Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

8509496074

CO-ORDINATED SCIENCES **0654/42**

Paper 4 Theory (Extended) **February/March 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)** State the balanced equation for photosynthesis.

..... [2]

(b) A student investigates the effect of temperature on the rate of photosynthesis of an aquatic plant.

The student counts the number of bubbles produced per minute at different temperatures.

The number of bubbles produced per minute is an indication of the rate of photosynthesis.

The results are shown in Table 1.1.

Table 1.1

temperature / °C	number of bubbles produced per minute
0	0
5	6
10	9
15	13
20	16
25	18
30	17
35	9
40	0

(i) State the temperature that resulted in the fastest rate of photosynthesis.

..... °C [1]

(ii) Place ticks (✓) next to **all** the statements that explain the results between 0 °C and 10 °C.

The kinetic energy of the particles increases.	
There are more frequent collisions between the substrate and enzyme.	
Fewer substrate molecules fit into the active site of enzymes.	
The temperature affects the pH of the enzymes.	
The number of bubbles increases as more substrate is produced.	

[2]

(iii) Explain the results at **40** °C from Table 1.1.

.....

.....

.....

.....

.....

..... [3]

(iv) Explain why the light intensity is kept constant during this investigation.

.....

.....

.....

..... [2]

[Total: 10]

2 **(a)** Table 2.1 shows some information about the charges and relative masses of three subatomic particles.

Table 2.1

	particle **A**	particle **B**	particle **C**
charge	+1	no charge	–1
relative mass	1	1	$\frac{1}{1840}$

Use the information in Table 2.1 to state the names of particles **A**, **B** and **C**.

particle **A** .....

particle **B** .....

particle **C** .....

[3]

(b) Fig. 2.1 shows a diagram of an atom of magnesium.

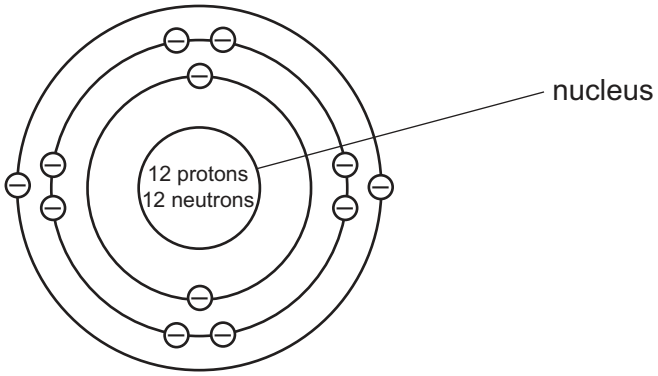


Fig. 2.1

(i) State why this atom of magnesium has a proton number (atomic number) of 12 and a nucleon number (mass number) of 24.

proton number of 12 because .....

.....

nucleon number of 24 because .....

.....

[2]

(ii) State the electronic structure of this atom of magnesium.

..... [1]

(c) Magnesium reacts with oxygen to form magnesium oxide, MgO.

Magnesium oxide is an **ionic** compound with a melting point of 2852 °C.

Oxygen reacts with hydrogen to form water, H_2O.

Water is a **covalent** compound with a melting point of 0 °C.

Explain the difference in the melting points of magnesium oxide and water in terms of attractive forces.

.....

.....

.....

..... [3]

(d) Magnesium oxide reacts with dilute hydrochloric acid, HC*l*.

Magnesium chloride, $MgCl_2$, is made.

The balanced symbol equation for the reaction is shown.

$$MgO + 2HCl \rightarrow MgCl_2 + H_2O$$

In an experiment, 2.0 g of magnesium oxide reacts with excess dilute hydrochloric acid.

Calculate the maximum mass of magnesium chloride that can be made.

Show your working.

[A_r: C*l*, 35.5; H, 1; Mg, 24; O, 16]

mass of magnesium chloride = ... g [2]

[Total: 11]

3 Fig. 3.1 shows a tennis player throwing a ball in the air before the player hits the ball.

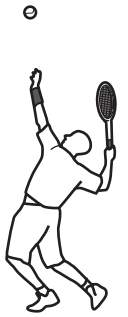


Fig. 3.1

(a) The ball has a mass of 56.25 g and is thrown vertically upwards with a velocity of 8.0 m / s.

(i) Calculate the kinetic energy of the ball immediately after it leaves the player's hand.

kinetic energy = ... J [3]

(ii) The tennis player notices that the ball has a velocity of zero when it reaches its maximum height.

Name the form of energy stored by the ball at its maximum height.

..... [1]

(b) Fig. 3.2 shows the tennis player hitting the same ball with the racket.

Fig. 3.2

This causes the ball to accelerate at 1600 m / s^2.

Calculate the force applied to the ball by the racket.

force = ... N [2]

(c) A student removes one of the nylon strings from the racket to investigate how it deforms when tensile forces are applied.

