formula that you use and show your working.

formula

working

kinetic energy = ... J [2]

(b) The elephant lifts a log of weight 3000 N through a vertical distance of 2 metres.

Calculate the work done by the elephant.

State the formula that you use and show your working.

formula

working

work done = ... J [2]

(c) The elephant weighs 40 000 N and stands with all four feet in contact with the ground. Each foot of the elephant has an area of 400 cm^2.

(i) Calculate the pressure, in N / cm^2, exerted by the elephant on the ground.

State the formula that you use and show your working.

formula

working

pressure = ... N / cm^2 [2]

(ii) Write down the pressure which you calculated in **(c)(i)** in Pa.

pressure = ... Pa [1]

(d) An elephant can communicate with other elephants using infrasound. This is a very low frequency vibration, which is usually impossible for a human to hear.

(i) Suggest a possible frequency for the infrasound used by the elephant.

Explain why you chose your answer.

frequency = ... Hz

explanation ....

.... [1]

(ii) Sound travels through the air as longitudinal waves.

Describe how the air particles move when a sound passes.

You may draw a diagram if it helps your answer.

....

....

.... [2]

(e) Two elephants, **A** and **B**, use infrasound waves to communicate over a long distance. The distance between the two elephants is 3000 m. This is shown in Fig. 11.1.

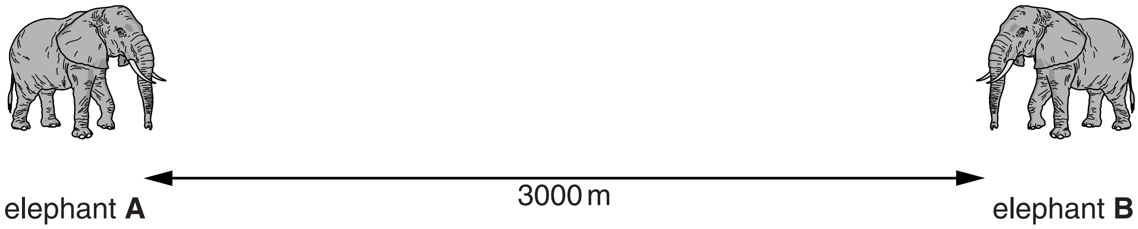


Fig. 11.1

Elephant **A** emits an infrasound noise. When elephant **B** hears the infrasound, it calls back immediately. Elephant **A** hears the answering call from elephant **B**.

The speed of infrasound in air is 330 m/s.

Calculate the minimum time for elephant **A** to call and hear an answer from elephant **B**.

State the formula that you use and show your working.

formula

working

time = ... s [2]

(f) Fig. 11.2 shows a small model elephant made of gold.

Fig. 11.2

Describe a method for measuring the volume of this small model elephant.

....

....

.... [2]

12 Salts are produced when acids are neutralised.

(a) Using **only** substances chosen from the list, complete the word equations for the reactions that produce the two salts, magnesium sulfate and zinc sulfate. Each substance may be used once, more than once or not at all.

hydrochloric acid **hydrogen** **magnesium**

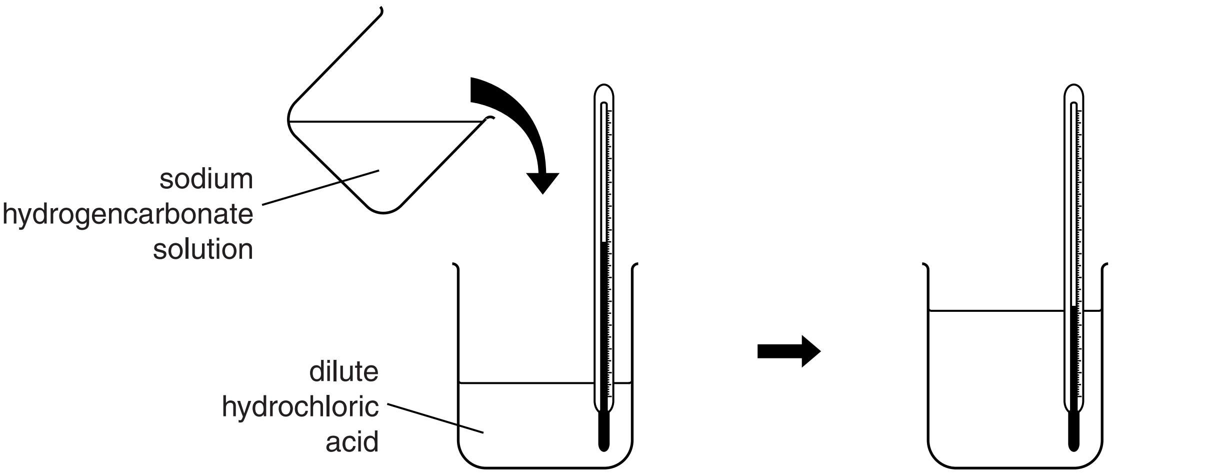
magnesium carbonate **magnesium oxide** **sulfuric acid**

water **zinc** **zinc carbonate** **zinc oxide**

	+		→	magnesium sulfate	+	hydrogen		
	+		→	zinc sulfate	+	carbon dioxide	+	

[2]

