

Q 4. An electron and a proton are detected in a cosmic ray experiment, the first with kinetic energy 10 keV, and the second with 100 keV. Which is faster, the electron or the proton? Obtain the ratio of their speeds. (electron mass = 9.11×10^{-31} kg, proton mass = 1.67×10^{-27} kg, 1 eV = 1.60×10^{-19} J).

Sol. According to the question ,

Kinetic energy of the electron, $K.E_e = 10000eV = 10000 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-15}$ J

Kinetic energy of the proton, $K.E_p = 100eV = 100 \times 1000 \times 1.6 \times 10^{-19} = 1.6 \times 10^{-14}$ J

For the velocity of an electron v_e , its kinetic energy is given by the relation:

$$K.E_e = \frac{1}{2} m v_e^2$$

$$\therefore v_e = \sqrt{\frac{2 \times K.E_e}{m}}$$

$$= \sqrt{\frac{2 \times 1.60 \times 10^{-15}}{9.11 \times 10^{-31}}} = 5.93 \times 10^9 \text{ m/s}$$

For the velocity of a proton v_p , its kinetic energy is given by the relation:

$$K.E_p = \frac{1}{2} m v_p^2$$

$$v_p = \sqrt{\frac{2 \times K.E_p}{m}}$$

$$\therefore v_p = \sqrt{\frac{2 \times 1.6 \times 10^{-14}}{1.67 \times 10^{-27}}} = 4.38 \times 10^6 \text{ m/s}$$

Hence, the electron is moving faster than the proton.

The ratio of their speeds:

$$\frac{v_e}{v_p} = \frac{5.93 \times 10^9}{4.38 \times 10^6} = 1354 : 1$$