Fig. 3.3 shows the equipment used.

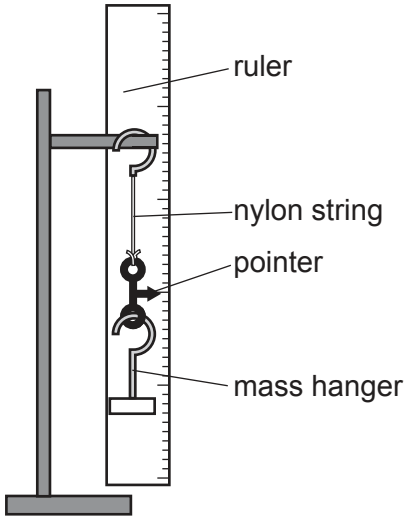


Fig. 3.3

The student adds masses to the mass hanger and records the extension of the nylon string.

Fig. 3.4 shows the results from this investigation.

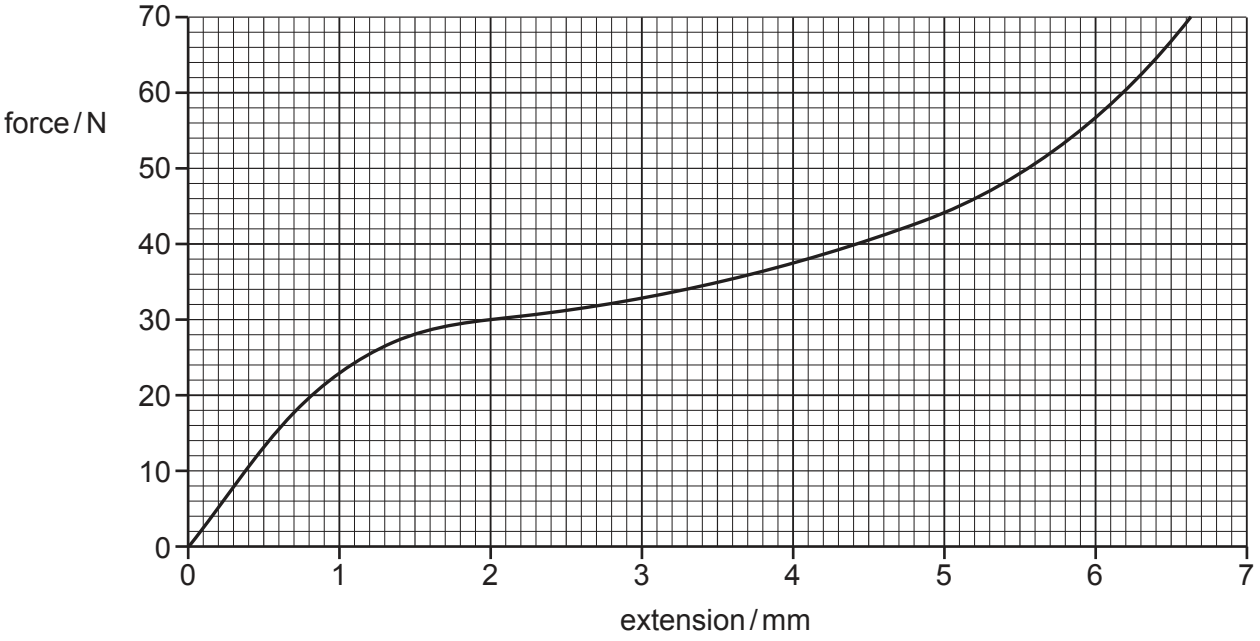


Fig. 3.4

(i) Use Fig. 3.4 to find the force required to give an extension of 3 mm.

force = ... N [1]

(ii) State Hooke's law.

.....

..... [1]

(iii) Describe how the graph in Fig. 3.4 shows that the nylon string does **not** obey Hooke's law.

.....

.....

.....

..... [2]

[Total: 10]

4 **(a)** A person monitored the concentration of glucose in their blood for 12 hours.

The results are shown in Fig. 4.1.

