CHAPTER 9

PHASE DIAGRAMS

PROBLEM SOLUTIONS

9.17 *A 90 wt% Ag-10 wt% Cu alloy is heated to a temperature within the β + liquid phase region. If the composition of the liquid phase is 85 wt% Ag, determine:*

(a) The temperature of the alloy

(b) The composition of the β phase

(c) The mass fractions of both phases

Solution

(a) In order to determine the temperature of a 90 wt% Ag-10 wt% Cu alloy for which β 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 Figure 9.7 that intersects the liquidus line at 85 wt% Ag; this is possible at about 850°C.

(b) The composition of the β 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, Equations 9.1 and 9.2 with C_0 = 90 wt% Ag, C_L = 85 wt% Ag, and C_β = 95 wt% Ag, as

$$W_\beta = \frac{C_0 - C_L}{C_\beta - C_L} = \frac{90 - 85}{95 - 85} = 0.50$$

$$W_L = \frac{C_\beta - C_0}{C_\beta - C_L} = \frac{95 - 90}{95 - 85} = 0.50$$

9.32 *For a copper-silver alloy of composition 25 wt% Ag-75 wt% Cu and at 775°C (1425°F) do the following:*

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

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

(c) Determine the mass fraction of eutectic α.

Solution

(a) This portion of the problem asks that we determine the mass fractions of α and β phases for an 25 wt% Ag-75 wt% Cu alloy (at 775°C). In order to do this it is necessary to employ the lever rule using a tie line that extends entirely across the α + β phase field. From Figure 9.7 and at 775°C, C_α = 8.0 wt% Ag, C_β = 91.2 wt% Ag, and C_{eutectic} = 71.9 wt% Sn. Therefore, the two lever-rule expressions are as follows:

$$W_\alpha = \frac{C_\beta - C_0}{C_\beta - C_\alpha} = \frac{91.2 - 25}{91.2 - 8.0} = 0.796$$

$$W_\beta = \frac{C_0 - C_\alpha}{C_\beta - C_\alpha} = \frac{25 - 8.0}{91.2 - 8.0} = 0.204$$

(b) Now it is necessary to determine the mass fractions of primary α and eutectic microconstituents for this same alloy. This requires us to utilize the lever rule and a tie line that extends from the maximum solubility of Ag in the α phase at 775°C (i.e., 8.0 wt% Ag) to the eutectic composition (71.9 wt% Ag). Thus

$$W_{\alpha'} = \frac{C_{\text{eutectic}} \text{ź}\ C_0}{C_{\text{eutectic}} \text{ź}\ C_\alpha} = \frac{71.9 - 25}{71.9 - 8.0} = 0.734$$

$$W_e = \frac{C_0 - C_\alpha}{C_{\text{eutectic}} - C_\alpha} = \frac{25 - 8.0}{71.9 - 8.0} = 0.266$$

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

$$W_{e\alpha} = W_\alpha - W_{\alpha'} = 0.796 - 0.734 = 0.062$$

9.34 *Consider the hypothetical eutectic phase diagram for metals A and B, which is similar to that for the lead-tin system, Figure 9.8. Assume that (1) α and β phases exist at the A and B extremities of the phase diagram, respectively; (2) the eutectic composition is 47 wt% B-53 wt% A; and (3) the composition of the β phase at the eutectic temperature is 92.6 wt% B-7.4 wt% A. Determine the composition of an alloy that will yield primary α and total α mass fractions of 0.356 and 0.693, respectively.*

Solution

We are given a hypothetical eutectic phase diagram for which C_{eutectic} = 47 wt% B, C_β = 92.6 wt% B at the eutectic temperature, and also that $W_{\alpha'}$ = 0.356 and W_α = 0.693; from this we are asked to determine the composition of the alloy. Let us write lever rule expressions for $W_{\alpha'}$ and W_α

$$W_\alpha = \frac{C_\beta - C_0}{C_\beta - C_\alpha} = \frac{92.6 - C_0}{92.6 - C_\alpha} = 0.693$$

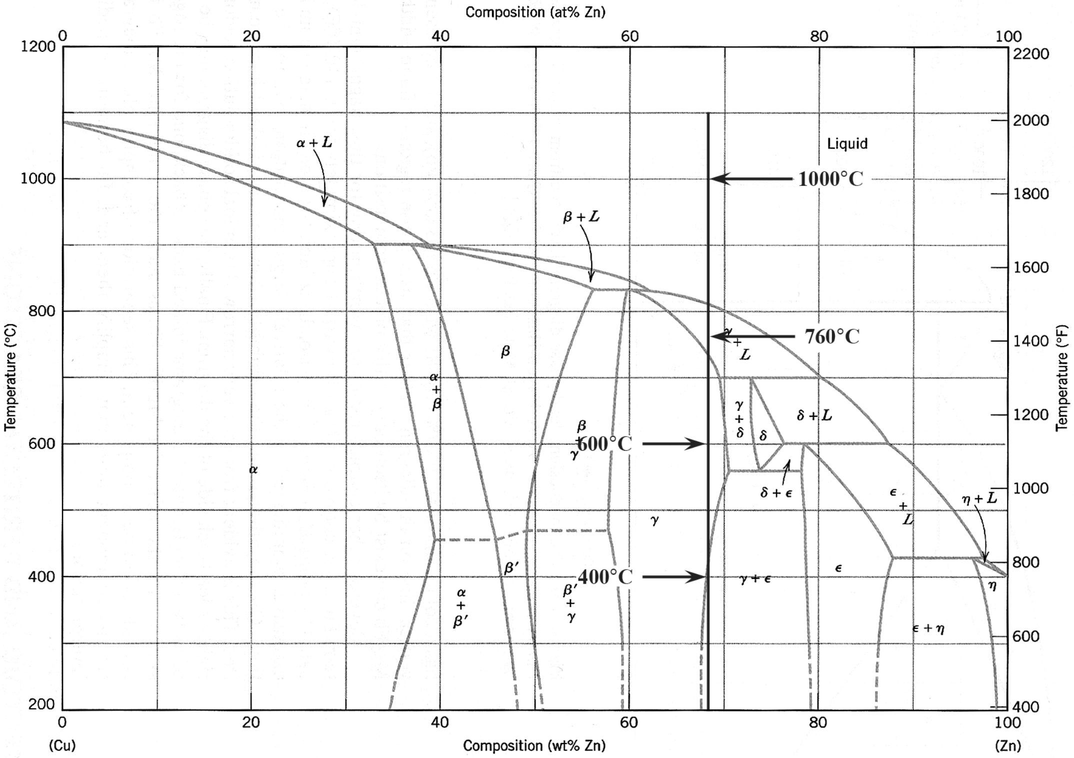
$$W_{\alpha'} = \frac{C_{\text{eutectic}} - C_0}{C_{\text{eutectic}} - C_\alpha} = \frac{47 - C_0}{47 - C_\alpha} = 0.356$$

