
Shrabanee Samantaray
"XII" "DB"
School no.: 9888
Home Assignment
Date: 9-7-2021...12-7-2021
PHYSICS

Cyclotron

CLASS-XII

SUBJECT : PHYSICS
CHAPTER NUMBER: 04
CHAPTER NAME : MOVING CHARGES AND MAGNETISM

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

Answer 1):

Given:

A/Q Due to magnetic, proton moves in circular path

Now Centrifugal force = Magnetic force.

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

$$\Rightarrow r = \frac{mv^2}{Bqv} = \frac{mv}{Bq} \quad \ldots(1)$$

Kinetic energy = potential energy of proton.

$$\Rightarrow \frac{1}{2}mv^2 = qV \quad \text{or} \quad \frac{1}{2}mpv^2 = eV$$

$$\Rightarrow mv^2 = \sqrt{2qVmp} \qquad v = 2\sqrt{2eV/mp}.$$

$$= \sqrt{2qVm} \qquad \ldots(ii)$$

If potential difference is double.

$$V = 2V$$

$$\Rightarrow v = \sqrt{2e \times \frac{2V}{mp}}$$

$$\Rightarrow v' = \sqrt{2v} \quad \ldots(iii)$$

Now Putting (II) in (I)

$$r = \frac{mv}{Bq} = \frac{\sqrt{2qVm}}{qB} = \frac{1}{B}\sqrt{2Vm/q})$$

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

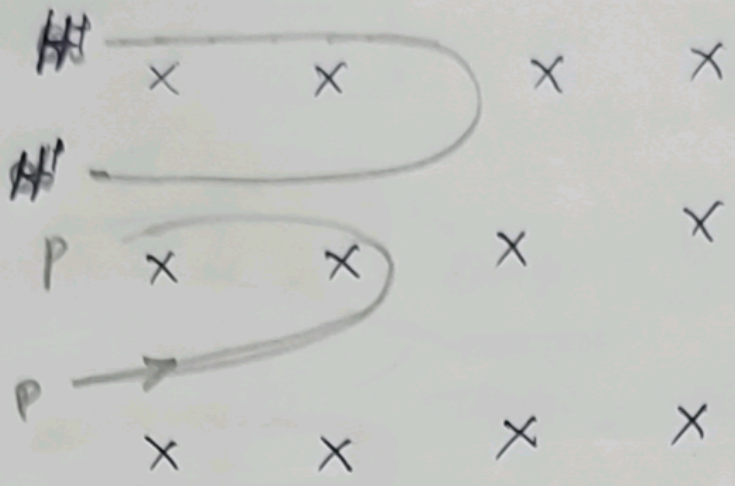
Radius of path $\propto \frac{1}{\sqrt{\text{Potential difference}}}$ inversely perpendicular to square root of potential difference

from (ii) If potential difference doubles radius of path = $\frac{1}{\sqrt{2}}$ times the initial.

Answer

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.

Answer 2:



