Problem Solutions

17.1 The charge that moves past the cross section is $\Delta Q = I(\Delta t)$, and the number of electrons is

$$n = \frac{\Delta Q}{|e|} = \frac{I(\Delta t)}{|e|}$$

$$= \frac{(80.0\times10^{-3}\ \text{C/s})[(10.0\ \text{min})(60.0\ \text{s/min})]}{1.60\times10^{-19}\ \text{C}} = \boxed{3.00\times10^{20}\ \text{electrons}}$$

The negatively charged electrons move in the direction opposite to the conventional current flow.

17.2 The period of revolution for the sphere is $T = 2\pi/\omega$, and the average current represented by this revolving charge is $I = \dfrac{q}{T} = \boxed{\dfrac{q\omega}{2\pi}}$

17.3 The current is $I = \dfrac{\Delta Q}{\Delta t} = \dfrac{6.0\times10^{-3}\ \text{C}}{2.0\ \text{s}} = 3.0\times10^{-3}\ \text{A} = \boxed{3.0\ \text{mA}}$

17.4 $\Delta Q = I(\Delta t)$ and the number of electrons is

$$n = \frac{\Delta Q}{|e|} = \frac{I(\Delta t)}{|e|} = \frac{(60.0\times10^{-6}\ \text{C/s})(1.00\ \text{s})}{1.60\times10^{-19}\ \text{C}} = \boxed{3.75\times10^{14}\ \text{electrons}}$$

17.5 The period of the electron in its orbit is $T = 2\pi r/v$, and the current represented by the orbiting electron is

$$I = \frac{\Delta Q}{\Delta t} = \frac{|e|}{T} = \frac{v|e|}{2\pi r}$$

$$= \frac{(2.19\times10^{6}\ \text{m/s})(1.60\times10^{-19}\ \text{C})}{2\pi(5.29\times10^{-11}\ \text{m})} = 1.05\times10^{-3}\ \text{C/s} = \boxed{1.05\ \text{mA}}$$

17.6 The mass of a single gold atom is

$$m_{atom}=\frac{M}{N_A}=\frac{197\ \text{g/mol}}{6.02\times10^{23}\ \text{atoms/mol}}=3.27\times10^{-22}\ \text{g}=3.27\times10^{-25}\ \text{kg}$$

The number of atoms deposited, and hence the number of ions moving to the negative electrode, is

$$n=\frac{m}{m_{atom}}=\frac{3.25\times10^{-3}\ \text{kg}}{3.27\times10^{-25}\ \text{kg}}=9.93\times10^{21}$$

Thus, the current in the cell is

$$I=\frac{\Delta Q}{\Delta t}=\frac{ne}{\Delta t}=\frac{\left(9.93\times10^{21}\right)\left(1.60\times10^{-19}\ \text{C}\right)}{(2.78\ \text{h})(3600\ \text{s/1 h})}=0.159\ \text{A}=\boxed{159\ \text{mA}}$$

17.7 The drift speed of electrons in the line is $v_d=\frac{I}{nqA}=\frac{I}{n|e|\left(\pi d^2/4\right)}$, or

$$v_d=\frac{4(1000\ \text{A})}{\left(8.5\times10^{28}/\text{m}^3\right)\left(1.60\times10^{-19}\ \text{C}\right)\pi(0.020\ \text{m})^2}=2.3\times10^{-4}\ \text{m/s}$$

The time to travel the length of the 200-km line is then

$$\Delta t=\frac{L}{v_d}=\frac{200\times10^3\ \text{m}}{2.34\times10^{-4}\ \text{m/s}}\left(\frac{1\ \text{yr}}{3.156\times10^7\ \text{s}}\right)=\boxed{27\ \text{yr}}$$

17.8 Assuming that, on average, each aluminum atom contributes one electron, the density of charge carriers is the same as the number of atoms per cubic meter. This is

$$n=\frac{\textit{density}}{\textit{mass per atom}}=\frac{\rho}{M/N_A}=\frac{N_A\rho}{M},$$

or $$n=\frac{\left(6.02\times10^{23}/\text{mol}\right)\left[\left(2.7\ \text{g/cm}^3\right)\left(10^6\ \text{cm}^3/1\ \text{m}^3\right)\right]}{26.98\ \text{g/mol}}=6.0\times10^{28}/\text{m}^3$$

The drift speed of the electrons in the wire is then

$$v_d=\frac{I}{n|e|A}=\frac{5.0\ \text{C/s}}{\left(6.0\times10^{28}/\text{m}^3\right)\left(1.60\times10^{-19}\ \text{C}\right)\left(4.0\times10^{-6}\ \text{m}^2\right)}=\boxed{1.3\times10^{-4}\ \text{m/s}}$$

17.9 (a) The carrier density is determined by the physical characteristics of the wire, not the current in the wire. Hence, n is $\boxed{\text{unaffected}}$.

(b) The drift velocity of the electrons is $v_d = I/nqA$. Thus, the drift velocity is $\boxed{\text{doubled}}$ when the current is doubled.

17.10 $I = \dfrac{\Delta V}{R} = \dfrac{120\text{ V}}{240\ \Omega} = 0.500\text{ A} = \boxed{500\text{ mA}}$

17.11 $(\Delta V)_{max} = I_{max} R = \left(80\times10^{-6}\text{ A}\right)R$

Thus, if $R = 4.0\times10^{5}\ \Omega$, $(\Delta V)_{max} = \boxed{32\text{ V}}$,

and if $R = 2000\ \Omega$, $(\Delta V)_{max} = \boxed{0.16\text{ V}}$

17.12 The volume of the copper is

$$V = \frac{m}{density} = \frac{1.00\times10^{-3}\text{ kg}}{8.92\times10^{3}\text{ kg/m}^3} = 1.12\times10^{-7}\text{ m}^3$$

Since, $V = A\cdot L$, this gives $A\cdot L = 1.12\times10^{-7}\text{ m}^3$. (1)

(a) From $R = \dfrac{\rho L}{A}$, we find that

$$A = \left(\frac{\rho}{R}\right)L = \left(\frac{1.70\times10^{-8}\ \Omega\cdot\text{m}}{0.500\ \Omega}\right)L = \left(3.40\times10^{-8}\text{ m}\right)L.$$

Inserting this expression for A into Equation 1 gives

$\left(3.40\times10^{-8}\text{ m}\right)L^2 = 1.12\times10^{-7}\text{ m}^3$, which yields $L = \boxed{1.82\text{ m}}$

