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Paper : Atomic Physics and spectroscopy.

code : BPH52

chapter : 1. [discharge Phenomenon through gases]

chapter 1.

Discharge phenomenon through gases.

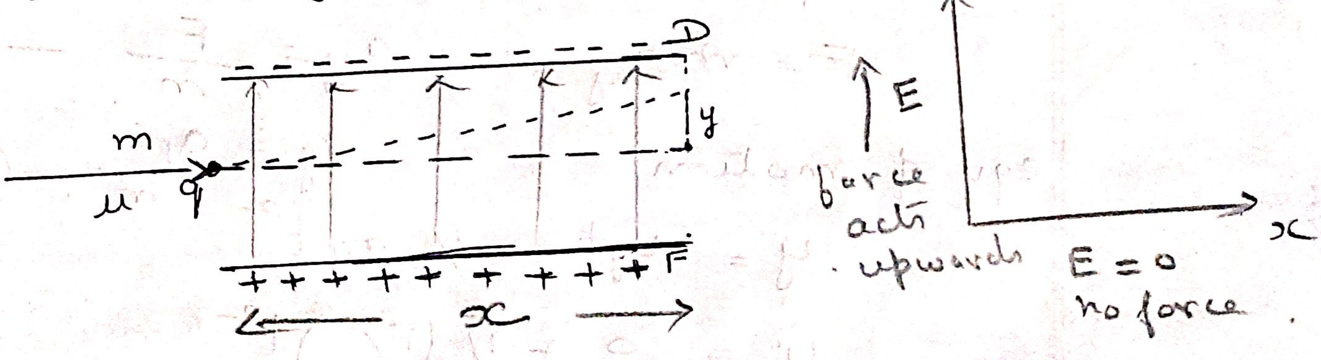
Introduction :

The earliest attempt to understand the structure of matter resulted in the concept of atoms, discovery of electrons and protons etc. The passage of electricity through gases rise to different types of very complicated and interesting results dependent chiefly on two factors the presence of gas and the strength of the electric field.

Moving of charge in transverse electric and magnetic fields.

Action with electric field :

Consider a charged particle of mass m, charge q and with initial velocity u. Let the electric field be produced between two parallel horizontal plates DF. Let x be the length of the plates.



The charged particle moving with initial velocity u on entering the electric field experiences a force in the direction of applied electric field. It starts deviating from its original direction (in the direction in the absence of electric field). and traces path which is at a distance 'y' from the original path.

To determine the path of the particle, we consider the motion of the particle along x-axis, there is no force, and hence no acceleration $(a_x = 0)$ hence velocity

$U_x = U$.

equation of motion:

$$x = u_x t + \frac{1}{2} \underset{(0)}{a_x} t^2$$

$$x = ut \quad \text{——} \quad (1)$$

consider the motion along y axis.

As the particle moves along x axis initially with velocity u and at that moment the initial velocity of the particle along y axis is zero.

$\therefore \; U_y = 0$ initially.

But force is acting along y axis

$$F = m a_y \quad \therefore \quad a_y = \frac{F}{m} \quad \text{——} \quad (A)$$

electric force $= qE$

$$a_y = \frac{qE}{m} \quad \text{——} \quad (2)$$

equ of motion

$$y = u_y t + \frac{1}{2} a_y t^2$$

$$y = 0 + \frac{1}{2}\left(\frac{F}{m}\right) t^2$$

$u = \frac{dist}{t}$

$u = \frac{x}{t}$

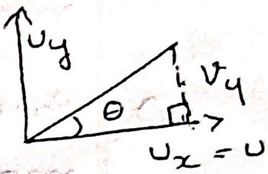
$\therefore \; t = \frac{x}{u}$

$$y = \frac{1}{2}\left(\frac{qE}{m}\right)\left(\frac{x}{u}\right)^2$$ from eq ① $t = \frac{x}{u}$ & eq ② $a_y = \left(\frac{qE}{m}\right)$

$$y = \frac{qE}{2m}\frac{x^2}{u^2} \quad \text{---} \ (3)$$

eqn ③ is similar to equation of parabola. Hence the charged particle traces a parabolic path inside the electric field

