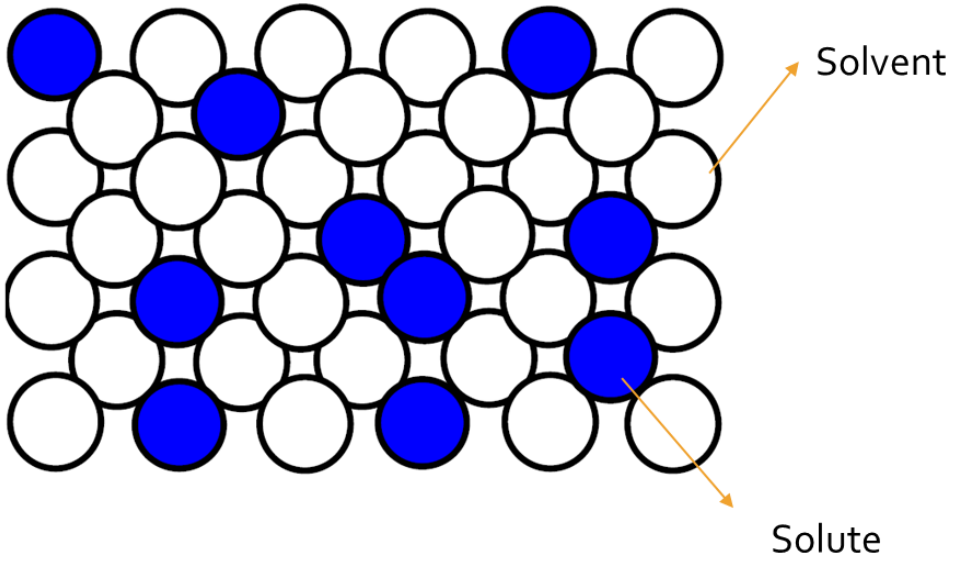
CHAPTER 6-7(10-11)

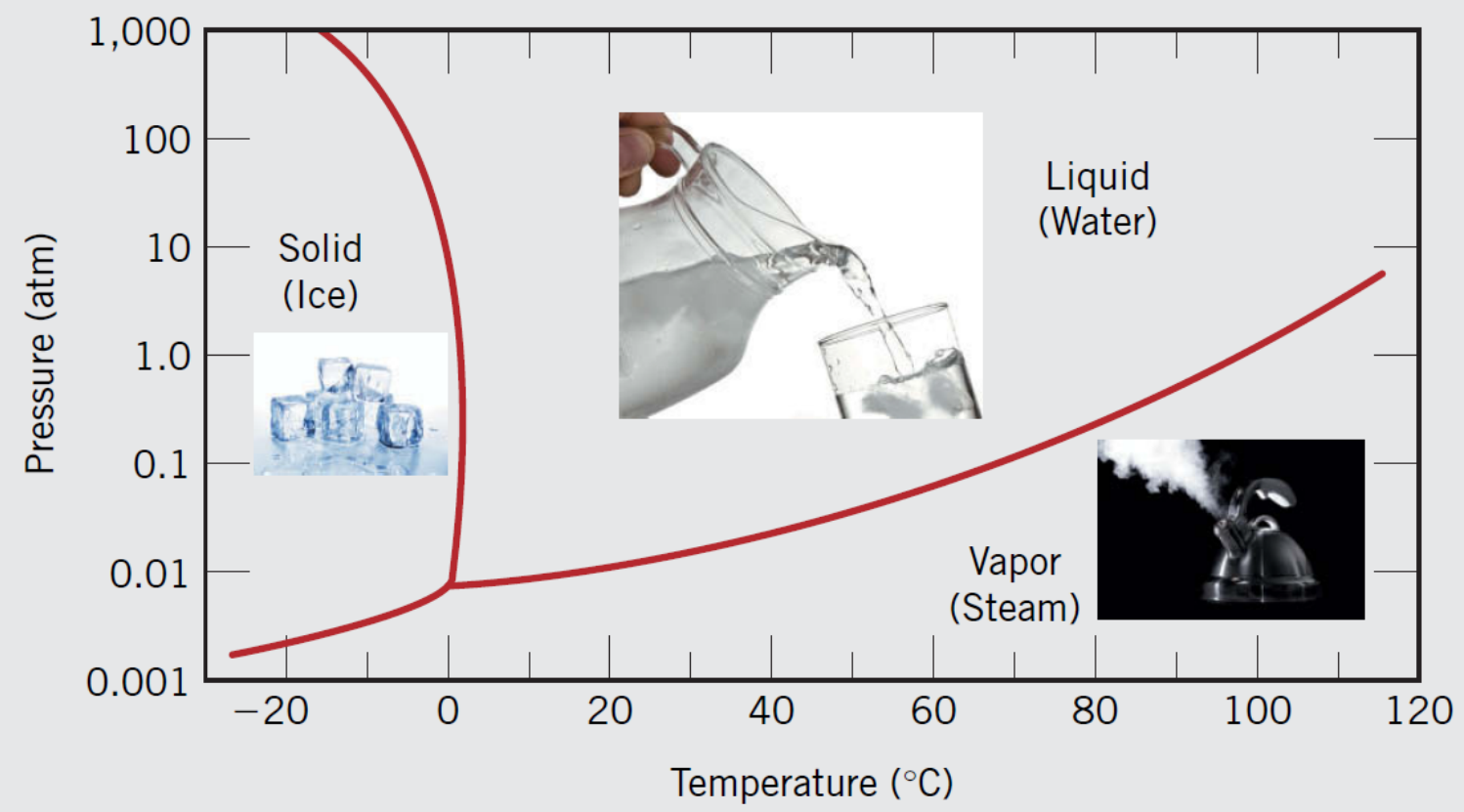
Solid Solutions and Phase Diagrams

Dispersion Strengthening and Eutectic Phase Diagrams



WHAT IS A SOLID SOLUTION?

