2. ***REASONING*** The current I is defined in Equation 20.1 as the amount of charge Δq per unit of time Δt that flows in a wire. Therefore, the amount of charge is the product of the current and the time interval. The number of electrons is equal to the charge that flows divided by the magnitude of the charge on an electron.

SOLUTION

a. The amount of charge that flows is

$$\Delta q = I\,\Delta t = (18\text{ A})\left(2.0\times10^{-3}\text{ s}\right) = \boxed{3.6\times10^{-2}\text{ C}}$$

b. The number of electrons N is equal to the amount of charge divided by e, the magnitude of the charge on an electron.

$$N = \frac{\Delta q}{e} = \frac{3.6\times10^{-2}\text{ C}}{1.60\times10^{-19}\text{ C}} = \boxed{2.3\times10^{17}}$$

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3. ***REASONING AND SOLUTION*** First determine the total charge delivered to the battery using Equation 20.1:

$$\Delta q = I\,\Delta t = (6.0\text{ A})(5.0\text{ h})\left(\frac{3600\text{ s}}{1\text{ h}}\right) = 1.1\times10^{5}\text{ C}$$

To find the energy delivered to the battery, multiply this charge by the energy per unit charge (i.e., the voltage) to get

$$\text{Energy} = (\Delta q)V = (1.1\times10^{5}\text{ C})(12\text{ V}) = \boxed{1.3\times10^{6}\text{ J}}$$

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5. **SSM** ***REASONING AND SOLUTION*** Ohm's law (Equation 20.2, $V = IR$) gives the result directly

$$I = \frac{V}{R} = \frac{240\ \text{V}}{11\ \Omega} = \boxed{22\ \text{A}}$$

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7. ***REASONING*** As discussed in Section 20.1, the voltage gives the energy per unit charge. Thus, we can determine the energy delivered to the toaster by multiplying the voltage V by the charge Δq that flows during a time Δt of one minute. The charge can be obtained by solving Equation 20.1, $I = (\Delta q)/(\Delta t)$, since the current I can be obtained from Ohm's law.

SOLUTION Remembering that voltage is energy per unit charge, we have

$$\text{Energy} = V\,\Delta q$$

Solving Equation 20.1 for Δq gives $\Delta q = I\,\Delta t$, which can be substituted in the previous result to give

$$\text{Energy} = V\,\Delta q = VI\,\Delta t$$

According to Ohm's law (Equation 20.2), the current is $I = V/R$, which can be substituted in the energy expression to show that

$$\text{Energy} = VI\,\Delta t = V\left(\frac{V}{R}\right)\Delta t = \frac{V^2\,\Delta t}{R} = \frac{(120\text{ V})^2\,(60\text{ s})}{14\;\Omega} = \boxed{6.2 \times 10^4\text{ J}}$$

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12. ***REASONING AND SOLUTION*** Using Equation 20.3 and the resistivity of aluminum from Table 20.1, we find

$$R = \frac{\rho L}{A} = \frac{\left(2.82\times10^{-8}\ \Omega\cdot\text{m}\right)\left(10.0\times10^{3}\ \text{m}\right)}{4.9\times10^{-4}\ \text{m}^2} = \boxed{0.58\ \Omega}$$

13. SSM WWW ***REASONING*** The resistance of a metal wire of length L, cross-sectional area A and resistivity ρ is given by Equation 20.3: $R = \rho L / A$. Solving for A, we have $A = \rho L / R$. We can use this expression to find the ratio of the cross-sectional area of the aluminum wire to that of the copper wire.

SOLUTION Forming the ratio of the areas and using resistivity values from Table 20.1, we have

$$\frac{A_{\text{aluminum}}}{A_{\text{copper}}} = \frac{\rho_{\text{aluminum}} L / R}{\rho_{\text{copper}} L / R} = \frac{\rho_{\text{aluminum}}}{\rho_{\text{copper}}} = \frac{2.82 \times 10^{-8} \ \Omega \cdot \text{m}}{1.72 \times 10^{-8} \ \Omega \cdot \text{m}} = \boxed{1.64}$$

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21. ***REASONING AND SOLUTION*** According to Equation 20.6c, the power delivered to the iron is

$$P = \frac{V^2}{R} = \frac{(120\ \text{V})^2}{24\ \Omega} = \boxed{6.0 \times 10^2\ \text{W}}$$

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22. ***REASONING*** To find the current, we can use the relation that the power P is the product of the current I and the voltage V, since the power and voltage are known.

SOLUTION Solving $P = IV$ (Equation 20.6a) for the current, we have

$$I = \frac{P}{V} = \frac{0.11\ \text{W}}{4.5\ \text{V}} = \boxed{0.024\ \text{A}}$$

23. ***REASONING AND SOLUTION*** The power delivered is $P = VI$ so

a.
$$P_{bd} = VI_{bd} = (120\ \text{V})(11\ \text{A}) = \boxed{1300\ \text{W}}$$

b.
$$P_{vc} = VI_{vc} = (120\ \text{V})(4.0\ \text{A}) = \boxed{480\ \text{W}}$$

c. The energy is $E = Pt$ so,

$$\frac{E_{bd}}{E_{vc}} = \frac{P_{bd}t_{bd}}{P_{vc}t_{vc}} = \frac{(1300\ \text{W})(15\ \text{min})}{(480\ \text{W})(30.0\ \text{min})} = \boxed{1.4}$$

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24. ***REASONING*** The total cost of keeping all the TVs turned on is equal to the number of TVs times the cost to keep each one on. The cost for one TV is equal to the energy it consumes times the cost per unit of energy (\$0.12 per kW·h). The energy that a single set uses is, according to Equation 6.10b, the power it consumes times the time of use.

SOLUTION The total cost is

$$\text{Total cost} = (110 \text{ million sets})(\text{Cost per set})$$

$$= (110 \text{ million sets})\left[\text{Energy (in kW}\cdot\text{h) used per set}\right]\left(\frac{\$0.12}{1\,\text{kW}\cdot\text{h}}\right)$$

The energy (in kW·h) used per set is the product of the power and the time, where the power is expressed in kilowatts and the time is in hours:

$$\text{Energy used per set} = P\,t = (75\text{ W})\left(\frac{1\text{ kW}}{1000\text{ W}}\right)(6.0\text{ h}) \qquad (6.10\text{b})$$

The total cost of operating the TV sets is

$$\text{Total cost} = (110 \text{ million sets})\left[(75\text{ W})\left(\frac{1\text{ kW}}{1000\text{ W}}\right)(6.0\text{ h})\right]\left(\frac{\$0.12}{1\,\text{kW}\cdot\text{h}}\right) = \boxed{\$5.9\times10^{6}}$$
