Cambridge Assessment International Education

Cambridge IGCSE™

CANDIDATE NAME

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121509519 3

CO-ORDINATED SCIENCES **0654/43**

Paper 4 Theory (Extended) **May/June 2025**

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.
- Take the weight of 1.0 kg to be 9.8 N (acceleration of free fall = 9.8 m / s^2).

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 Fig. 1.1 shows the circulatory system of a fish.

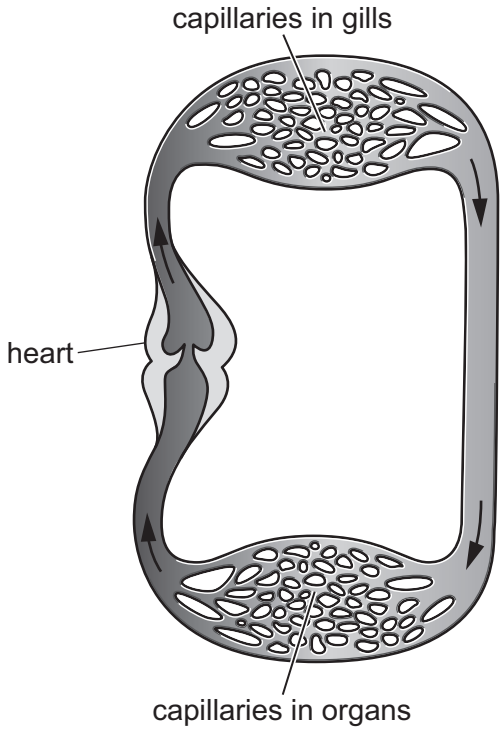

Fig. 1.1

(a) Put an **X** on Fig. 1.1 to show **one** area where oxygenated blood is flowing. [1]

(b) Mammals have a double circulation of blood.

Explain the advantages of a **double** circulation compared to the circulation in a fish.

.....

.....

.....

.....

..... [3]

(c) Capillaries have thin walls.

(i) Tick (✓) **one** box to identify which statement explains why capillaries have thin walls.

to allow blood to flow out ☐

to allow movement of substances in and out of blood ☐

to make space for more tissues in organs ☐

to increase the rate of blood flow ☐

[1]

(ii) Fish gills have a good blood supply as they have many capillaries with thin walls.

Suggest **one** other feature that makes the gills a good gas exchange surface.

.....

..... [1]

(d) The healthy range for platelets in human blood is between 150 000 and 400 000 platelets per mm^3.

An 8 mm^3 sample is taken from a patient.

The sample contains 1.022×10^6 platelets.

(i) Calculate the number of platelets per mm^3 in the sample.

..... platelets per mm^3 [1]

(ii) Suggest how this number of platelets may affect the patient if they cut themselves.

.....

.....

.....

.....

..... [3]

[Total: 10]

2 A patient has been told by his doctor to exercise to reduce his risk of coronary heart disease.

During exercise, the patient notices these effects:

- increased heart rate
- increased breathing rate and depth
- hotter body temperature.

(a) (i) Explain the effects of exercise on heart rate and breathing.

.....

.....

.....

.....

.....

..... [3]

(ii) Describe how the patient's body responds to the increase in body temperature.

.....

.....

.....

.....

.....

..... [3]

(b) The patient's doctor also suggests using a type of drug called statins as well as exercise.

(i) State what is meant by the term drug.

.....

.....

..... [2]

(ii) State **one** other way the patient may reduce his risk of coronary heart disease.

.....

..... [1]

[Total: 9]

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3 Fig. 3.1 is a diagram of the human male reproductive system.

