Phase diagram- H_2O system

- Let us consider the application of Gibbs phase rule to the PT phase diagram of water. The temperature is plotted on the X-axis and pressure on the Y-axis. There three phases in H_2O system namely solid, liquid and gas. At the triple point, three phases coexist in equilibrium, and since there is one component in the system (water), the number of degrees of freedom is given by

$$F = C - P + 2 = 1 - 3 + 2 = 0$$ **(Zero degrees of freedom)**

- Since none of the variables (temperature or pressure) can be changed and still keep the three phases in balance, the triple point is called **invariant point.**
- Consider next a point along the liquid-solid freezing curve of water system at any point along this line two phases will coexist. Thus from Gibbs phase rule,

$$F = C - P + 2 = 1 - 2 + 2 = 1$$ **(One degrees of freedom)**

- This result reveals that there is one degrees of freedom, and thus one variable (T or P) can be changed independently and still maintain a system with two coexisting phases.

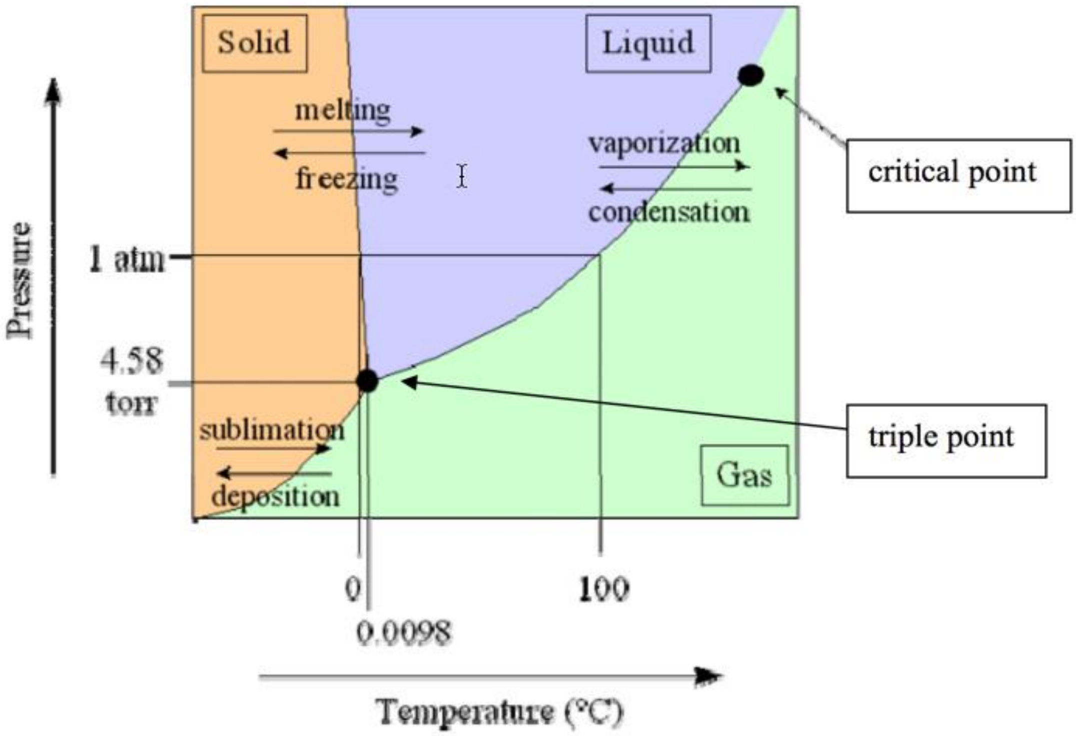

Figure1.2.Phase diagram of water system

- For a third case, consider a point on the water PT phase diagram inside a single phase. Then there will be only one phase present (P=1), and substituting into the phase-rule gives

$$F = C - P + 2 = 1 - 1 + 2 = 2 \quad \textbf{(Two degrees of freedom)}$$

- This result tells that there is two degrees of freedom, and thus two variables (T and P) can be changed independently and the system will remain a single phase.
- The **triple point** of a substance is the temperature and pressure at which gas, liquid, and solid coexist in thermodynamic equilibrium.
- Above the critical pressure and temperature, there is no distinction between the liquid phase and the gas phase. Basically, they merge into one phase that is called the **super critical fluid phase (SCF).**
- It is used on a large scale for the decaffeination of green coffee beans, the extraction of hops for beer production, and the production of essential oils and pharmaceutical products from plants.