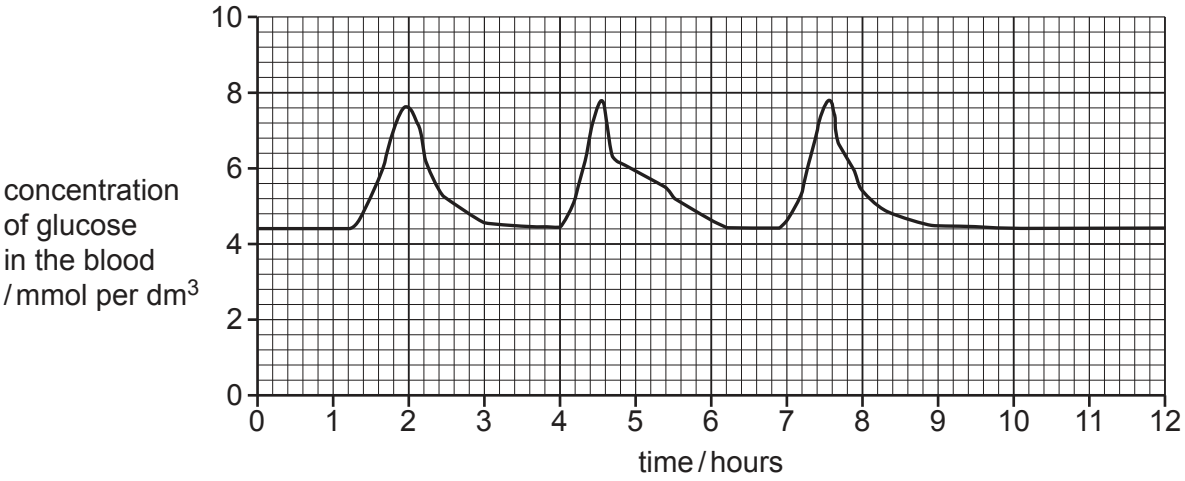


Fig. 4.1

(i) The concentration of glucose in the blood increases rapidly after a meal is eaten.

Suggest the number of meals the person had during the 12 hours.

..... [1]

(ii) Complete the sentences to explain the results between 2 and 3 hours.

The brain detects an increase in the concentration of glucose in the blood.

The ..... releases insulin.

The insulin stimulates the ..... to convert glucose to

..... and store it.

This lowers the concentration of glucose in the blood.

[3]

(b) Name two hormones that increase blood glucose concentration.

1 .....

2 .....

[2]

(c) Name the term used to describe the mechanism that is used to return blood glucose concentrations to a normal level.

..... [1]

(d) Glucose is absorbed in the small intestine.

(i) Define the term *absorption*.

.....

.....

..... [2]

(ii) Describe how the small intestine is adapted for efficient absorption.

.....

.....

.....

..... [2]

[Total: 11]

5 Petroleum is a fossil fuel.

Petroleum can be separated into useful fractions by fractional distillation.

Fig. 5.1 shows a fractionating column.

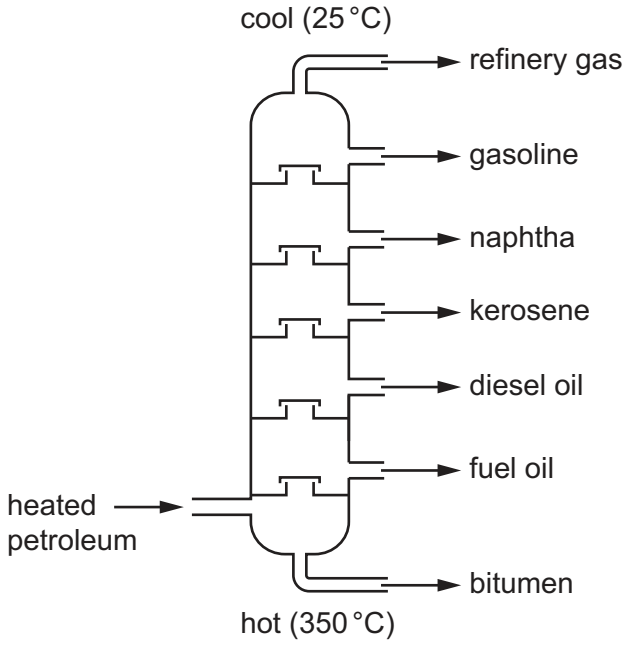


Fig. 5.1

(a) Explain why it is possible to separate the substances in petroleum by fractional distillation.

.....

..... [1]

(b) Table 5.1 shows the uses of some of the fractions.

Complete Table 5.1.

Table 5.1

fraction	use
refinery gas	bottled gas for heating
gasoline	fuel (petrol) in cars
naphtha	.....
diesel oil	.....
bitumen	.....

[3]

(c) Butane is a hydrocarbon found in the refinery gas fraction.

Complete Fig. 5.2 to show the structure of a butane molecule.

Show all the covalent bonds.

Fig. 5.2

[2]

(d) Methane, CH_4, is also a hydrocarbon found in the refinery gas fraction.

Methane burns in oxygen to form carbon dioxide and water.

Construct the balanced symbol equation for the burning of methane.

..... [2]

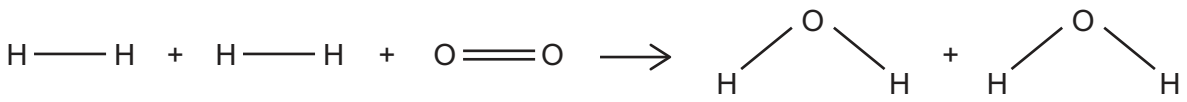
(e) When methane burns, an exothermic reaction takes place.