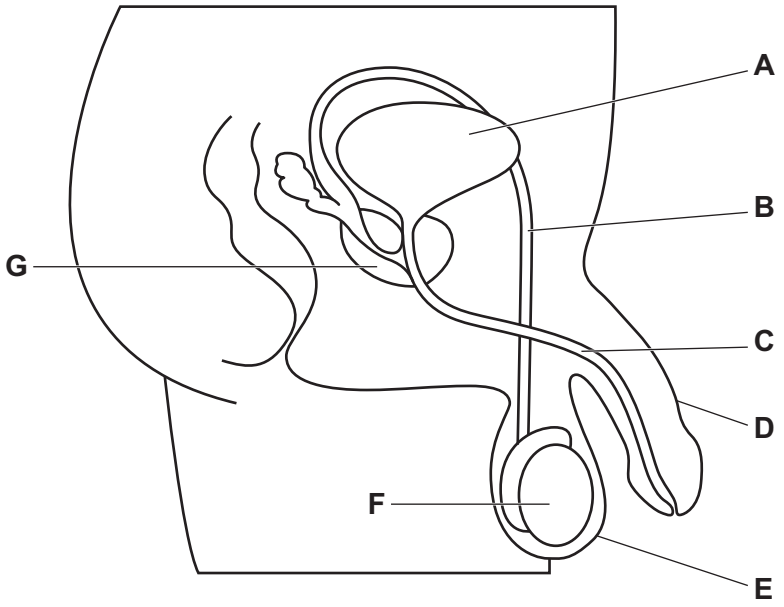


Fig. 3.1

(a) Using letters **A–G** in Fig. 3.1, identify the:

urethra .....

prostate gland. .....

[2]

(b) Complete Table 3.1 showing the adaptive features of sperm cells.

Table 3.1

feature	function
flagellum	.....
mitochondria	.....
.....	contains enzymes to digest the jelly coat on the egg

[3]

(c) Sperm cells contain a single set of chromosomes in their nucleus.

(i) State what is meant by a chromosome.

.....

..... [1]

(ii) State the name of the type of nucleus that only contains a single set of chromosomes.

..... [1]

(d) Gonorrhoea is a sexually transmitted infection caused by a bacterium.

(i) Complete the sentences about the way doctors treat gonorrhoea bacterial infections.

Choose words from the list.

antibodies **antibiotics** **antigens**

denaturation **mutations** **vaccinations**

Doctors always use ..... to treat gonorrhoea infections.

This increases the risk of bacteria with ..... being selected for and forming a population of resistant bacteria.

[2]

(ii) Describe **two** ways to control the spread of gonorrhoea.

1 .....

.....

2 .....

.....

[2]

[Total: 11]

4 **(a)** Fig. 4.1 is a diagram of a germinating bean seed.

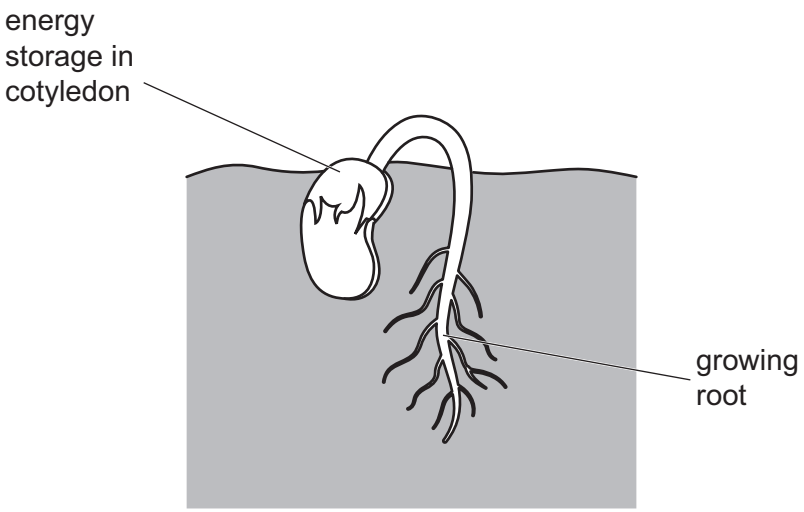


Fig. 4.1

Sucrose and amino acids are moved from storage in the cotyledons to the growing roots by translocation.

