Problem 1-14

The power output of a laser is measured in units of watts (W), where one watt is equal to one joule per second. ($1\ \text{W} = 1\ \text{J} \cdot \text{s}^{-1}$) What is the number of photons emitted per second by a 1.00 mW nitrogen laser? The wavelength emitted by a nitrogen laser is 337 nm.

Solution

The energy of one photon from this laser is given by

$$E = h\nu = \frac{hc}{\lambda} \approx \frac{(6.626 \times 10^{-34}\ \text{J} \cdot \cancel{\text{s}})\left(299\,792\,458\ \frac{\cancel{\text{m}}}{\cancel{\text{s}}}\right)}{337\ \cancel{\text{nm}} \times \frac{1\ \cancel{\text{m}}}{10^9\ \cancel{\text{nm}}}} \approx 5.89 \times 10^{-19}\ \text{J}.$$

The number of photons emitted per second is then

$$\dot{n} \approx \frac{1.00\ \cancel{\text{mW}} \times \frac{1\ \cancel{\text{W}}}{1000\ \cancel{\text{mW}}} \times \frac{1\ \frac{\cancel{\text{J}}}{\text{s}}}{1\ \cancel{\text{W}}}}{5.89 \times 10^{-19}\ \frac{\cancel{\text{J}}}{\text{photon}}} \approx 1.70 \times 10^{15}\ \frac{\text{photons}}{\text{s}}.$$