Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

2261939115

CO-ORDINATED SCIENCES **0654/42**

Paper 4 Theory (Extended) **May/June 2021**

2 hours

You must answer on the question paper.

No additional materials are needed.

INSTRUCTIONS

- Answer **all** questions.
- Use a black or dark blue pen. You may use an HB pencil for any diagrams or graphs.
- Write your name, centre number and candidate number in the boxes at the top of the page.
- Write your answer to each question in the space provided.
- Do **not** use an erasable pen or correction fluid.
- Do **not** write on any bar codes.
- You may use a calculator.
- You should show all your working and use appropriate units.

INFORMATION

- The total mark for this paper is 120.
- The number of marks for each question or part question is shown in brackets [ ].
- The Periodic Table is printed in the question paper.

This document has **28** pages. Any blank pages are indicated.

[Turn over

1 (a) Some plant cells are immersed in a **concentrated** salt solution.

Fig. 1.1 is a photomicrograph showing the appearance of the cells.

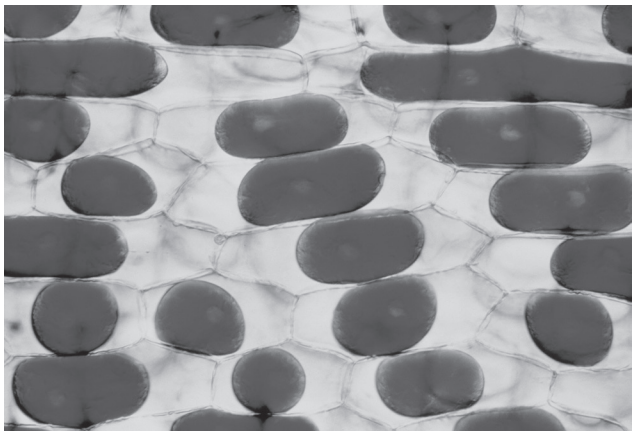


Fig. 1.1

Complete the sentences using words or phrases from the list to explain the appearance of the cells in Fig. 1.1.

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

active transport **a higher** **a lower** **osmosis**

plasmolysis **the same** **turgor**

The solution outside the cell has ..... water potential than the cells.

Water diffuses across the cell membrane by ..... from high water potential to low water potential.

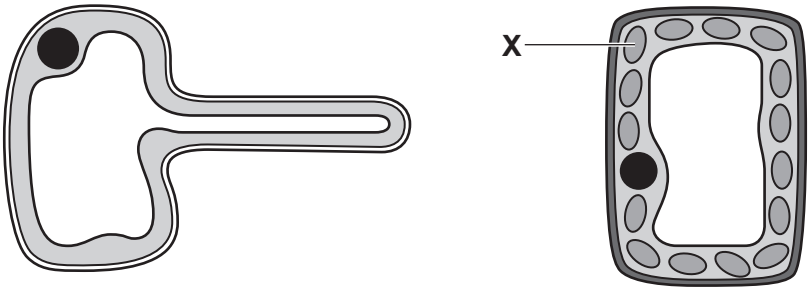
This reduces the ..... pressure of the cells.

The cytoplasm is pulled away from the cell wall.

This is called ..... .

[4]

(b) Fig. 1.2 shows two specialised plant cells.



root hair cell palisade cell

Fig. 1.2

(i) Name the cell structure labelled **X** in Fig. 1.2.

..... [1]

(ii) Explain why cell structure **X** is **not** needed in root hair cells.

.....

.....

..... [2]

(iii) Use Fig. 1.2 to identify two cell structures found in root hair cells but **not** in animal cells.

1 .....

2 .....
[2]

(c) Fig. 1.3 is a photomicrograph of a type of specialised animal cell.

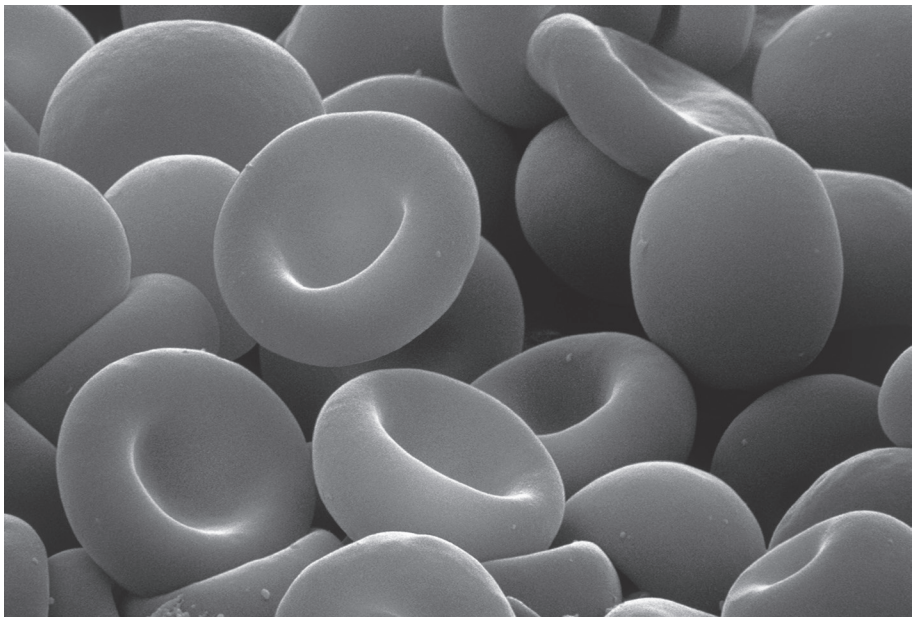


Fig. 1.3

(i) Name the cells shown in Fig. 1.3.

