Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

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CO-ORDINATED SCIENCES **0654/43**

Paper 4 Theory (Extended) **October/November 2022**

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 **32** pages. Any blank pages are indicated.

1 **(a)** Gills are the gas exchange surface in fish.

Fig. 1.1 is a photograph of gills in fish.

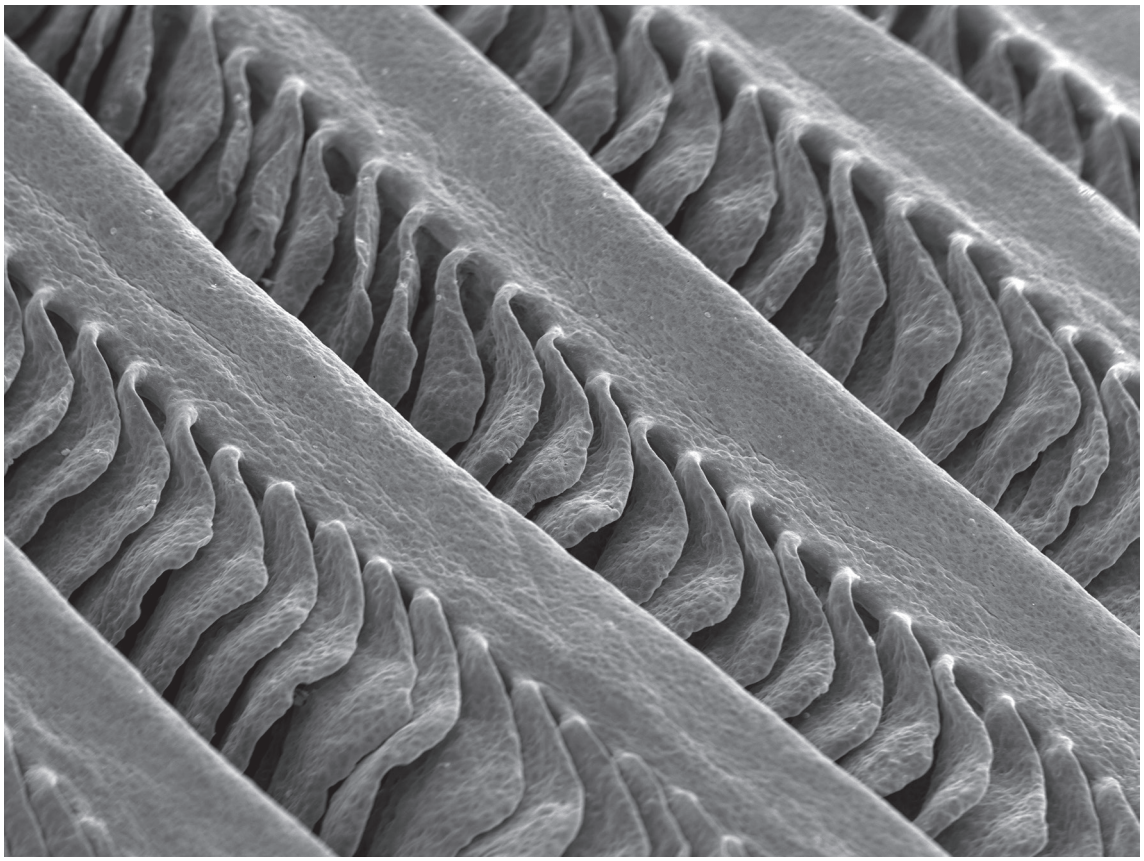

Fig. 1.1

Gills have adaptive features for gas exchange.

Use your scientific knowledge and Fig. 1.1 to suggest **two** of these adaptive features.

1 .....

2 .....

[2]

(b) Table 1.1 shows the composition of some gases in inspired and expired air.

Table 1.1

	gas	
	percentage of oxygen	percentage of carbon dioxide
inspired air	21	0.004
expired air	16	4

(i) Use Table 1.1 to calculate the difference in percentage of oxygen between inspired and expired air.

..... % [1]

(ii) Explain the difference in percentage of oxygen between inspired and expired air that is shown in Table 1.1.

.....

.....

..... [2]

(iii) State **one** difference in composition between inspired and expired air that is **not** shown in Table 1.1.

.....

..... [1]

(c) Red blood cells have adaptive features for the efficient transport of oxygen.

State **two** of these features.

1 .....

2 .....
[2]

(d) Lung cancer is a disease caused by smoking.

(i) Place ticks (✓) to show **two** other diseases caused by smoking.

chronic obstructive pulmonary disease (COPD)	
coronary heart disease	
kwashiorkor	
marasmus	
scurvy	

[2]

(ii) State the name of the component in tobacco smoke that causes cancer.

..... [1]

(iii) Describe how the goblet cells, mucus and ciliated cells protect the gas exchange system from some of the particles in tobacco smoke.

.....

.....

.....

.....

..... [3]

[Total: 14]

2 **(a)** A student investigates two liquid fuels, **A** and **B**, to find out which fuel releases most energy.

Fig. 2.1 shows the apparatus used. 1.5 g of each fuel is burned completely.