To determine the direction (or) angle at which it comes out.



$$\tan\theta = \frac{v_y}{u_x} = \frac{u_y}{u} \quad \text{---} \ (4)$$

3rd equation of motion:

$$v_y^2 = u_y^2 + 2a_y y$$

$$v_y^2 = 0 + 2\left(\frac{qE}{m}\right)y$$

$$v_y = \sqrt{\left(\frac{2qE}{m}\right)y} \quad \text{---} \ (5)$$

Action with magnetic field

Consider a charged particle of mass 'm', charge 'q' entering the magnetic field 'B' with velocity 'v'. It experiences a magnetic force F on it.

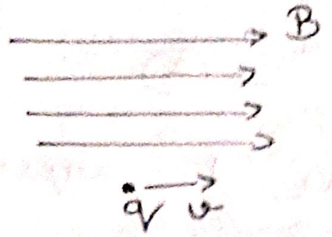
There are three cases

(1) moving charge particle parallel to magnetic field ($v \parallel B$)

(2) moving charge perpendicular to magnetic field ($v \perp B$)

(3) moving charge inclined at any angle to magnetic field.

(1) Particle moves parallel to the magnetic field



$$\text{Force} = \vec{q}(\vec{v} \times \vec{B})$$

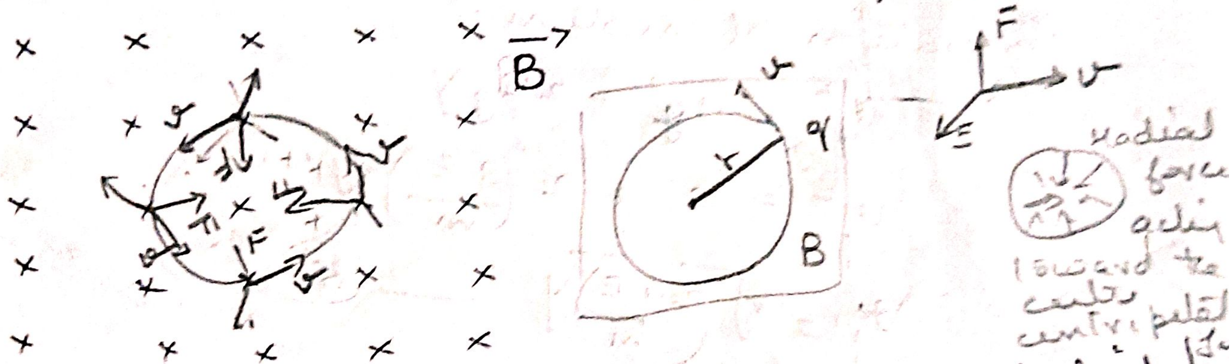
$$\vec{F} = q\, vB \sin\theta$$

$\theta = 0$ (zero .

$$\therefore \vec{F} = 0$$

since force is zero, there is no acceleration and thus the particle moves undeflected in the field.

(2) Particle moves perpendicular to the magnetic field.



If a charge enters a magnetic field at right angles to it, It moves in circular path due to magnetic force which acts as a centripetal force.

$$\therefore F = \frac{mv^2}{r} \quad \text{—} \ 1$$

m - mass
v - linear velocity
r - radius.

~~but~~ we know the magnetic force (or) (Lorentz force) is qvB.

$$\therefore q\cancel{v}B = \frac{mv^{\cancel{2}}}{r} \quad \text{—} \ 2$$

$$qB = \frac{mv}{r} \ \ 3 \Rightarrow r = \frac{mv}{qB} \ \text{—} \ 4$$

$|||^{ly}$ From (3) we have the relation for

$$v = \frac{qBr}{m} \quad (5)$$

Linear velocity $(v) = r\omega$ (ω - angular velocity)

$$\frac{qB\cancel{r}}{m} = \cancel{r}\omega \quad \therefore \boxed{\omega = \frac{qB}{m}} \quad (6)$$

$\frac{q}{m}$ = specific charge.

Time period

$T = 1/\nu$

ω = (specific charge) $\times$ B.
angular velocity, magnetic field.

