11. **REASONING** The resistance of a metal wire of length $L$, cross-sectional area $A$ and resistivity $\rho$ 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

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

17. **REASONING** The resistance of a metal wire of length $L$, cross-sectional area $A$ and resistivity $\rho$ is given by Equation 20.3: $R = \rho L / A$. The volume $V_2$ of the new wire will be the same as the original volume $V_1$ of the wire, where volume is the product of length and cross-sectional area. Thus, $V_1 = V_2$ or $A_1 L_1 = A_2 L_2$. Since the new wire is three times longer than the first wire, we can write

$$A_1 L_1 = A_2 L_2 = A_2 (3L_1) \quad \text{or} \quad A_2 = A_1 / 3$$

We can form the ratio of the resistances, use this expression for the area $A_2$, and find the new resistance.

**SOLUTION** The resistance of the new wire is determined as follows:

$$\frac{R_2}{R_1} = \frac{\rho L_2 / A_2}{\rho L_1 / A_1} = \frac{L_2 A_1}{L_1 A_2} = \frac{(3L_1) A_1}{L_1 (A_1 / 3)} = 9$$

Solving for $R_2$, we find that

$$R_2 = 9 R_1 = 9(21.0 \, \Omega) = 189 \, \Omega$$

19. **REASONING** We will ignore any changes in length due to thermal expansion. Although the resistance of each section changes with temperature, the total resistance of the composite does not change with temperature. Therefore,

$$\left(\frac{R_{\text{tungsten}}}{\rho_{\text{tungsten}}}\right)_0 + \left(\frac{R_{\text{carbon}}}{\rho_{\text{carbon}}}\right)_0 = \frac{R_{\text{tungsten}}}{\rho_{\text{tungsten}}} + \frac{R_{\text{carbon}}}{\rho_{\text{carbon}}}$$

At room temperature At temperature $T$
From Equation 20.5, we know that the temperature dependence of the resistance for a wire of resistance $R_0$ at temperature $T_0$ is given by $R = R_0[1 + \alpha(T - T_0)]$, where $\alpha$ is the temperature coefficient of resistivity. Thus,

$$\left(R_{\text{tungsten}}\right)_0 + \left(R_{\text{carbon}}\right)_0 = \left(R_{\text{tungsten}}\right)_0 (1 + \alpha_{\text{tungsten}} \Delta T) + \left(R_{\text{carbon}}\right)_0 (1 + \alpha_{\text{carbon}} \Delta T)$$

Since $\Delta T$ is the same for each wire, this simplifies to

$$\left(R_{\text{tungsten}}\right)_0 \alpha_{\text{tungsten}} = -\left(R_{\text{carbon}}\right)_0 \alpha_{\text{carbon}} \quad (1)$$

This expression can be used to find the ratio of the resistances. Once this ratio is known, we can find the ratio of the lengths of the sections with the aid of Equation 20.3 ($L = RA/\rho$).

**SOLUTION** From Equation (1), the ratio of the resistances of the two sections of the wire is

$$\frac{\left(R_{\text{tungsten}}\right)_0}{\left(R_{\text{carbon}}\right)_0} = \frac{-\alpha_{\text{carbon}}}{\alpha_{\text{tungsten}}} = \frac{-0.0005 \, [(\text{C}^o)^{-1}]}{0.0045 \, [(\text{C}^o)^{-1}]} = \frac{1}{9}$$

Thus, using Equation 20.3, we find the ratio of the tungsten and carbon lengths to be

$$\frac{L_{\text{tungsten}}}{L_{\text{carbon}}} = \frac{\left(R_{\text{tungsten}}\right)_0 A/\rho}{\left(R_{\text{carbon}}\right)_0 A/\rho} = \frac{\left(R_{\text{tungsten}}\right)_0}{\left(R_{\text{carbon}}\right)_0} \left(\frac{\rho_{\text{carbon}}}{\rho_{\text{tungsten}}}\right) = \left(\frac{1}{9}\right) \left(\frac{3.5 \times 10^{-5} \, \Omega \cdot \text{m}}{5.6 \times 10^{-8} \, \Omega \cdot \text{m}}\right) = 70$$

where we have used resistivity values from Table 20.1 and the fact that the two sections have the same cross-sectional areas.

**109. REASONING** Since we know that the current in the 8.00-Ω resistor is 0.500 A, we can use Ohm's law ($V = IR$) to find the voltage across the 8.00-Ω resistor. The 8.00-Ω resistor and the 16.0-Ω resistor are in parallel; therefore, the voltages across them are equal. Thus, we can also use Ohm's law to find the current through the 16.0-Ω resistor. The currents that flow through the 8.00-Ω and the 16.0-Ω resistors combine to give the total current that flows through the 20.0-Ω resistor. Similar reasoning can be used to find the current through the 9.00-Ω resistor.

**SOLUTION**
a. The voltage across the 8.00-Ω resistor is $V_8 = (0.500 \, \text{A})(8.00 \, \Omega) = 4.00 \, \text{V}$. Since this is also the voltage that is across the 16.0-Ω resistor, we find that the current through the 16.0-Ω resistor is $I_{16} = (4.00 \, \text{V})/(16.0 \, \Omega) = 0.250 \, \text{A}$. Therefore, the total current that flows through the 20.0-Ω resistor is

$$I_{20} = 0.500 \, \text{A} + 0.250 \, \text{A} = 0.750 \, \text{A}$$
b. The 8.00-Ω and the 16.0-Ω resistors are in parallel, so their equivalent resistance can be obtained from Equation 20.17, 
\[ \frac{1}{R_p} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots \], and is equal to 5.33 Ω. Therefore, the equivalent resistance of the upper branch of the circuit is 
\[ R_{upper} = 5.33 \, \Omega + 20.0 \, \Omega = 25.3 \, \Omega \], since the 5.33-Ω resistance is in series with the 20.0-Ω resistance. Using Ohm's law, we find that the voltage across the upper branch must be 
\[ V = (0.750 \, A)(25.3 \, \Omega) = 19.0 \, V \]. Since the lower branch is in parallel with the upper branch, the voltage across both branches must be the same. Therefore, the current through the 9.00-Ω resistor is, from Ohm's law,

\[ I_9 = \frac{V_{lower}}{R_9} = \frac{19.0 \, V}{9.00 \, \Omega} = 2.11 \, \text{A} \]