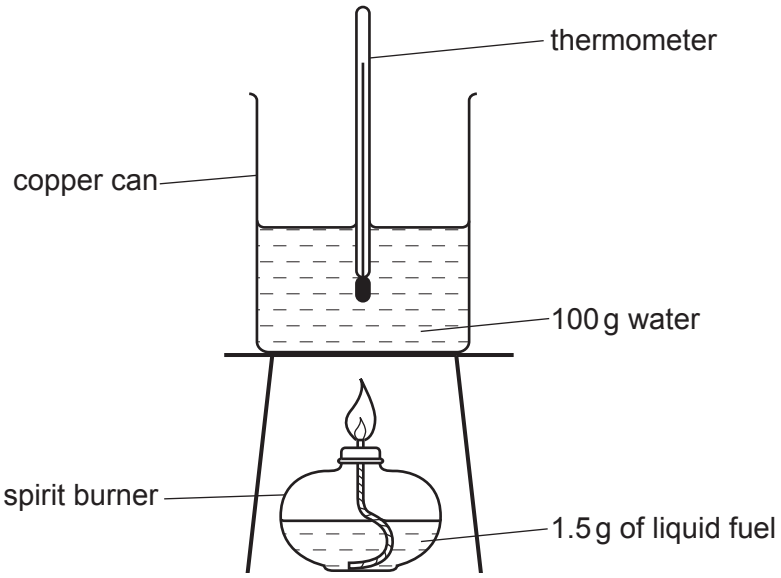

Fig. 2.1

Table 2.1 shows the student's results.

Table 2.1

fuel	temperature of water at start / °C	temperature of water at end / °C	temperature change / °C
A	16	25	9
B	16	34	18

(i) Describe how the results show which fuel releases the most energy.

.....

..... [1]

(ii) Fig. 2.2 is the equation representing the complete combustion of ethanol.

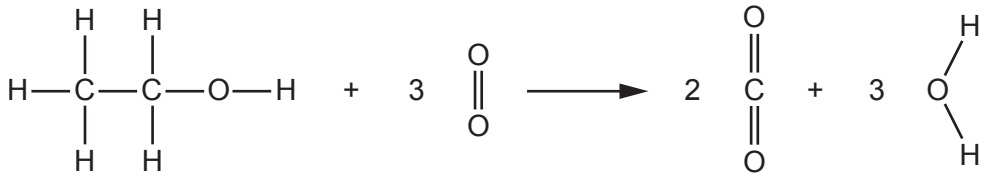

Fig. 2.2

This reaction is exothermic.

Place a tick (✓) in the box next to the correct explanation of an exothermic reaction.

More energy is given out by bond breaking than is taken in by bond making.	☐
More energy is given out by bond making than is taken in by bond breaking.	☐
More bonds are broken than are made.	☐
More energy is taken in by bond breaking than is given out by bond making.	☐

[1]

(b) Fig. 2.3 shows the energy level diagram for an exothermic reaction.

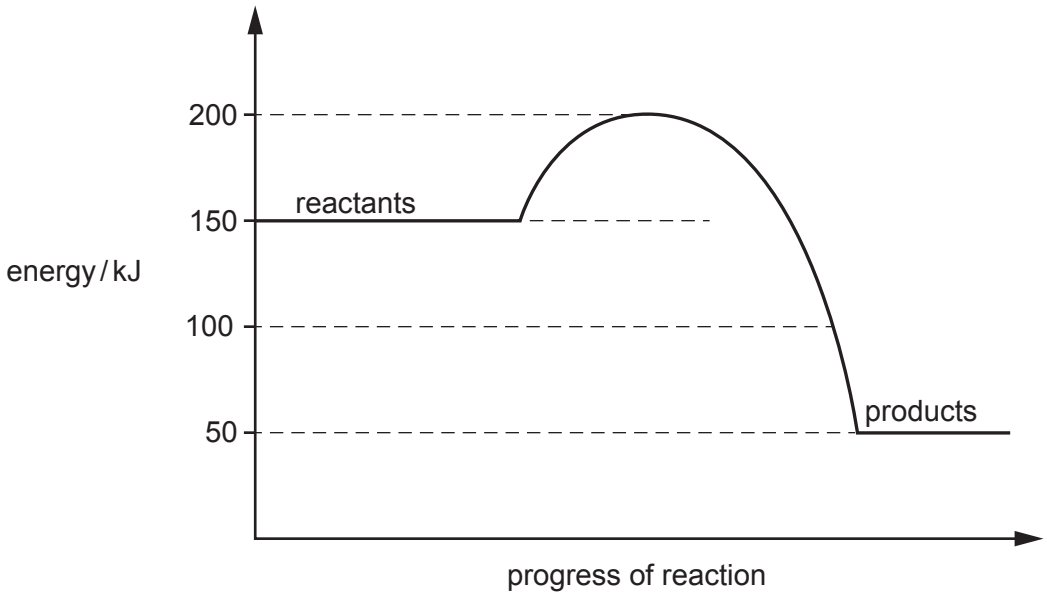

Fig. 2.3

(i) Use Fig. 2.3 to calculate the energy given out in the reaction.

energy given out = ... kJ [1]

(ii) Use Fig. 2.3 to calculate the activation energy for the reaction.

activation energy = ... kJ [1]

(c) Ethanol can be made by

- the catalytic addition of steam to ethene
- fermentation.

(i) Construct the balanced symbol equation for the addition of steam to ethene to make ethanol, C_2H_5OH.

..... + ... → ..... [2]

(ii) Describe how ethanol is made by fermentation.

.....

.....

.....

..... [3]

[Total: 9]

3 Fig. 3.1 shows a man in a canoe on a lake.

The combined mass of the man and the canoe is 120 kg.

