Material Science
Homework 6 Solution

1. (a) Liquid Phase ; C_L = 55 wt% Ag - 45 wt% Cu ; W_L = 100%

   (b) β + HfV_2 Phase ; C_β = 93 wt% Hf - 7 wt% V, C_{HfV_2} = 66 wt% Hf - 34 wt% V;

   $W_\beta = \frac{34-20}{34-7}$ = 51.9% ; $W_{HfV_2} = 1 - W_\beta$ = 48.1%

   (c) $C_{Zn} = \frac{2.12}{2.12+1.88}$ =53 wt% $C_{Cu} = 1 - C_{Zn}$=47wt%

   β + γ phase, C_β = 49 wt% Zn - 51 wt% Cu, C_γ = 58 wt% Zn - 42 wt% Cu;

   $W_\beta = \frac{58-53}{58-49}$ = 55.6% ; $W_\gamma = 1 - W_\beta$ = 44.4%

   (d) M_{Sn} = 4.5 × 118.71 g/mol = 534.2 g, M_{Pb} = 0.45 × 207.2 g/mol = 93.2 g ,

   $C_{Sn} = \frac{534.2}{534.2+93.2}$ = 85.1 wt%, $C_{Pb} = 1 - C_{Sn}$ = 14.9wt%

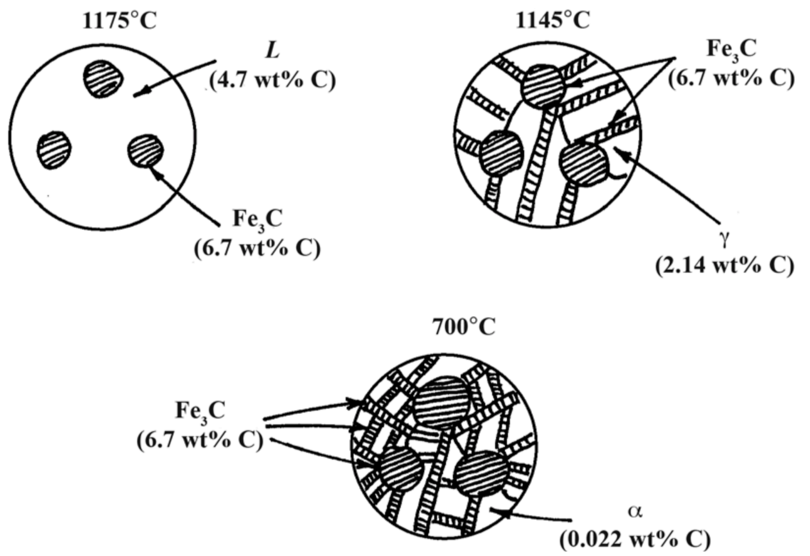
   β + L phase, C_β = 98 wt% Sn - 2wt% Pb, C_L = 75 wt% Sn - 25 wt% Pb

   $W_\beta = \frac{85.1-75}{98-75}$ = 43.9% ; $W_L = 1 - W_\beta$ = 56.1%

2. It is not possible to have a Cu-Ni alloy, which at equilibrium, consists of a liquid phase of composition 20 wt% Ni-80 wt% Cu and an α phase of composition 37 wt% Ni-63 wt% Cu. From Figure 10.3a, a single tie line does not exist within the α + L region that intersects the phase boundaries at the given compositions. At 20 wt% Ni, the L-(α + L) phase boundary is at about 1200°C, whereas at 37 wt% Ni the (L + α)-α phase boundary is at about 1230°C.

3. (a) 560°C; (b) $C_{\alpha,\ 560°C}$ =21 wt%Pb-79 wt%Mg (vary with Temp.);
   (c) 465°C; (d) $C_{L,\ 465°C}$ =67 wt% Pb-33 wt% Mg

4.



5.

(a) Coring is the phenomenon whereby concentration gradients exist across grains in polycrystalline alloys, with higher concentrations of the component having the lower melting temperature at the grain boundaries. It occurs, during solidification, as a consequence of cooling rates that are too rapid to allow for the maintenance of the equilibrium composition of the solid phase.One undesirable consequence of a cored structure is that, upon heating, the grain boundary regions will melt first and at a temperature below the equilibrium phase boundary from the phase diagram; this melting results in a loss in mechanical integrity of the alloy.

(b) The principal difference between congruent and incongruent phase transformations is that for congruent no compositional changes occur with any of the phases that are involved in the transformation. For incongruent there will be compositional alterations of the phases.

(c) Ferrite has a BCC crystal structure, that at lower and higher temperatures are called α-ferrite(~0.022 wt%C) and δ-ferrite(~0.09 wt%C), respectively.

Austenite has a FCC crystal structure, called γ-Fe(~ 0.76 wt% C).

Pearlite is a lamellar structure of α and Fe_3C(~ 6.67 wt% C) that develops in the iron-carbon system. When austenite cools to 727°C, the eutectoid reaction begins transforming to two phases that form have different compositions, so atoms must diffuse during the reaction. Most of the carbon in the austenite diffuses to the Fe_3C, and most of the iron atoms diffuse to the α.

(d) A “hypoeutectoid” steel has a carbon concentration less than the eutectoid; on the other hand, a “hypereutectoid” steel has a carbon content greater than the eutectoid.

(e) For a hypoeutectoid steel, the proeutectoid ferrite is a microconstituent that formed above the eutectoid temperature. The eutectoid ferrite is one of the constituents of pearlite that formed at a temperature below the eutectoid. The carbon concentration for both ferrites is 0.022 wt% C.