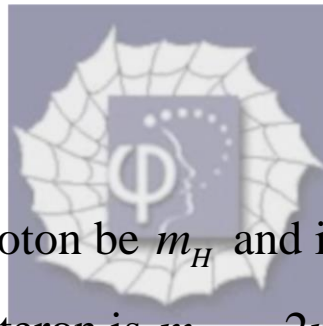


434.

Problem 34.21 (RHK)

A proton, a deuteron, and an alpha particle with the same kinetic energy enter a region of uniform magnetic field, moving at right angles to \vec{B} . The proton moves in a circle of radius r_H . In terms of r_H , we have to find the radii of (a) the deuteron path and (b) the alpha particle path.



Solution:

Let the mass of proton be m_H and its charge be e ,

The mass of a deuteron is, $m_{2H} = 2m_H$, and its charge is also e , as deuteron is an isotope of hydrogen.

The mass of an alpha particle is, $m_{4He} = 4m_H$ and its charge is $2e$.

It is given that the proton, deuteron and the alpha particle have the same kinetic energy K . The speed, v , of a particle of mass, m , and kinetic energy K is determined by the relation

$$\frac{1}{2}mv^2 = K,$$

or

$$v = \sqrt{\frac{2K}{m}}.$$

Therefore,

$$v_H = \sqrt{\frac{2K}{m_H}},$$

$$v_{2H} = \sqrt{\frac{2K}{m_{2H}}} = \sqrt{\frac{2K}{2m_H}} = \frac{1}{\sqrt{2}}v_H,$$

and

$$v_{4He} = \sqrt{\frac{2K}{m_{4He}}} = \sqrt{\frac{2K}{4m_H}} = \frac{1}{2}v_H.$$

The radius of the circular orbit of a charged particle of mass, m , charge, q , velocity, \hat{v} , in magnetic field \hat{B} , perpendicular to \hat{v} is determined by the relation

$$m \frac{v^2}{r} = qvB,$$

or

$$r = \frac{mv}{qB}.$$

We, therefore, find that in terms of

$$r_H = \frac{m_H v_H}{eB},$$

the radius of the deuteron orbit will be

$$r_{2H} = \frac{m_{2H} v_{2H}}{eB} = \frac{2m_H \times v_H / \sqrt{2}}{eB} = \sqrt{2} r_H,$$

and the radius of the alpha particle will be

$$r_{4He} = \frac{m_{4He} v_{4He}}{2eB} = \frac{4m_H \times v_H / 2}{2eB} = r_H.$$

