Paper 2A	☐ s.f. ☐ formula	70

Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL
Preliminary Examination
Secondary 4 (O-Level Programme)

PHYSICS 6091/02

Paper 2 Structured and Free Response

23 August 2024

1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.
Write in dark blue or black ink.
You may use a HB pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.

Section A
Answer **all** questions.
Write your answers in the spaces provided.

Section B
Answer **one** question.
Write your answers in the spaces provided.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

For examiner's use only:

Section A	/ 70
Section B	/ 10
Total	**/ 80**

Overall	**Marks**	**%**
Paper 1	40	30%
Paper 2A	70	50%
Paper 2B	10	
Paper 3	40	20%

Section A

Answer **all** the questions in this section.

1 A ball is thrown vertically upwards from ground level. Air resistance is **not** negligible. The variation with time t of the velocity v of the ball is shown in Fig. 1.1.

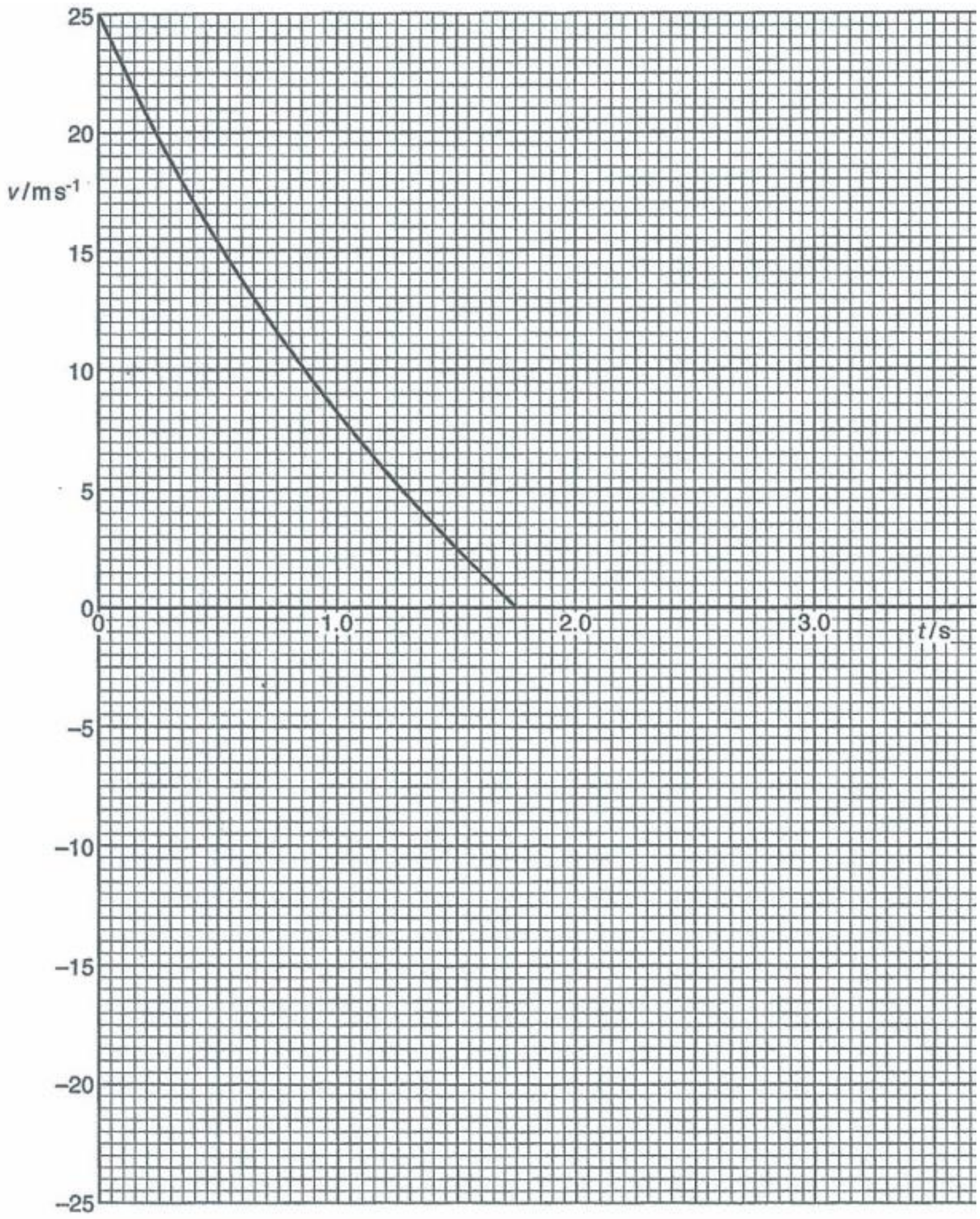

Fig. 1.1

(a) **(i)** Describe the motion of the ball from $t = 0$ s to $t = 1.75$ s.

....

....

.... [2]

(ii) Explain, in terms of forces acting, why the ball moves as described in **(a)(i)**.