..... [1]

(ii) Describe two ways the cells shown in Fig. 1.3 are adapted for their function.

1 .....

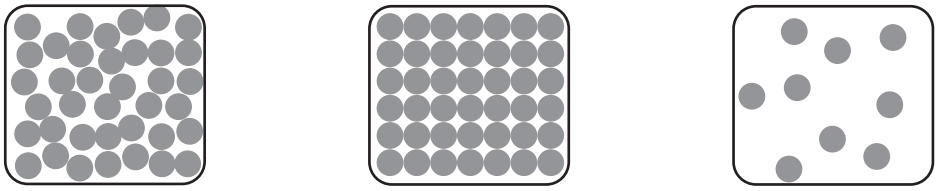
2 .....
[2]

[Total: 12]

2 Solid, liquid and gas are three states of matter.

(a) Fig. 2.1 shows the arrangements of particles in these three states.

Complete Fig. 2.1 by writing under each box the name of the state of matter shown.



.... [2]

Fig. 2.1

(b) An ice cube is left in a cup in a warm room.

After a few hours liquid water can be seen in the cup.

State the name of the process that has occurred in the cup.

..... [1]

(c) The freezing point of water is 0 °C.

Describe how the **movement** and **arrangement** of water particles change when water is cooled from 10 °C to –10 °C.

.....

.....

..... [2]

(d) Water, H_2O, is a covalent molecule.

Complete the dot-and-cross diagram in Fig. 2.2 to show the bonding in a water molecule.

You only need to show the outer shell electrons.

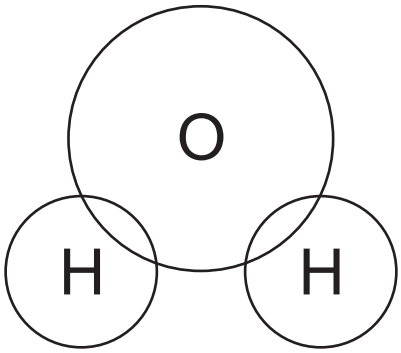


Fig. 2.2

[2]

[Total: 7]

3 **(a)** Fig. 3.1 shows a student observing an exploding firework.

Fig. 3.1

The firework produces light and sound at the same time.

The student measures the time between seeing the light and hearing the sound.

(i) It takes 3.50 seconds for the student to hear the sound.

Calculate the distance between the student and the firework.

The speed of sound in air is 340 m / s.

distance = ... m [2]

(ii) Suggest an appropriate measuring instrument the student uses to measure the time it takes to hear the sound.

..... [1]

(iii) Explain why this method cannot be used to measure the speed of light.

..... [1]

(b) Fig. 3.2 shows a ray of light being refracted as it passes from air into glass.

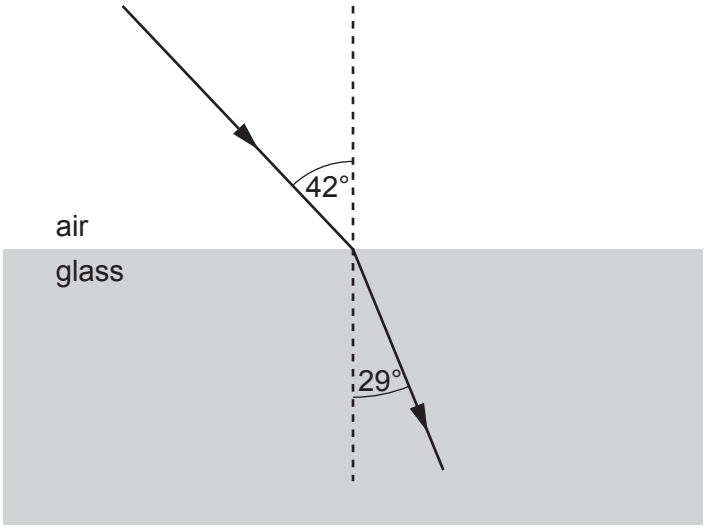


Fig. 3.2

Calculate the refractive index of the glass block.

State the formula you use and show your working.

Give your answer to **two** significant figures.

refractive index = ... [3]

(c) Fig. 3.3 shows an accurate diagram of a ray of light passing into an optical fibre.

