## DESIGN PROBLEMS

## **Electrical Resistivity of Metals**

18.D1 This problem asks that we calculate the composition of a copper-nickel alloy that has a room temperature resistivity of 2.5 x  $10^{-7}$   $\Omega$ -m. The first thing to do is, using the 90 Cu-10 Ni resistivity data, determine the impurity contribution, and, from this result, calculate the constant *A* in Equation 18.11. Thus,

$$\rho_{\text{total}} = 1.90 \text{ x } 10^{-7} (\Omega - \text{m}) = \rho_i + \rho_i$$

From Table 18.1, for pure copper, and using Equation 18.4

$$\rho_t = \frac{1}{\sigma} = \frac{1}{6.0 \text{ x } 10^7 (\Omega - \text{m})^{-1}} = 1.67 \text{ x } 10^{-8} (\Omega - \text{m})$$

Thus, for the 90 Cu-10 Ni alloy

$$\rho_i = \rho_{\text{total}} - \rho_t = 1.90 \text{ x } 10^{-7} - 1.67 \text{ x } 10^{-8}$$
  
= 1.73 x 10<sup>-7</sup> (Ω-m)

In the problem statement, the impurity (i.e., nickel) concentration is expressed in weight percent. However, Equation 18.11 calls for concentration in atom fraction (i.e., atom percent divided by 100). Consequently, conversion from weight percent to atom fraction is necessary. (Note: we now choose to denote the atom fraction of nickel as  $c'_{Ni}$ , and the weight percents of Ni and Cu by  $C_{Ni}$  and  $C_{Cu}$ , respectively.) Using these notations, this conversion may be accomplished by using a modified form of Equation 4.6a as

$$c'_{\text{Ni}} = \frac{C'_{\text{Ni}}}{100} = \frac{C_{\text{Ni}}A_{\text{Cu}}}{C_{\text{Ni}}A_{\text{Cu}} + C_{\text{Cu}}A_{\text{Ni}}}$$

Here  $A_{Ni}$  and  $A_{Cu}$  denote the atomic weights of nickel and copper (which values are 58.69 and 63.55 g/mol, respectively). Thus

$$c'_{\rm Ni} = \frac{(10 \text{ wt\%})(63.55 \text{ g/mol})}{(10 \text{ wt\%})(63.55 \text{ g/mol}) + (90 \text{ wt\%})(58.69 \text{ g/mol})}$$

Excerpts from this work may be reproduced by instructors for distribution on a not-for-profit basis for testing or instructional purposes only to students enrolled in courses for which the textbook has been adopted. Any other reproduction or translation of this work beyond that permitted by Sections 107 or 108 of the 1976 United States Copyright Act without the permission of the copyright owner is unlawful.