MT 250 Metallurgical Concepts

Physical Metallurgy

Home Assignment 3 (Due 29.9.2003)

1. Derive the one dimensional diffusion equation:
$$\frac{\partial C}{\partial t} = \frac{\partial}{\partial x}\left(D\frac{\partial C}{\partial x}\right).$$

2. In a table, list the planes which give rise to the first 10 peaks in a powder diffraction pattern for each of the following structures:
   a. fcc
   b. bcc
   c. simple cubic

   Each table should contain at least the following information for each peak p: (i) $(hkl)_p$, (ii) d_p and (iii) d_p^2/d_1^2.

3. Calculate the diffraction angle (2θ) for the first four peaks of *fcc* Al ($a = 0.404$ nm) using Cu-K_α radiation of wavelength $\lambda = 0.1542$ nm.

4. Calculate the c/a ratio for an ideal *hcp* crystal. What would be the (*hkil*) indices for the three lowest diffraction angle peaks for this crystal?

5. For gold, ΔH_v, the vacancy formation energy is about 1 eV per vacancy. If the vacancy concentration at the melting point of gold is about 10^{-4}, determine the temperature at which the vacancy concentration will be (a) 5×10^{-5} and (b) 10^{-8}.

6. Using the data in Table 4.2 in Shackelford's text, calculate the self diffusivity for iron in*bcc* and *fcc* iron.

7. The diffusion coefficient of nickel in austenitic (*fcc* structure) stainless steel is 10^{-22} and 10^{-15} m^2s^{-1} at 773 and 1273 K, respectively. Calculate the activation energy for the diffusion of Ni in this alloy over this temperature range.

8. For a small angle tilt boundary, derive the relationship among the misorientation angle, the distance between the edge dislocations, and the Burgers vector of these dislocations.

9. A fine grained metal may have a mean grain size of the order of 1 μm. Assuming that the grain boundary energy of the metal is 0.5 Jm^{-2}, what would be the approximate value of the total grain boundary energy per unit volume of the metal. Give your answer in Jm^{-3}.