(b) From equation (1), $A = \dfrac{\pi d^2}{4} = \dfrac{1.12\times10^{-7}\text{ m}^3}{L}$, or

$$d = \sqrt{\frac{4\left(1.12\times10^{-7}\text{ m}^3\right)}{\pi L}} = \sqrt{\frac{4\left(1.12\times10^{-7}\text{ m}^3\right)}{\pi(1.82\text{ m})}}$$

$$= 2.80\times10^{-4}\text{ m} = \boxed{0.280\text{ mm}}$$

17.13 From $R=\frac{\rho L}{A}$, we obtain $A=\frac{\pi d^2}{4}=\frac{\rho L}{R}$, or

$$d=\sqrt{\frac{4\rho L}{\pi R}}=\sqrt{\frac{4\left(5.6\times10^{-8}\ \Omega\cdot\text{m}\right)\left(2.0\times10^{-2}\ \text{m}\right)}{\pi(0.050\ \Omega)}}=1.7\times10^{-4}\ \text{m}=\boxed{0.17\ \text{mm}}$$

17.14 $$R=\frac{\rho L}{A}=\frac{\rho L}{\pi d^2/4}=\frac{4\left(1.7\times10^{-8}\ \Omega\cdot\text{m}\right)(15\ \text{m})}{\pi\left(1.024\times10^{-3}\ \text{m}\right)^2}=\boxed{0.31\ \Omega}$$

17.15 (a) $R=\frac{\Delta V}{I}=\frac{12\ \text{V}}{0.40\ \text{A}}=30\ \Omega$

(b) From, $R=\frac{\rho L}{A}$,

$$\rho=\frac{R\cdot A}{L}=\frac{(30\ \Omega)\left[\pi\left(0.40\times10^{-2}\ \text{m}\right)^2\right]}{3.2\ \text{m}}=\boxed{4.7\times10^{-4}\ \Omega\cdot\text{m}}$$

17.16 The new "wire" has length $L=L_0/3$ and cross-section $A=3A_0$. Thus, its resistance is

$$R=\frac{\rho L}{A}=\frac{\rho\left(L_0/3\right)}{3A_0}=\frac{1}{9}\left(\frac{\rho L_0}{A_0}\right)=\boxed{\frac{R_0}{9}}$$

17.17 The resistance is $R=\frac{\Delta V}{I}=\frac{9.11\ \text{V}}{36.0\ \text{A}}=0.253\ \Omega$, so the resistivity of the metal is

$$\rho=\frac{R\cdot A}{L}=\frac{R\cdot\left(\pi d^2/4\right)}{L}=\frac{(0.253\ \Omega)\pi\left(2.00\times10^{-3}\ \text{m}\right)^2}{4(50.0\ \text{m})}=1.59\times10^{-8}\ \Omega\cdot\text{m}$$

Thus, the metal is seen to be $\boxed{\text{silver}}$.

17.18 With different orientations of the block, three different values of the ratio L/A are possible. These are:

$$\left(\frac{L}{A}\right)_1=\frac{10\text{ cm}}{(20\text{ cm})(40\text{ cm})}=\frac{1}{80\text{ cm}}=\frac{1}{0.80\text{ m}},$$

$$\left(\frac{L}{A}\right)_2=\frac{20\text{ cm}}{(10\text{ cm})(40\text{ cm})}=\frac{1}{20\text{ cm}}=\frac{1}{0.20\text{ m}},$$

and $$\left(\frac{L}{A}\right)_3=\frac{40\text{ cm}}{(10\text{ cm})(20\text{ cm})}=\frac{1}{5.0\text{ cm}}=\frac{1}{0.050\text{ m}}$$

(a) $$I_{max}=\frac{\Delta V}{R_{min}}=\frac{\Delta V}{\rho(L/A)_{min}}=\frac{(6.0\text{ V})(0.80\text{ m})}{1.7\times10^{-8}\ \Omega\cdot\text{m}}=\boxed{2.8\times10^{8}\text{ A}}$$

(b) $$I_{min}=\frac{\Delta V}{R_{max}}=\frac{\Delta V}{\rho(L/A)_{max}}=\frac{(6.0\text{ V})(0.050\text{ m})}{1.7\times10^{-8}\ \Omega\cdot\text{m}}=\boxed{1.8\times10^{7}\text{ A}}$$

17.19 When the tube is stretched, the cross-sectional area decreases. Since the volume of mercury is constant, $V=A_f\cdot L_f=A_i\cdot L_i$, or $\left(\frac{\pi}{4}d_f^2\right)L_f=\left(\frac{\pi}{4}d_i^2\right)L_i$. This gives $d_f^2=d_i^2\left(L_i/L_f\right)$.

The total resistance of the circuit is

$$R=r+R_{Hg}=1.00\ \Omega+\frac{\rho_{Hg}L}{A}=1.00\ \Omega+\frac{4\rho_{Hg}L}{\pi d^2}$$

The change in current through the monitor is

$$\Delta I=\frac{\Delta V}{R_f}-\frac{\Delta V}{R_i}=\frac{\Delta V}{1.00\ \Omega+\dfrac{4\rho_{Hg}L_f^2}{\pi d_i^2L_i}}-\frac{\Delta V}{1.00\ \Omega+\dfrac{4\rho_{Hg}L_i}{\pi d_i^2}}$$

$$=\frac{0.100\text{ V}}{1.00\ \Omega+\dfrac{4(9.4\times10^{-7}\ \Omega\cdot\text{m})(1.35\text{ m})^2}{\pi(2.51\times10^{-3}\text{ m})^2(1.25\text{ m})}}-\frac{0.100\text{ V}}{1.00\ \Omega+\dfrac{4(9.4\times10^{-7}\ \Omega\cdot\text{m})(1.25\text{ m})}{\pi(2.51\times10^{-3}\text{ m})^2}}$$

giving $\Delta I=-2.5\times10^{-3}\text{ A}=$ a $\boxed{2.5\text{ mA decrease}}$

17.20 Solving $R = R_0\left[1+\alpha(T-T_0)\right]$ for the final temperature gives

$$T = T_0 + \frac{R-R_0}{\alpha R_0} = 20°\text{C} + \frac{140\ \Omega - 19\ \Omega}{\left[4.5\times10^{-3}\ (°\text{C})^{-1}\right](19\ \Omega)} = \boxed{1.4\times10^{3}\ °\text{C}}$$

