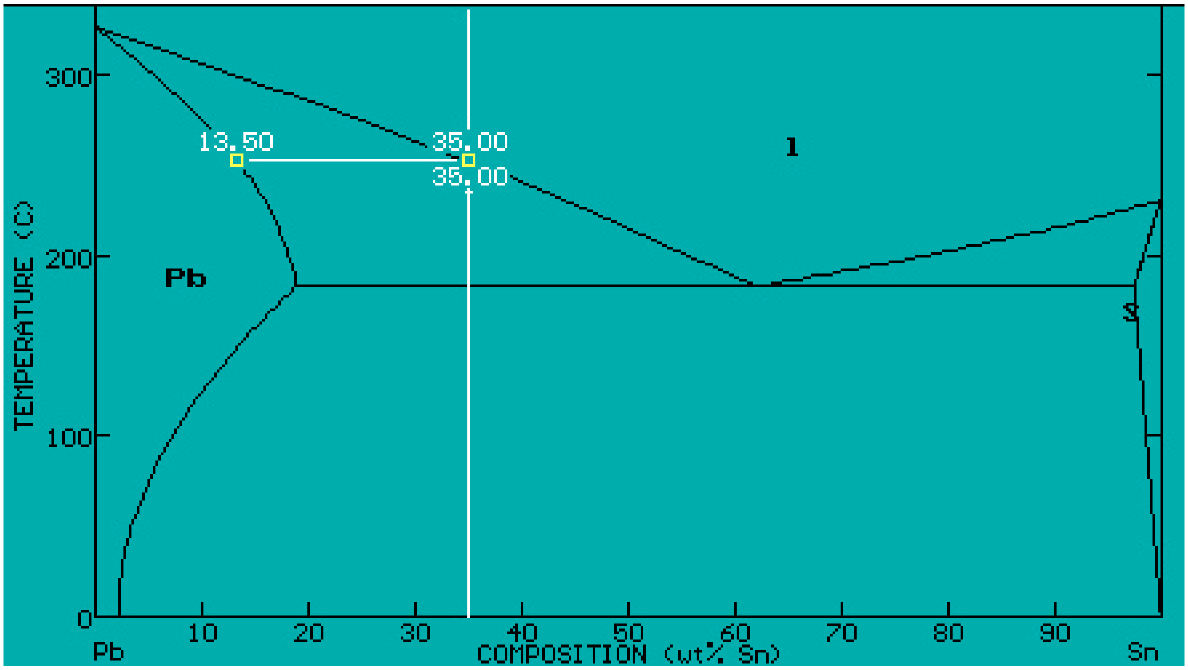
Example 10-1 (Askeland Homework Problem 10.10). Eutectic Phase Diagram.

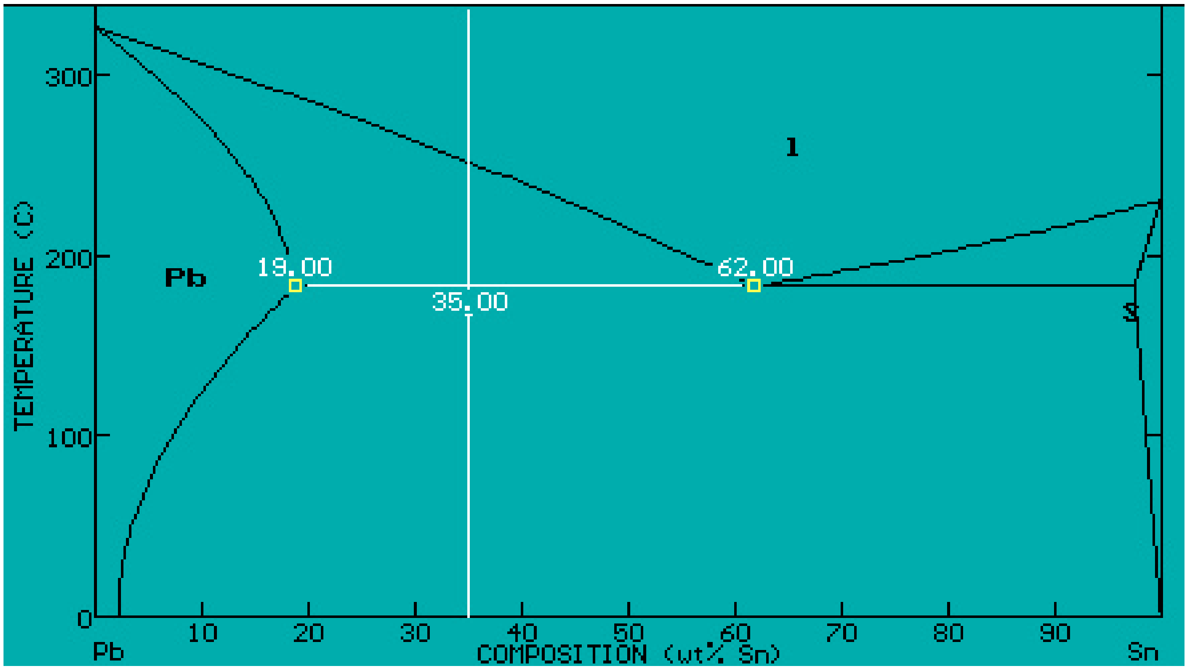
Consider a Pb-35%Sn alloy. Determine
a) if the alloy is hypoeutectic or hypereutectic,
b) the composition of the first solid to form during solidification
c) the amounts and compositions of each phase at 184C
d) the amounts and compositions of each phase at 182C
e) the amounts and compositions of each microconstituent at 182C, and
f) the amounts and compositions of each phase at 25C.

