UNIT –II

CHAPTER-2

EVAPORATION

Evaporation is a unit operation of vaporizing large quantities of volatile liquid to get a concentrated product

Evaporation v/s Distillation

Evaporation

Vaporization takes place below the boiling point

Takes only from the surface of the liquid

There is no bubble formation in evaporation

Not necessarily a separation or purification technique. Vaporisation occurs rapidly

Distillation

Vaporization takes place at the boiling point

Takes place from whole of the liquid

There is bubble formation

It is a separation or purifying technique. It is a slow process

Drying v/s Evaporation

Drying

It refers to the removal of relatively small amounts of water from solid or nearly solid material In most cases drying involves the removal of water at temperatures below its boiling point

Evaporation

It refers to the removal of relatively large amounts of water from solutions

Removal of water by boiling a solution- (wherever removing water is necessary)

Basic concept of phase equilibrium

Phase

- In the physical sciences, a phase is a region of space (a thermodynamic system), throughout which all physical properties of a material are essentially uniform.
- A simple description is that a phase is a region of material that is chemically uniform, physically distinct, and (often) mechanically separable.
- The term phase is sometimes used as a synonym for state of matter

Phase equilibrium

- Many compositions will form a uniform single phase, but depending on the temperature and pressure even a single substance may separate into two or more distinct phases. Within each phase, the properties are uniform but between the two phase properties differ.
- At equilibrium, evaporation and condensation processes exactly balance and there is no net change in the volume of either phase
- For a given composition, only certain phases are possible at a given temperature and pressure. The number and type of phases that will form is hard to predict and is usually determined by experiment.
- The results of such experiments can be plotted in phase diagrams

