UNIT – I
CONSTITUTION OF ALLOYS AND PHASE DIAGRAMS

CONSTITUTION OF ALLOYS

- Alloy is defined as a combination of two or more elements, of which one of the element should be a metal in major proportion. Alloys have metallic properties
- It could be metals or non- metals.
- Pure metals - high electrical conductivity, high ductility and corrosion resistance.
- but the mechanical properties such as tensile strength, yield point and hardness are improved by alloying.

CLASSIFICATION OF ALLOYS

- Alloys can be either a single phase or a mixture of phases.
- A phase is anything which is homogeneous and physically distinct.

(What are sild solutions? Explain about substitutional and interstitial solid solutions.)

Solid solutions

Solid solution is an alloy in which solute atoms are dispersed in solvent matrix and have same structure as that of the solvent.

Element in large amount – solvent

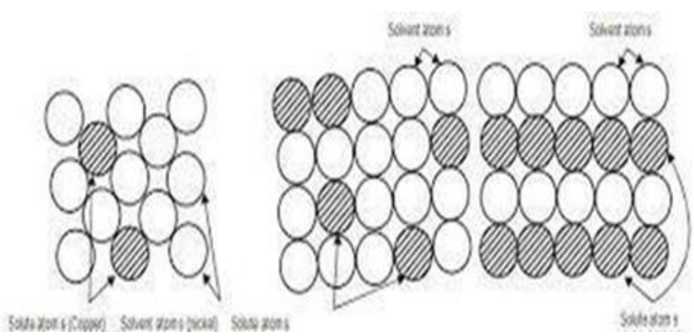
Element in small amount - solute

TYPES OF SOLID SOLUTIONS

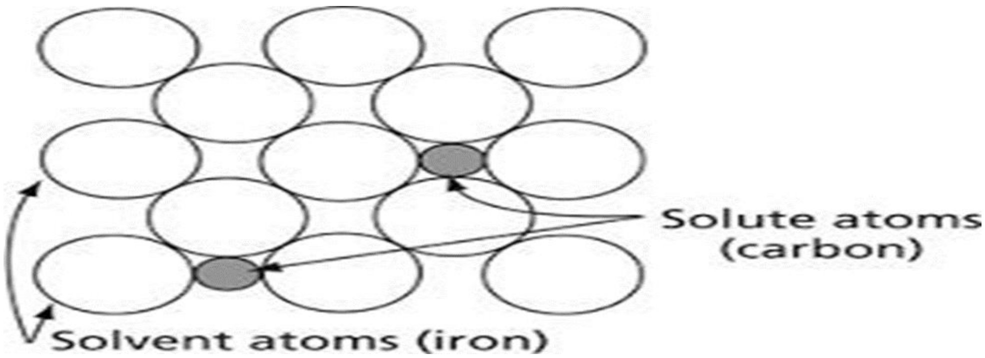
1. Substitutional solid solution
   a) Ordered Solid solutions
   b) Random solid solutions
2. Interstitial solid solutions
   a) Ordered Solid solutions
   b) Random solid solutions

1. Substitutional solid solution:

The atoms of the solvent metal are replaced by atoms of the solute. Substitution solid solution formation is favoured when the atomic sizes of the two metals are almost equal. In the ordered solid solution, the substitution of either atom in solvent is by a definite order, while this is not so in a disordered solid solution.



2. **Interstitial solid Solution:**
   These are formed only when the atoms of the solute element are very small compared with those of the solvent, thus enabling them to fit in to the interstices or spaces in the solvent.



FACTORS GOVERNING SOLID SOLUBILITY (OR)HUME–ROTHER'S RULES:

In the formation of solid solution, the solubility limit of a solute in the solvent is governed by certain factors.

1) **Relative size:**
   If the atomic sizes of solute and solvent differ by less than 15% - favorable for the formation of solid solutions. If the atomic size difference exceeds 15%, solid solution formation is extremely limited.
2) **Chemical Affinity:**
   When two elements have a high chemical affinity for each other, the greater is the tendency to restrict the solid solution and to form intermediate phases. This occurs when one element is electronegative and the other is electropositive.
3) **Relative valence:**
   A metal of higher valence dissolves only a small amount of the lower valence metal, while the lower valence metal dissolves greater amount of the higher valence metal.
4) **Crystal type:**
   If two metals are of the same crystal lattice and all other factors are favorable, it is possible for complete solid solubility to occur over the whole composition range.

