H.W

Home - Assignment

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1.) Given,
Proton is accelerated by potential difference = V
Here,
The direction velocity of the proton, is normal to the direction of magnetic field, so
$F_m = Bvq \sin\theta$
$= Bvq \sin 90^\circ = Bvq$
As, the velocity is $\perp$ar to magnetic field, and magnetic force, the proton will have a circular path.
The force on the proton will also be a centripetal force.
Hence,
magnetic force = Centripetal force
$\Rightarrow F_m = F_c$
$\Rightarrow Bvq = \frac{mv^2}{r}$
$\Rightarrow Bq = \frac{mv}{r} \Rightarrow r = \frac{mv}{q}$
As per the work energy theorem
Work done = Change in K.E
$\Rightarrow W = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$
$\Rightarrow qV = \frac{1}{2}m(v^2 - u^2)$
$\Rightarrow qV = \frac{1}{2}mv^2$
$\Rightarrow v^2 = \frac{2qV}{m}$
$\Rightarrow v = \sqrt{\frac{2qV}{m}}$

Putting the value of V in the radius:

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

$$\Rightarrow r = \left(\frac{m}{Bq}\right)\sqrt{\frac{2qV}{m}}$$

$$= \sqrt{\frac{2m^2qV}{B^2q^2m}}$$

$$= \sqrt{\frac{2mV}{B^2q}}$$

Now,
If the potential difference is doubled then,

$$r_1 = \sqrt{\frac{2m(2V)}{B^2q}}$$

$$= \left(\sqrt{\frac{2mV}{B^2q}}\right)\sqrt{2}$$

$$= \sqrt{2}\,r$$

$$\therefore R_1 = \sqrt{2}\,r$$

Radius of the circular path will increase by $\sqrt{2}$ times that of the initial radius of the circular path of proton.

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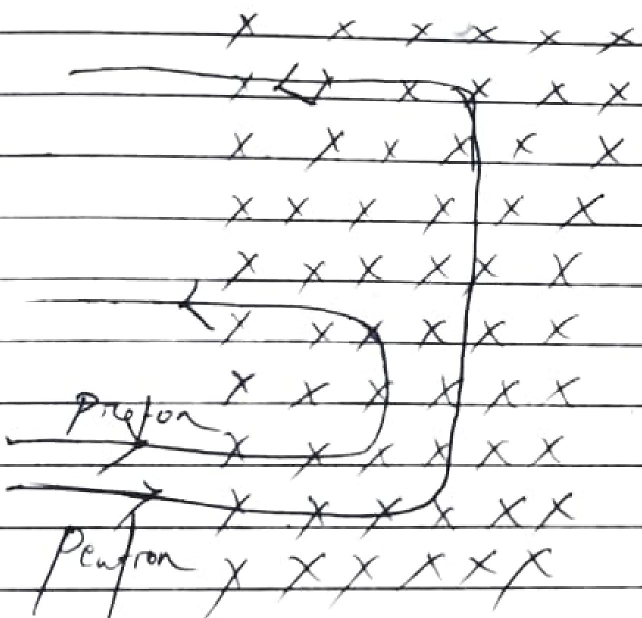
2) The trajectories of the 2 particles electron & protons



Here,
Let the mass of proton be m.
Then the mass of deutron will be 2m.
Now, we know that for radius of Circular path $r = \frac{mv}{Bq}$

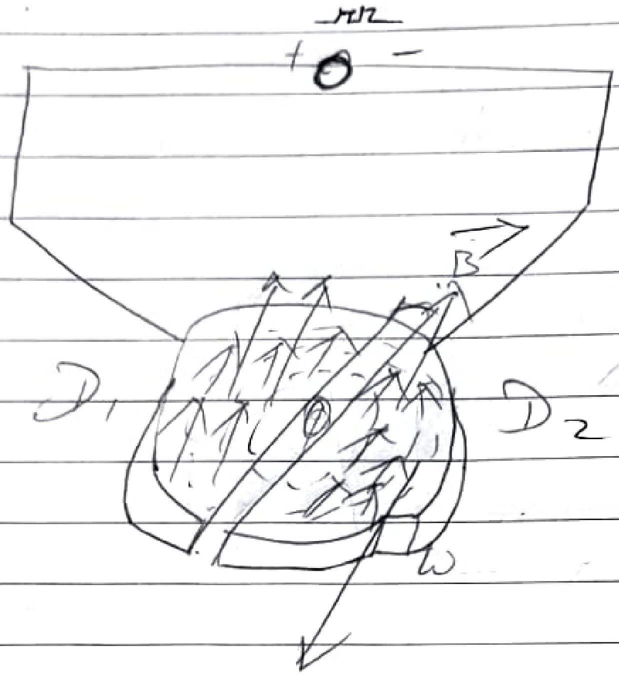
So, for proton, $r_p = \frac{mv}{Bq}$

& for electron, $r_d = \frac{2mv}{Bq}$

Hence, the ratio,

$$\frac{r_p}{r_d} = \frac{\frac{mv}{Bq_p}}{\frac{2mv}{Bq_p}} = \frac{1}{2} = 1 : 2$$