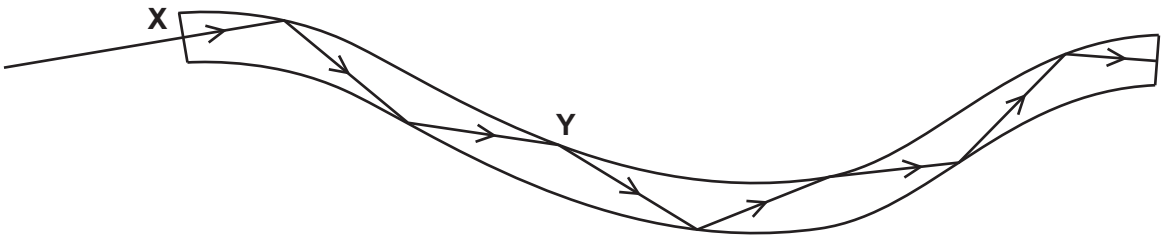


Fig. 3.3

(i) Explain why the ray does not change direction at point **X** on Fig. 3.3.

.....

..... [1]

(ii) State the full name of the type of reflection that occurs at point **Y** on Fig. 3.3.

..... [1]

(iii) State **one** use for optical fibres.

..... [1]

[Total: 10]

4 **(a)** Anaerobic respiration in yeast produces carbon dioxide.

A scientist investigates the effect of using different types of sugar on the volume of carbon dioxide produced by yeast in one minute.

The results are shown in Fig. 4.1.

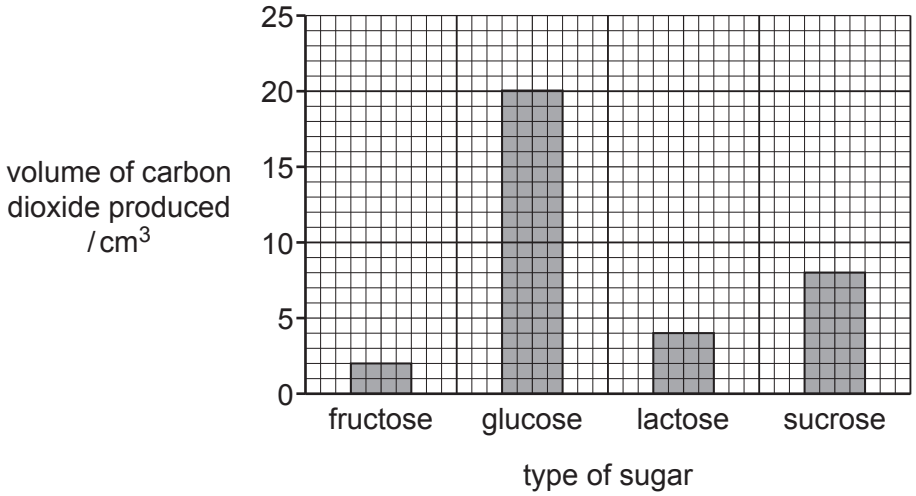


Fig. 4.1

(i) Compare the results for the different types of sugar.

Include comparative data from Fig. 4.1 in your answer.

.....

.....

.....

.....

.....

..... [3]

(ii) State one other product of anaerobic respiration in yeast.

..... [1]

(iii) State the word equation for the anaerobic respiration in **muscles**.

..... [2]

(b) Carbon dioxide produced by yeast causes bread to rise.

The temperature used during bread-making is carefully controlled.

At very high temperatures no carbon dioxide is produced.

Explain why.

Use ideas about enzymes in your answer.

.....

.....

.....

..... [2]

[Total: 8]

5 Ammonia, NH_3, is made in factories by the Haber process.

Fig. 5.1 shows how ammonia is made.

Nitrogen gas and hydrogen gas are the starting materials.

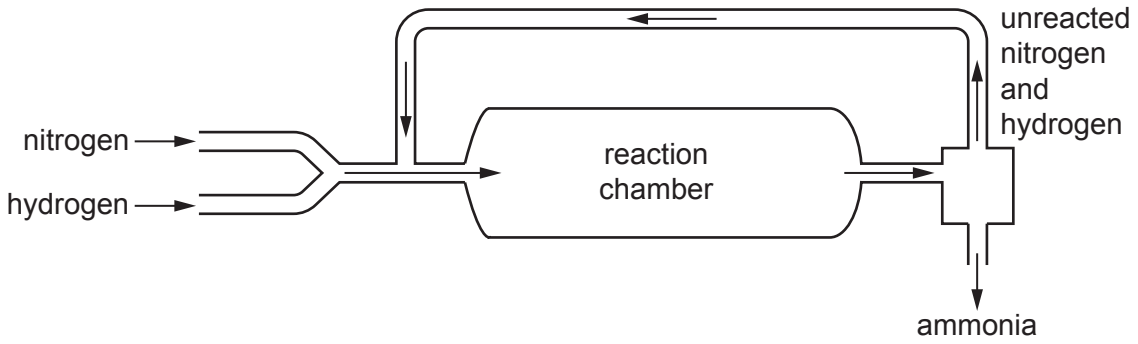


Fig. 5.1

(a) Describe the Haber process.

You should include:

- the sources of nitrogen gas and hydrogen gas
- the conditions used
- what the ammonia is used for.

.....

.....

.....

.....

..... [4]

(b) A factory making ammonia wants to make 680 kg of ammonia.

