Phase Equilibria

Introduction

The phase rule holds an important value for the quantitative treatment of systems in equilibrium. The phase rule predicts the conditions for a system to attain equilibrium. Gibbs rule was given by J.W. Gibbs in 1876 during an investigation of heterogeneous equilibrium. As for the rule, for a system in equilibrium,

$$F = C - P + 2$$

C is the number of components, P is the number of phases, F is the number of degrees of freedom.

General Terms

1. Phase

A phase is defined as a homogeneous and physically distinct part of any system bounded for a surface and is mechanically separable from the other parts of the system. Some of the examples for a phase can be given as:

a. A gas mixture consists of different types of gases which are completely miscible but hold only one phase i.e. gaseous.
b. Two immiscible liquids form two different phases, e.g. Carbon tetra chloride in water has two phases.
c. Completely miscible liquids exist in same phase in their mixture.

2. Component

A **component** is the **minimum number of independent chemical species** required to express the composition of **all phases** present in a system. In other words, the number of component of a system is defined as the smallest number of independently variable constituents by means of which the composition of each phase can be expressed directly or indirectly in terms of chemical equations. Some of the examples have been discussed further.

- Water exists in three phases : Ice, water and vapor. The number of chemical species in all the three systems is same that's H_2O. So the system is one component system
- Similarly, sulphur exists in four forms/phases i.e. rhombic, monoclinic, liquid and vapor but there is only one chemical constituent that's sulphur and hence its one component system.
- But a system containing sucrose and water has two different chemical constituents and hence it is two-component system.

For a system which is chemically reactive, the number of components can be given by equation, $C = N - m - n - R$

Here,

C represents Components of the system

N represents Number of chemical species

m is the independent equilibrium conditions

n is no. of relations between the concentrations

R is no. of independent chemical species

Degrees of Freedom

- The no. of independent variables that are needed in order to define a system completely.
- It includes the factors such as temperature, pressure, and concentration.
- State of a pure gas can be specified by temperature and pressure or pressure and volume as the third factor can be calculated from the first two.

- The greater the number of components of a system, higher is the degree of freedom of that system.
- Increasing the number of phases reduces the number of degrees of freedom.
- For a system with a given number of components, the number of phases are maximum when degree of freedom is zero.