Cambridge IGCSE

Cambridge Assessment International Education
Cambridge International General Certificate of Secondary Education

CANDIDATE NAME

CENTRE NUMBER

CANDIDATE NUMBER

1839017912

CO-ORDINATED SCIENCES **0654/41**

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

Cambridge Assessment International Education

1 **(a)** The graph in Fig. 1.1 shows the effect of light intensity on the rate of photosynthesis.

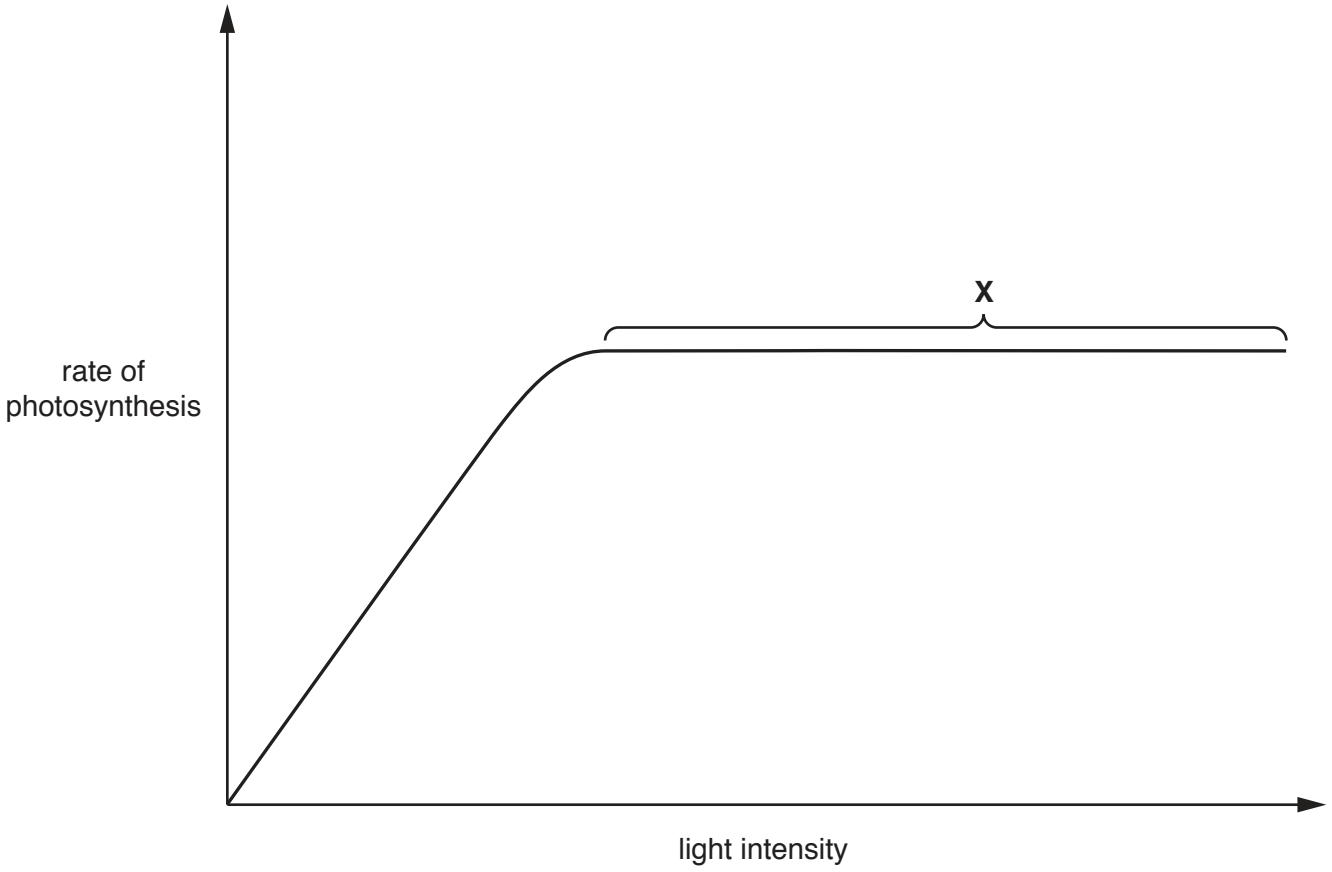

Fig. 1.1

(i) Describe the results shown in Fig. 1.1.

.....

.....

.....

..... [2]

(ii) Explain the reasons for the shape of the part of the graph labelled **X**.

.....

.....

.....

..... [2]

(b) Fig. 1.2 shows a cross-section through a leaf.

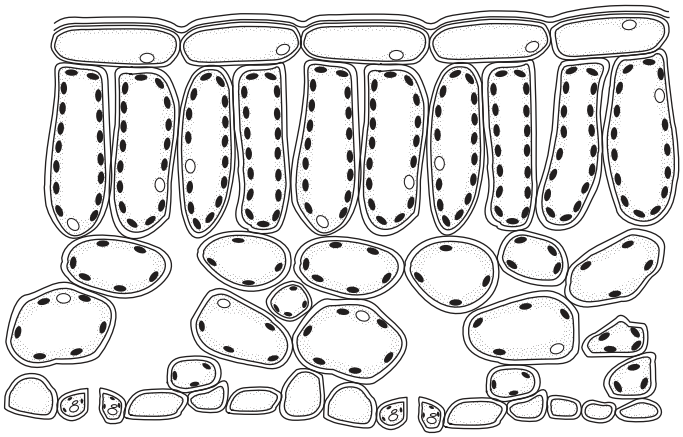

Fig. 1.2

(i) Describe **two** features of the leaf shown in Fig. 1.2 that allow efficient gas exchange to occur.