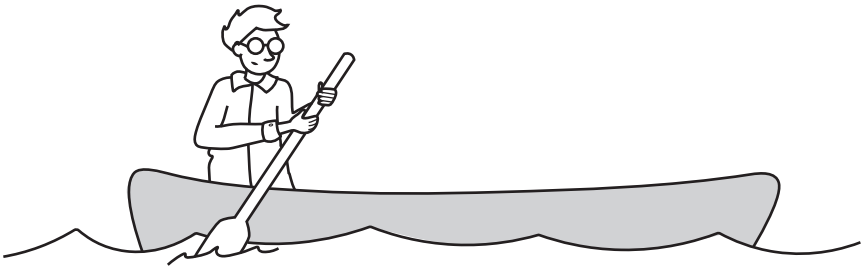

Fig. 3.1

(a) The canoe moves at a speed of 4.0 m/s.

(i) Calculate the kinetic energy of the man and the canoe.

kinetic energy = ... J [2]

(ii) The canoe takes 5.0 s to slow down to a speed of 0.5 m/s.

Calculate the constant deceleration of the canoe.

deceleration = ... m/s^2 [3]

(iii) On Fig. 3.2 draw a speed–time graph to show the canoe's deceleration.

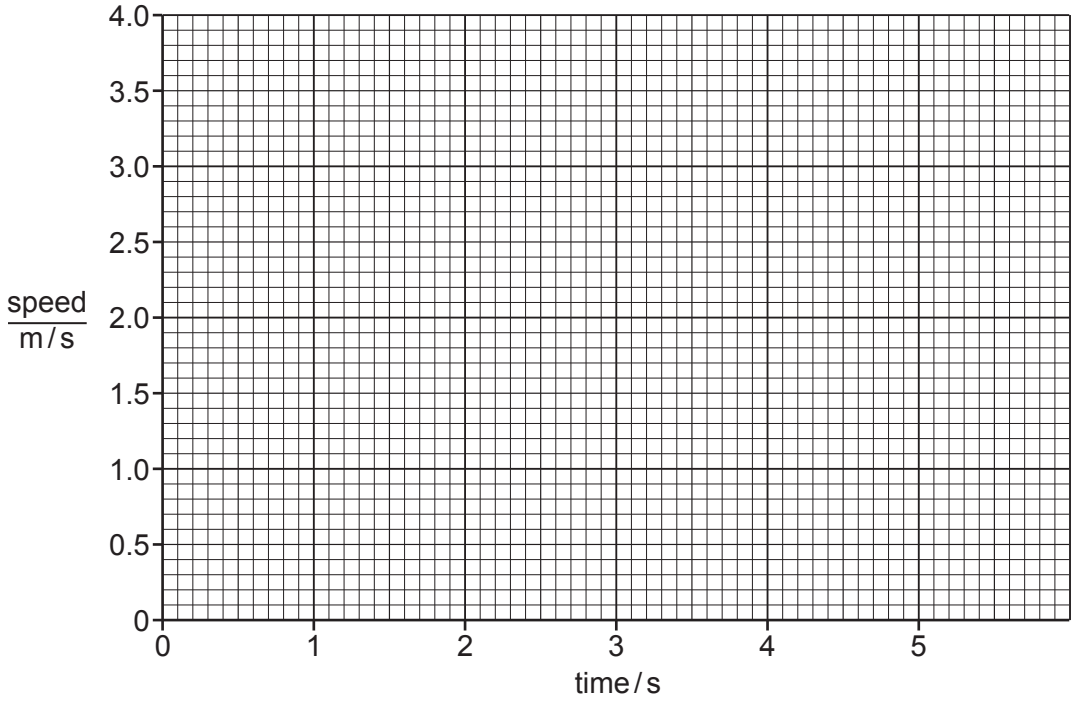

Fig. 3.2

[1]

(b) The canoe exerts a pressure of 0.5 kPa on the surface of the water.

Calculate the area of canoe in contact with the surface of the water.

The gravitational field strength, *g*, is 10 N / kg.

area = ... m^2 [3]

(c) Fig. 3.3 shows water waves on the surface of the lake.

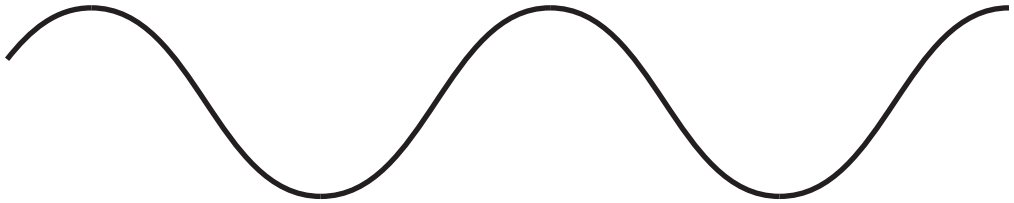

Fig. 3.3

(i) On Fig. 3.3, draw a double headed arrow (↕ or ↔) to show the wavelength of the wave. [1]

(ii) Use the words below to complete the sentences about waves.

You can use each word once, more than once or not at all.

compression energy force longitudinal matter perpendicular parallel rarefaction transverse

Waves transfer ..... without transferring ..... .

A water wave is an example of a ..... wave.

