## **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  $n_i(\text{Ge}) = 5 \times 10^{19} \text{ m}^{-3}$  and  $n_i(\text{Si}) = 7 \times 10^{16} \text{ m}^{-3}$ .

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

$$N_{\rm Ge} = \frac{N_{\rm A} \rho_{\rm Ge}}{A_{\rm Ge}}$$

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

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

Similarly, for Si

$$N_{\rm Si} = \frac{N_{\rm A} \rho_{\rm Si}}{A_{\rm Si}}$$

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

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

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

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

1.1 x 10<sup>-9</sup> electron/atom

And, for Si

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