State what is meant by an *exothermic* reaction.

..... [1]

(f) The reaction of hydrogen with oxygen to make water is another exothermic reaction.

Look at the equation for this reaction. It shows all the atoms and all the bonds.



(i) Put a (circle) around each of the bonds which are **broken** when the reaction takes place.

[1]

(ii) Explain why the reaction of hydrogen with oxygen is exothermic.

Use ideas about bond breaking and bond making.

.....

.....

..... [2]

[Total: 12]

6 **(a)** Electricity may be obtained using the sources listed.

fossil fuels

geothermal

solar

tidal

wind

(i) State which of the sources of energy is non-renewable.

..... [1]

(ii) State which two of the sources of energy are **not** dependent on the Sun.

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

(b) Many types of power station use steam to turn a turbine attached to a generator.

Explain, in terms of the forces and distances between molecules and the motion of molecules, why steam is able to fill its container.

.....

.....

.....

.....

.....

..... [3]

(c) Fig. 6.1 shows a diagram of a simple a.c. generator.

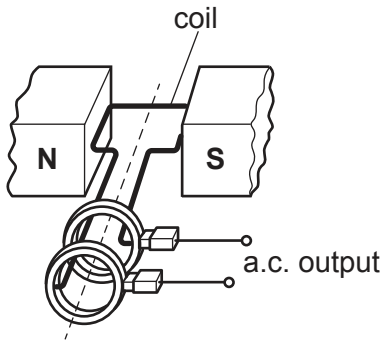


Fig. 6.1

(i) Explain why the generator produces an a.c. output.

.....

.....

.....

.....

.....

..... [3]

(ii) On the grid provided in Fig. 6.2, sketch a graph of voltage output against time for this generator.

You must show at least one full cycle.

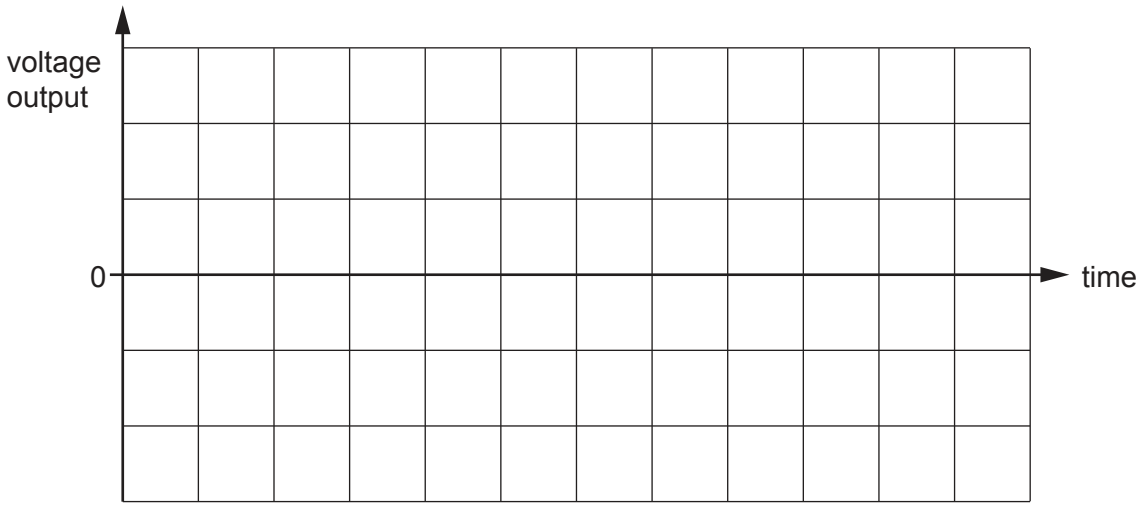


Fig. 6.2

[1]

[Total: 9]

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7 Fig. 7.1 is a diagram of a cross-section of a leaf.

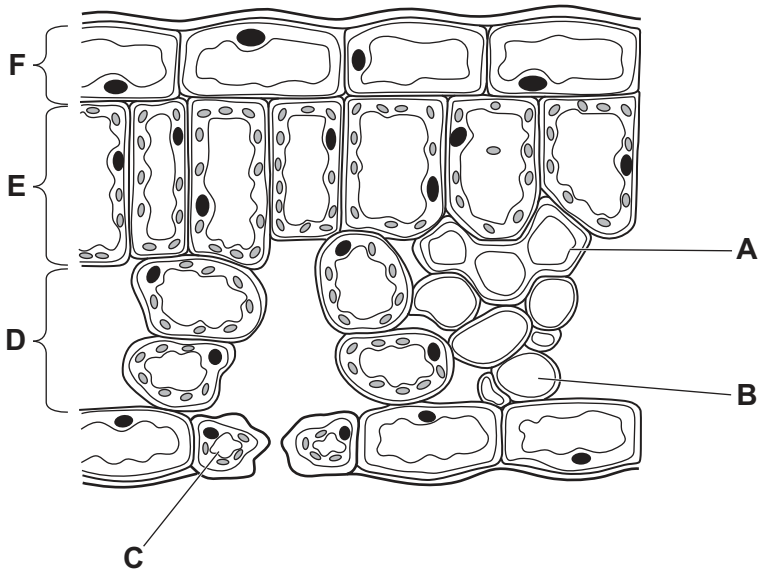

Fig. 7.1

(a) Identify the letter that represents the part in Fig. 7.1:

where most photosynthesis takes place .....

which transports water from roots to leaves .....

which controls gas exchange. .....

