PHASE RULE AND IT'S APPLICATIONS

❖ PHASE RULE :

Phase rule was first proposed by J.willard Gibbs in 1876. It is a simple equation relating degrees of freedom(F), number of components(C), number of phases(P) in a system at equilibrium. the least number of independent variables or degrees of freedom i.e. (pressure ,temperature ,concentration, density) can be correlated with number of component and phases for any system in the following ways .

$$F = C - P + 2$$

• Degree of freedom (F):

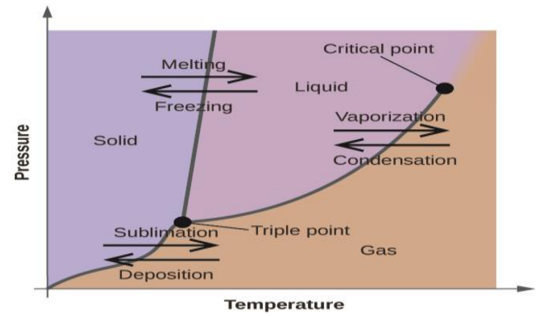
These are the minimum number of intensive variables required for defining a system completely.This is invarient if F =0, univarient if F=1 and bivariant if F=2 .

• Components :

These are the least number of chemically distinct species that are present in a system . For example a system of ethyl alcohol and water has two components.

• Phases :

It is a portion of a system that is distinctly separated from other portions by boundaries.



❖ APPLICATIONS OF PHASE RULE :

* Deciding proportion to two liquids to be taken during formulation of solution.
* Testing purity of liquid.
* Miscibility
* Solubility

• PARTIALLY MISCIBILE LIQUID AND CONJUGATE LIQUIDS :

A two liquid system in which there mutual solubility in one another is limited.

• MISCIBILITY TEMPERATURE :

The temperature at which two conjugate solutions are mutually stable .

❖ ONE COMPONENT SYSTEM :

Example , water system

The diagram is consist of a

A) regions or areas :

The phase diagram,3 regions or areas are available these are.

COB = solid state

AOB= vapour state

COA= liquid state

Applying the phase rule to the one component single phase system gives

$$F = C - P + 2$$
$$= 1 - 1 + 2$$
$$F = 2$$

B) Lines or curve :

In the phase diagram 3 lines are available above and below the lines .

OA = vapourization curve

OB = Sublimation curve

OC = Melting curve

Applying phase rule to one component , two phase system gives .

$$F = C - P + 2$$
$$= 1 - 2 + 2$$
$$= 1$$

C) Triple point :

The boundary line intersect at common point called triple point .

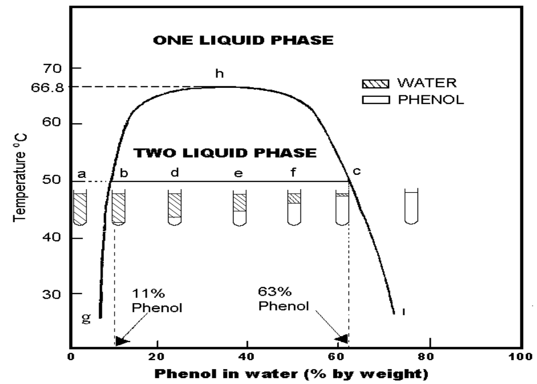
Triple point is consist of solid , liquid and vapour.

Applying phase rule to one component three phase

$$F = C - P + 2$$
$$= 1 - 3 + 2$$
$$= 0$$

❖ TWO COMPONENT SYSTEM :

Example , **1) phenol - water system**



- The left hand side of the parabolic curve represents the conjugate solution which give the percentage of phenol in water at various temperature. As the temperature increases solubility of phenol in water increase.

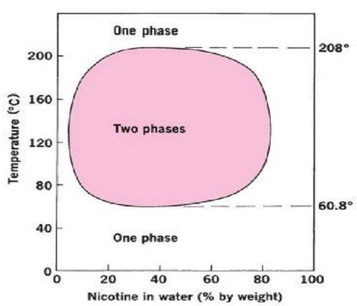
• The right hand side of the parabolic curve represents the another conjugate solution which give the percentage of water in phenol

At various temperature. As the temperature increases the solubility of water in phenol increases .

• These two curves meet at a maximum temperature ,this point on the curve corresponds to a temperature 66.8°c and the phenol composition of 33 % w/w . At this temperature the two conjugate solutions merge and only one layer results .

2) Nicotine and water system

Nicotine–water system showing upper and lower consolute temperatures.



• At room temperature the nicotine and water are miscible in all proportional.

• At higher temperature , their mutual solubility decreases.

• At further increase in temperature lead to enhance the solubility.

• At lower temperature also their mutual solubility decreases.

• As temperature further lowered their mutual solubility increases.

Thus nicotine and water shows close solubility curve . This system has lower and upper critical solution temperature.

For nicotine and water system ,

Upper consolute temperature = 208 °C

Composition = 33 % w/w nicotine in water.

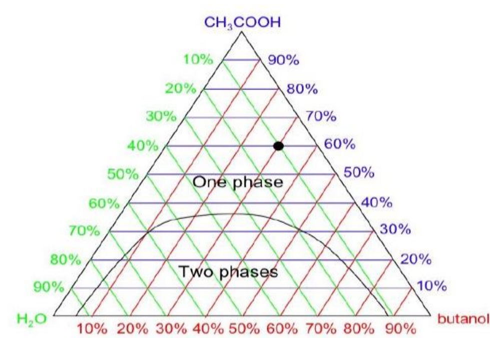
Lower consolute temperature = 60.8°C

Composition = 22% w/w nicotine in water.

Applications :

As the pressure is increased the upper consolute temperature rises and lowered consolute temperature lowered.

❖ THREE COMPONENT SYSTEM :



Consider,

Vertex A = CH_3COOH ,Vertex B = butanol

Vertex C = H_2O

•At vertex A concentration of component A is 100%w/w. Similarly concentration of component B is 100%w/w & concentration of component C is 100%w/w.

•Up on going from A to B along the line AB the concentration of component B is increases from 0 to 100 %w/w.In similar way the concentration of component C increases along the line BC & concentration of component A increases along the line CA .

• At any point inside the triangle the concentration of 3 components will be added up to 100 % .

For example ,

Consider point given in above figure .

Concentration of component CH_3COOH = 60% w/w

Concentration of component butanol = 30% w/w

Concentration of component H_2O = 10% w/w

Total concentration = 100% w/w.

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