9.8 *A 50 wt% Ni–50 wt% Cu alloy is slowly cooled from 1400°C to 1200°C.*

(a) At what temperature does the first solid phase form?

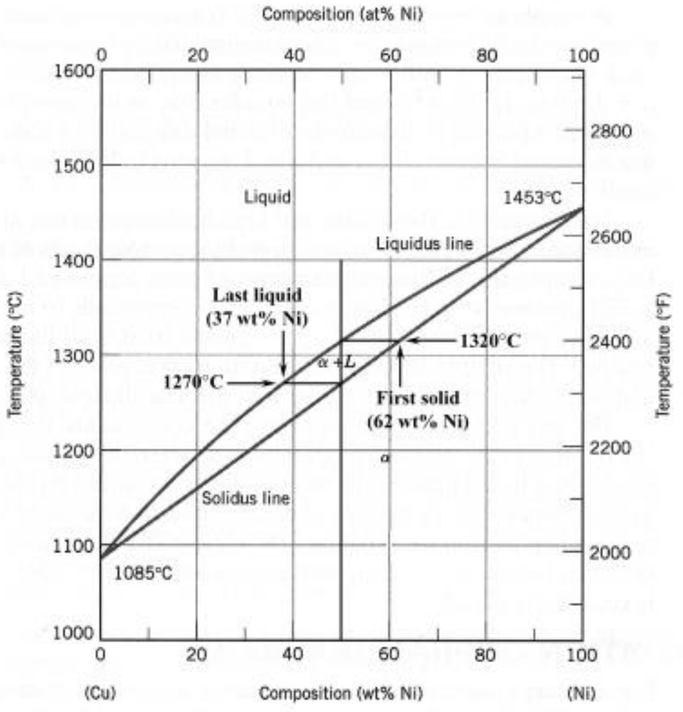
(b) What is the composition of this solid phase?

(c) At what temperature does the liquid solidify?

(d) What is the composition of this last remaining liquid phase?

Solution

Shown below is the Cu-Ni phase diagram (Figure 10.3a) and a vertical line constructed at a composition of 50 wt% Ni-50 wt% Cu.



(a)

(a) The first solid phase forms at the temperature at which a vertical line at this composition intersects the L–$(\alpha + L)$ phase boundary--i.e., at about 1320°C.

(b) The composition of this solid phase corresponds to the intersection with the L–$(\alpha + L)$ phase boundary, of a tie line constructed across the $\alpha + L$ phase region at 1320°C--i.e., C_α = 62 wt% Ni-38 wt% Cu.

(c) Complete solidification of the alloy occurs at the intersection of this same vertical line at 50 wt% Ni with the $(\alpha + L)$–α phase boundary—i.e., at about 1270°C.

(d) The composition of the last liquid phase remaining prior to complete solidification corresponds to the intersection with the L–$(\alpha + L)$ boundary, of the tie line constructed across the $\alpha + L$ phase region at 1270°C—i.e., C_L is about 37 wt% Ni-63 wt% Cu.

9.21 *For a lead–tin alloy of composition 80 wt% Sn–20 wt% Pb and at 180°C, do the following:*

(a) Determine the mass fractions of the α and β phases.

(b) Determine the mass fractions of primary β and eutectic microconstituents.

(c) Determine the mass fraction of eutectic β.

Solution

(a) This portion of the problem asks that we determine the mass fractions of α and β phases for an 80 wt% Sn-20 wt% Pb alloy (at 180°C). In order to do this, it is necessary to employ the lever rule using a tie line that extends entirely across the $\alpha + \beta$ phase field. From Figure 9.8 and at 180°C, C_α = 18.3 wt% Sn, C_β = 97.8 wt% Sn, and C_{eutectic} = 61.9 wt% Sn. Therefore, the two lever-rule expressions are as follows:

$$W_\alpha = \frac{C_\beta - C_0}{C_\beta - C_\alpha} = \frac{97.8 - 80}{97.8 - 18.3} = 0.224$$

$$W_\beta = \frac{C_0 - C_\alpha}{C_\beta - C_\alpha} = \frac{80 - 18.3}{97.8 - 18.3} = 0.776$$

(b) Now it is necessary to determine the mass fractions of primary β and eutectic microconstituents for this same alloy. This requires that we utilize the lever rule and a tie line that extends from the maximum solubility of Pb in the β phase at 180°C (i.e., 97.8 wt% Sn) to the eutectic composition (61.9 wt% Sn). Thus, mass fractions of primary β and eutectic microconstituents (denoted by $W_{\beta'}$ and W_e, respectively) are determined using the following lever-rule expressions:

$$W_{\beta'} = \frac{C_0 - C_{\text{eutectic}}}{C_\beta - C_{\text{eutectic}}} = \frac{80.0 - 61.9}{97.8 - 61.9} = 0.504$$

$$W_e = \frac{C_\beta - C_0}{C_\beta - C_{\text{eutectic}}} = \frac{97.8 - 80.0}{97.8 - 61.9} = 0.496$$

(c) And, finally, we are asked to compute the mass fraction of eutectic β, $W_{e\beta}$. This quantity is simply the difference between the mass fractions of total β and primary β as follows:

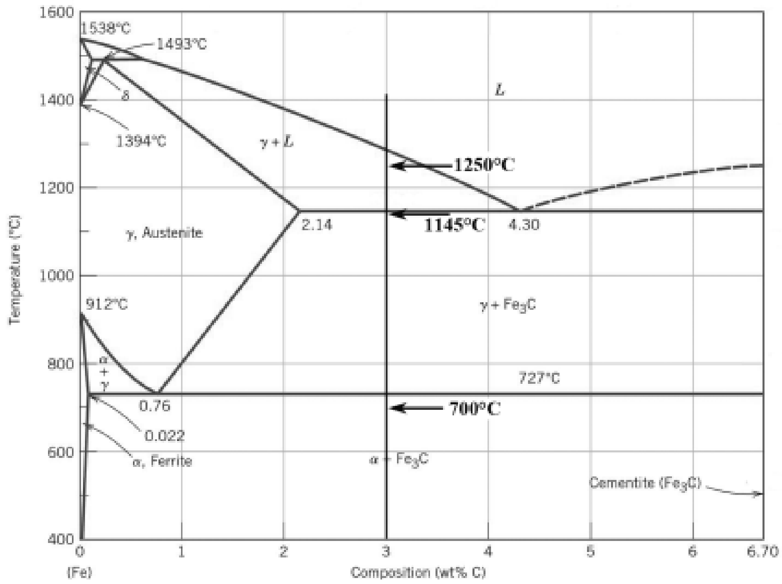
$$W_{e\beta} = W_\beta - W_{\beta'}$$

$$= 0.776 - 0.504 = 0.272$$

9.43 *For an iron–carbon alloy of composition 3 wt% C–97 wt% Fe, make schematic sketches of the microstructure that would be observed for conditions of very slow cooling at the following temperatures: 1250°C, 1145°C, and 700°C. Label the phases and indicate their compositions (approximate).*

Solution

Below is shown the Fe-Fe_3C phase diagram with a vertical line constructed at 3 wt% C; also along this line noted temperatures of 1250°C, 1145°C, and 700°C.



Schematic microstructures for this iron-carbon alloy at the three temperatures are shown below; approximate phase compositions are also indicated.