1 .....

.....

2 .....

.....

[2]

(ii) On Fig. 1.2, use a label line to label an example of a cell that is best adapted for photosynthesis.

Include the name of the cell. [2]

(c) State the chemical formulae of the **two** products of photosynthesis.

1 .....

2 .....

[1]

[Total: 9]

2 **(a)** Carbon is used to extract zinc from zinc oxide, ZnO.

(i) Write a balanced symbol equation for this reaction.

..... [2]

(ii) Zinc oxide consists of Zn^{2+} and O^{2-} ions.

State which ion is being reduced in this reaction.

Explain your answer in terms of the movement of electrons.

.....

.....

..... [1]

(iii) Explain why carbon **cannot** be used to extract aluminium from aluminium oxide.

.....

..... [1]

(b) Aluminium is extracted by the electrolysis of aluminium oxide.

Aluminium oxide consists of Al^{3+} and O^{2-} ions.

Fig. 2.1 shows the industrial apparatus used to produce aluminium.

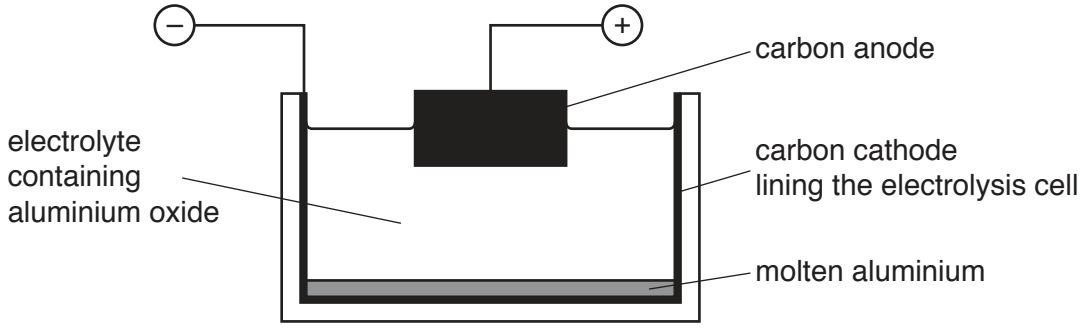

Fig. 2.1

(i) State the name of an ore that contains aluminium.

..... [1]

(ii) Explain why aluminium oxide must be in a liquid state for electrolysis to occur.

.....

..... [1]

(iii) Explain why cryolite is mixed with aluminium oxide for use in this electrolysis.

.....

..... [1]

(iv) Write the ionic half-equation for the reaction occurring at the cathode during this electrolysis.

..... [2]

(c) Aluminium ore is a finite resource, so aluminium must be conserved.

(i) State what is meant by the term *finite resource*.

.....

..... [1]

(ii) Suggest how aluminium can be conserved.

.....

..... [1]

[Total: 11]

[Turn over

3 Fig. 3.1 shows a motorcycle with a rear lamp.

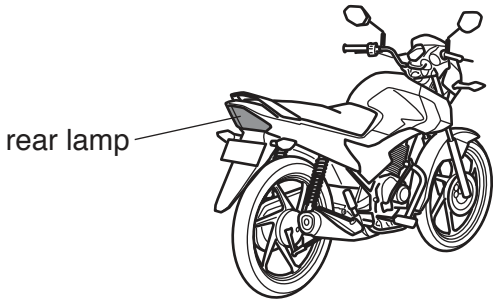

Fig. 3.1

(a) The lamp has a resistance of 30 Ω and is powered by a 12 V battery.

(i) Show that the current in the lamp is 0.40 A.

[1]

(ii) Calculate the power used by the lamp.

Show your working.

power = ... W [2]

(iii) Calculate the charge that passes through the lamp in 30 minutes.

Show your working.

charge = ... C [2]

(b) The battery is charged by an a.c. generator.

Fig. 3.2 shows a simple a.c. generator.

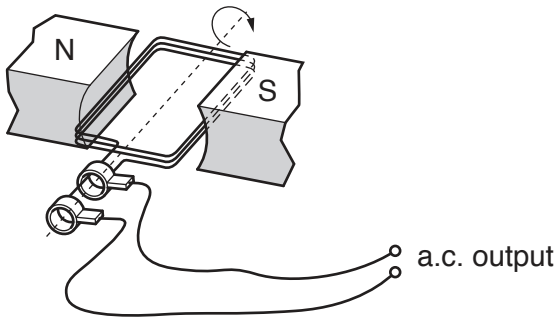

Fig. 3.2

(i) On Fig. 3.2, label the slip rings with the letter **R**. [1]

(ii) On Fig. 3.2, label the coil with the letter **C**. [1]

(iii) On Fig. 3.2, show the direction of the magnetic field with an arrow (⟶). [1]

(iv) The output is an alternating current. Describe the difference between direct current (d.c.) and alternating current (a.c.).

