Cambridge Assessment International Education

Cambridge IGCSE™ (9–1)

CANDIDATE NAME									
CENTRE NUMBER						CANDIDATE NUMBER				

7350348158

CO-ORDINATED SCIENCES **0973/41**

Paper 4 Theory (Extended) **October/November 2023**

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.

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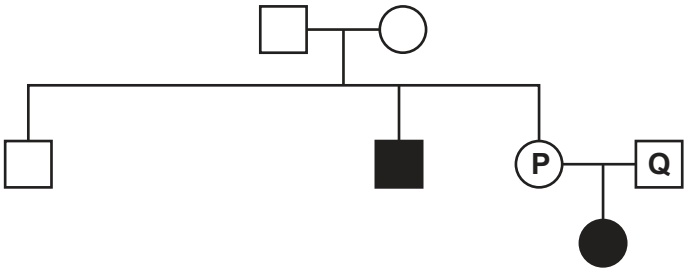
[Turn over

https://xtremepape.rs/

1 **(a)** Fig. 1.1 is a pedigree diagram for the inheritance of a genetic condition called cystic fibrosis.

The allele for cystic fibrosis is recessive **a**.

The allele for no cystic fibrosis is dominant **A**.



key

female with cystic fibrosis

male with cystic fibrosis

female without cystic fibrosis

male without cystic fibrosis

Fig. 1.1

(i) Use Fig. 1.1 to state:

the number of people with the genotype **aa** .....

the number of people with the sex chromosomes **XY**. .....

[2]

(ii) State the term that is used to describe the genotype **aa**.

..... [1]

(iii) The couple labelled **P** and **Q** in Fig. 1.1 decide to have another child.

Complete the genetic diagram in Fig. 1.2 to calculate the percentage likelihood of this child having cystic fibrosis.

		parent **P** gametes	
parent **Q** gametes			

percentage likelihood of child having cystic fibrosis. .....

Fig. 1.2

[3]

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(b) Cystic fibrosis causes mucus produced by cells lining the airways to become very thick and sticky.

(i) State the name of the cells in the airways that produce mucus.

..... [1]

(ii) Explain why people with cystic fibrosis are more likely to have frequent lung infections.

.....

.....

.....

..... [2]

(c) Lung cancer is another disease that affects the lungs.

State the major cause of lung cancer.

..... [1]

[Total: 10]

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2 Crude oil contains hydrocarbon molecules.

(a) State what is meant by a hydrocarbon.

.....

..... [1]

(b) Alkanes are hydrocarbon molecules.

(i) State the type of bond found in alkane molecules.

Tick (✓) **one** box.

double covalent	☐
intermolecular	☐
ionic	☐
single covalent	☐

[1]

(ii) Alkanes are saturated hydrocarbons.

State which molecule is a saturated hydrocarbon.

Tick (✓) **one** box.

C_2H_2	☐
C_2H_4	☐
C_3H_8	☐
C_4H_8	☐

[1]

(c) Larger alkanes are cracked to form smaller alkanes and another type of hydrocarbon molecule.

(i) State the name of this other type of hydrocarbon molecule.

..... [1]

(ii) State the conditions needed for cracking.

1 .....

2 .....

[2]

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(iii) The equation shows the cracking of $C_{24}H_{50}$.

Balance the equation.

$$C_{24}H_{50} \rightarrow C_{10}H_{22} + \text{.....} C_6H_{12} + \text{.....}$$ [2]

(d) Hydrocarbon molecules are used as fuels.

Burning fuels produce pollutants in the air. These pollutants cause problems.

Draw **one** line from each pollutant to the problem it causes.

pollutant	**problem**
carbon monoxide	acid rain
	particulates turn buildings black
sulfur dioxide	global warming
	poisoning of living organisms

[2]

[Total: 10]

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3 Nuclear power stations use nuclear fission to generate electricity.

The nuclear fission of uranium releases thermal energy.

The thermal energy produced is used to convert water into steam which drives the turbines that generate electricity.