Thus, we have two simultaneous equations with C_0 and C_α as unknowns. Solving them for C_0 gives C_0 = 32.6 wt% B.

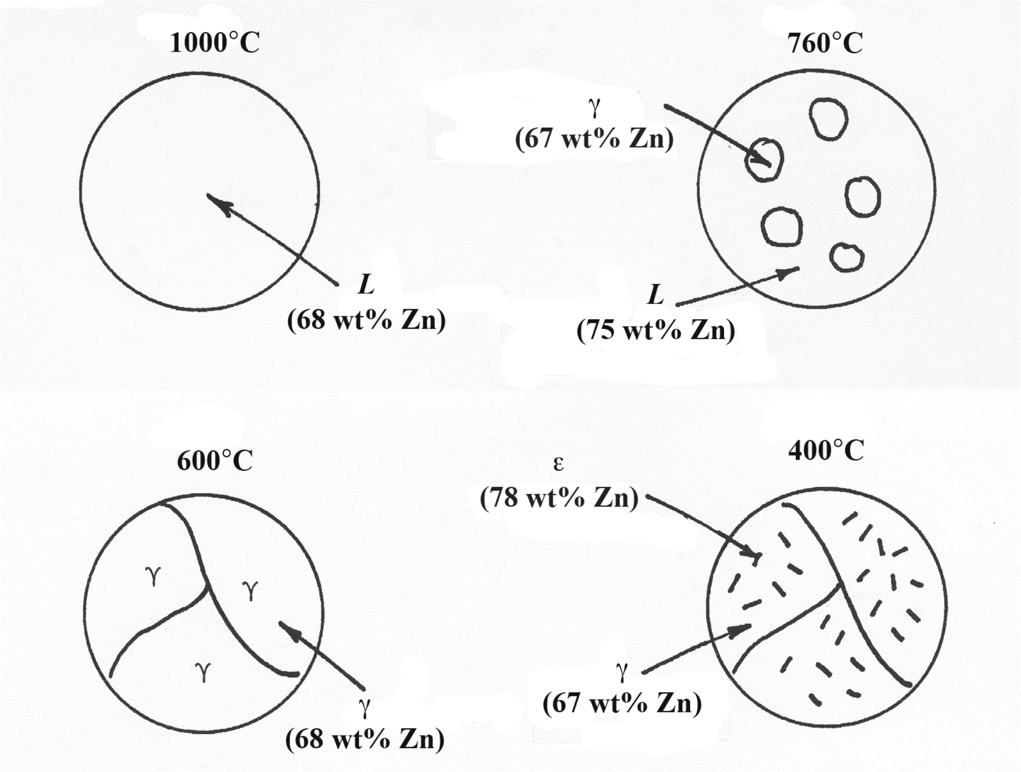
9.36 *For a 68 wt% Zn-32 wt% Cu alloy, make schematic sketches of the microstructure that would be observed for conditions of very slow cooling at the following temperatures: 1000°C (1830°F), 760°C (1400°F), 600°C (1110°F), and 400°C (750°F). Label all phases and indicate their approximate compositions.*

Solution

The illustration below is the Cu-Zn phase diagram (Figure 9.19). A vertical line at a composition of 68 wt% Zn-32 wt% Cu has been drawn, and, in addition, horizontal arrows at the four temperatures called for in the problem statement (i.e., 1000°C, 760°C, 600°C, and 400°C).



On the basis of the locations of the four temperature-composition points, schematic sketches of the four respective microstructures along with phase compositions are represented as follows:



9.50 *Consider 1.0 kg of austenite containing 1.15 wt% C, cooled to below 727°C (1341°F).*

(a) What is the proeutectoid phase?

(b) How many kilograms each of total ferrite and cementite form?

(c) How many kilograms each of pearlite and the proeutectoid phase form?

(d) Schematically sketch and label the resulting microstructure.

Solution

(a) The proeutectoid phase will be Fe_3C since 1.15 wt% C is greater than the eutectoid composition (0.76 wt% C).

(b) For this portion of the problem, we are asked to determine how much total ferrite and cementite form. Application of the appropriate lever rule expression yields

$$W_\alpha = \frac{C_{Fe_3C} - C_0}{C_{Fe_3C} - C_\alpha} = \frac{6.70 - 1.15}{6.70 - 0.022} = 0.83$$

which, when multiplied by the total mass of the alloy (1.0 kg), gives 0.83 kg of total ferrite.

Similarly, for total cementite,

$$W_{\mathrm{Fe_3C}} = \frac{C_0 - C_\alpha}{C_{\mathrm{Fe_3C}} - C_\alpha} = \frac{1.15 - 0.022}{6.70 - 0.022} = 0.17$$

And the mass of total cementite that forms is (0.17)(1.0 kg) = 0.17 kg.