17.21 From Ohm's law, $\Delta V = I_i R_i = I_f R_f$, so the current in Antarctica is

$$I_f = I_i\left(\frac{R_i}{R_f}\right) = I_i\left(\frac{R_0\left[1+\alpha(T_i-T_0)\right]}{R_0\left[1+\alpha(T_f-T_0)\right]}\right)$$

$$= (1.00\ \text{A})\left(\frac{1+\left[3.90\times10^{-3}\ (°\text{C})^{-1}\right](58.0°\text{C}-20.0°\text{C})}{1+\left[3.90\times10^{-3}\ (°\text{C})^{-1}\right](-88.0°\text{C}-20.0°\text{C})}\right) = \boxed{1.98\ \text{A}}$$

17.22 $R = R_0\left[1+\alpha(T-T_0)\right]$

$$= (10.0\ \Omega)\left[1+\left(3.80\times10^{-3}\ (°\text{C})^{-1}\right)(40.0°\text{C}-20.0°\text{C})\right] = \boxed{10.8\ \Omega}$$

17.23 At 80°C,

$$I = \frac{\Delta V}{R} = \frac{\Delta V}{R_0\left[1+\alpha(T-T_0)\right]} = \frac{5.0\ \text{V}}{(200\ \Omega)\left[1+\left(-0.5\times10^{-3}\ °\text{C}^{-1}\right)(80°\text{C}-20°\text{C})\right]},$$

or $\quad I = 2.6\times10^{-2}\ \text{A} = 26\ \text{mA}$

17.24 If $R = 100\ \Omega$ at $T = 40.0°\text{C}$, then $R = R_0\left[1+\alpha(T-T_0)\right]$ gives

$$R_0 = \frac{R}{1+\alpha(T-T_0)} = \frac{100\ \Omega}{1+\left[3.40\times10^{-3}\ (°\text{C})^{-1}\right](40.0°\text{C}-20.0°\text{C})} = 93.6\ \Omega$$

$$T = T_0 + \frac{R-R_0}{\alpha R_0} = 20.0°\text{C} + \frac{97.0\ \Omega - 93.6\ \Omega}{\left[3.40\times10^{-3}\ (°\text{C})^{-1}\right](93.6\ \Omega)} = \boxed{30.6°\text{C}}$$

17.25 $R_0 = \dfrac{\rho L}{A} = \dfrac{\left(1.7\times10^{-8}\ \Omega\cdot\text{m}\right)(10.0\ \text{m})}{3.00\times10^{-6}\ \text{m}^2} = 5.67\times10^{-2}\ \Omega$

(a) At $T = 30.0°\text{C}$, $R = R_0\left[1+\alpha(T-T_0)\right]$ gives a resistance of

$$R = (0.0567\ \Omega)\left[1+\left(3.9\times10^{-3}\ (°\text{C})^{-1}\right)(30.0°\text{C}-20.0°\text{C})\right] = \boxed{5.89\times10^{-2}\ \Omega}$$

(b) At $T = 10.0°\text{C}$, $R = R_0\left[1+\alpha(T-T_0)\right]$ yields

$$R = (0.0567\ \Omega)\left[1+\left(3.9\times10^{-3}\ (°\text{C})^{-1}\right)(10.0°\text{C}-20.0°\text{C})\right] = \boxed{5.45\times10^{-2}\ \Omega}$$

17.26 For aluminum, the coefficient of linear expansion is $\alpha = 24\times10^{-6}\ (°\text{C})^{-1}$ and the temperature coefficient of resistivity is $\alpha_e = 3.9\times10^{-3}\ (°\text{C})^{-1}$. At temperature T, the length and cross-sectional area may be expressed as $L = L_0\left[1+\alpha(T-T_0)\right]$ and $A = A_0\left[1+\alpha(T-T_0)\right]^2$, respectively.

Thus, $R = \rho\dfrac{L}{A} = \rho_0\left[1+\alpha_e(T-T_0)\right]\dfrac{L_0\left[1+\alpha(T-T_0)\right]}{A_0\left[1+\alpha(T-T_0)\right]^2} = \left(\rho_0\dfrac{L_0}{A_0}\right)\dfrac{\left[1+\alpha_e(T-T_0)\right]}{\left[1+\alpha(T-T_0)\right]}$.

At $T = 120°\text{C}$, this gives

$$R = R_0\frac{\left[1+\alpha_e(T-T_0)\right]}{\left[1+\alpha(T-T_0)\right]} = (1.234\ \Omega)\frac{\left[1+3.9\times10^{-3}\ (°\text{C})^{-1}(120-20.0)°\text{C}\right]}{\left[1+24\times10^{-6}\ (°\text{C})^{-1}(120-20.0)°\text{C}\right]} = \boxed{1.71\ \Omega}$$

17.27 (a) The resistance at 20.0°C is

$$R_0 = \rho\frac{L}{A} = \frac{\left(1.7\times10^{-8}\ \Omega\cdot\text{m}\right)(34.5\ \text{m})}{\pi\left(0.25\times10^{-3}\ \text{m}\right)^2} = 3.0\ \Omega,$$

and the current will be $I = \dfrac{\Delta V}{R_0} = \dfrac{9.0\ \text{V}}{3.0\ \Omega} = \boxed{3.0\ \text{A}}$

(b) At 30.0°C,

$$R = R_0\left[1+\alpha(T-T_0)\right]$$

$$= (3.0\ \Omega)\left[1+\left(3.9\times10^{-3}\ (°\text{C})^{-1}\right)(30.0°\text{C}-20.0°\text{C})\right] = 3.1\ \Omega$$

Thus, the current is $I = \dfrac{\Delta V}{R} = \dfrac{9.0\ \text{V}}{3.1\ \Omega} = \boxed{2.9\ \text{A}}$

17.28 The resistance of the heating element when at its operating temperature is

$$R = \frac{(\Delta V)^2}{\wp} = \frac{(120\ \text{V})^2}{1050\ \text{W}} = 13.7\ \Omega$$

From $R = R_0\left[1+\alpha\left(T-T_0\right)\right] = \frac{\rho_0 L}{A}\left[1+\alpha\left(T-T_0\right)\right]$, the cross-sectional area is

$$A = \frac{\rho_0 L}{R}\left[1+\alpha\left(T-T_0\right)\right]$$

$$= \frac{\left(150\times10^{-8}\ \Omega\cdot\text{m}\right)(4.00\ \text{m})}{13.7\ \Omega}\left[1+\left(0.40\times10^{-3}\ (^\circ\text{C})^{-1}\right)(320^\circ\text{C}-20.0^\circ\text{C})\right]$$

$$A = \boxed{4.90\times10^{-7}\ \text{m}^2}$$

17.29 (a) From $R = \rho L/A$, the initial resistance of the mercury is

$$R_i = \frac{\rho L_i}{A_i} = \frac{\left(9.4\times10^{-7}\ \Omega\cdot\text{m}\right)(1.0000\ \text{m})}{\pi\left(1.00\times10^{-3}\ \text{m}\right)^2/4} = \boxed{1.2\ \Omega}$$