In a water wave the oscillations are ..... to the direction of the wave. [2]

[Total: 12]

4 **(a)** A student investigates the effect of light intensity on the rate of photosynthesis in an aquatic plant. The plant is placed in a beaker of water containing an excess of carbon dioxide.

A lamp is placed 10 cm away from the beaker of water.

The student counts the number of oxygen bubbles produced by the aquatic plant in one minute.

The lamp is then moved increasing distances away from the beaker to decrease the light intensity.

The number of oxygen bubbles produced is directly proportional to the rate of photosynthesis.

Table 4.1 shows the results.

Table 4.1

distance of lamp from the aquatic plant / cm	number of oxygen bubbles produced per minute
10	37
20	37
30	36
40	32
50	25
60	15
70	6
80	1

(i) Use Table 4.1 to describe the effect of light intensity on the rate of photosynthesis.

Include data in your answer.

.....

.....

.....

..... [2]

(ii) State why an excess of carbon dioxide is provided for the aquatic plant during this investigation.

.....

..... [1]

(b) Complete the sentences to explain how a lack of magnesium affects plant growth.

Magnesium is required for the synthesis of ..... .

This substance transfers light energy into ..... energy for the synthesis of carbohydrates.

A deficiency of magnesium ions causes the leaves to turn ..... .

[3]

(c) Nitrate ions are required for the synthesis of amino acids.

State the name of the class of large molecules made from amino acids.

..... [1]

[Total: 7]

5 This question is about metals.

(a) Potassium is a metal in Group I of the Periodic Table.

Fig. 5.1 shows the electronic structure of three elements.

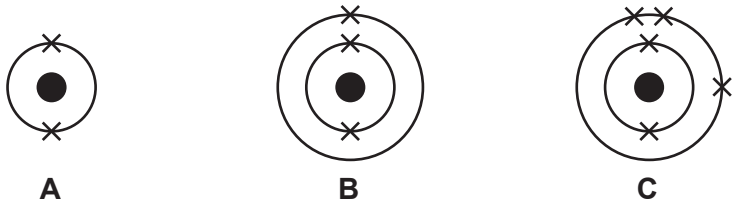

Fig. 5.1

(i) State which diagram **A**, **B** or **C**, shows the electronic structure of a Group I metal.

..... [1]

(ii) A student wants to confirm that a compound contains potassium.

The student uses a flame test.

State what the student observes if the compound contains potassium.

..... [1]

(b) Iron is a transition element.

Iron(II) sulfate contains iron(II) ions, Fe^{2+}.

Sodium hydroxide solution is used to test for iron(II) ions.

The iron(II) ions react with OH^- ions from the sodium hydroxide solution. A precipitate of iron(II) hydroxide, $Fe(OH)_2$, is made.

(i) State the colour of the precipitate of iron(II) hydroxide.

..... [1]

(ii) Construct the balanced ionic equation for the formation of $Fe(OH)_2$. Include state symbols.

..... [2]

(c) Magnesium reacts with oxygen to make magnesium oxide.

(i) Fig. 5.2 shows the electronic structure of a magnesium atom.
The proton number (atomic number) of magnesium is 12.

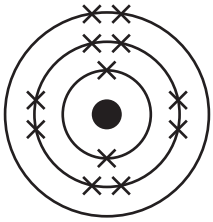

Fig. 5.2

Draw a diagram to show the electronic structure of an oxygen atom.
The proton number (atomic number) of oxygen is 8.

[1]

(ii) When magnesium reacts with oxygen, magnesium ions and oxide ions are made.
Fig. 5.3 shows the electronic structure of an oxide ion.

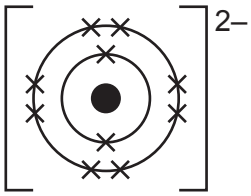

Fig. 5.3

Draw a diagram to show the electronic structure of a magnesium ion.

[2]

(iii) Explain why magnesium oxide has a high melting point.

.....

.....

..... [2]

(d) Potassium oxide is also an ionic compound.

Potassium ions, K^+, combine with oxide ions, O^{2-}, to form potassium oxide.

Determine the formula of potassium oxide.

..... [1]

[Total: 11]

6 Fig. 6.1 shows a marble staircase made up of 17 steps.

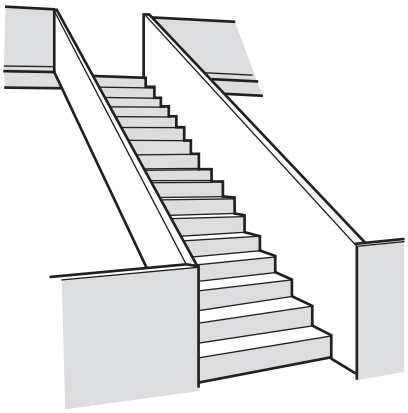

Fig. 6.1

(a) Fig. 6.2 shows the dimensions of one of the marble steps which has a mass of 72 kg.

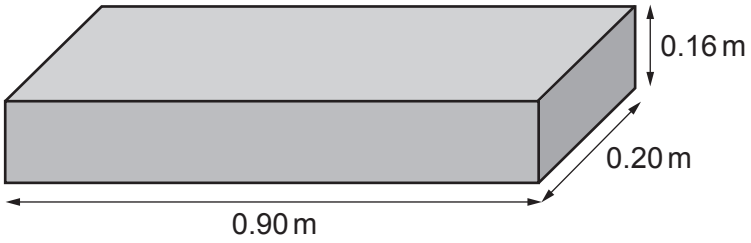

Fig. 6.2

(i) Calculate the density of the marble step.

density = ... kg / m^3 [3]

(ii) On a hot, sunny day the marble step expands.