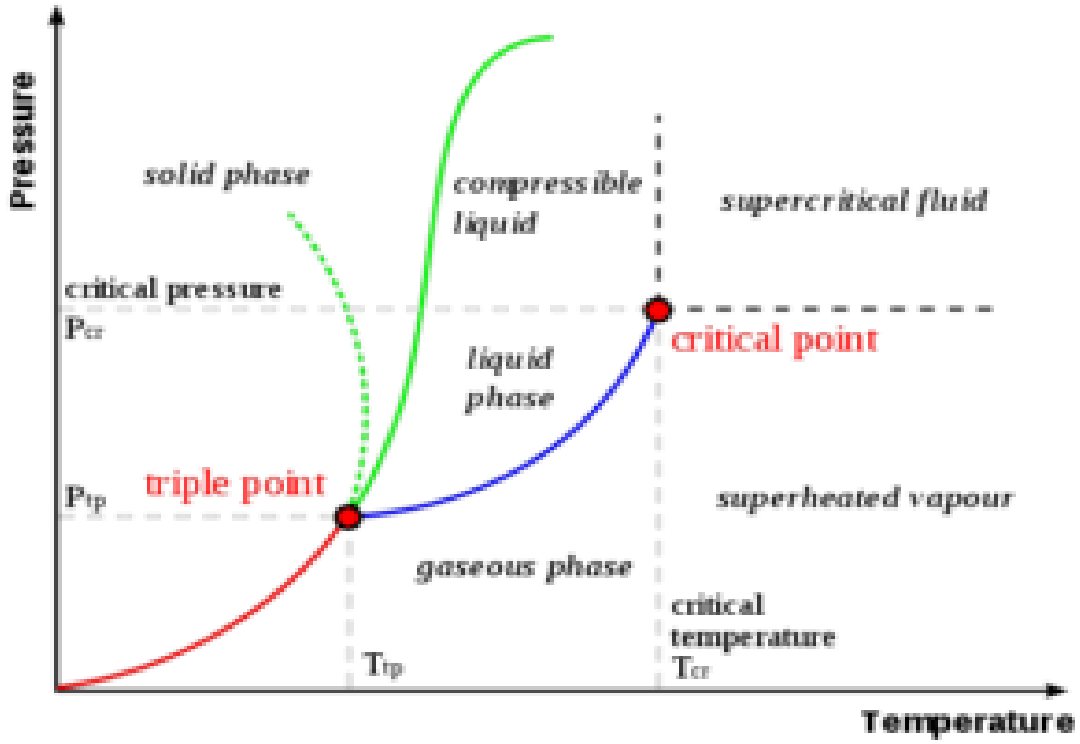
Triple point

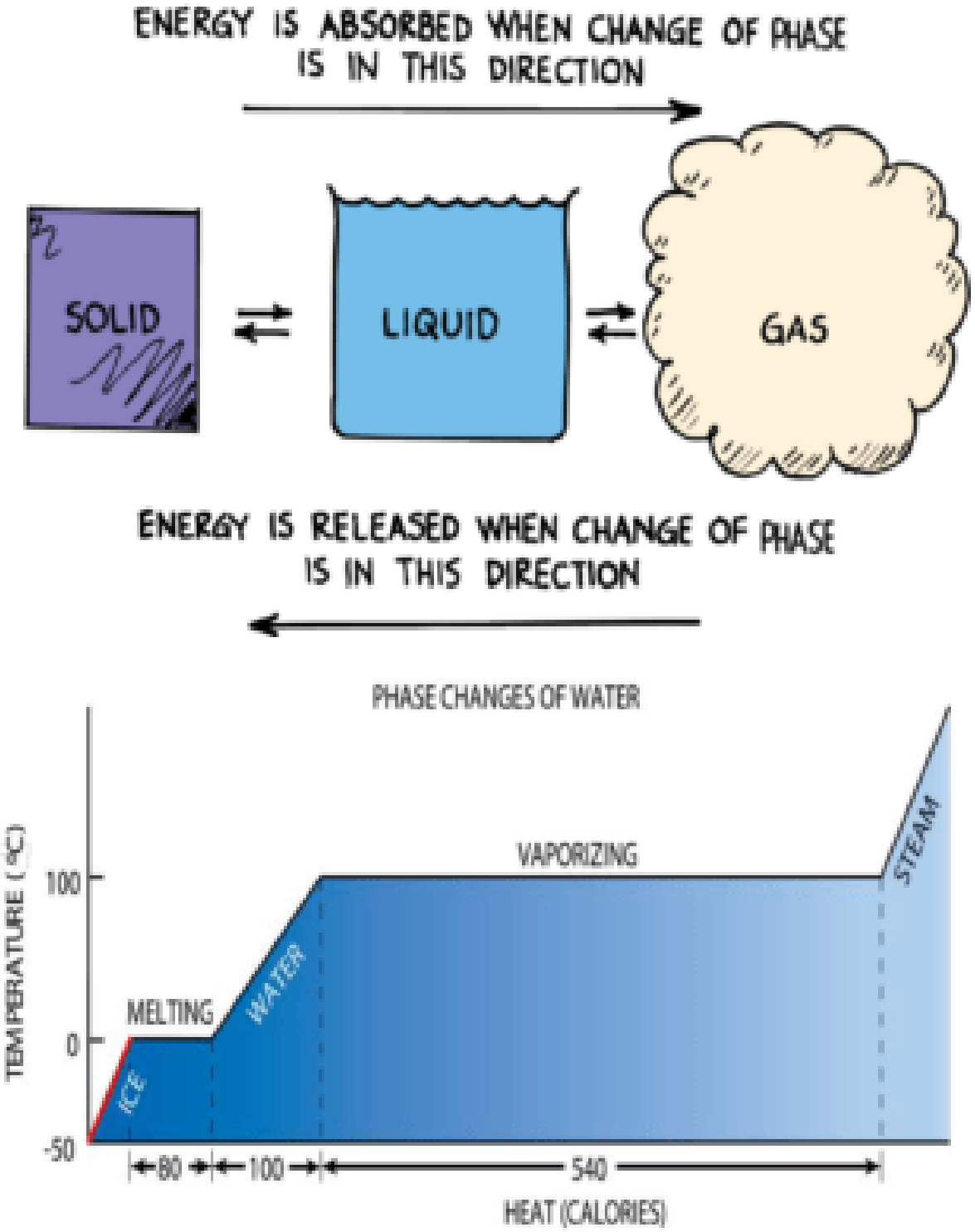
Another interesting feature of the phase diagram is the point where the solid-liquid phase line meets the liquid-gas phase line. The intersection is referred to as the at the triple point, all three phases can coexist

If you think about the three lines which meet at that point, they represent conditions of:

- Solid-liquid equilibrium
- Liquid-vapour equilibrium
- Solid-vapour equilibrium

If you controlled the conditions of temperature and pressure in order to land on this point, you would see an equilibrium which involved the solid melting and subliming, and the liquid in contact with it boiling to produce a vapour – and all the reverse changes happening as well.