On Fig. 4.1, draw **two** label lines and correct labels to identify the part of the plant acting as the:

- **source**
- **sink**.

[2]

(b) Germinating seeds contain an enzyme called amylase.

Explain why seeds need amylase to grow.

.....

.....

.....

.....

..... [3]

(c) There are two types of amylase: α-amylase and β-amylase.

The pancreas in humans secretes α-amylase.

Bacteria secrete β-amylase to digest food outside bacteria cells.

Fig. 4.2 is a graph showing the activity of the different amylase enzymes at different pH.

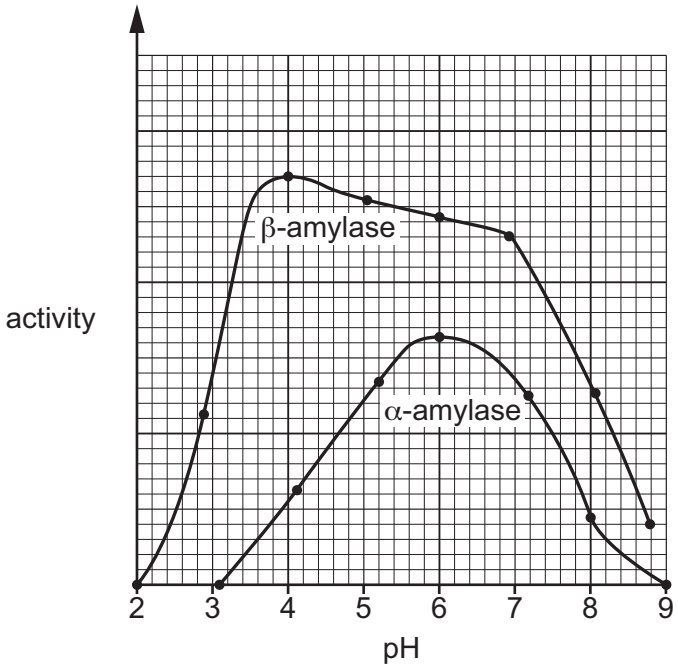


Fig. 4.2

(i) β-amylase is active over a wider range of pH than α-amylase.

Outline **other** differences between the activity of α-amylase and β-amylase at different pH values as shown in Fig. 4.2.

.....

.....

.....

..... [2]

(ii) Explain the activity of α-amylase at pH 9.

.....

.....

.....

..... [2]

(iii) Suggest why β-amylase needs to be active over a wider range of pH than α-amylase.

.....

..... [1]

[Total: 10]

5 A student investigates black ink using paper chromatography.

Fig. 5.1 shows:

- the chromatogram the student obtains
- the measurements the student may make.

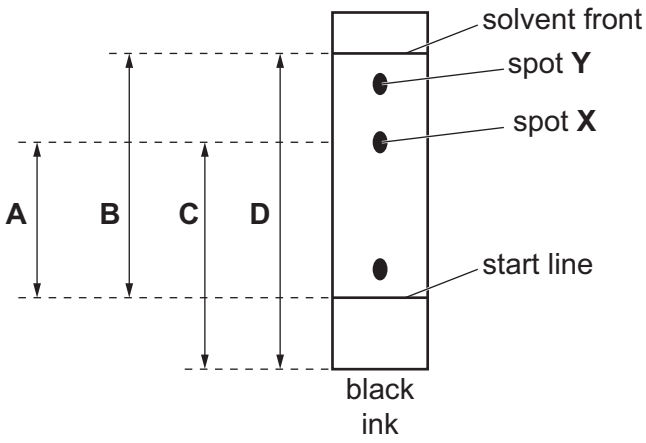


Fig. 5.1

(a) State if black ink is a pure or impure substance.

Use Fig. 5.1 to explain your answer.

statement .....

explanation .....

.....

[1]

(b) State which **two** measurements on Fig. 5.1 are needed to calculate the R_f value of spot **X**.