Phases and Phase Diagrams



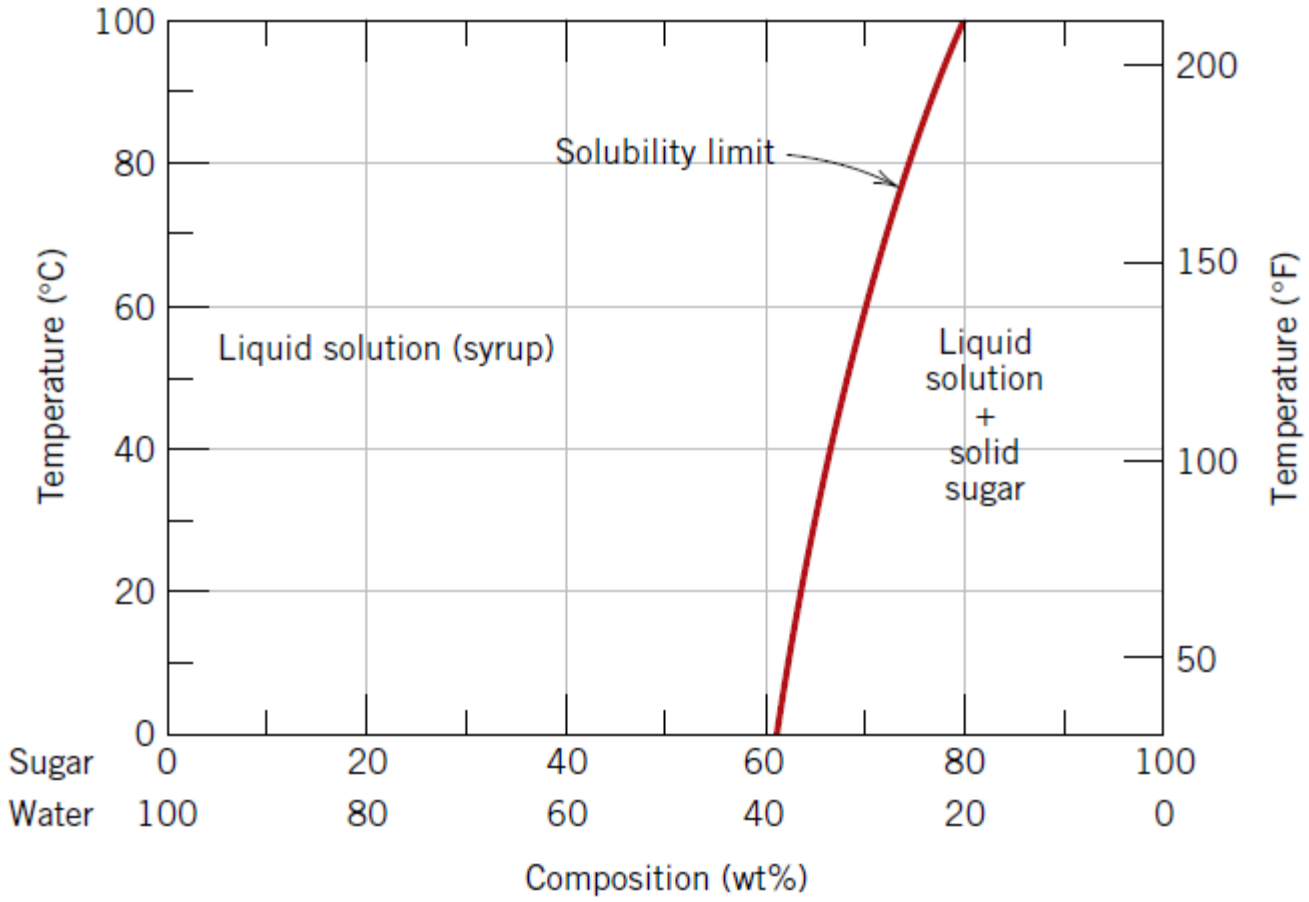
Phase: Physical and chemical properties of a component are uniform

Phases and Phase Diagrams: Solubility

Solubility limit: Maximum amount of the component that can be dissolved in the phase