....

....

....

.... [3]

(b) State the time where the gradient of the graph is equal to the magnitude of the acceleration of free fall.

time = ... [1]

(c) The ball falls back to ground level at $t = 3.50$ s without reaching terminal velocity.

Sketch, on Fig. 1.1, the variation of the velocity of the ball with time from $t = 1.75$ s to $t = 3.50$ s.

[2]

2 Fig. 2.1 shows an electric motor and pulley wheel being used to raise a load M. The electric motor uses a belt to turn the pulley wheel.

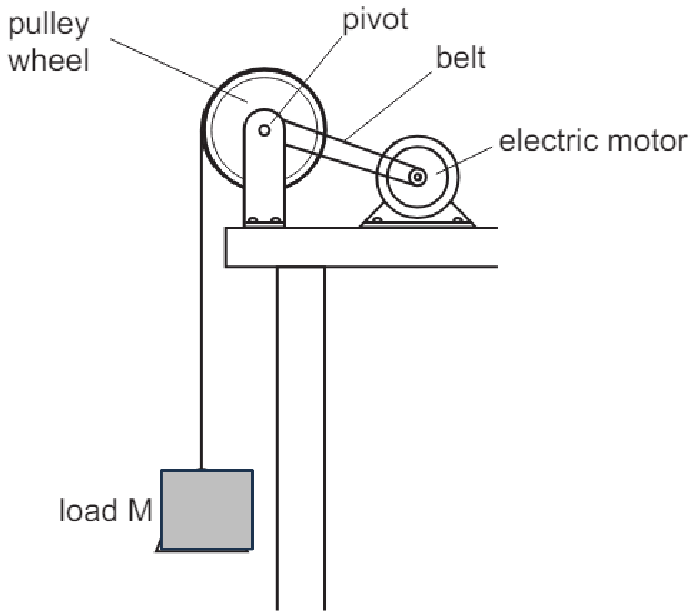

Fig. 2.1

(a) When the electric motor lifts the load, it transfers energy.

Describe the energy transfers between **the electric motor, the load M and the surrounding air**.

Assume there are no energy transfers to the belt and pulley wheel.

....

....

....

....

.... [3]

(b) Fig. 2.2 shows the force on the pulley from the load M.

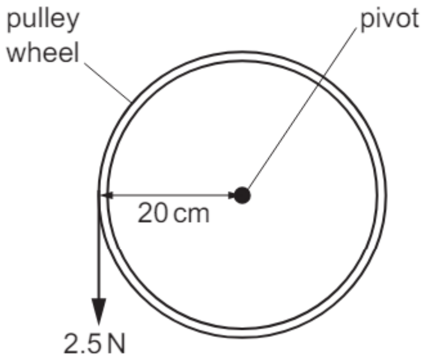

Fig. 2.2

The weight of load M is 2.5 N and the weight acts at a distance of 20 cm from the pivot of the pulley wheel.

Calculate the moment of the weight of load M about the pivot.

moment = ... [2]

(c) Fig. 2.3 shows the dimensions of load M.