(c) Now we are asked to calculate how much pearlite and the proeutectoid phase (cementite) form. Applying Equation 9.22, in which $C_1' = 1.15$ wt% C

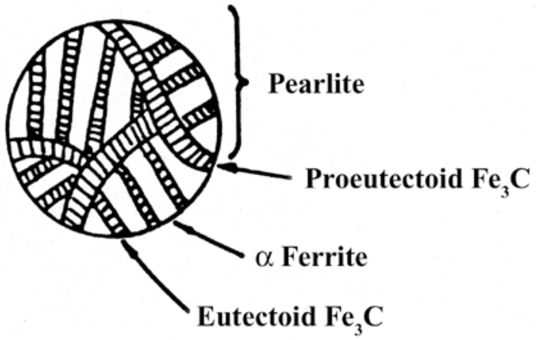
$$W_p = \frac{6.70 - C_1'}{6.70 - 0.76} = \frac{6.70 - 1.15}{6.70 - 0.76} = 0.93$$

which corresponds to a mass of 0.93 kg. Likewise, from Equation 9.23

$$W_{\mathrm{Fe_3C'}} = \frac{C_1' - 0.76}{5.94} = \frac{1.15 - 0.76}{5.94} = 0.07$$

which is equivalent to 0.07 kg of the total 1.0 kg mass.

(d) Schematically, the microstructure would appear as:



9.53 *The microstructure of an iron–carbon alloy consists of proeutectoid ferrite and pearlite; the mass fractions of these two microconstituents are 0.286 and 0.714, respectively. Determine the concentration of carbon in this alloy.*

Solution

This problem asks that we determine the carbon concentration in an iron-carbon alloy, given the mass fractions of proeutectoid ferrite and pearlite. From Equation 9.20

$$W_p = 0.714 = \frac{C_0' - 0.022}{0.74}$$

which yields C_0' = 0.55 wt% C.

9.54 *The mass fractions of total ferrite and total cementite in an iron-carbon alloy are 0.88 and 0.12, respectively. Is this a hypoeutectoid or hypereutectoid alloy? Why?*

Solution

In this problem we are given values of W_α and W_{Fe_3C} for an iron-carbon alloy (0.88 and 0.12, respectively), and then are asked to specify whether the alloy is hypoeutectoid or hypereutectoid. Employment of the lever rule for total α leads to

$$W_\alpha = 0.88 = \frac{C_{Fe_3C} - C_0}{C_{Fe_3C} - C_\alpha} = \frac{6.70 - C_0}{6.70 - 0.022}$$

Now, solving for C_0, the alloy composition, leads to C_0 = 0.82 wt% C. Therefore, the alloy is *hypereutectoid* since C_0 is greater than 0.76 wt% C.

CHAPTER 9

PHASE DIAGRAMS

PROBLEM SOLUTIONS

Solubility Limit

9.1 *Consider the sugar–water phase diagram of Figure 9.1.*

(a) How much sugar will dissolve in 1500 g water at 90°C (194°F)?

(b) If the saturated liquid solution in part (a) is cooled to 20°C (68°F), some of the sugar will precipitate out as a solid. What will be the composition of the saturated liquid solution (in wt% sugar) at 20°C?

(c) How much of the solid sugar will come out of solution upon cooling to 20°C?

Solution

(a) We are asked to determine how much sugar will dissolve in 1000 g of water at 90°C. From the solubility limit curve in Figure 9.1, at 90°C the maximum concentration of sugar in the syrup is about 77 wt%. It is now possible to calculate the mass of sugar using Equation 4.3 as

$$C_{\text{sugar}}(\text{wt\%}) = \frac{m_{\text{sugar}}}{m_{\text{sugar}} + m_{\text{water}}} \times 100$$

$$77 \text{ wt\%} = \frac{m_{\text{sugar}}}{m_{\text{sugar}} + 1500 \text{ g}} \times 100$$

Solving for m_{sugar} yields $m_{\text{sugar}} = 5022$ g

(b) Again using this same plot, at 20°C the solubility limit (or the concentration of the saturated solution) is about 64 wt% sugar.

(c) The mass of sugar in this saturated solution at 20°C (m'_{sugar}) may also be calculated using Equation 4.3 as follows:

$$64 \text{ wt\%} = \frac{m'_{\text{sugar}}}{m'_{\text{sugar}} + 1500 \text{ g}} \times 100$$

which yields a value for m'_{sugar} of 2667 g. Subtracting the latter from the former of these sugar concentrations yields the amount of sugar that precipitated out of the solution upon cooling m''_{sugar}; that is

$$m''_{\text{sugar}} = m_{\text{sugar}} - m\tilde{Q}_{\text{sugar}} = 5022\text{ g} - 2667\text{ g} = 2355\text{ g}$$

9.2 *At 500°C (930°F), what is the maximum solubility (a) of Cu in Ag? (b) Of Ag in Cu?*

Solution

(a) From Figure 9.7, the maximum solubility of Cu in Ag at 500°C corresponds to the position of the β–(α + β) phase boundary at this temperature, or to about 2 wt% Cu.

(b) From this same figure, the maximum solubility of Ag in Cu corresponds to the position of the α–(α + β) phase boundary at this temperature, or about 1.5 wt% Ag.

