



**Cambridge Assessment International Education**  
Cambridge International General Certificate of Secondary Education

CANDIDATE  
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**CO-ORDINATED SCIENCES**

**0654/42**

Paper 4 (Extended)

**October/November 2019**

**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 (a) Carbon dioxide is produced during the anaerobic respiration of yeast.

A baker investigates the optimum temperature required for the anaerobic respiration of yeast for bread-making.

Fig. 1.1 is a graph of the results.

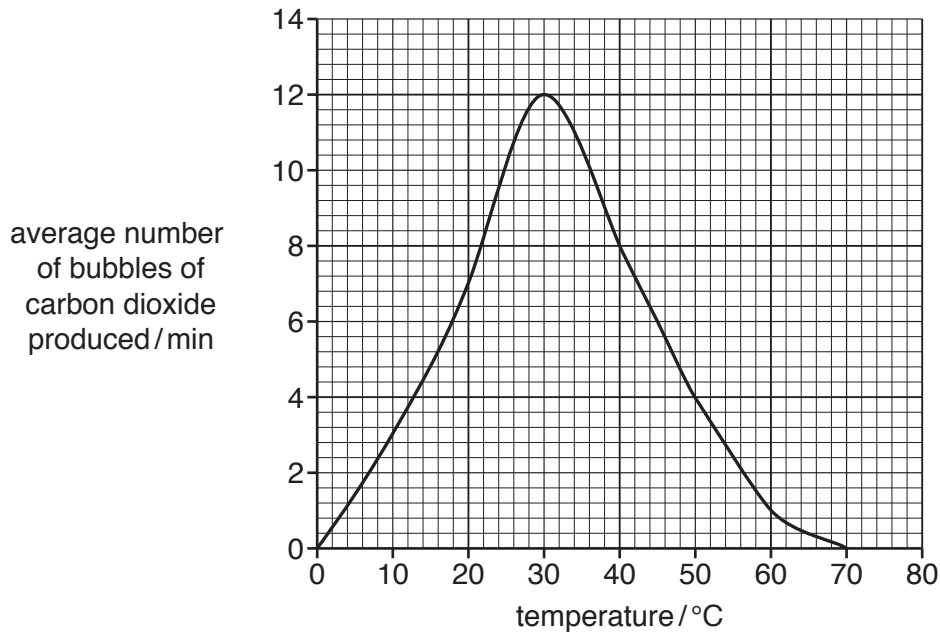


Fig. 1.1

- (i) State the average number of bubbles of carbon dioxide produced per minute at 45°C.

..... [1]

- (ii) Anaerobic respiration of yeast is controlled by enzymes.

Use evidence from Fig. 1.1 to support this statement.

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

- (iii) Apart from controlling the temperature, suggest **one** way the baker could increase the number of carbon dioxide bubbles produced per minute.

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

(b) Table 1.1 shows some of the features of aerobic and anaerobic respiration.

**Table 1.1**

type of respiration	carbon dioxide is produced	lactic acid is produced	oxygen is required	releases energy
aerobic respiration				
anaerobic respiration in animals				
anaerobic respiration in yeast				

Complete Table 1.1 by placing a tick (✓) in the boxes to show the correct features of each type of respiration. [3]

[Total: 7]

2 Ethene,  $C_2H_4$ , and propene,  $C_3H_6$ , are in the same homologous series.

(a) (i) Define the term *homologous series*.

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

(ii) Name the homologous series to which ethene and propene belong.

..... [1]

(b) Atoms in a molecule of ethene are held together by covalent bonds.

Fig. 2.1 shows the outer shell electrons in a carbon atom and a hydrogen atom.

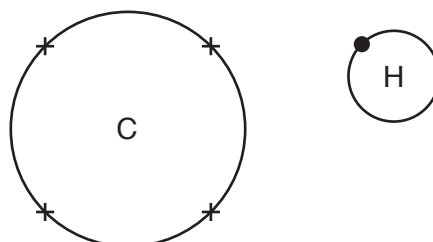


Fig. 2.1

In the space below, draw the dot-and-cross diagram to show all the outer shell electrons in a molecule of ethene.

