PHYSICAL PHARMACEUTICS-I

UNIT 2 NOTES

STATES OF MATTER

- STATE OF MATTER
- LATENT HEATS
- VAPOUR PRESSURE
- SUBLIMATION CRITICAL POINT
- EUTECTIC MIXTURE
- GASES
- AEROSOLS
- RELATIVE HUMIDITY
- LIQUID COMPLEXES, LIQUID CRYSTALS, GLASSY STATE
- POLYMORPHISM

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- REFRACTIVE INDEX
- OPTICAL ROTATION
- DIELECTRIC CONSTANT
- DIPOLE MOMENT
- DISSOCIATION CONSTANT

IMPERFECT PHARMACY

STATES OF MATTER

- Anything that has mass and occupies space is known as
- Matter is made up of tiny particles called Atom.
- It is mainly divided into 3 physical states :

① Solid State
② Liquid State
③ Gaseous State

SOLIDS

- Solids are defined as those substances that have a definite shape & definite volume.
- Example : Tablet, Capsule

LIQUIDS

- Liquids are defined as those substances that have a definite volume but not definite shape.
- Example : Syrup, Water

GASES

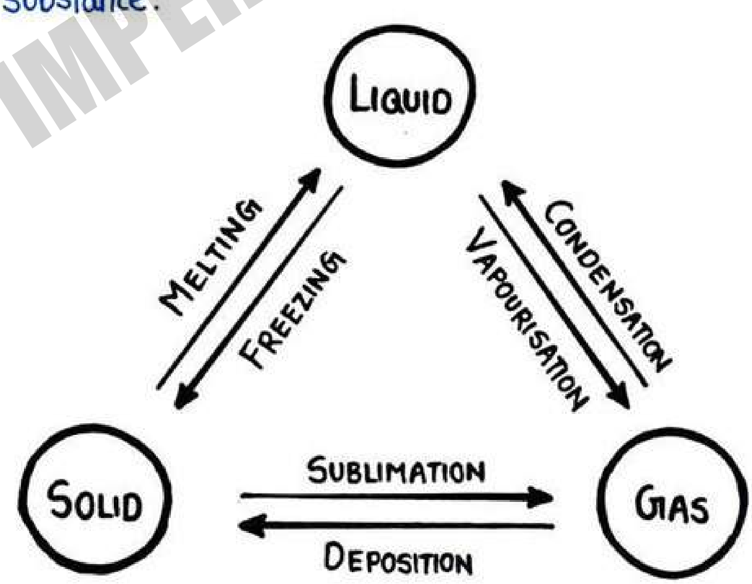
- Gases are defined as those substances that neither have definite shape nor definite volume.
- Example : Aerosols.

PROPERTIES OF SOLID, LIQUID & GASEOUS STATE

PROPERTY	SOLID	LIQUID	GAS
• SHAPE	Definite	Indefinite	INDEFINITE
• VOLUME	Definity	Definite	INDEFINITE
• INTERMOLECULAR SPACE	LEAST	INTERMEDIATE	HIGHEST
• KINETIC ENERGY	LEAST	INTERMEDIATE	HIGHEST
• COMPRESSIBILITY	LEAST	INTERMEDIATE	HIGHEST
• DIFUSION RATE	LEAST	INTERMEDIATE	HIGHEST
• RIGIDITY	HIGHEST	INTERMEDIATE	LEAST
• DENSITY	HIGHEST	INTERMEDIATE	LEAST
• FLOW PROPERTY	LEAST	INTERMEDIATE	HIGHEST

CHANGES IN STATE OF MATTER

- Matter can be changed from 1 state to another.
- Changes of state takes place when Heat is absorbed or released by a substance.



LATENT HEAT

- The term Latent Heat was introduced by British Chemist Joseph Black in 1762.
- Latent Heat is defined as Heat or Energy that is absorbed or release during the phase change of the substance. It can be either from a solid to liquid, liquid to Gas or Vice-Versa.
- It can be understood as a hidden heat energy that is supplied or extracted to change the state of matter without changing its temperature.

