ENGG*2120 Fall 2011

Chapter 9 Assignment with answers

1. Describe the Phase Diagram.

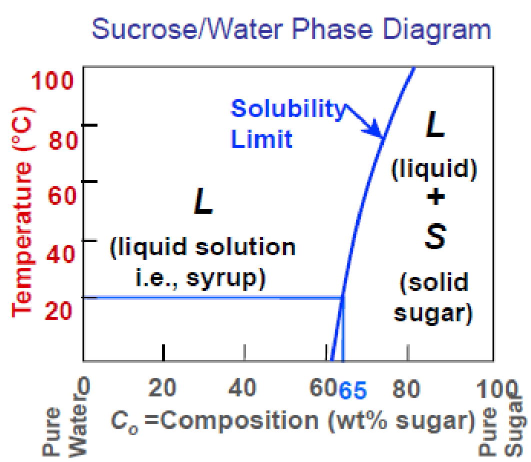
Ans:

Phase diagram:
A graphical representation of the materials structure, properties with respect to various physical parameters like temperature, pressure as well as materials composition

Need of Phase diagram:

- Control the synthesis process to achieve the materials with required properties.
- Choose the suitable composition of the materials for required application. In addition phase diagrams provides valuable information about melting casting crystallisation phenomena

2. Determine how much sugar will dissolve in 1500 g water at 90^0C using sugar–water phase diagram.



Ans:

We are asked to determine how much sugar will dissolve in 1000 g of water at 90^0C. From the solubility limit curve, at 90^0C the maximum concentration of sugar in the syrup is about 77 wt%. It is now possible to calculate the mass of sugar using below equation

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

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

Solving for m_{sugar} yields m_{sugar} = 5022 g

3. Cite the phases that are present and the phase compositions for the following alloys:

8.2 mol Ni and 4.3 mol Cu at 1250^{0}C.

Ans:

For an alloy composed of 8.2 mol Ni and 4.3 mol Cu and at 1250^{0}C, it is first necessary to determine the Ni and Cu concentrations, which we will do in wt% as follows:

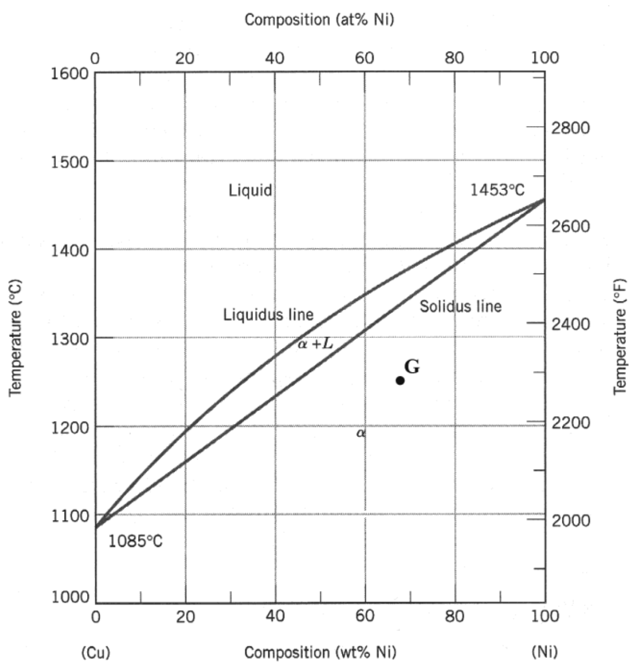
$$n'_{\text{Ni}} = n_{m_{\text{Ni}}} A_{\text{Ni}} = (8.2 \text{ mol})(58.69 \text{ g/mol}) = 481.3 \text{ g}$$

$$n'_{\text{Cu}} = n_{m_{\text{Cu}}} A_{\text{Cu}} = (4.3 \text{ mol})(63.55 \text{ g/mol}) = 273.3 \text{ g}$$

$$C_{\text{Ni}} = \frac{481.3 \text{ g}}{481.3 \text{ g} + 273.3 \text{ g}} \times 100 = 63.8 \text{ wt\%}$$

$$C_{\text{Cu}} = \frac{273.3 \text{ g}}{481.3 \text{ g} + 273.3 \text{ g}} \times 100 = 36.2 \text{ wt\%}$$

The Cu-Ni phase diagram is shown below; the point labelled “G” represents the 63.8 wt% Ni-36.2 wt% Cu composition at 1250^{0}C.



(a)

As may be noted, point G lies within α phase field. Therefore, only α phase is present; its composition is 63.8 wt% Ni-36.2 wt% Cu.

4. 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?