[3]

(c) Ethane is produced by the addition reaction between ethene and hydrogen.

(i) Write the symbol equation for the addition reaction between ethene and hydrogen.

..... [2]

(ii) Predict the product formed when propene reacts with hydrogen.

Explain your answer.

product .....

explanation .....

..... [2]

[Total: 10]

3 (a) X-rays and  $\gamma$ -radiation are both used in hospitals.

(i) Place X-rays and  $\gamma$ -radiation in their correct places in the incomplete electromagnetic spectrum in Fig. 3.1.

		infra-red	visible light	ultraviolet		
--	--	-----------	---------------	-------------	--	--

Fig. 3.1

[2]

(ii) Suggest one use of  $\gamma$ -radiation in a hospital.

..... [1]

(b) A hospital has a generator for use in an emergency if the mains electricity supply fails.

The generator is powered by an engine that uses diesel fuel.

(i) Describe the three energy transfers involved in generating electrical energy from diesel fuel.

1 .....

2 .....

3 .....

[3]

(ii) The generator is described as having an efficiency of 25%.

Describe what is meant by this statement.

.....

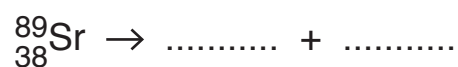
.....

..... [1]

(c) The isotope strontium-89 is used in the treatment of bone cancer.

Strontium-89 decays by beta-particle emission to produce yttrium-89.

Use the correct nuclide notation to complete the symbol equation for this  $\beta$ -decay process.



[2]

[Total: 9]

4 Fig. 4.1 is a picture of a racehorse.

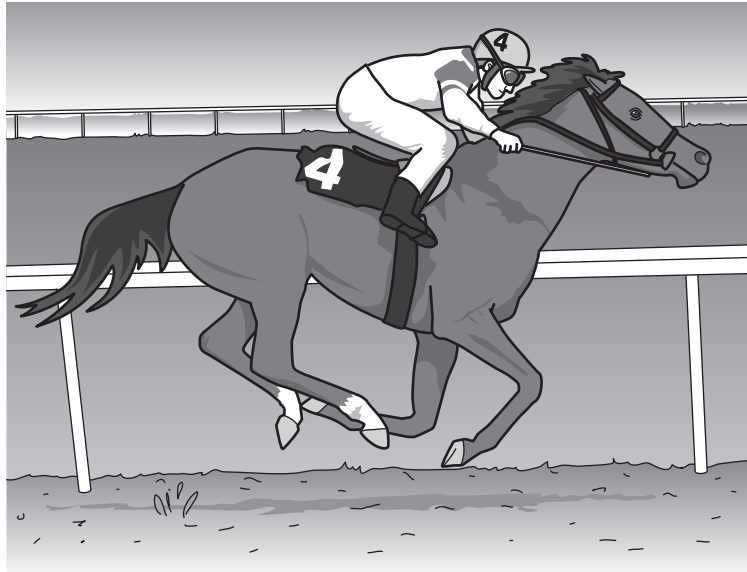


Fig. 4.1

(a) Racehorses have been selectively bred to win races.

Outline the process of selective breeding to produce racehorses.

.....

.....

.....

.....

..... [3]

(b) Describe **one** similarity and **one** difference between selective breeding and natural selection.

similarity .....

.....

difference .....

..... [2]

(c) Explain why selective breeding is **not** an example of adaptation.

.....

..... [1]

[Total: 6]

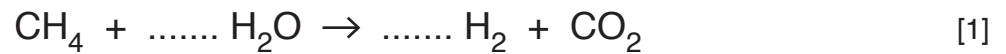
- 5 (a) Ammonia is manufactured in the Haber process.

In this process nitrogen reacts with hydrogen.

Nitrogen and hydrogen are obtained from the raw materials air, methane and steam.

- (i) Hydrogen is obtained when methane reacts with steam.

Balance the symbol equation.