Let Mass of deutron = 2m

Mass of proton = m

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

or R_P

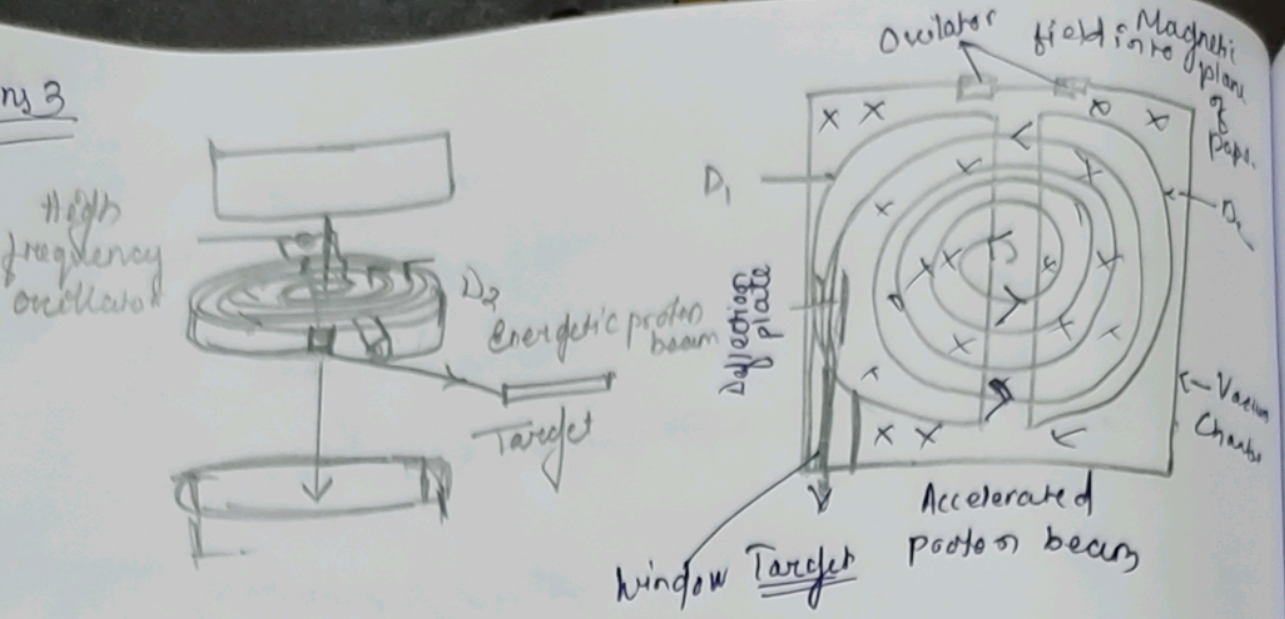
R (deutron) $= \frac{2m \times v}{qB}$

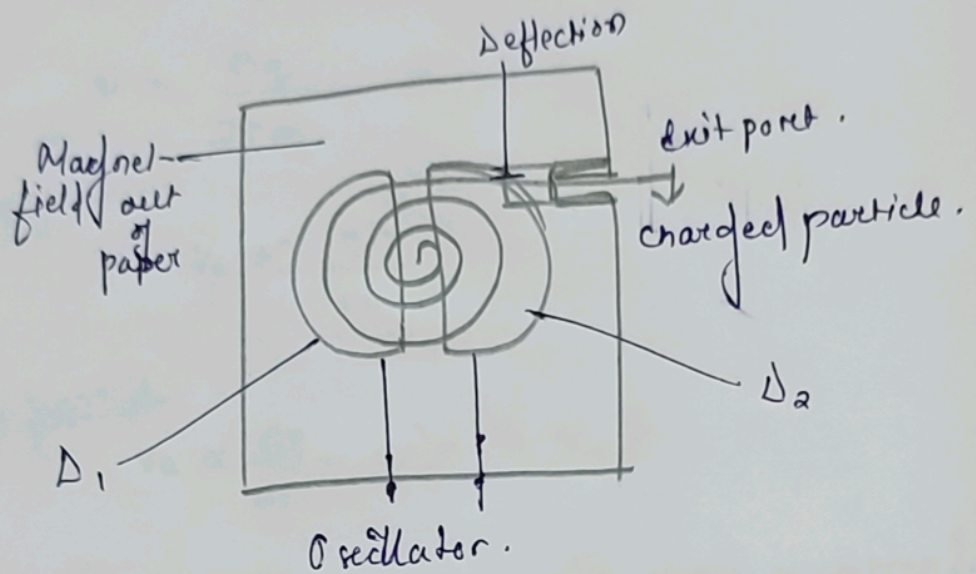
or R_{H^+}

$\therefore$ Ratio $\left(\frac{\text{proton}}{\text{deutron}}\right) = \frac{R_P}{R_{H^+}} = \frac{\frac{mv}{qB}}{\frac{2mv}{qB}} = \frac{1}{2}$

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 3





Working principle of cyclotron :—

* Cyclotron uses crossed electric and magnetic fields that increases kinetic energy of charged particle without changing frequency of revolution.