The balanced symbol equation for the reaction is shown.

$$N_2 + 3H_2 \rightleftharpoons 2NH_3$$

(i) Calculate the mass of hydrogen, H_2, that is needed to make 680 kg of ammonia, NH_3.

[A_r: H, 1; N, 14]

mass of hydrogen = ... kg [2]

(ii) State the chemical test and its positive result for hydrogen gas.

test .....

result .....
[2]

(iii) 560 kg of nitrogen gas, N_2, are needed in the factory.

Calculate the volume of nitrogen gas needed.

The molar gas volume is 24 dm^3 at room temperature and pressure (r.t.p.).

Show your working.

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

[Total: 11]

6 **(a)** Metals are good conductors of thermal energy.

Describe the two mechanisms of energy transfer that make metals good thermal conductors.

1 .....

.....

2 .....

.....
[2]

(b) A student investigates how the surface colour of an object affects how fast the object loses thermal energy.

Fig. 6.1 shows the equipment used.

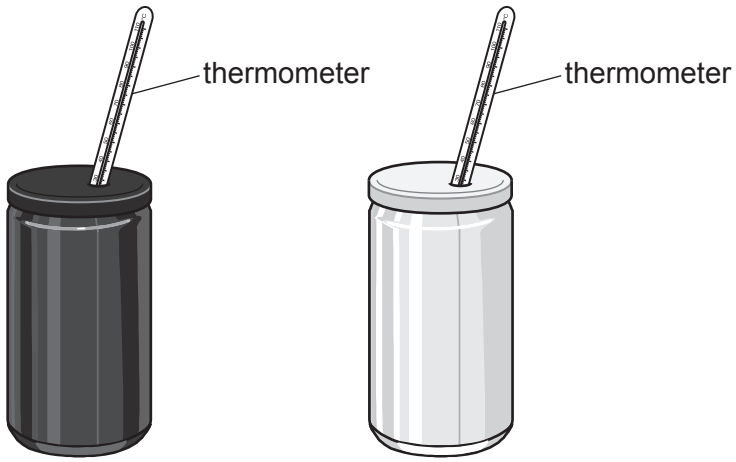


Fig. 6.1

She uses two identical aluminium cans one of which has been painted black and the other white.

She fills both cans with an equal volume of hot water at the same temperature and records the temperature of the water every minute for 60 minutes.

Fig. 6.2 shows her results.

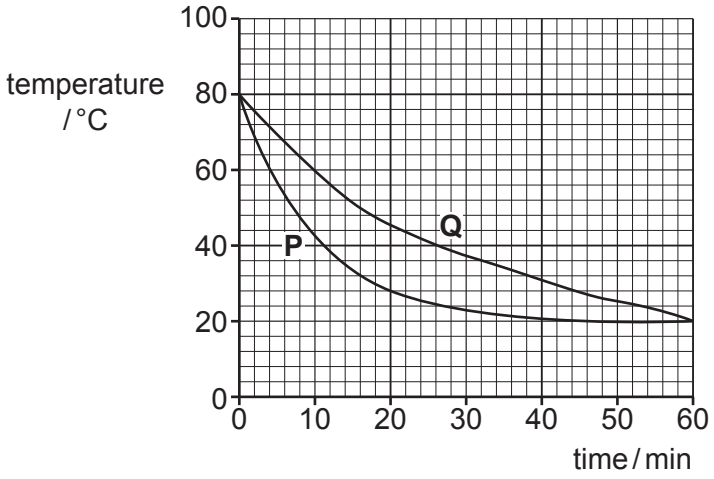


Fig. 6.2

(i) Use the information in Fig. 6.2 to state the temperature of the room.

..... °C [1]

(ii) State which line in Fig. 6.2, **P** or **Q**, is for the can painted black.

Explain your answer in terms of energy transfer by radiation.

line .....

explanation .....

.....

.....

.....

[2]

(c) The student reheats the water in one of the cans using an electric immersion heater.

The heater has a power rating of 1.5 kW and is switched on for 120 seconds.

(i) Calculate the amount of energy used by the electric immersion heater.

energy = ... J [3]

(ii) State the amount of electrical work done by the heater during this process.

..... [1]

(d) During the experiment, the student spills some water on the table.

The water evaporates.

State two ways to increase the rate of evaporation.

1 .....

.....

2 .....

.....

[2]

[Total: 11]

7 Different species have different numbers of chromosomes in their cells.

(a) State where chromosomes are found in cells.

..... [1]

(b) State the female and male sex chromosomes in humans.

female .....

male .....

[1]

(c) State the number of chromosomes in each human body cell.

..... [1]

(d) Table 7.1 shows the number of chromosomes found in each body cell of four different organisms.

Table 7.1

organism	number of chromosomes
goldfish	94
potato	48
pea	14
fruit fly	8

(i) State the number of chromosomes in each body cell of a goldfish.

..... [1]

(ii) State the number of chromosomes in one gamete of a fruit fly.

..... [1]

(e) A mutation is a change in a chromosome.

State one factor that increases the rate of mutation in cells.

..... [1]

(f) State two roles of mitosis in the body.