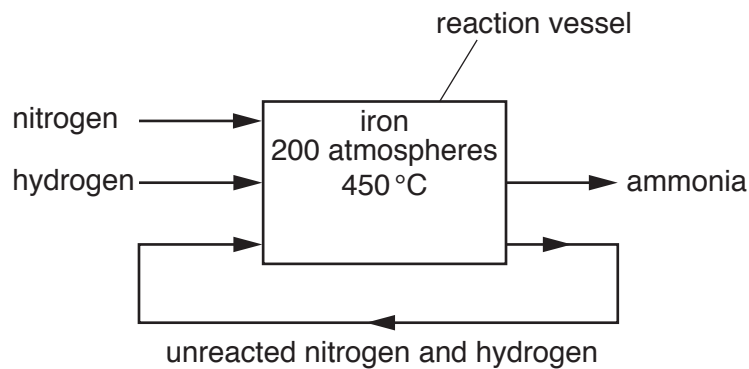


- (ii) Nitrogen can be obtained when hydrogen is burned in air.

Name the substance removed from air when hydrogen burns.

..... [1]

- (b) Fig. 5.1 shows the conditions inside the reaction vessel in the Haber process.



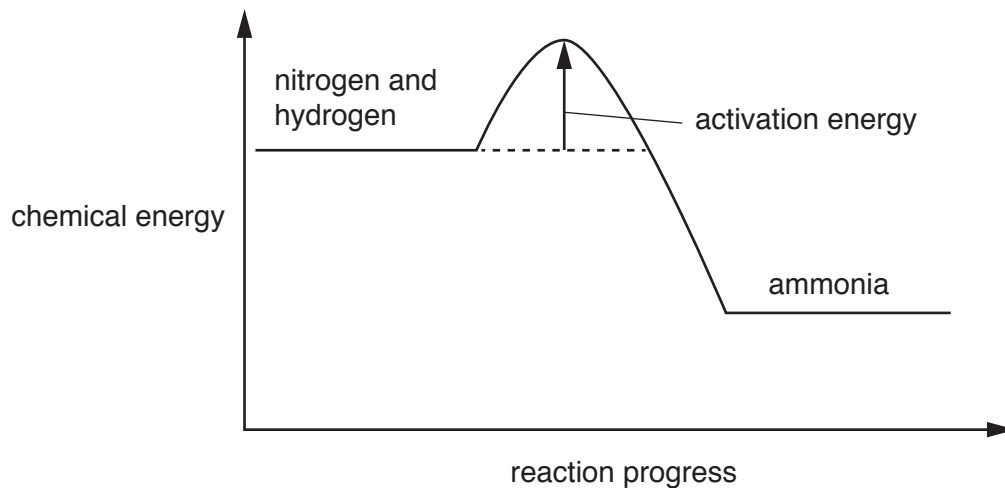
**Fig. 5.1**

State and explain the purpose of the iron in the reaction vessel.

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



(c) Fig. 5.2 is an energy level diagram for the reaction between nitrogen and hydrogen.



**Fig. 5.2**

(i) Explain how the energy level diagram shows that the reaction is exothermic.

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

(ii) Explain why a high temperature is needed to obtain a high rate of reaction.

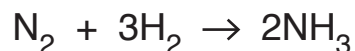
Use ideas about the movement and energy of molecules and about activation energy in your answer.

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

10

(d) A chemical company produces  $3.4 \times 10^9$  g of ammonia.

The equation for the reaction between nitrogen and hydrogen is shown.



Complete steps 1 to 4 to calculate the volume of hydrogen, measured at room temperature and pressure, used to make this ammonia.

[A<sub>r</sub>: H,1; N,14]

molar gas volume = 24 dm<sup>3</sup> at room temperature and pressure.

**step 1**

Show that the relative molecular mass of ammonia is 17.

**step 2**

Calculate the number of moles of ammonia produced.

number of moles = .....

**step 3**

Calculate the number of moles of hydrogen used.

number of moles = .....

**step 4**

Calculate the volume of hydrogen used.

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

[Total: 13]

- 6 (a) Dolphins are a species of aquatic mammal.

Dolphins produce sound waves in the frequency range 200 Hz–130 000 Hz.