Suggest what happens to the density of the marble step when it expands.

..... [1]

(iii) Explain, in terms of particle movement, why the marble expands.

.....

..... [1]

(b) (i) On a hot, sunny day the marble steps feel cold because of conduction.

Describe the process of conduction in marble.

.....

.....

.....

..... [2]

(ii) Explain why conduction causes the marble to feel cold.

.....

..... [1]

[Total: 8]

7 **(a)** Yeast produces carbon dioxide during anaerobic respiration.

A scientist adds 2 g of yeast to 250 cm^3 of glucose solution and leaves the mixture for 10 days.

Each day, at the same time, he records the volume of carbon dioxide produced in one hour.

Fig. 7.1 shows the results.

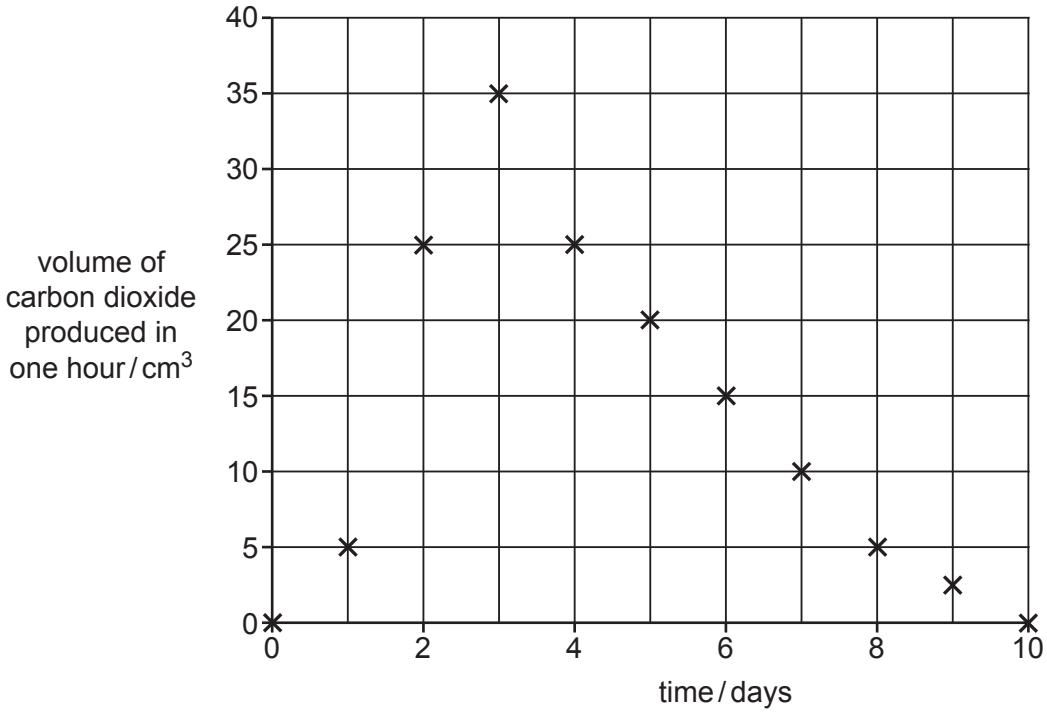

Fig. 7.1

(i) Use Fig. 7.1 to identify the day with the greatest rate of anaerobic respiration.

..... [1]

(ii) Explain why the volume of carbon dioxide decreases as shown in Fig. 7.1.

.....

.....

..... [2]

(b) The investigation is repeated with boiled yeast.

Explain with reference to enzymes why no carbon dioxide is produced.

.....

.....

.....

..... [3]

(c) Table 7.1 shows some products of different types of respiration.

Complete Table 7.1 by placing ticks (✓) to show the correct products of each type of respiration.

One has been done for you.

Table 7.1

	products of respiration		
type of respiration	carbon dioxide	water	lactic acid
aerobic in humans			
anaerobic in humans			
anaerobic in yeast	✓		

[3]

(d) Substances enter and leave a yeast cell by diffusion.

A student writes an incorrect definition of diffusion.

Circle the **two** words that are **not** correct.

'Diffusion is the total movement of particles from a region of their higher concentration to a region of their lower concentration up a concentration gradient, as a result of their random movement.'

[2]

[Total: 11]

8 **(a)** Water must be treated so that it is safe to drink.

Draw lines to link each stage in the water treatment process to the reason why it is used.

stage	reason
filtration	kills microbes
chlorination	allows larger solid particles to settle out
	traps finer particles using sand

[2]

(b) Water can be tested to identify some of the chemicals in it.

A scientist tests a sample of water from a river with acidified aqueous silver nitrate and also with acidified aqueous barium chloride.

Table 8.1 shows the results.

Table 8.1

test	with acidified aqueous silver nitrate	with acidified aqueous barium chloride
result	cream precipitate	white precipitate

The scientist thinks that the water contains both **chloride** and **sulfate** ions.

State whether the scientist is correct.

Explain your answer.

.....

.....

..... [2]

(c) Barium chloride, $BaCl_2$, reacts with sodium sulfate, Na_2SO_4.

Barium sulfate, $BaSO_4$, and sodium chloride, $NaCl$, are made.

