

Answer on Question #63736, Physics / Atomic and Nuclear Physics

A cyclotron has a diameter of 25cm and accelerates protons at 1MeV

- calculate speed of these protons
- calculate momentum of these protons
- calculate the magnetic field strength assuming that the protons move around the edge of the machine
- calculate the frequency

Solution:

$$E = 1\text{MeV} = 1 \times 10^6 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-13} \text{ J}, m = 1.67 \times 10^{-27} \text{ kg}, q = 1.6 \times 10^{-19} \text{ C}, r = 2.5 \times 10^{-1} \text{ m}$$

a) $E = mv^2/2$

$$v = \sqrt{2 \times 1.6 \times 10^{-13} \text{ J} / 1.67 \times 10^{-27} \text{ kg}} = 1.38 \times 10^7 \text{ m/s}$$

b) $p = mv$

$$p = 1.38 \times 10^7 \text{ m/s} \times 1.67 \times 10^{-27} \text{ kg} = 2.31 \times 10^{-20} \text{ m kg/s}$$

c) $B = mv/rq$

$$B = 1.67 \times 10^{-27} \text{ kg} \times 1.38 \times 10^7 \text{ m/s} / 2.5 \times 10^{-1} \text{ m} \times 1.6 \times 10^{-19} \text{ C} = 5.7 \times 10^{-1} \text{ T}$$

d) $v = Bq/2\pi m$

$$v = 5.7 \times 10^{-1} \text{ T} \times 1.6 \times 10^{-19} \text{ C} / 2 \times 3.14 \times 1.67 \times 10^{-27} \text{ kg} = 8.82 \times 10^6 \text{ 1/s}$$

Answer: a) $1.38 \times 10^7 \text{ m/s}$; b) $2.31 \times 10^{-20} \text{ m kg/s}$; c) $5.7 \times 10^{-1} \text{ T}$; d) $8.82 \times 10^6 \text{ 1/s}$