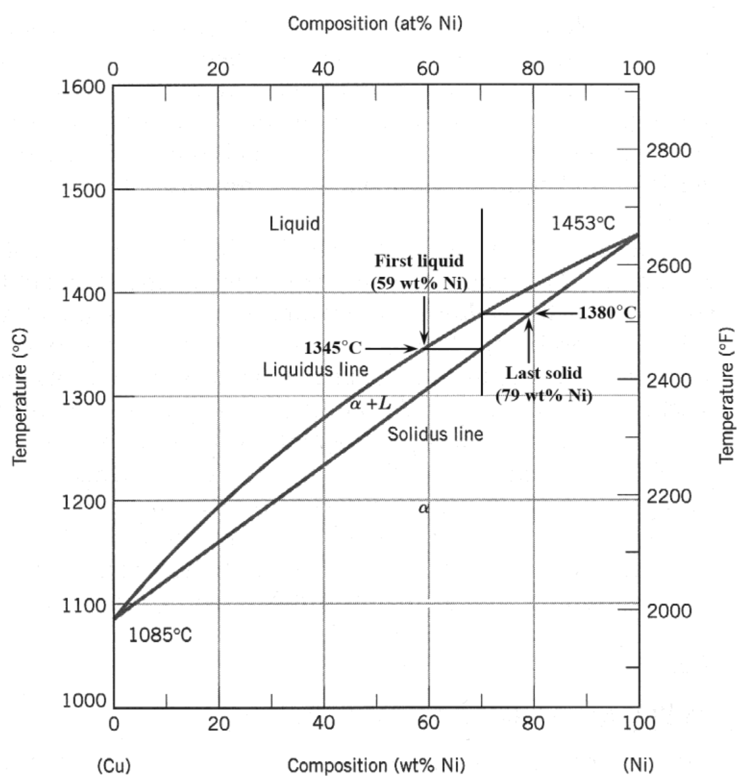
(b) What is the composition of this liquid phase?

(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?

Ans:

As shown below in the Cu-Ni phase diagram and a vertical line constructed at a composition of 70 wt% Ni-30 wt% Cu.



(a)

(a) Upon heating from 1300°C, the first liquid phase forms at the temperature at which this vertical line intersects the α-(α + *L*) phase boundary--i.e., about 1345°C.

(b) The composition of this liquid phase corresponds to the intersection with the (α + *L*)-*L* phase boundary, of a tie line constructed across the α + *L* phase region at 1345°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 (α + *L*)-*L* phase boundary--i.e., about 1380°C;

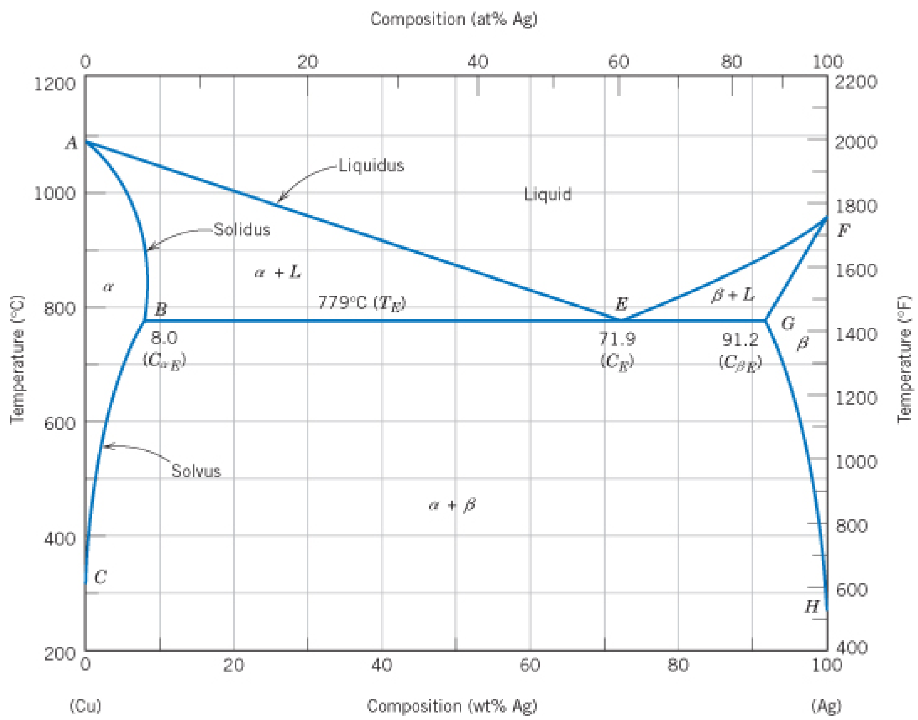
(d) The composition of the last solid remaining prior to complete melting corresponds to the intersection with α-(α + *L*) phase boundary, of the tie line constructed across the α + *L* phase region at 1380°C--i.e., about 79 wt% Ni.

5. 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



Ans:

(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 above figure 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

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

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

6. What is the difference between a phase and a microconstituent?

Ans:

A "phase" is a homogeneous portion of the system having uniform physical and chemical characteristics, whereas a "microconstituent" is an identifiable element of the microstructure (that may consist of more than one phase).