Construct the balanced symbol equation for this reaction.

..... [2]

(d) Carbon dioxide dissolves in rainwater to make the water weakly acidic.

Suggest the pH of the rainwater produced.

pH = ... [1]

(e) The atoms in carbon dioxide, CO_2, are bonded by sharing electrons.

Fig. 8.1 shows some dot-and-cross diagrams.

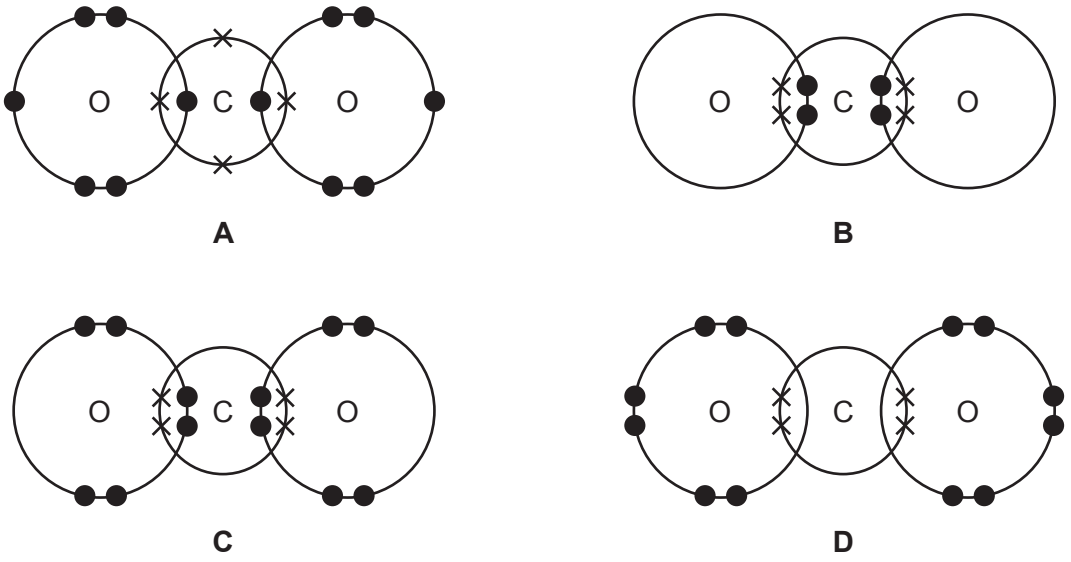

Fig. 8.1

(i) State which diagram **A**, **B**, **C** or **D**, shows the arrangement of the outer shell electrons in carbon dioxide.

diagram = ... [1]

(ii) State the name of this type of bonding that holds the atoms together in carbon dioxide.

..... [1]

(f) Complete the following sentences about some of the problems caused by carbon dioxide.

Choose words from the list. Each word or phrase may be used once, more than once or not at all.

climate change **greenhouse** **oxidation**

noble **rusting**

Carbon dioxide is a ..... gas.

Increased concentrations of carbon dioxide in the atmosphere

contribute to ..... .

[2]

[Total: 11]

9 Fig. 9.1 shows the equipment used by a teacher to demonstrate the properties of ionising radiation to a group of students. They are using a source which emits β-particles.

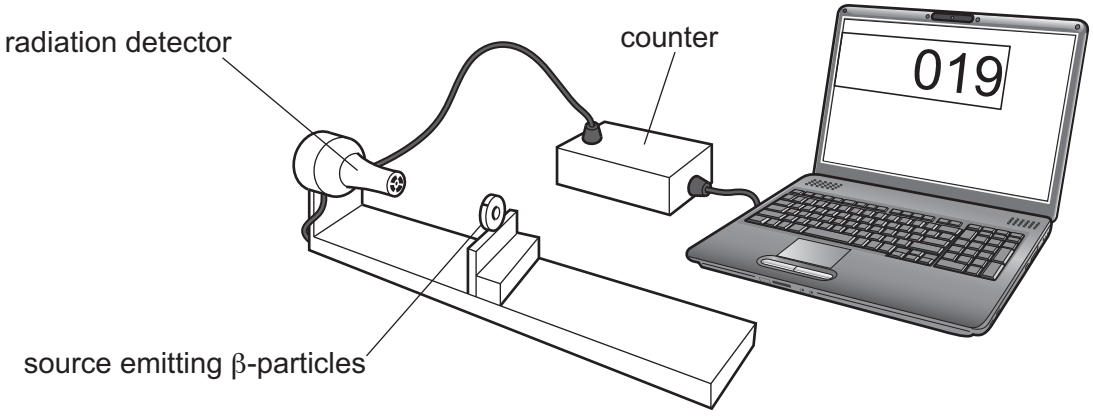

Fig. 9.1

(a) The radioactive source can be moved further away from the radiation detector. The teacher measures the distance between the source and the radiation detector and records the count rate using the laptop.

Fig. 9.2 shows the results plotted as a graph.

