The Compton Effect

1. A $0.3\,\mathrm{MeV}$ X-ray photon makes a head-on collision with an electron at rest initially. Using the conservation of energy and momentum, find the recoil velocity of the electron. $(0.65c)$

2. X-rays are Compton scattered at an angle of $60°$. If the wavelength of the scattered radiation is $0.0312\,\mathrm{nm}$, find the wavelength of the incident radiation. (0.3Å)

3. If the maximum energy imparted to an electron in Compton scattering is $45\,\mathrm{keV}$, what is the wavelength of the incident photon? $(9.36\,\mathrm{pm})$

4. Calculate the maximum fractional frequency shift in wavelength for an incident photon of wavelength $0.1\,\mathrm{nm}$, scattered off a proton at rest. (2.61×10^{-5})

5. Determine the maximum scattering angle in a Compton scattering experiment for which the scattered photon can produce a positron-electron pair. (Hint: A positron is a positively charged particle, with an electron mass. Hence, the energy required is $2m_ec^2$.) $(60°)$

6. A photon is Compton scattered off a stationary electron through an angle of $45°$ and its final energy is half its initial energy. Calculate the value of the initial energy. $(1.77\,\mathrm{MeV})$

7. X-rays detected at a scattering angle of $163°$ have a wavelength of $0.1867\,\mathrm{nm}$. Find the wavelength and the energy of the incident photon. $(0.182\,\mathrm{nm}$,$6.82\,\mathrm{keV})$

8. In a Compton-effect experiment in which the incident X-rays have a wavelength of $10\,\mathrm{pm}$, the scattered X-rays have a wavelength of $10.5\,\mathrm{pm}$. Find both the magnitude and the direction of the momentum that the recoil electrons will have. $(4.2 \times 10^{-23}\,\mathrm{kgms^{-1}}$, $67.1°)$

9. Find the energy of an X-ray photon that can impart a maximum energy of $50\,\mathrm{keV}$ to an electron.

   $(141\,\mathrm{keV})$

10. At what scattering angle will incident $100\,\mathrm{keV}$ X-rays leave a target with an energy of $90\,\mathrm{keV}$?

    $(64.83°)$

11. A $210\,\mathrm{MeV}$ photon collides with an electron at rest. What is the maximum energy loss? What would be the energy loss when the target is a proton? Explain the difference in the results.

    $(210\,\mathrm{MeV}, 64.3\,\mathrm{MeV})$

12. In a Compton scattering experiment, the wavelength of the incident X-rays is $7.078 \times 10^{-2}\,\mathrm{nm}$ while the wavelength of the outgoing X-rays is $7.314 \times 10^{-2}\,\mathrm{nm}$. At what angle was the scattered radiation measured? $(89.05°)$

13. In a Compton scattering experiment, a detector is set at an angle of $57°$. What must be the frequency of the incoming X rays, in order to produce a final X ray with a frequency 1% less than the initial frequency? $(2.74 \times 10^{18}\,\mathrm{Hz})$