Phase diagram of sugar- Water solution

- Let us first consider the phase diagram of sugar- water solution. The composition of sugar in water in wt.% is plotted on the X-axis and temperature on the Y-axis.
- The phase diagram consists of only two sections.
- The curve that divides the two sections represents the solubility limit. When sugar is added to water, sugar solution (syrup) is formed which is a homogeneous solution. This is the single phase system which is shown on the left side of this curve. On the right side of this curve the system exists in equilibrium as a two-phase system, syrup + sugar.
- From the diagram, the solubility limit of sugar at various temperatures can be read, e.g. at $20^{\circ}C$ the maximum solubility of sugar in water is 65 wt%.
- Beyond this concentration the solution is saturated; the sugar that is added remains as solid sugar in the liquid syrup. But now if the temperature is raised to about $60^{\circ}C$, the sugar dissolves because the solubility limit is 70 wt.% at this temperature.

Solubility limit – for almost all alloy systems, at a specific temperature, a maximum of solute atoms can dissolve in solvent phase to form a solid solution. The limit is known as solubility limit. In general, solubility limit changes with temperature. If solute available is more than the solubility limit that may lead to formation of different phase, either a solid solution or compound.

- Changing T can change the no of phases: path A to B
- Changing Co can change the no of phases: path B to D

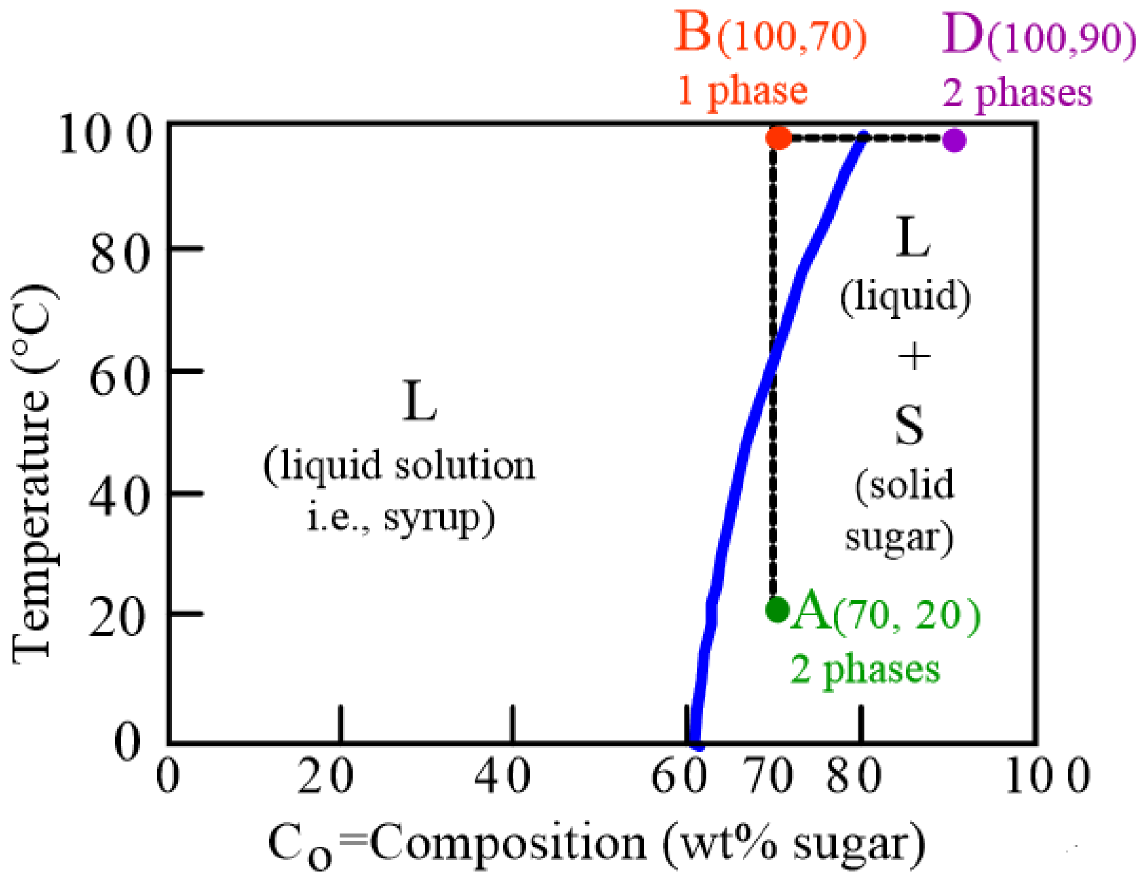

Figure.1.3. Phase diagram of sugar-Water solution