The load is removed from the pulley and dropped into a tank containing an unknown liquid. It is completely submerged in the liquid and remains stationary with the same orientation shown in Fig. 2.3 without touching the base of the tank.

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

Fig. 2.3 (not to scale)

Show that the density of the unknown liquid is 3 500 kg / m^3.

[2]

3 A cylinder that contains a fixed amount of a gas is shown in Fig. 3.1.

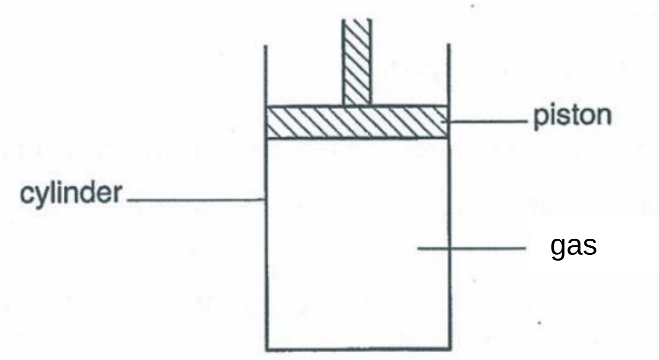

Fig. 3.1

The cylinder is fitted with a piston that moves freely.

(a) Explain how the molecules of the gas produce a pressure on the piston.

....

....

.... [2]

(b) The gas in the cylinder is heated.

Explain, using ideas about molecules, why a downward force needs to be applied on the piston to keep the volume of the gas constant.

....

....

.... [2]

(c) An engineer using the cylinder wants to minimise heat transfer from the gas to the surrounding air.

Suggest why:

(i) the piston is made of wood,

....

.... [1]

(ii) the piston has a seal around it, which prevents the movement of air into and gas out of the cylinder,

....

.... [1]

(iii) the outer walls of the cylinder are silver in colour.

....

.... [1]

4 A loudspeaker emits a sound wave, which is a longitudinal wave. The variation of the air pressure with distance from the loudspeaker at a particular time is shown in Fig. 4.1.

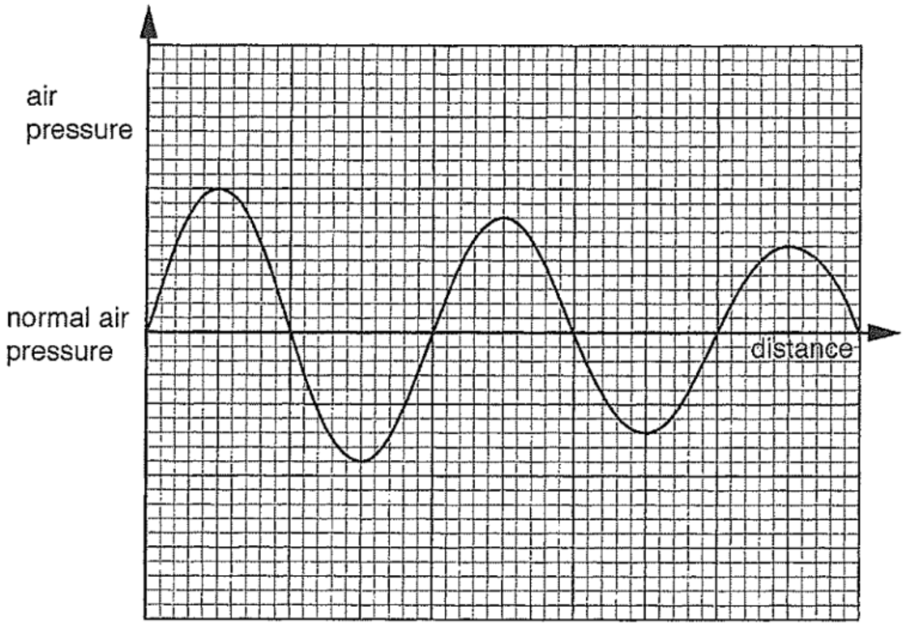

Fig. 4.1 (not to scale)

(a) State what is meant by a *longitudinal wave*.