(b) Fig. 12.1 shows what happens to the temperature when sodium hydrogencarbonate solution reacts with dilute hydrochloric acid.



temperature of reactants = 25 °C temperature of products = 21 °C

Fig. 12.1

(i) Complete the boxes to show the type of energy transformation that occurs in this reaction.

.... energy → .... energy [1]

(ii) Explain your answer to **(b)(i)**.

....

.... [1]

(c) Fig. 12.2 shows apparatus a student uses to investigate the rate of reaction between calcium carbonate and excess dilute hydrochloric acid.

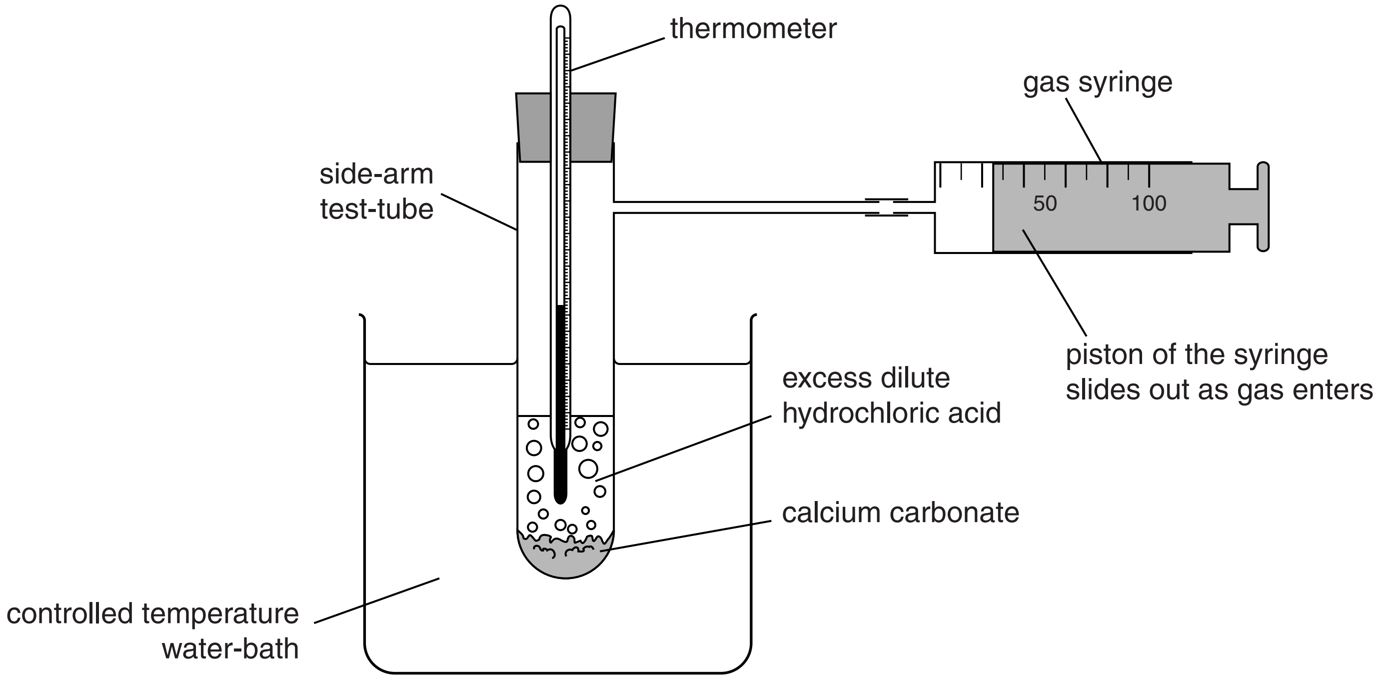


Fig. 12.2

The student obtains data using the following method.

- She pushes the piston completely into the gas syringe.
- She adds a known amount of dilute hydrochloric acid to the side-arm test-tube and checks that the temperature is steady.
- She adds a known mass of calcium carbonate to the side-arm test-tube, places the bung in position and starts her stopwatch.
- She records the volume of gas in the gas syringe every 10 seconds for 90 seconds.

Fig. 12.3 shows a graph of her results.