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

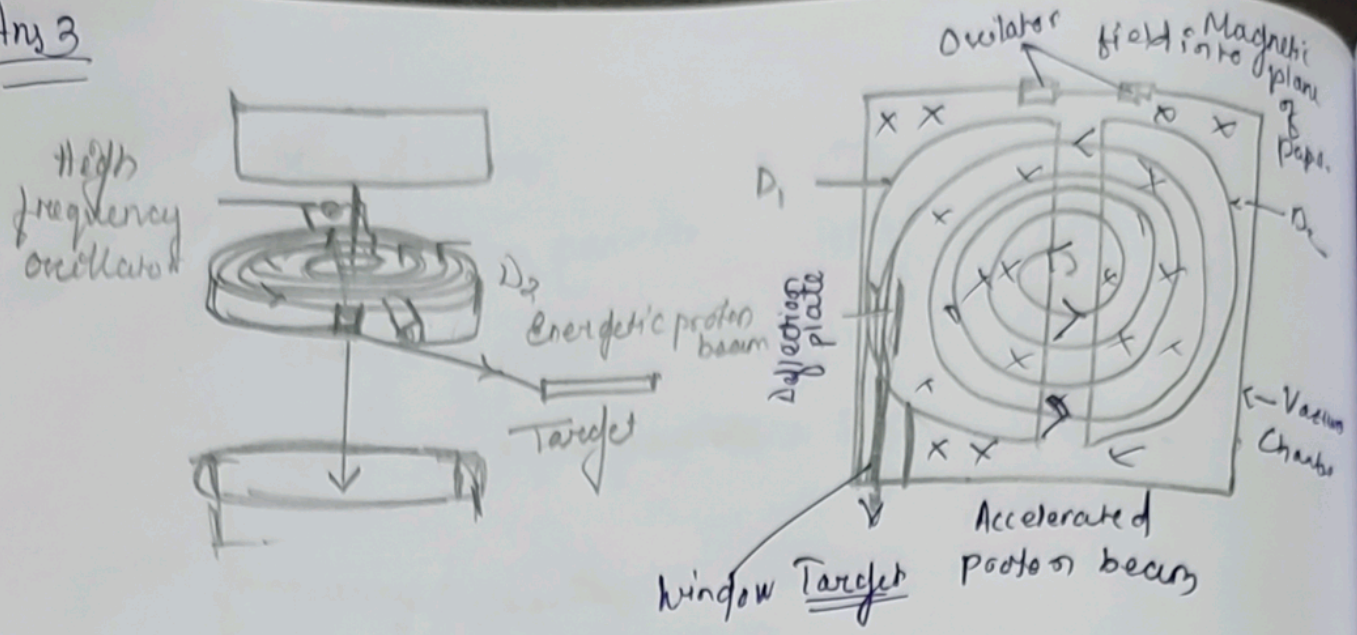
$\frac{v}{r} = \frac{qB}{m}$

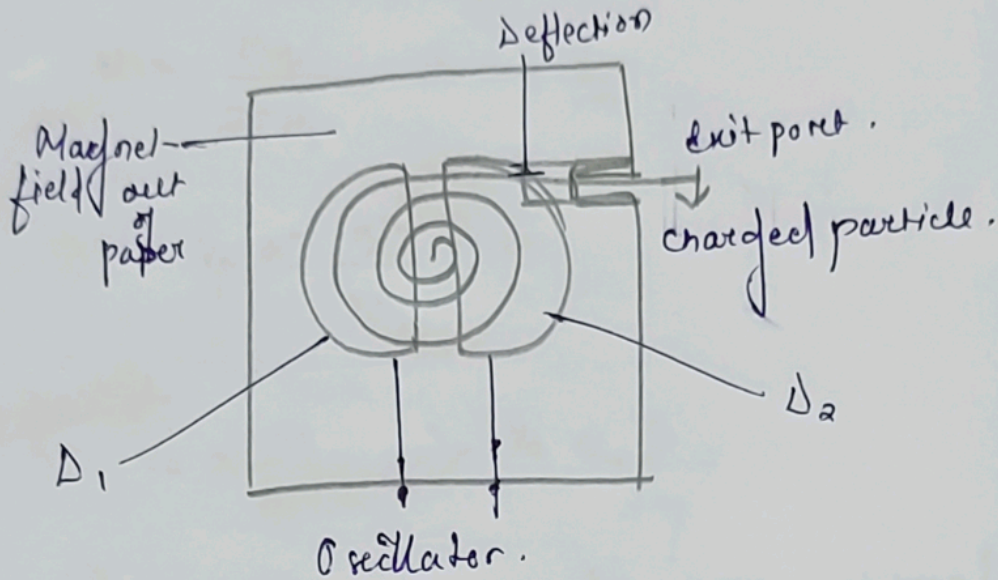
$\omega = \frac{qB}{m}$

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

∴ frequency independent of velocity, proved!

Ans 3





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Home Assignment

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 4

Let Mass of proton = m

" alpha particle = $4m$

Charge of proton = q

" alpha particle = $2q$

i) Cyclotron frequency

$$\nu = \frac{Bq}{2\pi m} \Rightarrow \nu \propto \frac{q}{m}$$

proton

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

alpha particle

$$\nu_a \propto \frac{2q}{4m} \Rightarrow \nu_a \propto \frac{q}{2m}$$

∴ particles not accelerate with same cyclotron frequency frequency of proton twice frequency of alpha particle.

4) ii)

$$\text{Velocity } (v) = \frac{Bqr}{m}$$

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

Proton

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

Alpha particle

$$v \propto \frac{2q}{4m}$$

$$\Rightarrow v \propto \frac{q}{2m}.$$

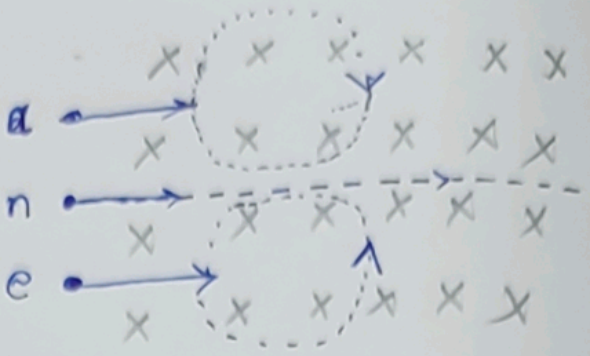
∴ Particles not exit with same velocity.

Velocity of proton twice velocity of alpha particle.

Proton velocity, has higher velocity than α-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 the figure. Trace their paths in the field and justify your answer.

Ans 8



Charged particle experiences a force when entering magnetic field.

Magnetic field move the charged particle in circular path

Force $\propto$ Velocity of particle.

Radius of circular path

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

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

B and V constants $\Rightarrow r \propto \frac{m}{q}$

∴ • Neutron (n) moves along straight line as it has no charge

• Electron (e) inscribes circle of smaller radius than alpha particle as mass to charge ratio of alpha particle > electron.

• Alpha particle (α) moves in clockwise direction, electron (e) in anticlockwise motion using right hand rule. Neutron (n) in straigh line.


THANK YOU !