(b) Since the volume of mercury is constant, $V = A_f\cdot L_f = A_i\cdot L_i$ gives the final cross-sectional area as $A_f = A_i\cdot\left(L_i/L_f\right)$. Thus, the final resistance is given by $R_f = \frac{\rho L_f}{A_f} = \frac{\rho L_f^2}{A_i\cdot L_i}$. The fractional change in the resistance is then

$$\Delta = \frac{R_f - R_i}{R_i} = \frac{R_f}{R_i} - 1 = \frac{\rho L_f^2/\left(A_i\cdot L_i\right)}{\rho L_i/A_i} - 1 = \left(\frac{L_f}{L_i}\right)^2 - 1,$$

$$\Delta = \left(\frac{100.04}{100.00}\right)^2 - 1 = \boxed{8.0\times10^{-4}}\ \text{or}\ \boxed{\text{a }0.080\%\text{ increase}}$$

17.30 The resistance at 20.0°C is

$$R_0 = \frac{R}{1+\alpha(T-T_0)} = \frac{200.0\ \Omega}{1+\left[3.92\times10^{-3}\ (^\circ\text{C})^{-1}\right](0^\circ\text{C}-20.0^\circ\text{C})} = 217\ \Omega$$

Solving $R = R_0\left[1+\alpha(T-T_0)\right]$ for T gives the temperature of the melting potassium as

$$T = T_0 + \frac{R-R_0}{\alpha R_0} = 20.0^\circ\text{C} + \frac{253.8\ \Omega - 217\ \Omega}{\left[3.92\times10^{-3}\ (^\circ\text{C})^{-1}\right](217\ \Omega)} = \boxed{63.2^\circ\text{C}}$$

17.31 $I = \dfrac{\wp}{\Delta V} = \dfrac{600\ \text{W}}{120\ \text{V}} = \boxed{5.00\ \text{A}}$

and $\quad R = \dfrac{\Delta V}{I} = \dfrac{120\ \text{V}}{5.00\ \text{A}} = \boxed{24.0\ \Omega}$

17.32 The energy produced by the Sun in 1.0 second is

$$E = \wp\cdot t = \left(4.0\times10^{26}\ \text{W}\right)(1.0\ \text{s})$$

$$= 4.0\times10^{26}\ \text{W}\cdot\text{s}\left(\frac{1\ \text{kW}}{10^3\ \text{W}}\right)\left(\frac{1\ \text{h}}{3600\ \text{s}}\right) = 1.1\times10^{20}\ \text{kWh}$$

At a rate of 8.0¢ per kilowatt-hour, the cost of this energy is

$$cost = \left(1.1\times10^{20}\ \text{kWh}\right)\left(\frac{\$0.08}{\text{kWh}}\right) = \boxed{8.8\times10^{18}\ \text{dollars}}$$

17.33 The maximum power that can be dissipated in the circuit is

$$\wp_{max} = (\Delta V)I_{max} = (120\ \text{V})(15\ \text{A}) = 1.8\times10^3\ \text{W}$$

Thus, one can operate at most $\boxed{\text{18 bulbs}}$ rated at 100 W per bulb.

17.34 (a) The power loss in the line is

$$\wp_{loss} = I^2R = (1000\ \text{A})^2\left[(0.31\ \Omega/\text{km})(160\ \text{km})\right] = 5.0\times10^7\ \text{W} = \boxed{50\ \text{MW}}$$

(b) The total power transmitted is

$$\wp_{input} = (\Delta V)I = (700\times10^3\ \text{V})(1000\ \text{A}) = 7.0\times10^8\ \text{W} = 700\ \text{MW}$$

Thus, the fraction of the total transmitted power represented by the line losses is

$$fraction\ loss = \frac{\wp_{loss}}{\wp_{input}} = \frac{50\ \text{MW}}{700\ \text{MW}} = 0.071\ \text{or}\ \boxed{7.1\%}$$

17.35 The energy required to bring the water to the boiling point is

$$E = mc(\Delta T) = (0.500\ \text{kg})(4186\ \text{J/kg}\cdot{}^\circ\text{C})(100^\circ\text{C} - 23.0^\circ\text{C}) = 1.61\times10^5\ \text{J}$$

The power input by the heating element is

$$\wp_{input} = (\Delta V)I = (120\ \text{V})(2.00\ \text{A}) = 240\ \text{W} = 240\ \text{J/s}$$

Therefore, the time required is

$$t = \frac{E}{\wp_{input}} = \frac{1.61\times10^5\ \text{J}}{240\ \text{J/s}} = 672\ \text{s}\left(\frac{1\ \text{min}}{60\ \text{s}}\right) = \boxed{11.2\ \text{min}}$$

17.36 (a) $E = \wp\cdot t = (90\ \text{W})(1\ \text{h}) = (90\ \text{J/s})(3600\ \text{s}) = 3.2\times10^5\ \text{J}$

(b) The power consumption of the color set is

$$\wp = (\Delta V)I = (120\ \text{V})(2.50\ \text{A}) = 300\ \text{W}$$

Therefore, the time required to consume the energy found in (a) is

$$t = \frac{E}{\wp} = \frac{3.2\times10^5\ \text{J}}{300\ \text{J/s}} = 1.1\times10^3\ \text{s}\left(\frac{1\ \text{min}}{60\ \text{s}}\right) = \boxed{18\ \text{min}}$$

17.37 The energy input required is

$$E = mc(\Delta T) = (1.50\text{ kg})(4186\text{ J/kg}\cdot{}^\circ\text{C})(50.0^\circ\text{C} - 10.0^\circ\text{C}) = 2.51\times10^5\text{ J}$$

and, if this is to be added in $\Delta t = 10.0\text{ min} = 600\text{ s}$, the power input needed is

$$\wp = \frac{E}{\Delta t} = \frac{2.51\times10^5\text{ J}}{600\text{ s}} = 419\text{ W}$$

The power input to the heater may be expressed as $\wp = (\Delta V)^2/R$, so the needed resistance is

$$R = \frac{(\Delta V)^2}{\wp} = \frac{(120\text{ V})^2}{419\text{ W}} = \boxed{34.4\ \Omega}$$

