CHAPTER 5

5.8 *The purification of hydrogen gas by diffusion through a palladium sheet was discussed in Section 5.3. Compute the number of kilograms of hydrogen that pass per hour through a 5-mm thick sheet of palladium having an area of 0.20 m^2 at 500°C. Assume a diffusion coefficient of 1.0×10^{-8} m^2/s, that the respective concentrations at the high- and low-pressure sides of the plate are 2.4 and 0.6 kg of hydrogen per cubic meter of palladium, and that steady-state conditions have been attained.*

5.9 *A sheet of steel 1.5-mm thick has nitrogen atmospheres on both sides at 1200°C and is permitted to achieve a steady-state diffusion condition. The diffusion coefficient for nitrogen in steel at this temperature is 6×10^{-11} m^2/s, and the diffusion flux is found to be 1.2×10^{-7} $kg/m^2 \cdot s$. Also, it is known that the concentration of nitrogen in the steel at the high-pressure surface is 4 kg/m^3. How far into the sheet from this high-pressure side will the concentration be 2 kg/m^3? Assume a linear concentration profile.*

5.10 *A sheet of BCC iron 1-mm thick was exposed to a carburizing gas atmosphere on one side and a decarburizing atmosphere on the other side at 725°C. After reaching steady state, the iron was quickly cooled to room temperature. The carbon concentrations at the two surfaces of the sheet were determined to be 0.012 and 0.0075 wt%, respectively. Compute the diffusion coefficient if the diffusion flux is 1.4×10^{-8} $kg/m^2 \cdot s$. Hint: Use Equation 4.9 to convert the concentrations from weight percent to kilograms of carbon per cubic meter of iron.*

5.11 *When α-iron is subjected to an atmosphere of nitrogen gas, the concentration of nitrogen in the iron, C_N (in weight percent), is a function of hydrogen pressure, p_{N_2}(in MPa), and absolute temperature (T) according to*

$$C_N = 1.34 \times 10^{-2} \sqrt{P_{H_2}} exp\left(-\frac{27.2kJ/mol}{RT}\right) \qquad (5.14)$$

Furthermore, the values of D_0 and Q_d for this diffusion system are 1.4×10^{-7} m^2/s and 13,400 J/mol, respectively. Consider a thin iron membrane 1-mm thick that is at 250°C. Compute the diffusion flux through this membrane if the nitrogen pressure on one side of the membrane is 0.15 MPa (1.48 atm) and that on the other side is 7.5 MPa (74 atm).