B.Sc. Sem - V chem(H)
study materials
Quantum Mechanics
(Physical chemistry)

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Compton effect

When X-ray photon striking on an electron and being scattered away from its original direction of motion while an electron receives an impulse and being to move. In the collision the photon may be regarded as KE(T)

$\therefore$ loss in photon energy = gain in electron energy

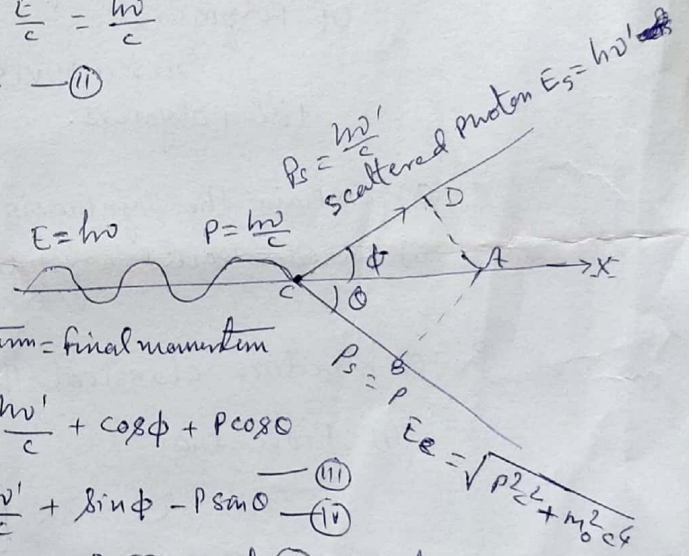
$$h\nu - h\nu' = T \quad \text{— (I)}$$

$\because E = pc$

$E = h\nu$

for photon $p = \frac{E}{c} = \frac{h\nu}{c}$

$$\therefore p = \frac{h\nu}{c} \quad \text{— (II)}$$



Initial momentum = final momentum

$$\frac{h\nu}{c} + 0 = \frac{h\nu'}{c}\cos\phi + p\cos\theta \quad \text{— (III)}$$

$$0 = \frac{h\nu'}{c} + \sin\phi - p\sin\theta \quad \text{— (IV)}$$

multiplying by c in eq^n (III) and (IV), we get

$$pc\cos\theta = h\nu - h\nu'\cos\phi$$

$$pc\sin\theta = h\nu'\sin\phi$$

Squaring and adding by eliminating θ.

$$p^2c^2 = (h\nu)^2 - 2h\nu(h\nu')\cos\phi + (h\nu')^2 \quad \text{— (V)}$$

$\because E = T + m_0c^2$

$$E = \sqrt{m_0^2c^4 + p^2c^2}$$

or $(T + m_0c^2)^2 = m_0^2c^4 + p^2c^2$

$$p^2c^2 = T^2 + 2m_0c^2T$$

$\because T = h\nu - h\nu'$

$$p^2c^2 = (h\nu)^2 - 2h\nu(h\nu') + (h\nu')^2 + 2m_0c^2(h\nu - h\nu')$$

$$2m_0c^2(h\nu - h\nu') = 2h\nu(h\nu')(1 - \cos\phi) \quad \text{— (VI)}$$

Dividing eq^{2} (VI) by $2h^2c^2$

$$\frac{m_0 c}{h}\left(\frac{\nu}{c}-\frac{\nu'}{c}\right) = \frac{\nu\nu'}{cc}(1-\cos\phi)$$

$$\frac{m_0 c}{h}\left(\frac{1}{\lambda}-\frac{1}{\lambda'}\right) = \frac{1-\cos\phi}{\lambda\lambda'}$$

$$\lambda-\lambda' = \frac{h}{m_0 c}(1-\cos\phi)$$

$$\boxed{\Delta\lambda = \frac{h}{m_0 c}(1-\cos\phi)}$$