Unit-2

Physical Pharmaceutics

States of Matter and properties of matter:

State of matter, changes in the state of matter, latent heats, vapour pressure, sublimation critical point, eutectic mixtures, gases, aerosols – inhalers, relative humidity, liquid complexes, liquid crystals, glassy states, solid crystalline, amorphous & polymorphism.

Physicochemical properties of drug molecules:

Refractive index, optical rotation, dielectric constant, dipole moment, dissociation constant, determinations and applications

States of Matter and properties of matter:

State of matter, changes in the state of matter, latent heats, vapour pressure, sublimation critical point, eutectic mixtures, gases, aerosols – inhalers, relative humidity, liquid complexes, liquid crystals, glassy states, solid crystalline, amorphous & polymorphism.

State of matter:

Matter can exist in one of three states: solid, liquid, or gas. The state of matter of a substance is determined by the kinetic energy of its particles. The kinetic energy of a particle is the energy it has due to its motion.

- Solid: In a solid, the particles are tightly packed together and have very little kinetic energy. This means that the particles in a solid cannot move around very much. Solids have a definite shape and volume.
- Liquid: In a liquid, the particles are still close together, but they have more kinetic energy than they do in a solid. This means that the particles in a liquid can move around each other, but they are still held together by forces of attraction. Liquids have a definite volume, but they do not have a definite shape. They take on the shape of the container they are in.
- Gas: In a gas, the particles are far apart and have a lot of kinetic energy. This means that the particles in a gas move around very quickly and can easily move past each other. Gases do not have a definite shape or volume. They expand to fill the container they are in.

Properties of matter:

S.No.	Properties	Solid	Liquid	Gas
1.	Shape	Fixed	No Fixed	No Fixed
2.	Volume	Fixed	Fixed	No Fixed
3.	Fluidity	Not Flow	Can flow	Can flow
4.	Rigidity	Rigid	Not Rigid	Not Rigid
5.	Intermolecular Force	maximum	Less than solids	Very less
6.	Intermolecular Space	Very less	More than solids	Maximum and less than gas
7.	Compressibility	Negligible	Compressible	Highly compressible
8.	Density and Mass	Maximum	Less than solid	No density & Mass

9.	Surface	Very Less	Less than gas	Maximum
10.	Flow property	No flow property	Less than gas	High flow property

Changes in the State of Matter

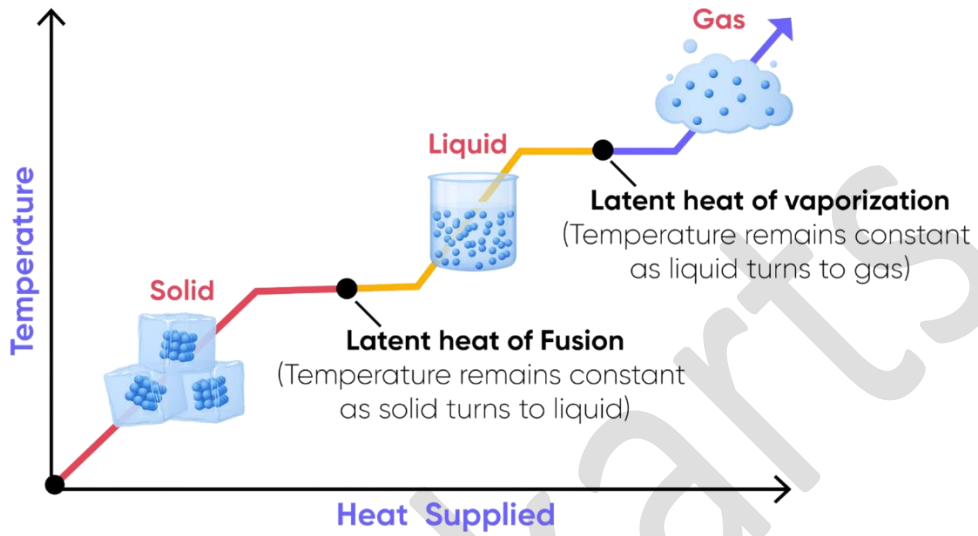
The state of matter of a substance can change under different conditions. The most common changes in the state of matter are:

