Home Assignment

09/07/21

① A proton is accelerated through a potential difference V, subjected to a uniform magnetic field acting normal to the velocity of the proton. If the potential difference is doubled, how will the radius of the circular path described by the proton in the magnetic field change?

Ans. V = potential difference

Angle between motion B = 90°

$\frac{1}{2}mv^2 = qV$

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

$\frac{1}{2}mv_2^2 = q(2V)$

$R_1 = \frac{mv}{qB}$

$\frac{v_1}{v_2} = \frac{1}{\sqrt{2}}$

$R_2 = \left(\frac{m}{qB}\right)v^2$

$v_2 = v_1\sqrt{2}$

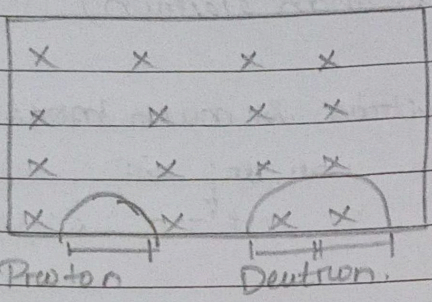
$R_2 = \left(\frac{m}{qB}\right)v\sqrt{2}$

$$\boxed{\frac{R_1}{R_2} = \frac{1}{\sqrt{2}}}$$

Arpita,

② A deutron and a proton moving with the same speed enter the same magnetic field region at right angles to the direction of the field. Show the trajectories followed by two particles in the magnetic field. Find the ratio of the radii of the circular paths which the two particles may describe.

Ans.



Mass of deutron = 2m (1 proton + 1 neutron)

Mass of proton = m (1 proton)

$\therefore R(\text{proton}) = \dfrac{mV}{qB}$

$R(\text{deutron}) = \dfrac{2m \times V}{qB}$

$\therefore \text{Ratio}\left(\dfrac{\text{Proton}}{\text{Deutron}}\right) = \dfrac{1}{2}$.

③ Draw a schematic sketch of the cyclotron. State its working principle. Show that the cyclotron frequency is independent of the velocity of the charged particle.

Ans. Working principle of cyclotron:

The cyclotron uses crossed electric and magnetic fields which increase the kinetic energy of a charged particle without changing its frequency of revolution.

Such that,

$F_c = F_m$

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

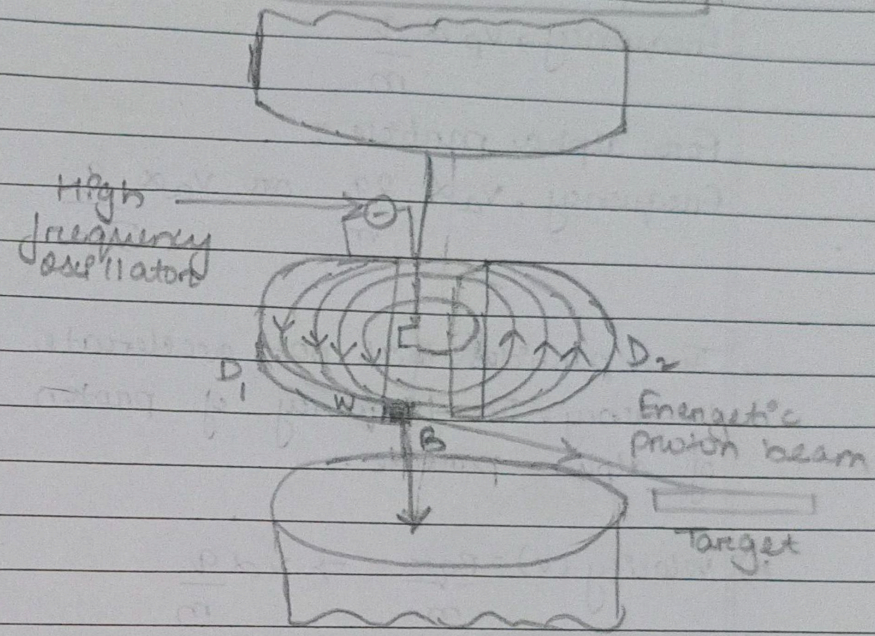
$$\frac{v}{r} = \frac{qB}{m}$$

$$\omega = \frac{qB}{m}$$

$$2\pi f = \frac{qB}{m}$$

$$f = \frac{qB}{2\pi m}$$

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



The frequency is independent of velocity.

(4) An α-particle and a proton are released from the centre of the cyclotron and made to accelerate.

a) Can both be accelerated at the same cyclotron frequency? Give reason to justify your answer.

b) When they are accelerated in turn, which of the two will have higher velocity at the exit slit of the dees?

Ans. a) Let us consider -

Mass of proton = m

Charge of proton = q

Mass of alpha particle = 4m.

Charge of alpha particle = 2q

Cyclotron frequency $(\nu) = \frac{Bq}{2\pi m} \Rightarrow \nu \propto \frac{q}{m}$

For proton :

Frequency, $\nu_p \propto \frac{q}{m}$

For alpha particle :

Frequency, $\nu_\alpha \propto \frac{2q}{m}$ or $\nu_\alpha \propto \frac{q}{2m}$

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

b) velocity (v) $= \frac{Bqr}{m} \Rightarrow v \propto \frac{q}{m}$

For proton :

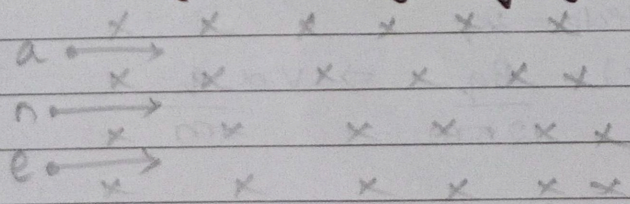
velocity, $v_p \propto \frac{q}{m}$

For alpha particle :

velocity, $v_\alpha \propto \frac{2q}{4m} \Rightarrow v_\alpha \propto \frac{q}{2m}$

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

(5) A neutron, an electron and an alpha particle moving with equal velocities, enter a uniform magnetic field going into the plane of the paper as shown in figure. Trace their paths in the field and justify your answer.



Ans. Radius of particle (r) = $\frac{mv}{qB}$

Here, velocity and magnetic field are same.

So,

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

$\alpha = 4 \times$ mass of proton
$= 2 \times$ charge of proton

$r_\alpha = \frac{4 \times m_p}{2 \times p} = \frac{2 \times m_p}{p}$

r_n = Here charge on neutron 1 and 2
So, path is st-line No deflection.

$r_p = \frac{M_p}{p}$

$\boxed{r_\alpha = 2 \times r_p}$

Neutron is straight line.