3) The ~~Sym~~ schematic sketch of the cyclotron is



Working Principle,

A charged particle can be accelerated to very high energies by making it pass through a moderate electric field a no. of times. This can be done with the help of a perpendicular magnetic field which throws the charged particle into a circular motion, the frequency of which does not depends on the speed of the particle and the radius of the circular orbit.

Now,

In this cyclotron,

The magnetic force experienced by the charge particle provides the centripetal force required to describe its circular path.

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$$F_e = F_m$$

$$\Rightarrow \frac{mv^2}{r} = Bvq \sin 90^\circ$$

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

$$\Rightarrow v = \frac{Bqr}{m}$$

Now,
The time taken by the charged particle to complete semi circular path of a cyclotron

$$t = \frac{\pi r}{v} = \frac{\pi \cdot m}{Bq}$$

So, time taken by the charged particle to complete one circular motion

$$T = \frac{2\pi r}{v} = \frac{2\pi m}{Bq}$$

Now,
The frequency of the cyclotron will be

$$F = \frac{1}{T}$$

$$= \frac{1}{\frac{2\pi m}{Bq}} = \frac{Bq}{2\pi m}$$

Hence, it is proved

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4.) Here,
Let's consider the mass of proton to be m
and Charge of proton to be q.
then,
The mass of α-particle will be 4m.
and Charge of it will be 2q.
Now,
both α-particle and proton will accelerate
at the same time due to Electric field
Now,
Cyclotron's frequency of proton

$$F_p = \frac{1}{2\pi}\frac{Bq}{m} = \left(\frac{B}{2\pi}\right)\frac{q}{m}$$

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

Cyclotron frequency of α-particle

$$F_\alpha = \frac{B \times 2q}{2\pi \times 4m}$$

$$= \left(\frac{B}{2\pi}\right)\frac{q}{2m}$$

$$\Rightarrow F_\alpha \propto \frac{q}{2m}$$

From this, by taking ratio of the both of
the frequency we get,

$$\frac{F_p}{F_\alpha} = \left(\frac{B}{2\pi}\right)\frac{q}{m} \times \left(\frac{2\pi}{B}\right)\cdot\frac{2m}{q}$$

$$\Rightarrow \frac{F_p}{F_\alpha} = 2$$

$$\Rightarrow F_p = 2F_\alpha$$

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Hence, they both cannot be accelerated with same cyclotron frequency as its frequency of proton is twice that of α-particle as mass of α-particle is twice of proton.

5) Now,
For velocity of particle, $V = \frac{Bqr}{m}$

Now,
velocity of proton will be

$$V_p = \frac{Bqr}{m} = (Br)\frac{q}{m}$$

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

velocity of α-particle will be

$$V_\alpha = \frac{B \times 2q \times r}{4m} = (Br)\frac{q}{2m}$$

$$\Rightarrow V_\alpha \propto \frac{q}{2m}$$

$$\Rightarrow V_\alpha \propto \frac{q}{2m}$$

Now,
Taking the ratio of both the velocities

$$\frac{V_p}{V_\alpha} = \frac{Brq}{m} \times \frac{2m}{Brq}$$

$$\Rightarrow \frac{V_p}{V_\alpha} = 2$$

$$\Rightarrow V_p = 2V_\alpha$$

The proton will have a higher velocity than the α-particle.

5.) As the motion of charge particle are present perpendicular to the magnetic force the particle will move in a circular path and will experiences centripetal force.

So, the expression for radius is

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

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

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

$$\Rightarrow r = \left(\frac{v}{B}\right)\frac{m}{q}$$

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

Here,

→ The neutron will move in a straight line because it has no charge. It is neutral so, it will not come under the influence of any force.

→ Electrons and α-particle will have a circular path as they have charge. And the radius of the circular path followed by the electron will be less than that of the α-particle as the mass of electron is less that α-particle and as r ∝ m so, with more mass the radius of the particles circular path will increase.

→ Now, the electron will move in anticlockwise direction but the α-particles will move in the clockwise direction as the current & its velocity are in the same direction.