.....

.....

..... [1]

(c) The motorcycle engine is noisy and emits sound waves that pass through the air.

The sound waves pass through the air as a series of compressions (C) and rarefactions (R).

Fig. 3.3 shows the positions of the compressions and rarefactions as the sound wave passes through the air.

Fig. 3.3

Suggest how and explain why the positions of the compressions and rarefactions change if the pitch of the sound increases.

.....

.....

..... [3]

[Total: 12]

4 The pie chart in Fig. 4.1 shows the different causes of deforestation in a country.

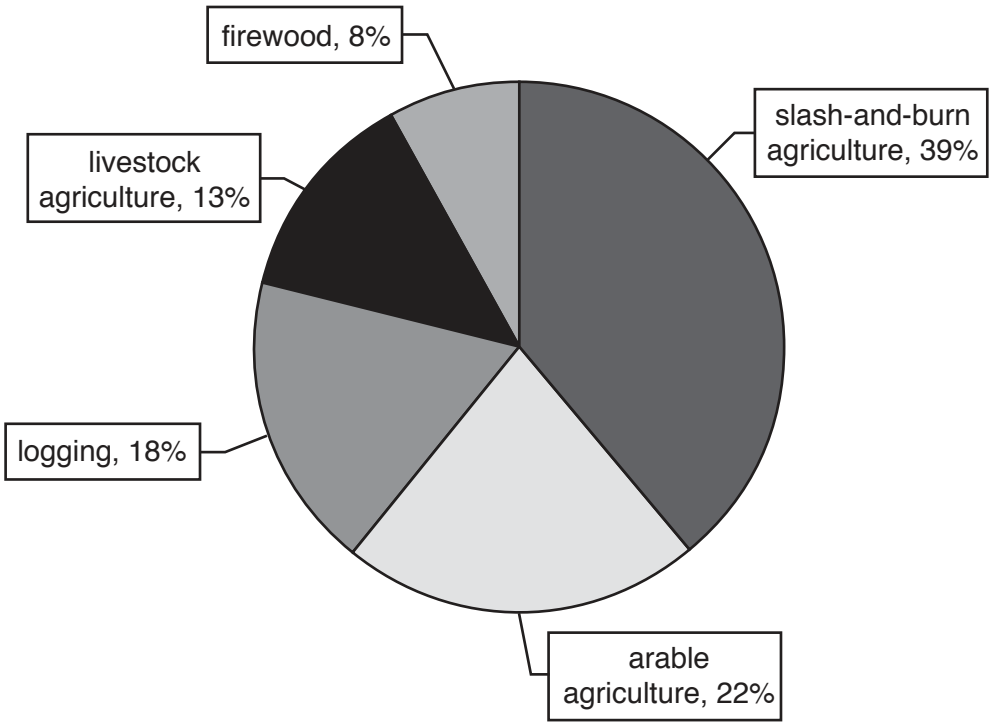

Fig. 4.1

(a) Calculate the **total** percentage of deforestation caused by agriculture.

.....% [1]

(b) Describe how slash-and-burn agriculture can increase the carbon dioxide concentration in the atmosphere.

.....

.....

.....

.....

..... [3]

(c) Describe the undesirable effects of deforestation on soil.

.....

.....

.....

.....

..... [3]

(d) Forests are ecosystems.

Define the term *ecosystem*.

.....

.....

.....

..... [2]

[Total: 9]

5 Petroleum is the raw material for the production of many useful substances.

Fig. 5.1 shows processes **A**, **B** and **C** that can be used in the production of ethanol.

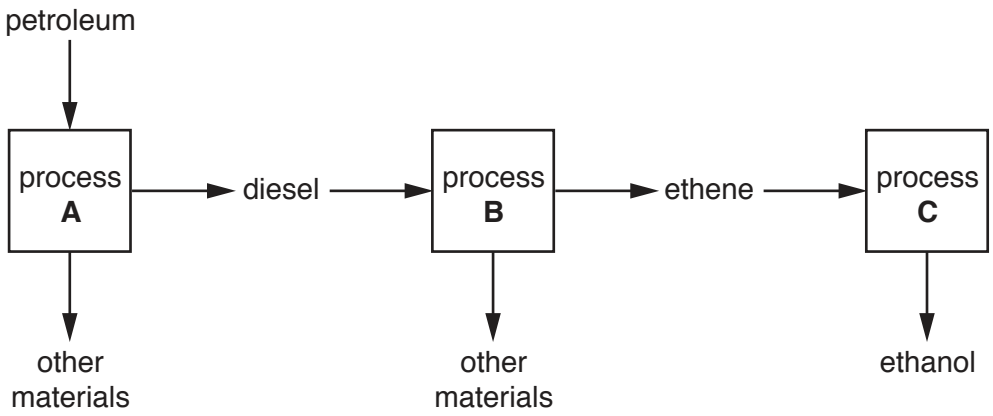

Fig. 5.1

(a) Name the processes by drawing one line from each process to its name.

process	name
	catalytic addition
A	cracking
B	fermentation
C	fractional distillation
	polymerisation

[2]

(b) The formula of ethanol is C_2H_5OH.

