The Hall Effect

18.41 (a) This portion of the problem calls for us to determine the electron mobility for some hypothetical metal using the Hall effect. This metal has an electrical resistivity of 3.3 x 10^{-8} (Ω-m), while the specimen thickness is 15 mm, I_x = 25 A and B_z = 0.95 tesla; under these circumstances a Hall voltage of –2.4 x 10^{-7} V is measured. It is first necessary to convert resistivity to conductivity (Equation 18.4). Thus

$$\sigma = \frac{1}{\rho} = \frac{1}{3.3 \text{ x} 10^{-8} \ (\Omega - \text{m})} = 3.0 \text{ x } 10^{7} \ (\Omega\text{ - m})^{-1}$$

The electron mobility may be determined using Equation 18.20b; and upon incorporation of Equation 18.18, we have

$$\mu_e = \left|R_\text{H}\right|\sigma$$

$$= \frac{\left|V_\text{H}\right| d\,\sigma}{I_x B_z}$$

$$= \frac{\left(\left|-2.4 \text{ x } 10^{-7} \text{ V}\right|\right)\left(15 \text{ x } 10^{-3} \text{ m}\right)\left[3.0 \text{ x } 10^{7} \ (\Omega - \text{m})^{-1}\right]}{(25 \text{ A})(0.95 \text{ tesla})}$$

$$= 0.0045 \ \text{m}^2/\text{V - s}$$

(b) Now we are to calculate the number of free electrons per cubic meter. From Equation 18.8 we have

$$n = \frac{\sigma}{|e|\,\mu_e}$$

$$= \frac{3.0 \text{ x } 10^{7} \ (\Omega\text{ - m})^{-1}}{\left(1.602 \text{ x } 10^{-19} \text{ C}\right)\left(0.0045 \ \text{m}^2/\text{V - s}\right)}$$

$$= 4.17 \text{ x } 10^{28} \ \text{m}^{-3}$$