- Melting: Melting is the change of a solid to a liquid. This happens when heat is added to the solid, causing the particles to vibrate more and move further apart. The melting point is the temperature at which a solid melt.
- Freezing: Freezing is the change of a liquid to a solid. This happens when heat is removed from the liquid, causing the particles to slow down and move closer together. The freezing point is the temperature at which a liquid freeze.
- Vaporization: Vaporization is the change of a liquid to a gas. This happens when heat is added to the liquid, causing the particles to vibrate more and move further apart until they escape from the liquid's surface. The boiling point is the temperature at which a liquid vaporizes.
- Condensation: Condensation is the change of a gas to a liquid. This happens when heat is removed from the gas, causing the particles to slow down and move closer together. The condensation point is the temperature at which a gas condenses.
- Sublimation: Sublimation is the change of a solid directly to a gas. This happens when heat is added to the solid, causing the particles to vibrate so much that they escape from the solid's surface without becoming a liquid first. The sublimation point is the temperature at which a solid sublime.
- Deposition: Deposition is the change of a gas directly to a solid. This happens when heat is removed from the gas, causing the particles to slow down and move closer together until they form a solid.

Latent heats:

- Latent heat is the heat absorbed or released by a substance during a change of state, such as from a solid to a liquid or from a liquid to a gas.
- The word "latent" means "hidden," and this is because the heat is not apparent in the change in temperature of the substance during the phase change.
- The amount of latent heat required for a substance to change its state is called the latent heat of fusion or the latent heat of vaporization, depending on whether the substance is changing from a solid to a liquid or from a liquid to a gas.
- They are the amounts of heat energy absorbed or released by a substance during a phase change at a constant temperature, without changing the substance's temperature itself.

LATENT HEAT



Vapour Pressure:

- The pressure of a vapour in contact with its solid or on liquid form.
- When both is equal or gas is in equilibrium that time the pressure exerted by vapour on surface is called vapour pressure.

OR

- Vapour pressure is a measure of the tendency of a material to change into the gaseous or vapour state, and it increases with temperature.
- The temperature at which the vapour pressure at the surface of a liquid becomes equal to the pressure exerted by the surroundings is called the boiling point of the liquid.

Factors that affect Vapour pressure:

1. **Temperature:** The temperature of liquid or solid increase its vapour pressure also increases.
2. **Intermolecular Forces:** Those liquid in which the intermolecular force are weak shows high vapour.
3. **Surface Area:** Vapour pressure is independent of surface area.
4. **Solute concentration:** The vapor pressure of a liquid decreases when a solute is added to the liquid. This is because the solute molecules interfere with the evaporation of the liquid molecules.

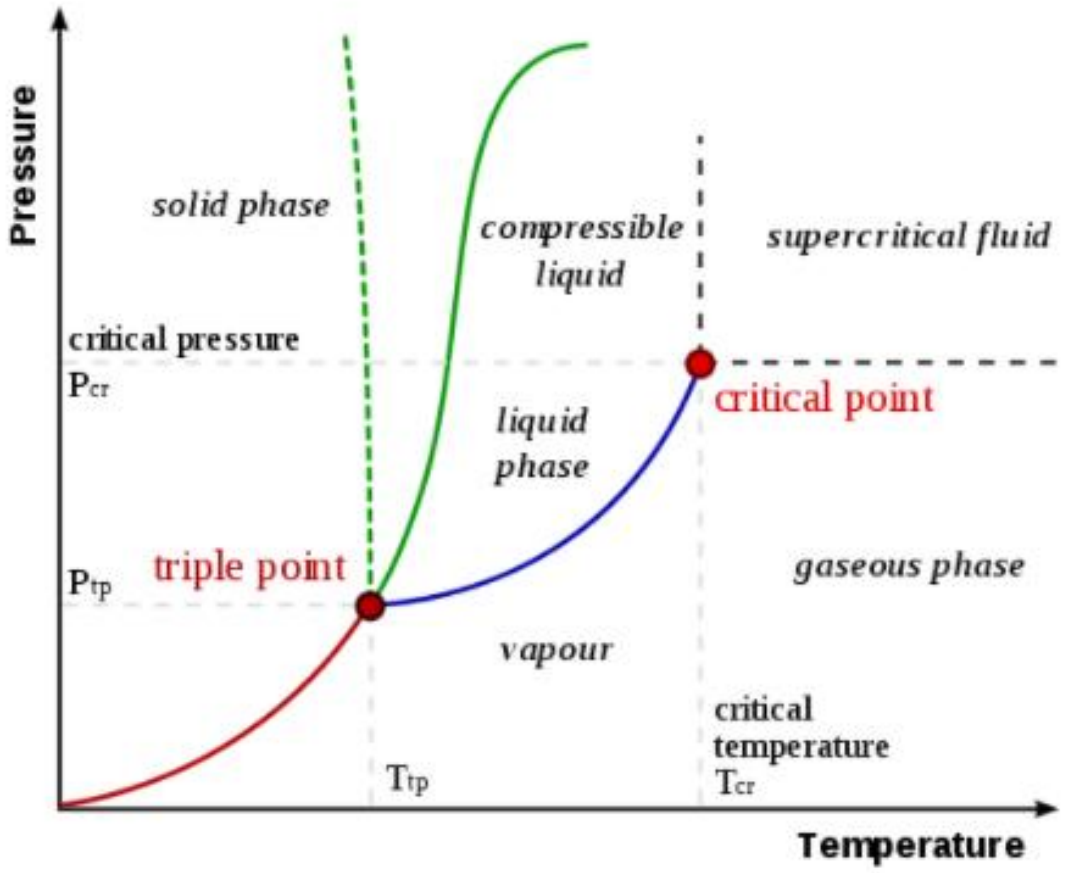
Sublimation Critical Point:

Sublimation:

- A change of state directly from solid to gas without changing into a liquid state is called sublimation.
- Sublimation is an endothermic phase transition of solid matter.

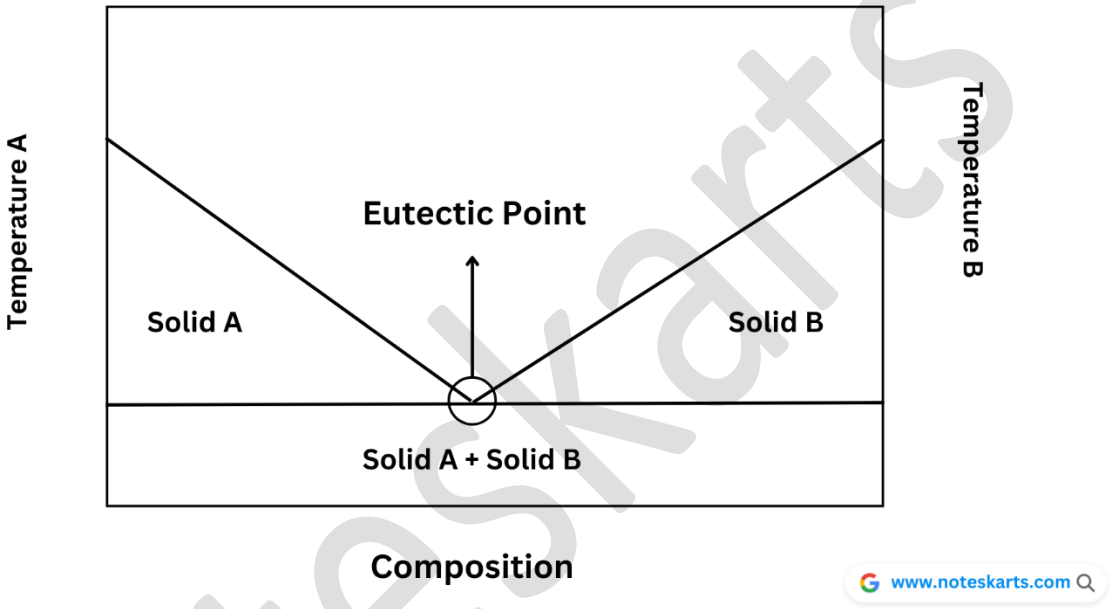
Sublimation Critical Point:

- The sublimation critical point of a substance is the highest temperature and pressure at which the substance can sublime. At this point, the gas and liquid phases of the substance are indistinguishable, and the substance exists as a supercritical fluid.
- The sublimation critical point is different from the triple point, which is the temperature and pressure at which all three phases of a substance (solid, liquid, and gas) can coexist in equilibrium.
- For example -78.5°C is the sublimation critical point of dry ice.



Eutectic Mixture:

- The term eutectic is derived from the Greek words "eu" meaning "good" and "tectic" meaning "melting".
- A eutectic mixture is a homogeneous mixture of two or more substances that melts or solidifies at a single temperature lower than each constituent's melting point. The lowest possible melting point over all of the mixing ratios of the constituents is called the eutectic temperature.



The % composition of both substance at which solid mixture get liquified is called eutectic point.

Example: Menthal, Thymol, Camphor, Phenol, etc.

Gases:

- Gases are a state of matter that have no fixed shape or volume.
- They are made up of particles that are far apart, fast-moving, and not organized in any particular way.
- Gases are highly compressible and have very large intermolecular distances. They have a lower density than other states of matter, such as solids and liquids.

Aerosols:

- Aerosols are a suspension of fine solid particles or liquid droplets in air or another gas.

Inhalers:

- An inhaler is a device that delivers medication directly to the lungs. The medication is a mist or spray that the person breathes in. Inhalers are also known as puffers, pumps, or allergy sprays.
- Inhalers are portable and handheld. They can help people with asthma or a bad cold breathe more easily.
- The medication works quickly to open up narrowed airways.