1 .....

2 .....

[2]

(g) The list shows some statements about meiosis.

Place ticks (✓) in the boxes next to **all** the correct statements.

Meiosis produces genetically identical cells.	
Meiosis produces sperm in humans.	
Meiosis is a type of cell division.	
Meiosis results in the production of diploid cells.	
Meiosis only occurs when there is a mutation in cells.	

[2]

[Total: 10]

8 A student is investigating indigestion tablets.

Indigestion tablets neutralise excess acid in the stomach.

The student adds one tablet to 50 cm^3 of dilute hydrochloric acid.

He measures the time taken for the tablet to completely react.

The student repeats the experiment using different concentrations of hydrochloric acid.

The temperature of the acid is always 25 °C.

Fig. 8.1 shows the apparatus he uses.

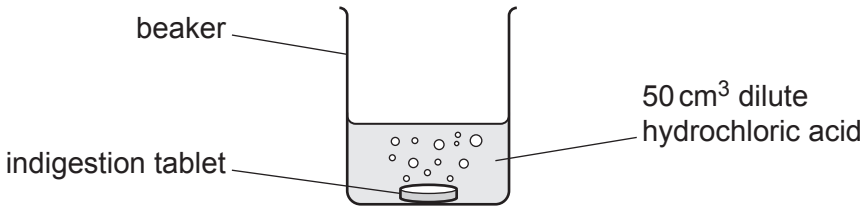


Fig. 8.1

Fig. 8.2 shows a graph of the student's results.

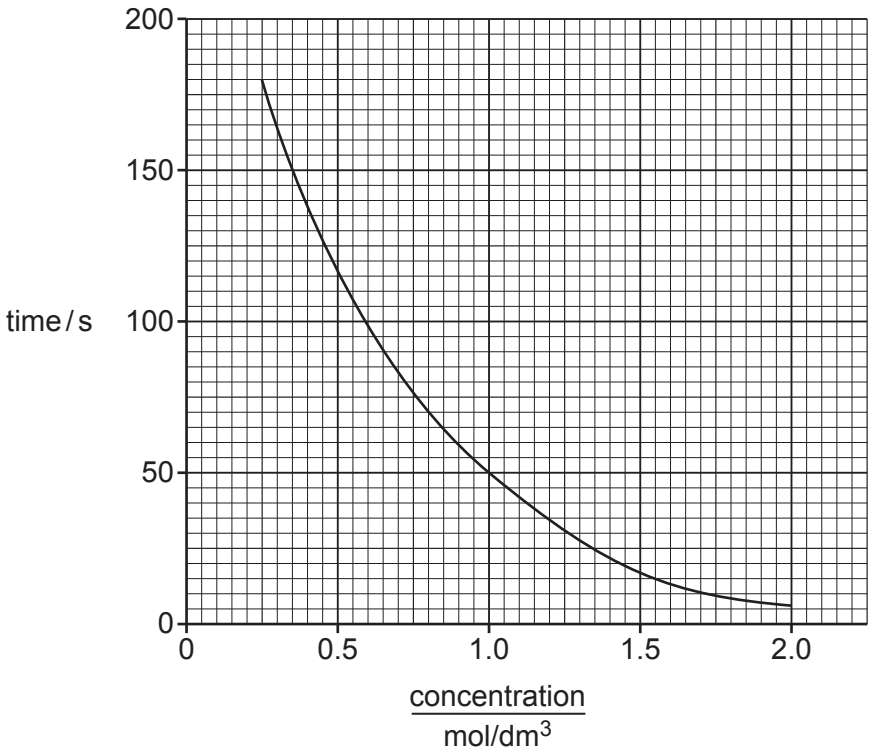


Fig. 8.2

(a) Look at Fig. 8.2.

State how long it takes for the tablet to fully react when the student uses hydrochloric acid with a concentration of 1.0 mol / dm^3.

time = ... s [1]

(b) The student does the experiment again.

He makes only one change. He uses dilute hydrochloric acid at a temperature of 35 °C instead of 25 °C.

Sketch a line on Fig. 8.2 to predict the results at **35 °C**. [1]

(c) The student's results show that it takes less time for indigestion tablets to react when the acid is more concentrated.

Explain why reactions are faster when reactants are more concentrated.

Explain your answer in terms of collisions between particles.

.....

.....

..... [2]

(d) Indigestion tablets contain calcium carbonate, $CaCO_3$.

Look at the symbol equation for the reaction of calcium carbonate with dilute hydrochloric acid.

The equation is not balanced.

Balance the equation.

$$CaCO_3 + HCl \rightarrow CaCl_2 + CO_2 + H_2O$$

[1]

(e) In one experiment the student measures the temperature of the acid before he adds the tablet.

He also measures the temperature after all the tablet has reacted.

The temperature **decreases**.

State the name for this type of energy transfer.

..... [1]

(f) Dilute hydrochloric acid is an acid.

Define an *acid* in terms of proton transfer.

..... [1]

[Total: 7]

9 Nuclear power stations use uranium as a fuel.

(a) Name the process which releases energy from uranium in nuclear power stations.