State the audible frequency range for a **human**.

from ..... Hz to ..... Hz [1]

- (b) (i) Dolphins locate fish using very high frequency sound called ultrasound. They detect ultrasound reflected from the fish.

A dolphin emits a pulse of ultrasound with a frequency of 50 000 Hz. The ultrasound pulse reflects off a fish 20 m away, and returns to the dolphin.

The speed of ultrasound in water is 1500 m/s.

Calculate the time taken for the ultrasound pulse to reflect off the fish and return to the dolphin.

time = ..... s [2]

- (ii) Calculate the wavelength of ultrasound waves with a frequency of 50 000 Hz.

wavelength = ..... m [2]

- (iii) The dolphin changes the frequency of the sound it emits to 100 000 Hz.

Suggest what effect, if any, this will have on the time taken for the pulse to travel to the fish and return to the dolphin.

Explain your answer.

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

(c) Ultrasound waves travel at 1500 m/s through water.

Suggest the speed of these waves through **air**.

Explain your answer.

speed .....

explanation .....

.....

[1]

(d) Ultrasound waves are longitudinal waves. Electromagnetic waves are transverse waves.

Describe the differences between longitudinal and transverse waves.

Your description should refer to the direction of propagation of the waves and the direction of oscillation or vibration.

You may draw a diagram if it helps your answer.

.....

.....

..... [2]

(e) At room temperature, water is a liquid. When water is cooled sufficiently, it turns to ice, a solid.

Describe the differences between water and ice, in terms of the forces between molecules and the motion of molecules.

.....

.....

.....

..... [2]

[Total: 11]

- 7 (a) Fig. 7.1 shows the alimentary canal and associated organs.

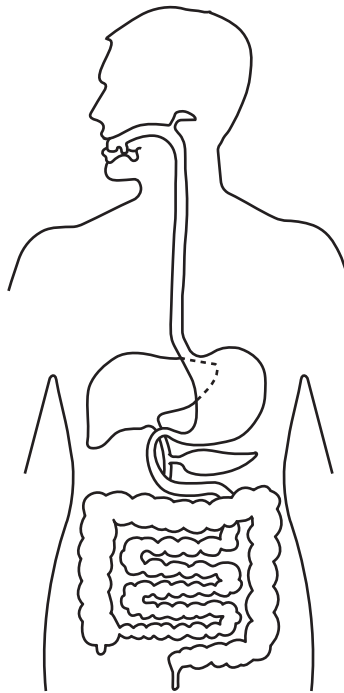


Fig. 7.1

- (i) On Fig. 7.1, label the organ where bile is **produced** with a label line and the correct name. [2]
- (ii) Lipase is produced in the pancreas.  
On Fig. 7.1, draw an **X** to identify the pancreas. [1]
- (iii) Name **one** part of the alimentary canal where mechanical digestion occurs.  
..... [1]

(b) A student investigates the action of lipase on the fats present in milk.

Lipase is a digestive enzyme.

- A mixture of milk and sodium carbonate solution is added to two test-tubes, **A** and **B**.
- A few drops of indicator are added to each test-tube and the solutions turn pink.
- The indicator turns pink in alkaline solutions and colourless in acidic solutions.
- Lipase is added to test-tube **A** and lipase and bile salts are added to test-tube **B**.
- The student times how long it takes for the indicator to turn colourless.

Table 7.1 shows the results.

**Table 7.1**

test-tube	contents of test-tube	time taken for indicator to turn colourless/s
<b>A</b>	milk, sodium carbonate solution, indicator and lipase	254
<b>B</b>	milk, sodium carbonate solution, indicator, lipase and bile salts	213

(i) The solutions in test-tubes **A** and **B** become acidic.

State the type of substance produced which causes the solutions to become acidic.

..... [1]

(ii) Calculate the difference in time it takes between test-tube **A** and test-tube **B** to become acidic.

.....seconds [1]

(iii) Explain why the contents of test-tube **B** become acidic more quickly than test-tube **A**.

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

[Total: 9]

- 8 (a) A student tries to draw the lattice structure of a crystal of sodium chloride.

