Chapter 26

7. The cross-sectional area of wire is given by $A = \pi r^2$, where r is its radius (half its thickness). The magnitude of the current density vector is

$$J = i/A = i/\pi r^2,$$

so

$$r = \sqrt{\frac{i}{\pi J}} = \sqrt{\frac{0.50\ \text{A}}{\pi\left(440\times10^4\ \text{A/m}^2\right)}} = 1.9\times10^{-4}\ \text{m}.$$

The diameter of the wire is therefore $d = 2r = 2(1.9 \times 10^{-4}\ \text{m}) = 3.8 \times 10^{-4}$ m.

14. Since the potential difference V and current i are related by $V = iR$, where R is the resistance of the electrician, the fatal voltage is $V = (50 \times 10^{-3}\ \text{A})(2000\ \Omega) = 100$ V.

17. We find the conductivity of Nichrome (the reciprocal of its resistivity) as follows:

$$\sigma = \frac{1}{\rho} = \frac{L}{RA} = \frac{L}{(V/i)A} = \frac{Li}{VA} = \frac{(1.0\ \text{m})(4.0\ \text{A})}{(2.0\ \text{V})(1.0\times10^{-6}\ \text{m}^2)} = 2.0\times10^{6}/\Omega\cdot\text{m}.$$

19. The resistance of the wire is given by $R = \rho L/A$, where ρ is the resistivity of the material, L is the length of the wire, and A is its cross-sectional area. In this case,

$$A = \pi r^2 = \pi\left(0.50\times10^{-3}\ \text{m}\right)^2 = 7.85\times10^{-7}\ \text{m}^2.$$

Thus,

$$\rho = \frac{RA}{L} = \frac{\left(50\times10^{-3}\Omega\right)\left(7.85\times10^{-7}\ \text{m}^2\right)}{2.0\,\text{m}} = 2.0\times10^{-8}\,\Omega\cdot\text{m}.$$

23. We use $J = E/\rho$, where E is the magnitude of the (uniform) electric field in the wire, J is the magnitude of the current density, and ρ is the resistivity of the material. The electric field is given by $E = V/L$, where V is the potential difference along the wire and L is the length of the wire. Thus $J = V/L\rho$ and

$$\rho = \frac{V}{LJ} = \frac{115\ \text{V}}{(10\ \text{m})(1.4\times10^4\ \text{A/m}^2)} = 8.2\times10^{-4}\,\Omega\cdot\text{m}.$$

40. The resistance is $R = P/i^2 = (100\ \text{W})/(3.00\ \text{A})^2 = 11.1\ \Omega$.

41. (a) Electrical energy is converted to heat at a rate given by $P = V^2/R$, where V is the potential difference across the heater and R is the resistance of the heater. Thus,

$$P = \frac{(120\ \text{V})^2}{14\ \Omega} = 1.0\times10^3\ \text{W} = 1.0\ \text{kW}.$$

(b) The cost is given by $(1.0\,\text{kW})(5.0\,\text{h})(5.0\,\text{cents/kW}\cdot\text{h}) = \text{US\$}0.25$.

49. (a) Assuming a 31-day month, the monthly cost is

$$(100\ \text{W})(24\ \text{h/day})(31\text{days/month})\,(6\ \text{cents/kW}\cdot\text{h}) = 446\ \text{cents} = \text{US\$}4.46\,.$$

(b) $R = V^2/P = (120\ \text{V})^2/100\ \text{W} = 144\ \Omega$.

(c) $i = P/V = 100\ \text{W}/120\ \text{V} = 0.833\ \text{A}$.

53. (a) From $P = V^2/R$ we find $R = V^2/P = (120\ \text{V})^2/500\ \text{W} = 28.8\ \Omega$.

(b) Since $i = P/V$, the rate of electron transport is

$$\frac{i}{e} = \frac{P}{eV} = \frac{500\ \text{W}}{(1.60\times10^{-19}\ \text{C})(120\ \text{V})} = 2.60\times10^{19}\ /\ \text{s}.$$

66. The horsepower required is $P = \dfrac{iV}{0.80} = \dfrac{(10\text{A})(12\ \text{V})}{(0.80)(746\ \text{W/hp})} = 0.20\ \text{hp}.$

ard the negative terminal.