WORKSHOP WEEK 3

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

$$\Delta q = I\Delta t = (6.0\text{ A})(5.0\text{ h})[(3600\text{ s})/(1\text{ h})] = 1.1 \times 10^5\text{ C}$$

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

$$\text{Energy} = (\Delta q)V = (1.1 \times 10^5\text{ C})(12\text{ V}) = \boxed{1.3 \times 10^6\text{ J}}$$

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

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

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

$$R = \frac{\rho L}{A} = \frac{\left(2.82 \times 10^{-8}\ \Omega\cdot\text{m}\right)\left(10.0 \times 10^3\text{ m}\right)}{4.9 \times 10^{-4}\text{ m}^2} = \boxed{0.58\,\Omega}$$

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11. **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

$$\frac{A_{\text{aluminum}}}{A_{\text{copper}}} = \frac{\rho_{\text{aluminum}} L/R}{\rho_{\text{copper}} L/R} = \frac{\rho_{\text{aluminum}}}{\rho_{\text{copper}}} = \frac{2.82\times10^{-8}\ \Omega\cdot\text{m}}{1.72\times10^{-8}\ \Omega\cdot\text{m}} = \boxed{1.64}$$

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12. ***REASONING*** The resistance R of a wire that has a length L and a cross-sectional area A is given by Equation 20.3 as $R = \rho\frac{L}{A}$. Both wires have the same length and cross-sectional area. Only the resistivity ρ of the wire differs, and Table 20.1 gives the following values: $\rho_{\text{Aluminum}} = 2.82 \times 10^{-8}$ Ω·m and $\rho_{\text{Copper}} = 1.72 \times 10^{-8}$ Ω·m. Applying Equation 20.3 to both wires and dividing the two equations will allow us to eliminate the unknown length and cross-sectional area algebraically and solve for the resistance of the copper wire.

SOLUTION Applying Equation 20.3 to both wires gives

$$R_{\text{Copper}} = \rho_{\text{Copper}}\frac{L}{A} \quad \text{and} \quad R_{\text{Aluminum}} = \rho_{\text{Aluminum}}\frac{L}{A}$$

Dividing these two equations, eliminating L and A algebraically, and solving the result for R_{Copper} give

$$\frac{R_{\text{Copper}}}{R_{\text{Aluminum}}} = \frac{\rho_{\text{Copper}} L/A}{\rho_{\text{Aluminum}} L/A} = \frac{\rho_{\text{Copper}}}{\rho_{\text{Aluminum}}}$$

$$R_{\text{Copper}} = R_{\text{Aluminum}}\left(\frac{\rho_{\text{Copper}}}{\rho_{\text{Aluminum}}}\right) = (0.20\ \Omega)\left(\frac{1.72\times10^{-8}\ \Omega\cdot\text{m}}{2.82\times10^{-8}\ \Omega\cdot\text{m}}\right) = \boxed{0.12\ \Omega}$$

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13. ***REASONING AND SOLUTION*** The resistance of the cable is

$$R = \frac{V}{I} = \frac{\rho L}{A}$$

Since $A = \pi r^2$, the radius of the cable is

$$r = \sqrt{\frac{\rho L I}{\pi V}} = \sqrt{\frac{(1.72\times10^{-8}\ \Omega\cdot\text{m})(0.24\ \text{m})(1200\ \text{A})}{\pi(1.6\times10^{-2}\ \text{V})}} = \boxed{9.9\times10^{-3}\ \text{m}}$$