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

(c) The student calculates the R_f value of spot **Y** to be 0.80.

The distance travelled by spot **Y** is 2.8 cm.

Calculate the distance travelled by the solvent.

distance travelled by solvent = ... cm [2]

(d) Paper chromatography has a stationary phase and a mobile phase.

The stationary phase is a solid. The mobile phase is a liquid.

Describe what happens to the **separation** and **motion** of the particles when a solid changes to a liquid.

separation .....

.....

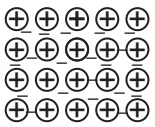
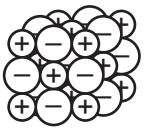
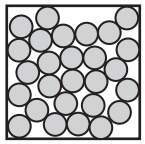
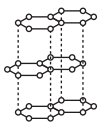
motion .....

.....

[2]

(e) Different substances have different structures.

Draw **one** line from each statement to the structure.

statement	**structure**
The substance is a gas.	
The substance is an ionic solid.	
The substance is a solid metal.	
The substance is a giant covalent solid.	
	

[4]

[Total: 10]

6 Fig. 6.1 shows the structure of magnesium oxide.

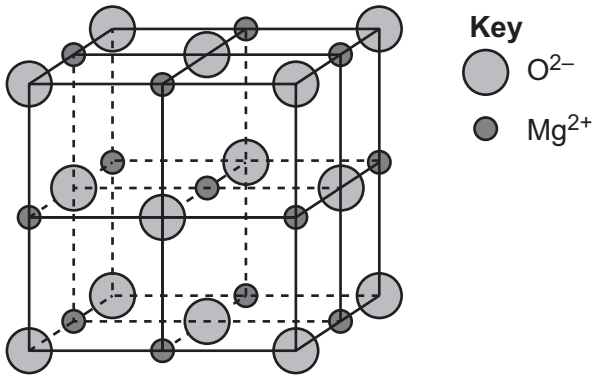


Fig. 6.1

(a) Deduce the formula of magnesium oxide.

formula ..... [1]

(b) Oxides can be classified as acidic, basic or amphoteric.

Classify magnesium oxide.

Explain your answer.

classification .....

explanation .....

.....

[2]

(c) Magnesium is in Group II and period 3 of the Periodic Table.

Determine the electronic configuration of a magnesium atom.

..... [1]

(d) Magnesium occurs naturally in three stable isotopes, ^{24}Mg, ^{25}Mg and ^{26}Mg.

Describe the similarity and the difference between the three isotopes.

similarity .....

difference .....

[2]

(e) The compound magnesium sulfate, $MgSO_4$, is found in sea water.

Calculate the amount (mol) of magnesium sulfate in a 3.05 g sample of magnesium sulfate where all the magnesium atoms are the isotope ^{26}Mg.

[A_r: O, 16; S, 32]

amount (mol) of magnesium sulfate = ... [3]

(f) A student measures the boiling point of a sample of sea water.

The boiling point is 102 °C.

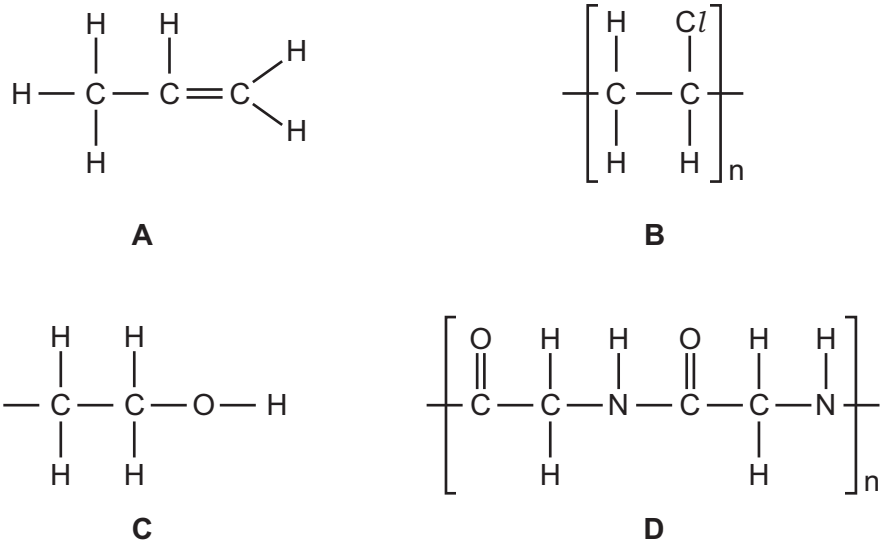
Describe how the student knows that the sea water is **not** pure water.

.....

..... [1]

[Total: 10]

7 Look at the structures of the carbon compounds shown in Fig. 7.1.



A **B**

C **D**

Fig. 7.1

(a) **(i)** State which compound is a hydrocarbon.

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

..... [1]

(ii) State which compound is propene.

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

..... [1]

(iii) State which compound is made from the reaction of ethene with steam in the presence of an acid catalyst.

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

..... [1]

(iv) State which compound is made in a condensation polymerisation reaction.

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

..... [1]

(b) Compound **C**, C_2H_5OH, completely combusts in oxygen.

Construct the balanced symbol equation for the reaction.

..... [2]

(c) A mixture containing 11.2 g of another carbon compound, C_4H_8, is allowed to react with 0.6 g of hydrogen, H_2.

$$C_4H_8 + H_2 \rightarrow C_4H_{10}$$

Show, by calculation, that C_4H_8 is the limiting reactant.

[A_r: C, 12; H, 1]

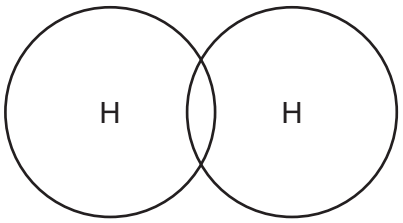
C_4H_8 is the limiting reactant because .....

.....

[3]

(d) Hydrogen, H_2, is a simple covalent molecule.

Complete the dot-and-cross diagram to show the bonding in a hydrogen molecule.



[1]

[Total: 10]

8 A student reacts hydrochloric acid with sodium carbonate.

(a) The reaction is exothermic.

State what is meant by an exothermic reaction.

.....

..... [1]

(b) Fig. 8.1 shows the reaction pathway diagram for the reaction.

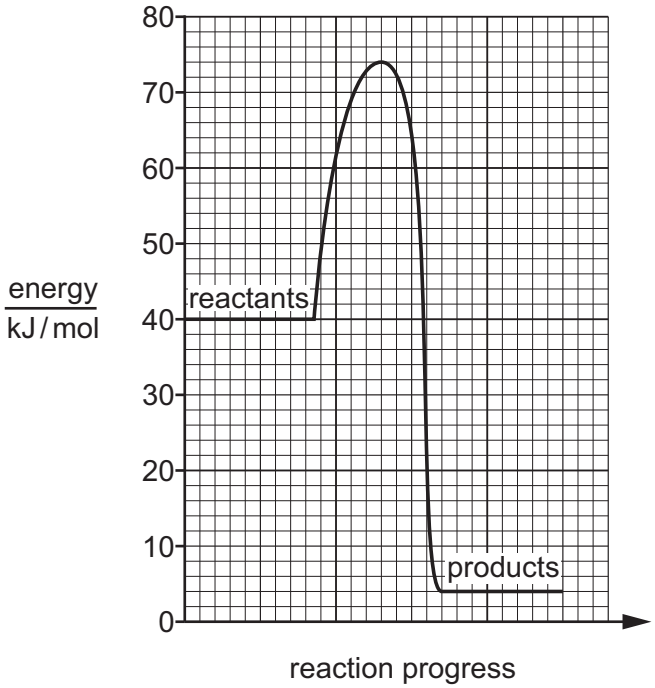


Fig. 8.1

(i) State the activation energy for the reaction.

activation energy = ... kJ / mol [1]

(ii) State the enthalpy change for the reaction.

enthalpy change = ... kJ / mol [2]

(c) The student repeats the experiment using a catalyst.