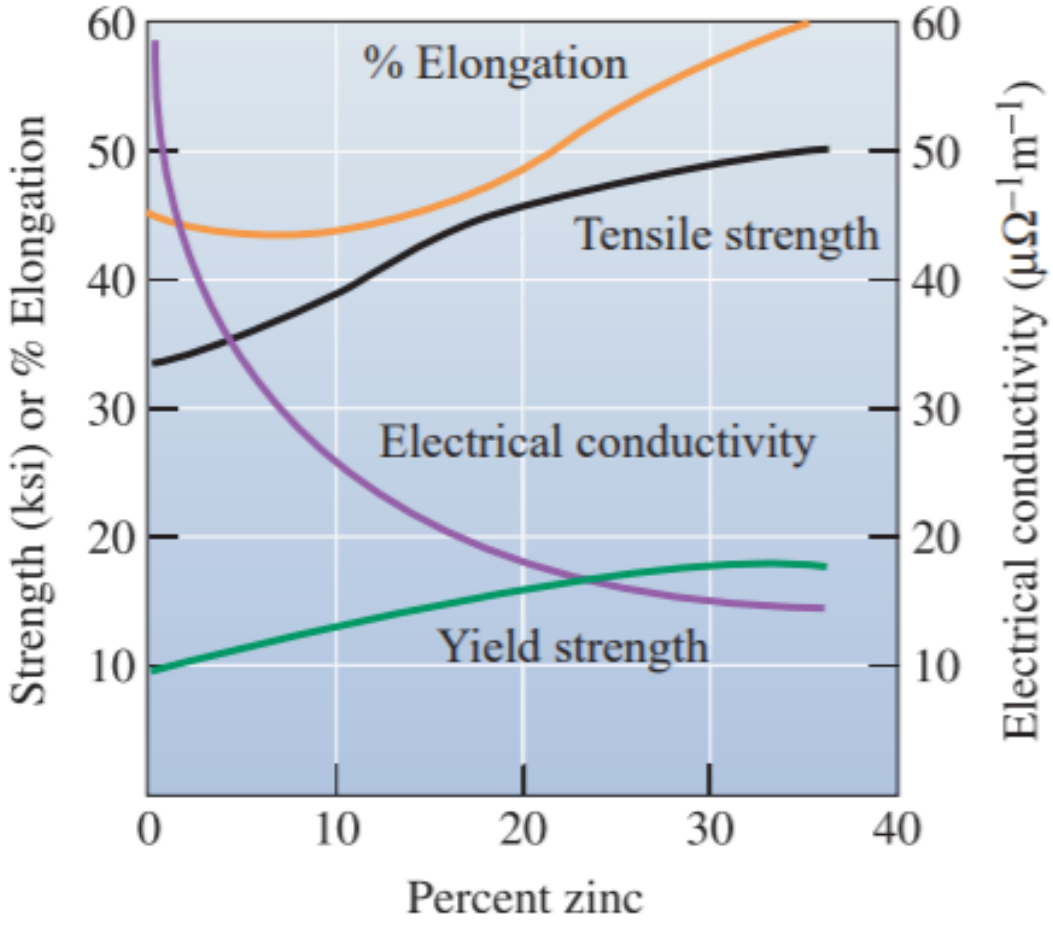
Unlimited solubility (Hume-Rothery):

1) Size: $\Delta r = \frac{r_1 - r_2}{r_!} \times 100 : r_1 > r_2$
2) Crystal structure
3) Valence
4) Electronegativity



Why Solid solutions?

- Metallic compounds!
- Increase in hardness and both types of strengths
- Ductility increases.
- Electrical conductivity decreases

