PHYS 232 PS 6 Solutions

P29.10 $q\mathbf{E} = \left(-1.60\times10^{-19}\text{ C}\right)\left(20.0\text{ N/C}\right)\hat{\mathbf{k}} = \left(-3.20\times10^{-18}\text{ N}\right)\hat{\mathbf{k}}$

$$\sum \mathbf{F} = q\mathbf{E} + q\mathbf{v}\times\mathbf{B} = m\mathbf{a}$$

$$\left(-3.20\times10^{-18}\text{ N}\right)\hat{\mathbf{k}} - 1.60\times10^{-19}\text{ C}\left(1.20\times10^{4}\text{ m/s}\,\hat{\mathbf{i}}\right)\times\mathbf{B} = \left(9.11\times10^{-31}\right)\left(2.00\times10^{12}\text{ m/s}^2\right)\hat{\mathbf{k}}$$

$$-\left(3.20\times10^{-18}\text{ N}\right)\hat{\mathbf{k}} - \left(1.92\times10^{-15}\text{ C}\cdot\text{m/s}\right)\hat{\mathbf{i}}\times\mathbf{B} = \left(1.82\times10^{-18}\text{ N}\right)\hat{\mathbf{k}}$$

$$\left(1.92\times10^{-15}\text{ C}\cdot\text{m/s}\right)\hat{\mathbf{i}}\times\mathbf{B} = -\left(5.02\times10^{-18}\text{ N}\right)\hat{\mathbf{k}}$$

The magnetic field may have an x component. $B_z = \boxed{0}$ and $B_y = \boxed{-2.62\text{ mT}}$.

P29.14 $$\frac{|\mathbf{F}_B|}{\ell} = \frac{mg}{\ell} = \frac{I|\boldsymbol{\ell}\times\mathbf{B}|}{\ell}$$

$$I = \frac{mg}{B\ell} = \frac{\left(0.0400\text{ kg/m}\right)\left(9.80\text{ m/s}^2\right)}{3.60\text{ T}} = \boxed{0.109\text{ A}}$$

The direction of *I* in the bar is $\boxed{\text{to the right}}$.

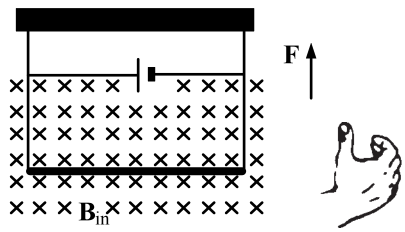

FIG. P29.14

P29.20 (a) $2\pi r = 2.00\text{ m}$

so $r = 0.318\text{ m}$

$$\mu = IA = \left(17.0\times10^{-3}\text{ A}\right)\left[\pi\left(0.318\right)^2\text{ m}^2\right] = \boxed{5.41\text{ mA}\cdot\text{m}^2}$$

(b) $\boldsymbol{\tau} = \boldsymbol{\mu}\times\mathbf{B}$

so $\tau = \left(5.41\times10^{-3}\text{ A}\cdot\text{m}^2\right)\left(0.800\text{ T}\right) = \boxed{4.33\text{ mN}\cdot\text{m}}$

P29.33 $q(\Delta V) = \frac{1}{2}mv^2$ or $v = \sqrt{\frac{2q(\Delta V)}{m}}$.

Also, $qvB = \frac{mv^2}{r}$ so $r = \frac{mv}{qB} = \frac{m}{qB}\sqrt{\frac{2q(\Delta V)}{m}} = \sqrt{\frac{2m(\Delta V)}{qB^2}}$.

Therefore, $$r_p^2 = \frac{2m_p(\Delta V)}{eB^2}$$

$$r_d^2 = \frac{2m_d(\Delta V)}{q_dB^2} = \frac{2\left(2m_p\right)(\Delta V)}{eB^2} = 2\left(\frac{2m_p(\Delta V)}{eB^2}\right) = 2r_p^2$$

and $$r_\alpha^2 = \frac{2m_\alpha(\Delta V)}{q_\alpha B^2} = \frac{2(4m_p)(\Delta V)}{(2e)B^2} = 2\left(\frac{2m_p(\Delta V)}{eB^2}\right) = 2r_p^2.$$