Explain why ethanol is **not** a hydrocarbon.

.....

..... [1]

(c) Fig. 5.2 shows a camping stove which uses ethanol as the fuel.

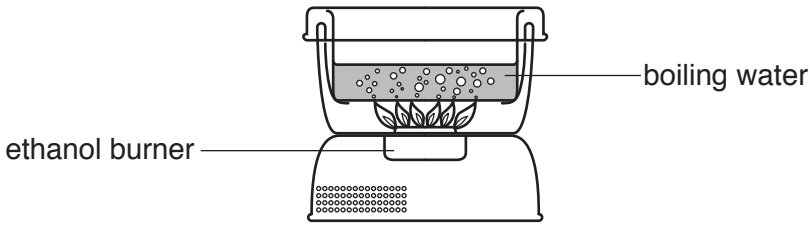

Fig. 5.2

Complete combustion of ethanol produces carbon dioxide and water.

The balanced equation for this reaction is shown.

$$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

The stove uses 22 g of ethanol to boil 1 dm^3 of water.

(i) Complete steps 1 to 3 to calculate the maximum mass of carbon dioxide produced when boiling 1 dm^3 of water.

Show your working.

[M_r: carbon dioxide, 44; ethanol, 46]

Step 1

Calculate the number of moles in 22 g of ethanol.

number of moles = ...

Step 2

Calculate the number of moles of carbon dioxide produced when 22 g of ethanol burns.

number of moles = ...

Step 3

Calculate the mass of carbon dioxide produced when boiling 1 dm^3 of water.

mass = ... g
[3]

(ii) A similar stove uses butane as the fuel.

Butane produces less carbon dioxide when boiling 1 dm^3 of water.

Suggest whether using the butane stove or the ethanol stove causes less damage to the environment.

Explain your answer.

type of stove .....

explanation .....

.....

.....

[2]

[Total: 8]

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6 **(a)** The visible light produced by the headlamps of a train is part of the electromagnetic spectrum.

(i) Write visible light in the correct position in the incomplete electromagnetic spectrum in Fig. 6.1.

gamma		ultraviolet			microwaves	

Fig. 6.1

[1]

(ii) All electromagnetic waves travel at the same speed.

State the speed of light in a vacuum.

..... m/s [1]

(b) The approaching train can be heard through the air and as a ringing sound in the steel rails.

The speed of sound in air is 330 m/s and the speed of sound in steel is 6000 m/s.

(i) Suggest a value for the speed of sound through water.

Explain your answer.

speed of sound in water = ... m/s

explanation .....

.....

[1]

(ii) Calculate the time difference between a sound travelling 0.50 km through air and 0.50 km through steel rails.

Show your working.

time difference = ... s [2]

(iii) The train emits sound waves with a frequency of 500 Hz which travel through the air at a speed of 330 m / s.

Calculate the wavelength of these waves.

Show your working.

wavelength = ... m [2]

(iv) Sound waves are longitudinal waves. Visible light waves are transverse waves.

Describe the differences between longitudinal and transverse waves in terms of the direction of travel of the waves, and the direction of oscillation or vibration.

You may draw a diagram if it helps your answer.

.....

.....

.....

.....

..... [2]

[Total: 9]

[Turn over

7 **(a)** A student investigates the effect of temperature on the rate of diffusion of red dye into agar jelly cubes.

The student prepares three cubes of agar jelly **A**, **B** and **C**.

- Each cube is equal in size.
- **A** is kept at 30 °C, **B** is kept at 25 °C, **C** is kept at 20 °C.
- Three separate containers of red dye are also kept at 30 °C, 25 °C and 20 °C.
- Each cube is immersed in red dye equal to its temperature for 10 minutes.
- The cubes are then removed from the dye and cut in half.

Fig. 7.1 shows the cubes cut in half.

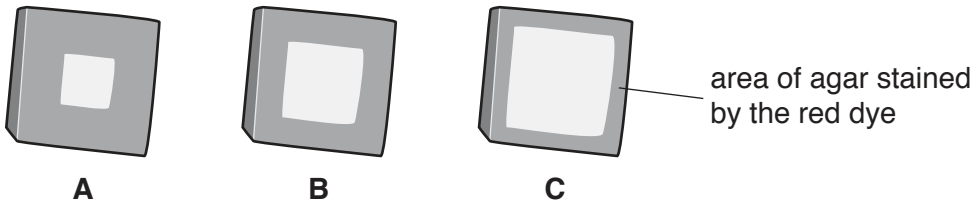

Fig. 7.1

Table 7.1 shows the results.

Table 7.1

cube	temperature of cube and dye / °C	diffusion distance (after 10 minutes) / cm	rate of diffusion / cm per min
A	30	1.0	
B	25	0.7	0.07
C	20	0.5	0.05

(i) Calculate the rate of diffusion for cube **A**.

..... cm per min [1]

(ii) Use the results in Table 7.1 to describe the relationship between temperature and the rate of diffusion.

