Problem 1-2

Radiation in the infrared region is often expressed in terms of wave numbers, $\tilde{\nu} = 1/\lambda$. A typical value of $\tilde{\nu}$ in this region is $10^3\ \text{cm}^{-1}$. Calculate the values of ν, λ, and E for radiation with $\tilde{\nu} = 10^3\ \text{cm}^{-1}$ and compare your results with those in Figure 1.11.

Solution

If $\tilde{\nu} = 10^3\ \text{cm}^{-1}$, then the wavelength is

$$\lambda = \frac{1}{\tilde{\nu}} = \frac{1}{10^3\ \frac{1}{\cancel{\text{cm}}} \times \frac{100\ \cancel{\text{cm}}}{1\ \text{m}}} = 1 \times 10^{-5}\ \text{m}.$$

The relationship between the wavelength λ, frequency ν, and speed v of a wave is given by

$$\lambda\nu = v.$$

Infrared radiation is electromagnetic, which means $v = c$, the speed of light.

$$\lambda\nu = c$$

Solve for the frequency.

$$\nu = \frac{c}{\lambda} = \frac{299\,792\,458\ \frac{\cancel{\text{m}}}{\text{s}}}{1 \times 10^{-5}\ \cancel{\text{m}}} \approx 3 \times 10^{13}\ \text{Hz}$$

The energy of the radiation is

$$E = h\nu = (6.626 \times 10^{-34}\ \text{J} \cdot \cancel{\text{s}}) \left(3 \times 10^{13}\ \cancel{\text{s}^{-1}}\right) \approx 2 \times 10^{-20}\ \text{J}.$$