ENTRI

Particle properties of Waves
Part 7
Problems on Compton Effect & Pair Production

1. X-rays of wavelength 10.0 pm are scattered from a target.

a) Find the wavelength of the X-rays scattered through 45^0.
b) Find the maximum wavelength present in the scattered X-rays.
c) Find the maximum kinetic energy of the recoil electrons.

Solution :

Given λ= 10.0 pm

a) $\lambda' = \lambda + \lambda_c(1-\cos\theta)$

$\lambda' = 10 + 2.426\ (1-\cos 45^0)$

$= (10 + 0.7)\text{pm} = 10.7\text{pm}$

b) $\lambda' = \lambda + 2\lambda_c$

$= 10 + (2\times 2.426)$

$= 14.9\ \text{pm} \approx 15\ \text{pm}$

C) K= hν - hν'

$$K_{max} = \frac{hc}{\lambda} - \frac{hc}{\lambda'} = \text{hc}\left(\frac{1}{\lambda} - \frac{1}{\lambda'}\right)$$

$$= 1.6\times10^{-6}\ \text{ev}\left(\frac{\lambda'-\lambda}{\lambda\lambda'}\right)$$

$$= 1.6\times10^{-6}\ \text{ev}\left(\frac{5\ pm}{10pm\times15pm}\right)$$

$$= 0.413\times10^{5}\text{eV} = 41.3\ \text{KeV}$$

2. A beam of γ − radiation having photon of energy 510 KeV is incident on a foil of aluminium. Calculate the wavelength of scattered radiation at 90^0 and direction of the recoil electron.

Solution :

Given E_i = 510 KeV

θ= 90^0

λ' = ?

$\lambda' - \lambda = \lambda_c(1-\cos\theta)$

Since $E = h\nu = \frac{hc}{\lambda}$

$$\lambda = \frac{hc}{E} = \frac{1.26\times10^{-6} eV}{510\times10^{3} eV}$$

$= 0.243\times 10^{-11}$m

$= 2.43\times 10^{-12}$m

= 2.43 pm

When $\theta = 90^0$

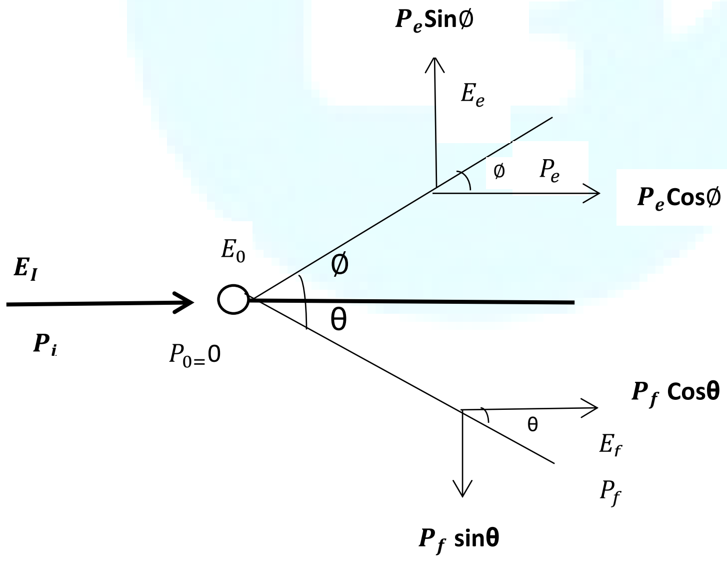
$\lambda' - \lambda = \lambda_c(1-\cos 90^0) \longrightarrow \lambda' = \lambda + \lambda_c$

$\lambda' = 2.43+2.42 = 4.8$ pm

$$K = hc\left(\frac{\lambda'-\lambda}{\lambda\lambda'}\right)$$

$$= 1.26\times10^{-6}\left(\frac{2.426pm}{2.43\times4.8pm}\right)$$

$K = 25\times 10^4$eV = 250 K eV



Along X-axis $P_i = P_e \cos\emptyset + P_f \cos\theta$

Along Y-axis $0 = P_f \sin\emptyset - P_f \sin\theta$

$P_e \cos\emptyset = P_i - P_f \cos\theta \longrightarrow (1)$

$P_f \sin\emptyset = P_f \sin\theta \longrightarrow (2)$

$\frac{(2)}{(1)} \Longrightarrow \tan \emptyset = \frac{P_f \ \text{Sin}\theta}{P_i - P_f \text{Cos}\theta}$

Put $\theta = 90^0$ $\tan \emptyset = \frac{P_f}{P_i} = \frac{P_f}{P_i} \times \frac{C}{C} = \frac{E_f}{E_i}$

E= PC

$\frac{E_f}{E_i} = \frac{250\ KeV}{510\ KeV}$

$\tan \emptyset = 0.5$

$\emptyset = tan^{-1} 0.5$