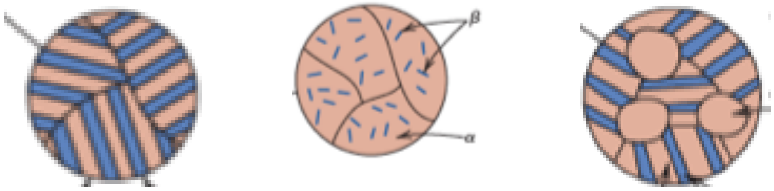
Quiz 4 Properties of Materials CME 300
October 19, 2011

a) The interaction parameter usually has an inverse temperature dependence, $\chi = B/T$.
Explain why this leads to phase separation on cooling (Upper Critical Solution Temperature or UCST) and guess at a functional form that could lead to phase separation on heating (Lower Critical Solution Temperature or LCST).

$$\frac{\Delta G}{kT} = \frac{\phi_A}{N_A}\ln(\phi_A) + \frac{\phi_B}{N_B}\ln(\phi_B) + \phi_A\phi_B\chi_{AB}$$

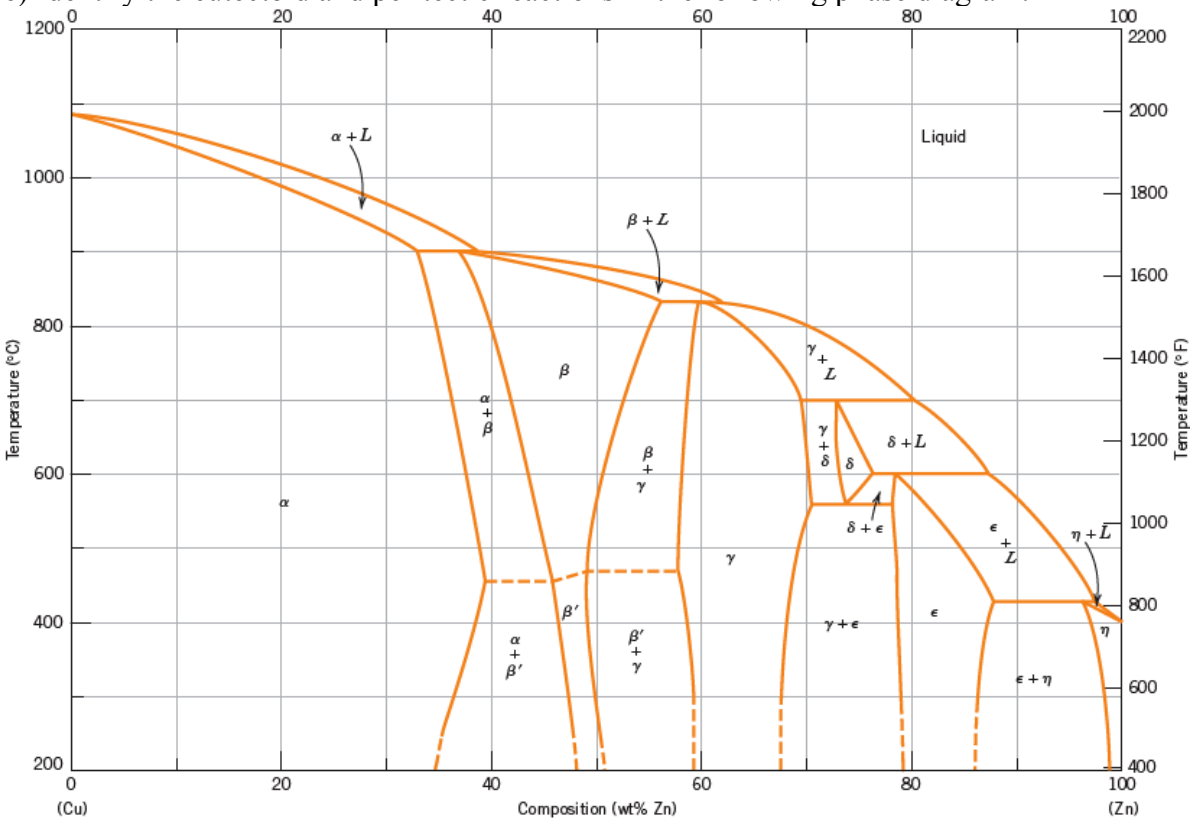
b) Sketch a eutectic phase diagram and circle the eutectic point. Label all regions in this phase diagram.