PHASE DIAGRAMS (OR) EQUILIBRIUM DIAGRAMS

(What are phase diagrams? Mention the types of phase diagrams.)

- Phase diagrams are graphical representation of phases in the system at various temperatures, pressures and compositions.
- The phase diagrams are constructed by using equilibrium conditions.
- Depending on the number of component (elements), the phase diagrams are called as unary (one component), binary (two component) and ternary (three component) phase diagrams.

Classification of Equilibrium Diagrams

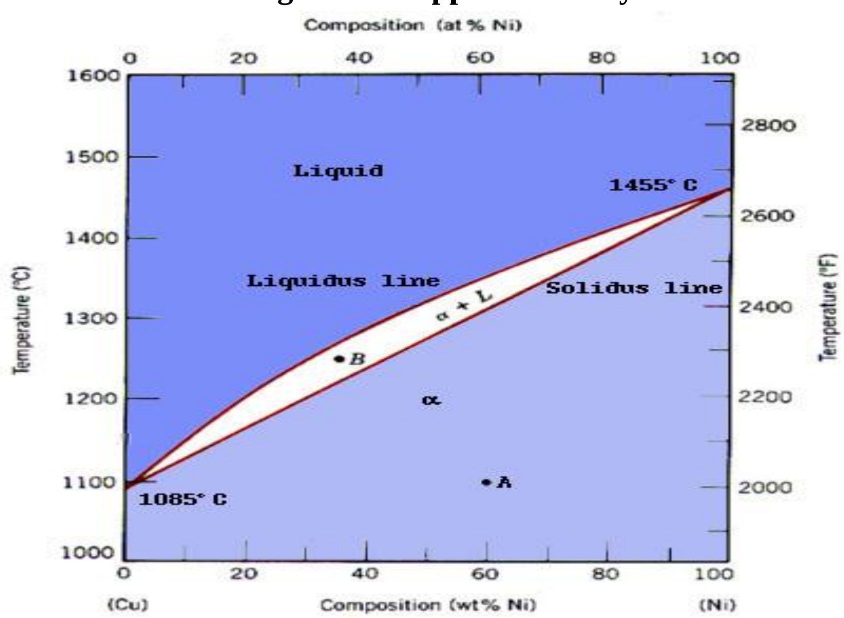
1. Isomorphous phase diagrams
2. Eutectic phase diagrams
3. Eutectoid phase diagrams
4. Peritectic phase diagrams
5. Peritectoid phase diagrams

(Explain the various reactions taking place during alloy formation with their phase diagrams.)

1. **Isomorphous Phase diagram (Isomorphous reaction)**

When two metals are completely soluble in the liquid and solid states, then the reaction is known as Isomorphous reaction. It exists as a single phase. And also a single type of crystal structure exists for all the compositions of components. The resultant phase diagram is known as binary Isomorphous phase diagram. Eg : Cu – Ni, Au- Ag. Au-Cu. Au –Ni.

Phase diagram of Copper-Nickel System

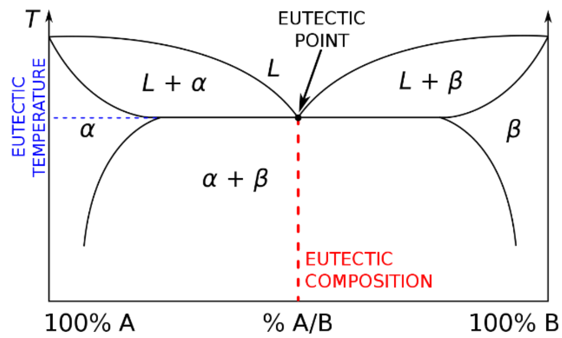


Three different phase regions appear on the diagram.

They are 1. a solid region, 2. a liquid (L) region, 3. a two phase region (a+L)

2. **Eutectic phase diagram**

Systems in which two metals A & B are not completely soluble through all ranges of composition and the second phase will form at grain boundaries is known as eutectic system. Examples: Cu- Ag system, Lead – Silver system



Consists of six regions

1. Liquid phase – L
2. α Solid solution phase – α (A is more than B)
3. β Solid solution phase - β (B is more than A)
4. α Solid + liquid phase – L + α
5. β Solid + Liquid phase - L + β
6. α + β Solid solutions phase - α + β

Eutectic reaction

(What is a eutectic reaction?)