....

.... [1]

(b) On Fig. 4.1,

(i) draw a line with arrows to indicate the wavelength of the wave, and label this line as **W**,

(ii) mark a point to show a centre of rarefaction, and label this point as **R**,

(iii) mark a point where the air molecules are at the maximum displacement from their rest positions, and label this point as **M**.

[3]

(c) A student is standing at point A which is at a distance of one wavelength from the loudspeaker. He moves to point B which is at a distance of two wavelengths from the loudspeaker.

He claims that as he moves from A to B, the frequency of the sound wave decreases.

State and explain whether the claim is correct.

....

....

.... [2]

(d) The speed of the sound wave is 330 m / s. The wavelength of the sound wave is 3.3 m.

Sketch, on Fig. 4.1, the variation of the air pressure with distance from the loudspeaker after 15 ms.

Show all relevant workings below.

[2]

5 Fig. 5.1 illustrates three ways in which different electromagnetic waves may be used to send television signals into a home.

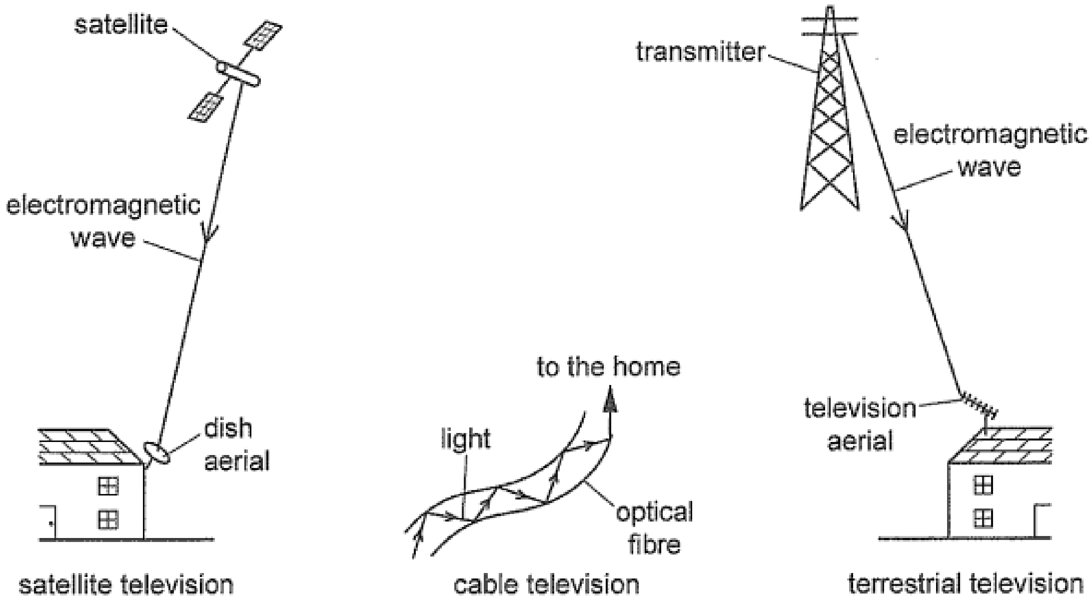

Fig. 5.1

In a satellite television, electromagnetic waves travel from a satellite in outer space to a dish aerial on the ceiling of the home.

In a cable television, light travels through optical fibres to the home.

In a terrestrial television, electromagnetic waves travel from a transmitter on Earth to a television aerial in the home.

(a) State the region of the electromagnetic spectrum used in each of these systems.

satellite ....

terrestrial ....

[2]

(b) A satellite is in orbit at a height of 36 000 km above the Earth's surface.

Calculate the time it takes for a signal to travel from the satellite to the dish aerial on Earth.

time = ... [2]

(c) In cable television, light is transmitted through an optical fibre, which is made of a core of plastic surrounded by an outer wall of glass.

(i) Explain why the light is not refracted out of the optical fibre, but stays within the walls of the optical fibre.

....

....