(a) State **one** advantage of generating electricity from nuclear fission.

.....

..... [1]

(b) Barium-141 ($^{141}_{56}Ba$) is produced by the nuclear fission of uranium.

Barium-141 decays by emitting a beta-particle.

(i) Use the correct nuclide notation to show the decay of barium-141.

$$^{141}_{56}Ba \rightarrow \ ^{\ldots\ldots}_{\ldots\ldots}La + \ ^{\ldots\ldots}_{\ldots\ldots}\beta$$

[2]

(ii) A 160 g sample of barium-141 has a half-life of 18 minutes.

Calculate the time it will take for the mass of barium-141 in the sample to decrease to 10 g.

time = ... minutes [2]

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(c) Fig. 3.1 shows a simple turbine, similar to those used in a nuclear power station.

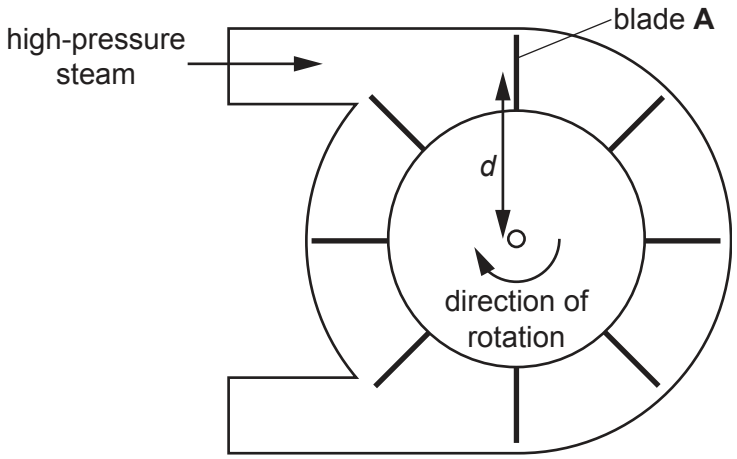

Fig. 3.1

(i) The high-pressure steam is at a pressure of 1.8×10^7 Pa.

Blade **A** has a surface area of $0.12\,m^2$.

Show that the force acting on blade **A** is 2.2×10^6 N.

[1]

(ii) The moment of the force, from the high-pressure steam acting on blade **A**, is 1.35×10^6 N m.

Calculate the distance *d*, from the centre of blade **A** to the pivot of the turbine.

distance *d* = ... m [2]

(iii) When the turbine spins, blade **A** moves with a constant speed but a changing velocity.

Explain why the velocity of blade **A** changes.

.....

..... [1]

[Total: 9]

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4 **(a)** A student investigates the effect of different types of sugar on the anaerobic respiration in yeast.

She mixes yeast with five different types of sugar solutions of the same concentration and measures the volume of gas produced after 2 hours.

Table 4.1 shows the results.

Table 4.1

sugar	volume of gas produced in 2 hours / cm^3
A	9
B	16
C	82
D	3
E	65

(i) Identify the sugar in Table 4.1 that produces the largest volume of gas.

..... [1]

(ii) Calculate the rate of anaerobic respiration for sugar **A** in Table 4.1.

rate of anaerobic respiration for sugar **A** = ... cm^3 / min [2]

(iii) State the name of the gas produced in this investigation.

..... [1]

(iv) State **one** practical use for the anaerobic respiration of yeast.

..... [1]

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(b) Describe **three** ways that aerobic respiration is different from anaerobic respiration in **humans**.

1 .....

.....

2 .....

.....

3 .....

.....

[3]

(c) Respiration is one of the characteristics of living organisms.

State **one other** characteristic.

..... [1]

[Total: 9]

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5 **(a)** The pH of a solution describes how acidic or alkaline it is.

State which of these values shows the pH of a strong acid.

Tick (✓) **one** box.

14 ☐

7 ☐

5 ☐

1 ☐

[1]

(b) Complete the sentences about dilute hydrochloric acid and aqueous sodium hydroxide.