[3]

(b) Draw an **X** on Fig. 7.1 to identify a spongy mesophyll cell. [1]

(c) The part labelled **B** in Fig. 7.1 is responsible for translocation.

(i) Name the part labelled **B**.

..... [1]

(ii) Name the two main substances transported by the part labelled **B**.

1 .....

2 .....

[2]

(d) Table 7.1 compares the processes of transpiration and translocation.

Place ticks (✓) in the boxes to show the correct features of transpiration and translocation.

Table 7.1

	transpiration	translocation
transports substances to regions of storage		
transports water		
movement of substances is in one direction only		
transport is from source to sink		

[2]

[Total: 9]

8 A scientist investigates the reaction between marble chips (calcium carbonate) and dilute hydrochloric acid.

The scientist uses 20 g of marble chips and 40 cm^3 of dilute hydrochloric acid.

The temperature of the acid is 25 °C.

Fig. 8.1 shows the apparatus used.

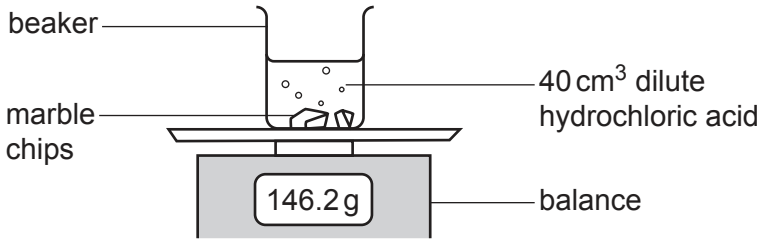

Fig. 8.1

The scientist measures the mass every 20 seconds until the reaction stops.

The scientist calculates the loss in mass.

Fig. 8.2 shows the results.