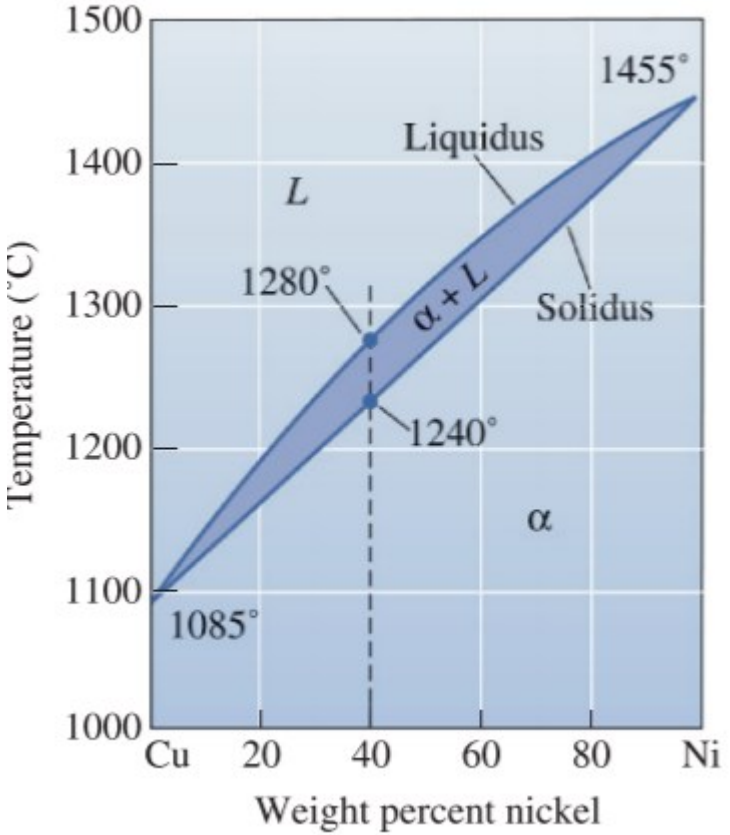


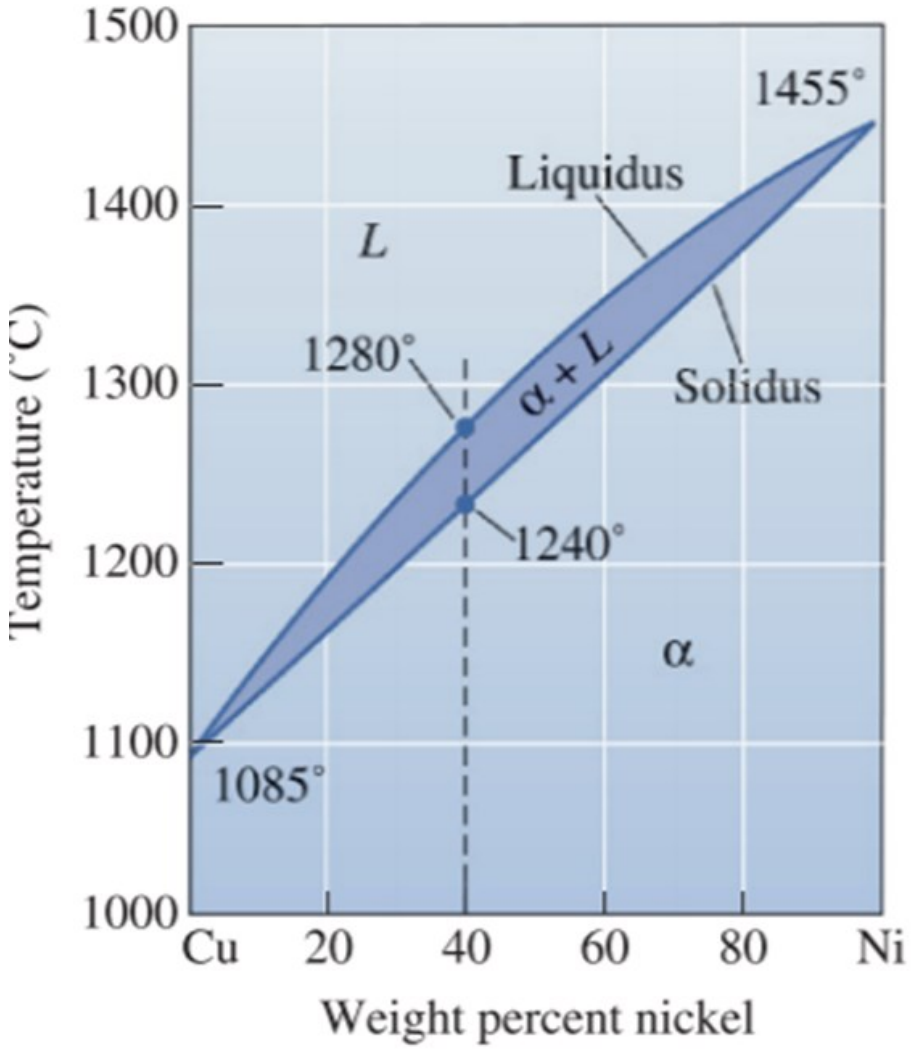
Example

- A Cu-Ni alloy contains 47 wt % Cu and is at 1300C.

A. What is the weight percent of Cu in the liquid and solid phases at this temperature?

B. What weight percent of this alloy is liquid and what weight percent is solid?





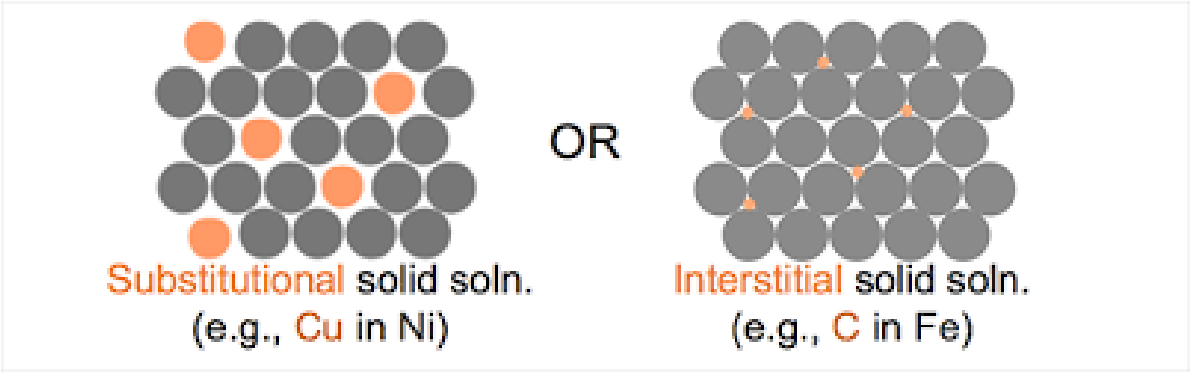
47 wt% Cu
53 wt% Ni
1300 C

What is the weight percent of Cu in the liquid and solid phases at this temperature?

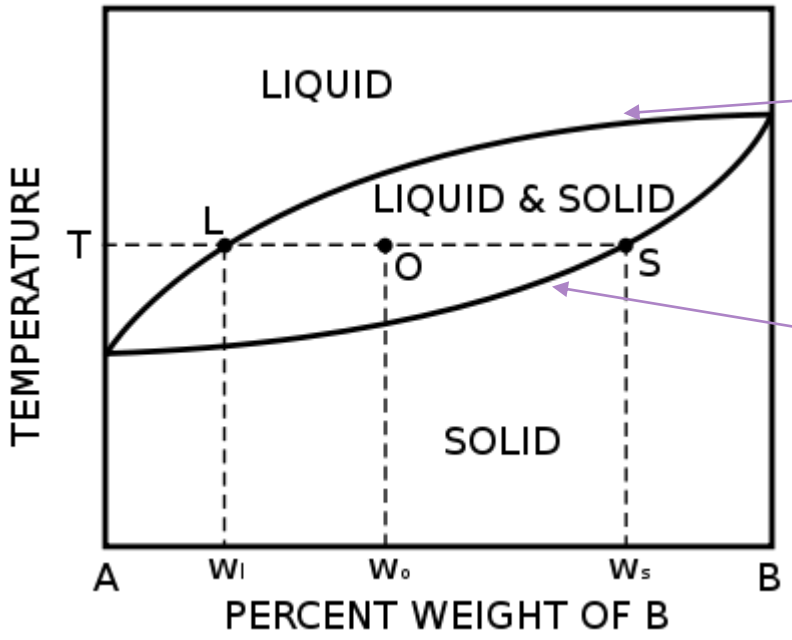
What weight percent of this alloy is liquid and what weight percent is solid?

