438.

<u>Problem 34.31 (RHK)</u>

A 22.5-eV *positron* (*positively charged electron*) *is projected into a uniform magnetic field* $B = 455\ \mu T$ *with its velocity vector making an angle of* 65.5^0 *with* $\vec{B}$. *We have to find* (a) *the period,* (b) *the pitch p, and* (c) *the radius r of the helical path.*

<u>Solution:</u>

It is given that the velocity vector makes an angle of 65.5^0 with the magnetic field vector $\vec{B}$. Magnitude of the magnetic field vector

$B = 455\ \mu T$.

We will first find the magnitude of velocity of a 22.5-eV positron.

$$\frac{1}{2} m_e v^2 = 22.5 \times 1.6 \times 10^{-19} \text{ J},$$

$$\therefore\ v = \left(\frac{2 \times 22.5 \times 1.6 \times 10^{-19}}{9.11 \times 10^{-31}} \right)^{1/2} \text{ m s}^{-1} = 2.8113 \times 10^6 \text{ m s}^{-1}.$$

We resolve the velocity vector into components, v_{P},

which is parallel to the field, and $v_{\perp}$,which is orthogonal

to the magnetic field vector $\vec{B}$.

$v_{\text{P}} = v\cos 65.5^0 = 2.8113\times 10^6 \times \cos 65.5^0$ m s^{-1} $= 1.1658\times 10^6$ m s^{-1}

and

$v_{\perp} = 2.8113\times 10^6 \times \sin 65.5^0$ m s^{-1} $= 2.5581\times 10^6$ m s^{-1}.

The radius of the helical path will be determined by

$v_{\perp}$ and the pitch by v_{P}.

We have

$$\frac{m_e v_{\perp}}{r} = eB,$$

and

$$\therefore \quad \frac{2\pi}{T} = \frac{v_{\perp}}{r} = \frac{eB}{m_e}.$$

The period of the circular orbit is therefore

$$T = \frac{2\pi m_e}{B} = \frac{2\pi \times 9.11\times 10^{-31}}{1.6\times 10^{-19} \times 455\times 10^{-6}} \text{ s} = 7.86\times 10^{-8} \text{ s} = 78.6 \text{ ns}.$$

The pitch of the helical path

$$p = T\times v_{\text{P}} = 7.86\times 10^{-8} \times 1.1658\times 10^6 \text{ m}$$

$$= 9.16 \text{ cm}.$$

The radius of the helical path

$$r = \frac{m_e v_{\perp}}{eB} = \frac{T}{2\pi} v_{\perp} = \frac{7.86\times 10^{-8} \times 2.5581\times 10^6}{2\pi} \text{ m} = 3.2 \text{ cm}.$$