c) In your eutectic phase diagram indicate where you might grow the following three morphologies.



d) Explain how and why the eutectic structure forms.

e) Identify the eutectoid and peritectic reactions in the following phase diagram:



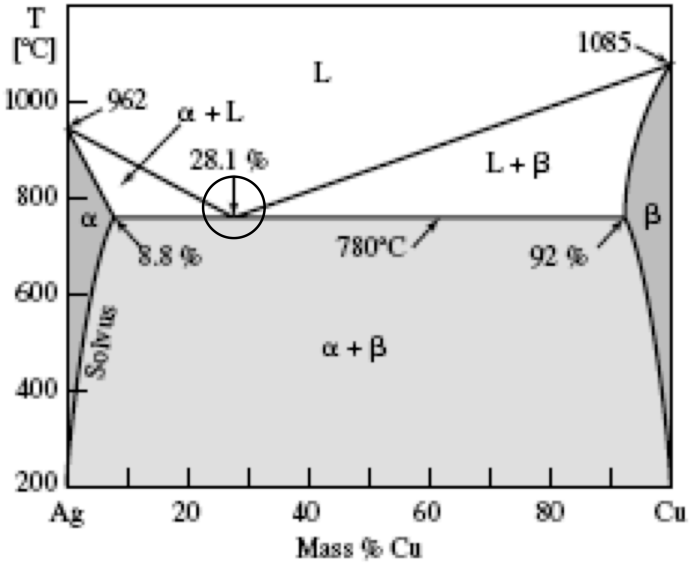
Answers Quiz 4 CME 300 October 19, 2011

a) For the Flory-Huggins equation:

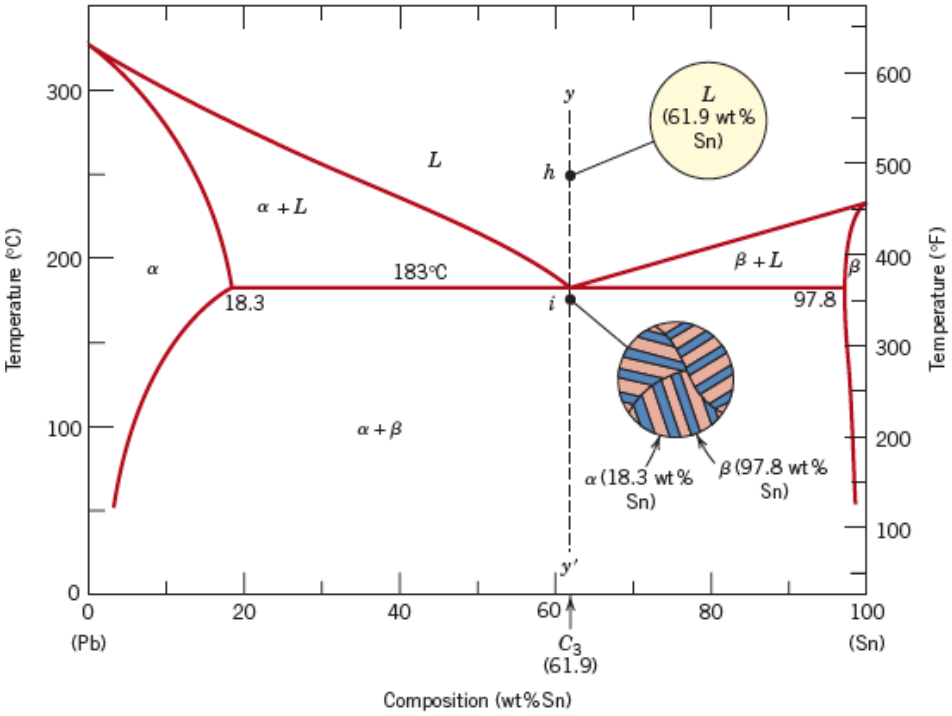
$$\frac{\Delta G}{kT} = \frac{\phi_A}{N_A}\ln(\phi_A) + \frac{\phi_B}{N_B}\ln(\phi_B) + \phi_A\phi_B\chi_{AB}$$

,
the first two terms are negative and favor mixing. The last term is positive and decreases with increasing temperature so that at low temperatures the last term makes the overall free energy change on mixing positive and phase separation occurs.
For a LCST the interaction parameter should have a form $\chi = A - B/T$ so that the free energy change is positive at high temperatures (phase separates) and becomes negative (miscible) at low temperatures.