State the effect of using a catalyst on the activation energy for the reaction.

..... [1]

(d) The student repeats the experiment at a higher temperature.

The reaction is faster.

Explain why, using collision theory.

.....

.....

.....

.....

..... [3]

(e) The reaction makes sodium chloride solution, water and carbon dioxide.

Complete the state symbols in the balanced chemical equation.

$2HCl(aq) + Na_2CO_3(s) \rightarrow 2NaCl(.....) + H_2O(.....) + CO_2(.....)$

[2]

[Total: 10]

9 **(a)** **(i)** Circle **all** the vector quantities.

energy **gravitational field strength**

temperature **time** **weight**

[2]

(ii) Define the term velocity.

.....

..... [2]

(b) Fig. 9.1 shows the speed–time graph for a cyclist travelling along a straight horizontal road.

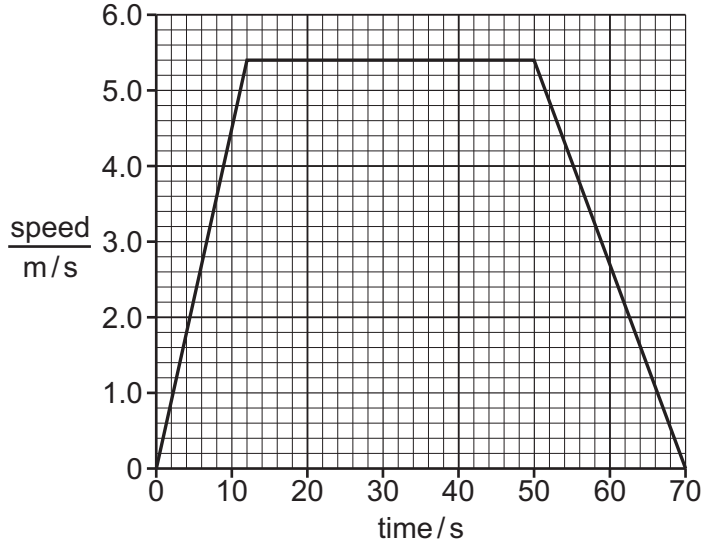


Fig. 9.1

Calculate the acceleration of the cyclist during the first 12 seconds.

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

(c) **(i)** In a crash test, a car experiences a deceleration of $35\,m/s^2$.

Calculate the ratio: $\frac{\text{deceleration of car}}{\text{acceleration due to gravity}}$

ratio = ... [1]

(ii) Before the crash, the car has a velocity of $28\,m/s$.

The kinetic energy of the car is $470\,kJ$.

Calculate the mass of the car.

mass = ... kg [2]

[Total: 9]

10 **(a)** State how the Big Bang Theory describes the beginning of the Universe.

.....

..... [2]

(b) The Universe has many stable stars.

Complete the boxes in Fig. 10.1 with the next stages in the life cycle of a very large mass stable star.

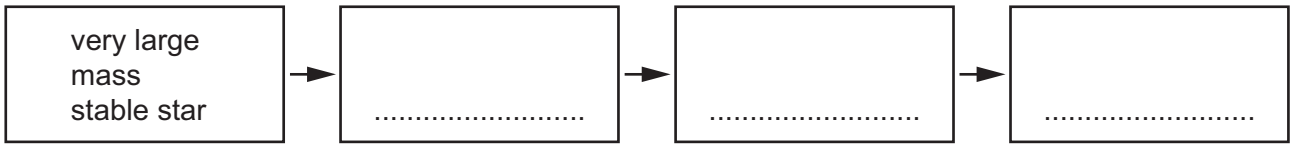


Fig. 10.1

[3]

(c) **(i)** State where most of the mass of the Solar System is located.