EXPLANATION OF LATENT HEAT

- Suppose, We have a block of ice & we want to convert it into water.
- We all know that ice turns to water at 0°C & vice versa.
- Now, assume we start heating ice at 0°C.
- You will observe, when you do so, temperature of ice doesn't change.
- It starts converting into water but the temperature does not rise until the entire ice block has been converted to water.
- Actually, all the heat supplied to the ice at 0°C is used by the ice to change its phase from solid to liquid & that's why temperature of ice doesn't rise and this heat is known as Latent Heat.

TYPES OF LATENT HEAT

There are mainly two types of Latent Heat

① Latent Heat of Fusion

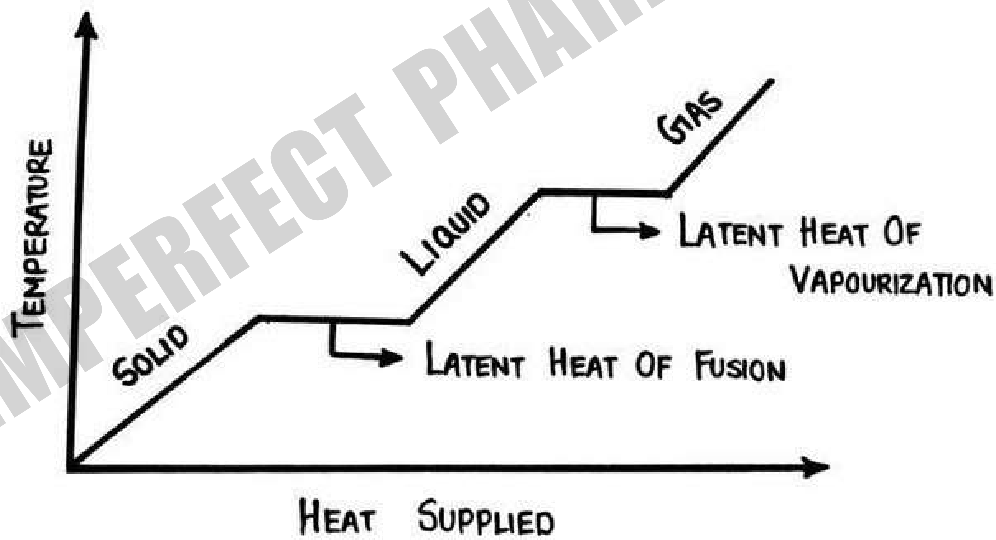
② Latent Heat of Vapourization

LATENT HEAT OF FUSION

- The energy supplied per unit mass of a substance at its melting point to convert the state of the substance from solid to liquid or vice versa is known as Latent Heat Of Fusion.
- Latent Heat of Fusion of water is 334 Joules / Gram of Water.

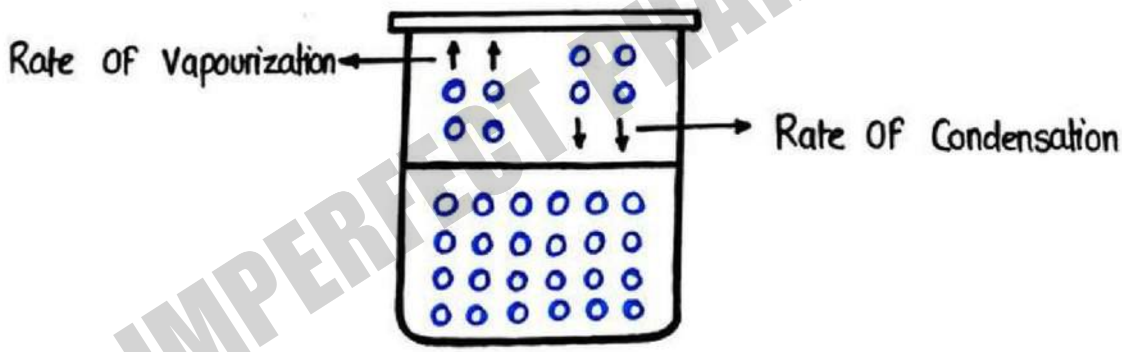
LATENT HEAT OF VAPOURIZATION

- The energy supplied per unit mass of a substance at its boiling point to convert the state of the substance from liquid to Gas or vice versa is known as Latent Heat Of Vapourization.
- Latent Heat of Vapourization of water is approx 2250 Joules / Gram of water.



