10/07/21

HOME ASSIGNMENT - 4

(1) We know that radius of circular path

$$r = \frac{mv}{qB} = \sqrt{\frac{2mV}{qB^2}}$$

So, if accelerating voltage is doubled i.e. if $V' = 2V$

then;

$$\frac{r'}{r} = \sqrt{\frac{V'}{V}} = \sqrt{\frac{2V}{V}} = \sqrt{2} \Rightarrow r' = \sqrt{2}r.$$

(2) mass of deutron = 2m (1 proton & 1 neutron)
mass of proton = m (1 proton.)

$\therefore$ R (proton) $= \frac{mv}{qB}$

R (deutron) $= \frac{2m \times v}{qB}$

$\therefore$ Ratio $\left(\frac{\text{proton}}{\text{deutron}}\right) = \frac{1}{2}$

And the trajectory is circular.

(3) It is a device used to accelerate charged particles like protons, deuterons, α-particles etc. to very high energies.

Principle:

A charged particle can be accelerated to high speeds by passing it through electric field.

DOMS

many ~~num~~ number of times and at the same time magnetic field makes the charged particle to move in circular path.

Theory:

Let a charge particle of charge q and mass m enters a region of magnetic field vector B with a velocity vector v, normal to field vector B. The particle follows a circular path, the necessary centripetal force is provided by the magnetic field.

Therefore,

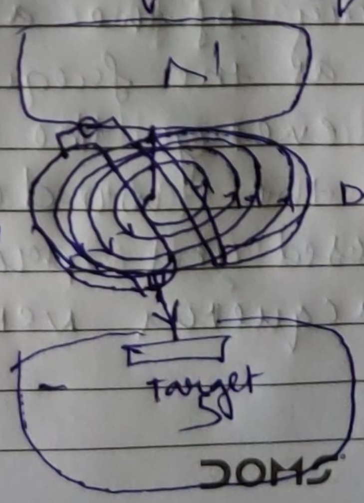
magnetic force on charge q = Centripetal force on charge q.

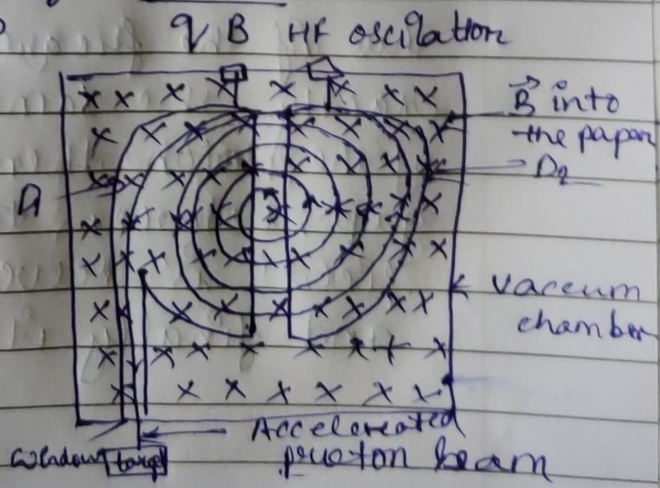
or $qvB \sin 90^\circ = \frac{mv^2}{r}$

$$\boxed{r = \frac{mv}{qB}}$$

Period of revolution of the charged particle

$$T = \frac{2\pi r}{v} = \frac{2\pi}{v} \cdot \frac{mv}{qB} = \frac{2\pi m}{qB}$$





Clearly, this frequency is independent of both the velocity of the particle and the radius of the orbit and is called cyclotron frequency or magnetic resonance frequency.

Working:

- Suppose a positive ion, say a proton, enters the gap between the two dees and finding D_1 to be -ve. It gets accelerated towards Dee D_1.

- As it enters the dee D_1, it does not experience any electric field due to shielding effect of the metallic dee. The perpendicular magnetic field throws it into a circular path with constant speed.

- At the instant the proton comes out of dee D_1, It finds dee D_1 positive and dee D_2 negative. It now gets accelerated towards dee D_2.

- It moves faster through D_2 describing a larger semicircle than before.

- Thus if the frequency of the applied voltage is kept exactly the same as the frequency of revolution of the proton, then every the proton reaches the gap between the two dees, the electric field is reversed and proton receives a push and finally it acquires very high energy.

- This condition in which frequency of applied voltage is equal to the frequency of revolution of charged particle is called the cyclotron's resonance condition.

- The accelerated proton is ejected through a window by a deflecting voltage and hits the target.

(4) (i) Let us consider
Mass of proton = m,
charge of proton = q,
Mass of alpha particle = 4m
charge of Alpha particle = 2q.

Cyclotron frequency,
$$f = \frac{Bq}{2\pi m}$$
$$\Rightarrow f \propto \frac{q}{m}$$

$f_P \propto \frac{q}{m}$ and $f_a \propto \frac{2q}{4m}$

$$\Rightarrow f_a \propto \frac{q}{2m}$$

Thus particles will not accelerate with same cyclotron frequency. The frequency of proton is twice than the frequency of alpha particle.

(ii) Velocity, $v = \frac{Bqr}{m}$ $\Rightarrow v \propto \frac{q}{m}$

For proton: $v_p \propto \frac{q}{m}$ and for alpha particle, $v_a \propto \frac{2q}{4m}$

$$\Rightarrow v_a \propto \frac{q}{2m}$$

Thus, particles will not exit the dees with same velocity. The velocity of proton is twice than the velocity of alpha particles.

5) We know that a charged particle will experience a force when it enters a magnetic field. The magnetic field will ~~not~~ move the charged particle in a circular path, as the force is ~~per~~ perpendicular to the velocity of particle.

$$\frac{mv^2}{r} = Bqv.$$

$$r = \frac{mv}{Bq}$$

As B and v are constant,

$$r \propto \frac{m}{q}$$

The neutron will move along the straight line as it has no charge.

The electron will inscribe a circle of radius smaller than that of alpha particle as the mass to charge ratio of the alpha particle is more than that of the electron.

So, alpha particle will move in clockwise direction and the electron will move in anticlockwise direction.