PH2400 Quiz 3, Spring 2015

Show your work for full credit.

1. A sodium-vapor lamp has a power output of 10W. Using 589.3nm as the average wavelength of the source, calculate the number of photons emitted per second. (5 points)

\[ E = nh \nu = n \frac{hc}{\lambda} \]

Therefore, a 10W lamp gives

\[ \frac{10 J}{s} = \frac{12 J/s}{1.6 \times 10^{-19} eV/s} = 6.25 \times 10^{19} eV/s \]

and

\[ \frac{6.25 \times 10^{19} eV/s}{\frac{h c}{\lambda}} = \frac{6.25 \times 10^{19} eV/s \times 5.89 \times 10^{-7}}{4.136 \times 10^{-15} eV \cdot \text{m} \cdot \text{s}^{3} \times 10^{8} \text{m/s}} = 2.9 \times 10^{19} \frac{eV}{s} \]

number of photons = \(\frac{2.9 \times 10^{19}}{s}\)

2. X-rays of wavelength 0.200nm are scattered from a block of carbon. If the scattered photon is detected at 90° relative to the incident X-ray, find the kinetic energy imparted (in eV) to the recoiling electron. (5 points)

Conservation of energy:

\[ \frac{h c}{\lambda_0} = \frac{h c}{\lambda} + k_e \]

\[ k_e = h c \left( \frac{1}{\lambda_0} - \frac{1}{\lambda} \right) \]

\[ = (4.136 \times 10^{-15} \text{ eV} \cdot \text{s}) \left( 3 \times 10^8 \text{ m/s} \right) \left( \frac{1}{2 \times 10^{-10} \text{ m}} - \frac{1}{\lambda} \right) \]

and from Compton formula,

\[ \lambda = \lambda_0 + \frac{h}{mc} \left( 1 - \cos 90° \right) = 2.02 \times 10^{-10} \text{ m} + \frac{4.136 \times 10^{-15} \text{ eV} \cdot \text{s}}{1.51 \times 10^6 \text{ eV}} \]

so

\[ k_e = 74.5 \text{ eV} \]

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