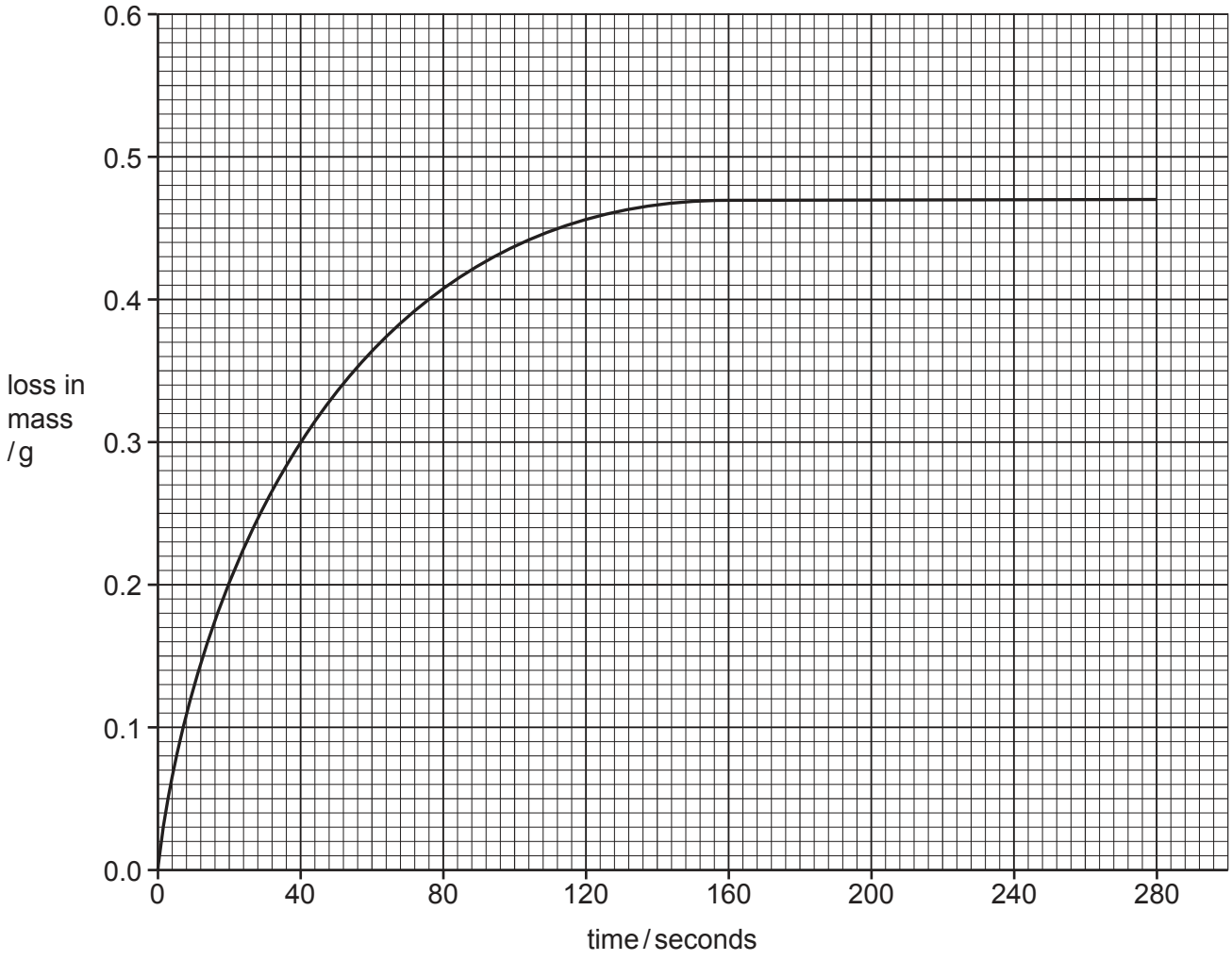

Fig. 8.2

(a) **(i)** Use Fig. 8.2 to state the loss in mass after 40 seconds.

loss in mass = ... g [1]

(ii) Use Fig. 8.2 to state how long it takes for the reaction to stop.

time = ... seconds [1]

(b) The scientist does the experiment again.

This time the scientist uses dilute hydrochloric acid which is **less concentrated** than in the first experiment.

The reaction is **slower**.

Explain why reactions are slower when reactants are less concentrated.

Explain your answer in terms of collisions between particles.

.....

.....

..... [2]

(c) Carbon dioxide gas is made in the reaction.

State the chemical test and its positive result for carbon dioxide gas.

test .....

result .....
[2]

(d) In this experiment, 0.47 g of carbon dioxide gas is made.

Calculate the volume occupied by 0.47 g of carbon dioxide gas.

The molar gas volume at 25 °C is 24 dm^3.

Show your working.

[A_r: C, 12; O, 16]

volume = ... dm^3 [3]

[Total: 9]

9 Visible light is a transverse wave and is part of the electromagnetic spectrum.

(a) State what is meant by a transverse wave.

.....

..... [1]

(b) Fig. 9.1 shows a ray of visible light from a torch (flashlight) shining into a rectangular glass block.

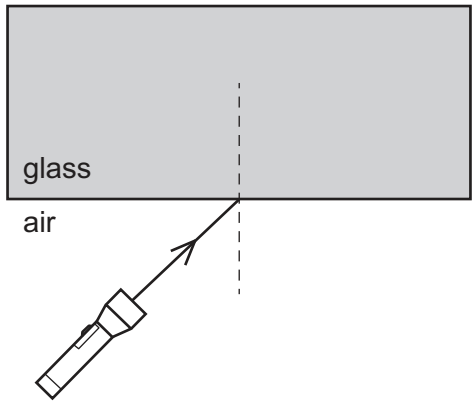

Fig. 9.1

(i) Complete Fig. 9.1 to show the path the ray takes through and out of the block. [2]

(ii) State the term used to describe what happens to the ray of light as it enters the glass block.

..... [1]

(iii) Explain why this happens to the ray of light.

.....

..... [1]

(c) Fig. 9.2 shows the electrical circuit used in the torch.

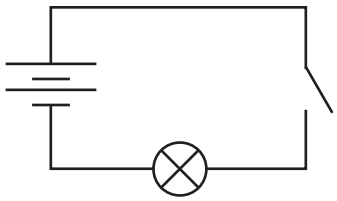

Fig. 9.2

When the switch is closed, the current in the lamp is 1.8A and the potential difference across the lamp is 3.0V.

Calculate the power output of the lamp.

power = ... W [2]

(d) Fig. 9.3 shows two lamps, identical to the torch lamp, connected in parallel.

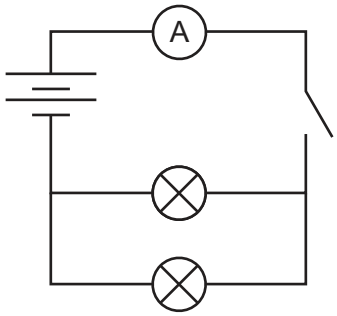

Fig. 9.3

(i) When the switch is closed, the ammeter reads 2.6A.