Example: Asthma pump

Relative Humidity:

- Humidity is the total amount of water vapour present in air.
- Relative humidity may be defined as the ratio of amount of the water vapour in the air at a specific temperature to the maximum amount of that air which hold the water at that temperature.

Or

- Relative humidity (RH) is the ratio of the amount of water vapor in the air to the amount of water vapor the air could hold at a specific temperature. It is expressed as a percentage. The higher the RH, the more moisture is in the air.

Liquid Complexes:

- Liquid complex are binary system or mixtures that have co-existence between the two phases
- Solid – Liquid (Suspension), Liquid-liquid (emulsion), Solid-Gas (Granular), Liquid-Gas (Foams)
- They exhibit unusual mechanical responses to apply stress or strain due to the geometrical arrangement.

Liquid Crystals:

- They have long rod like molecules. They do not melt to give the liquid substance directly.
- They passed through an intermediate state between solid state and liquid state. It is known as liquid crystal.

$$Solid\ State = \frac{Intermediate}{State} Liquid\ state$$

Glassy States:

- A glassy state is a non-equilibrium state of matter that exhibits properties of both solids and liquids.
- Glass is a transparent brittle does not have a proper structure and have solid appearance.

Solid:

- Solid consists of ion atom and molecules which are held in fixed position and closely packed.
- The interparticle attraction in solid are strongest than liquids hence solid have following characteristics such as- definite shape, volume, mass and melting point.

Type of solid:

1. Crystalline
2. Amorphous

Different between Crystalline and Amorphous

S.no	Crystalline	Amorphous
1.	The atom and molecule are arranged in definite pattern.	The atom and molecule are non-arranged in definite pattern.
2.	Crystalline solid have shape melting & boiling point.	Amorphous solid have low melting and boiling point.
3.	It is partially incompressible	It is partially compressible
4.	Higher energy is required for molecules to escape from crystal form.	Less energy is required for molecule to escape from amorphous form.
5.	Long range order	Short range order
6.	Atoms are arranged in regular 3 dimension	They do not have regular arrangement
	Example: Potassium nitrate, copper	Example: Cellophane, polyvinyl chloride

Polymorphisms:

- It is the ability of a molecule to crystalline into more than one different crystal structure.
- The term polymorph means the substance have same molecular composition but have different crystalline forms.
- Substance in 2 different form is known as dimorphic while in 3 different form is known as trimorphic.
- Polymorphs are chemically same but are different with respect to physicochemical properties.
- The different forms have different thermodynamic properties such as melting point, vapour pressure, solubility and bioavailability.

Physiochemical properties of drug molecules:

- Refractive index
- Optical rotation
- Dielectric constant
- Dipole moment
- Dissociation constant

Refractive index:

It is the ration of speed of light between any two medium.

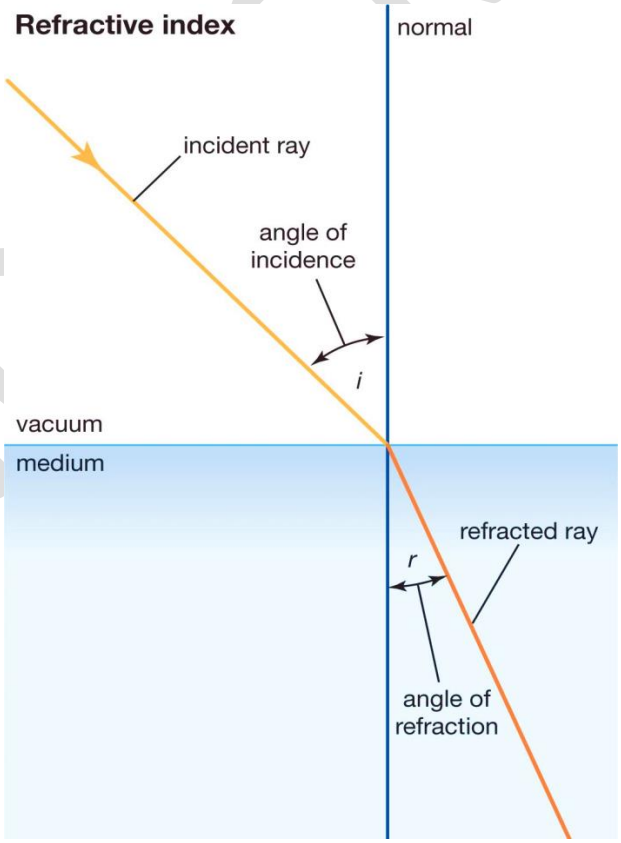
$$n = \frac{c}{v}$$

Where:

n= Refraction index

c= velocity of empty space/ air

v= velocity of light in a substance

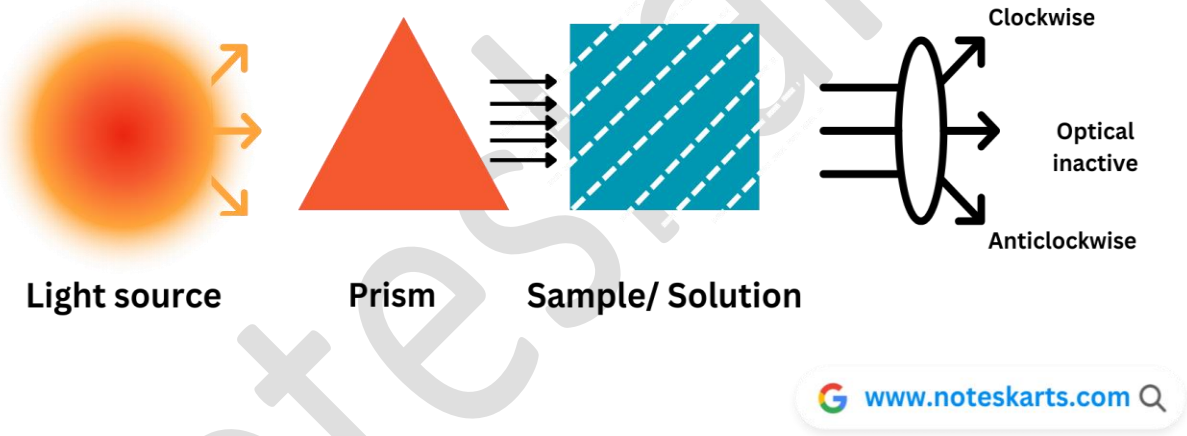


Application:

- it is used to measure the concentration of a solute in an aqueous solution. For a solution of sugar, the refractive index can be used to determine the sugar content (Brix degree).
- It can be used also in determination of drug concentration in pharmaceutical industry.
- It is used to calculate the focusing power of lenses, and the dispersive power of prisms.
- It is applied for estimation of thermophysical properties of hydrocarbons and petroleum mixtures.

Optical rotation:

- When we pass light through any medium it light turn or rotate then it is optical activate or if light not rotate then medium is optically inactive.



Clockwise= Dextro-rotatory (+)

Anticlockwise= Levo-rotatory (-)

Application of optical rotation:

- It is used to identify whether the substance is optically active or not.
- Purity of substance is determined.
- The concentration is determined.
- Optical activity is used in study of structure of anisotropic material.
- Polarimetry is used in analysis of various drugs and pharmaceutical formulation.

Dielectric constant:

Dielectric constant is the ratio of force between two change and same distance a part in air to the same charges kept in other medium.

It is the ratio of permittivity of medium upon permittivity of free space

$$k = \frac{\varepsilon}{\varepsilon_0}$$

Where,

- κ is the dielectric constant
- $\boldsymbol{\varepsilon}$ is the permittivity of the substance
- $\boldsymbol{\varepsilon}_0$ is the permittivity of the free space

Applications:

- Dielectrics are used to manufacture capacitor.
- Used to manufacture transformer.
- They are used in measuring and heating presses.

Dipole moment:

The mathematical product of the charge into distance.

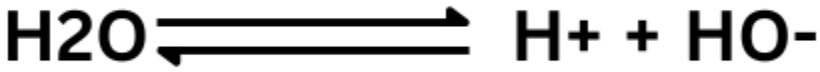
$$\mu = q \times r$$

Where,

- μ = dipole moment
- q = changes product
- r = distance

Dissociation constant:

- The breaking of any electrolyte into ions is called dissociation.
- Strong electrolyte dissociates completely (100%) a weak electrolyte dissociate less than 100%.



According to law of mass action.

$$Ka = \frac{[H^+]\,[A^-]}{[HA]}$$

The dissociation constant is usually written as a quotient of the equilibrium concentration (in mol/L).

Application of Dissociation constant:

- The dissociation constant is used in pharmacy to measure the tendency of a larger object to divide into smaller components. This value is used to understand the chemical behavior of a drug molecule.
- The dissociation constant is also used to determine the affinity between a protein and a ligand in protein-ligand binding. A higher dissociation constant indicates a less tightly bound ligand.
- The dissociation constant is also used to determine the deprotonation of atoms and molecules.