When a liquid of eutectic composition is slowly cooled to the eutectic temperature, the single liquid phase transforms simultaneously into two solid forms. This transformation is known as the eutectic reaction.

The eutectic reaction can be written as,

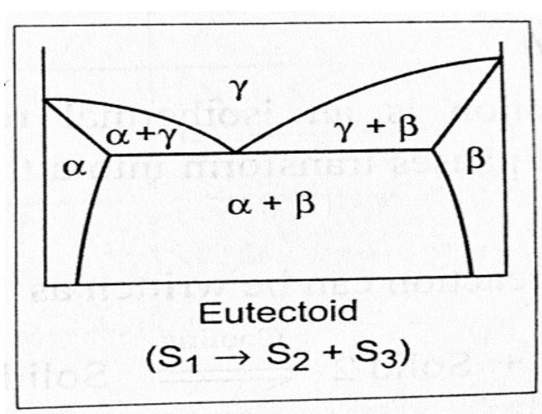
$$\text{Liquid} \xrightarrow{\text{Eutectic temperature(cooling)}} \alpha \text{ Solid solution} + \beta \text{ Solid solution}$$

Thus, during a eutectic reaction, three phases coexist at equilibrium.

3. Eutectoid phase diagram: (Eutectoid reaction)

Eutectoid reaction is a reaction in which one solid phase transforms into two new solid phases upon cooling. This can be represented as,

$$\text{Solid 1} \rightleftharpoons \text{Solid 2} + \text{solid 3}$$

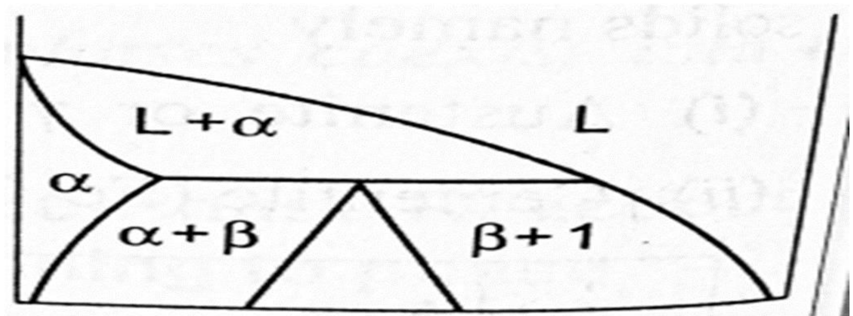


4. **Peritectic phase diagram (Peritectic reactions)**

In Peritectic reaction, upon cooling, a solid phase and a liquid phase transforms isothermally and reversibly in to solid phase having a different composition.

The Peritectic reaction can be written as,

$$\text{Liquid} + \text{Solid 1} \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} \text{Solid 2}$$



Peritectic
$(L + S_1 \rightarrow S_2)$

5. **Peritectoid phase diagram:**

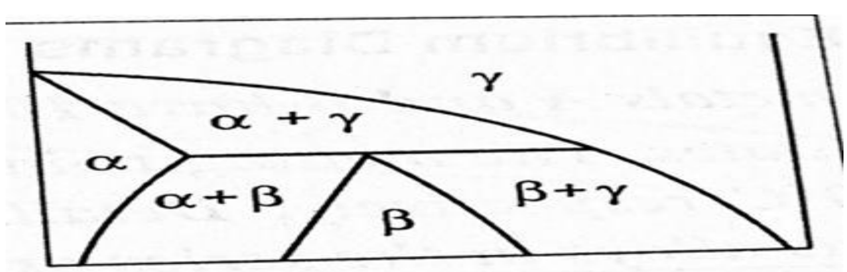
The Peritectoid reaction is an isothermal reversible reaction in which two solid phases transform into a third solid phase upon cooling.

The peritectoid reaction can be written as

$$\text{Solid 1} + \text{Solid 2} \underset{\text{Heating}}{\overset{\text{Cooling}}{\rightleftharpoons}} \text{Solid 3}$$

The peritectoid is an ***'upside-down' eutectoid.***

Peritectoid systems are found in Ni–Zn, Fe–Nb.



Peritectoid
$(S_1 + S_2 \rightarrow S_3)$