Answer on Question #50853-Physics-Electromagnetism

In a cyclotron, the diameter of the pole faces is $d = 100\ cm = 1\ m$ and the magnetic field between the pole faces is $B = 0.60\ T$. The cyclotron is used for accelerating protons. Calculate the kinetic energy of proton in eV and speed of the proton as it emerges from the cyclotron. Also determine the cyclotron frequency.

Solution

$$\frac{mv^2}{r} = evB \to v = \frac{eBr}{m} \to K = \frac{mv^2}{2} = \frac{m}{2}\left(\frac{eBr}{m}\right)^2 = \frac{e^2B^2r^2}{2m}.$$

The kinetic energy of proton is

$$K = \frac{(1.6 \cdot 10^{-19} \cdot 0.6 \cdot 0.5)^2}{2 \cdot 1.67 \cdot 10^{-27}} = 0.6898 \cdot 12J = 4.3\ MeV.$$

A speed of the proton as it emerges from the cyclotron is

$$v = \frac{eBr}{m} = \frac{1.6 \cdot 10^{-19} \cdot 0.6 \cdot 0.5}{1.67 \cdot 10^{-27}} = 2.87 \cdot 10^7 \frac{m}{s}.$$

The cyclotron frequency is

$$f = \frac{1}{2\pi}\frac{v}{r} = \frac{1}{2\pi}\frac{2.87 \cdot 10^7}{0.5} = 9.1\ MHz.$$