..... [1]

(ii) The Sun has eight planets orbiting it.

Describe the relationship between the orbital speed and the orbital radius of the planets as orbital radius increases.

.....

..... [1]

(d) A radioactive source emits two types of radiation.

When no source is present, a radiation detector records 14 counts per minute.

The source is placed 5.0 cm from the radiation detector for all measurements recorded in Table 10.1.

The absorbing material is placed between the source and detector.

Table 10.1

absorbing material	detector reading in counts per minute
none	240
paper	180
5 mm aluminium	181
10 cm lead	22

State which **two** types of ionising radiation are emitted by the source.

Explain your answer.

first type of radiation .....

explanation .....

.....

second type of radiation .....

explanation .....

.....

[2]

[Total: 9]

11 **(a)** Fig. 11.1 shows a diagram of a water wave.

On Fig. 11.1, mark the amplitude and the wavelength of the wave using double-headed arrows (↔ or ↕).

Label the amplitude **A** and the wavelength **W**.

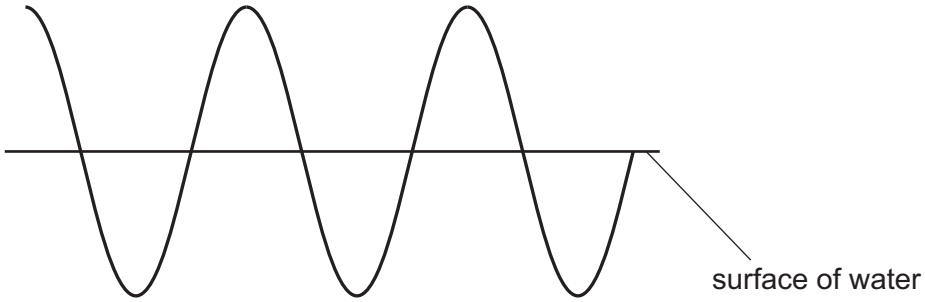


Fig. 11.1

[2]

(b) A water wave has a wavelength of 0.078 m.

The frequency of the wave is 0.50 Hz.

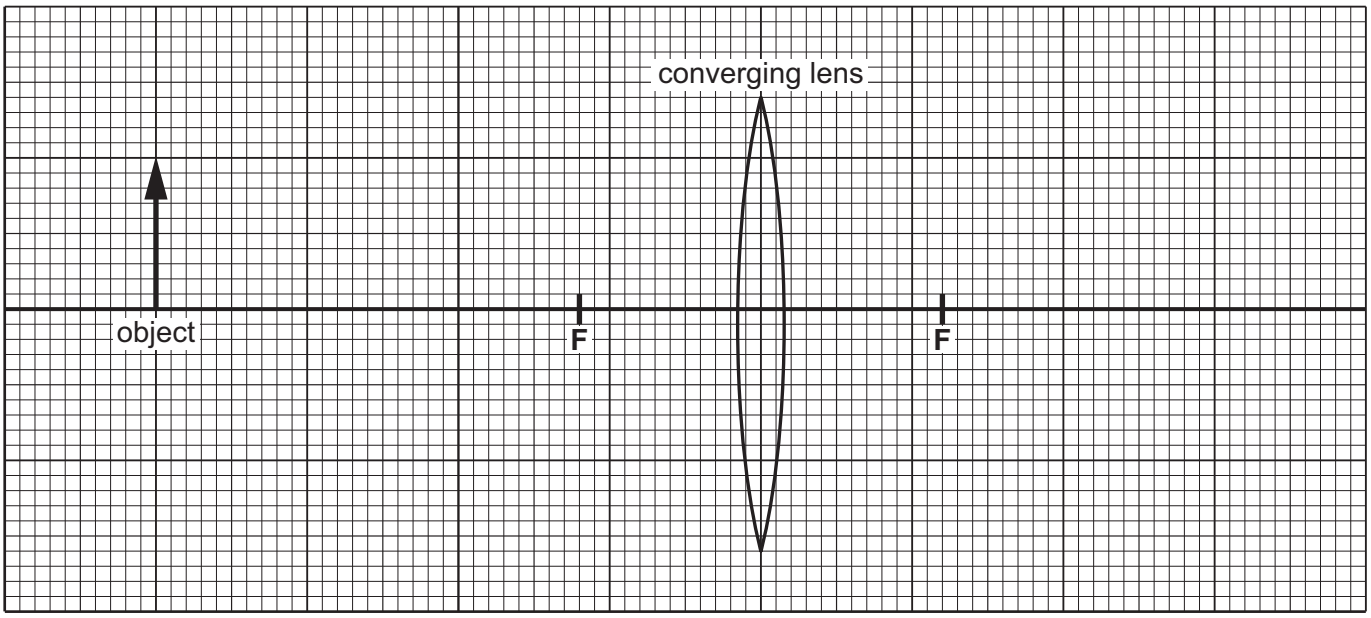
Calculate the wave speed.