$\omega = 2\pi\nu$

$\omega = \frac{2\pi}{T}$.

$$T = \frac{2\pi}{\omega} = \frac{2\pi m}{qB} \quad (7)$$

(Time period is independent of v)

$|||^{ly}$ $\nu = \frac{\omega}{2\pi} = \frac{qB}{2\pi m}$.

Kinetic energy $= E = \frac{1}{2}mv^2$

$$= \frac{1}{2}\cancel{m}\left(\frac{qBr}{\cancel{m}}\right)^{\cancel{2}}.$$

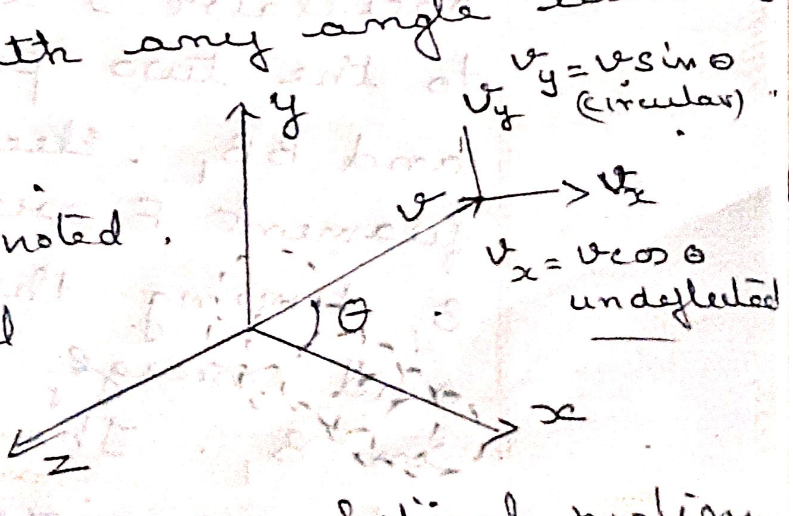
$$\boxed{E = \frac{q^2B^2r^2}{2m}.} \quad (8)$$

(c) Particle moves with any angle with the magnetic field.

important ~~point~~ parameter to be noted.

1) radius of the helical motion

(2) Pitch of the "



helical motion

radius is same as equation (4)

The pitch of the helical path is given by

Pitch = Time period × velocity along x axis

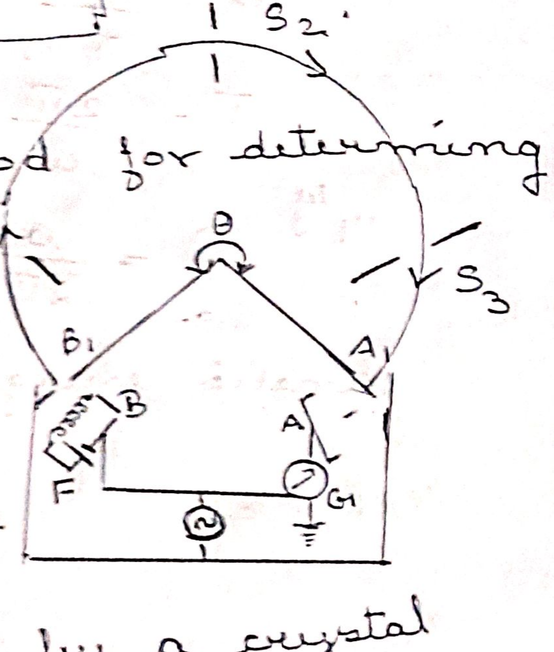
$$P = T v_x .$$

from (7)

$$P = \frac{2\pi m}{qB} v\cos\theta .$$

$$\boxed{P = \frac{2\pi m}{qB} v\cos\theta} \quad - (9)$$

Dunnington's method for determining e/m.



The apparatus is shown in Fig. An alternating voltage at a constant high frequency produced by a crystal oscillator O is applied simultaneously to the two pairs of electrodes AA_1 and BB_1. Electrons from the hot filament F are accelerated towards B_1 during the positive half-cycle, and emerge through a fine opening in B_1. The electron are then bent into a circular path by a magnetic field B applied normal to the plane