Home Assignment

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?
2. A deuteron 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 the two particles in the magnetic field. Find the ratio of the radii of the circular paths which the two particles may describe.
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.

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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?

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 the figure. Trace their paths in the field and justify your answer.

9 Jul

1 V = Potential difference

angle between motion B $\Rightarrow 90^\circ$

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

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

$$R_2 = \left(\frac{m}{qB}\right) v_2$$

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

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

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

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

$$\frac{V_1}{V_2} = \frac{1}{\sqrt{2}}$$

$$V_2 = V_1\sqrt{2}$$

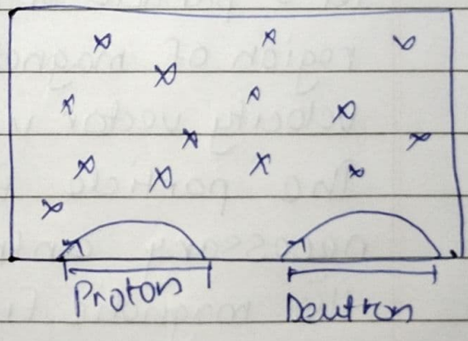
2 Mass of deutron = 2m

Mass of proton = m

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

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

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



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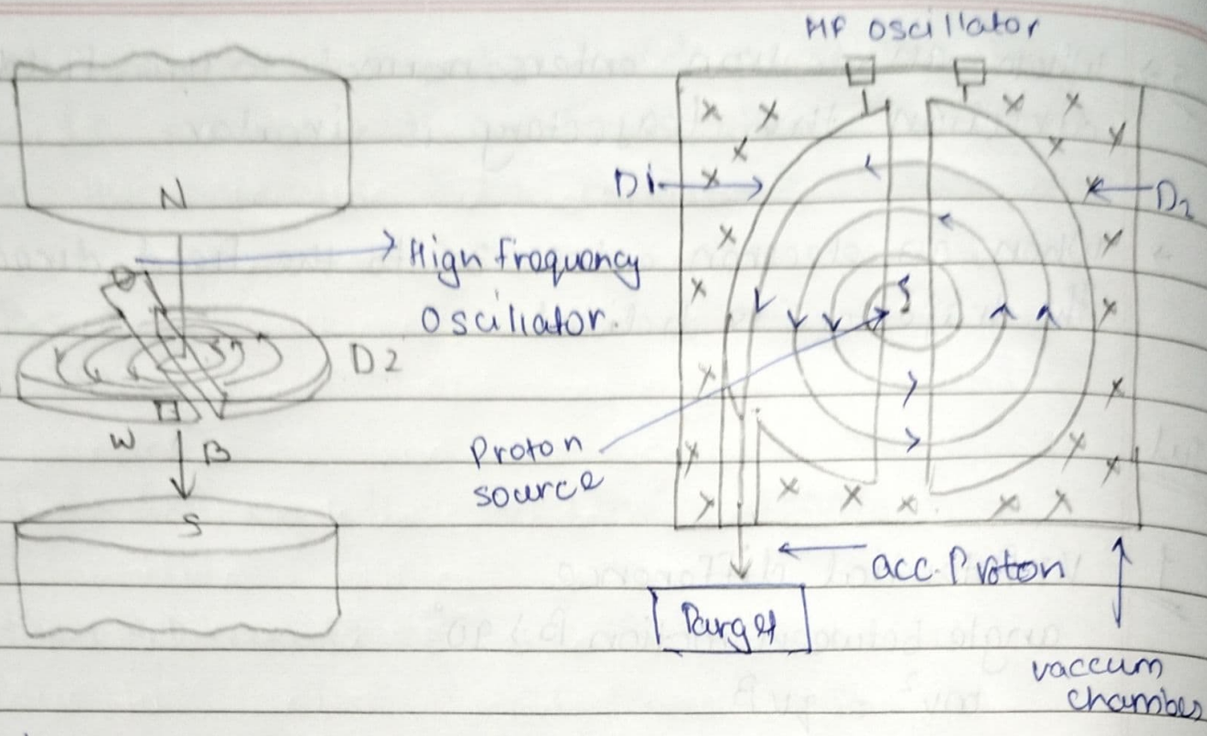

Principal :- A charge particle can be accelerated to very high energy by making it pass through a moderate electric field a no. of times. This can be done with the help of a ⊥ magnetic field which throws the charged particle into a circular motions, the frequency of which does not depend on the speed of the particle and the radius of the circular orbit.

let a particle of charge q and mass m enters a region of magnetic field vector B with a ~~vector~~ velocity vector v, normal to the 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

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

Period of revolution of the charged particle is given by

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

∴ Frequency is independent of both the velocity of the ~~particle~~ and charged particle.

4 i) 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, $\nu_a \propto \frac{2q}{4m}$ or $\nu_a \propto \frac{q}{2m}$

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

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

For proton: velocity, $v_p \propto \frac{q}{m}$

for alpha particle: velocity, $v_a \propto \frac{2q}{4m}$ or $v_a \propto \frac{q}{2m}$

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

5 ⇒ α particle will trace circular path in clockwise direction as it's deviation will be in the direction $(\vec{v} \times \vec{B})$
i.e, perpendicular to the velocity of particle.
neutron will pass without any deviation as magnetic field does not exert neutral particle. Electron will trace circular path in anticlockwise direction as its deviation will be in the direction opposite to $(\vec{v} \times \vec{B})$ with a smaller radius due to larger charge/mass ratio as
$r = mv/qB$