.....

..... [1]

(iii) State **one** variable, other than the size of the cubes, that should be kept constant in this investigation.

..... [1]

(b) Explain why the red dye diffuses into the agar jelly.

.....

.....

.....

.....

..... [2]

(c) Materials diffuse in and out of living cells.

Name the gas produced by respiration that diffuses **out** of cells.

..... [1]

[Total: 6]

[Turn over

8 (a) (i) Using information in the Periodic Table on page 32, calculate the relative molecular masses of the gases nitrogen and chlorine.

M_r (nitrogen) = ...

M_r (chlorine) = ...
[1]

(ii) Using your answer to **(a)(i)**, state and explain which of these two gases diffuses at the greater rate.

gas .....

explanation .....

.....
[1]

(b) Chlorine occurs naturally as a mixture of mainly two isotopes, chlorine-35 and chlorine-37.

Complete Table 8.1 to show some information about the atomic structures of these isotopes.

Table 8.1

isotope	number of nucleons	number of protons	number of neutrons	number of electrons
chlorine-35	35	17		
chlorine-37	37	17		

[2]

(c) A student mixes colourless aqueous solutions of chlorine and sodium bromide.

Fig. 8.1 shows the apparatus she uses.

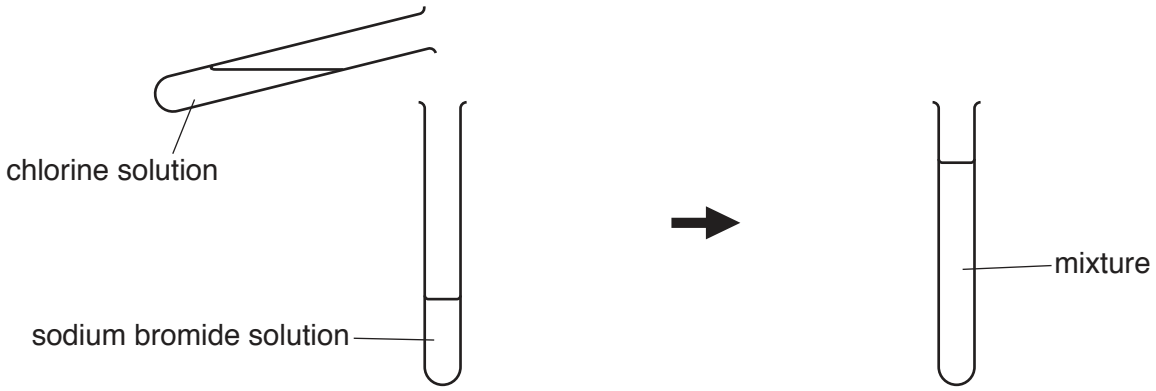

Fig. 8.1

(i) A reaction occurs when chlorine solution is mixed with sodium bromide solution.

Predict and explain the student's observation when these solutions are mixed.

observation .....

explanation .....

.....

[2]

(ii) Write a word equation for the reaction that occurs when these solutions are mixed.

..... [2]

(d) The student adds an orange solution of bromine to a colourless solution of sodium fluoride.

Predict and explain the student's observation when the solution of bromine is added to the solution of sodium fluoride.

observation .....

explanation .....

.....

[2]

[Total: 10]

[Turn over

9 **(a)** During a mission to the Moon in 1971, an astronaut dropped a feather and a hammer.

The feather and hammer were released from the same height at the same time. Both fell for 1.3 s, and landed at the same time.

The acceleration due to gravity on the Moon is 1.6 m / s^2.

Assume that the Moon has no atmosphere.