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

acceptor **catalyst** **donor** **an electron** **a proton**

Dilute hydrochloric acid is defined as an acid because it is ....

Aqueous sodium hydroxide is defined as a base because it is ....

[3]

(c) **(i)** Hydrochloric acid, HC*l*, reacts with copper carbonate, $CuCO_3$.

Copper chloride, $CuCl_2$, water and carbon dioxide are made.

Construct the balanced symbol equation for this reaction.

..... [2]

(ii) Describe the test for carbon dioxide and its positive result.

test .....

positive result .....

[2]

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(d) 2.45 g of sulfuric acid reacts with 1.60 g of copper oxide.

Copper sulfate, $CuSO_4$, is made.

$$H_2SO_4 + CuO \rightarrow CuSO_4 + H_2O$$

Calculate the number of moles of sulfuric acid and the number of moles of copper oxide.

Use your answers to determine the **limiting reactant** in this reaction.

Show your working.

[A_r: H, 1; Cu, 64; O, 16; S, 32]

limiting reactant = ... [4]

[Total: 12]

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6 Fig. 6.1 shows a bee collecting pollen from a flower.

Fig. 6.1

(a) The maximum speed of a bee is 5.8 m / s.

(i) Calculate the maximum distance a bee can travel in 60 seconds.

maximum distance = ... m [2]

(ii) The mass of the bee is 0.20 g.

Calculate the kinetic energy of the bee when it is moving at 5.8 m / s.

kinetic energy = ... J [3]

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(b) The flower uses brightly coloured petals to attract the bee. The petals reflect ultraviolet light and visible light, both of which are part of the electromagnetic spectrum.

State **one** similarity and **one** difference between visible light and ultraviolet light.

similarity .....

.....

difference .....

.....

[2]

(c) The bee becomes positively charged as it flies through the air.

Suggest how this charge is produced.

.....

.....

.....

.....

..... [3]

(d) When suspended in water, the pollen from the flower can be used to study Brownian motion.

Describe how Brownian motion provides evidence for the kinetic molecular model of matter.

.....

.....

.....

.....

..... [3]

[Total: 13]

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7 **(a)** A scientist measures the activity of the enzyme amylase at different temperatures.

Fig. 7.1 shows a graph of the results.

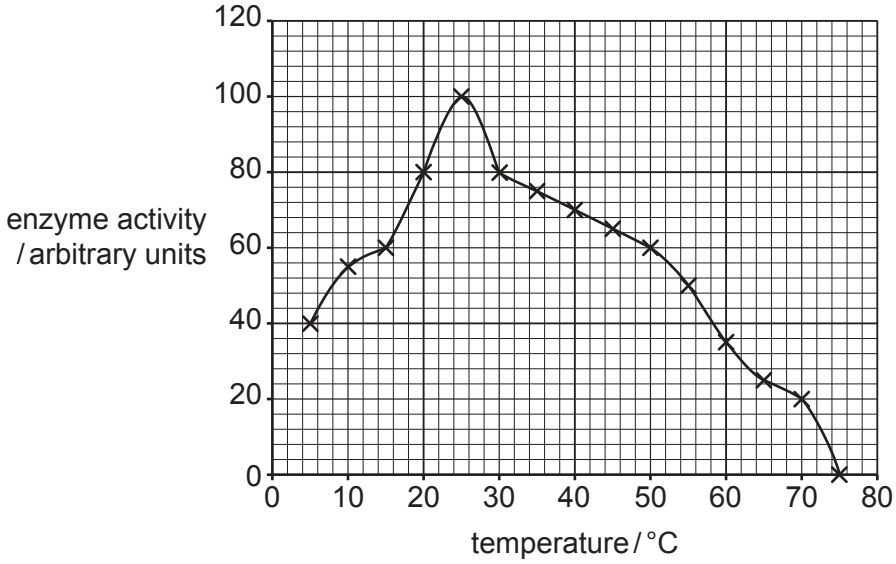

Fig. 7.1

Complete the sentences to describe and explain the results in Fig. 7.1.

