Chapter 17

ANSWERS TO MULTIPLE CHOICE QUESTIONS

6. When the potential across the device is 2 V, the current is 2 A, so the resistance is $R = \Delta V/I = 2\text{ V}/2\text{ A} = 1\ \Omega$, and (a) is the correct choice.

7. The power consumption of the set is $P = (\Delta V)I = (120\text{ V})(2.5\text{ A}) = 3.0\times10^2\text{ W} = 0.30\text{ kW}$. Thus, the energy used in 8.0 h of operation is $E = P\cdot t = (0.30\text{ kW})(8.0\text{ h}) = 2.4\text{ kWh}$, at a cost of $cost = (2.4\text{ kWh})(8.0\text{ cents/kWh}) = 19$ cents. The correct choice is (c).

9. When the potential difference across the device is 3.0 V, the current is 2.5 A, so the resistance is $R = \Delta V/I = 3.0\text{ V}/2.5\text{ A} = 1.2\ \Omega$, and (b) is the correct choice.

10. Resistors in a parallel combination all have the same potential difference across them. Thus, from Ohm's law, $I = \Delta V/R$, the resistor with the smallest resistance carries the largest current. Choice (a) is the correct response.

11. The current through the resistor is $I = \Delta V/R = 1.0\text{ V}/10.0\ \Omega = 0.10\text{ A}$, and the charge passing through in a 20 s interval is $\Delta Q = I\cdot\Delta t = (0.10\text{ C/s})(20\text{ s}) = 2.0\text{ C}$. Thus, (c) is the correct choice.

12. Resistors in a series combination all carry the same current. Thus, from Ohm's law, $\Delta V = IR$, the resistor with the highest resistance has the greatest voltage drop across it. Choice (c) is the correct response.

13. $$\frac{P_A}{P_B} = \frac{(\Delta V)^2/R_A}{(\Delta V)^2/R_B} = \frac{R_B}{R_A} = \frac{\rho L_B/A_B}{\rho L_A/A_A} = \frac{\rho L_B/(\pi d_B^2/4)}{\rho L_A/(\pi d_A^2/4)} = \left(\frac{L_B}{L_A}\right)\left(\frac{d_A}{d_B}\right)^2 = \left(\frac{1}{2}\right)(2)^2 = 2$$

Thus, $P_A/P_B = 2$, and the correct choice is (c).

ANSWERS TO EVEN NUMBERED CONCEPTUAL QUESTIONS

6. (a) The 25 W bulb has the higher resistance. Because $R = (\Delta V)^2/P$, and both operate from 120 V, the bulb dissipating the least power has the higher resistance.

(b) When the voltage is constant, the current and power are directly proportional to each other, $P = (\Delta V)I = (\text{constant})I$. Thus, the higher power bulb (100 W) carries more current.

8. An electrical shock occurs when your body serves as a conductor between two points having a difference in potential. The concept behind the admonition is to avoid simultaneously touching points that are at different potentials.

10. The knob is connected to a variable resistor. As you increase the magnitude of the resistance in the circuit, the current is reduced, and the bulb dims.

PROBLEM SOLUTIONS

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

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

17.25 The volume of the gold wire may be written as $V = A\cdot L = m/\rho_d$, where ρ_d is the density of gold. Thus, the cross-sectional area is $A = m/\rho_d L$. The resistance of the wire is $R = \rho_e L/A$, where ρ_e is the electrical resistivity. Therefore,

$$R = \frac{\rho_e L}{m/\rho_d L} = \frac{\rho_e\rho_d L^2}{m} = \frac{(2.44\times10^{-8}\ \Omega\cdot\text{m})(19.3\times10^3\text{ kg/m}^3)(2.40\times10^3\text{ m})^2}{1.00\times10^{-3}\text{ kg}}$$

giving $R = 2.71\times10^6\ \Omega = \boxed{2.71\text{ M}\Omega}$

17.33 (a) The power consumed by the device is $P = I(\Delta V)$, so the current must be

$$I = \frac{P}{\Delta V} = \frac{1.00\times10^3\ \text{W}}{1.20\times10^2\ \text{V}} = \boxed{8.33\ \text{A}}$$

(b) From Ohm's law, the resistance is $R = \frac{\Delta V}{I} = \frac{1.20\times10^2\ \text{V}}{8.33\ \text{A}} = \boxed{14.4\ \Omega}$

17.35 (a) $R_{\text{Cu}} = \frac{\rho_{\text{Cu}} L}{A} = \frac{4\rho_{\text{Cu}} L}{\pi d^2} = \frac{4(1.7\times10^{-8}\ \Omega\cdot\text{m})(1.00\ \text{m})}{\pi(0.205\times10^{-2}\ \text{m})^2} = 5.2\times10^{-3}\ \Omega$

and $P_{\text{Cu}} = I^2 R_{\text{Cu}} = (20.0\ \text{A})^2(5.2\times10^{-3}\ \Omega) = \boxed{2.1\ \text{W}}$