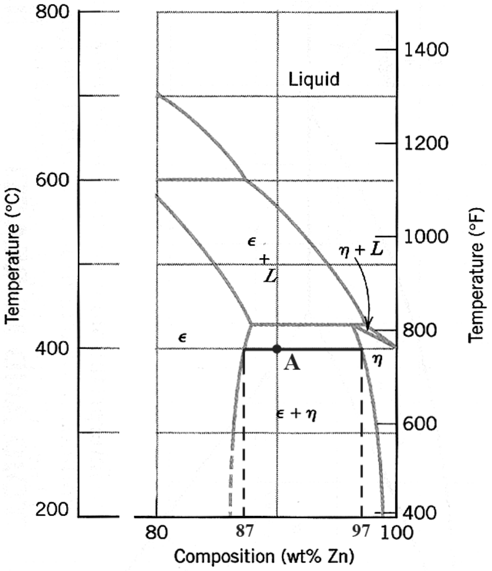
9.8 *Cite the phases that are present and the phase compositions for the following alloys:*

(a) 90 wt% Zn-10 wt% Cu at 400°C (750°F)
(b) 75 wt% Sn-25 wt% Pb at 175°C (345°F)
(c) 55 wt% Ag-45 wt% Cu at 900°C (1650°F)
(d) 30 wt% Pb-70 wt% Mg at 425°C (795°F)

Solution

This problem asks that we cite the phase or phases present for several alloys at specified temperatures.

(a) That portion of the Cu-Zn phase diagram (Figure 9.19) that pertains to this problem is shown below; the point labeled "A" represents the 90 wt% Zn-10 wt% Cu composition at 400°C.

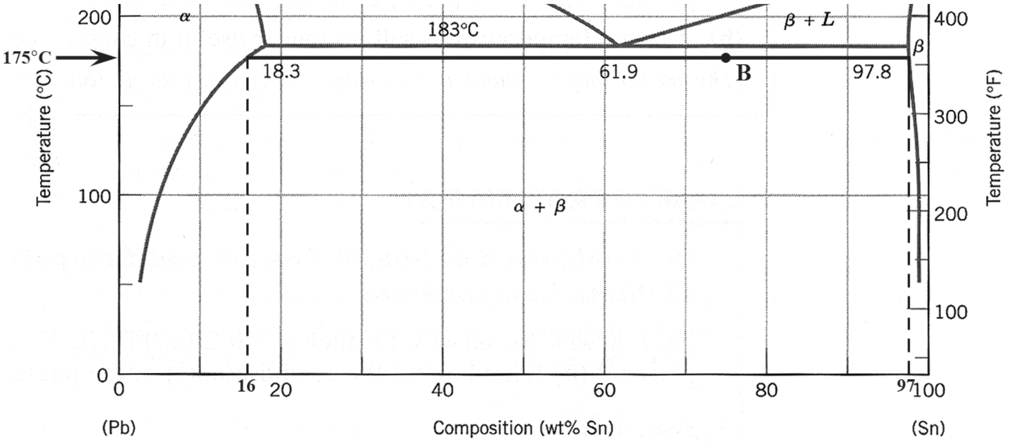


As may be noted, point A lies within the ε and η phase field. A tie line has been constructed at 400°C; its intersection with the ε–ε + η phase boundary is at 87 wt% Zn, which corresponds to the composition of the ε phase. Similarly, the tie-line intersection with the ε + η–η phase boundary occurs at 97 wt% Zn, which is the composition of the η phase. Thus, the phase compositions are as follows:

$$C_{\varepsilon} = 87 \text{ wt\% Zn-13 wt\% Cu}$$

$$C_{\eta} = 97 \text{ wt\% Zn-3 wt\% Cu}$$

(b) That portion of the Pb-Sn phase diagram (Figure 9.8) that pertains to this problem is shown below; the point labeled “B” represents the 75 wt% Sn-25 wt% Pb composition at 175°C.

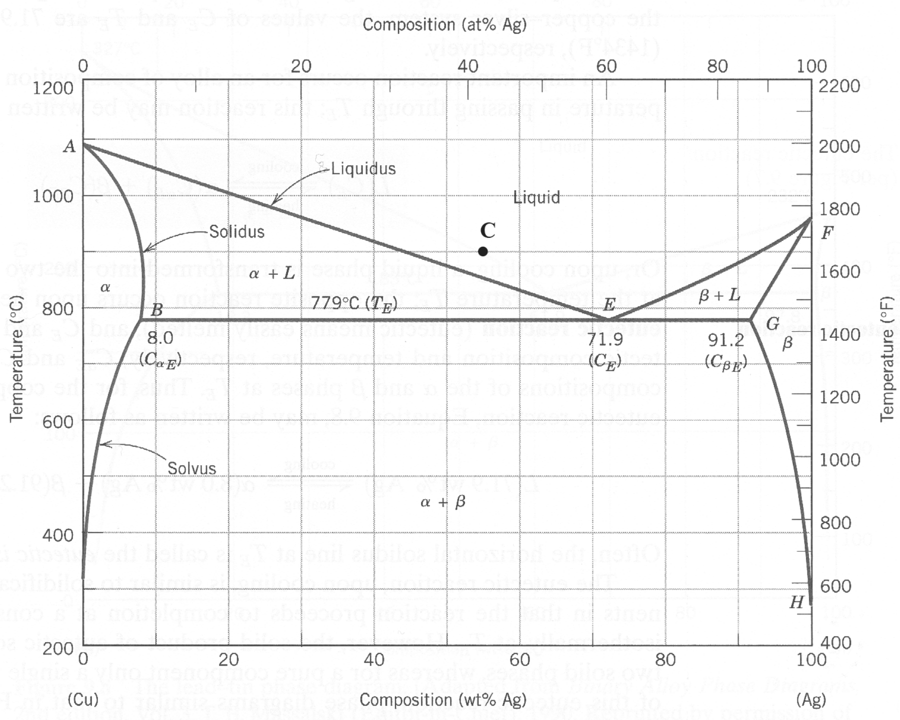


As may be noted, point B lies within the α + β phase field. A tie line has been constructed at 175°C; its intersection with the α–α + β phase boundary is at 16 wt% Sn, which corresponds to the composition of the α phase. Similarly, the tie-line intersection with the α + β–β phase boundary occurs at 97 wt% Sn, which is the composition of the β phase. Thus, the phase compositions are as follows:

