State of Matter Part III

Latent heats:

In **Latent heat, energy absorbed or released by a substance during a change in its physical state (phase) that occurs without changing its temperature.**

The latent heat associated with melting a solid or freezing a liquid is called the heat of fusion; that associated with vaporizing a liquid or a solid or condensing a vapour is called the heat of vaporization.

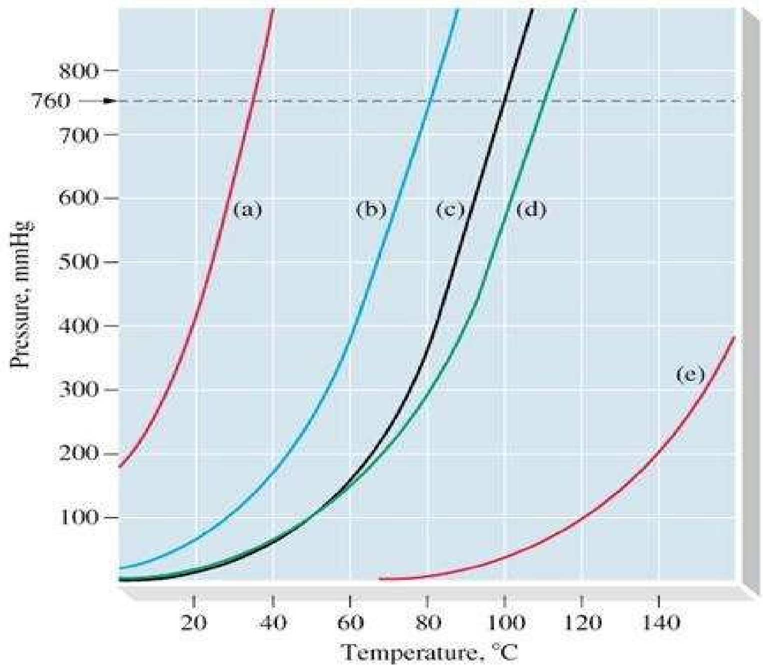
The latent heat is normally expressed as the amount of heat (in units of joules or calories) per mole or unit mass of the substance undergoing a change of state.

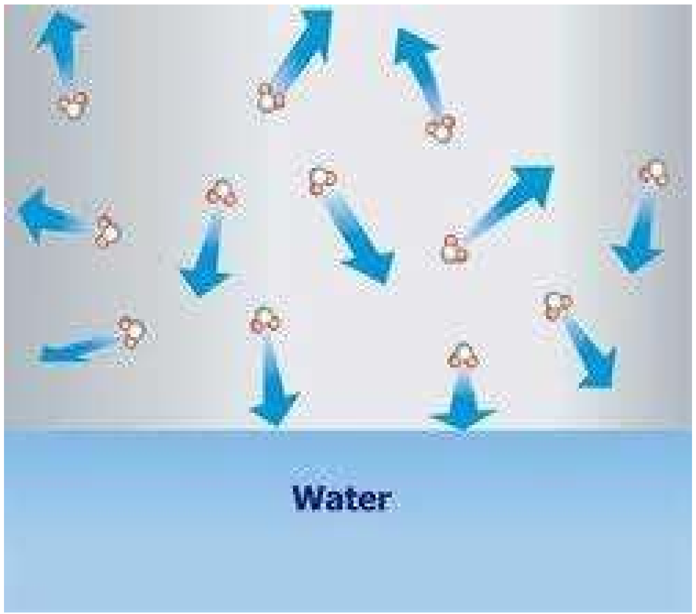
Examples are latent heat of fusion and latent heat of vaporization involved in phase changes, i.e. a substance condensing or vaporizing at a specified temperature and pressure.

Vapour pressure:

The vapor pressure of a liquid is the equilibrium pressure of a vapor above its liquid (or solid); that is, the pressure of the vapor resulting from evaporation of a liquid (or solid) above a sample of the liquid (or solid) in a closed container. Examples:

substance	vapor pressure at 25^{o}C
diethyl ether	0.7 atm
bromine	0.3 atm
ethyl alcohol	0.08 atm
water	0.03 atm





As the temperature of a liquid or solid increases its vapor pressure also increases. Conversely, vapor pressure decreases as the temperature decreases.

Factors That Affect Vapor Pressure

1. Surface Area: The vapor pressure is the equilibrium pressure where the rate of evaporation is equal to the rate of condensation. Since the scaling factor is the same, the vapor pressure is independent of the surface area.

2. Types of Molecules: the types of molecules that make up a solid or liquid determine its vapor pressure. If the intermolecular forces between molecules are:

relatively strong, the vapor pressure will be relatively low.

relatively weak, the vapor pressure will be relatively high.