(b) $R_{\text{Al}} = \frac{\rho_{\text{Al}} L}{A} = \frac{4\rho_{\text{Al}} L}{\pi d^2} = \frac{4(2.82\times10^{-8}\ \Omega\cdot\text{m})(1.00\ \text{m})}{\pi(0.205\times10^{-2}\ \text{m})^2} = 8.54\times10^{-3}\ \Omega$

and $P_{\text{Al}} = I^2 R_{\text{Al}} = (20.0\ \text{A})^2(8.54\times10^{-3}\ \Omega) = \boxed{3.42\ \text{W}}$

(c) $\boxed{\text{No}}$, the aluminum wire would not be as safe. If surrounded by thermal insulation, it would get much hotter than the copper wire.

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

$$E = mc(\Delta T) = (0.500\ \text{kg})(4\,186\ \text{J/kg}\cdot{}^\circ\text{C})(100^\circ\text{C} - 23.0^\circ\text{C}) = 1.61\times10^5\ \text{J}$$

The power input by the heating element is

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

Therefore, the time required is

$$t = \frac{E}{P_{\text{input}}} = \frac{1.61\times10^5\ \text{J}}{240\ \text{J/s}} = 671\ \text{s}\left(\frac{1\ \text{min}}{60\ \text{s}}\right) = \boxed{11.2\ \text{min}}$$

17.39 (a) $R_{\text{A}} = \frac{(\Delta V)^2}{P_{\text{A}}} = \frac{(120\ \text{V})^2}{25.0\ \text{W}} = \boxed{576\ \Omega}$

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

(b) $\Delta t_{\text{A}} = \frac{Q}{I_{\text{A}}} = Q\left(\frac{R_{\text{A}}}{\Delta V}\right) = (1.00\ \text{C})\left(\frac{576\ \Omega}{120\ \text{V}}\right) = \boxed{4.80\ \text{s}}$

(c) The charge is the same. However, as it leaves the bulb, it is at a lower potential than when it entered the bulb.

(d) $P = \frac{W}{\Delta t}$, so $\Delta t_{\text{A}} = \frac{W}{P_{\text{A}}} = \frac{1.00\ \text{J}}{25.0\ \text{J/s}} = \boxed{0.040\,0\ \text{s}}$

(e) Energy enters the bulb by electrical transmission and leaves by heat and radiation.

(f) $E = P_{\text{A}}(\Delta t) = \left[(25.0\ \text{W})\left(\frac{1\ \text{kW}}{10^3\ \text{W}}\right)\right]\left[(30.0\ \text{d})\left(\frac{24.0\ \text{h}}{1\ \text{d}}\right)\right] = 18.0\ \text{kWh}$

and $cost = E\times rate = (18.0\ \text{kWh})(\$0.110/\text{kWh}) = \boxed{\$1.98}$

17.43 $P = (\Delta V)I = (75.0\times10^{-3}\ \text{V})(0.200\times10^{-3}\ \text{A}) = 1.50\times10^{-5}\ \text{W} = 15.0\times10^{-6}\ \text{W} = \boxed{15.0\ \mu\text{W}}$

17.45 Total length of transmission lines: $L = 2(50.0\ \text{m}) = 100\ \text{m}$. Thus, the resistance of these lines is $R = (0.108\ \Omega/300\ \text{m})(100\ \text{m}) = 3.60\times10^{-2}\ \Omega$.

(a) The total potential drop along the transmission lines is $(\Delta V)_{\text{lines}} = IR$, giving

$$(\Delta V)_{\text{house}} = (\Delta V)_{\text{source}} - (\Delta V)_{\text{lines}} = 120\ \text{V} - (110\ \text{A})(3.60\times10^{-2}\ \Omega) = \boxed{116\ \text{V}}$$

(b) $P_{\text{delivered}} = I(\Delta V)_{\text{house}} = (110\ \text{A})(116\ \text{V}) = 1.28\times10^{4}\ \text{W} = \boxed{12.8\ \text{kW}}$

17.47 The power dissipated in a conductor is $P = (\Delta V)^2/R$, so the resistance may be written as $R = (\Delta V)^2/P$. Hence,

$$\frac{R_B}{R_A} = \frac{\cancel{(\Delta V)^2}}{P_B}\cdot\frac{P_A}{\cancel{(\Delta V)^2}} = \frac{P_A}{P_B} = 3 \qquad \text{or} \qquad R_B = 3R_A$$

Since $R = \rho L/A = \rho L/(\pi d^2/4)$, this result becomes

$$\frac{\cancel{4\rho L}}{\cancel{\pi} d_B^2} = 3\left(\frac{\cancel{4\rho L}}{\cancel{\pi} d_A^2}\right) \qquad \text{or} \qquad \frac{d_A^2}{d_B^2} = 3$$

and yields $\boxed{d_A/d_B = \sqrt{3}}$.