$$C_\alpha = 16 \text{ wt\% Sn-84 wt\% Pb}$$

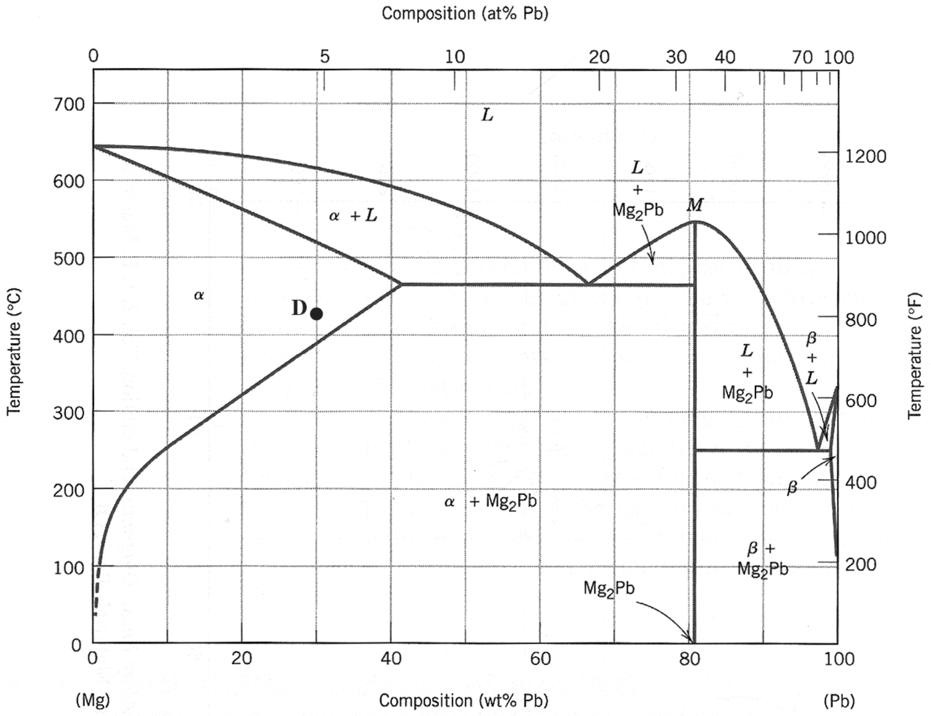
$$C_\beta = 97 \text{ wt\% Sn-3 wt\% Pb}$$

(c) The Ag-Cu phase diagram (Figure 9.7) is shown below; the point labeled "C" represents the 55 wt% Ag-45 wt% Cu composition at 900°C.



As may be noted, point C lies within the Liquid phase field. Therefore, only the liquid phase is present; its composition is 55 wt% Ag-45 wt% Cu.

(d) The Mg-Pb phase diagram (Figure 9.20) is shown below; the point labeled "D" represents the 30 wt% Pb-70 wt% Mg composition at 425°C.



As may be noted, point D lies within the α phase field. Therefore, only the α phase is present; its composition is 30 wt% Pb-70 wt% Mg.

9.12 *A 50 wt% Pb-50 wt% Mg alloy is slowly cooled from 700°C (1290°F) to 400°C (750°F).*

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

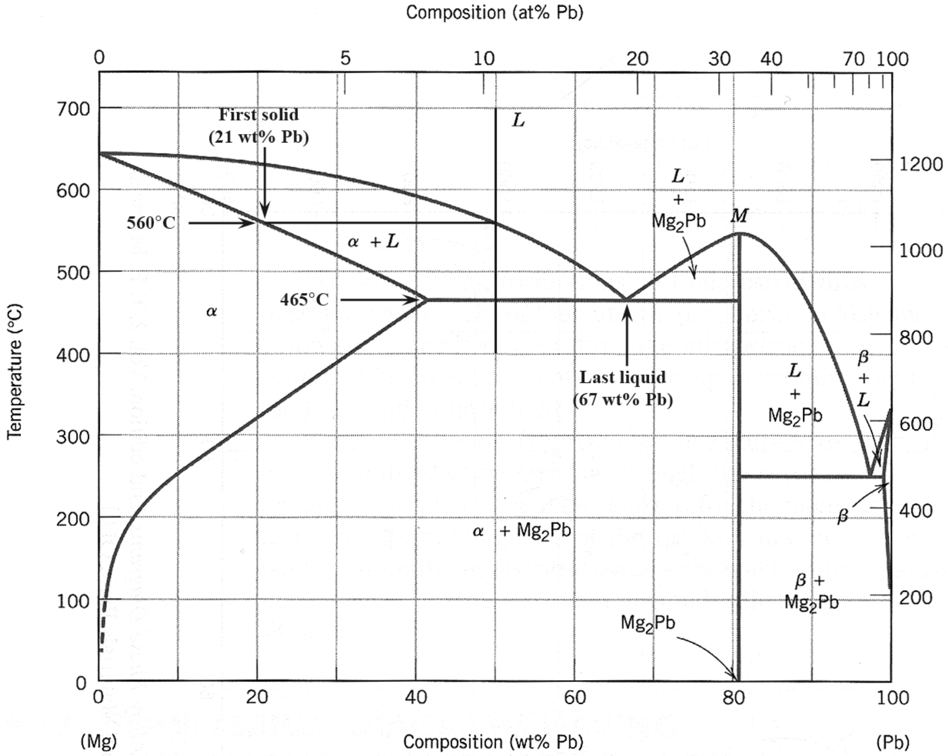
(b) What is the composition of this solid phase?

(c) At what temperature does the liquid solidify?

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

Solution

Shown below is the Mg-Pb phase diagram (Figure 9.20) and a vertical line constructed at a composition of 50 wt% Pb-50 wt% Mg.



