725.

<u>Problem 49.65 (RHK)</u>

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*.

<u>Solution:</u>

(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

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

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)

$E = 17.5 \text{ keV},$

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

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