Mechanism

When heat applied in solution, the motion of molecules increase and molecules present in the surface overcome the surface tension of the liquid and it evaporates because surface molecules have less cohesive force than others.

Distinguishing factors of evaporation

- Residue is a concentrated liquid
- Evaporating liquid is the only one component
- No attempt is made to separate the mixture of vapour
- Purpose is to get concentrated liquid only

Applications

- Manufacturing of bulk drugs
- Manufacturing of biological products
- Miscellaneous – demineralized water

Factors Influencing Evaporation

Rate of evaporation depends on several factors

M=KS (b-b') / P

M = Mass of vapour formed per unit time (m3/s)

S = Surface area of the liquid exposed (m2)

P = Atmospheric pressure (Kpa)

B = Maximum vapour pressure at the temp of air (Kpa)

b' = Pressure due to vapour of the liquid (Kpa)

K = Constant (m/s)

Factors Affecting Evaporation

Temperature and time

Surface area

Agitation

Atmospheric aqueous vapour pressure

Atmospheric pressure on the liquid under evaporation

Type of product required

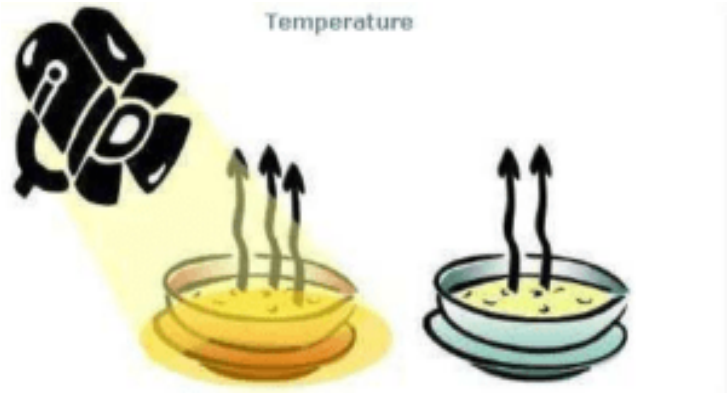
Moisture content and concentration of solute

Economic factors

1. Temperature and time

The rate of evaporation is directly proportional to the temperature. Higher the temperature, greater will be the evaporation Ex – Alkaloids, Harmones, Enzymes, antibiotics – heat sensitive

If time of exposure is longer, greater will be the evaporation, provided the constituents are thermostable. Exposure of a drug to a relatively high temp. for a short period of time may be less destructive of active principle than a lower temp. with long exposure time.

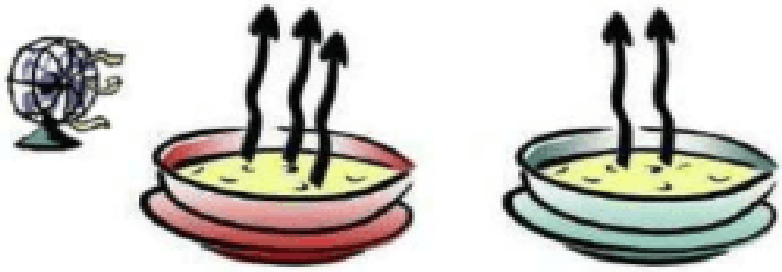


2. Surface area

- The rate of evaporation is directly proportional to the surface area of the vessel exposed to evaporation.
- Greater the surface area of the liquid, greater will be the evaporation

3. Agitation

When vegetable extracts are concentrated in steam pan, a film may be formed on the surface and/or precipitate matter may deposit on the heating surface. Film reduces the heating surface and precipitated matter hinders the transfer of heat.



4. Atmospheric aqueous vapour pressure

Rate of evaporation is indirectly proportional to the vapour pressure of the liquid Lower the pressure, greater will be the evaporation

5. Atmospheric pressure on the liquid under evaporation

The rate of evaporation is inversely proportional to the atmospheric pressure on the liquid under evaporation.

