B.Sc. 6th Semester
Physical Chemistry
Section- B
Phase Equilibrium

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* Two Component Systems

When the two Independent components are present in a heterogeneous system, the system is named as a two component system.

The least number of phases possible in any system is one. So, maximum degree of freedom for two component systems will be

$$F = C - P + 2$$

$$F = 2 - 1 + 2 = 3 \qquad \boxed{F = 3}$$

So, three variables are required to define a two component system. The three variables are pressure (P), temperature (T) and concentration (C). This will require a three dimensional phase diagram.

However, in order to simply the study, a two component system is usually studied in the form of a condensed system.

* Condensed System and Condensed Phase Rule

Two component (Pb-Ag) System

It can have a maximum of following phases:
Solid lead, Solid silver, Solution of molten Pb and Ag and vapours

The boiling points of silver (961°c) and lead (327°c) are considerably high and the vapour pressure of the system is very low. So, the vapour phase can be ignored and the system can be termed as condensed system. And the phase rule equation reduced to

$$F = C - P + 1 \quad (2)$$

(in place of $F = C - P + 2$)

As, vapour phase is ignored, therefore there will be no effect of pressure on the system and it will no longer be included in the degree of freedom.

T and (P)

Equation (2) is called as condensed phase Rule OR Reduced Phase Rule equation.

☆ Eutectic System

Example Pb- Ag (two Component) System.

· The binary system, in which two components are miscible in all proportions in the molten (Liquid) state. They do not react chemically and each component has a property of lowering freezing points of each other. Such a binary system is called as Eutectic (easy to melt) system.

The phase diagram of Pb- Ag system is shown in Figure - 2. (8)