Amylase breaks down the substrate ..... into smaller molecules of ..... .

As temperature increases, the activity of amylase increases until it reaches its optimum temperature of ..... °C.

As the temperature increases, the amylase particles gain ..... energy. This results in more frequent successful collisions between amylase and its substrate.

At temperatures above 75 °C, all of the amylase has become ..... .

This means the ..... of amylase has changed shape and is no longer complementary to the substrate.

[6]

(b) State **two** parts of the alimentary canal which secrete amylase.

1 .....

2 .....

[2]

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(c) Enzymes are proteins.

(i) List the chemical elements present in all proteins.

.....

..... [2]

(ii) State the name of the chemical test for the presence of proteins.

..... [1]

[Total: 11]

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8 Non-metallic elements exist as simple molecules with covalent bonds.

Non-metallic elements can also exist as giant covalent structures.

(a) Oxygen is a simple molecule with covalent bonds.

Table 8.1 gives some properties of four substances, **A**, **B**, **C** and **D**.

Table 8.1

	melting point / °C	boiling point / °C	conducts electricity in liquid state?
A	1538	2862	yes
B	780	1420	yes
C	–91	98	no
D	–218	–183	no

State the most likely set of properties for oxygen.

Choose from **A**, **B**, **C** or **D**.

answer ..... [1]

(b) **(i)** Iron reacts with oxygen to make hydrated iron oxide (rust).

$$4Fe + 3O_2 + 6H_2O \longrightarrow 4Fe(OH)_3$$

224 g of oxygen reacts with iron to make 1 kg of rust.

Calculate the volume occupied by 224 g of oxygen gas.

The molar gas volume at room temperature and pressure is 24 dm^3.

[A_r: O, 16]

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

(ii) Chromium is added to iron to form the alloy stainless steel.

Describe how the properties of iron are changed by adding chromium.

.....

..... [1]

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(c) Ammonia, NH_3, is also a simple molecule with covalent bonds.

Complete the dot-and-cross diagram in Fig. 8.1 to show the covalent bonding in ammonia.

Only show the outer shell electrons.

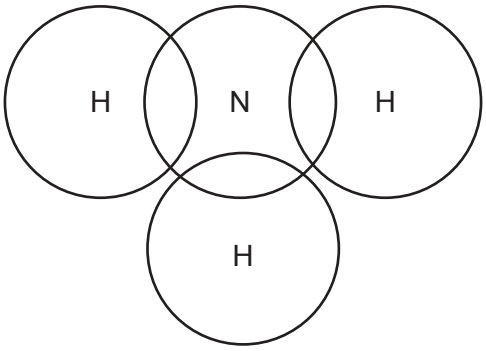
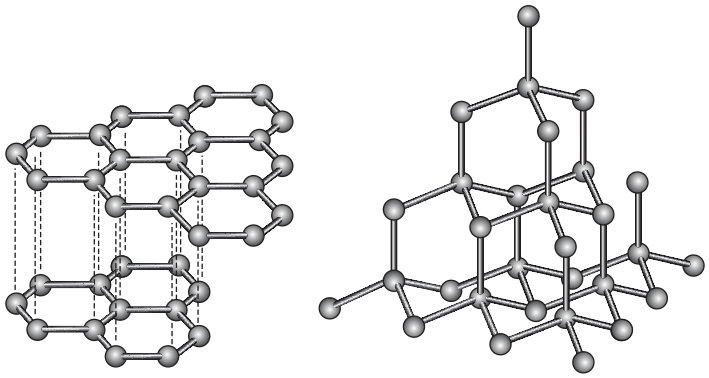


Fig. 8.1

[2]

(d) Graphite and diamond are giant covalent structures.

Fig. 8.2 shows the structures of graphite and diamond.



graphite diamond

Fig. 8.2

Explain why graphite is used as an electrical conductor but diamond is **not**.

Use ideas about structure and bonding.

.....

.....

.....