17.38 (a) At the operating temperature,

$$\wp = (\Delta V)I = (120\text{ V})(1.53\text{ A}) = \boxed{184\text{ W}}$$

(b) From $R = R_0\left[1+\alpha(T-T_0)\right]$, the temperature T is given by $T = T_0 + \dfrac{R-R_0}{\alpha R_0}$. The resistances are given by Ohm's law as

$$R = \frac{(\Delta V)}{I} = \frac{120\text{ V}}{1.53\text{ A}},\text{ and } R_0 = \frac{(\Delta V)_0}{I_0} = \frac{120\text{ V}}{1.80\text{ A}}$$

Therefore, the operating temperature is

$$T = 20.0^\circ\text{C} + \frac{(120/1.53) - (120/1.80)}{\left(0.400\times10^{-3}\ (^\circ\text{C})^{-1}\right)(120/1.80)} = \boxed{461^\circ\text{C}}$$

17.39 The resistance per unit length of the cable is

$$\frac{R}{L}=\frac{\wp/I^2}{L}=\frac{\wp/L}{I^2}=\frac{2.00\ \text{W/m}}{(300\ \text{A})^2}=2.22\times10^{-5}\ \Omega/\text{m}$$

From $R=\rho L/A$, the resistance per unit length is also given by $R/L=\rho/A$. Hence, the cross-sectional area is $\pi r^2=A=\frac{\rho}{R/L}$, and the required radius is

$$r=\sqrt{\frac{\rho}{\pi(R/L)}}=\sqrt{\frac{1.7\times10^{-8}\ \Omega\cdot\text{m}}{\pi(2.22\times10^{-5}\ \Omega/\text{m})}}=0.016\ \text{m}=\boxed{1.6\ \text{cm}}$$

17.40 (a) The power input to the motor is

$$\wp_{input}=(\Delta V)I=(120\ \text{V})(1.75\ \text{A})=210\ \text{W}=0.210\ \text{kW}.$$

At a rate of \$0.06/kWh, the cost of operating this motor for 4.0 h is

$$cost=(Energy\ used)\cdot rate=\left(\wp_{input}\cdot t\right)\cdot rate$$

$$=(0.210\ \text{kW})(4.0\ \text{h})(6.0\ \text{cents/kWh})=\boxed{5.0\ \text{cents}}$$

(b) The efficiency is

$$Eff=\frac{\wp_{output}}{\wp_{input}}=\frac{(0.20\ \text{hp})(0.746\ \text{kW/hp})}{0.210\ \text{kW}}=0.71\ \text{or}\ \boxed{71\%}$$

17.41 The total power converted by the clocks is

$$\wp=(2.50\ \text{W})\left(270\times10^6\right)=6.75\times10^8\ \text{W},$$

and the energy used in one hour is

$$E=\wp\cdot t=\left(6.75\times10^8\ \text{W}\right)(3600\ \text{s})=2.43\times10^{12}\ \text{J}.$$

The energy input required from the coal is

$$E_{coal}=\frac{E}{efficiency}=\frac{2.43\times10^{12}\ \text{J}}{0.250}=9.72\times10^{12}\ \text{J}$$

The required mass of coal is thus

$$m = \frac{E_{coal}}{heat\ of\ combustion} = \frac{9.72 \times 10^{12}\ \text{J}}{33.0 \times 10^{6}\ \text{J/kg}} = 2.95 \times 10^{5}\ \text{kg}$$

or $$m = \left(2.95 \times 10^{5}\ \text{kg}\right)\left(\frac{1\ \text{metric ton}}{10^{3}\ \text{kg}}\right) = \boxed{295\ \text{metric tons}}$$

17.42 (a) $E = \wp \cdot t = (40.0\ \text{W})(14.0\ \text{d})(24.0\ \text{h/d}) = 1.34 \times 10^{4}\ \text{Wh} = 13.4\ \text{kWh}$

$$cost = E \cdot (rate) = (13.4\ \text{kWh})(\$0.120/\text{kWh}) = \boxed{\$1.61}$$

(b) $E = \wp \cdot t = (0.970\ \text{kW})(3.00\ \text{min})(1\ \text{h}/60\ \text{min}) = 4.85 \times 10^{-2}\ \text{kWh}$

$$cost = E \cdot (rate)$$

$$= \left(4.85 \times 10^{-2}\ \text{kWh}\right)(\$0.120/\text{kWh}) = \$0.00583 = \boxed{0.583\ \text{cents}}$$

(c) $E = \wp \cdot t = (5.20\ \text{kW})(40.0\ \text{min})(1\ \text{h}/60\ \text{min}) = 3.47\ \text{kWh}$

$$cost = E \cdot (rate) = (3.47\ \text{kWh})(\$0.120/\text{kWh}) = \$0.416 = \boxed{41.6\ \text{cents}}$$

17.43 $E = \wp \cdot t = (0.180\ \text{kW})(21\ \text{h})$ and $cost = E \cdot rate = (\wp \cdot t)(\$0.0700/\text{kWh})$,

so $$cost = [(0.180\ \text{kW})(21\ \text{h})](\$0.0700/\text{kWh}) = \$0.26 = \boxed{26\ \text{cents}}$$

17.44 The energy used was $E = \frac{cost}{rate} = \frac{\$200}{\$0.080/\text{kWh}} = 2.5 \times 10^{3}\ \text{kWh}$.

The total time the furnace operated was $t = \frac{E}{\wp} = \frac{2.5 \times 10^{3}\ \text{kWh}}{24\ \text{kW}} = 104\ \text{h}$, and since January has 31 days, the average time per day was

$$average\ daily\ operation = \frac{104\ \text{h}}{31\ \text{d}} = \boxed{3.4\ \text{h/d}}$$

17.45 The energy saved is

$$\Delta E = \left(\wp_{high} - \wp_{low}\right) \cdot t = (40\text{ W} - 11\text{ W})(100\text{ h}) = 2.9 \times 10^3\text{ Wh} = 2.9\text{ kWh},$$

and the monetary savings is

$$savings = \Delta E \cdot rate = (2.9\text{ kWh})(\$0.080/\text{kWh}) = \$0.23 = \boxed{23\text{ cents}}$$

17.46 The power needed is $\wp = 1500\ \dfrac{\text{kcal}}{\text{h}}\left(\dfrac{4186\text{ J}}{1\text{ kcal}}\right)\left(\dfrac{1\text{ h}}{3600\text{ s}}\right) = 1744\text{ W}$,

so the current required is $I = \dfrac{\wp}{\Delta V} = \dfrac{1744\text{ W}}{110\text{ V}} = 15.9\text{ A}$

Thus, you should $\boxed{\text{use the 20-A fuse}}$.