The student knows that sodium chloride is a salt consisting of sodium ions,  $\text{Na}^+$ , and chloride ions,  $\text{Cl}^-$ .

Fig. 8.1 shows their diagram.

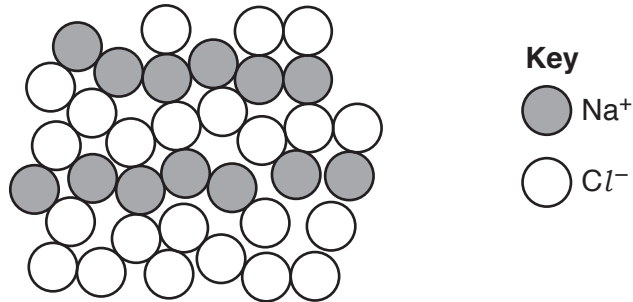


Fig. 8.1

State two reasons why their diagram is incorrect.

1 .....

.....

2 .....

.....

[2]

(b) A technician has run out of the insoluble salt, lead chloride.

He has a good supply of the salts shown in Table 8.1, and has recorded their solubilities.

**Table 8.1**

salt	solubility in water
calcium sulfate	insoluble
copper sulfate	soluble
lead nitrate	soluble
lead sulfate	insoluble
silver chloride	insoluble
sodium chloride	soluble
sodium nitrate	soluble

(i) He prepares a precipitate of lead chloride by reacting lead nitrate and sodium chloride.

Explain why he chooses these salts.

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

(ii) Write the word equation for this reaction.

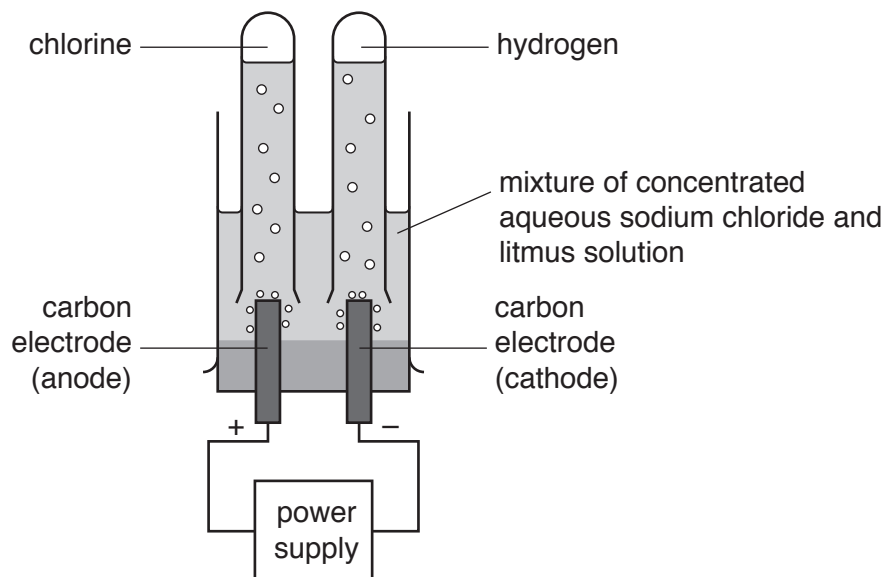
..... [1]



- (c) Fig. 8.2 shows apparatus used to demonstrate the electrolysis of concentrated aqueous sodium chloride.

Before electrolysis occurs the electrolyte is purple because it contains litmus solution.

Bubbles of gas are observed at both electrodes.



**Fig. 8.2**

- (i) Bubbles of chlorine are formed at the anode.

Predict the change in colour of the electrolyte around the anode.

..... [1]

- (ii) Explain how chlorine atoms form at the anode.

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

[Total: 8]

- 9 (a) Fig. 9.1 shows two trains.

The trains are identical, except one is painted black and one is painted white. Both have shiny surfaces.

The trains are both stored at a station on a sunny day.