..... [1]

(b) Uranium-238 is unstable and decays to produce an isotope of thorium.

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

$$^{238}_{92}U \rightarrow {}^{234}_{.....}Th + {}^{.....}_{.....}.....$$

[2]

(c) The isotope of thorium produced is also unstable and decays releasing more ionising radiation.

Fig. 9.1 shows how the activity of a sample of thorium-234 varies over time.

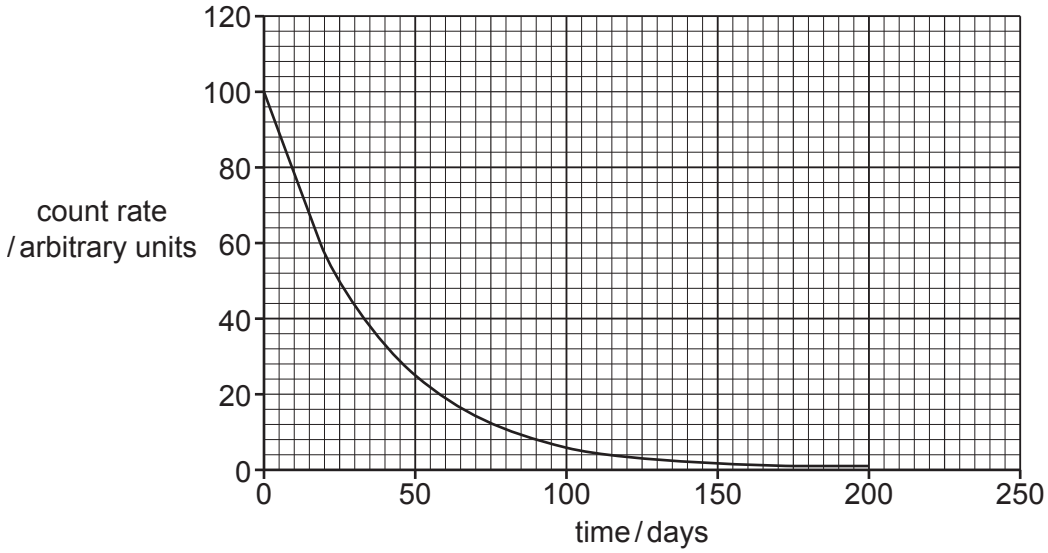


Fig. 9.1

Use Fig. 9.1 to calculate the half-life of thorium-234.

half-life = ... [2]

(d) Fig. 9.2 shows radioactive emissions passing between two oppositely charged plates.

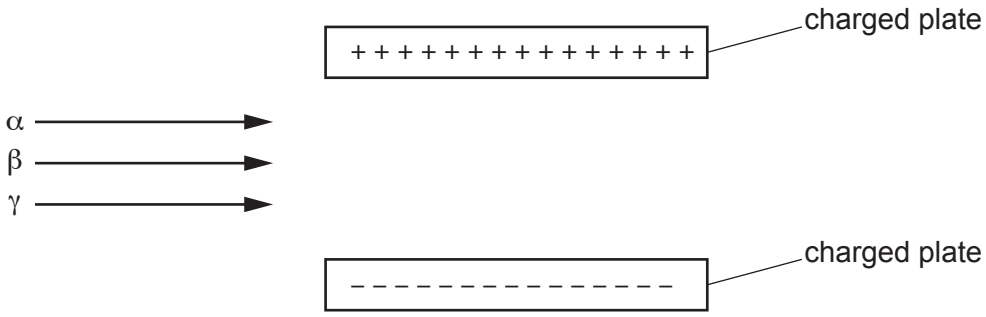


Fig. 9.2

(i) An electric field exists between the charged plates.

Describe what is meant by an electric field.

.....

..... [1]

(ii) Complete Fig. 9.2 to show the paths of an α-particle, a β-particle and a γ-ray as they pass through the electric field. [3]

[Total: 9]

10 (a) Fig. 10.1 shows a plant's response to light.

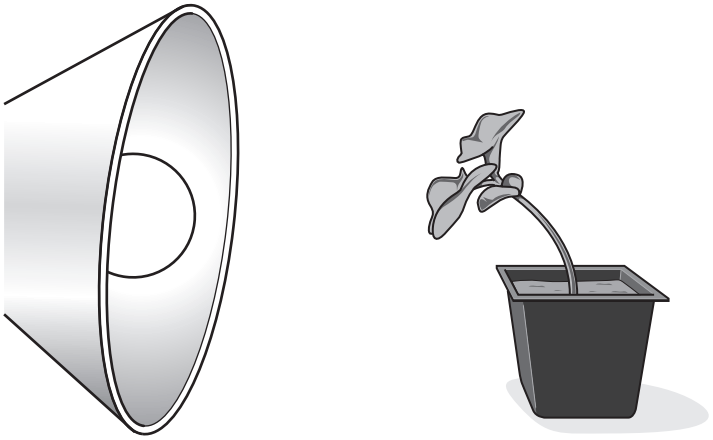


Fig. 10.1

(i) Name the tropic response shown in Fig. 10.1.

