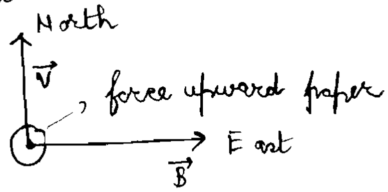
27.24. $F_B = qVB$ $\quad \therefore B = \dfrac{F_B}{qV} = \dfrac{8.2 \times 10^{-13} N}{(1.6 \times 10^{-19} c)(2.8 \times 10^{6} m/s)} = 1.8\,T$

The direction of the magnetic field must be along east applying the right hand rule.



27.28. The perpendicular component of velocity to magnetic field contributes to magnetic force.

$F = q V_\perp B \sin\theta = m \dfrac{V_\perp^2}{r}$

$r = \dfrac{m V_\perp}{qB} = \dfrac{(9.11 \times 10^{-31} Kg)(3 \times 10^{6} m/s) \sin 45^\circ}{(1.6 \times 10^{-19} c)(0.28 T)} = 4.314 \times 10^{-5} m$

The parallel component of velocity remains unchanged and pitch will be the distance travelled due to that velocity in one cycle of time period T.

$T = \dfrac{2\pi r}{V_\perp} = 2\pi \dfrac{m V_\perp}{qB} \cdot \dfrac{1}{V_\perp} = \dfrac{2\pi m}{qB}$

$p = V_{\parallel} T = V \cos 45^\circ \left(\dfrac{2\pi m}{qB}\right) = \dfrac{(3 \times 10^{6} m/s) \cos 45^\circ \times 2\pi (9.11 \times 10^{-31} Kg)}{(1.6 \times 10^{-19} c)(0.28 T)}$

$= 2.7 \times 10^{-4} m$

27.51. The magnetic force causes ions to move in a circle.

$qVB = \dfrac{mV^2}{r}$ $\qquad m = \dfrac{qBr}{V}$

$\dfrac{m}{r} = \dfrac{qB}{V} =$ const. ($\because$ all particles are of same charge and in same magnetic field)

$= \dfrac{76\,U}{22.8\,cm}$

$\therefore m_{21} = 21 \times \dfrac{76U}{22.8} = 70U$ $\qquad m_{21.6} = 21.6 \times \dfrac{76U}{22.8} = 72U$

$m_{21.9} = 21.9 \times \dfrac{76U}{22.8} = 73U$ $\qquad m_{22.2} = 22.2 \times \dfrac{76U}{22.8} = 74U$

27.66. a) The frequency of the voltage has to match the frequency of revolution of the particle to have a synchronised motion.

Time period of motion $= \dfrac{2\pi r}{V} = \dfrac{\text{Dist. or Circumference of circle}}{\text{Velocity}}$

$= T$

For centripetal acceleration -

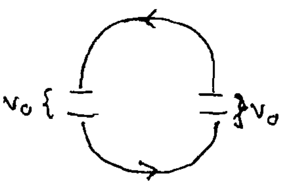
$$\frac{mv^2}{r} = qvB \qquad \therefore r = \frac{mv}{qB}$$

$$f = \frac{1}{T} = \frac{v}{2\pi r} = \frac{v}{2\pi} \times \frac{qB}{mv} = \frac{qB}{2\pi m}$$

b) The small gap has an electric field with increases the kinetic energy of the particle.

$$F = qE = q\frac{V_0}{d}$$

$$K.E. = F.d = qV_0$$



In one circular motion the particle passes through the gaps twice. Hence net increase in energy is $2qV_0$

c) $$K_{max} = \frac{1}{2} m v_{max}^2 = \frac{1}{2} m \left(\frac{r_{max} qB}{m}\right)^2 = \frac{1}{2} \frac{r_{max}^2 q^2 B^2}{m}$$

$$= \frac{1}{2} \frac{(0.5\,m)^2 (1.6 \times 10^{-19} C)^2 (0.6\,T)^2}{1.67 \times 10^{-27} Kg}$$

$$= 6.898 \times 10^{-13} J \; \frac{(1\,eV)}{1.6 \times 10^{-19} J} \times \frac{1\,MeV}{10^6\,eV} = 4.3\,MeV$$

The max. energy is gained in the outermost rim (r_{max}) of cyclotron.

27.69. The magnetic force accelerates the rod and makes it move a certain distance.
From equations of motion –

$$v^2 = u^2 + 2as$$

$$v^2 = 2as \qquad \therefore a = \frac{v^2}{2s}$$

$$F_B = ma = IBl$$

$$\therefore I = \frac{ma}{Bl} = m\frac{v^2}{2s} \times \frac{1}{Bl} = \frac{(1.5\times10^{-3}\,kg)(25\,m/s)^2}{2\,(1m)\,(0.24m)\,(1.8\,T)} = 1.1\,A$$

Using the right hand thumb rule, since the force on the rod is along the direction of acceleration, the magnetic force must be pointing downward.