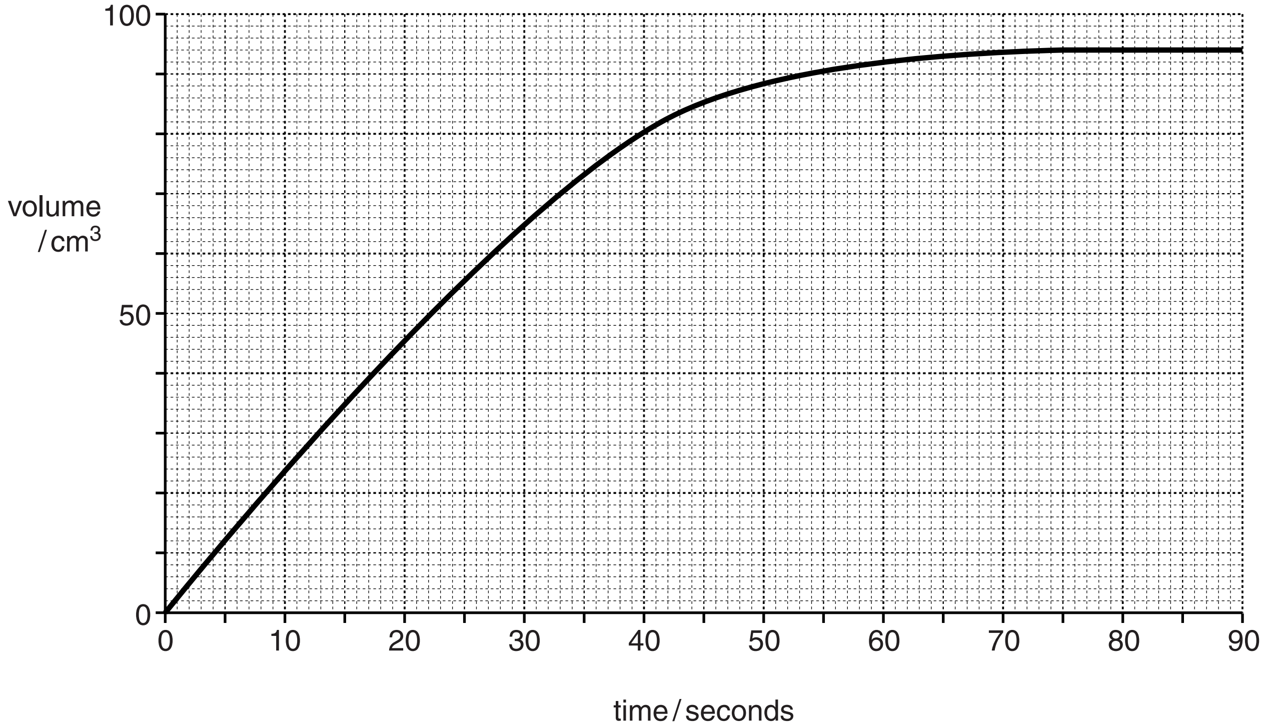


Fig. 12.3

(i) Explain the shape of the graph between 75 and 90 seconds.

....

....

.... [2]

(ii) The student repeated her experiment but this time she uses **half** of the mass of calcium carbonate used in the first experiment. She made sure that all the other variables have the same values as in the first experiment.

On Fig. 12.3 sketch the graph of her results from the second experiment. [3]

(iii) Explain in terms of collisions why the rate of the reaction increases when the temperature of the acid is increased.

....

....

....

.... [2]

13 A student removed the stamen from a flower and placed it on a microscope slide. She squashed the tip of the stamen, causing a sticky yellow powder to come out.

She then used a hand lens to examine the stamen. Fig. 13.1 is a drawing of what she saw, with one part greatly magnified.

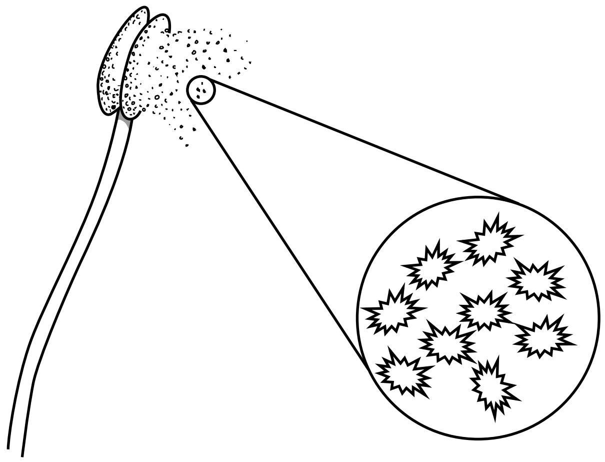


Fig. 13.1

(a) On Fig. 13.1, label an anther. [1]

(b) Name the yellow powder, and explain its function.

name ....

function ....

