Home Assignment

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1) Given:-

Proton is accelerated through a potential difference V, subjected to a uniform magnetic field acting normal to the velocity of the proton.

So, centripetal force = magnetic force

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

$\Rightarrow r = \frac{mv}{qB}$ —— ①

Now, kinetic energy of proton = potential energy of proton

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

$\Rightarrow (mv) = \sqrt{2qVm}$

Putting value of 'mv' in eq. ①,

$r = \frac{\sqrt{(2qVm)}}{qB}$

$\Rightarrow r = \frac{1}{B}\sqrt{\frac{2Vm}{q}}$

$\Rightarrow r \propto \frac{1}{\sqrt{V}}$.

Hence, Radius of the path is inversely proportional to square root of potential difference.

Now, if the potential difference is doubled, then radius of the path becomes $1/\sqrt{2}$ times of its initial.

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

Mass of proton = m (1 proton)

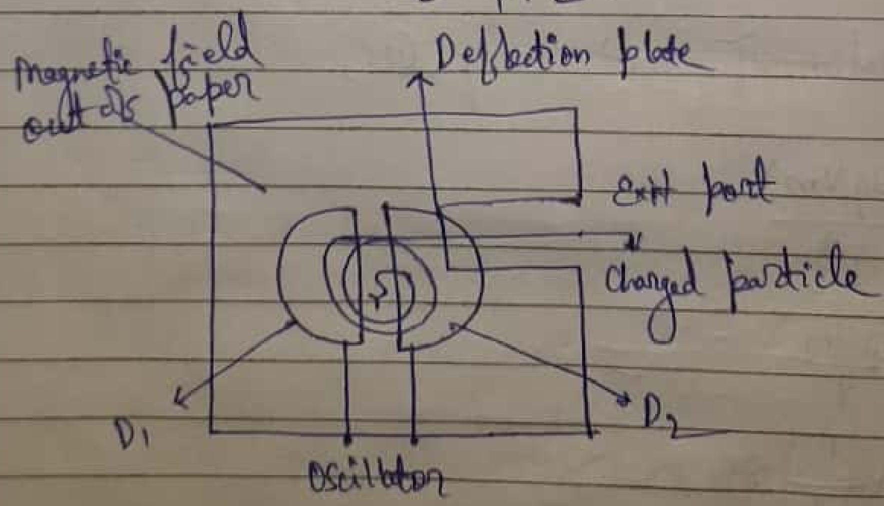
$\therefore R(\text{proton}) = \frac{mV}{qB}$ [R → Radius]

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

$\therefore \text{Ratio}\left(\frac{\text{Proton}}{\text{deutron}}\right) = \frac{\frac{mV}{qB}}{\frac{2mV}{qB}}$

$= \frac{1}{2}$.

$= 1:2$.

3) 

Working principle of cyclotron :-

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

Such that,

$F_c = F_m$

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

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

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

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

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

∴ The cyclotron frequency is independent of velocity.

4) a) Cyclotron frequency, $n = \frac{1}{2\pi}\left(\frac{q}{m}\right)B$

For a proton, $\frac{q}{m} = \frac{e}{m_p}$

For an α-particle $\frac{q}{m} = \frac{2e}{4m_p} = \frac{1}{2}\frac{e}{m_p}$

As $n \propto \frac{q}{m}$, they cannot be accelerated at the same cyclotron frequency.

b) Velocity, $v = Bqr$

$\Rightarrow v \propto \frac{q}{m}$

for proton, Velocity $v_p \propto \frac{q}{m}$

for an α-particle, Velocity $V_\alpha \propto \frac{2q}{4m}$ or $V_\alpha \propto \frac{q}{2m}$

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

5) A charged particle will experience a force when it enters a magnetic field. The magnetic field will move the charged particle in a circular path, as the force is perpendicular to the velocity of the particle. The radius of the circular path will be given by,

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

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

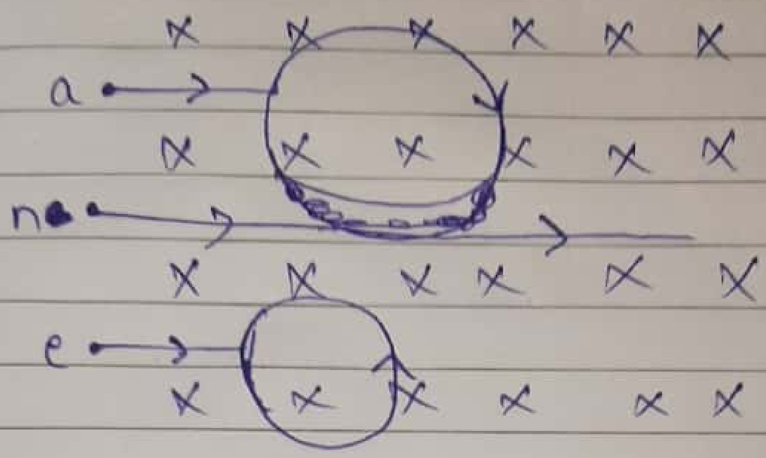
As, B and v are constant,

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

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 the alpha particle as the mass to charge ratio of the alpha particle is more than that of the electron.

So, the alpha-particle will move in clockwise direction and the electron will move in anticlockwise direction according to the right hand rule.



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