..... [3]

[Total: 10]

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9 A student is investigating electromagnetic induction by dropping a magnet through a coil of wire.

The coil of wire is connected to a device which measures the electromotive force (e.m.f.) induced in the coil.

Fig. 9.1 shows the equipment used by the student.

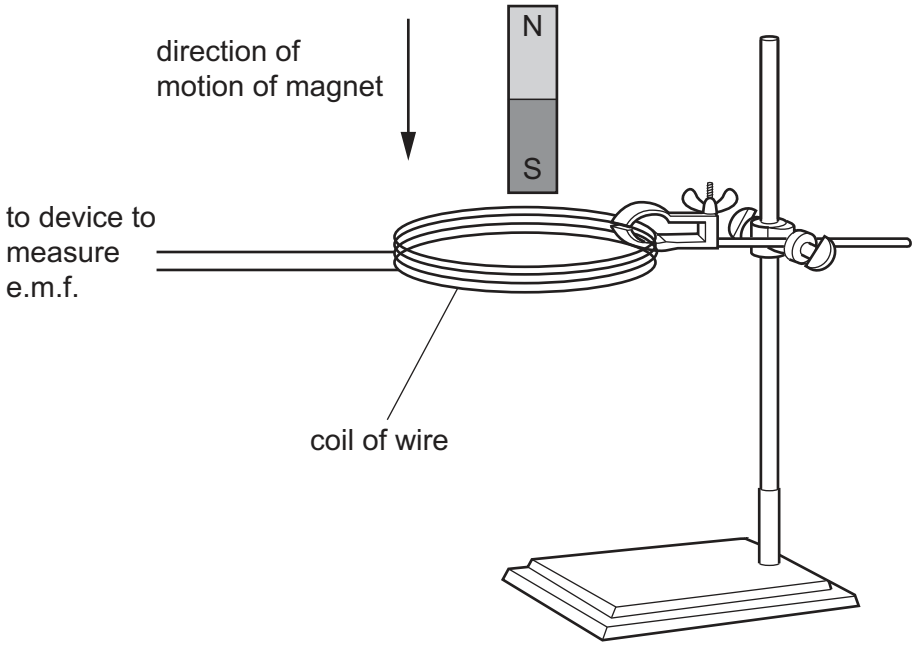

Fig. 9.1

(a) Fig. 9.2 shows the induced electromotive force (e.m.f.) measured as the magnet falls through the coil of wire.

Fig. 9.2 shows two peaks, **X** and **Y**.

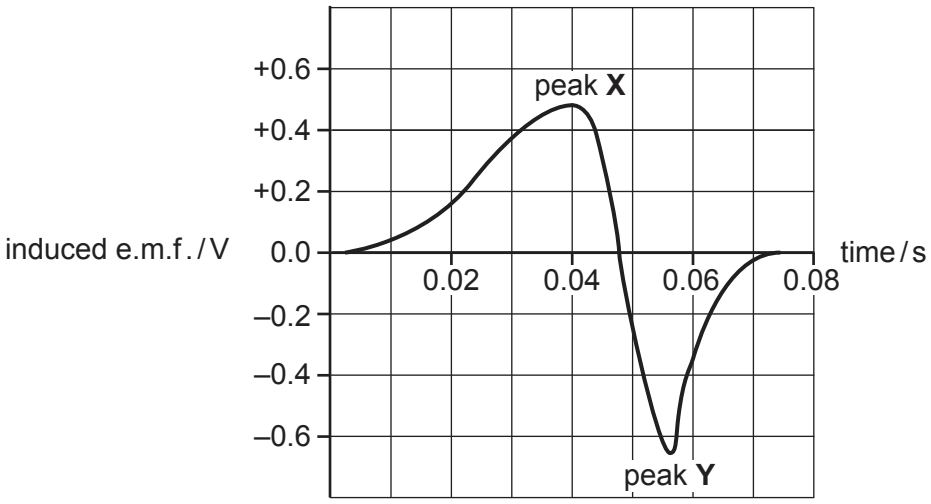

Fig. 9.2

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(i) Explain why:

peak **X** is positive and peak **Y** is negative

.....