State the current in each lamp.

current = ... A [1]

(ii) Calculate the quantity of charge passing through one of the lamps in Fig. 9.3 when it is switched on for 30 seconds.

Give the correct unit for your answer.

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

[Total: 11]

10 (a) The blood groups of some people are recorded.

Fig. 10.1 shows the results.

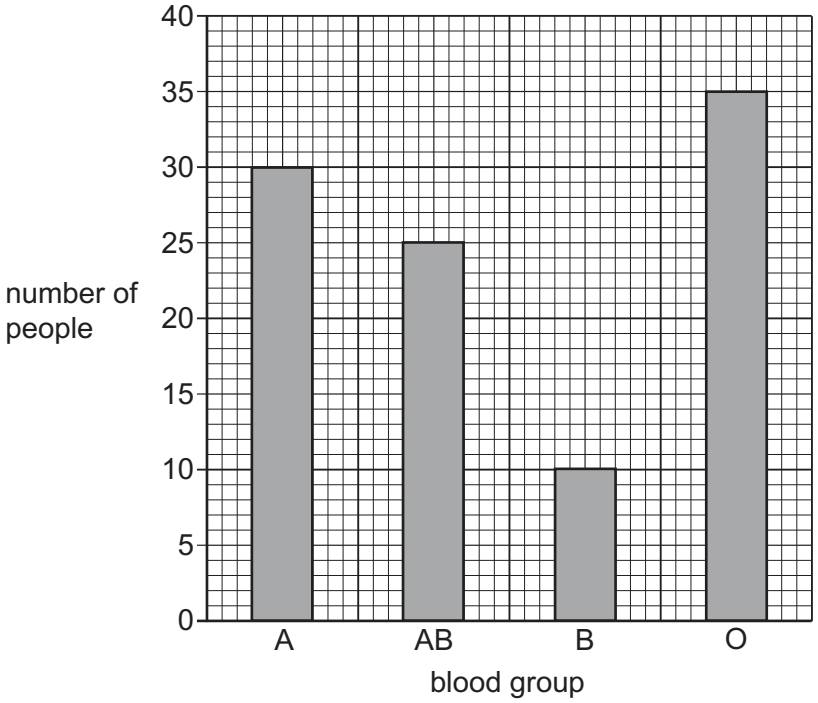

Fig. 10.1

(i) State the total number of people who had their blood group recorded.

..... [1]

(ii) Describe the evidence in Fig. 10.1 that shows blood group is an example of discontinuous variation.

.....

.....

.....

..... [2]

(iii) Complete this sentence about discontinuous variation.

Discontinuous variation is mostly caused by ..... alone. [1]

(iv) Name one example of **continuous** variation in humans.

..... [1]

(b) Blood contains four main components.

The boxes on the left show the components of blood.

The boxes on the right show the functions of each component.

Draw lines to link each component with its function.

component	function
plasma	antibody production
platelet	blood clotting
red blood cell	transport of ions, soluble nutrients and hormones
white blood cell	transport of oxygen

[3]

(c) Describe two ways the structure of a red blood cell is adapted to its function.

1 .....

2 .....

[2]

[Total: 10]

11 Sodium, Na, is an element in Group I of the Periodic Table.

Sodium has the electronic structure 2.8.1.

(a) Sodium atoms can form sodium ions, Na^+.

Chlorine atoms can form chloride ions, Cl^-.

Describe, in terms of electrons, how a sodium atom forms a sodium ion and a chlorine atom forms a chloride ion.

sodium atom .....

.....

chlorine atom .....

.....

[1]

(b) Sodium ions, Na^+, form ionic bonds with chloride ions, Cl^-.

Describe how ionic bonds form between sodium ions and chloride ions.

.....

.....

..... [2]

(c) Solid aluminium chloride is another ionic compound.

Aluminium chloride contains aluminium ions, Al^{3+}, and chloride ions, Cl^-.

Determine the formula of aluminium chloride.

..... [1]

(d) Fig. 11.1 shows the apparatus used to extract aluminium from aluminium ore.

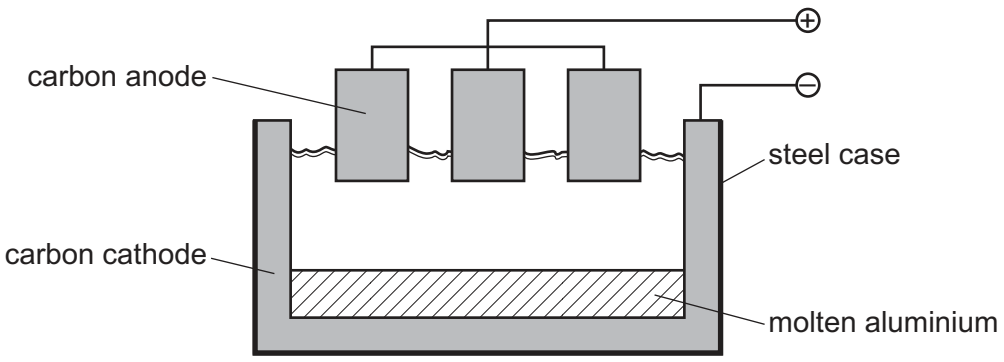

Fig. 11.1

Describe how aluminium is extracted from aluminium ore.

