

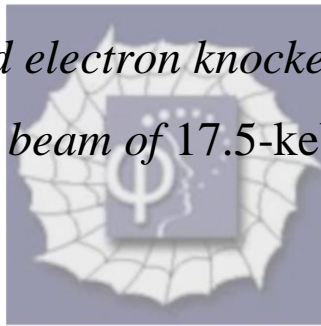
725.

Problem 49.65 (RHK)

We have to show that (a) when a photon of energy E scatters from a free electron, the maximum recoil kinetic energy of the electron is given by

$$K_{\max} = \frac{E^2}{E + mc^2/2} .$$

(b) We have to find the maximum kinetic energy of the Compton scattered electron knocked out of a thin copper foil by an incident beam of 17.5-keV x rays.



Solution:

(a)

The Compton scattering on change of wavelength of a photon when it is scattered from a free electron at rest is

$$\lambda' - \lambda = \frac{h}{mc}(1 - \cos \phi) ,$$

where λ and λ' are the wavelengths corresponding to the incident and the scattered photons, respectively.

The wavelength of the photon is back scattered is obtained by using the scattering angle of π rad in the Compton scattering equation. We have

$$\lambda' = \lambda + \frac{2h}{mc}$$

The energy of the incident photon is

$$E = \frac{hc}{\lambda}$$

The energy of the back scattered photon will be

$$E' = \frac{hc}{\lambda'} = \frac{hc}{\lambda(1 + 2h/mc\lambda)}$$

$$= \frac{E}{(1 + 2E/mc^2)}$$

Therefore, the recoil energy of the electron on back scattering of photon will be

$$E_{el} = E + mc^2 - E'$$

The maximum recoil kinetic energy of the electron will therefore be

$$KE_{\max} = E_{el} - mc^2 = E - E' = \frac{E^2}{E + mc^2/2}$$

(b)

$$E = 17.5 \text{ keV},$$

$$mc^2 = 0.511 \text{ MeV} = 511 \text{ keV}.$$

$$\therefore KE_{\max} = \frac{(17.5)^2}{17.5 + 511/2} \text{ keV} = 1.12 \text{ keV}.$$

