**720.**

## Problem 49.54 (RHK)

*The quantity* $h/mc$ *is often called the Compton wavelength* $\lambda_C$, *of the scattering particle and that Compton scattering equation is written as*

$$\Delta\lambda = \lambda_C\left(1-\cos\phi\right).$$

*We have to calculate the Compton wavelength of an electron*; *of a proton*. (b) *We have to find the energy of a photon whose wavelength is equal to the Compton wavelength of the electron*; *of the proton*. (c) *We have to show that in general the energy of a photon whose wavelength is equal to the Compton wavelength of a particle is just the rest energy of the particle*.

## Solution:

(a)

The mass of an electron, $m_e = 9.11\times10^{-31}$ kg.

The Compton wavelength of electron will be

$$\left(\lambda_C\right)_e = \frac{h}{m_e c} = \frac{6.63\times10^{-34}}{9.11\times10^{-31}\times3\times10^{8}} \text{ m s}^{-1}$$

$$= 2.43\times10^{-11} \text{ m s}^{-1}.$$

The mass of a proton, $m_p = 1.67 \times 10^{-27}$ kg.

The Compton wavelength of proton will be

$$(\lambda_C)_p = \frac{h}{m_p c} = \frac{6.63 \times 10^{-34}}{1.67 \times 10^{-27} \times 3 \times 10^{8}} \text{ m s}^{-1}$$

$$= 1.32 \times 10^{-15} \text{ m s}^{-1}.$$

(b)

The energy of a photon which has a wavelength equal to Compton wavelength of electron will be

$$\varepsilon = \frac{1240 \text{ eV. nm}}{\lambda}$$

$$= \frac{1240}{2.43 \times 10^{-2}} \text{ eV} = 510 \times 10^{5} \text{ eV}$$

$$= 0.51 \text{ MeV}.$$

The energy of a photon which has a wavelength equal to Compton wavelength of proton will be

$$\varepsilon = \frac{1240 \text{ eV. nm}}{\lambda}$$

$$= \frac{1240}{1.32 \times 10^{-6}} \text{ eV} = 939.4 \times 10^{6} \text{ eV}$$

$$= 939.4 \text{ MeV}.$$

(c)

In general Compton wavelength of a particle of rest mass $m$ is

$$\lambda_C = \frac{h}{mc}.$$

The energy of a photon of wavelength $\lambda_C$ will therefore be

$$\varepsilon = \frac{hc}{\lambda_C} = \frac{hc}{h/mc} = mc^2,$$

which is the rest mass energy of particle of mass *m*.