

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 $2.5 \times 10^{-7} \Omega\text{-m}$. 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,

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

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

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

Thus, for the 90 Cu-10 Ni alloy

$$\begin{aligned} \rho_i &= \rho_{\text{total}} - \rho_t = 1.90 \times 10^{-7} - 1.67 \times 10^{-8} \\ &= 1.73 \times 10^{-7} (\Omega\text{-m}) \end{aligned}$$

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

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