

57. (a) The momentum of the photon is given by $p = E/c$, where E is its energy. Its wavelength is

$$\lambda = \frac{h}{p} = \frac{hc}{E} = \frac{1240 \text{ eV} \cdot \text{nm}}{1.00 \text{ eV}} = 1240 \text{ nm} .$$

See Exercise 3. The momentum of the electron is given by $p = \sqrt{2mK}$, where K is its kinetic energy and m is its mass. Its wavelength is

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{2mK}} .$$

According to Exercise 49, if K is in electron volts, this is

$$\lambda = \frac{1.226 \text{ nm} \cdot \text{eV}^{1/2}}{\sqrt{K}} = \frac{1.226 \text{ nm} \cdot \text{eV}^{1/2}}{\sqrt{1.00 \text{ eV}}} = 1.23 \text{ nm} .$$

(b) For the photon,

$$\lambda = \frac{hc}{E} = \frac{1240 \text{ eV} \cdot \text{nm}}{1.00 \times 10^9 \text{ eV}} = 1.24 \times 10^{-6} \text{ nm} .$$

Relativity theory must be used to calculate the wavelength for the electron. According to Eq. 38-51, the momentum p and kinetic energy K are related by $(pc)^2 = K^2 + 2Kmc^2$. Thus,

$$\begin{aligned} pc &= \sqrt{K^2 + 2Kmc^2} \\ &= \sqrt{(1.00 \times 10^9 \text{ eV})^2 + 2(1.00 \times 10^9 \text{ eV})(0.511 \times 10^6 \text{ eV})} \\ &= 1.00 \times 10^9 \text{ eV} . \end{aligned}$$

The wavelength is

$$\lambda = \frac{h}{p} = \frac{hc}{pc} = \frac{1240 \text{ eV} \cdot \text{nm}}{1.00 \times 10^9 \text{ eV}} = 1.24 \times 10^{-6} \text{ nm} .$$