Centre Number	Index Number	Name	Class
S3016			

RAFFLES INSTITUTION
2024 Preliminary Examination

PHYSICS **9749/03**
Higher 2

18 September 2024
Paper 3 Longer Structured Questions **2 hours**

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

READ THESE INSTRUCTIONS FIRST

Write your index number, name and class in the spaces at the top of this page.
Write in dark blue or black pen in the spaces provided in this booklet.
You may use pencil for any diagrams or graphs.
Do not use staples, paper clips, glue or correction fluid.
The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer **one** question only and **circle the question number** on the cover pages.

You are advised to spend one and half hours on Section A and half an hour on Section B.
The number of marks is given in brackets [ ] at the end of each question or part question.

***This booklet only contains Section B.**

For Examiner's Use		
Section B (circle 1 question)	8	/ 20
	9	/ 20
Deduction		

This document consists of **12** printed pages.

Section B

Answer **one** question from this section in the spaces provided.

8 A research facility located in the northern hemisphere is used to study the effects of the solar wind from the Sun. At its location, the Earth's magnetic field is found to have a magnetic flux density of 5.2×10^{-5} T at an angle of $70°$ below the horizontal.

(a) A vertical window at the research facility has an aluminium frame ABCD with length 80 cm and width 55 cm, as shown in Fig. 8.1.

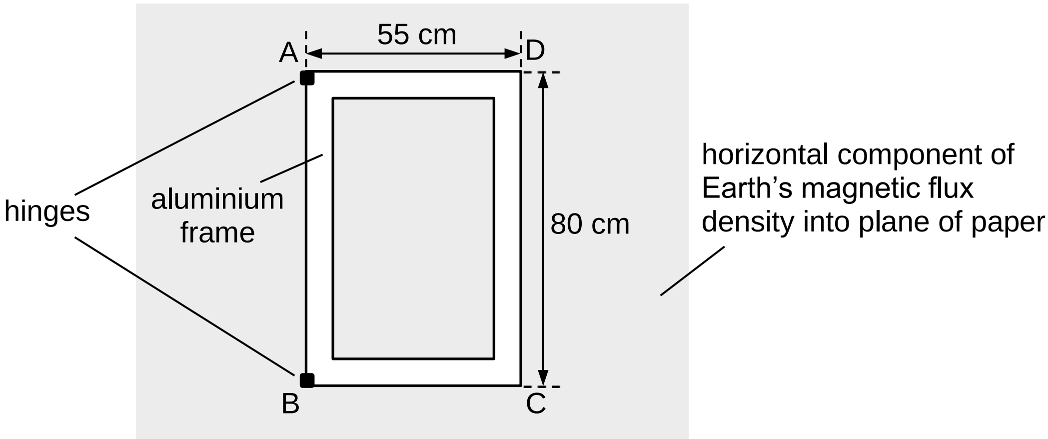

Fig. 8.1

The window is hinged along the side AB. When the window is closed as in Fig. 8.1, the horizontal component of the Earth's magnetic flux density is directed normally into the plane of the window.

(i) Calculate the magnetic flux through the window when it is closed.

magnetic flux = ... Wb [2]

(ii) The window is opened by pushing it into the plane of the paper in a time of 0.30 s. When fully opened, the plane of the window is parallel to the horizontal component of the Earth's magnetic flux density.

During the opening of the window,

1. use the laws of electromagnetic induction to explain why there is a current induced in the aluminium frame,

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.... [3]

2. determine the change in the magnetic flux through the window,

magnetic flux = ... Wb [1]

3. calculate the magnitude of the average e.m.f. induced in side CD of the frame.

e.m.f. = ... V [2]

(b) An electron and an alpha particle from the solar wind enter a region of uniform magnetic field. Both particles are travelling along the same path with the same speed just before they enter the uniform magnetic field, as shown in Fig. 8.2.

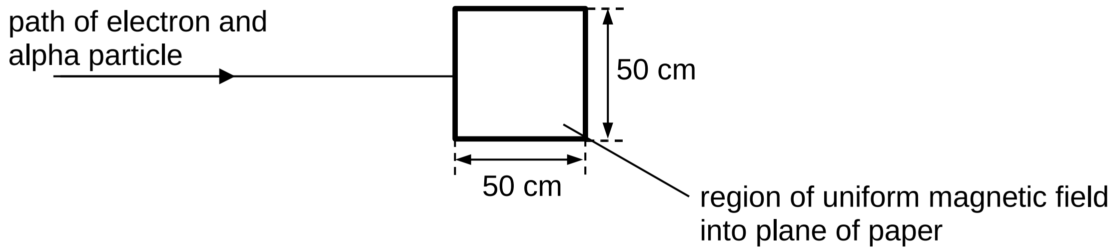

Fig. 8.2

The direction of the magnetic field is into the plane of the paper.