Vapour Pressure

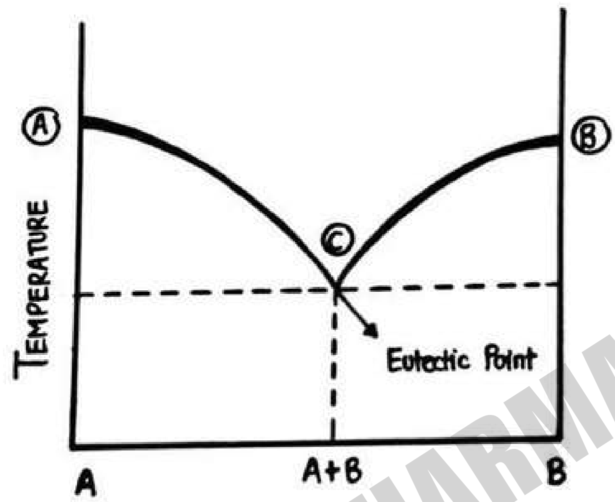
- When a liquid is kept inside a closed container, the liquid molecules due to its kinetic energy leaves the liquid surface & goes into the free space above it & this process is known as Vapourization.
- When the number of molecules increases above the liquid, some molecules returns back to the liquid surface & mixed again & the process is known as Condensation.
- After a certain time Rate of Vapourization = Rate of Condensation. & a dynamic equillibrium achieved b/w liquids & vapour.
- Now at this equillibrium phase, the pressure exerted by vapours of the liquids is known as Vapour Pressure of that liquid.



Factors Affecting Vapour Pressure

- Nature of Liquid
- Temperature
- Intermolecular Forces

- The term Eutectic Mixture is derived from a Greek word Eutektos that means 'Easily Melted'
- When two or more solid components mixed with each other and the melting point of the mixture get decreased compare to the Melting Point of the individual components then this type of mixture is known as Eutectic Mixture.



- Below the eutectic point mixture exist as solid while above it converts into liquids. Example: Thymol - camphor, Menthol - Camphor etc.

FACTORS AFFECTING EUTECTIC MIXTURE

- Ratio of Component
- Presence of Impurity

APPLICATION

- In the selection of Excipients.
- To Prevent the incompatability
- In Drug designing & Drug Delivery.

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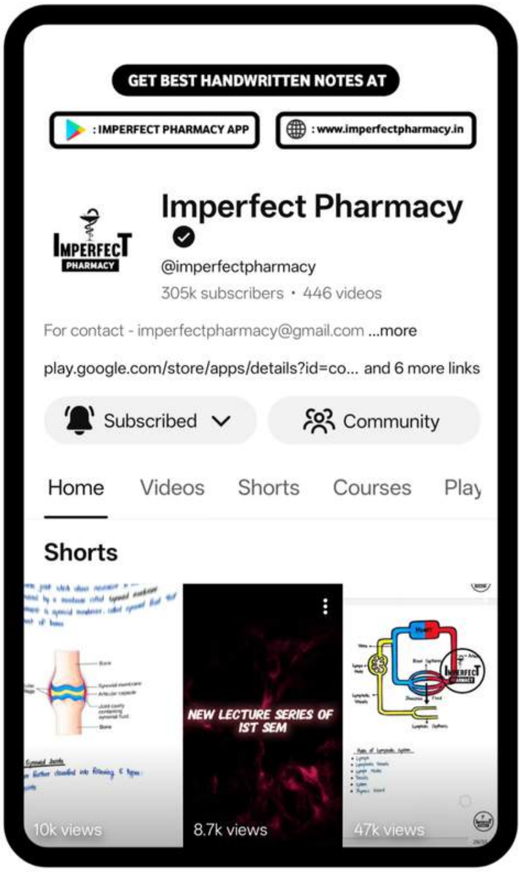