wave speed = ... m/s [2]

(c) **(i)** Lenses refract light.

Complete the ray diagram for the lens in Fig. 11.2 to show the location of the image formed.

Draw the image formed with an arrow.



F = principal focus

Fig. 11.2

[3]

(ii) In another experiment, an object is placed at a distance of less than the focal length from a thin converging lens.

Describe the characteristics of the image formed.

.....

..... [2]

(d) The Sun transfers energy via infrared waves to the Earth.

The Earth emits infrared radiation into space.

State and explain what happens to the temperature of the Earth during the daytime and during the nighttime.

daytime .....

.....

nighttime .....

.....

[3]

[Total: 12]

12 **(a)** Fig. 12.1 shows two identical resistors each of resistance 3.8 Ω connected to a cell.

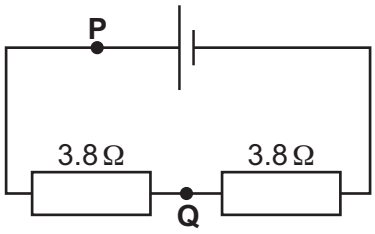


Fig. 12.1

(i) The electromotive force (e.m.f.) of the cell is 1.5 V.

Define e.m.f.

.....

..... [2]

(ii) State the potential difference (p.d.) between points **P** and **Q**.

State the unit of your answer.

p.d. = ... unit ..... [2]

(iii) Calculate the combined resistance of the two resistors.

resistance = ... Ω [1]

(b) Fig. 12.2 shows a piece of metal wire with a resistance of 40 Ω along its length.

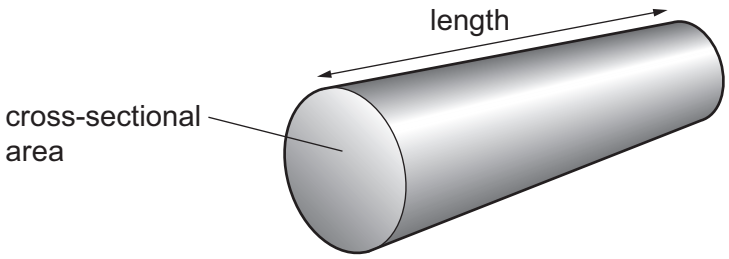


Fig. 12.2

A potential difference is applied across the ends of the wire.

Describe the process of electrical conduction in the wire.

.....

.....

.....

.....

..... [3]

(c) A second piece of wire of the same material and length as in Fig. 12.2 has double the diameter.

(i) Circle the change, if any, to the cross-sectional area of the wire.

halved **no change** **doubled** **multiplied by 4**

[1]

(ii) Determine the resistance of this piece of wire.

resistance = ... Ω [1]

[Total: 10]

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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 –	113 Nh nihonium –	114 Fl flerovium –	115 Mc moscovium –	116 Lv livermorium –	117 Ts tennessine –	118 Og oganesson –

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.).