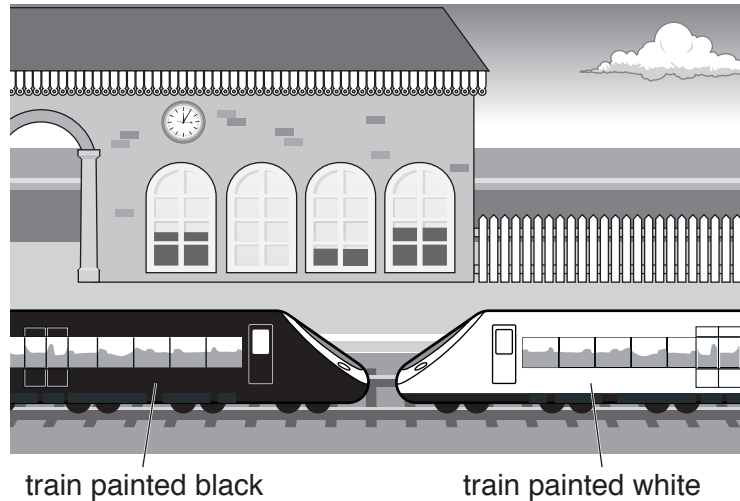


Fig. 9.1

- (i) State the method of energy transfer by which energy passes from the Sun to the Earth.

..... [1]

- (ii) After four hours the temperature inside each train is measured.

The temperature inside the train painted black is  $40^{\circ}\text{C}$ .

The temperature inside the train painted white is  $30^{\circ}\text{C}$ .

Suggest a reason for this difference in temperature.

..... [1]

- (iii) Explain what would happen to the temperature inside the train painted white if the painted surface was not shiny.

..... [1]

- (b) A train of mass 450 000 kg slows down with a constant deceleration of  $0.6 \text{ m/s}^2$  until the train stops.

Calculate the force needed to cause the train to decelerate by  $0.6 \text{ m/s}^2$ .

force = ..... N [2]

- (c) The train has two headlamps connected in parallel.

The lamps each have a power rating of 350 W and are operated with a potential difference of 75 V.

- (i) Show that the current through each headlamp is 4.7 A.

[2]

- (ii) Calculate the combined resistance of these two lamps connected in parallel.

combined resistance = .....  $\Omega$  [3]

[Total: 10]

10 Water is taken into roots through the root hair cells by osmosis.

(a) (i) Complete the sentence to define the term *osmosis*.

Osmosis is the net movement of water ..... from a region of higher water potential (..... solution) to a region of lower water potential (concentrated solution), through a partially permeable ..... [3]

(ii) Describe how the root hair cells are adapted for water uptake.

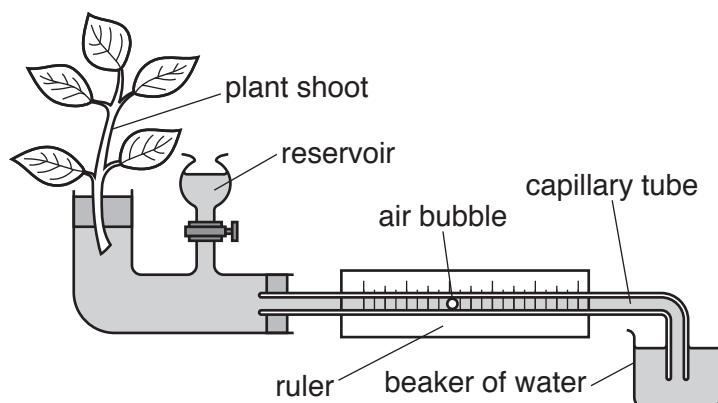
..... [1]

(b) Name the term used to describe how water molecules are held together in the xylem.

..... [1]

- (c) A student investigates the effect of humidity on the rate of transpiration.

The apparatus in Fig. 10.1 is used to measure the rate of water uptake by a plant shoot. This is approximately equal to the rate of transpiration.



**Fig. 10.1**

The student determines the rate of water uptake by measuring the distance travelled by the air bubble in two minutes.

The investigation is repeated with a clear plastic bag over the plant shoot to increase the humidity.

The results are shown in Table 10.1.

**Table 10.1**

	distance air bubble travelled /mm	time /min	rate of water uptake
without plastic bag	18	2	9
with plastic bag	8	2	4

- (i) Deduce the units used for the rate of water uptake in Table 10.1.