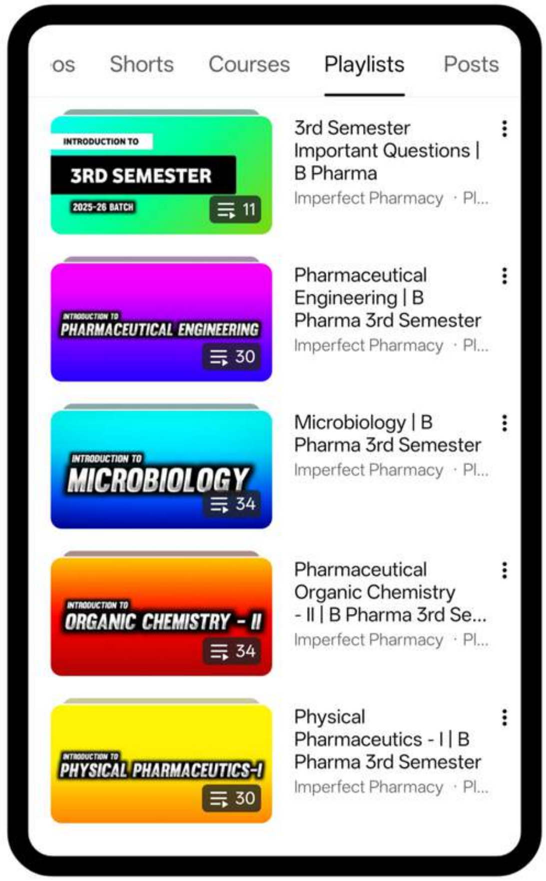

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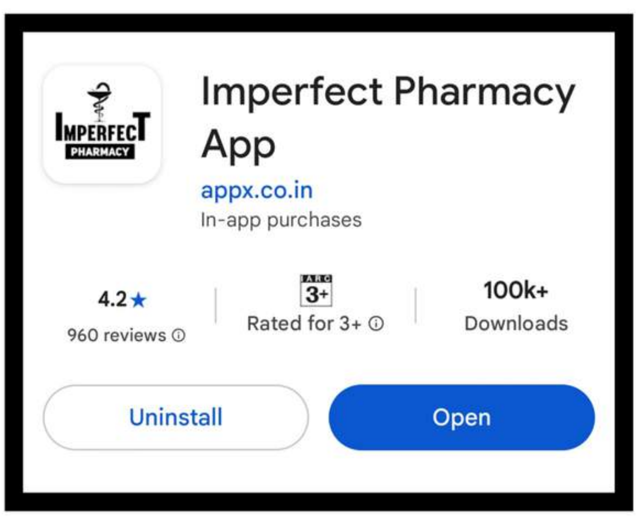


GASES

- Gases are those substances that neither have fixed shape nor fix volume.
- Gaseous molecules posses very weak or neglegible intermolecular forces thus molecules are free to move in all directions.

PARAMETERS OF GAS

There are mainly 4 parameters that infiuences the properties of Gases.

- Volume (V)
- Pressure (P)
- Temperature (T)
- Number of Moles (n)

GAS LAWS

There are various Gas laws that are given to explain the nature of Gas as follows :-

1. Boyle's Law
2. Charle's Law
3. Avogadro's Law
4. Gay Lussac's Law
5. Ideal Gas Law

BOYLE'S LAW

According to boyle's law at constant temperature, Pressure & Volume are inversely proportional to each other.

$$\boxed{V \propto 1/P}$$

CHARLE'S LAW

According to Charle's law, at constant pressure Volume of the gas is directly proportional to Temperature

$$\boxed{V \propto T}$$

AVOGADRO'S LAW

According to avogadro's law, at constant Temperature & Pressure Volume of the gas is directly proportional to no. of moles

$$\boxed{V \propto n}$$

GAY LUSSAC'S LAW

According to Gay Lussac's Law, at constant volume, Pressure of gas is directly proportional to temperature.