Recap

- **Solvent**: Host or substance with the majority of concentration in the solution. Normally it has stronger bonding that he solute
- **Solute**: Component that is dissolved by that solvent.
- **Solubility**: Ability of the solvent to dissolve a solute
- **phase** is a region of space (a thermodynamic system), throughout which all physical and chemical properties of a material are essentially uniform



Recap:Isomorphous Phase Diagram



Liquidus -the line connecting Ts at which liquid starts to solidify under equilibrium conditions

$$\%L = \frac{Ws - W_0}{Ws - W_l}$$

the temperature at which the last of the liquid phase solidifies

$$\%S = \frac{W_0 - W_l}{Ws - W_l}$$

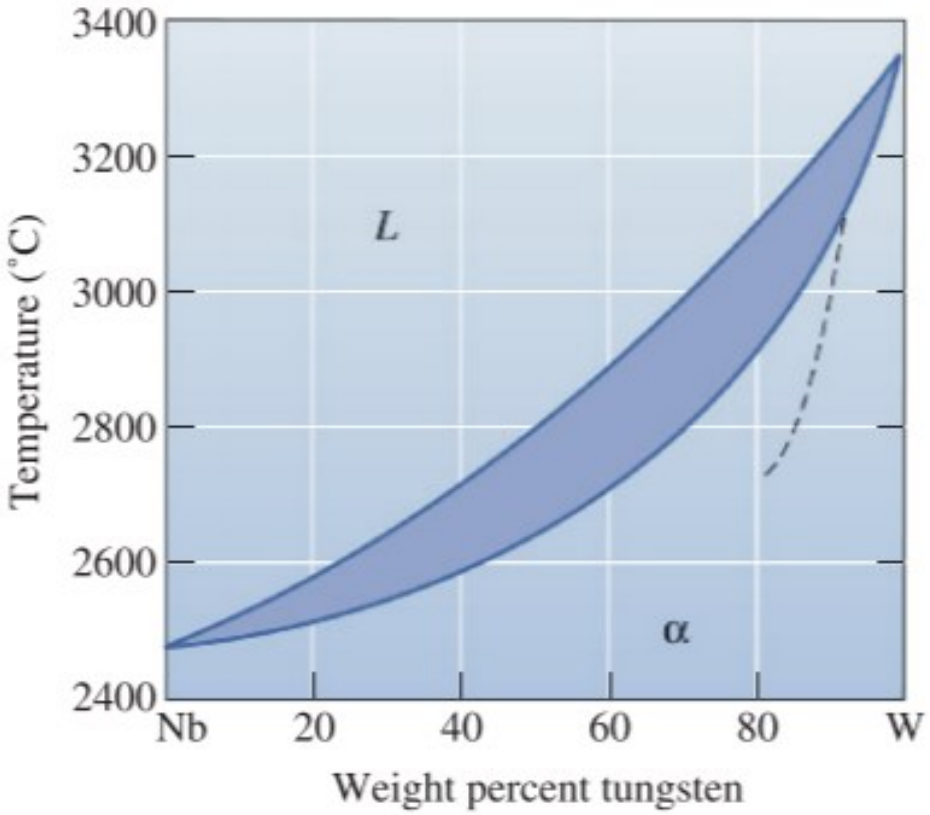