17.47 The energy that must be added to the water is

$$E = mc(\Delta T) = (200\text{ kg})\left(4186\ \frac{\text{J}}{\text{kg} \cdot {}^\circ\text{C}}\right)(80^\circ\text{C} - 15^\circ\text{C})\left(\frac{1\text{ kWh}}{3.60 \times 10^6\text{ J}}\right) = 15\text{ kWh}$$

and the cost is $cost = E \cdot rate = (15\text{ kWh})(\$0.080/\text{kWh}) = \boxed{\$1.2}$

17.48 (a) From $\wp = (\Delta V)^2/R$, the resistance of each bulb is

$$R_{dim} = \frac{(\Delta V)^2}{\wp_{dim}} = \frac{(120\text{ V})^2}{25.0\text{ W}} = \boxed{576\ \Omega}\text{ and}$$

$$R_{bright} = \frac{(\Delta V)^2}{\wp_{bright}} = \frac{(120\text{ V})^2}{100\text{ W}} = \boxed{144\ \Omega}$$

(b) The current in the dim bulb is

$$I = \frac{\wp_{dim}}{\Delta V} = \frac{25.0 \text{ W}}{120 \text{ V}} = 0.208 \text{ A},$$

so the time for 1.00 C to pass through the bulb is

$$\Delta t = \frac{\Delta Q}{I} = \frac{1.00 \text{ C}}{0.208 \text{ A}} = \boxed{4.80 \text{ s}}$$

When the charge emerges from the bulb, it has $\boxed{\text{lower potential energy}}$

(c) The time for the dim bulb to dissipate 1.00 J of energy is

$$\Delta t = \frac{\Delta E}{\wp_{dim}} = \frac{1.00 \text{ J}}{25.0 \text{ W}} = \boxed{0.0400 \text{ s}}$$

Electrical potential energy is $\boxed{\text{transformed into internal energy and light}}$

(d) In 30.0 days, the energy used by the dim bulb is

$$E = \wp_{dim} \cdot t = (25.0 \text{ W})(30.0 \text{ d})(24.0 \text{ h/d}) = 1.80 \times 10^4 \text{ Wh} = 18.0 \text{ kWh}$$

and the cost is $cost = E \cdot rate = (18.0 \text{ kWh})(\$0.0700/\text{kWh}) = \boxed{\$1.26}$

The electric company sells $\boxed{\text{energy}}$, and the unit cost is

$$unit\ cost = \left(\frac{\$0.0700}{\text{kWh}}\right)\left(\frac{1 \text{ kWh}}{3.60 \times 10^6 \text{ J}}\right) = \boxed{\$1.94 \times 10^{-8}/\text{Joule}}$$

17.49 From $\wp = (\Delta V)^2/R$, the total resistance needed is

$$R = \frac{(\Delta V)^2}{\wp} = \frac{(20 \text{ V})^2}{48 \text{ W}} = 8.3 \ \Omega$$

Thus, from $R = \rho L/A$, the length of wire required is

$$L = \frac{R \cdot A}{\rho} = \frac{(8.3 \ \Omega)(4.0 \times 10^{-6} \text{ m}^2)}{3.0 \times 10^{-8} \ \Omega \cdot \text{m}} = 1.1 \times 10^3 \text{ m} = \boxed{1.1 \text{ km}}$$

17.50 (a) The power required by the iron is

$$\wp = (\Delta V)I = (120\text{ V})(6.0\text{ A}) = 7.2\times10^{2}\text{ W},$$

and the energy transformed in 20 minutes is

$$E = \wp\cdot t = \left(7.2\times10^{2}\ \frac{\text{J}}{\text{s}}\right)\left[(20\text{ min})\left(\frac{60\text{ s}}{1\text{ min}}\right)\right] = \boxed{8.6\times10^{5}\text{ J}}$$

(b) The cost of operating the iron for 20 minutes is

$$cost = E\cdot rate$$

$$= \left[(8.6\times10^{5}\text{ J})\left(\frac{1\text{ kWh}}{3.60\times10^{6}\text{ J}}\right)\right](\$0.080/\text{kWh}) = \$0.019 = \boxed{1.9\text{ cents}}$$

17.51 Ohm's law gives the resistance as $R = (\Delta V)/I$. From $R = \rho L/A$, the resistivity is given by $\rho = R\cdot(A/L)$. The results of these calculations for each of the three wires are summarized in the table below.

L (m)	R (Ω)	ρ ($\Omega\cdot$m)
0.540	10.4	1.41×10^{-6}
1.028	21.1	1.50×10^{-6}
1.543	31.8	1.50×10^{-6}

The average value found for the resistivity is

$$\bar{\rho} = \frac{\Sigma\rho_i}{3} = \boxed{1.47\times10^{-6}\ \Omega\cdot\text{m}}$$

which differs from the value of $\rho = 150\times10^{-8}\ \Omega\cdot\text{m} = 1.50\times10^{-6}\ \Omega\cdot\text{m}$ given in Table 17.1 by $\boxed{2.0\%}$.

17.52 The resistance of the 4.0 cm length of wire between the feet is

$$R = \frac{\rho L}{A} = \frac{(1.7\times10^{-8}\ \Omega\cdot\text{m})(0.040\text{ m})}{\pi(0.011\text{ m})^{2}} = 1.79\times10^{-6}\ \Omega,$$

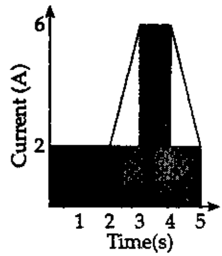
so the potential difference is

$$\Delta V = IR = (50\text{ A})(1.79\times10^{-6}\ \Omega) = 8.9\times10^{-5}\text{ V} = \boxed{89\ \mu\text{V}}$$

17.53 The period of the revolving charge is $T = \dfrac{2\pi}{\omega} = \dfrac{2\pi}{100\pi \text{ rad/s}} = 2.00 \times 10^{-2}$ s, so the average current is

$$I = \frac{\Delta Q}{\Delta t} = \frac{q}{T} = \frac{8.00 \times 10^{-9}\text{ C}}{2.00 \times 10^{-2}\text{ s}} = 4.00 \times 10^{-7}\text{ A} = \boxed{0.400\ \mu\text{A}}$$