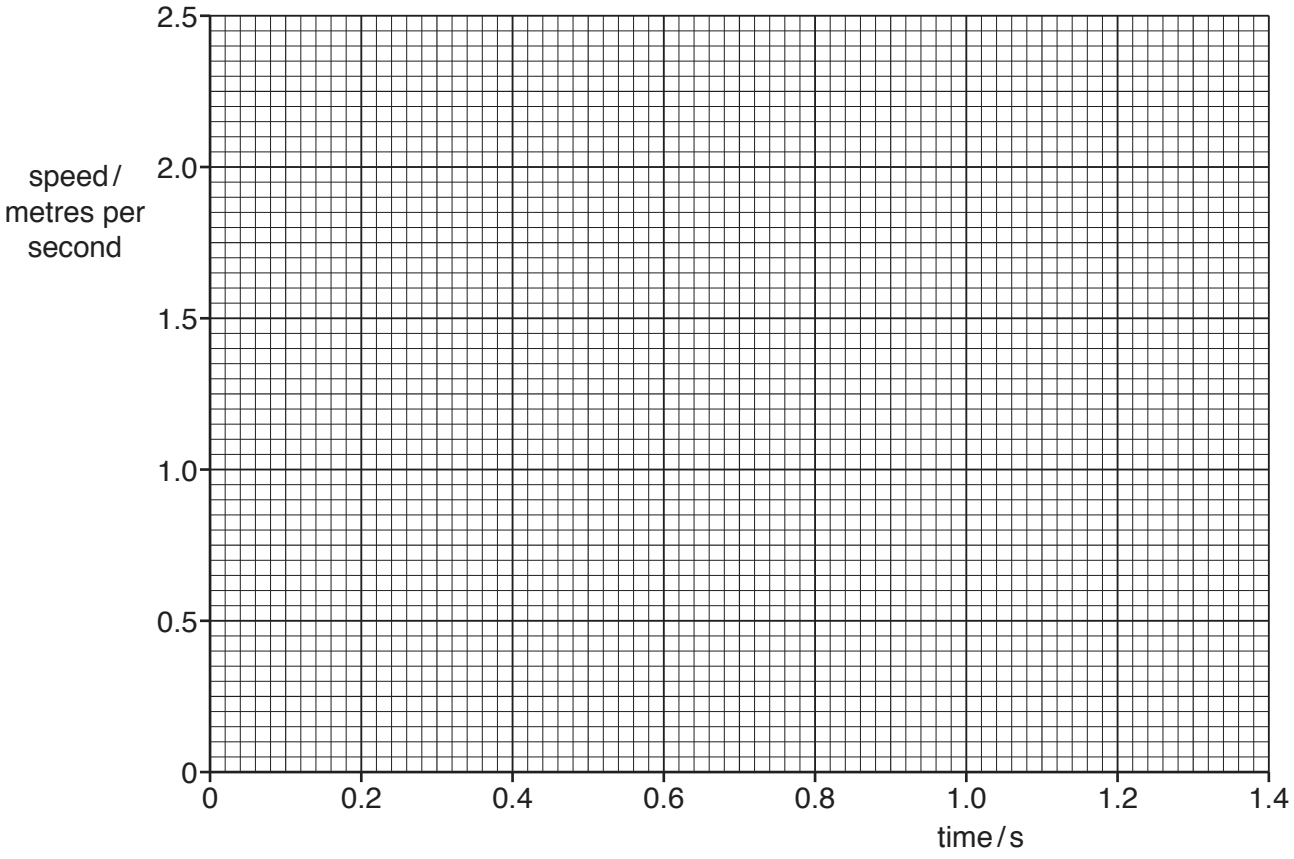

Fig. 9.1

(i) On Fig. 9.1 draw the speed-time graph for the falling feather. [2]

(ii) The experiment is repeated on Earth. State **two** differences in the results obtained.

Explain your answers.

difference 1 .....

explanation .....

.....

.....

difference 2 .....

explanation .....

.....

.....

[4]

(b) The astronaut wears a white suit rather than a black suit.

Suggest and explain a reason for this.

.....

.....

..... [2]

(c) The astronaut is exposed to more ionising radiation than people who remain on the Earth.

State **one** harmful effect of ionising radiation on the human body.

.....

..... [1]

(d) Alpha radiation is one form of ionising radiation.

An isotope of plutonium, $^{239}_{94}Pu$, decays by alpha emission to produce an isotope of uranium.

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

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

[2]

[Total: 11]

10 **(a)** Fig. 10.1 shows a cross-section through a vein when seen under a light microscope.

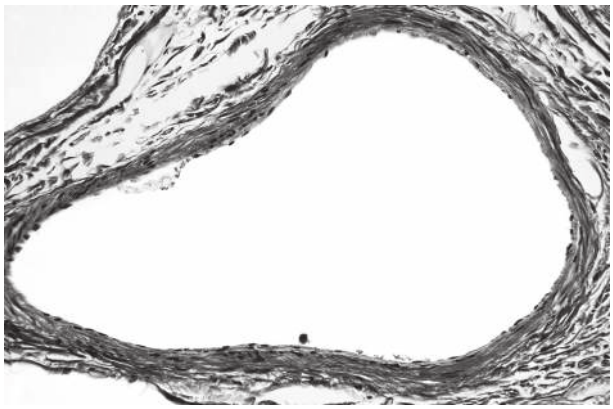

Fig. 10.1

(i) On Fig. 10.1 draw two label lines to identify the:

- lumen
- wall of the vein. [2]

(ii) Name **one** structure of veins **not** visible in Fig. 10.1.

..... [1]

(b) Explain why the wall of an artery is much thicker than the wall of a vein.

.....

.....

.....

..... [2]

(c) Coronary heart disease is caused by a blockage in the coronary arteries.

State **two** lifestyle factors that **increase** the risk of coronary heart disease.

1.....

2..... [2]

(d) Hormones are released into blood.

(i) Name the hormone that:

- is released in stressful situations

  .....

- **decreases** the glucose concentration of the blood.

  .....

[2]

(ii) Auxin is a plant hormone.

State the effect of auxin on plant cells.

..... [1]

[Total: 10]

11 (a) A student investigates the rate of reaction of calcium carbonate with dilute hydrochloric acid.

The word equation for the reaction is shown.

calcium carbonate + hydrochloric acid ⟶ calcium chloride + water + carbon dioxide

Fig. 11.1 shows some of the apparatus he uses.

