재료공학개론 (400.020.001)

2023년 6월 12일 Seong-Hyeon Hong

Final Exam

1.(25 points) For Pb-Sn phase diagram,

a)(5 points) What kind of invariant reaction is in this phase diagram? Specify the invariant reaction.

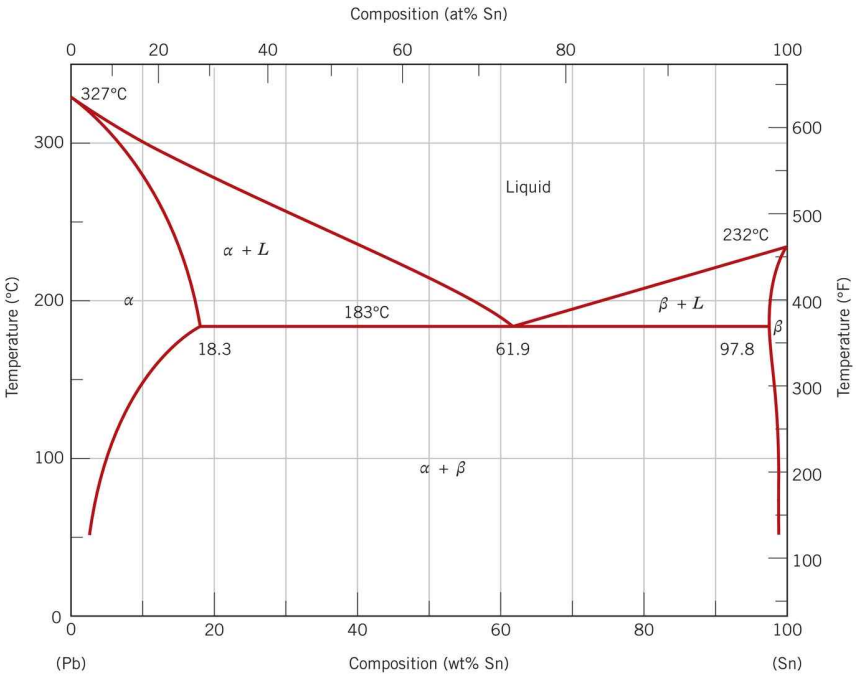
A lead-tin alloy of composition 30 wt% Sn-70 wt% Pb is slowly heated from a temperature of 150°C. Answer the following questions.

b)(5 points) At what temperature does the first liquid phase form? What is the composition of this liquid phase?

c)(5 points) What are the compositions and the relative amount of the phases present at 184°C? (just above the invariant reaction)

d)(5 points) At what temperature does complete melting of the alloy occur? What is the composition of the last solid remaining prior to complete melting?

e)(5 points) Schematically sketch and label the resulting microstructure as this alloy is cooled from the liquid phase region to just below the invariant temperature.



Adapted from *Binary Alloy Phase Diagrams*, 2nd edition, Vol. 3, T. B. Massalski (Editor-in-Chief), 1990. Reprinted by permission of ASM International, Materials Park, OH.

2.(10 points) Rewrite the expression for the total free energy change for nucleation for the case of a cubic nucleus of edge length a (instead of a sphere of radius r). Now solve for both the critical cube edge length, a*, and ΔG*. Is ΔG* greater for a cube or a sphere? Why?

3.(10 points) Fill in the table by indicating whether each of the terms in the column heading is zero (0) or less than zero (<0) or greater than zero (>0) for each class of materials. $\frac{\partial N}{\partial T}$ is the change in the number of a charge carriers with temperature, $\frac{\partial N}{\partial \rho_d}$ is the change in N with defect concentration, $\frac{\partial \mu}{\partial T}$ is the change in mobility with T, and $\frac{\partial \mu}{\partial \rho_d}$ is the change in μ with defect concentration.

Material Class	$\frac{\partial N}{\partial T}$	$\frac{\partial N}{\partial \rho_d}$	$\frac{\partial \mu}{\partial T}$	$\frac{\partial \mu}{\partial \rho_d}$
Semiconductor				
Electron conductor				
Ionic conductor				

4.(10 points)

a)(5 points) Cite three reasons why ferrous alloys are used so extensively.

b)(5 points) Cite three characteristics of ferrous alloys that limit their utilization.

5.(35 points)

a)(5 points) Describe the band structures for conductor, semiconductor, and insulator.

b)(5 points) Name and describe the four types of polarization mechanisms and explain how each mechanism can be distinguished.

c)(5 points) What is piezoelectricity? What is piezoelectricity used for?

d)(5 points) Briefly explain the two principal mechanisms of heat conduction in solid and compare the relative magnitude of these contributions for each of metals, ceramics, and polymeric materials.

e)(5 points) Express the thermal shock resistance parameter (TSR) for a material using its fracture strength, thermal conductivity, modulus of elasticity, and linear coefficient of thermal expansion.

f)(5 points) Classify the magnetic materials into five classes based on the extent and nature of the interactions between electrons in the solids and an external magnetic field.

g)(5 points) Briefly describe the phenomenon of magnetic hysteresis and why it occurs for ferro- and ferrimagnetic materials.

6.(10 points)
a)(5 points) Briefly explain why metals are opaque to electromagnetic radiation having photon energies within the visible region of the spectrum.

b)(5 points) For inherently transparent dielectric materials, note three sources of internal scattering that can lead to translucency and opacity.