.... [2]

(c) This flower is insect pollinated.

State **two** ways in which you would expect the flower to be adapted for insect pollination.

1 ....

2 .... [2]

(d) Fig. 13.2 shows some fruits from the same plant.

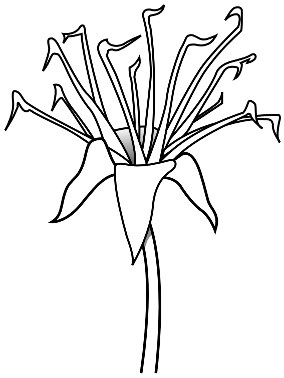


Fig. 13.2

(i) Suggest how these fruits are dispersed away from the parent plant. Give a reason for your answer.

....

....

.... [2]

(ii) State what you would find inside one of these fruits if it is opened up.

.... [1]

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DATA SHEET
The Periodic Table of the Elements

Group

I	II											III	IV	V	VI	VII	0
							1 **H** Hydrogen 1										4 **He** Helium 2
7 **Li** Lithium 3	9 **Be** Beryllium 4											11 **B** Boron 5	12 **C** Carbon 6	14 **N** Nitrogen 7	16 **O** Oxygen 8	19 **F** Fluorine 9	20 **Ne** Neon 10
23 **Na** Sodium 11	24 **Mg** Magnesium 12											27 **Al** Aluminium 13	28 **Si** Silicon 14	31 **P** Phosphorus 15	32 **S** Sulfur 16	35.5 **Cl** Chlorine 17	40 **Ar** Argon 18
39 **K** Potassium 19	40 **Ca** Calcium 20	45 **Sc** Scandium 21	48 **Ti** Titanium 22	51 **V** Vanadium 23	52 **Cr** Chromium 24	55 **Mn** Manganese 25	56 **Fe** Iron 26	59 **Co** Cobalt 27	59 **Ni** Nickel 28	64 **Cu** Copper 29	65 **Zn** Zinc 30	70 **Ga** Gallium 31	73 **Ge** Germanium 32	75 **As** Arsenic 33	79 **Se** Selenium 34	80 **Br** Bromine 35	84 **Kr** Krypton 36
85 **Rb** Rubidium 37	88 **Sr** Strontium 38	89 **Y** Yttrium 39	91 **Zr** Zirconium 40	93 **Nb** Niobium 41	96 **Mo** Molybdenum 42	**Tc** Technetium 43	101 **Ru** Ruthenium 44	103 **Rh** Rhodium 45	106 **Pd** Palladium 46	108 **Ag** Silver 47	112 **Cd** Cadmium 48	115 **In** Indium 49	119 **Sn** Tin 50	122 **Sb** Antimony 51	128 **Te** Tellurium 52	127 **I** Iodine 53	131 **Xe** Xenon 54
133 **Cs** Caesium 55	137 **Ba** Barium 56	139 **La** Lanthanum 57 *	178 **Hf** Hafnium 72	181 **Ta** Tantalum 73	184 **W** Tungsten 74	186 **Re** Rhenium 75	190 **Os** Osmium 76	192 **Ir** Iridium 77	195 **Pt** Platinum 78	197 **Au** Gold 79	201 **Hg** Mercury 80	204 **Tl** Thallium 81	207 **Pb** Lead 82	209 **Bi** Bismuth 83	209 **Po** Polonium 84	210 **At** Astatine 85	222 **Rn** Radon 86
223 **Fr** Francium 87	226 **Ra** Radium 88	227 **Ac** Actinium 89 †															
			140 **Ce** Cerium 58	141 **Pr** Praseodymium 59	144 **Nd** Neodymium 60	147 **Pm** Promethium 61	150 **Sm** Samarium 62	152 **Eu** Europium 63	157 **Gd** Gadolinium 64	159 **Tb** Terbium 65	162 **Dy** Dysprosium 66	165 **Ho** Holmium 67	167 **Er** Erbium 68	169 **Tm** Thulium 69	173 **Yb** Ytterbium 70	175 **Lu** Lutetium 71
			232 **Th** Thorium 90	231 **Pa** Protactinium 91	238 **U** Uranium 92	237 **Np** Neptunium 93	244 **Pu** Plutonium 94	243 **Am** Americium 95	247 **Cm** Curium 96	247 **Bk** Berkelium 97	251 **Cf** Californium 98	252 **Es** Einsteinium 99	257 **Fm** Fermium 100	258 **Md** Mendelevium 101	259 **No** Nobelium 102	260 **Lr** Lawrencium 103

* 58–71 Lanthanoid series
† 90–103 Actinoid series

Key

a **X** b	a = relative atomic mass **X** = atomic symbol b = atomic (proton) number

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