.....

peak **Y** has a larger magnitude than peak **X**.

.....

.....

[2]

(ii) The data in Fig. 9.2 was obtained using a coil made of 800 turns of wire.

On Fig. 9.2, sketch the data which would be obtained if a coil containing 400 turns was used with the same magnet. [2]

(b) When writing up the results, the student is not sure whether to write about the induced potential difference or the induced electromotive force (e.m.f.).

Place ticks in Table 9.1 against each statement that is correct for potential difference and for electromotive force (e.m.f.).

You may place **one** or **two** ticks in each row. The first row has been done for you.

Table 9.1

	electromotive force (e.m.f.)	potential difference
is measured in volts	✓	✓
is equal to work done per unit charge		
relates to the energy supplied by the source		
relates to the energy transferred by a circuit component		

[2]

(c) The coil of wire used in the investigation is made of copper. Copper is a solid.

Complete the sentences to describe the arrangement of atoms in a solid and the properties of a solid.

In a solid, the arrangement of atoms is ..... .

The forces between atoms are ..... which allows the atoms to .....

but keeps them in a ..... position.

[2]

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(d) Copper is a good thermal conductor.

Describe how thermal energy is transferred in copper.

.....

.....

.....

..... [3]

[Total: 11]

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10 Fig. 10.1 shows aerial photographs of the same area taken at different times.

Photograph **A** was taken in 1985.

Photograph **B** was taken in 2000.

Areas of forest are darker in the photograph and areas that have been cleared of trees are lighter.

