Problem 1-1

Radiation in the ultraviolet region of the electromagnetic spectrum is usually described in terms of wavelength, λ, and is given in nanometers (10^{-9} m). Calculate the values of ν, $\tilde{\nu}$, and E for ultraviolet radiation with $\lambda = 200$ nm and compare your results with those in Figure 1.11.

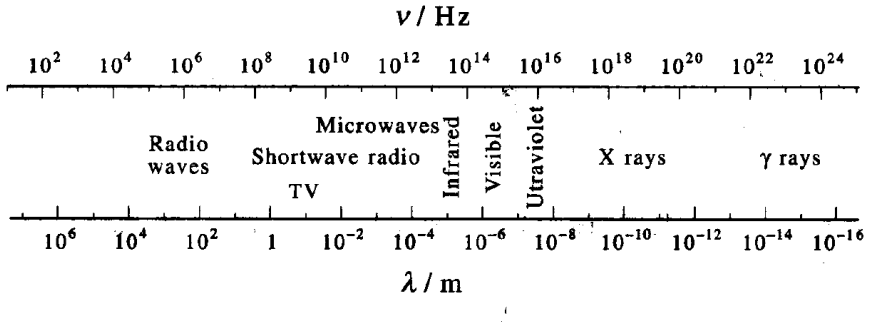

FIGURE 1.11
The regions of electromagnetic radiation.

Solution

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

$$\lambda\nu = v.$$

For electromagnetic radiation in particular, $v = c$, the speed of light.

$$\lambda\nu = c$$

Solve for the frequency.

$$\nu = \frac{c}{\lambda} = \frac{299\,792\,458\ \frac{\cancel{\text{m}}}{\text{s}}}{200\ \cancel{\text{nm}} \times \frac{1\ \cancel{\text{m}}}{10^9\ \cancel{\text{nm}}}} \approx 1.50 \times 10^{15}\ \text{Hz}$$

The wavenumber is

$$\tilde{\nu} = \frac{1}{\lambda} = \frac{1}{200\ \cancel{\text{nm}} \times \frac{1\ \cancel{\text{m}}}{10^9\ \cancel{\text{nm}}} \times \frac{100\ \text{cm}}{1\ \cancel{\text{m}}}} = 5.00 \times 10^4\ \text{cm}^{-1},$$

and the energy is

$$E = \frac{hc}{\lambda} = \frac{(6.626 \times 10^{-34}\ \text{J} \cdot \cancel{\text{s}}) \left(299\,792\,458\ \frac{\cancel{\text{m}}}{\cancel{\text{s}}}\right)}{200\ \cancel{\text{nm}} \times \frac{1\ \cancel{\text{m}}}{10^9\ \cancel{\text{nm}}}} \approx 9.93 \times 10^{-19}\ \text{J}.$$