The particles enter the region of the magnetic field at right angles to the edge of the region. Both particles follow circular paths in the magnetic field.

(i) Explain why the charged particles follow circular paths in the magnetic field.

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.... [2]

(ii) Show that the radius r_α of the circular path of the alpha particle is related to the radius r_e of the circular path of the electron by the equation

$$r_\alpha = 3.6 \times 10^3 r_e .$$

Explain your working.

[2]

(iii) The radius of the circular path of the electron is observed to be about 7 mm.

On Fig. 8.2, draw a possible path for the alpha particle as it passes through and beyond the region of the magnetic field.

[1]

(iv) The uniform magnetic field in Fig. 8.2 is now replaced with a varying magnetic field. The variation with time *t* of the magnetic flux density *B* of this new magnetic field is shown in Fig. 8.3.

Positive values of *B* indicate that the magnetic field is directed into the plane of the paper.

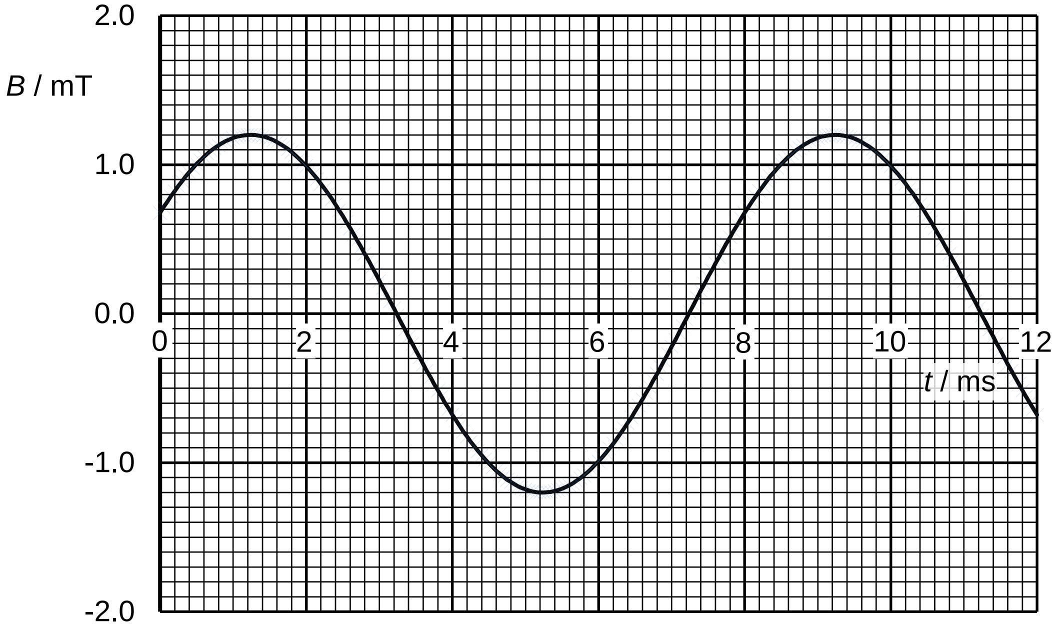

Fig. 8.3

Another electron travelling perpendicularly to the magnetic field and at a speed of 1.2×10^{6} m s^{-1} enters the centre of the magnetic field at time $t = 0$ ms.

From Fig. 8.3, at $t = 0$ ms, $B = 0.70$ mT.

1. Show that the radius of curvature of the electron's path is 9.8 mm at $B = 0.70$ mT.

[1]

2. Calculate the period of the electron's motion at $B = 0.70$ mT .

T = ... s [2]

3. Describe the path of the electron in the magnetic field for the first 4.0 ms, assuming it stays in the magnetic field for the whole of this duration.

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4. In reality, the electron leaves the magnetic field before 4.0 ms.

Without any calculations, state a possible time when this occurs.

Explain your answer.

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[Total: 20]

9 **(a)** Photoelectrons are emitted with insignificant time lag when electromagnetic radiation of a certain frequency is incident on a metal plate.

State and explain one other observation from the photoelectric effect that provides evidence for the particulate nature of electromagnetic radiation.

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(b) Two parallel zinc plates placed a distance *d* apart are used to investigate the photoelectric effect, as shown in Fig. 9.1. Zinc has a work function of 4.33 eV.

