Intrinsic Semiconduction

18.18 (a) For this part of the problem, we first read, from Figure 18.16, the number of free electrons (i.e., the intrinsic carrier concentration) at room temperature (298 K). These values are n_i(Ge) = 5 x 10^{19} m^{-3} and n_i(Si) = 7 x 10^{16} m^{-3}.

Now, the number of atoms per cubic meter for Ge and Si (N_{Ge} and N_{Si}, respectively) may be determined using Equation 4.2 which involves the densities (ρ'_{Ge} and ρ'_{Si}) and atomic weights (A_{Ge} and A_{Si}). (*Note:* here we use ρ' to represent density in order to avoid confusion with resistivity, which is designated by ρ. Also, the atomic weights for Ge and Si, 72.59 and 28.09 g/mol, respectively, are found inside the front cover.) Therefore,

$$N_{Ge} = \frac{N_A \rho'_{Ge}}{A_{Ge}}$$

$$= \frac{(6.023 \text{ x } 10^{23} \text{ atoms/mol})(5.32 \text{ g/cm}^3)(10^6 \text{ cm}^3/\text{m}^3)}{72.59 \text{ g/mol}}$$

$$= 4.4 \text{ x } 10^{28} \text{ atoms/m}^3$$

Similarly, for Si

$$N_{Si} = \frac{N_A \rho'_{Si}}{A_{Si}}$$

$$= \frac{(6.023 \text{ x } 10^{23} \text{ atoms/mol})(2.33 \text{ g/cm}^3)(10^6 \text{ cm}^3/\text{m}^3)}{28.09 \text{ g/mol}}$$

$$= 5.00 \text{ x } 10^{28} \text{ atoms/m}^3$$

Finally, the ratio of the number of free electrons per atom is calculated by dividing n_i by N. For Ge

$$\frac{n_i(\text{Ge})}{N_{Ge}} = \frac{5 \text{ x } 10^{19} \text{ electrons/m}^3}{4.4 \text{ x } 10^{28} \text{ atoms/m}^3}$$

$$1.1 \text{ x } 10^{-9} \text{ electron/atom}$$

And, for Si