(a) Upon cooling from 700°C, the first solid phase forms at the temperature at which a vertical line at this composition intersects the *L*-(α + *L*) phase boundary--i.e., about 560°C;

(b) The composition of this solid phase corresponds to the intersection with the α-(α + *L*) phase boundary, of a tie line constructed across the α + *L* phase region at 560°C--i.e., 21 wt% Pb-79 wt% Mg;

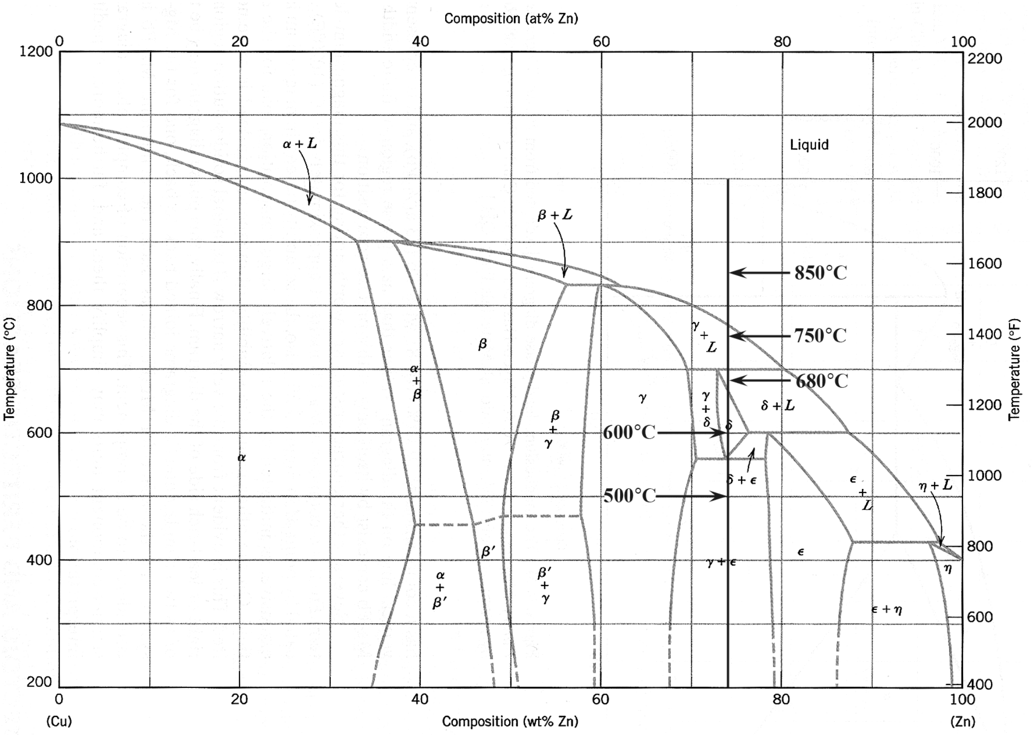
(c) Complete solidification of the alloy occurs at the intersection of this same vertical line at 50 wt% Pb with the eutectic isotherm--i.e., about 465°C;

(d) The composition of the last liquid phase remaining prior to complete solidification corresponds to the eutectic composition--i.e., about 67 wt% Pb-33 wt% Mg.

9.13 *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.*

Solution

This problem asks us to determine the phases present and their concentrations at several temperatures, for an alloy of composition 74 wt% Zn-26 wt% Cu. From Figure 9.19 (the Cu-Zn phase diagram), which is shown below with a vertical line constructed at the specified composition:



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

At 750°C, γ and liquid phases are present; C_γ = 67 wt% Zn-33 wt% Cu; C_L = 77 wt% Zn-23 wt% Cu

At 680°C, δ and liquid phases are present; C_δ = 73 wt% Zn-27 wt% Cu; C_L = 82 wt% Zn-18 wt% Cu

At 600°C, the δ phase is present; C_δ = 74 wt% Zn-26 wt% Cu

At 500°C, γ and ε phases are present; C_γ = 69 wt% Zn-31 wt% Cu; C_ε = 78 wt% Zn-22 wt% Cu

9.17 *A 90 wt% Ag-10 wt% Cu alloy is heated to a temperature within the* β *+ liquid phase region. If the composition of the liquid phase is 85 wt% Ag, determine:*

(a) The temperature of the alloy

(b) The composition of the β *phase*

(c) The mass fractions of both phases

Solution

(a) In order to determine the temperature of a 90 wt% Ag-10 wt% Cu alloy for which β and liquid phases are present with the liquid phase of composition 85 wt% Ag, we need to construct a tie line across the β + *L* phase region of Figure 9.7 that intersects the liquidus line at 85 wt% Ag; this is possible at about 850°C.

(b) The composition of the β 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, Equations 9.1 and 9.2 with C_0 = 90 wt% Ag, C_L = 85 wt% Ag, and C_β = 95 wt% Ag, as

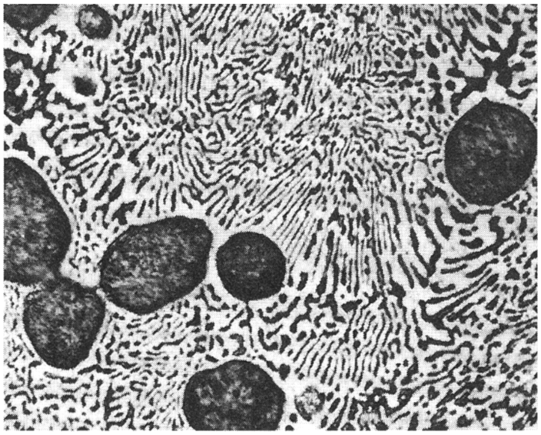
$$W_\beta = \frac{C_0 - C_L}{C_\beta - C_L} = \frac{90 - 85}{95 - 85} = 0.50$$