In order to answer these questions, we will draw a series of tie lines on the phase diagram.

Part a). Since the alloy has an overall composition of 35% Sn, which is less than the eutectic composition of 62%, the alloy is hypoeutectic.



Part b). The first solid to form during solidification occurs when the sample cools down to the liquidus line. This is drawn in the diagram below. A tie line constructed from that point reaches the lead-rich alpha phase at 13.5% Sn. This is therefore the composition of the first solid phase.



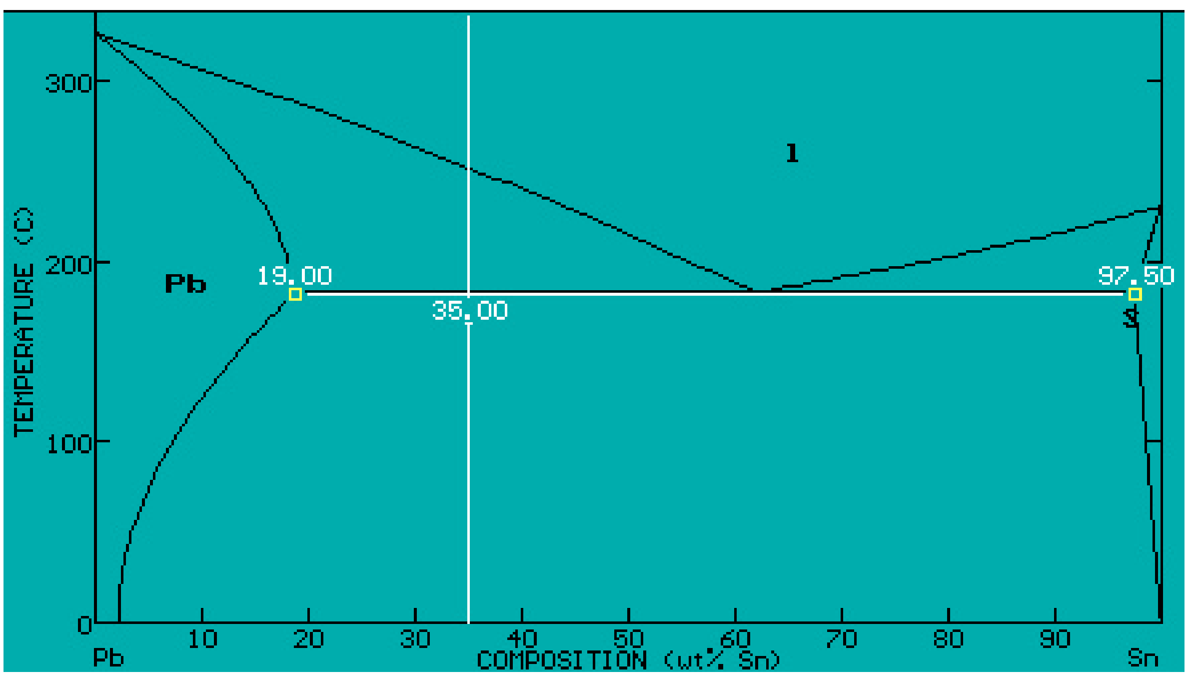
Part c). At 184C (just above the eutectic transformation), the sample consists of liquid and alpha (lead-rich phase). The ends of a tie line constructed at this temperature indicate that the concentration of the solid (lead rich, alpha) phase is 19% Sn, and the concentration of the liquid is 62% Sn. With the lever law, and the fact that the overall composition of the sample is 35% Sn, this allows us to calculate the amount of each phase.

$$\text{Alpha} = \frac{62-35}{62-19}$$ The lever law, with the numeric values inserted

$$\text{Alpha} = 0.62791$$ The sample contains 62.8% alpha

$$\text{Liquid} = 1-\text{Alpha}$$

$$\text{Liquid} = 0.37209$$ and 37.2% liquid



Part d). At a temperature of 182C, we lie just below the eutectic temperature. Consequently, the sample has solidified and consists of two phases (lead-rich alpha and tin-rich beta), and two microconstituents (primary alpha and lamellar eutectic). First, we determine the information requested for the phases.