6. Type of product required

The selection of the method and apparatus to be used for evaporation depends upon type of product required.

7. Moisture Content of Feed

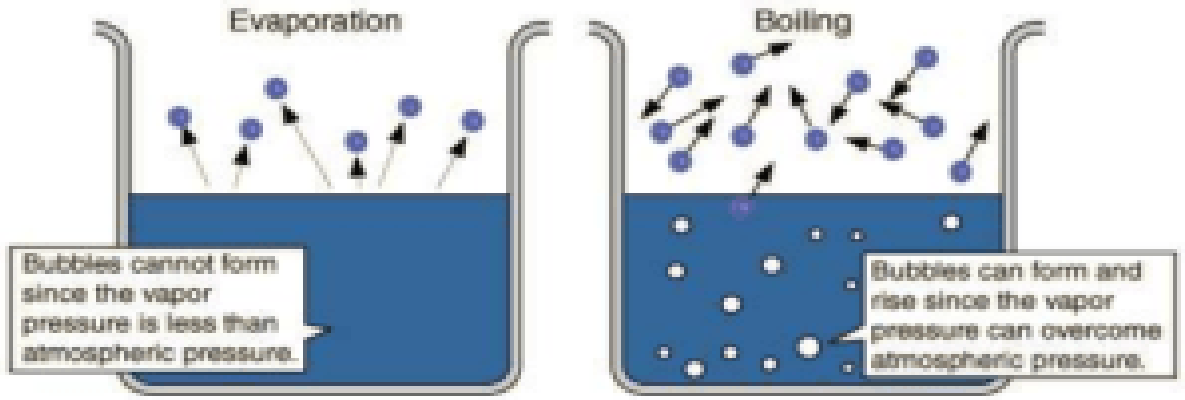
Some drug constituents undergoes hydrolysis readily in presence of moisture at high temperature. To prevent the decomposition, the material is exposed to low temp. initially, then exposed to higher temp.

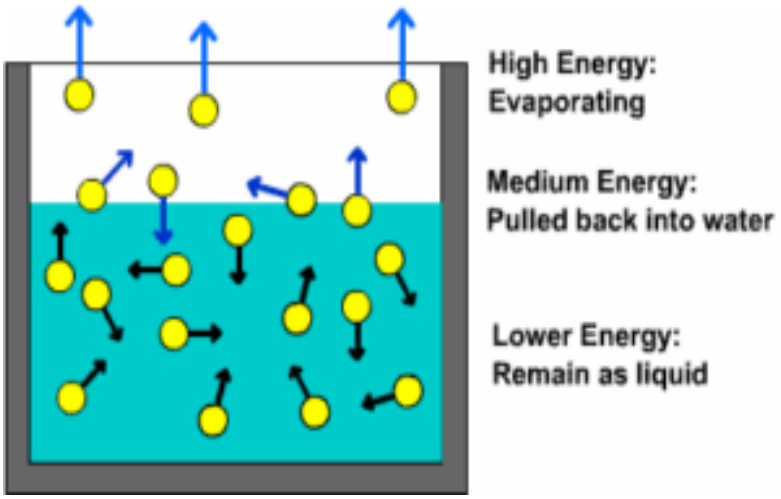
8. Economic factors

Economies of labour, fuel, floor space & materials are primary considerations. The recovery of solvent & utilization of waste heat are also important as they involves considerable reduction of cost.

Theory of Evaporation

- For molecules of a liquid to evaporate, they must be located near the surface, be moving in the proper direction, and have sufficient kinetic energy
- Since the kinetic energy of a molecule is proportional to its temperature, evaporation proceeds more quickly at higher temperatures. As the faster-moving molecules escape, the remaining molecules have lower average kinetic energy, and the temperature of the liquid thus decreases. This phenomenon is also called evaporative cooling.





- Let F kg be the feed/h to the evaporator, whose solid content is XF (weight fraction) & enthalpy is hF J/kg
- Let L kg be the product collected/h from the evaporator, whose solute composition is XL (weight fraction) & enthalpy is hL
- Let V kg be the vapor liberated/hr from the evaporator, whose solute composition is y (weight fraction) & enthalpy is hV J/kg
- In most evaporators, the vapor is pure water as there is no entrainment & therefore y is zero.

----------**THANKYOU**----------