Answer on Question 58655, Physics, Quantum Mechanics

Question:

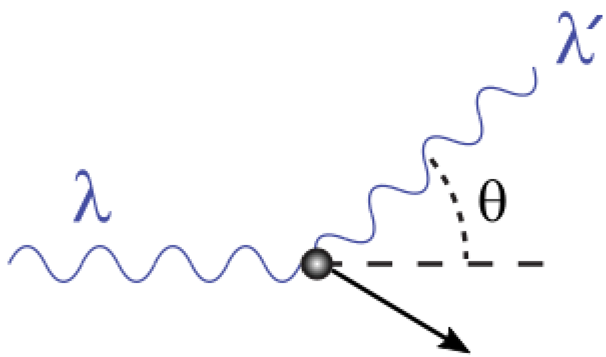
Photons of wavelength of 2.17 pm are incident on free electrons

(a) find wavelength of photon that is scattered at 35° from the incident direction.

(b) do the same if the scattering angle is 115°.

Solution:

In this question, we are dealing with the famous Compton effect. Here's the explanation of the Compton effect:



A photon of wavelength λ comes in from left, collides with a free electron at rest, and a new photon of wavelength λ' emerges at an angle θ (in case of (a), $\theta = 35^{\circ}$; in case of (b), $\theta = 115^{\circ}$). Part of the energy of the photon is transferred to the recoiling electron (the arrow in the picture indicates the direction of motion of the electron).

a) We can find λ' from the Compton Scattering equation:

$$\lambda' - \lambda = \frac{h}{m_e c}(1 - cos\theta),$$

here, λ the initial wavelength of the photon, λ' is the wavelength after scattering, $\frac{h}{m_e c}$ is the Compton wavelength, and it is equal to $2.43 \cdot 10^{-12}$ m, h is the Planck's constant, m_e is the electron rest mass, c is the speed of light, θ is the scattering angle.

Therefore, from this formula we can calculate λ' for the photon that is scattered at 35° from the incident direction:

$$\lambda' = \lambda + \frac{h}{m_e c}(1 - cos\theta) = 2.17 \cdot 10^{-12}\ m + 2.43 \cdot 10^{-12}\ m\ \cdot (1 - cos35^{\circ}) =$$
$$= 2.61 \cdot 10^{-12}\ m = 2.61\ pm.$$

b) We can calculate λ' for the photon that is scattered at 115° from the incident direction from the same formula:

$$\lambda' = \lambda + \frac{h}{m_e c}(1 - cos\theta) = 2.17 \cdot 10^{-12}\ m + 2.43 \cdot 10^{-12}\ m\ \cdot (1 - cos115^{\circ}) =$$
$$= 5.63 \cdot 10^{-12}\ m = 5.63\ pm.$$

Answer:

a) $\lambda'(35^{\circ}) = 2.61 \cdot 10^{-12}\ m = 2.61\ pm.$

b) $\lambda'(115^{\circ}) = 5.63 \cdot 10^{-12}\ m = 5.63\ pm.$