Example

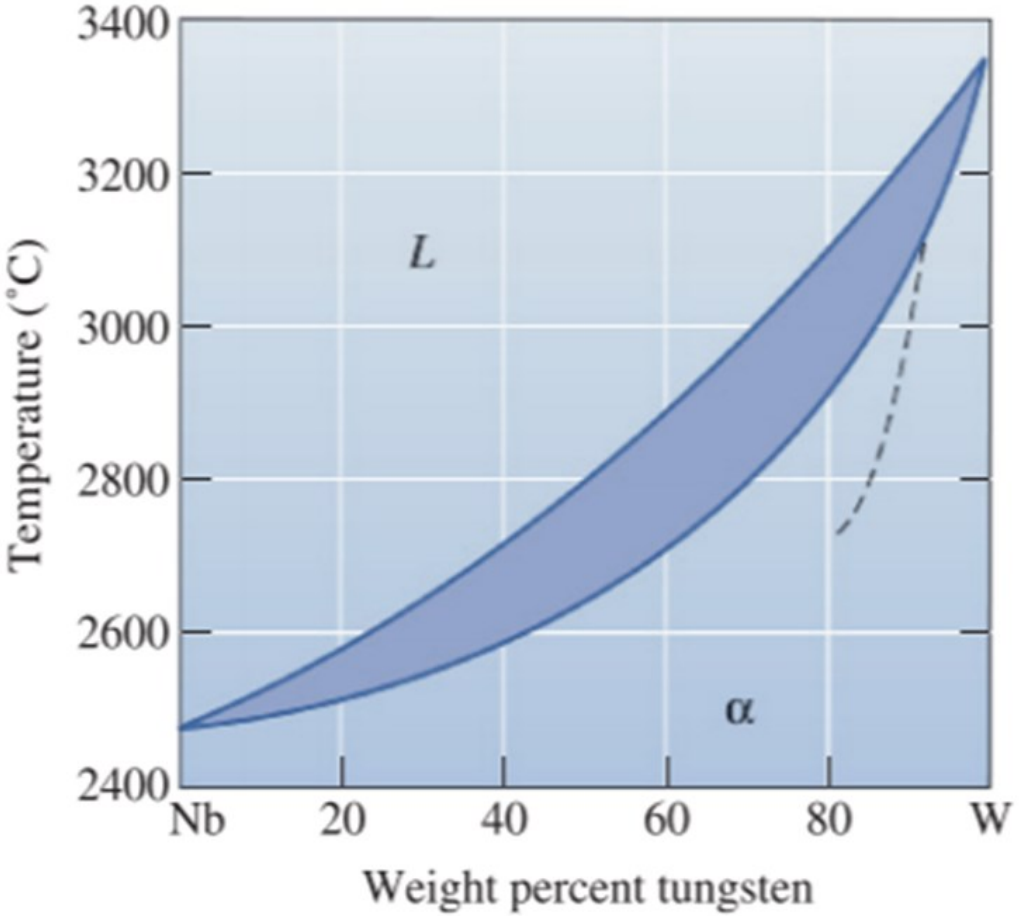
- A Nb-60 wt% W alloy is heated to 2800°C. Determine

(a) the composition of the solid and liquid phases in wt%

(b) the amount of each phase in wt% W

(c) assuming that the density of the solid is 16.05 g/cm3 and that of the liquid is 13.91 g/cm3, determine the amount of each phase in vol%.

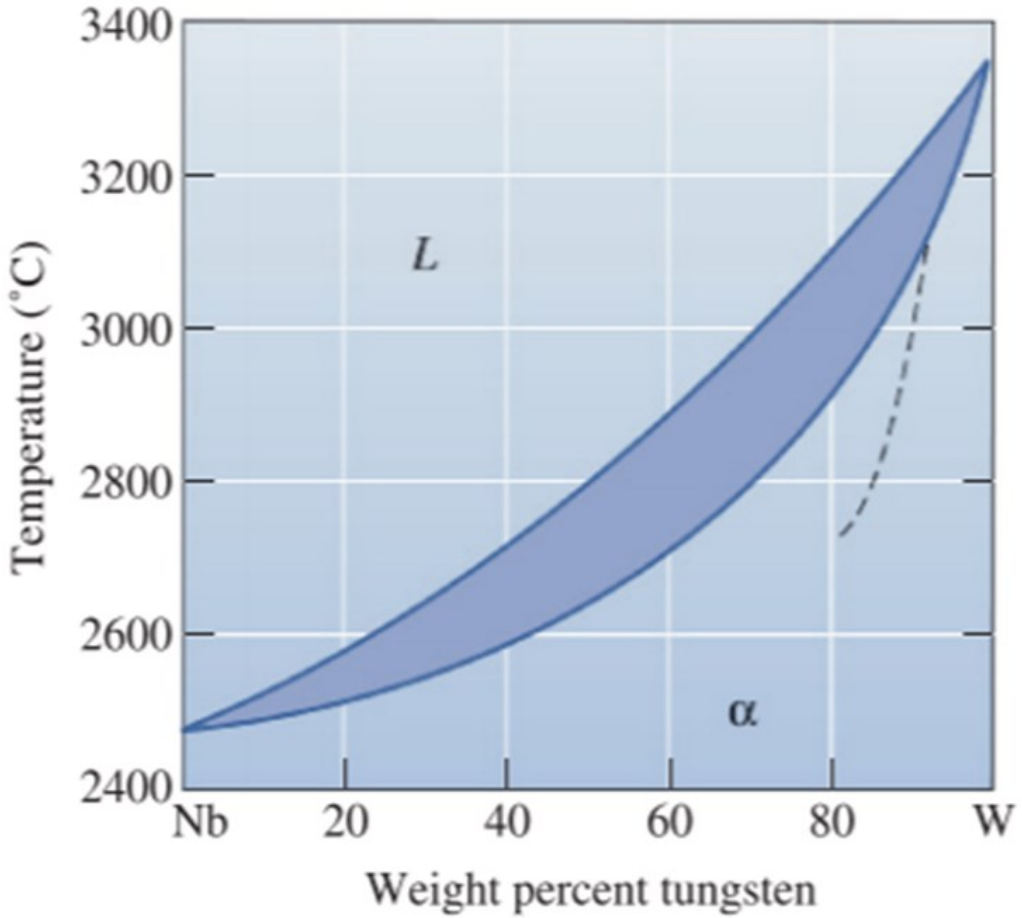




40 wt% Nb
60 wt% W
2800°C

- the composition of the solid and liquid phases in wt% Nb?

- the amount of each phase in wt% ?



40 wt% Nb %L=47.8%
60 wt% W %S=52.2%
2800°C

- Assuming that the density of the solid is 16.05 g/cm3 and that of the liquid is 13.91 g/cm3, determine the amount of each phase in vol%.