17.54 (a) The charge passing through the conductor in the interval $0 \le t \le 5.0$ s is represented by the area under the I vs t graph given in Figure P17.54. This area consists of two rectangles and two triangles. Thus,



$$\Delta Q = A_{rectangle\,1} + A_{rectangle\,2} + A_{triangle\,1} + A_{triangle\,2}$$

$$= (5.0\text{ s} - 0)(2.0\text{ A} - 0) + (4.0\text{ s} - 3.0\text{ s})(6.0\text{ A} - 2.0\text{ A})$$

$$+ \frac{1}{2}(3.0\text{ s} - 2.0\text{ s})(6.0\text{ A} - 2.0\text{ A}) + \frac{1}{2}(5.0\text{ s} - 4.0\text{ s})(6.0\text{ A} - 2.0\text{ A})$$

$$\Delta Q = \boxed{18\text{ C}}$$

(b) The constant current that would pass the same charge in 5.0 s is

$$I = \frac{\Delta Q}{\Delta t} = \frac{18\text{ C}}{5.0\text{ s}} = \boxed{3.6\text{ A}}$$

17.55 (a) From $\wp = (\Delta V)I$, the current is $I = \dfrac{\wp}{\Delta V} = \dfrac{8.00 \times 10^{3}\text{ W}}{12.0\text{ V}} = \boxed{667\text{ A}}$

(b) The time before the stored energy is depleted is

$$t = \frac{E_{storage}}{\wp} = \frac{2.00 \times 10^{7}\text{ J}}{8.00 \times 10^{3}\text{ J/s}} = 2.50 \times 10^{3}\text{ s}$$

Thus, the distance traveled is

$$d = v \cdot t = (20.0\text{ m/s})(2.50 \times 10^{3}\text{ s}) = 5.00 \times 10^{4}\text{ m} = \boxed{50.0\text{ km}}$$

17.56 The volume of aluminum available is

$$V = \frac{mass}{density} = \frac{115 \times 10^{-3}\ \text{kg}}{2.70 \times 10^{3}\ \text{kg/m}^3} = 4.26 \times 10^{-5}\ \text{m}^3$$

(a) For a cylinder whose height equals the diameter, the volume is

$$V = \left(\frac{\pi d^2}{4}\right) d = \frac{\pi d^3}{4},$$

and the diameter is $d = \left(\frac{4V}{\pi}\right)^{1/3} = \left[\frac{4\left(4.26 \times 10^{-5}\ \text{m}^3\right)}{\pi}\right]^{1/3} = 0.03785\ \text{m}$

The resistance between ends is then

$$R = \frac{\rho L}{A} = \frac{\rho d}{\left(\pi d^2/4\right)} = \frac{4\rho}{\pi d} = \frac{4\left(2.82 \times 10^{-8}\ \Omega \cdot \text{m}\right)}{\pi(0.03785\ \text{m})} = \boxed{9.49 \times 10^{-7}\ \Omega}$$

(b) For a cube, $V = L^3$, so the length of an edge is

$$L = (V)^{1/3} = \left(4.26 \times 10^{-5}\ \text{m}\right)^{1/3} = 0.0349\ \text{m}$$

The resistance between opposite faces is

$$R = \frac{\rho L}{A} = \frac{\rho L}{L^2} = \frac{\rho}{L} = \frac{2.82 \times 10^{-8}\ \Omega \cdot \text{m}}{0.0349\ \text{m}} = \boxed{8.07 \times 10^{-7}\ \Omega}$$

17.57 The current in the wire is $I = \frac{\Delta V}{R} = \frac{15.0\ \text{V}}{0.100\ \Omega} = 150\ \text{A}$

Then, from $v_d = I/nqA$, the density of free electrons is

$$n = \frac{I}{v_d e\left(\pi r^2\right)} = \frac{150\ \text{A}}{\left(3.17 \times 10^{-4}\ \text{m/s}\right)\left(1.60 \times 10^{-19}\ \text{C}\right)\pi\left(5.00 \times 10^{-3}\ \text{m}\right)^2},$$

or $$n = \boxed{3.77 \times 10^{28}/\text{m}^3}$$

17.58 At temperature T, the resistance of the carbon wire is $R_c = R_{0c}\left[1+\alpha_c\left(T-T_0\right)\right]$, and that of the nichrome wire is $R_n = R_{0n}\left[1+\alpha_n\left(T-T_0\right)\right]$. When the wires are connected end to end, the total resistance is

$$R = R_c + R_n = \left(R_{0c}+R_{0n}\right)+\left(R_{0c}\alpha_c + R_{0n}\alpha_n\right)\left(T-T_0\right)$$

If this is to have a constant value of $10.0\ \text{k}\Omega$ as the temperature changes, it is necessary that

$$R_{0c}+R_{0n} = 10.0\ \text{k}\Omega \qquad (1)$$

and $$R_{0c}\alpha_c + R_{0n}\alpha_n = 0 \qquad (2)$$

From equation (1), $R_{0c} = 10.0\ \text{k}\Omega - R_{0n}$, and substituting into equation (2) gives

$$\left(10.0\ \text{k}\Omega - R_{0n}\right)\left[-0.50\times10^{-3}\ (°\text{C})^{-1}\right]+R_{0n}\left[0.40\times10^{-3}\ (°\text{C})^{-1}\right]=0$$

Solving this equation gives $R_{0n} = \boxed{5.6\ \text{k}\Omega\ \text{(nichrome wire)}}$

Then, $R_{0c} = 10.0\ \text{k}\Omega - 5.6\ \text{k}\Omega = \boxed{4.4\ \text{k}\Omega\ \text{(carbon wire)}}$

17.59 (a) From $\wp = \dfrac{(\Delta V)^2}{R}$, the resistance is $R = \dfrac{(\Delta V)^2}{\wp} = \dfrac{(120\ \text{V})^2}{100\ \text{W}} = 144\ \Omega$

(b) Solving $R = \dfrac{\rho L}{A}$ for the length gives

$$L = \frac{R\cdot A}{\rho} = \frac{(144\ \Omega)\left(0.010\ \text{mm}^2\right)}{5.6\times10^{-8}\ \Omega\cdot\text{m}}\left(\frac{1\ \text{m}^2}{10^6\ \text{mm}^2}\right) = 26\ \text{m}$$

(c) The filament is tightly coiled $\boxed{\text{to fit the required length into a small space}}$

(d) From $L = L_0\left[1+\alpha\left(T-T_0\right)\right]$, where $\alpha = 4.5\times10^{-6}\ (°\text{C})^{-1}$, the length at $T_0 = 20°\text{C}$ is

$$L_0 = \frac{L}{1+\alpha\left(T-T_0\right)} = \frac{26\ \text{m}}{1+\left(4.5\times10^{-6}\ (°\text{C})^{-1}\right)(2600°\text{C}-20°\text{C})} = \boxed{25\ \text{m}}$$

17.60 Each speaker has a resistance of $R = 4.00\ \Omega$ and can handle 60.0 W of power. From $\wp = I^2 R$, the maximum safe current is

$$I_{max} = \sqrt{\frac{\wp}{R}} = \sqrt{\frac{60.0\ \text{W}}{4.00\ \Omega}} = 3.87\ \text{A}$$

Thus, the system $\boxed{\text{is not adequately protected}}$ by a 4.00 A fuse.