.... [2]

(ii) Hence, or otherwise, state one advantage of optical fibres over copper wires.

....

.... [1]

6 Fig. 6.1 shows an electrical plug that is wrongly connected to an electrical heater with a metal casing.

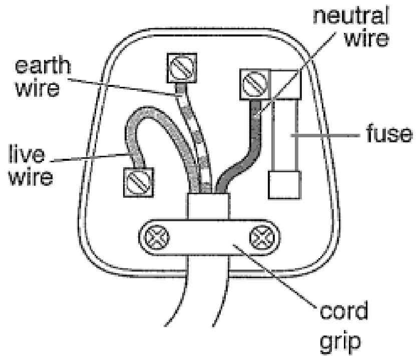

Fig. 6.1

(a) State the colours of the wires given below.

live ....

neutral ....

earth .... [1]

(b) State two connections that are wrong with the wiring in Fig. 6.1.

....

.... [1]

(c) Explain why the connections described in **(b)** could be potentially dangerous.

....

....

.... [2]

(d) Explain how double insulation of the electrical heater could remove the danger described in **(c)**.

....

....

.... [2]

7 Fig. 7.1 shows two vertical, cylindrical tubes and a cylindrical magnet all held in a vacuum.

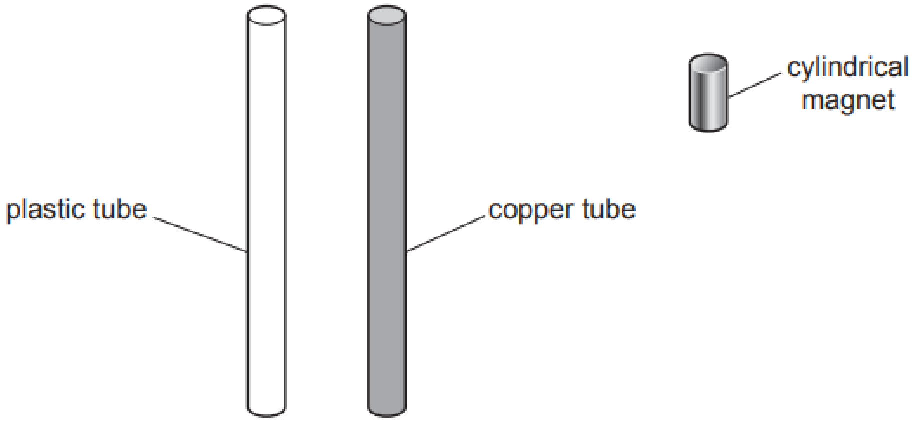

Fig. 7.1 (not to scale)

One tube is made of plastic and the other tube is made of copper. The two cylindrical tubes have identical dimensions.

The magnetic field of the cylindrical magnet is extremely strong.

The magnet is released from rest at the top of the plastic tube and copper tube respectively, and the time taken for the magnet to fall to the lower end of each tube is recorded.

(a) State which material of tube the magnet takes a longer time to fall to its lower end.

material = ... [1]

(b) Explain why there is an induced current in the tube stated in **(a)**.

....

....

....

.... [3]

(c) Hence, explain, in terms of forces acting, why the magnet takes a longer time to fall to the lower end of the tube stated in **(a)**.

....

....

.... [2]

(d) When the magnet falls towards the top of the tube stated in **(a)**, the induced current in the tube flows in a clockwise direction when viewed from the top of the tube.

State which pole of the cylindrical magnet enters the tube first.

.... [1]

8 Plutonium-239 decays by α-emission to form the isotope uranium-X.

A sample of plutonium-239 emitting α-particles produced the following results in Table 8.1 when its emission was measured at different distances from it and at different times. The count rate from background radiation was taken and found to be 20 per minute.

Table 8.1

distance / cm	count rate / minute (t = 0)	count rate / minute (t = 12 000 years)	count rate / minute (t = 24 000 years)	count rate / minute (t = 36 000 years)
1.0	3 620	2 570	1 820	1 290
2.0	920	656	470	338
3.0	420	303	220	161

(a) State one possible source of the background radiation.

