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B.Sc - Part - II (Hons)

Modern Physics

Measurement of specific charge of an electron by Thomson's method

It uses the following two properties of electrons

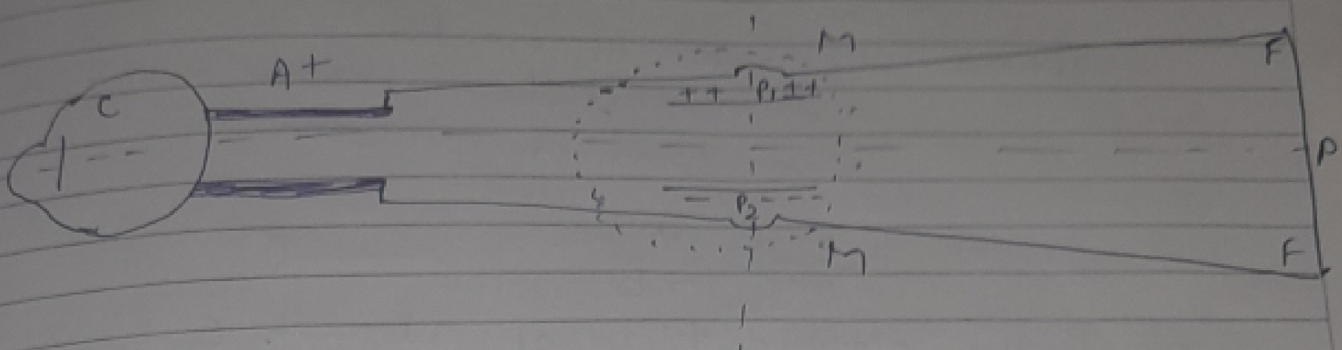
1. Electrons are deflected by electric and magnetic fields.
2. Moving electrons affect photographic plate.

Apparatus: – The apparatus consists of

1. Source of ~~Electrons~~ Electrons: – Early apparatus of experiment used discharge tube containing air at a reduced pressure nearly 10^{-2} mm of Mercury. A Steam of cathode rays (electrons) originates from cathode and is limited to a very fine beam by means of fine slit in the anode A.

In modern apparatus the source of electron beam is usually an electron gun, which consists of heated filament, a grid and an anode. The anode has a fine slit through which electron beam emerges.

2. Crossed Electric and Magnetic fields: The electric field and magnetic field both are mutually perpendicular and also perpendicular to stream of electron. The electric and magnetic fields are so adjusted that the electric and magnetic forces on electron beam are equal and opposite. The electric field is produced by applying a p.d. across the two parallel metallic plates P_1 and P_2. The magnetic field is applied by an electromagnet MM.



fig(1)

3. A <u>fluorescent screen</u> :- It is a screen coated with zinc sulphide. Moving electrons produce fluorescence on the screen.

The whole apparatus in enclosed in an evacuated chamber.

<u>Working and Theory</u> :- First of all the electron beam is allowed to fall on fluorescent screen in the absence of electric and magnetic fields. A greenish blue spot is seen in point P.

Now the magnetic field of strength B is switched on, its direction being perpendicular to plane of paper and inwards, the electron beam is deflected in the plane of paper downwards, because each electron experiences a magnetic force evB downward in the plane of paper (by fleming's left hand rule).

Teacher's Signature ____________

This force provides the necessary centripetal force for circular path of radius r given by.

$$\frac{mv^2}{r} = evB$$

where m = mass of electron
e = magnitude of charge on electron
v = speed of electron

$$\frac{e}{m} = \frac{v}{rB} \quad \text{——} (1)$$

Next the electric field of strength E is switched on between plates P_1 and P_2 by applying a potential difference V between them, the direction of electric field being from P_1 to P_2. If d is the separation between plates then

electric field strength $E = \frac{V}{d}$ —— (2)

The potential difference V is so adjusted that the electric force on electron eE is equal in magnetic force evB on electron so that the electron beam in both fields is focussed at point P of screen. Thus,

$$\not{e}E = \not{e}vB$$

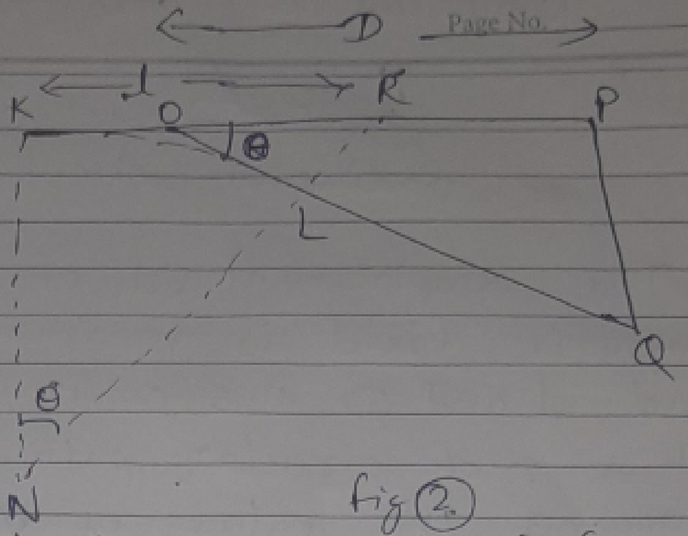
$$v = \frac{E}{B} \quad \text{——} (3)$$

Substituting this value of v in eqn (1) we get

$$\frac{e}{m} = \frac{E}{rB^2} \quad \text{——} (4)$$

Using (2)

$$\frac{e}{m} = \frac{V}{rB^2 d} \quad \text{——} (5)$$



To find r :-

Let l be the length of magnetic field along initial direction of electron beam, with centre at O, i.e

KR = l. P is

fig (2)

undeflected spot and Q is the position of spot deflected in the presence of magnetic field alone. The electron ~~traverses~~ traverses circular arc KL centred at N in the magnetic field. At L, the magnetic fields ends and the electron then follows the straight line path, LQ tangential at L, when produced LQ meets at O.

∠POQ = θ. KN is normal to KR

NL when produced meets at R. ∠KNR = θ.

Let y be deflection of electron beam on screen in the magnetic field alone.

In △OPQ, $\tan\theta = \frac{PQ}{OP} = \frac{y}{D}$ — (6)

where D is the distance of screen from the centre of magnetic field.

In △KNR,

$\tan\theta = \frac{KR}{KN} = \frac{l}{r}$ — (7)

Comparing (6) and (7), we get

$$\frac{y}{D} = \frac{l}{r}$$

or radius of circular path $r = \frac{lD}{y}$

The displacement (y) of spot on screen in magnetic field is measured by a microscope and l and D are constants of apparatus. Thus r of circular path may be determined. Knowing the values of V, B, d and r, the specific charge $\left(\frac{e}{m}\right)$ of electrons may be estimated. The experimental value of

$$\frac{e}{m} = 1.7593 \times 10^{11} \text{ Coul / Kg.}$$