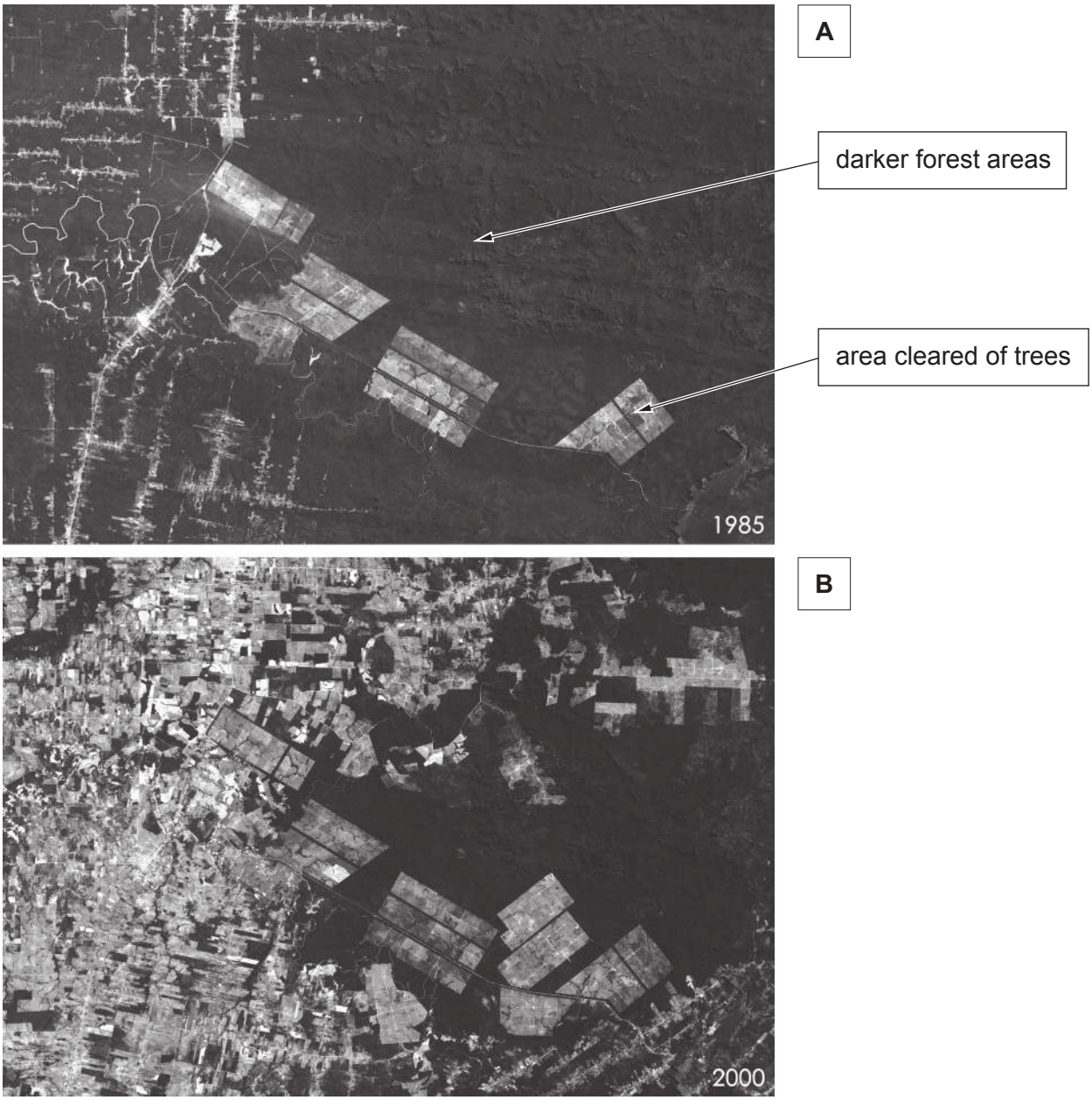

Fig. 10.1

https://xtremepape.rs/

(a) The change shown in Fig. 10.1, between 1985 and 2000, affected the environment.

(i) Explain why this change affected the concentration of carbon dioxide in the atmosphere.

.....

.....

.....

..... [2]

(ii) Describe the effects of this change on animal species in the area.

.....

.....

.....

.....

..... [3]

(b) The area in Fig. 10.1 can be described as an ecosystem.

Define the term ecosystem.

.....

.....

.....

..... [2]

(c) State the principal source of energy input into the ecosystem.

..... [1]

(d) Asexual reproduction can be useful to plants in the wild.

State **two** advantages of asexual reproduction.

1 .....

.....

2 .....

.....

[2]

[Total: 10]

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11 **(a)** Molten lead(II) bromide conducts electricity.

(i) When molten lead(II) bromide is electrolysed, lead is made at the cathode.

State the product at the anode.

..... [1]

(ii) Explain why molten lead(II) bromide conducts electricity.

.....

..... [2]

(b) Aqueous copper(II) sulfate can be electrolysed using **carbon** electrodes.

Copper is formed at the cathode.

Construct the ionic half-equation for the formation of copper.

..... [2]

(c) A student electrolyses aqueous copper(II) sulfate using **copper** electrodes.

The student weighs the electrodes before the experiment to find their mass.

After the electrolysis, the student washes and dries the electrodes and then weighs the electrodes again to find their mass.

Table 11.1 shows the results.

Table 11.1

	mass of electrode before electrolysis / g	mass of electrode after electrolysis / g	change in mass of electrode / g
anode	2.63	2.01	–0.62
cathode	2.46		

(i) The student forgot to record the mass of the cathode after the electrolysis.

Suggest the change in mass of the cathode in grams.

Write your answer in Table 11.1. [1]

(ii) The anode loses mass.

Explain why the anode loses mass.

.....

.....

..... [2]

[Total: 8]

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12 Fig. 12.1 shows a ray of light refracted as it enters a glass block.