A tie line drawn at 182C has ends that identify the phases (lead-rich alpha and tin-rich beta), and the compositions of each phase. The lead-rich phase contains 19% Sn, and the tin-rich phase contains 97.5% Sn. As before the lever law and the knowledge that the overall sample composition is 35% Sn lets us use these values to calculate the amount of each phase.

$$\text{Alpha} = \frac{97.5 - 35}{97.5 - 19}$$ The lever law, with the numeric values inserted

$$\text{Alpha} = 0.79618$$ The sample contains 79.6% alpha (lead-rich)

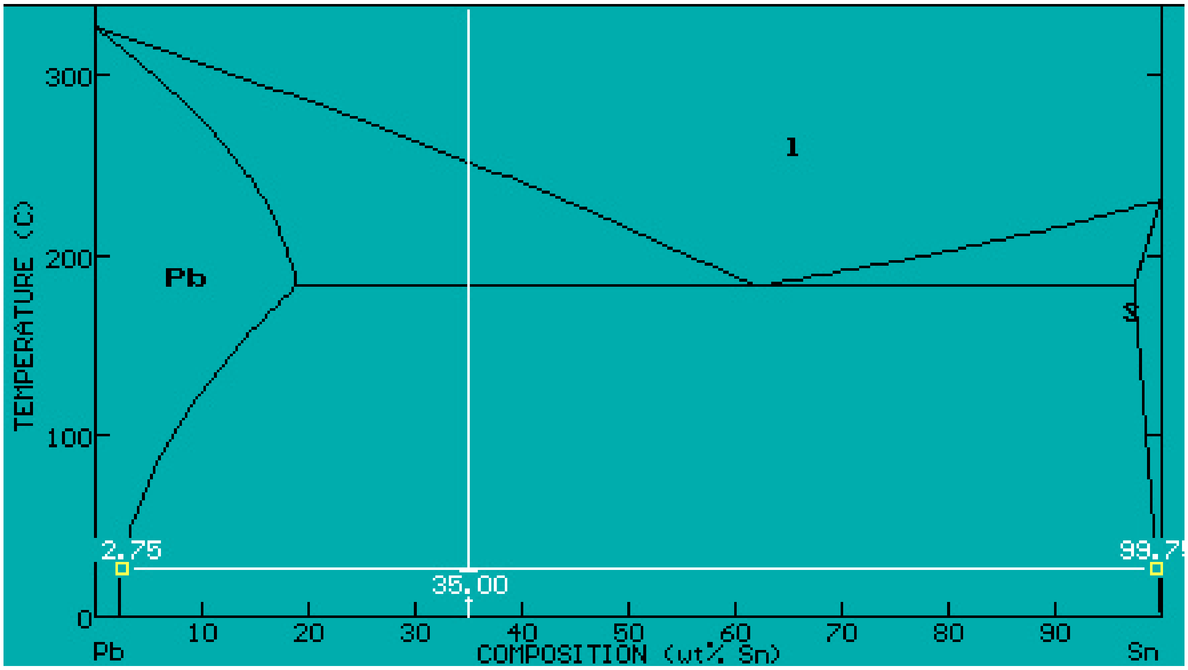
$$\text{Beta} = 1 - \text{Alpha}$$

$$\text{Beta} = 0.20382$$ And 20.4% beta (tin-rich)

Part e). From part c) above, we know that 62.8% of the sample transformed to primary alpha before the remaining liquid underwent the eutectic transformation. The remaining 37.2% of the sample then formed the lamellar eutectic microconstituent. From part d) we know that 20.4% of the sample is the beta phase, and all of that is in the eutectic. Hence, the only remaining unknown is the amount of alpha in the eutectic, which is simply the difference...

$$\text{Alpha} = 0.37209 - 0.20382$$ between the total amount of eutectic and amount of beta in eutectic, or

$$\text{Alpha} = 0.16827$$ 16.8% alpha in the eutectic.



Part f). When the sample is cooled to 25C, the tie line identifies the phases present as lead-rich alpha and tin-rich beta. However, as compared to the situation at 182C (in part d above), the composition of the phases has changed. The solubility of each phase for the other element has decreased, and now the lead-rich alpha phase contains only 2.75% Sn, while the tin-rich beta phase contains 99.75% Sn (and only 0.25% lead). The lever law gives us the total amount of each phase, in the same way as above.

$$\text{Alpha} = \frac{99.75 - 35}{99.75 - 2.75}$$ Lever law

$\text{Alpha} = 0.66753$ 66.8% alpha

$$\text{Beta} = 1 - \text{Alpha}$$

$\text{Beta} = 0.33247$ and 33.2% beta

Not only have the equilibrium amounts of the two phases changed, but so has their distribution in the microconstituents. Much of the additional tin-rich beta phase has precipitated within the primary alpha, while the proportions of the alpha and beta in the lamellar eutectic has changed slightly.