PHY 1B(b) Chapter 17 Solutions

2. The drift speed in a conductor of cross-sectional area A and carrying current I is

$$v_d = \frac{I}{nqA}$$, where n is the number of free charges carriers per unit volume and q is the charge of each of those charge carriers. In the given conductor,

$$v_d = \frac{I}{nqA} = \frac{2.50\ C/s}{(7.50\times10^{28}\ m^{-3})(1.60\times10^{-19}\ C)(4.00\times10^{-6}\ m^2)}$$

$$= \boxed{5.21\times10^{-5}\ m/s}$$

7. $$v_d = \frac{I}{nqA} = \frac{I}{n|e|(\pi d^2/4)}$$

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

$$= 2.3\times10^{-4}\ m/s$$

The time to travel the length of the 200 km line:

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

$$= \boxed{27\ yrs.}$$

8. density $= \rho = \dfrac{\text{number of atoms}}{\text{cubic meter}}$

$$\Rightarrow n = \frac{\rho}{M/N_A} = \frac{N_A \rho}{M}$$

(mass per atom)

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

$$\Rightarrow \boxed{n = 6.0\times10^{28}/\text{m}^3}$$

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

$$= \boxed{1.3\times10^{-4}\ \text{m/s}}$$

12. Volume of copper is

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

Since $V = A\cdot L$,

$$A\cdot L = 1.12\times10^{-7}\ \text{m}^3$$

$\Rightarrow$ a) From $R = \dfrac{\rho L}{A}$,

$$A = \left(\frac{\rho}{R}\right)L = \frac{(1.70\times10^{-8}\ \Omega\cdot\text{m})}{.500\ \Omega}L = (3.40\times10^{-8}\ \text{m})L$$

12. a) $\Rightarrow A \cdot L = (3.40 \times 10^{-8}\ m \cdot L) \cdot L$

$$= 1.12 \times 10^{-7}\ m^3$$

$$\Rightarrow \boxed{L = 1.82\ m}$$

b) From $A \cdot L = 1.12 \times 10^{-7}\ m^3$

Also, $A = \frac{\pi d^2}{4}$

$$\Rightarrow d = \left(\frac{4A}{\pi}\right)^{1/2} = \sqrt{\frac{4(1.12 \times 10^{-7}\ m^3)}{\pi L}}$$

$$= 2.80 \times 10^{-4}\ m \quad \text{or} \quad \boxed{0.280\ mm}$$

36. a) $E = P \cdot t = (90\ W)(1\ h) = (90\ J/s)(3600\ s)$

$$= \boxed{3.2 \times 10^5\ J}$$

b) Power consumption $= P = (\Delta V) I = (120\ V)(2.5\ A)$

$$\Rightarrow P = 300\ W$$

$$t = \frac{E}{P} = \frac{3.2 \times 10^5\ J}{300\ W} = 1.1 \times 10^3\ s \left(\frac{1\ min}{60\ s}\right)$$

$$\Rightarrow \boxed{t = 18\ min.}$$

39. Resistance per unit length $= \frac{R}{L}$

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

Cross-sectional area, ~~$A = \pi R^2$~~
$A = \pi r^2$

From $A = \frac{\rho}{R/L}$, $\pi r^2 = \frac{\rho}{R/L} \Rightarrow r = \sqrt{\frac{\rho}{\pi(R/L)}}$

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

49. From $P = \frac{(\Delta V)^2}{R}$,

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

From $R = \frac{\rho L}{A}$, $L = \frac{R\cdot A}{\rho}$

$$\Rightarrow L = \frac{(8.3\ \Omega)(4.0\times10^{-6}\ m^2)}{3.0\times10^{-8}\ \Omega\cdot m}$$

$$= 1.1\times10^{3}\ m = \boxed{1.1\ km}$$

57. $I = \frac{\Delta V}{R} = \frac{15.0\,V}{0.100\,\Omega} = 150\,A$

From $v_d = \frac{I}{nqA}$,

$$n = \frac{I}{v_d e(\pi r^2)} = \frac{150\,A}{(3.17\times10^{-4}\,m/s)(1.60\times10^{-9}\,C)\pi(5.00\times10^{-3}\,m)^2}$$

$\Rightarrow \boxed{n = 3.77\times10^{28}/m^3}$

60. Each speaker has a resistance of $4.00\,\Omega$ and can handle 60.0 W of power.

From $P = I^2R$,

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

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