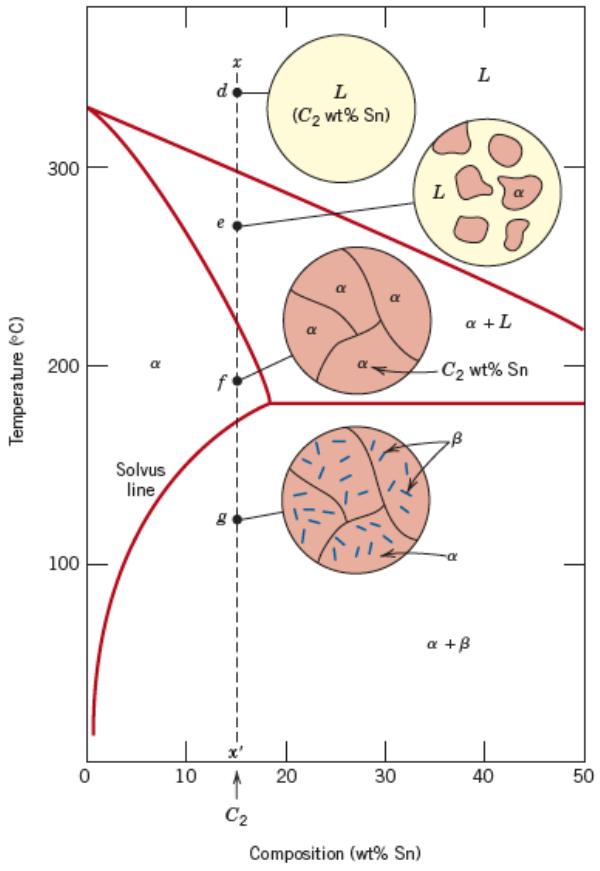
b)



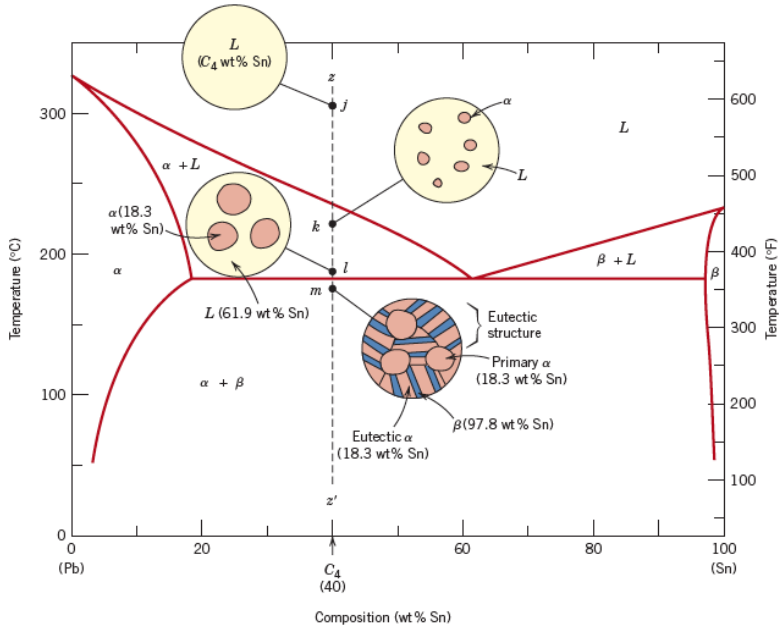
c) First is a eutectic:



Second is from the following region:



Third from:



d)

A balance between thermodynamically driven phase separation and the kintic limits of diffusion of the two components to their respective phases from the liquid state leads to the eutectic lamellar structure:

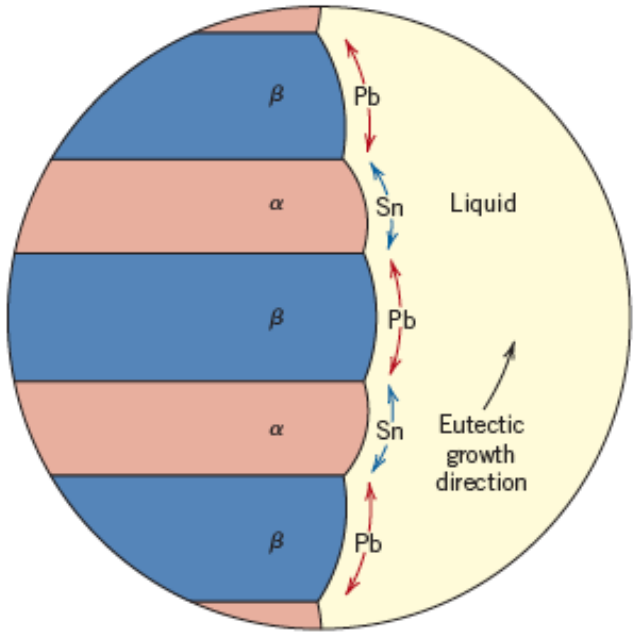
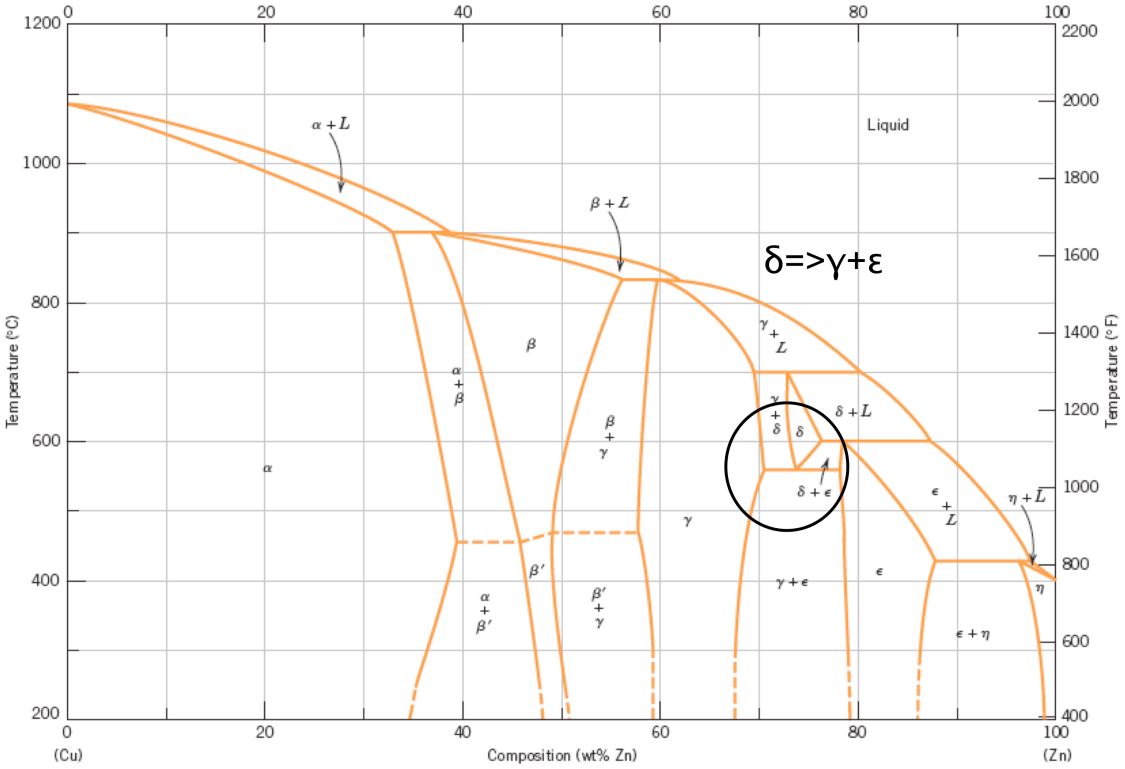


Figure 9.15 Schematic representation of the formation of the eutectic structure for the lead–tin system. Directions of diffusion of tin and lead atoms are indicated by blue and red arrows, respectively.

The overall amount of α and β is governed by the tie line at the eutectic, the size of the lamellar sheets by the balance of thermodynamics and diffusion following the transport scheme shown above.

e)

Eutectoid:



Peritectic: