437.

Problem 34.29 (RHK)

Ionisation measurements show that a particular nuclear particle carries a double charge $(=2e)$ *and is moving with a speed of* $0.710c$. *It follows a circular path of radius* 4.72 m *in a magnetic field of* 1.33 T. *We have to find the mass of the particle and identify it.*

Solution:

For a relativistic charged particle, charge *q*, moving in a circular orbit, radius *r*, in magnetic field, *B*, its momentum, *p*, in terms of *q*, *B*, and *r* is

$p = qBr.$

In our problem

$q = 2e,$

$B = 1.33 \text{ T},$

and

$r = 4.72 \text{ m}.$

Therefore,

$$p = 2 \times 1.6 \times 10^{-19} \times 1.33 \times 4.72 \text{ kg m s}^{-1}$$

$$= 2.0088 \times 10^{-18} \text{ kg m s}^{-1}.$$

For a relativistic particle

$$p = \frac{mv}{\sqrt{1 - v^2/c^2}},$$

or

$$m = \frac{p}{v}\sqrt{1 - v^2/c^2}.$$

Speed of the particle

$$v = 0.710c = 0.710 \times 3 \times 10^8 \text{ m s}^{-1} = 2.13 \times 10^8 \text{ m s}^{-1}.$$

Therefore, the mass of the charged particle is

$$m = \frac{2.008 \times 10^{-18} \times \left(1 - 0.710^2\right)^{1/2}}{2.13 \times 10^8} \text{ kg}$$

$$= 6.6414 \times 10^{-27} \text{ kg}.$$

In units of mass of a proton, the mass of the charged particle of charge $2e$ is

$$\frac{m}{m_p} = \frac{6.6414 \times 10^{-27}}{1.67 \times 10^{-27}} = 3.97.$$

Therefore, the nuclear particle is an alpha particle.