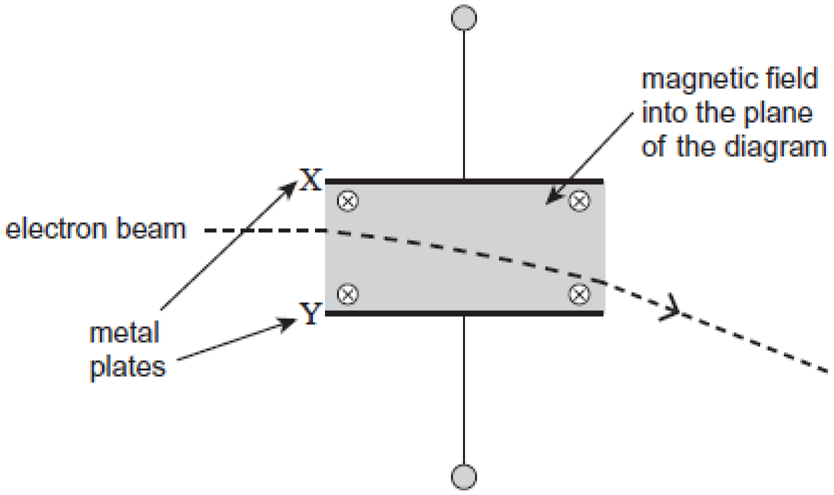
Practice Question Set For A-Level
Subject : Physics
Paper-3 Topic: Section B (Section 12_ Turning Point In Physics)

Name of the Student:____
Max. Marks : 17 Marks **Time : 17 Minutes**

Q1.

The diagram below shows part of an evacuated tube that is used to determine the specific charge (e / m) for an electron. An electron beam is directed between the two parallel metal plates, X and Y. In the region between the plates, a magnetic field is applied perpendicularly into the plane of the diagram. An electric field can be applied in this region by applying a potential difference (pd) between the plates.



(a) The diagram shows the path of the electron beam when the magnetic field is applied and the pd between X and Y is zero.

(i) Explain why the path followed by the electron beam in the magnetic field is a circular arc.

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(2)

(ii) Show that the speed v of the electrons is given by $v = \frac{Ber}{m}$

where r is the radius of the path of an electron in the magnetic field and B is the flux density of the magnetic field.

(1)

(iii) A pd V is now applied between X and Y without changing the flux density of the magnetic field. V is adjusted until the electron beam is not deflected as it travels in the region between the plates.

Determine an expression for the speed v of the electrons in terms of V, B and the separation d of the metal plates.

(1)

(b) Use the equation given in part (ii) and your answer to part (iii) to show that the specific charge for the electron = $\frac{V}{B^2 r d}$

(1)

(c) If the charge on an electron is known then its mass can be determined from the specific charge. Describe how Millikan's experiment with charged oil droplets enables the electronic charge to be determined.

Include in your answer:

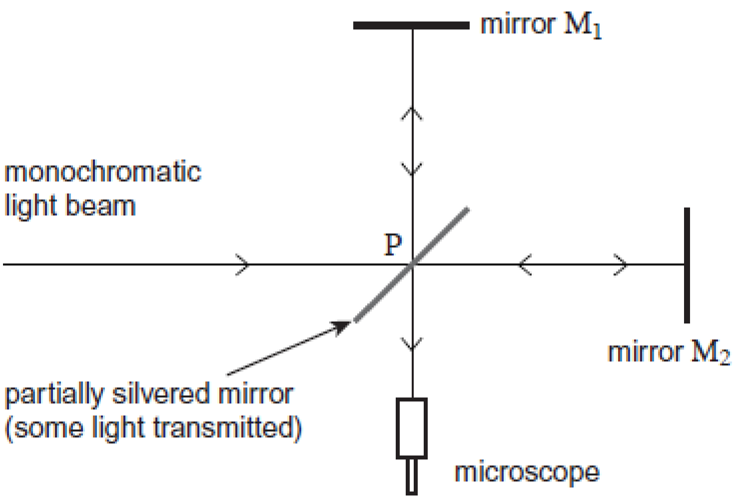
- the procedures used to determine the radius of a droplet and the charge on a droplet
- how the measurements made are used
- how the electronic charge can be deduced.

The quality of your written communication will be assessed in your answer.

(6)
(Total 11 marks)

Q2.

The diagram shows the paths of light rays through a simplified version of the apparatus used by Michelson and Morley.



In the apparatus, light waves reflected by the mirrors M_1 and M_2, meet at P so that they superpose and produce interference fringes. These are observed using the microscope.

Michelson and Morley predicted that the fringes would shift when the apparatus was rotated through 90°. They thought that this shift would enable them to measure the speed of the Earth through a substance, called the aether, that was thought to fill space.

(a) Explain why Michelson and Morley expected that the fringe positions would shift when the apparatus was rotated through 90°.

(2)

(b) In their apparatus they made the distances PM_1 and PM_2 the same and equal to d. They used light of wavelength (λ) about 550 nm and knew that the speed of light c was 3.0×10^8 m s^{-1}. Using known astronomical data, they calculated the speed v at which they thought the Earth moved through the aether. They were then able to predict that when the apparatus was rotated through 90° the fringes should shift by a distance $0.4f$, where f was the fringe spacing.

(i) To determine v, Michelson and Morley assumed that the Sun was stationary with respect to the aether as the Earth moved through it.
Suggest, using this assumption, how the speed v of the Earth through the aether could be determined. You do not need to do the calculation.

(1)

(ii) Michelson and Morley calculated v to be 3.0×10^4 m s^{-1}.
They worked out Δf, the magnitude of the expected shift of the fringes, using the formula $\Delta f = \frac{2v^2 d}{c^2 \lambda} f$.

Calculate the distance d they used in their experiment.

d = ____________________ m

(1)

(c) Although a shift of $0.4\,f$ was easily detectable, no shift was observed. Explain what this null result demonstrated and its significance for Einstein in his special theory of relativity.

(2)

(Total 6 marks)