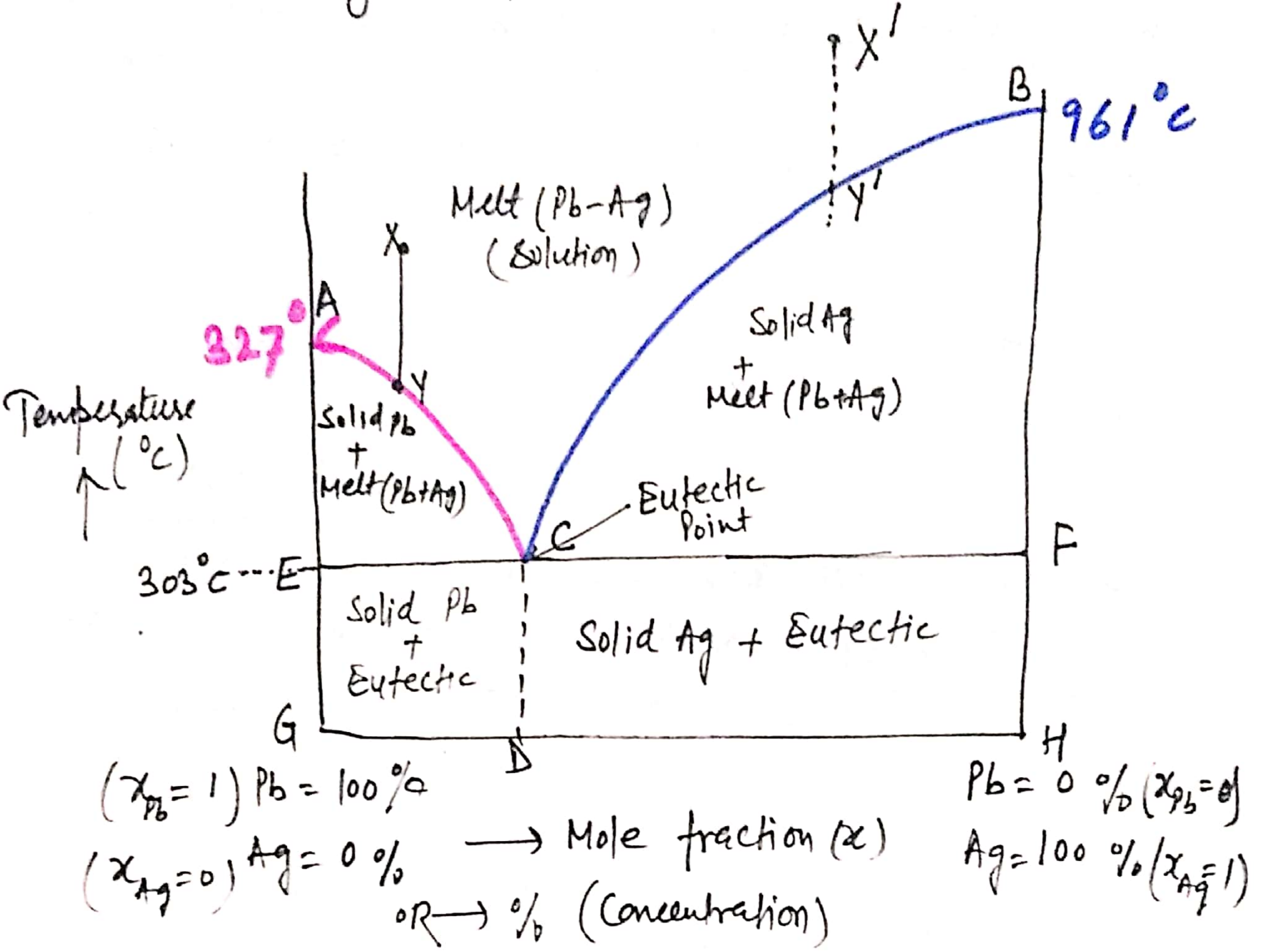

Figure - 2 - Phase diagram of Pb- Ag System

Temperature corresponding to points A and B are the melting points of pure Pb and pure Ag respectively.

a) Curve AC and BC

Addition of silver to lead lowers its melting point along AC. Thus, AC is the freezing point curve of Pb in presence of silver. Similarly, curve BC is the freezing point curve of silver in presence of lead.

Along AC, solid lead and melt co-exist, while along BC, solid silver and melt (liquid) co-exist.

At constant pressure, the degree of freedom along AC and BC will be

$F = C - P + 1$

$F = 2 - 2 + 1 = 1 \Rightarrow \boxed{F=1}$ system is univariant.

(b) Eutectic Point (C)

The two curves AC and BC meet at point C, where three phases (Pb solid, solid Ag. and their melt) co-exist. Point C is the Eutectic point.

At this point

$F = C - P + 1$

$= 2 - 3 + 1 = 0 \Rightarrow \boxed{F=0}$

Hence, the system is invariant at point C. The temperature of the Eutectic is 303°c called as Eutectic temperature and the corresponding composition of solution is (2.6 % silver + 97.4 % Pb) is called as Eutectic composition.

(C) Areas (ACE, BCE, CDGE and CDHF)

All areas have two phases each. Therefore, degree of freedom (as shown in Fig. 2)

$F = C - P + 1$

$F = 2 - 2 + 1 = 1 \Rightarrow \boxed{F=1}$

The system is univariant.

(d) Area above ACB

It has single phase i.e Liquid (Melt). The degree of freedom will be

$$F = C - P + 1$$

$$= 2 - 1 + 1 = 2 \qquad \boxed{F = 2}$$

The system is bivariant in this area.

Most Important

Desilverisation of Lead (Pattinson's Process)

The process, which is used for the recovery of silver from argentiferrous lead is called Pattinson's process and involves the desilverisation of lead. in accordance to the phase diagram of Pb-Ag (figure 2.)

The argentiferrous lead contains a small percentage of silver. For its recovery, it is heated above its melting point upto (X in Fig 2), when a liquid melt consisting Pb-Ag solution is obtained. Now if solution is cooled, then after reaching at point Y (Fig 2), Pb continues to separate out and is regularly removed (along curve AYC). In the end, a Eutectic solution is obtained (Point C).. The melt is now richer in silver. In this way the maximum concentration of silver (2.6 %, by mass) in the melt can be obtained.