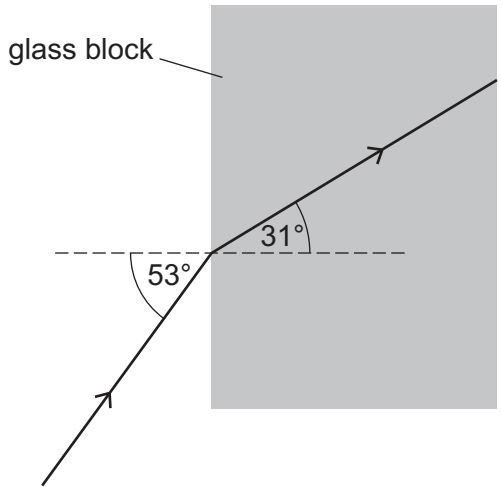

Fig. 12.1

(a) Use Fig. 12.1 to calculate the refractive index of the glass block.

Give your answer to 3 significant figures.

refractive index = ... [2]

(b) Fig. 12.2 shows how the refractive index of glass varies with the wavelength of light used.

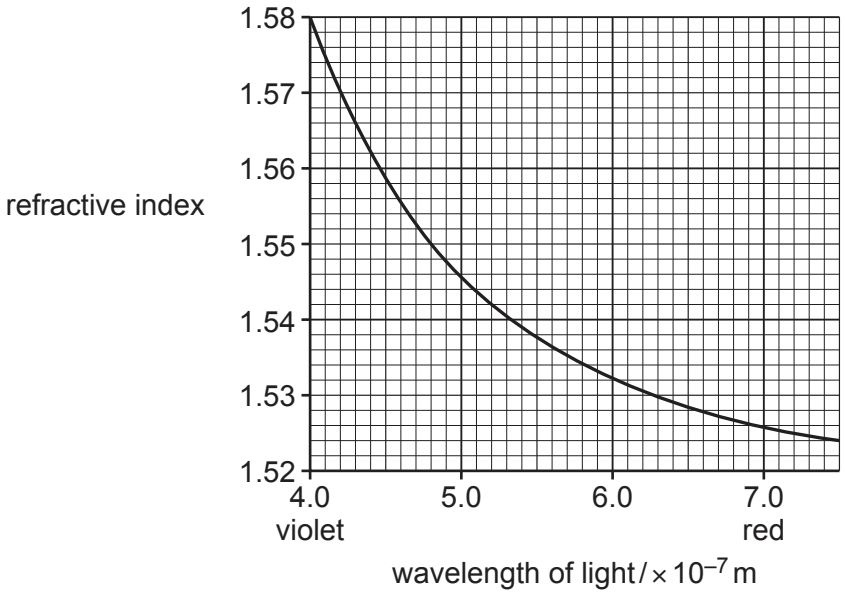

Fig. 12.2

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(i) Use Fig. 12.2 to determine the wavelength of light used in Fig. 12.1.

wavelength = ... m [1]

(ii) Violet light has a wavelength of 4.0×10^{-7} m.

Red light has a wavelength of 7.0×10^{-7} m.

Describe how Fig. 12.2 shows that red light travels faster through glass than violet light.

.....

.....

..... [1]

(c) Fig. 12.3 shows the dimensions of the glass block.

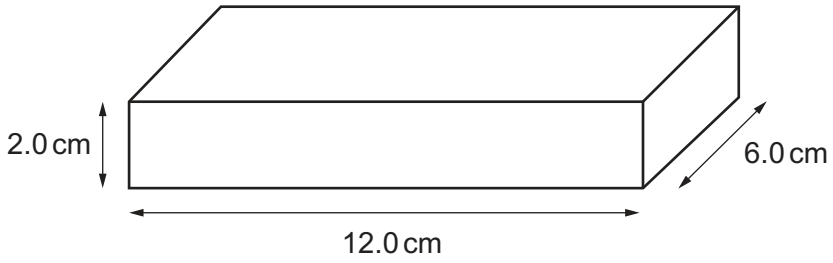

Fig. 12.3

The density of glass is 2.80 g / cm^3.

Use Fig. 12.3 to calculate the mass of the glass block.

mass = ... g [3]

[Total: 7]

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The Periodic Table of Elements

Key

atomic number atomic symbol name relative atomic mass

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 –		

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.).

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