..... [1]

- (ii) Explain the reduced rate of water uptake by the shoot covered with the clear plastic bag.

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

[Total: 9]

11 Fig. 11.1 shows part of Group I of the Periodic Table.

3 <b>Li</b> lithium 7
11 <b>Na</b> sodium 23
19 <b>K</b> potassium 39
37 <b>Rb</b> rubidium 85

Fig. 11.1

(a) Fig. 11.2 shows the apparatus a teacher uses to place a piece of potassium into a bowl of water.

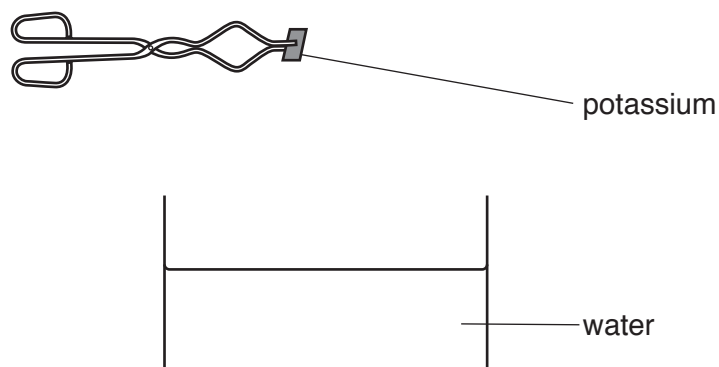


Fig. 11.2

(i) The teacher places the piece of potassium into the water. Describe her observations.

.....

.....

..... [2]

- (ii) Predict how the observations would differ if she uses rubidium instead of potassium.

Explain your answer.

.....

.....

..... [2]

- (b) Two isotopes of potassium are potassium-39 and potassium-41.

**Table 11.1**

isotope	number of protons	number of neutrons	number of electrons
potassium-39			
potassium-41			

- (i) Complete Table 11.1. [3]

- (ii) Predict if there are any differences in the reactions of these isotopes with water.

Explain your answer.

prediction .....

explanation .....

..... [2]

[Total: 9]

12 A fishing boat floats on the sea.

- (a) A heavy anchor is dropped from the boat and accelerates as it falls through the water to the sea bed.

Name the downward force that makes the anchor accelerate.

..... [1]

- (b) The boat has a small generator to generate electricity.

Fig. 12.1 shows a simple generator.

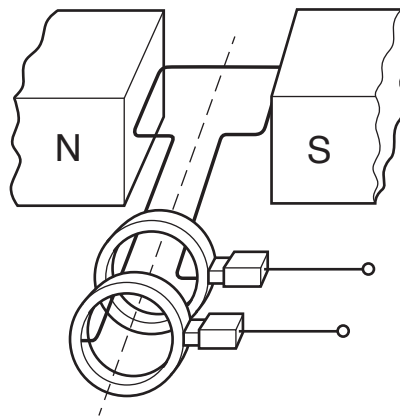


Fig. 12.1

- (i) On Fig. 12.1 label a slip ring with the letter **R**. [1]
- (ii) Describe how the use of slip rings produces an alternating voltage output from the rotating coil.