Alloys: Solid solutions and Metallic compounds

Solid Solutions	Metallic Compounds
Metals come together without bonding	The excess of e- will cause bonding
More mobility	More stable
Can happen naturally and are the majority in nature	Are synthetized for specific applications
Application in day to day materials	Applications in high tech
Transition metals carbides and nitrides And bronze and brass, in which some of the copper atoms are substituted with either tin or zinc atoms.	Mostly made of the so-called post-transition metals, i.e. aluminum, gallium, indium, thallium, tin and lead; Plus some, if not all, of the metalloids, e.g. silicon, germanium, arsenic, antimony and tellurium

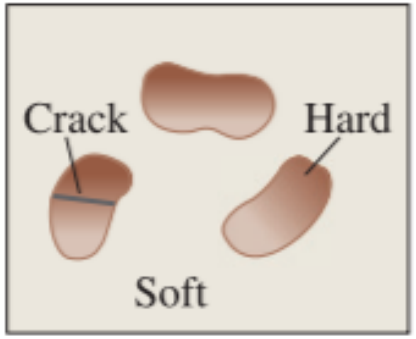
Dispersion strengthening

Increasing the strength of a material by forming an additional phase

The size, shape, and amount of second phase particles controls the mechanical properties of the alloy.

Soft phase: Matrix or original component

Hardening phase: New phase formed by adding the “precipitate”



Recap

- Solubility limit: Maximum amount of the component that can be dissolved in the phase

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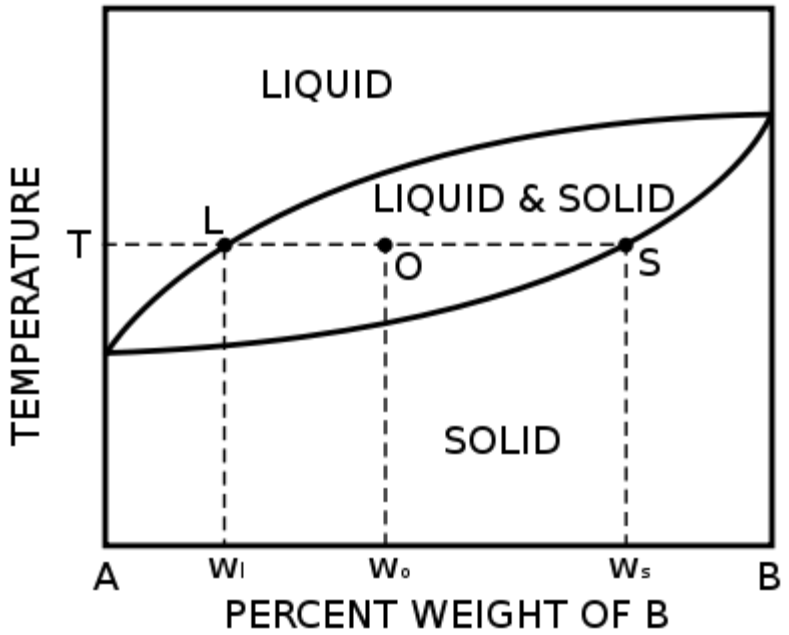
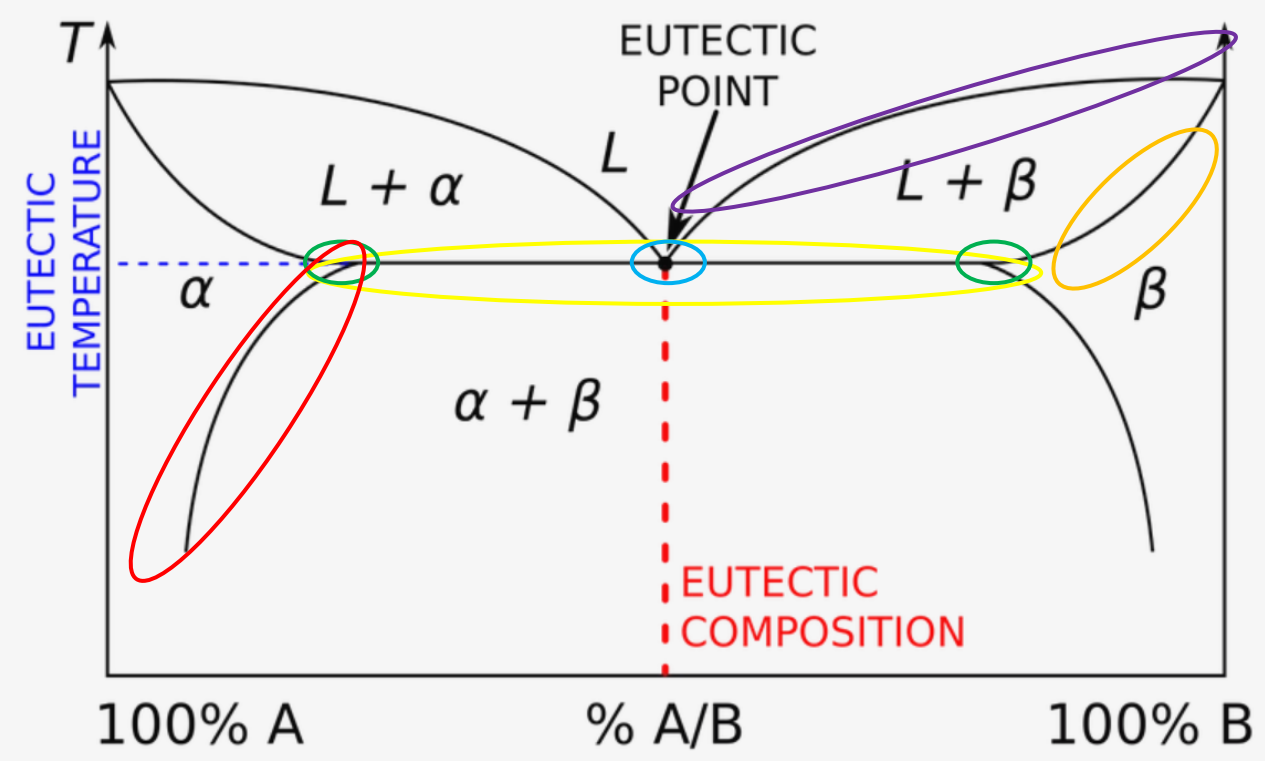