$$W_L = \frac{C_\beta - C_0}{C_\beta - C_L} = \frac{95 - 90}{95 - 85} = 0.50$$

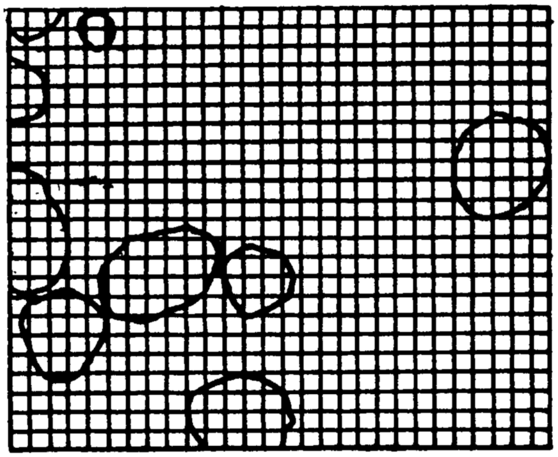
9.38 *On the basis of the photomicrograph (i.e., the relative amounts of the microconstituents) for the lead–tin alloy shown in Figure 9.17 and the Pb–Sn phase diagram (Figure 9.8), estimate the composition of the alloy, and then compare this estimate with the composition given in the figure legend of Figure 9.17. Make the following assumptions: (1) the area fraction of each phase and microconstituent in the photomicrograph is equal to its volume fraction; (2) the densities of the α and β phases as well as the eutectic structure are 11.2, 7.3, and 8.7 g/cm^3, respectively; and (3) this photomicrograph represents the equilibrium microstructure at 180°C (355°F).*

Solution

Below is shown the micrograph of the Pb-Sn alloy, Figure 9.17:



Primary α and eutectic microconstituents are present in the photomicrograph, and it is given that their densities are 11.2 and 8.7 g/cm^3, respectively. Below is shown a square grid network onto which is superimposed outlines of the primary α phase areas.



The area fraction of this primary α phase may be determined by counting squares. There are a total of 644 squares, and of these, approximately 104 lie within the primary α phase particles. Thus, the area fraction of primary α is 104/644 = 0.16, which is also assumed to be the volume fraction.

We now want to convert the volume fractions into mass fractions in order to employ the lever rule to the Pb-Sn phase diagram. To do this, it is necessary to utilize Equations 9.7a and 9.7b as follows:

$$W_{\alpha'} = \frac{V_{\alpha'}\,\rho_{\alpha'}}{V_{\alpha'}\,\rho_{\alpha'} + V_{\text{eutectic}}\,\rho_{\text{eutectic}}}$$

$$= \frac{(0.16)(11.2\ \text{g/cm}^3)}{(0.16)(11.2\ \text{g/cm}^3) + (0.84)(8.7\ \text{g/cm}^3)} = 0.197$$

$$W_{\text{eutectic}} = \frac{V_{\text{eutectic}}\,\rho_{\text{eutectic}}}{V_{\alpha'}\,\rho_{\alpha'} + V_{\text{eutectic}}\,\rho_{\text{eutectic}}}$$

$$= \frac{(0.84)(8.7\ \text{g/cm}^3)}{(0.16)(11.2\ \text{g/cm}^3) + (0.84)(8.7\ \text{g/cm}^3)} = 0.803$$

From Figure 9.8, we want to use the lever rule and a tie-line that extends from the eutectic composition (61.9 wt% Sn) to the α–(α + β) phase boundary at 180°C (about 18.3 wt% Sn). Accordingly

$$W_{\alpha'} = 0.197 = \frac{61.9 - C_0}{61.9 - 18.3}$$

wherein C_0 is the alloy composition (in wt% Sn). Solving for C_0 yields C_0 = 53.3 wt% Sn. This value is in good agreement with the actual composition—viz. 50 wt% Sn.

9.40 *Two intermetallic compounds, AB and AB_2, exist for elements A and B. If the compositions for AB and AB_2 are 34.3 wt% A–65.7 wt% B and 20.7 wt% A–79.3 wt% B, respectively, and element A is potassium, identify element B.*

Solution

This problem gives us the compositions in weight percent for the two intermetallic compounds AB and AB_2, and then asks us to identify element B if element A is potassium. Probably the easiest way to solve this problem is to first compute the ratio of the atomic weights of these two elements using Equation 4.6a; then, since we know the atomic weight of potassium (39.10 g/mol, per inside the front cover), it is possible to determine the atomic weight of element B, from which an identification may be made.

First of all, consider the AB intermetallic compound; inasmuch as it contains the same numbers of A and B atoms, its composition in atomic percent is 50 at% A-50 at% B. Equation 4.6a may be written in the form:

$$C_B' = \frac{C_B A_A}{C_A A_B + C_B A_A} \times 100$$

where A_A and A_B are the atomic weights for elements A and B, and C_A and C_B are their compositions in weight percent. For this AB compound, and making the appropriate substitutions in the above equation leads to

$$50 \text{ at\% B} = \frac{(65.7 \text{ wt\% B})(A_A)}{(34.3 \text{ wt\% A})(A_B) + (65.7 \text{ wt\% B})(A_A)} \times 100$$

Now, solving this expression yields,

$$A_B = 1.916\, A_A$$

Since potassium is element A and it has an atomic weight of 39.10 g/mol, the atomic weight of element B is just

