## **Conduction in Ionic Materials**

18.47 We are asked in this problem to determine the electrical conductivity for the nonstoichiometric  $Fe_{(1 - x)}O$ , given x = 0.040 and that the hole mobility is  $1.0 \times 10^{-5} \text{ m}^2/\text{V-s}$ . It is first necessary to compute the number of vacancies per cubic meter for this material. For this determination let us use as our basis 10 unit cells. For the sodium chloride crystal structure there are four cations and four anions per unit cell. Thus, in ten unit cells of FeO there will normally be forty  $O^{2^-}$  and forty  $Fe^{2^+}$  ions. However, when x = 0.04, (0.04)(40) = 1.6 of the  $Fe^{2^+}$  sites will be vacant. (Furthermore, there will be  $3.2 \text{ Fe}^{3^+}$  ions in these ten unit cells inasmuch as two  $Fe^{3^+}$  ions are created for every vacancy). Therefore, each unit cell will, on the average contain 0.16 vacancies. Now, the number of vacancies per cubic meter is just the number of vacancies per unit cell divided by the unit cell volume; this volume is just the unit cell edge length (0.437 nm) cubed. Thus

$$\frac{\# \text{vacancies}}{\text{m}^3} = \frac{0.16 \text{ vacancies/unit cell}}{(0.437 \times 10^{-9} \text{ m})^3}$$

=  $1.92 \times 10^{27}$  vacancies/m<sup>3</sup>

Inasmuch as it is assumed that the vacancies are saturated, the number of holes (*p*) is also  $1.92 \times 10^{27} \text{ m}^{-3}$ . It is now possible, using Equation 18.17, to compute the electrical conductivity of this material as

$$\sigma = p | e | \mu_h$$

=  $(1.92 \times 10^{27} \text{ m}^{-3})(1.602 \times 10^{-19} \text{ C})(1.0 \times 10^{-5} \text{ m}^2/\text{V-s}) = 3076 (\Omega - \text{m})^{-1}$ 

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.