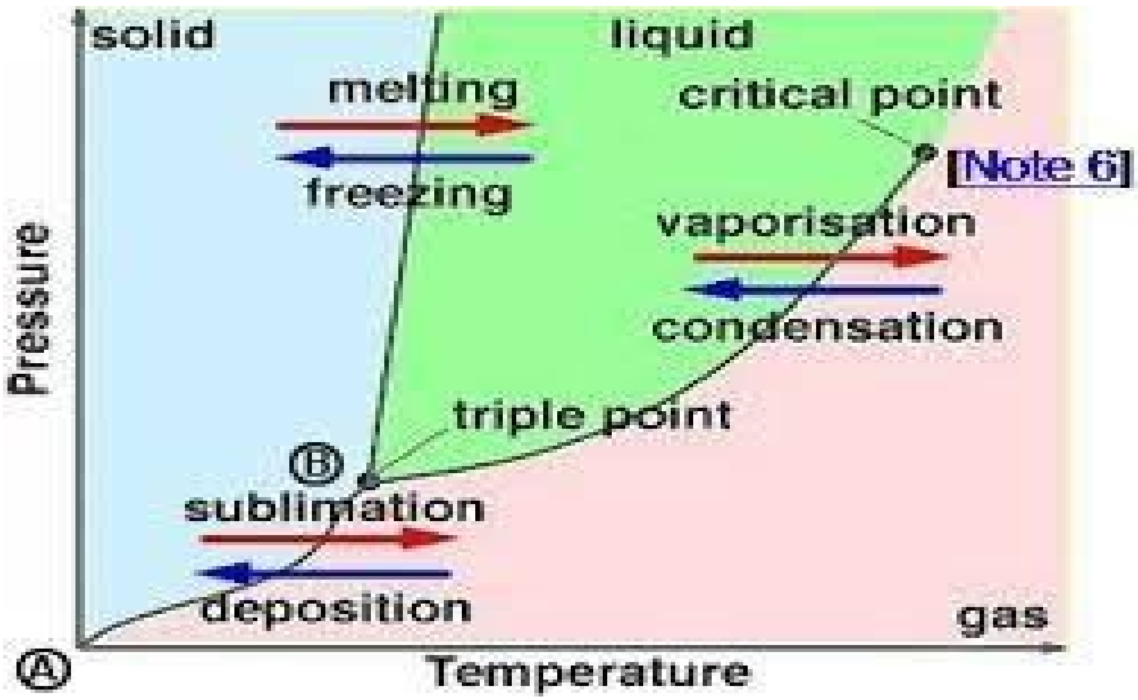
3. Temperature: at a higher temperature, more molecules have enough energy to escape from the liquid or solid. At a lower temperature, fewer molecules have sufficient energy to escape from the liquid or solid.

4. Intermolecular Forces: Those liquids in which the intermolecular forces are weak shows high vapour pressure.

Sublimation critical point:

Sublimation is the change of state from a solid to a gas without passing through the liquid state. Carbon dioxide is an example of a material that easily undergoes sublimation.

The temperature at which the vapor pressure of the solid phase of a compound is equal to the total pressure of the gas phase in contact with it; analogous to the boiling point of a liquid.



Phase Rule: Phase rule is a rule relating the possible numbers of phases, constituents, and degrees of freedom in a chemical system. This Rule was proposed by J. Willard Gibbs in 1876.

The phase can he defined as *any homogeneous part of a system having all the physical and chemical properties. The properties are identical throughout. A system may consist of one phase or more than one phase.*

(1) A system containing only liquid water is a single-phase or single-phase system (P =1)

(2) A system containing liquid water and steam (a gas) is a two-phase or two-phase systems (P = 2).

(3) A system containing liquid water, steam and solid ice is a three-phase or three-phase phase For a system at equilibrium the phase rule relates:

$$F = C - P + 2$$

Where

P = number of phases that can coexist

F = number of components making up the phases, and

F= number of independent variables or degrees of freedom.

Eutectic mixtures:

A eutectic mixture is defined as a mixture of two or more components which usually do not interact to form a new chemical compound but, which at certain ratios, inhibit the crystallization process of one another resulting in a system having a lower melting point than either of the components . Eutectic mixtures, can be formed between Active Pharmaceutical Ingredients (APIs), between APIs and excipients or between excipients; thereby providing a vast scope for its applications in pharmaceutical industry.

Eutectic mixture formation is usually, governed by following factors:

(a) The components must be miscible in liquid state and mostly immiscible in solid state,

(b) Intimate contact between eutectic forming materials is necessary for contact induced melting point depression,

(c) The components should have chemical groups that can interact to form physical bonds such has intermolecular hydrogen bonding etc.,

(d) The molecules which are in accordance to modified VantHoff's equation can form eutectic mixtures .

Applications of Eutectic Mixtures in Pharmaceutical Industry

1. During pre formulation stage, compatibility studies between APIs and excipient play a crucial role in excipient selection.
2. Testing for eutectic mixture formation can help in anticipation of probable physical incompatibility between drug and excipient molecules.
3. Eutectic mixtures are commonly used in drug designing and delivery processes for various routes of administration.
4. During manufacturing of pharmaceutical dosage form, it is extremely necessary to anticipate the formation of eutectics and avoid manufacturing problems if any. For example, during tablet compaction the heat produced in the punch and die cavities may lead to fusion or melting of tablet powder compacts leading to manufacturing defects. Thus knowledge of eutectic points of powder components may help avoid these problems.
5. During pharmaceutical analysis, understanding of eutectic mixtures can help in the identification of compounds having similar melting points. Compounds having similar melting points, as a rule will have different eutectic point with a common other component . This knowledge could be used to identify compounds like Ergotamine, Allobarbital etc.