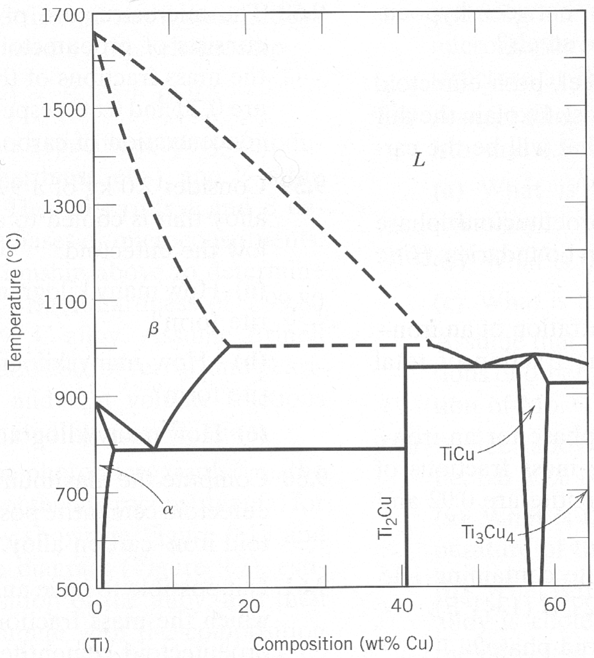
$$A_B = (1.916)(39.10 \text{ g/mol}) = 74.92 \text{ g/mol}$$

Upon consultation of the period table of the elements (Figure 2.6) we note the element that has an atomic weight closest to this value is arsenic (74.92 g/mol). Therefore, element B is arsenic, and the two intermetallic compounds are KAs and KAs_2.

9.43 *Figure 9.37 is a portion of the titanium-copper phase diagram for which only single-phase regions are labeled. Specify all temperature-composition points at which eutectics, eutectoids, peritectics, and congruent phase transformations occur. Also, for each, write the reaction upon cooling.*

Solution

Below is shown the titanium-copper phase diagram (Figure 9.37).



There is one eutectic on this phase diagram, which exists at about 51 wt% Cu-49 wt% Ti and 960°C. Its reaction upon cooling is

$$L \rightarrow Ti_2Cu + TiCu$$

There is one eutectoid for this system. It exists at about 7.5 wt% Cu-92.5 wt% Ti and 790°C. This reaction upon cooling is

$$\beta \rightarrow \alpha + Ti_2Cu$$

There is one peritectic on this phase diagram. It exists at about 40 wt% Cu-60 wt% Ti and 1005°C. The reaction upon cooling is

$$\beta + L \rightarrow \mathrm{Ti_2Cu}$$

There is a single congruent melting point that exists at about 57.5 wt% Cu-42.5 wt% Ti and 982°C. The reaction upon cooling is

$$L \rightarrow \mathrm{TiCu}$$

9.47 *(a) What is the distinction between hypoeutectoid and hypereutectoid steels?*

(b) In a hypoeutectoid steel, both eutectoid and proeutectoid ferrite exist. Explain the difference between them. What will be the carbon concentration in each?

Solution

(a) 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.

(b) 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.

9.48 *What is the carbon concentration of an iron–carbon alloy for which the fraction of total ferrite is 0.94?*

Solution

This problem asks that we compute the carbon concentration of an iron-carbon alloy for which the fraction of total ferrite is 0.94. Application of the lever rule (of the form of Equation 9.12) yields

$$W_\alpha = 0.94 = \frac{C_{\text{Fe}_3\text{C}} - C_0'}{C_{\text{Fe}_3\text{C}} - C_\alpha} = \frac{6.70 - C_0'}{6.70 - 0.022}$$

and solving for C_0'

$$C_0' = 0.42 \text{ wt\% C}$$

9.51 *Consider 2.5 kg of austenite containing 0.65 wt% C, cooled to below 727°C (1341°F).*

(a) What is the proeutectoid phase?

(b) How many kilograms each of total ferrite and cementite form?

(c) How many kilograms each of pearlite and the proeutectoid phase form?

(d) Schematically sketch and label the resulting microstructure.

Solution

(a) Ferrite is the proeutectoid phase since 0.65 wt% C is less than 0.76 wt% C.

(b) For this portion of the problem, we are asked to determine how much total ferrite and cementite form. For ferrite, application of the appropriate lever rule expression yields

$$W_\alpha = \frac{C_{Fe_3C} - C_0}{C_{Fe_3C} - C_\alpha} = \frac{6.70 - 0.65}{6.70 - 0.022} = 0.91$$

which corresponds to (0.91)(2.5 kg) = 2.27 kg of total ferrite.

Similarly, for total cementite,

$$W_{Fe_3C} = \frac{C_0 - C_\alpha}{C_{Fe_3C} - C_\alpha} = \frac{0.65 - 0.022}{6.70 - 0.022} = 0.09$$

Or (0.09)(2.5 kg) = 0.23 kg of total cementite form.

(c) Now consider the amounts of pearlite and proeutectoid ferrite. Using Equation 9.20

$$W_p = \frac{C_0' - 0.022}{0.74} = \frac{0.65 - 0.022}{0.74} = 0.85$$

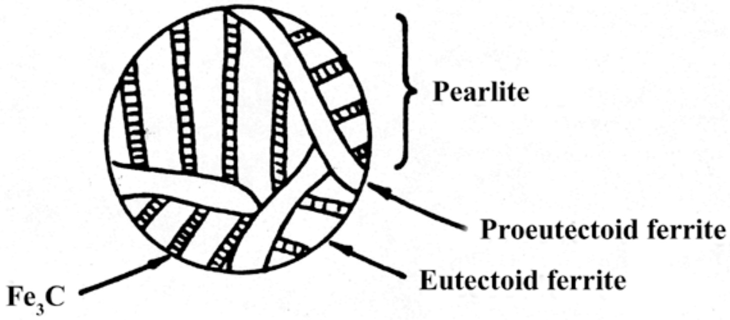
This corresponds to (0.85)(2.5 kg) = 2.12 kg of pearlite.

Also, from Equation 9.21,

$$W_{\alpha'} = \frac{0.76 - 0.65}{0.74} = 0.15$$

Or, there are (0.15)(2.5 kg) = 0.38 kg of proeutectoid ferrite.

(d) Schematically, the microstructure would appear as:


Pearlite
Proeutectoid ferrite
Eutectoid ferrite
Fe_3C