430.

Problem 34.13 (RHK)

An electron is accelerated from rest by a potential difference of 350 V. *It then enters a uniform magnetic field of magnitude* 200 mT, *its velocity being at right angles to the field. We have to calculate* (a) *the speed of the electron and* (b) *radius of its path in the magnetic field.*

Solution:

Mass of an electron, $m_e = 9.11 \times 10^{-31}$ kg.

Kinetic energy of 350 eV that electron acquires a potential difference of 350 V is much less than its rest mass energy, which is 0.5 MeV. We, therefore, will treat this problem as non-relativistic. The speed v of the electron can be calculated from its kinetic energy.

$$\frac{1}{2} m_e v^2 = 350 \text{ eV} = 350 \times 1.6 \times 10^{-19} \text{ J} = 5.6 \times 10^{-17} \text{ J}.$$

Therefore,

$$v = \sqrt{\frac{2 \times 5.6 \times 10^{-17}}{9.11 \times 10^{-31}}} \text{ m s}^{-1} = 1.108 \times 10^{7} \text{ m s}^{-1}.$$

Let R be the radius of the circular orbit of the electron as it moves in a uniform magnetic field at right angles to the direction of its velocity. Equating the centripetal acceleration with the force on the moving electron due to the magnetic field, we get

$$\frac{m_e v^2}{R} = evB,$$

or

$$R = \frac{m_e v}{eB} = \frac{9.11\times10^{-31}\times1.108\times10^{7}}{1.6\times10^{-19}\times200\times10^{-3}}\ \text{m} = 3.15\times10^{-4}\ \text{m}$$

$$= 0.315\ \text{mm}.$$