Exercise 1.42

A watt is a measure of power (the rate of energy change) equal to 1 J/s. (**a**) Calculate the number of joules in a kilowatt-hour. (**b**) An adult person radiates heat to the surroundings at about the same rate as a 100-watt electric incandescent light bulb. What is the total amount of energy in kcal radiated to the surroundings by an adult over a 24 h period?

Solution

Part (a)

Use dimensional analysis, starting with the given kilowatt-hour.

$$1 \text{ kilowatt-hour} = 1 \cancel{\text{kW}} \cdot \cancel{\text{hr}} \times \frac{1000 \cancel{\text{W}}}{1 \cancel{\text{kW}}} \times \frac{1 \frac{\text{J}}{\cancel{\text{sec}}}}{\cancel{\text{W}}} \times \frac{60 \cancel{\text{min}}}{1 \cancel{\text{hr}}} \times \frac{60 \cancel{\text{sec}}}{1 \cancel{\text{min}}} = 3.6 \times 10^6 \text{ J}$$

Part (b)

Start with the definition of work.

$$\begin{aligned}
\text{Work} &= \text{Power} \times \text{Time} \\
&= 100 \text{ W} \times 24 \text{ hr} \\
&= \left(100 \frac{\text{J}}{\cancel{\text{s}}}\right) \times \left(24 \cancel{\text{hr}} \times \frac{60 \cancel{\text{min}}}{1 \cancel{\text{hr}}} \times \frac{60 \cancel{\text{sec}}}{1 \cancel{\text{min}}}\right) \\
&= 8.64 \times 10^6 \text{ J} \\
&= 8.64 \times 10^6 \cancel{J} \times \frac{1 \cancel{\text{cal}}}{4.184 \cancel{J}} \times \frac{1 \text{ kcal}}{1000 \cancel{\text{cal}}} \\
&\approx 2 \times 10^3 \text{ kcal}
\end{aligned}$$