Include the starting materials and the essential reaction conditions.

.....

.....

.....

..... [3]

(e) Copper is extracted from copper ore by heating the copper ore with carbon.

The equation for the reaction is shown.

$$2CuO + C \rightarrow 2Cu + CO_2$$

Carbon is the reducing agent in this reaction.

Define, in terms of electrons, what is meant by the term *reducing agent*.

.....

..... [1]

[Total: 8]

12 Fig. 12.1 shows a speed-time graph for a train.

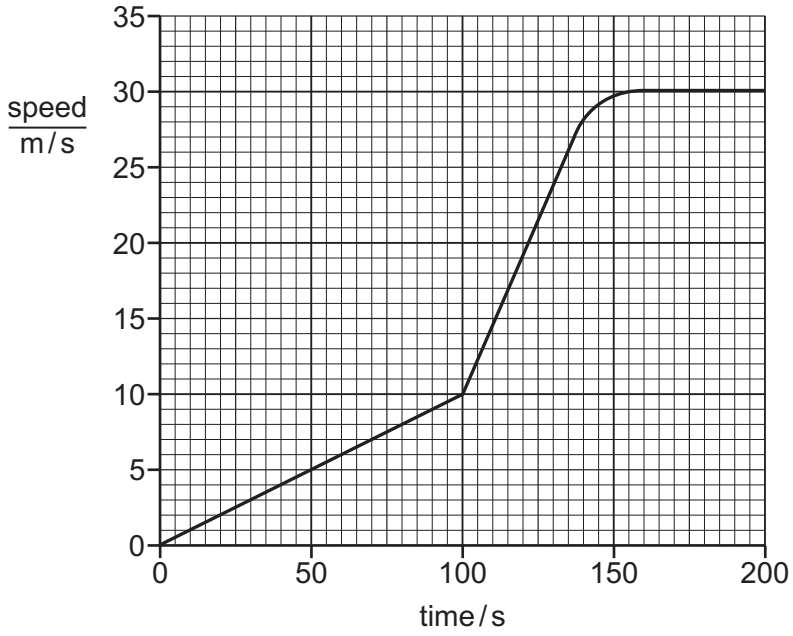

Fig. 12.1

(a) Use Fig. 12.1 to calculate the distance travelled by the train in the first 100 s.

distance = ... m [2]

(b) Use Fig. 12.1 to calculate the acceleration of the train from 0 s to 100 s.

acceleration = ... m/s^2 [2]

(c) Use Fig. 12.1 to describe the motion of the train from 100 s to 200 s.

.....

.....

.....

.....

..... [3]

(d) Fig. 12.2 shows the forces acting on the train when it is travelling at constant speed.

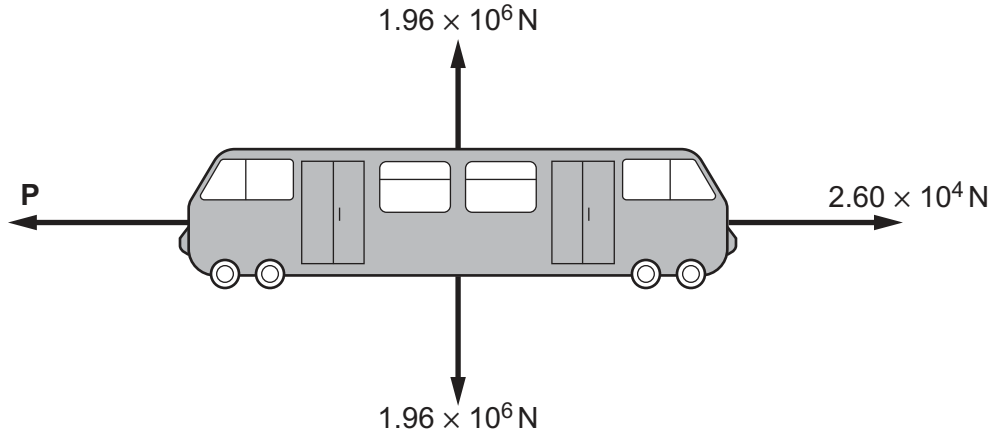

Fig. 12.2

(i) State the magnitude of the force **P**.

..... [1]

(ii) Calculate the mass of the train.

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

mass = ... kg [1]

(e) The train is made of steel painted dark grey.

On sunny days, the inside of the train can get very hot.

Explain why painting the train white would reduce the heating effect.

.....

..... [1]

[Total: 10]

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.).