..... [1]

(ii) Explain the response to light seen in Fig. 10.1.

Use ideas about auxin in your answer.

.....

.....

.....

.....

.....

..... [3]

(b) Adrenaline is a hormone released in the human body during stressful situations.

One of the effects is the increase of blood glucose concentration.

(i) Suggest the name of the target organ for this hormonal response.

..... [1]

(ii) State two other effects of adrenaline on the human body.

1 .....

2 .....
[2]

(iii) Name one other hormone that increases the blood glucose concentration.

..... [1]

(c) Describe two ways that the transmission of information by hormonal control is different from nervous control.

1 .....

.....

2 .....

.....
[2]

[Total: 10]

11 **(a)** Table 11.1 shows some information about particles found in an atom.

Complete Table 11.1.

Table 11.1

particle	relative mass	relative charge
electron	$\frac{1}{1840}$	.....
neutron	.....	0
proton	1	.....

[3]

(b) The diagrams in Fig. 11.1 each show the nucleus of a different atom.

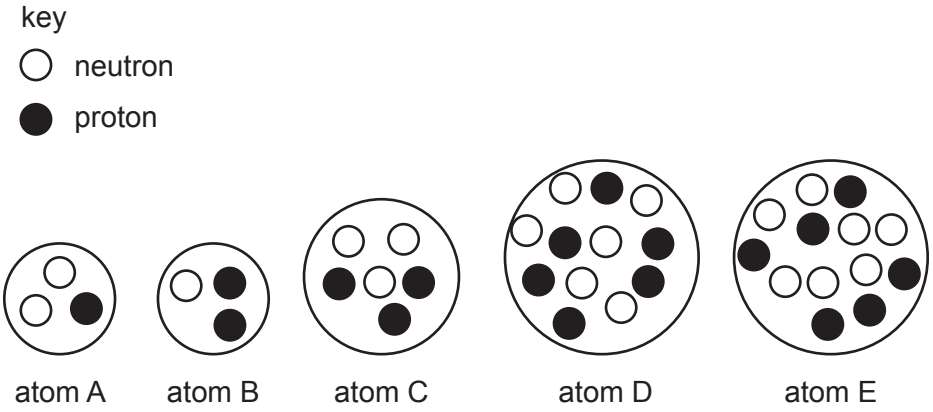


Fig. 11.1

(i) State which atom has a *proton number* (atomic number) of 3.

..... [1]

(ii) State which atom has a *nucleon number* (mass number) of 6.

..... [1]

(iii) State which **two** atoms are isotopes of the same element.

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

[Total: 6]

BLANK PAGE

12 Fig. 12.1 shows a cyclist.

Fig. 12.1

(a) The cyclist starts from rest and accelerates with constant acceleration.

The cyclist reaches 12 m / s after 20 seconds.

He then continues at this constant speed for 15 seconds.

(i) On Fig. 12.2, plot a speed–time graph for the cyclist.

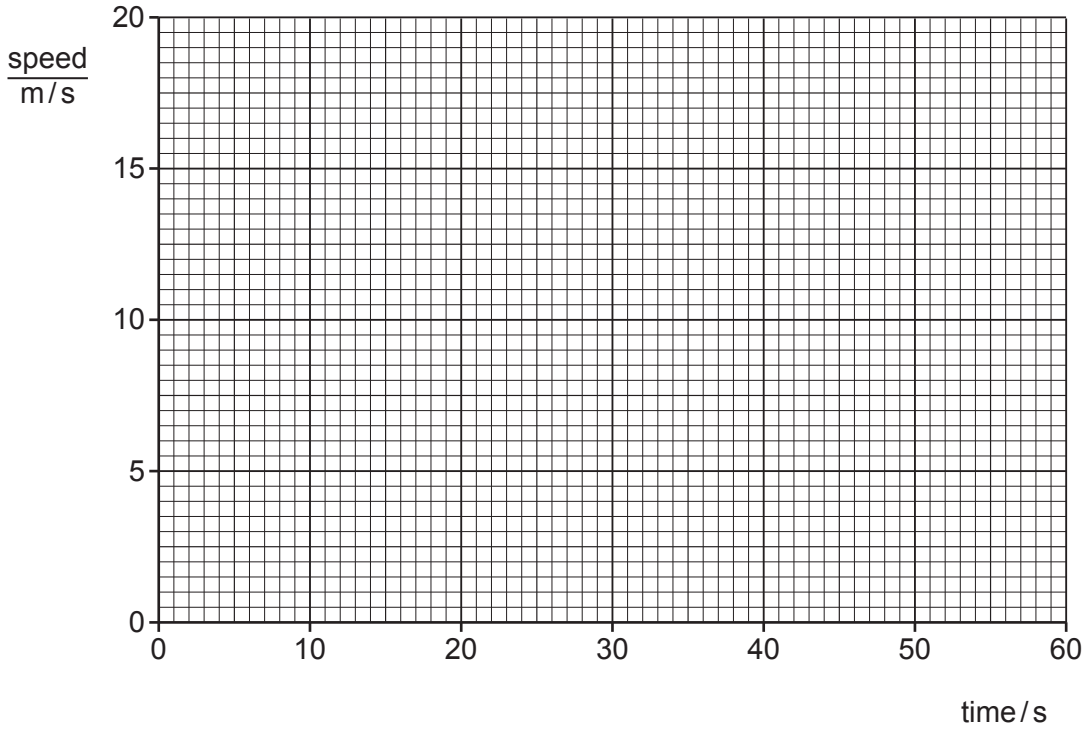


Fig. 12.2

[2]

(ii) Calculate the acceleration of the cyclist during the first 20 seconds.

