

1. (a) The charge that passes through any cross section is the product of the current and time. Since $4.0 \text{ min} = (4.0 \text{ min})(60 \text{ s/min}) = 240 \text{ s}$, $q = it = (5.0 \text{ A})(240 \text{ s}) = 1200 \text{ C}$.
- (b) The number of electrons N is given by $q = Ne$, where e is the magnitude of the charge on an electron. Thus $N = q/e = (1200 \text{ C})/(1.60 \times 10^{-19} \text{ C}) = 7.5 \times 10^{21}$.

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

$$r = \sqrt{\frac{i}{\pi J}} = \sqrt{\frac{0.50 \text{ A}}{\pi(440 \times 10^4 \text{ A/m}^2)}} = 1.9 \times 10^{-4} \text{ m} .$$

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

16. (a) $i = V/R = 23.0 \text{ V}/15.0 \times 10^{-3} \Omega = 1.53 \times 10^3 \text{ A}$.

(b) The cross-sectional area is $A = \pi r^2 = \frac{1}{4}\pi D^2$. Thus, the magnitude of the current density vector is

$$J = \frac{i}{A} = \frac{4i}{\pi D^2} = \frac{4(1.53 \times 10^3 \text{ A})}{\pi(6.00 \times 10^{-3} \text{ m})^2} = 5.41 \times 10^7 \text{ A/m}^2 .$$

(c) The resistivity is $\rho = RA/L = (15.0 \times 10^{-3} \Omega)(\pi)(6.00 \times 10^{-3} \text{ m})^2/[4(4.00 \text{ m})] = 10.6 \times 10^{-8} \Omega \cdot \text{m}$.
The material is platinum.

35. The relation $P = V^2/R$ implies $P \propto V^2$. Consequently, the power dissipated in the second case is

$$P = \left(\frac{1.50 \text{ V}}{3.00 \text{ V}} \right)^2 (0.540 \text{ W}) = 0.135 \text{ W} .$$

39. Let R_H be the resistance at the higher temperature (800°C) and let R_L be the resistance at the lower temperature (200°C). Since the potential difference is the same for the two temperatures, the power dissipated at the lower temperature is $P_L = V^2/R_L$, and the power dissipated at the higher temperature is $P_H = V^2/R_H$, so $P_L = (R_H/R_L)P_H$. Now $R_L = R_H + \alpha R_H \Delta T$, where ΔT is the temperature difference $T_L - T_H = -600^\circ\text{C} = -600\text{ K}$. Thus,

$$P_L = \frac{R_H}{R_H + \alpha R_H \Delta T} P_H = \frac{P_H}{1 + \alpha \Delta T} = \frac{500\text{ W}}{1 + (4.0 \times 10^{-4}/\text{K})(-600\text{ K})} = 660\text{ W} .$$