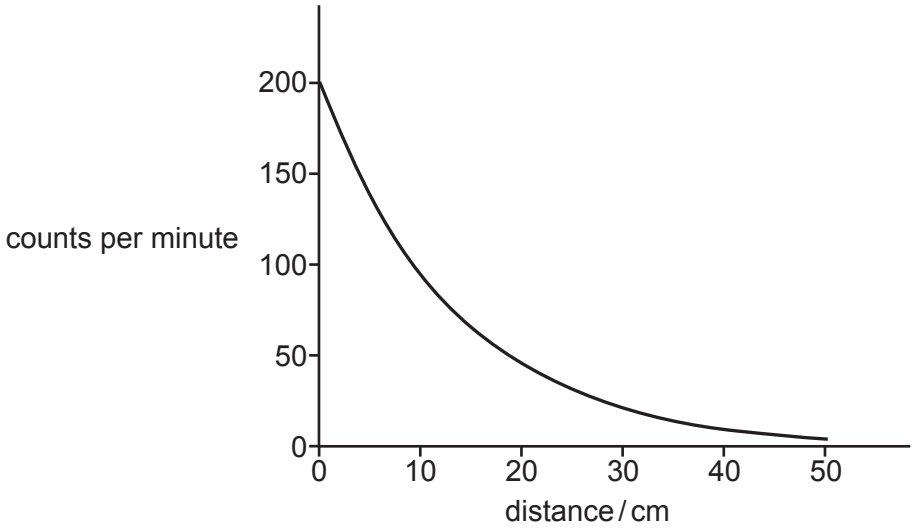

Fig. 9.2

(i) Describe the trend shown in Fig. 9.2.

.....

.....

.....

..... [2]

(ii) Use Fig. 9.2 to explain why the teacher tells the students to stand at least 2 m away from the radioactive source for their own safety.

.....

.....

.....

..... [2]

(iii) The teacher replaces the radioactive source with one which only emits α-particles.

The source which only emits α-particles also measures a count rate of 200 per minute at a distance of 0 m.

On Fig. 9.2, draw a line to show the results the teacher obtains when using the source which emits only α-particles.

[2]

(b) Fig. 9.3 shows the information sticker on the laptop.

power input = 65 W

potential difference = 19.5 V

Fig. 9.3

(i) The laptop has an efficiency of 80%.

Calculate the useful power output of the laptop.

power = ... W [2]

(ii) Power for the laptop comes from a 230 V supply through a device in the charger which changes the potential difference to 19.5 V.

State the name of this device.

..... [1]

[Total: 9]

10 (a) Albinism is a condition that results in a lack of colour in the skin causing a very pale appearance.

The allele for albinism is recessive, **a**.

The allele for no albinism is dominant, **A**.

Fig. 10.1 is a pedigree diagram showing the inheritance of albinism.

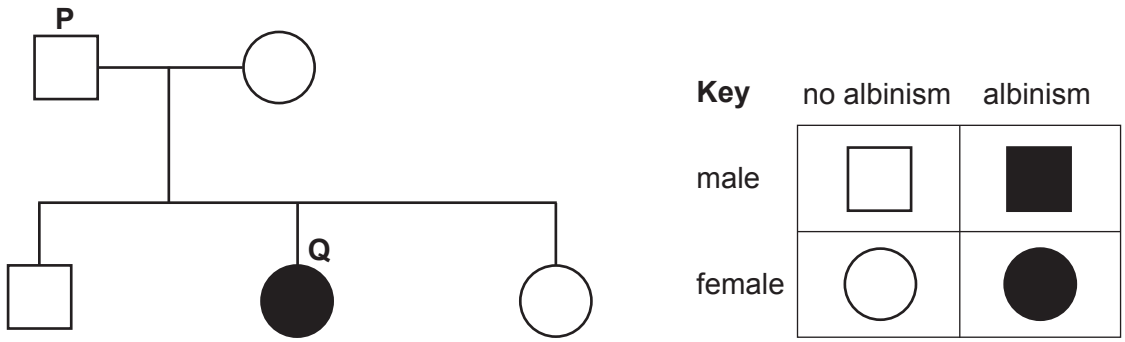

Fig. 10.1

The boxes on the left represent person **P** and person **Q** as shown in Fig. 10.1.

The boxes on the right complete statements about person **P** and person **Q**.

Draw **two** lines from person **P** and **two** lines from person **Q** to make **four** correct statements.

	has a heterozygous genotype.
Person **P**	has albinism.
	has a homozygous recessive genotype.
	has the genotype **AA**.
Person **Q**	
	is male.
	is female without albinism.

[4]

(b) Alleles are passed to offspring during sexual reproduction.

The sex cell in human males is sperm.

(i) State the name of the sex cell in human females.

..... [1]

(ii) State the number of chromosomes in one human sperm cell.

..... [1]

(iii) State the number of sex chromosomes in a body cell of a human male.

..... [1]

(iv) State the number of parents required for **asexual** reproduction.

..... [1]

[Total: 8]

11 Diamond is one **form** of carbon.

(a) **(i)** State the name of another form of carbon.

..... [1]

(ii) Diamond is used in cutting tools such as those shown in Fig. 11.1.

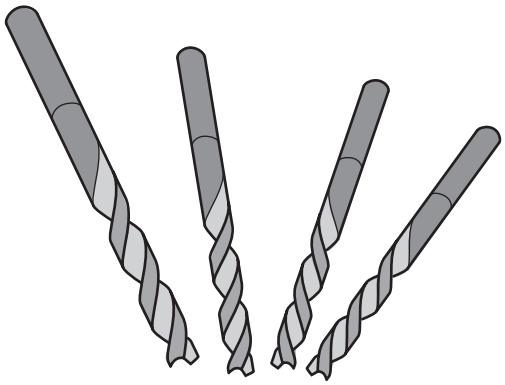

Fig. 11.1

State why diamond is used.

