37. An 11.0-W energy-efficient fluorescent light bulb is designed to produce the same illumination as a conventional 40.0-W incandescent light bulb. Assuming a cost of $0.110/kWh for energy from the electric company, how much money does the user of the energy-efficient bulb save during 100 h of use?

\[ P = \frac{W}{\Delta t} = \frac{W}{\Delta t} \] \[ P \Delta t = \text{Energy} \]

\[ P \Delta t = (11 \text{ W})(100 \text{ h})(\frac{3600 \text{ s}}{\text{h}}) = 3.96 \times 10^6 \text{ J} = 3.96 \text{ MJ} \]

\[ \text{Cost} = 3.96 \times 10^6 \text{ J} \left( \frac{\$0.110}{\text{kWh}} \right) \left( \frac{\text{kWh}}{1000 \text{ W} \cdot \text{s}} \right) \left( \frac{1 \text{ s}}{3600 \text{ s}} \right) = 12 \text{ \$} \]

For the incandescent:

\[ P \Delta t = \frac{40 \text{ W}}{100 \text{ h}} \left( \frac{3600 \text{ s}}{\text{h}} \right) = 1.44 \times 10^7 \text{ J} \]

\[ \text{Cost} = 1.44 \times 10^7 \text{ J} \left( \frac{\$0.110}{3.6 \times 10^6 \text{ J}} \right) = \$0.44 = 44 \text{ \$} \]

44 \text{ \$} - 12 \text{ \$} = 32 \text{ \$ saved}

Interesting! That adds up, man.
The cost of energy delivered to residences by electrical transmission varies from $0.070/kWh to $0.258/kWh throughout the United States; $0.110/kWh is the average value. At this average price, calculate the cost of (a) leaving a 40.0-W porch light on for two weeks while you are on vacation, (b) making a piece of dark toast in 3.00 min with a 970-W toaster, and (c) drying a load of clothes in 40.0 min in a 5.20 × 10³-W dryer.

\[
\begin{align*}
\text{(a)} & \quad \$0.110 \frac{\text{kw}}{\text{kwh}} \cdot 24 \text{ h} \cdot 7 \text{ days} \cdot 2 \text{ wks} \cdot 40 \text{ W} \cdot \frac{1}{1000 \text{ W}} \cdot \frac{1}{1} \cdot \frac{1}{1} = \$1.48 \\
\text{(b)} & \quad \$0.110 \frac{\text{kw}}{\text{kwh}} \cdot 970 \text{ W} \cdot \frac{1}{1000 \text{ W}} \cdot \frac{1}{1} \cdot \frac{1}{60 \text{ min}} \cdot \frac{1}{1} = \$0.00534 \\
\text{(c)} & \quad \$0.110 \frac{\text{kw}}{\text{kwh}} \cdot 5200 \text{ W} \cdot \frac{1}{1000 \text{ W}} \cdot \frac{1}{1} \cdot \frac{1}{60 \text{ min}} \cdot \frac{1}{1} = \$0.381
\end{align*}
\]
40. Review. A rechargeable battery of mass 15.0 g delivers an average current of 18.0 mA to a portable DVD player at 1.60 V for 2.40 h before the battery must be recharged. The recharger maintains a potential difference of 2.30 V across the battery and delivers a charging current of 13.5 mA for 4.20 h. (a) What is the efficiency of the battery as an energy storage device? (b) How much internal energy is produced in the battery during one charge–discharge cycle? (c) If the battery is surrounded by ideal thermal insulation and has an effective specific heat of 975 J/kg·°C, by how much will its temperature increase during the cycle?

\[
\text{Efficiency} = \frac{\text{useful output}}{\text{total input}} = \frac{249 J}{469 J} = 0.53 \text{ (53\%)}
\]

(c) \[ \text{Initial internal energy} = 469 J = 249 J + 221 J \]

(c) \[ \Delta T = \frac{Q}{mc_p} = \frac{221 J}{0.015 kg \times (975 J/kg \cdot ^\circ C)} = 15.1 ^\circ C \]
A certain toaster has a heating element made of Nichrome wire. When the toaster is first connected to a 120-V source (and the wire is at a temperature of 20.0°C), the initial current is 1.80 A. The current decreases as the heating element warms up. When the toaster reaches its final operating temperature, the current is 1.55 A. (a) Find the power delivered to the toaster when it is at its operating temperature. (b) What is the final temperature of the heating element?

(a) \[ P = I \Delta V = (1.53 \text{A})(120 \text{V}) = 184 \text{W} \]

(b) \[ R = R_0 (1 + \alpha \Delta T) \]

From Table for Nichrome:

\[ R_f = \frac{120 \text{V}}{1.53 \text{A}} = 78.4 \Omega \]

\[ R_0 = \frac{120 \text{V}}{1.80 \text{A}} = 66.7 \Omega \]

\[ 78.4 \Omega = 66.7 \Omega (1 + (0.400 \times 10^{-3}) \Delta T) \]

\[ \Delta T = \frac{78.4 - 66.7}{0.400 \times 10^{-3}} = 441 \degree \text{C} \]

\[ T = 20 \degree \text{C} + 441 \degree \text{C} = 461 \degree \text{C} \]

Wow! That's not!
47. Review. The heating element of an electric coffee maker operates at 120 V and carries a current of 2.00 A. Assuming the water absorbs all the energy delivered to the resistor, calculate the time interval during which the temperature of 0.500 kg of water rises from room temperature (23.0°C) to the boiling point.

\[
P = I \Delta V = (2.00 \text{ A})(120 \text{ V}) = 240 \text{ W}
\]

\[
Q = mC_p \Delta T
\]

\[
Q = (0.500 \text{ kg})(4.18 \text{ J/kg°C})(100°C - 23°C)
\]

\[
= 161 \text{ kJ}
\]

\[
\Delta t = \frac{1.61 \times 10^5 \text{ J}}{240 \text{ W}} = 672 \text{ sec} = 11.2 \text{ min.}
\]

Sounds about right.