17.61 The cross-sectional area of the conducting material is $A = \pi\left(r_{outer}^2 - r_{inner}^2\right)$.

Thus,

$$R = \frac{\rho L}{A} = \frac{\left(3.5\times10^5\ \Omega\cdot\text{m}\right)\left(4.0\times10^{-2}\ \text{m}\right)}{\pi\left[\left(1.2\times10^{-2}\ \text{m}\right)^2 - \left(0.50\times10^{-2}\ \text{m}\right)^2\right]} = 3.7\times10^7\ \Omega = \boxed{37\ \text{M}\Omega}$$

17.62 (a)

ΔV	I	$R = \Delta V/I$
−1.5 V	-0.30×10^{-5} A	$5.0\times10^5\ \Omega$
−1.0 V	-0.20×10^{-5} A	$5.0\times10^5\ \Omega$
−0.50 V	-0.10×10^{-5} A	$5.0\times10^5\ \Omega$
+0.40 V	+0.010 A	40 Ω
+0.50 V	+0.020 A	25 Ω
+0.55 V	+0.040 A	14 Ω
+0.70 V	+0.072 A	9.7 Ω
+0.75 V	+0.10 A	7.5 Ω

(b) The resistance of the diode is very large when the applied potential difference has one polarity, and is rather small when the potential difference has the opposite polarity.

17.63 The power the beam delivers to the target is

$$\wp = (\Delta V)I = \left(4.0\times10^{6}\text{ V}\right)\left(25\times10^{-3}\text{ A}\right) = 1.0\times10^{5}\text{ W}.$$

The mass of cooling water that must flow through the tube each second if the rise in the water temperature is not to exceed 50°C is found from $\wp = (\Delta m/\Delta t)c(\Delta T)$ as

$$\frac{\Delta m}{\Delta t} = \frac{\wp}{c(\Delta T)} = \frac{1.0\times10^{5}\text{ J/s}}{(4186\text{ J/kg}\cdot{}^\circ\text{C})(50^\circ\text{C})} = \boxed{0.48\text{ kg/s}}$$

17.64 The volume of the material is

$$V = \frac{mass}{density} = \frac{50.0\text{ g}}{7.86\text{ g/cm}^3}\left(\frac{1\text{ m}^3}{10^6\text{ cm}^3}\right) = 6.36\times10^{-6}\text{ m}^3$$

Since $V = A\cdot L$, the cross-sectional area of the wire is $A = V/L$.

(a) From $R = \dfrac{\rho L}{A} = \dfrac{\rho L}{V/L} = \dfrac{\rho L^2}{V}$, the length of the wire is given by

$$L = \sqrt{\frac{R\cdot V}{\rho}} = \sqrt{\frac{(1.5\ \Omega)\left(6.36\times10^{-6}\text{ m}^3\right)}{11\times10^{-8}\ \Omega\cdot\text{m}}} = \boxed{9.3\text{ m}}$$

(b) The cross-sectional area of the wire is $A = \dfrac{\pi d^2}{4} = \dfrac{V}{L}$. Thus, the diameter is

$$d = \sqrt{\frac{4V}{\pi L}} = \sqrt{\frac{4\left(6.36\times10^{-6}\text{ m}^3\right)}{\pi(9.3\text{ m})}} = 9.3\times10^{-4}\text{ m} = \boxed{0.93\text{ mm}}$$

17.65 (a) The cross-sectional area of the copper in the hollow tube is

$$A = (circumference)\cdot(thickness) = (0.080\text{ m})\left(2.0\times10^{-3}\text{ m}\right) = 1.6\times10^{-4}\text{ m}^2$$

Thus, the resistance of this tube is

$$R = \frac{\rho L}{A} = \frac{\left(1.7\times10^{-8}\ \Omega\cdot\text{m}\right)(0.24\text{ m})}{1.6\times10^{-4}\text{ m}^2} = \boxed{2.6\times10^{-5}\ \Omega}$$

(b) The mass may be written as $m = (density)\cdot Volume = (density)\cdot A\cdot L$.

From $R = \rho L/A$, the cross-sectional area is $A = \rho L/R$, so the expression for the mass becomes

$$m = (density)\cdot\frac{\rho L^2}{R} = (8920\ \text{kg/m}^3)\cdot\frac{(1.7\times10^{-8}\ \Omega\cdot\text{m})(1500\ \text{m})^2}{4.5\ \Omega} = \boxed{76\ \text{kg}}$$

17.66 (a) At temperature T, the resistance is $R = \dfrac{\rho L}{A}$, where $\rho = \rho_0\left[1+\alpha(T-T_0)\right]$,

$L = L_0\left[1+\alpha'(T-T_0)\right]$, and $A = A_0\left[1+\alpha'(T-T_0)\right]^2 \approx A_0\left[1+2\alpha'(T-T_0)\right]$

Thus,

$$R = \left(\frac{\rho_0 L_0}{A_0}\right)\frac{\left[1+\alpha(T-T_0)\right]\cdot\left[1+\alpha'(T-T_0)\right]}{\left[1+2\alpha'(T-T_0)\right]} = \boxed{\frac{R_0\left[1+\alpha(T-T_0)\right]\cdot\left[1+\alpha'(T-T_0)\right]}{\left[1+2\alpha'(T-T_0)\right]}}$$

(b) $$R_0 = \frac{\rho_0 L_0}{A_0} = \frac{(1.7\times10^{-8}\ \Omega\cdot\text{m})(2.00\ \text{m})}{\pi(0.100\times10^{-3})^2} = 1.082\ \Omega$$

Then $R = R_0\left[1+\alpha(T-T_0)\right]$ gives

$$R = (1.082\ \Omega)\left[1+(3.9\times10^{-3}/^\circ\text{C})(80.0^\circ\text{C})\right] = \boxed{1.420\ \Omega}$$

The more complex formula gives

$$R = \frac{(1.420\ \Omega)\cdot\left[1+(17\times10^{-6}/^\circ\text{C})(80.0^\circ\text{C})\right]}{\left[1+2(17\times10^{-6}/^\circ\text{C})(80.0^\circ\text{C})\right]} = \boxed{1.418\ \Omega}$$