1. For a 40 wt% Sn – 60 wt% Pb alloy at 150°C (300°F),
   (a) What phase(s) is (are) present?
   (b) What is (are) the composition(s) of the phase(s)?
   (c) Calculate the relative amount of each phase present in terms of mass fraction.

(a) Locate this temperature-composition point on the phase diagram (point B in the above figure. Inasmuch as it is within the \( \alpha + \beta \) region, both \( \alpha \) and \( \beta \) phases will coexist.

(b) Since two phases are present, it becomes necessary to construct a tie line across the \( \alpha + \beta \) phase field at 150°C, as indicated in the above figure. The composition of the \( \alpha \) phase corresponds to the tie line intersection with the \( \alpha/(\alpha+\beta) \) solvus phase boundary – about 10 wt% Sn – 90 wt% Pb \((C_\alpha)\). Similarly for the \( \beta \) phase, which will have a composition approximately 98 wt% Sn – 2 wt% Pb \((C_\beta)\).

(c) Since the alloy consists of two phases, it is necessary to employ the lever rule. If \( C_1 \) denotes the overall alloy composition, mass fractions may be computed by subtracting compositions, in terms of weight percent tin, as follows:
2. For an alloy of composition 74 wt% Zn – 26 wt% Cu, cite the phases present and their compositions at the following temperatures: 850°C, 750°C, 680°C, 600°C, and 500°C.

This problem asks us to determine the phases present and their concentrations at several temperatures, as an alloy of composition 74 wt% Zn-26 wt% Cu is cooled. From the above figure:

At 850°C, a liquid phase is present; $C_L = 74$ wt% Zn-26 wt% Cu

At 750°C, $\gamma$ and liquid phases are present; $C_L = 76$ wt% Zn-24 wt% Cu; $C_\gamma = 68$ wt% Zn-32 wt% Cu

At 680°C, $\delta$ and liquid phases are present; $C_\delta = 74$ wt% Zn-26 wt% Cu; $C_L = 82$ wt% Zn-18 wt% Cu
At 600°C, the $\delta$ phase is present; $C_\delta = 74$ wt% Zn-26 wt% Cu

At 500°C, $\gamma$ and $\varepsilon$ phases are present; $C_\gamma = 69$ wt% Zn-31 wt% Cu; $C_\varepsilon = 78$ wt% Zn-22 wt% Cu

3. A copper – nickel alloy of composition 70 wt% Ni – 30 wt% Cu is slowly heated from a temperature of 1300°C (2370°F).
   (a) At what temperature does the first liquid phase form?
   (b) What is the composition of this liquid phase?
   (c) At what temperature does complete melting of the alloy occur?
   (d) What is the composition of the last solid remaining prior to complete melting?

Upon heating a copper-nickel alloy of composition 70 wt% Ni-30 wt% Cu from 1300°C and utilizing the above figure:
   (a) The first liquid forms at the temperature at which a vertical line at this composition intersects the $\alpha$-($\alpha$ + L) phase boundary—i.e., about 1350°C;
(b) The composition of this liquid phase corresponds to the intersection with the \((\alpha + L)\)-L phase boundary, of a tie line constructed across the \(\alpha + L\) phase region at 1350°C--i.e., 59 wt% Ni;

(c) Complete melting of the alloy occurs at the intersection of this same vertical line at 70 wt% Ni with the \((\alpha + L)\)-L phase boundary--i.e., about 1380°C;

(d) The composition of the last solid remaining prior to complete melting corresponds to the intersection with \(\alpha-(\alpha + L)\) phase boundary, of the tie line constructed across the \(\alpha + L\) phase region at 1380°C--i.e., about 78 wt% Ni.

4. A 90 wt% Ag – 10 wt% Cu alloy is heated to a temperature within the \(\beta\) + liquid phase region. If the composition of the liquid phase is 85 wt% Ag, determine the following:

(a) The temperature of the alloy.
(b) The composition of the \(\beta\) phase.
(c) The mass fractions of both phases.

(a) In order to determine the temperature of a 90 wt% Ag-10 wt% Cu alloy for which \(\beta\) and liquid phases are present with the liquid phase of composition 85 wt% Ag, we need to construct a tie line across the \(\beta + L\) phase region of the
above figure that intersects the liquidus line at 85 wt% Ag; this is possible at about 850°C.

(b) The composition of the $\beta$ phase at this temperature is determined from the intersection of this same tie line with solidus line, which corresponds to about 95 wt% Ag.

(c) The mass fractions of the two phases are determined using the lever rule, using the following relations, with $C_o = 90$ wt% Ag, $C_L = 85$ wt% Ag, and $C_\beta = 95$ wt% Ag, as

\[
W_\beta = \frac{C_o - C_L}{C_\beta - C_L} = \frac{90 - 85}{95 - 85} = 0.50
\]

\[
W_L = \frac{C_\beta - C_o}{C_\beta - C_L} = \frac{95 - 90}{95 - 85} = 0.50
\]
5. A 30 wt% Sn – 70 wt% Pb alloy is heated to a temperature within the $\alpha$ + liquid phase region. If the mass fraction of each phase is 0.5, estimate:

(a) The temperature of the alloy.

(b) The compositions of the two phases.

(a) We are given that the mass fractions of $\alpha$ and liquid phases are both 0.5 for a 30 wt% Sn-70 wt% Pb alloy and asked to estimate the temperature of the alloy. Using the above phase diagram, by trial and error with a ruler, a tie line within the $\alpha$ + L phase region that is divided in half for an alloy of this composition exists at about 225°C.

(b) We are now asked to determine the compositions of the two phases. This is accomplished by noting the intersections of this tie line with both the solidus and liquidus lines. From these intersections, $C_\alpha = 15$ wt% Sn, and $C_L = 45$ wt% Sn.