The conclusion is: $$\boxed{r_\alpha = r_d = \sqrt{2}r_p}.$$

P29.42 In the velocity selector: $$v = \frac{E}{B} = \frac{2\ 500\ \text{V/m}}{0.035\ 0\ \text{T}} = 7.14\times10^4\ \text{m/s}.$$

In the deflection chamber: $$r = \frac{mv}{qB} = \frac{(2.18\times10^{-26}\ \text{kg})(7.14\times10^4\ \text{m/s})}{(1.60\times10^{-19}\ \text{C})(0.035\ 0\ \text{T})} = \boxed{0.278\ \text{m}}.$$

***P29.45** Note that the "cyclotron frequency" is an angular speed. The motion of the proton is described by $\sum F = ma$:

$$|q|vB\sin 90° = \frac{mv^2}{r}$$

$$|q|B = m\frac{v}{r} = m\omega$$

(a) $$\omega = \frac{|q|B}{m} = \frac{(1.60\times10^{-19}\ \text{C})(0.8\ \text{N}\cdot\text{s/C}\cdot\text{m})}{(1.67\times10^{-27}\ \text{kg})}\left(\frac{\text{kg}\cdot\text{m}}{\text{N}\cdot\text{s}^2}\right) = \boxed{7.66\times10^7\ \text{rad/s}}$$

(b) $$v = \omega r = (7.66\times10^7\ \text{rad/s})(0.350\ \text{m})\left(\frac{1}{1\ \text{rad}}\right) = \boxed{2.68\times10^7\ \text{m/s}}$$

(c) $$K = \frac{1}{2}mv^2 = \frac{1}{2}(1.67\times10^{-27}\ \text{kg})(2.68\times10^7\ \text{m/s})^2\left(\frac{1\ \text{eV}}{1.6\times10^{-19}\ \text{J}}\right) = \boxed{3.76\times10^6\ \text{eV}}$$

(d) The proton gains 600 eV twice during each revolution, so the number of revolutions is

$$\frac{3.76\times10^6\ \text{eV}}{2(600\ \text{eV})} = \boxed{3.13\times10^3\ \text{revolutions}}.$$

(e) $\theta = \omega t$ $$t = \frac{\theta}{\omega} = \frac{3.13\times10^3\ \text{rev}}{7.66\times10^7\ \text{rad/s}}\left(\frac{2\pi\ \text{rad}}{1\ \text{rev}}\right) = \boxed{2.57\times10^{-4}\ \text{s}}$$

P29.52 (a) The boundary between a region of strong magnetic field and a region of zero field cannot be perfectly sharp, but we ignore the thickness of the transition zone. In the field the electron moves on an arc of a circle:

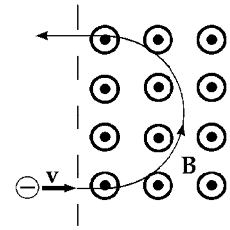

FIG. P29.52(a)

$\sum F = ma$:

$$|q|vB\sin 90° = \frac{mv^2}{r}$$

$$\frac{v}{r} = \omega = \frac{|q|B}{m} = \frac{(1.60\times10^{-19}\text{ C})(10^{-3}\text{ N}\cdot\text{s/C}\cdot\text{m})}{(9.11\times10^{-31}\text{ kg})} = 1.76\times10^{8}\text{ rad/s}$$

The time for one half revolution is,

from $\Delta\theta = \omega\Delta t$

$$\Delta t = \frac{\Delta\theta}{\omega} = \frac{\pi\text{ rad}}{1.76\times10^{8}\text{ rad/s}} = \boxed{1.79\times10^{-8}\text{ s}}.$$

(b) The maximum depth of penetration is the radius of the path.

Then $v = \omega r = (1.76\times10^{8}\text{ s}^{-1})(0.02\text{ m}) = 3.51\times10^{6}\text{ m/s}$

and

$$K = \frac{1}{2}mv^2 = \frac{1}{2}(9.11\times10^{-31}\text{ kg})(3.51\times10^{6}\text{ m/s})^2 = 5.62\times10^{-18}\text{ J} = \frac{5.62\times10^{-18}\text{ J}\cdot\text{e}}{1.60\times10^{-19}\text{ C}}$$

$$= \boxed{35.1\text{ eV}}.$$