$$\%L = \frac{Ws - W_0}{Ws - W_l}$$

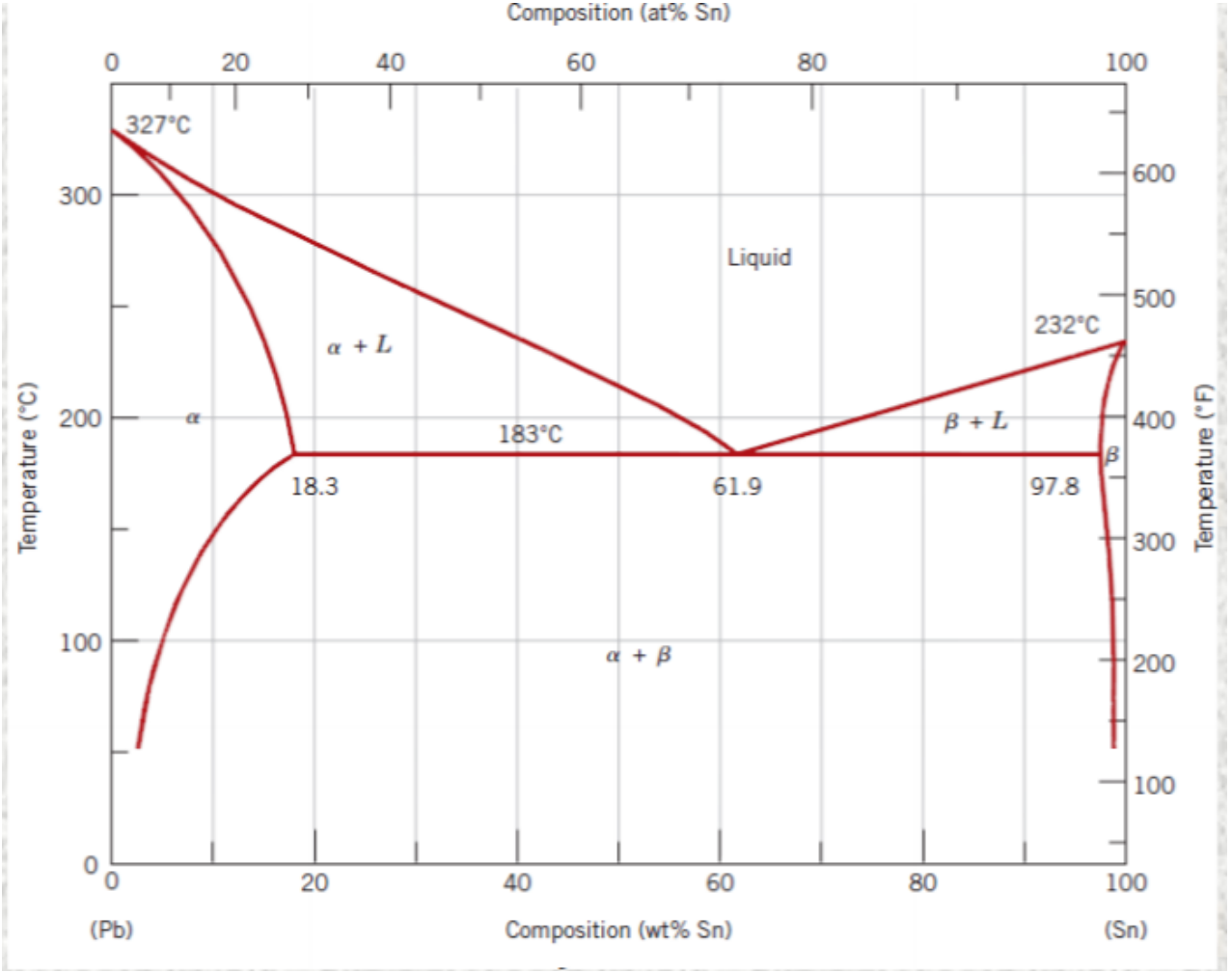
$$\%S = \frac{W_0 - W_l}{Ws - W_l}$$



Binary-Eutectic systems

Alloy formation.

- Eutectic line:
- Eutectic point:
- Max solubility limit:
- Solvus:
- Liquidus:
- Solidus:



Example

A solution of 10 wt% Sn - 90 wt% Pb at 200 C goes through a process:

How many phases are initially?

You heat up the mixture. At which temp will the first liquid appear? At that temperature, What is the wt% of Pb in the liquid?

What is the wt% Pb of the α and β phase at 100 C?