$$\boxed{P \propto T}$$

IDEAL GAS LAW

Ideal Gas law is nothing but a combination of all the Gas laws :

$$\boxed{PV = nRT}$$

Here P = Pressure
V = Volume
n = no of Moles
R = Universal Gas Constant
T = Temperature

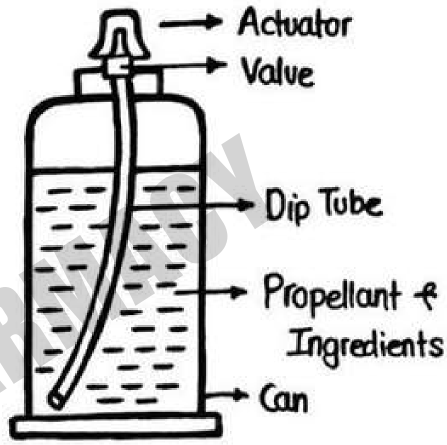
AEROSOL

- The Aerosol is referred to a pressurized package in which drug is dissolved or suspended in a compressed or liquefied gas.
- Aerosol technology is the basis of many pharmaceutical products like Pulmonary Sprays, Muscle Relaxant Spray & Non Pharma products like Deo's, Insectisides, Room Fresheners, Color Sprays.

COMPONENTS OF AEROSOLS

An Aerosol system composed of following components :

- Actuator
- Value
- Dip Tube
- Propellant & Ingredients
- Can



ADVANTAGES

- Direct application of drugs to the affected areas
- Rapid Administration
- Easy to Apply

DISADVANTAGES

- Costly
- Allergic in some cases.
- Difficult disposal of empty containers

INHALERS

- An Inhaler is a medical device used for delivering medications to body directly via lungs.
- It is mainly used in the treatment of Asthama & COPD (Chronic Obstructive Pulmonary Disease)

TYPES OF INHALERS

Inhalers are of generally 3 types
① Metered Dose Inhalers
② Dry Powder Inhalers
③ Soft Mist Inhalers.

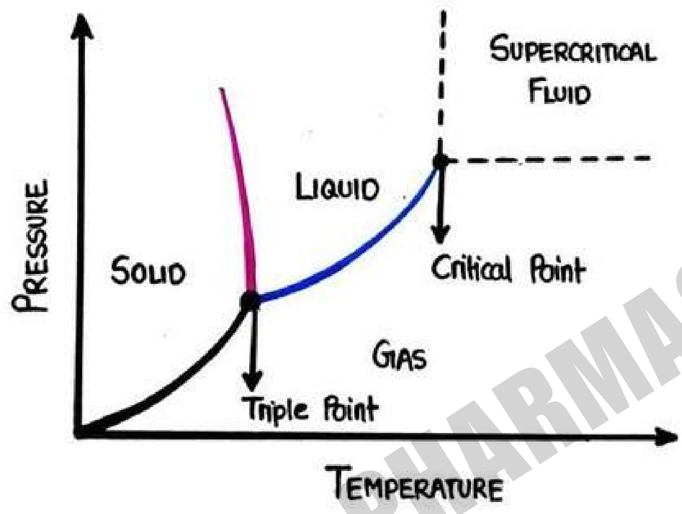
RELATIVE HUMIDITY

- The word Humidity stands for Amount of Water Vapour present in Air.
- Now the Relative Humidity is defined as Amount of water vapour present in air divided by Maximum amount of water vapours that the air can hold at same temperature.

$$\boxed{\text{RELATIVE HUMIDITY} = \frac{\text{Amount of Vapour Present in Air}}{\text{Max. Amount that Air can Hold}} \times 100}$$

SUBLIMATION CRITICAL POINT

- Sublimation is the process in which a solid is directly converted into gas without converting into liquid.
- The term Critical Point refers to a point in the phase diagram above which the substance exists as a Supercritical Fluid, that shows the properties of both gas & liquids.