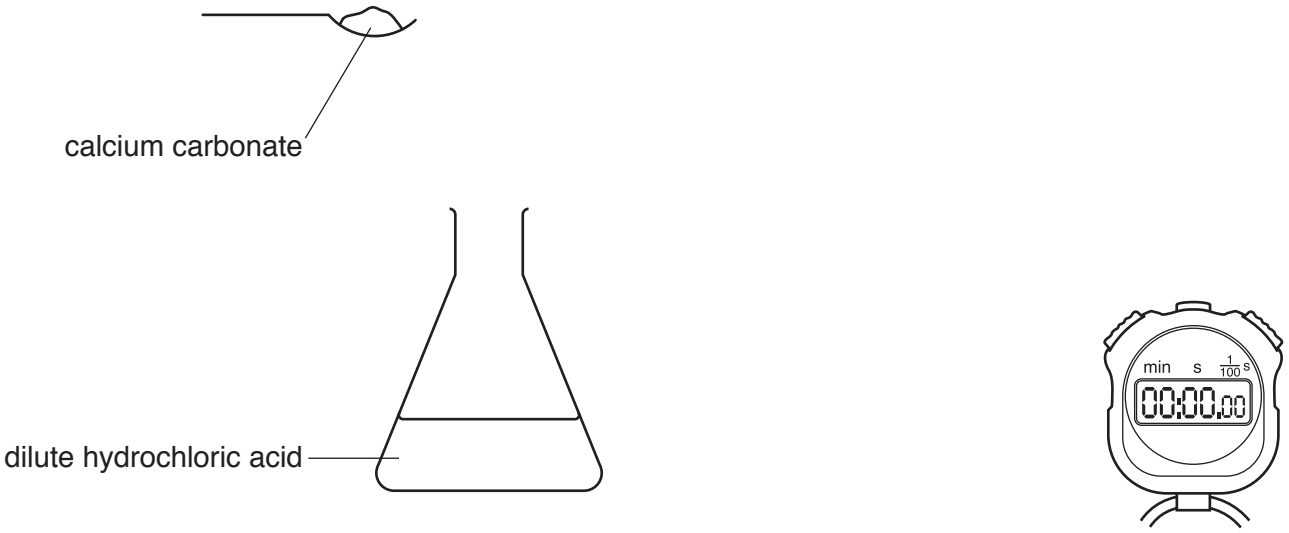

Fig. 11.1

(i) Suggest what other equipment he needs and how he would use it to calculate the rate of carbon dioxide produced.

You may draw on Fig. 11.1 to help your answer.

.....

.....

.....

.....

..... [2]

(ii) He carries out the experiment using dilute hydrochloric acid at 20 °C.

He repeats the experiment at 30 °C.

Fig. 11.2 shows his results.

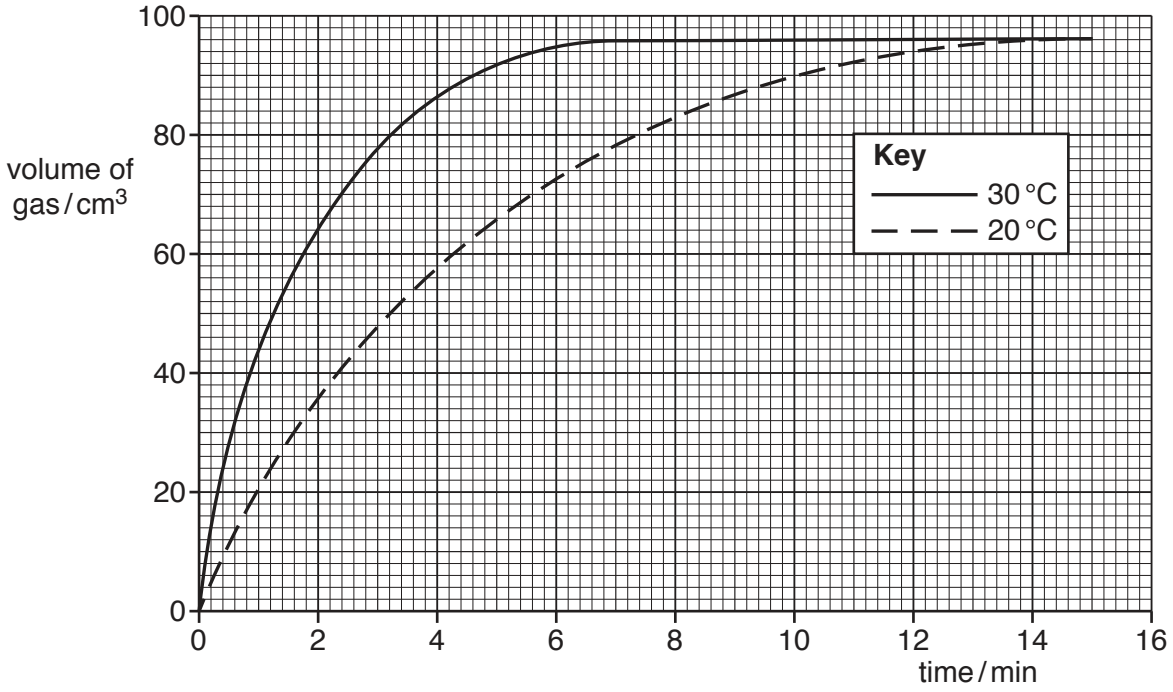

Fig. 11.2

State and explain the differences between the graphs in terms of the movement of reacting particles.

