Question #81585, Physics / Other

In a Compton scattering experiment, an x-ray photon scatters through an angle of 21.4° from a free electron that is initially at rest. The electron recoils with a speed of 1,880 km/s.

(a)Calculate the wavelength of the incident photon.

(b) Calculate the angle through which the electron scat

Solution

(a)

$$\lambda' - \lambda = \frac{h}{m_e c}(1 - \cos\theta) = 0.0243 \cdot 10^{-10}(1 - \cos 21.4°) = 0.001675 \cdot 10^{-10} m$$

$$hc\left(\frac{1}{\lambda} - \frac{1}{\lambda'}\right) = \frac{m_e c^2}{\sqrt{1 - \left(\frac{v}{c}\right)^2}} - m_e c^2$$

$$\left(\frac{1}{\lambda} - \frac{1}{\lambda'}\right) = \frac{1}{\left(\frac{h}{m_e c}\right)}\left(\frac{1}{\sqrt{1 - \left(\frac{v}{c}\right)^2}} - 1\right) = \frac{1}{0.0243 \cdot 10^{-10}}\left(\frac{1}{\sqrt{1 - \left(\frac{1880}{299792}\right)^2}} - 1\right) = 8.092 \cdot 10^6 m^{-1}$$

Thus,

$$\left(\frac{1}{\lambda} - \frac{1}{\lambda + 0.001675 \cdot 10^{-10}}\right) = 8.092 \cdot 10^6$$

$$\lambda = 0.144\ nm.$$

(b)

$$p_e \sin\phi = p_{ph} \sin\theta$$

$$\sin\phi = \frac{p_{ph}}{p_e}\sin\theta$$

$$\sin\phi = \frac{\frac{h}{\lambda'}}{m_e v}\sin\theta = \frac{\frac{6.63 \cdot 10^{-34}}{1.441675 \cdot 10^{-10}}}{(9.109 \cdot 10^{-31})(1880000)}\sin 21.4° = 0.9799$$

$$\phi = \sin^{-1} 0.9799 = 78.5°.$$