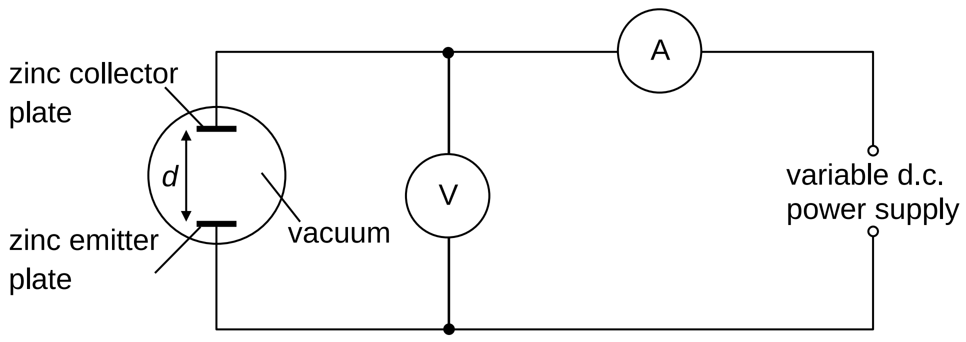

Fig. 9.1

Electromagnetic radiation of wavelength 210 nm is incident on the zinc emitter plate. The potential of the zinc collector plate is varied from –3.0 V to +3.0 V with respect to the zinc emitter plate.

The variation of the current I with the potential difference V is shown in Fig. 9.2.

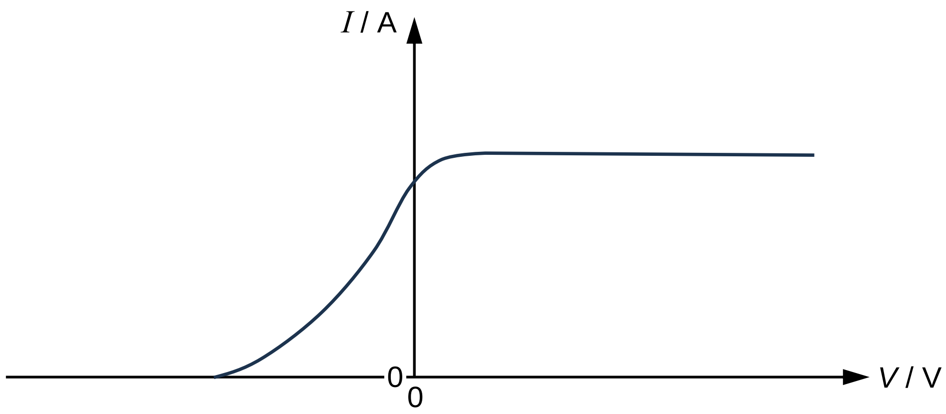

Fig. 9.2

(i) Calculate the threshold wavelength for the zinc plate.

wavelength = ... nm [2]

(ii) Calculate the maximum speed of the emitted photoelectrons.

speed = ... m s^{-1} [2]

(iii) Photoelectrons in **(b)** are emitted perpendicularly to the zinc emitter plate.

Explain why the subsequent motion of the emitted photoelectrons is different when $V = 0$ V and $V = +3.0$ V .

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(iv) On Fig 9.2, draw the variation of I with V if the zinc emitter plate is now illuminated with radiation of a shorter wavelength but the same intensity as in **(b)**.

[2]

(c) Electrons are accelerated in a vacuum before passing through a graphite film, as shown in Fig. 9.3. The electrons are then incident on a fluorescent screen.

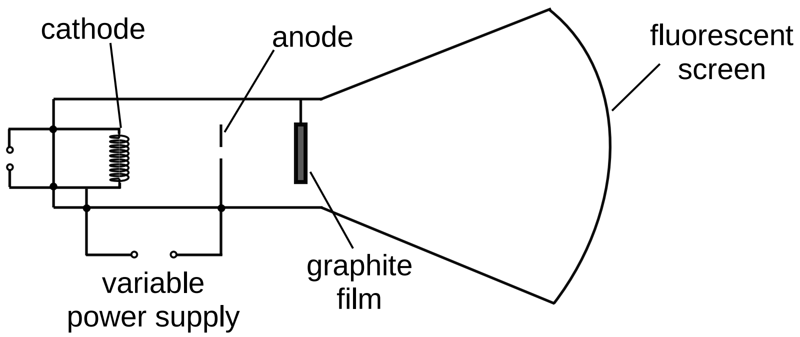

Fig 9.3

Concentric rings of light are observed on the screen.

(i) Explain how the observation of the concentric rings of light provides evidence for the wave nature of electrons.

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.... [2]

(ii) The electrons are accelerated from rest through a potential difference of 5.0 kV.

Calculate the de Broglie wavelength of the accelerated electrons.

wavelength = ... m [3]

(iii) Optical and electron microscopy techniques are widely utilised for imaging and analysing microscopic structures.

With reference to **(c)(ii)**, state and explain an advantage of an electron microscope compared to an optical microscope.

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[Total: 20]

End of Paper 3 Section B