.....

..... [1]

(b) Silicon dioxide, SiO_2, has a similar structure to diamond.

Fig. 11.2 shows the structure of silicon dioxide.

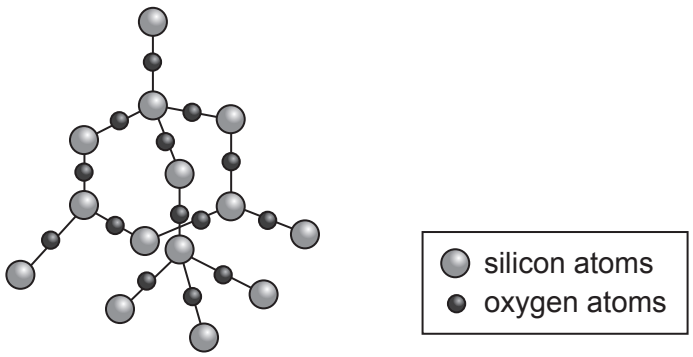

Fig. 11.2

Describe the **structure** and **bonding** in silicon dioxide.

Use Fig. 11.2 to help you.

.....

.....

..... [2]

(c) One of the isotopes of carbon is called carbon-12 and the other is called carbon-14.

Table 11.1 shows some information about carbon-12.

Complete the table for carbon-14.

Table 11.1

	number of protons	number of neutrons	number of electrons
carbon-12	6	6	6
carbon-14			

[1]

(d) Relative atomic mass, A_r, is defined in terms of a carbon atom.

Complete the definition of relative atomic mass.

Choose words from the list. Each word may be used once, more than once or not at all.

average **compound** **density**

element **formula** **mass**

Relative atomic mass is the ..... mass of naturally occurring atoms of an ..... on a scale where the ^{12}C atom has a ..... of exactly 12 units.

[3]

(e) Calculate the number of moles in 0.6 g of carbon.

[A_r: C, 12;]

moles = ... [1]

[Total: 9]

12 Fig. 12.1 shows a circuit containing two resistors connected in parallel with a 9.0 V battery.

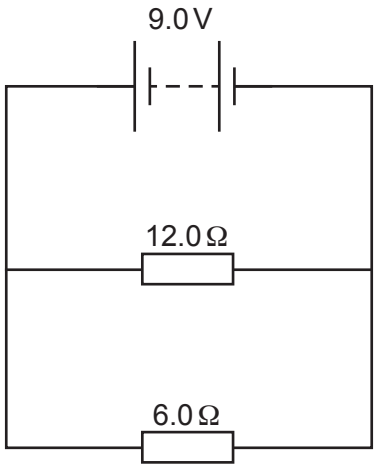

Fig. 12.1

(a) (i) Calculate the total resistance of the circuit shown in Fig. 12.1.

total resistance = ... Ω [2]

(ii) Calculate the current passing through the 6.0 Ω resistor.

current = ... A [2]

(b) The 9.0 V battery is connected in series with a lamp, a variable resistor and a switch.

(i) Draw a circuit diagram showing a 9.0 V battery connected in series with a lamp, a variable resistor and a switch.

[2]

(ii) The variable resistor is used to change the voltage across and the current in the lamp.

On Fig. 12.2, sketch a graph showing the current-voltage characteristic of a filament lamp.

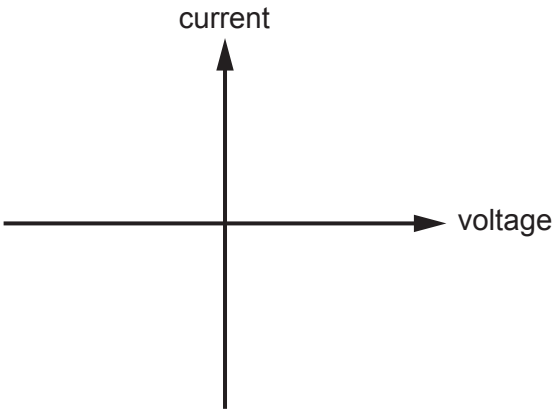

Fig. 12.2

[1]

(c) Fig. 12.3 shows a circuit containing a thermistor and a lamp in series with an ammeter. A voltmeter is connected in parallel across the thermistor.

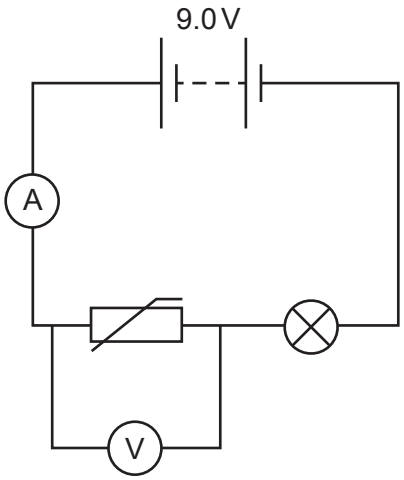

Fig. 12.3

(i) Describe what happens to the readings on the ammeter and voltmeter when the temperature of the thermistor increases.

Use the words **increases**, **decreases** or **stays the same**.

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

ammeter .....

voltmeter .....

[1]

(ii) Explain why the brightness of the lamp changes as the temperature of the thermistor increases.

.....

.....

.....

.....

..... [3]

[Total: 11]

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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.).