.... [1]

(b) A nuclear physicist claims that the count rate per minute due to plutonium-239 **alone** is inversely proportional to the square of the distance from it.

Using data from the column for count rate per minute at t = 0, show that the claim is true.

[2]

(c) **(i)** State the half-life of plutonium-239.

half-life = ... [1]

(ii) Hence, determine the time when the measured count rate, at a distance of 3.0 cm, will be 70 per minute.

time = ... [1]

(d) Write the nuclear equation for the alpha decay of plutonium-239 to uranium-X.

The chemical symbols for plutonium and uranium are Pu and U respectively, and the proton number of uranium is 92.

[2]

(e) Explain why α-particles are not suitable for measuring the thickness of paper, and suggest an alternative type of nuclear emission which is suitable.

....

....

.... [2]

(f) Suggest one precaution to control human exposure to ionising radiation.

....

.... [1]

9 A battery with an electromotive force (e.m.f.) of 9.0 V is connected in series with a light-dependent resistor (LDR) R_L and a fixed resistor of resistance 1 800 Ω, as shown in Fig. 9.1.

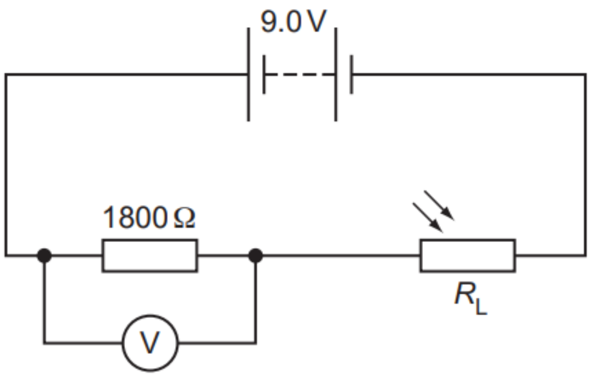

Fig. 9.1

(a) State what is meant by “an e.m.f. of 9.0 V”.

....

.... [1]

(b) A voltmeter is connected across the fixed resistor. The reading on the voltmeter is 6.3 V.

Calculate

(i) the current in the circuit,

current = ... [1]

(ii) the resistance R_L of the LDR.

resistance = ... [2]

(c) An electrical engineer wishes to connect a lamp within the circuit so that it lights up when light intensity decreases.

On Fig. 9,1, draw the lamp connected within the circuit, and explain how this connection helps the engineer to achieve his objective.

....

....

.... [2]

(d) At a certain low level of light intensity, the resistance of the lamp becomes four times the resistance of the LDR.

State and explain whether the lamp or the LDR dissipates more power.

....

....

.... [2]

(e) State two changes that can be made to the filament of the lamp in **(d)** so that its resistance will decrease to be the **same** as the resistance of the LDR. Assume that the material of the filament remains the same.

(1) ....

....

(2) ....

.... [2]

Paper 2B	☐ s.f. ☐ formula	10

Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL
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PHYSICS **6091/02**

Paper 2 Structured and Free Response

23 August 2024
1 hour 45 minutes

Candidates answer on the Question Paper.
No Additional Materials are required.

Section B

Answer only **one** of the two questions.

10 Two examples of fields in Physics are the electric field and the magnetic field.

(a) Define *electric field*.

....

....

.... [1]

(b) A pair of parallel charged plates of opposite charge are placed on a surface as shown in Fig. 10.1. It can be assumed that there is no flow of charge between the plates and the surface.