.....

.....

.....

.....

..... [3]

(b) Lead chloride is an insoluble salt.

Describe a method of making solid lead chloride from reactants chosen from Table 11.1.

Table 11.1

compound	solubility in water
calcium chloride	soluble
calcium nitrate	soluble
calcium sulfate	insoluble
lead carbonate	insoluble
lead nitrate	soluble
lead sulfate	insoluble
magnesium sulfate	soluble
silver chloride	insoluble
sodium chloride	soluble
sodium nitrate	soluble

reactants ..... and .....

method .....

.....

.....

.....

[4]

(c) Lead chloride has a melting point of 501 °C.

Explain how the structure of lead chloride causes it to have a high melting point.

.....

.....

..... [2]

[Total: 11]

12 Fig. 12.1 shows a solar-powered golf cart, with solar cells on the roof.

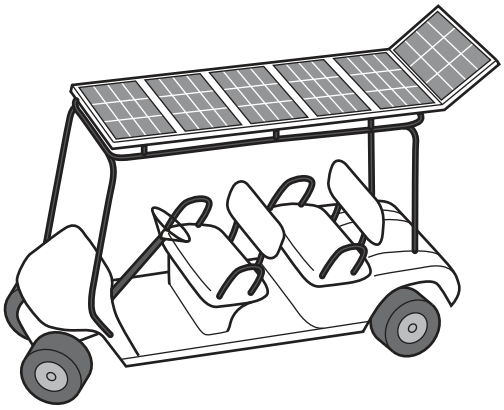

Fig. 12.1

The solar cells produce electrical energy using solar energy. The Sun is the source of this energy.

(a) Name **two** energy resources that do **not** have the Sun as their source of energy.

1 .....

2 ..... [1]

(b) During the golf cart's journey, the temperature in the tyres increases.

The volume of air in the tyres does not change.

Explain in terms of molecules the effect on the pressure of a gas due to an increase in temperature at constant volume.

.....

.....

.....

..... [2]

[Turn over

(c) The golf cart often travels across sloping fields so stability is important in its design.

Fig. 12.2 shows the cart on a slope.

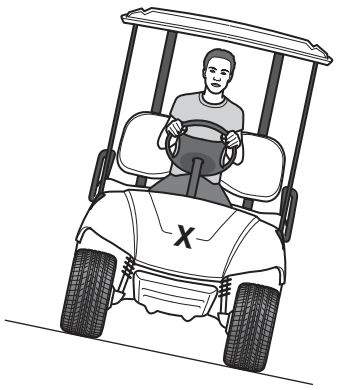

Fig. 12.2

The centre of mass of the golf cart is shown by the letter **X**.

State the effect of raising the centre of mass of the golf cart on its stability.

.....

..... [1]

(d) A spectator takes a photograph of a golfer with a camera.

The camera uses a thin converging lens to focus light rays onto the light sensor inside the camera.

(i) Complete the ray diagram in Fig. 12.3 to show this.

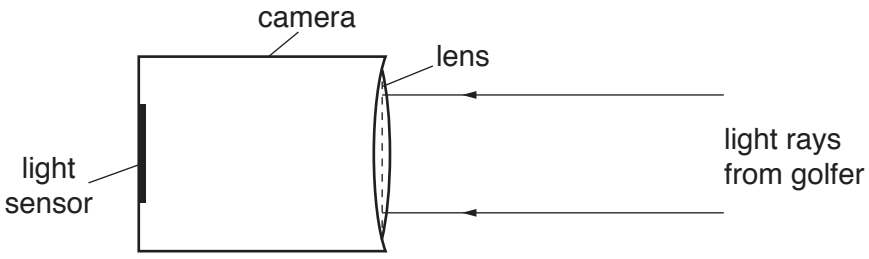

Fig. 12.3

[1]

(ii) The lens is made from glass. Glass has a refractive index of 1.33.

Define refractive index in terms of the speed of light in a vacuum and in glass.

.....

..... [1]

(iii) The image produced by the lens on the light sensor is a real image.

Describe the difference between a real image and a virtual image.

.....

..... [1]

(e) Describe in terms of the forces between the atoms why solids have a fixed shape.

.....

..... [1]

[Total: 8]

13 Enzymes are biological catalysts with a specific shape.

(a) Explain the importance of the shape of an enzyme.

.....

.....

.....

.....

..... [3]

(b) A student tests different solutions for the nutrients they contain.

Table 13.1 shows the results.

Table 13.1

solution	colour with iodine solution	colour with Biuret solution	colour with Benedict's solution
A	blue-black	blue	red
B	yellow-brown	blue	blue
C	blue-black	purple	red
D	yellow-brown	blue	red
E	blue-black	blue	green

One of the solutions **A**, **B**, **C**, **D** or **E** contains an enzyme.

Using the information in Table 13.1 identify which solution contains an enzyme.

Explain your answer.

solution .....

explanation .....

.....

.....

[3]

[Total: 6]

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The Periodic Table of Elements

Group I	Group II											Group III	Group IV	Group V	Group VI	Group VII	Group 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.).