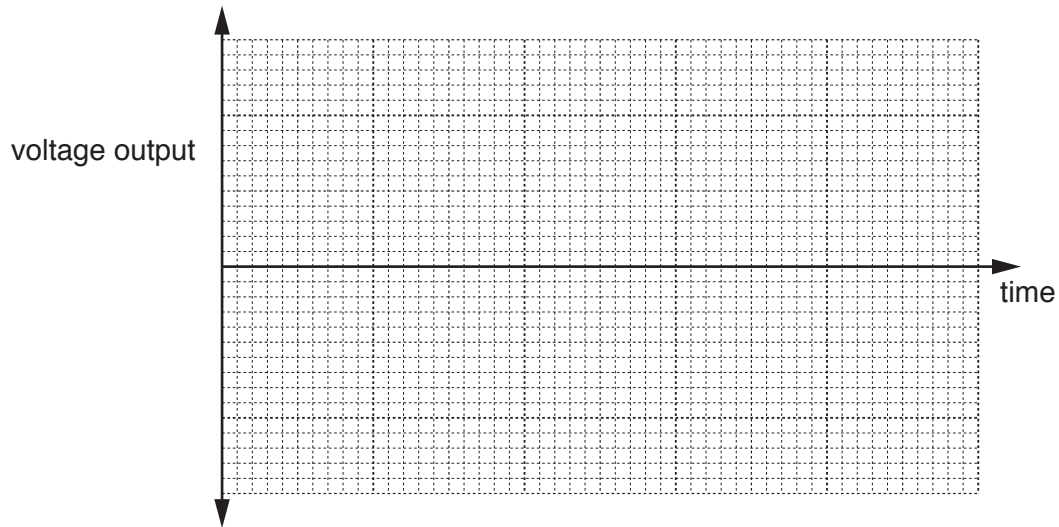
.....

.....

..... [2]



- (iii) On the grid in Fig. 12.2, sketch a graph of voltage output against time for the generator, when the coil is rotating at a constant speed.



**Fig. 12.2**

[2]

- (c) An electric heater on the boat uses the electricity generated at 240 V.

The current passing through the heater is 20 A.

Calculate the charge passing through the heater in one hour.

State the unit of your answer.

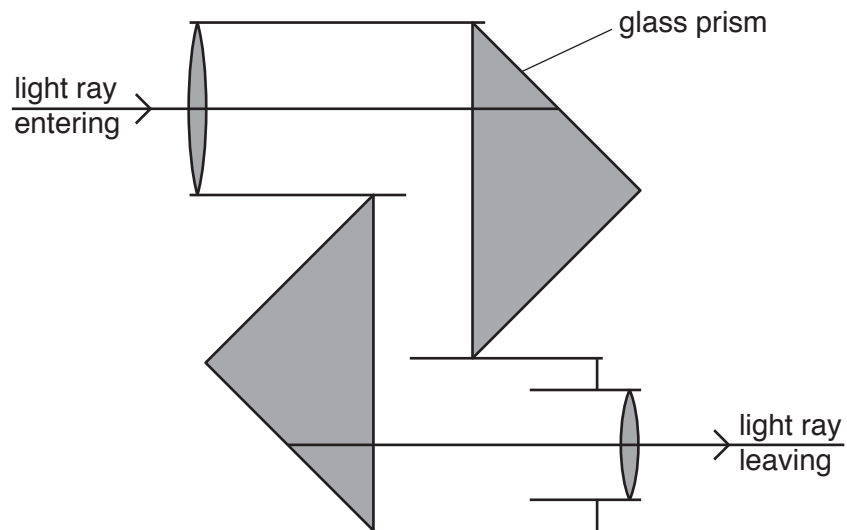
charge = ..... unit ..... [3]

(d) A fisherman on the boat is using a pair of binoculars to look at the sea.

Binoculars use glass prisms to reflect light.

Fig. 12.3 shows part of a pair of binoculars.

A ray of light is shown entering and leaving.



**Fig. 12.3**

On Fig. 12.3, complete the ray diagram to show the path of the light ray through the two prisms. [1]

[Total: 10]

13 (a) Adrenaline is a hormone.

Describe how adrenaline is transported around the body.

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

(b) When a person is scared, adrenaline is released causing the concentration of glucose in the blood to increase.

(i) Suggest why an **increase** in blood glucose concentration might be needed when someone is scared.

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

(ii) Describe two **other** effects of adrenaline on the body.

1 .....

.....

2 .....

..... [2]

(c) The body tries to maintain blood glucose concentration within certain limits.

If the blood glucose concentration exceeds these limits, the body responds to return the blood glucose concentration to normal.

(i) Name the term used to describe this mechanism.

..... [1]

(ii) Describe how the liver and pancreas work to reduce the blood glucose concentration if it gets too high.

.....

.....

.....

.....

..... [3]

[Total: 9]

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	<b>Key</b> atomic number atomic symbol name relative atomic mass										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 —

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