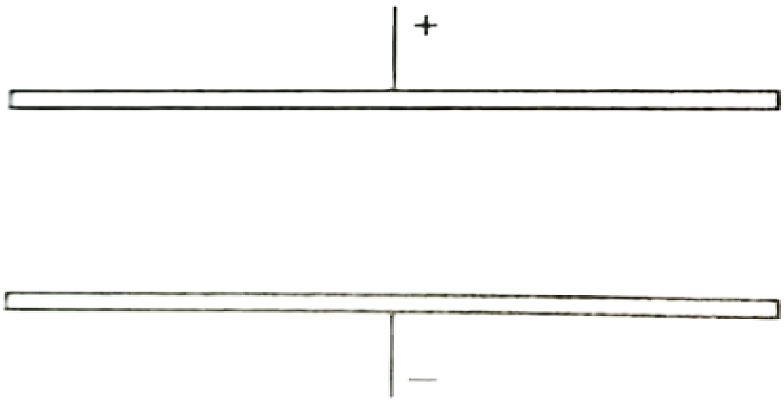

Fig. 10.1

(i) On Fig. 10.1, draw the electric field pattern in the region between the parallel plates.

[1]

(ii) The parallel plates are now placed in a region with a uniform magnetic field.

An electron is placed in between the parallel plates and immediately given a slight horizontal push to the right. The electron subsequently moves horizontally to the right with constant velocity.

By considering the **magnitudes** and **directions** of the **electrostatic and magnetic forces acting on the electron**, explain why the electron moves horizontally with constant velocity.

....

....

....

.... [3]

(iii) **1.** On Fig. 10.1, draw the magnetic field pattern that causes the direction of the force on the electron stated in **(b)(ii)**.

[1]

2. Explain how you determined the direction of the magnetic field in **(b)(iii)1**.

....

....

.... [2]

(iv) The electron emerges out from the parallel plates to point C, and approaches an uncharged metal rod along the direction CX as shown in Fig. 10.2.

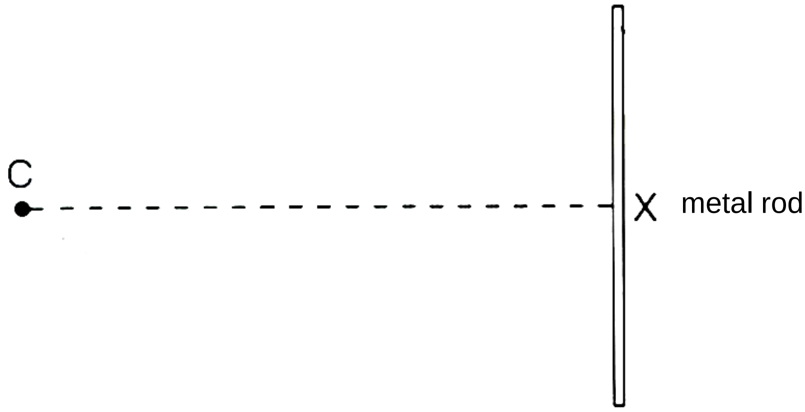

Fig. 10.2

Explain why the electron accelerates towards the metal rod.

....

....

.... [2]

11 Water exists in three different states, namely solid, liquid and gaseous. The same mass of water in different states has a different amount of energy in its internal store.

(a) **(i)** Define *internal energy*.

....

....

.... [2]

(ii) Hence, explain why steam at a temperature of 100 °C feels hotter to the touch than the same mass of water at the same temperature.

....

....

.... [2]

(b) 200 g of ice cubes at a temperature of 0 °C are poured into a container containing an electrical heater and 50 g of water at a temperature of 100 °C.

Ice melts at 0 °C.

The following data are provided:

- current through electrical heater = 3.0 A
- electromotive force (e.m.f.) of electrical heater = 24 V
- time electrical heater is switched on = 15 minutes
- specific heat capacity of ice = 2.1×10^3 J / (kg °C)
- specific heat capacity of liquid water = 4.2×10^3 J / (kg °C)
- specific latent heat of fusion of water = 334 J / g
- specific latent heat of vaporisation of water = 2.3×10^3 J / g

(i) Show that the energy transferred electrically by the heater is 64.8 kJ.

[1]

(ii) Hence, determine the final temperature of the mixture.

final temperature = ... [3]

(iii) In reality, the actual final temperature of the mixture is different from the value in **(b)(ii)**.

State and explain whether the actual final temperature of the mixture is higher or lower than the value in **(b)(ii)**.

....

....

.... [2]

--- END OF PAPER ---