

CME 300 Properties of Materials

Homework 4 October 12, 2011

1) The Scherrer equation can be obtained by taking the derivative of the Bragg Equation. Perform this derivative. Begin by multiplying λ and d by an integer m such that $md = t$, the Scherrer Size. Differentiate keeping in mind that $m\lambda$ is a constant. The smallest increment in t is d , so “ dt ” is equal to d . You must reuse Bragg’s law to simplify your final expression to obtain the Scherrer Equation using $d\theta = B$.

2) Debye-Waller thermal broadening of diffraction peaks is modeled with a Gaussian function, that predicts a diffracted peak shape of $I(q) = \exp\left(\frac{-q^2\langle u^2 \rangle}{3}\right)$ where q is the scattering vector

$$q = \frac{2\pi}{d_{\text{Bragg}}} = \frac{4\pi}{\lambda} \sin(\theta) \text{ and } \langle u^2 \rangle \text{ is the mean square free path for the atoms about the lattice}$$

site. Compare the Debye-Waller function with the Gaussian Distribution function and give a value for the standard deviation about the peak (peak width) due to thermal broadening. Do you think it is logical to use the Gaussian Distribution to describe a diffraction peak (explain your answer, you need to explain what a Gaussian Distribution is normally used to describe).

3) Why can’t diffraction be used to make a picture of a crystal lattice? (Your answer should consider how a crystal would appear in inverse space).

4) In class we discussed the phase diagram for two polymers that display partial miscibility. Sketch a plot of the free energy change on mixing versus composition at a temperature where there is a miscibility gap. Show in this plot the origin of the spinodal and binodal regimes. Sketch the morphology that result from spinodal and binodal decomposition. Show the spinodal and binodal curves in a UCST system and indicate the points that are determined from your free energy versus composition plot.

Problems from Hummel (Chapter 5)

- 5.1. Give the amounts of the liquid and solid (α) phases (in percent) which are present when a Cu–28 mass % Ni alloy is very slowly cooled to a temperature corresponding to Tie Line #2 in Figure 5.5.
- 5.2. Figure 5.17 depicts the Cu–Sn phase diagram in which the single phase regions are labeled only.
 - (a) Label the two-phase regions.
 - (b) State the three-phase reactions that occur and give the temperatures at which they take place. Write the pertinent reaction equations.
- 5.3. State the maximal solubility of (a) copper in silver and (b) silver in copper. At which temperatures do these maximal solubilities occur?
- 5.4. What is the approximate solubility of copper in silver at room temperature?
- 5.5. Give the phases present and their compositions for an Al–5 mass % Cu alloy at 400°C.
- 5.6. Assume an Ag–10 mass % Cu alloy. To what temperature does this alloy have to be heated so that 50% of the sample is liquid?
- 5.7. Does a copper–nickel binary alloy exist whose solid phase at equilibrium contains 36 mass % Ni and whose liquid phase contains 20 mass % Ni? Explain. Refer to Figure 5.3.
- 5.8. A silver–20 mass % copper alloy is slowly heated from room temperature.
 - (a) State the temperature at which a liquid phase starts to form.
 - (b) State the composition of this liquid phase.
 - (c) At which temperature is the alloy completely liquefied?
 - (d) Give the composition of the solid just before complete melting has occurred.

Problems from Callister p. 304

- 9.4** What thermodynamic condition must be met for a state of equilibrium to exist?
- 9.8** Cite the phases that are present and the phase compositions for the following alloys:
- (a) 15 wt% Sn–85 wt% Pb at 100°C (212°F)
 - (b) 25 wt% Pb–75 wt% Mg at 425°C (800°F)
 - (c) 85 wt% Ag–15 wt% Cu at 800°C (1470°F)
 - (d) 55 wt% Zn–45 wt% Cu at 600°C (1110°F)
 - (e) 1.25 kg Sn and 14 kg Pb at 200°C (390°F)
 - (f) 7.6 lb_m Cu and 144.4 lb_m Zn at 600°C (1110°F)
 - (g) 21.7 mol Mg and 35.4 mol Pb at 350°C (660°F)
 - (h) 4.2 mol Cu and 1.1 mol Ag at 900°C (1650°F)
- 9.9** Is it possible to have a copper–silver alloy that, at equilibrium, consists of a β phase of composition 92 wt% Ag–8 wt% Cu, and also a liquid phase of composition 76 wt% Ag–24 wt% Cu? If so, what will be the approximate temperature of the alloy? If this is not possible, explain why.