State the unit for your answer.

acceleration = ... unit ..... [3]

(iii) Describe how to calculate the distance travelled by the cyclist using the speed–time graph.

.....

..... [1]

(b) State one difference and one similarity between speed and velocity.

difference .....

.....

similarity .....

.....

[2]

(c) Fig. 12.3 shows the forces acting on the cyclist while he is travelling at constant speed.

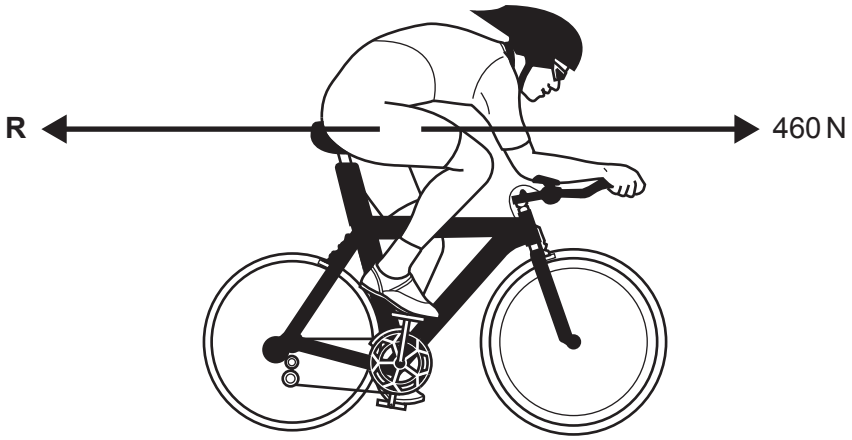


Fig. 12.3

(i) State the size of force **R** on Fig. 12.3.

..... [1]

(ii) Suggest the cause of force **R** on Fig. 12.3.

.....

..... [1]

[Total: 10]

13 The electrolysis of concentrated aqueous sodium chloride, NaC*l*, produces two useful gases.

Fig. 13.1 shows the apparatus used.

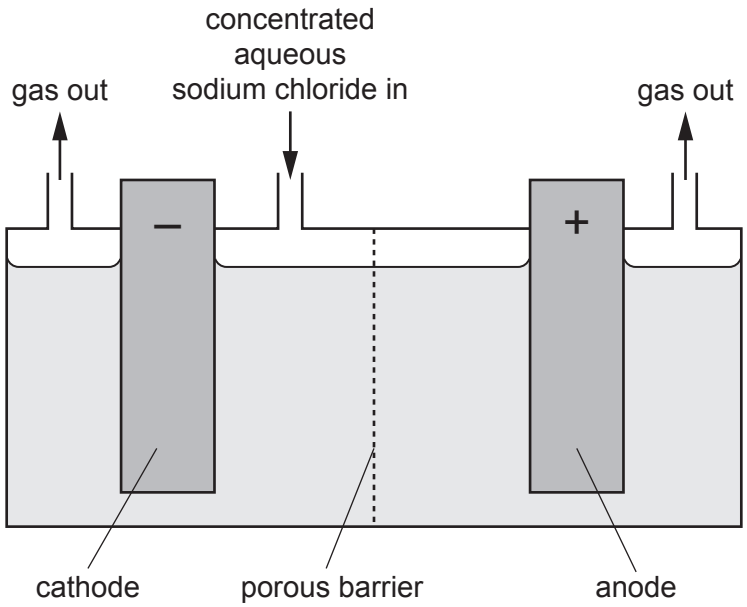


Fig. 13.1

(a) State the formulae of all the **ions** present in concentrated aqueous sodium chloride.

1 .....

2 .....

3 .....

4 .....

[2]

(b) State the name of the **gas** that forms at each electrode.

anode .....

cathode .....

[2]

(c) State the name of the solution remaining after electrolysis.

Explain why the solution is **alkaline**.

name of solution .....

explanation .....

.....

[2]

(d) Lead is extracted from molten lead(II) bromide, $PbBr_2$, by electrolysis.

The ionic half-equation is shown.

$$Pb^{2+} + 2e^- \longrightarrow Pb$$

Explain, in terms of electrons, if lead ions are oxidised or reduced in this reaction.

.....

..... [1]

(e) Aluminium is extracted from aluminium oxide, Al_2O_3, by electrolysis.

Construct the ionic half-equation for the formation of aluminium at the cathode.

Use e^- to represent an electron.

..... [2]

[Total: 9]

The Periodic Table of Elements

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 –		

Key

atomic number
atomic symbol
name
relative atomic mass

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.).