- Triple Point is that temperature & pressure at which a substance exist in equillibrium in all the three phases i.e., solid, Liquid & Gas.
- The Sublimation Critical Point refers to a point in the phase diagram where a substance undergoes a phase transition from Solid to Gas without passing through liquid phase.
- The sublimation critical point of dry ice is -78.5°C that means Dry Ice sublimates at this temperature.

LIQUID COMPLEXES

- The term Liquid Complexes is also known as Complex Fluid.
- Liquid Complexes are basically the Gases or Liquids that contains particles of other substances dispersed within them.
- These are the binary mixtures that have co-existence between two phases.

TYPES OF LIQUID COMPLEXES

1. Solid- Liquid Complexes (Suspensions)
2. Solid- Gas Complexes (Aerosols)
3. Liquid- Gas Complexes (Foams)
4. Liquid- Liquid Complexes (Emulsions)

PROPERTIES OF LIQUID COMPLEXES

- Inherently Disordered
- Strongly Heterogenous
- Unusual responses towards applied stress/ strain

LIQUID CRYSTALS

- Liquid Crystal is a state of Matter which has properties similar to crystalline solids as well as liquids.
- It is also known as Mesophase or 4^{th} state of Matter.
- It is an intermediate state of Solid & Liquid Phase.

$$\boxed{\text{SOLID} \rightleftharpoons \text{LIQUID CRYSTAL} \rightleftharpoons \text{LIQUID}}$$

CLASSIFICATION OF LIQUID CRYSTALS

On the basis of Orientation & position it is classified into 3 types:

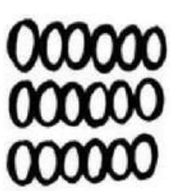
① Nematic Phase
② Smetic Phase
③ Cholestric Phase

NEMATIC PHASE

They possess Orientational Order but don't have Positional Order.

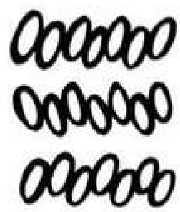
SMECTIC PHASE

They have some positional as well as some Orientational Order.



Cholestric Phase

They have neither positional nor orientational order.



Properties Of Liquid Crystals

- Flowability
- Ordered Arrangement
- They have Surface Tension
- They are Anisotropic in nature

Application Of Liquid Crystals

- Display Making
- Temperature Sensors
- Drug Delivery
- Cosmetic Products like Makeup Remover, Lipsticks etc.

GLASSY STATE

- Glassy State also termed as Super Cooled Liquids.
- They are amorphous in nature.
- Glassy State is generally formed by melting crystalline solids at very high temperature & then by cooling it rapidly.

Characteristics Of Glassy State

- Transparency
- Solid Appearance
- Brittleness
- Random arrangement of molecules.

SOLIDS

- Solid are those substances having a definite shape, size and Volume.
- They possess strong intermolecular forces.
- They are generally incompressible.

TYPES OF SOLIDS

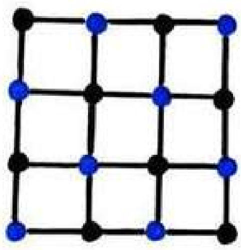
Solids are of generally two types

① Crystalline Solids

② Amorphous Solids

Crystalline Solids

- The solids that features highly ordered arrangements of their particles (atoms, ions & molecules) in microscopic structure are called as Crystalline Solids.
- They are also referred as True Solids.
- Example : Salt, Iron, Gold etc.

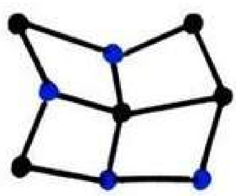


Types Of Crystalline Solids

① Ionic Solids
② Metallic Solids
③ Covalent Solids
④ Molecular Solids

Amorphous Solids

- The solids in which the particles are not arranged in any specific order are known as Amorphous Solids
- They are also reffered as Pseudo Solids or Super Cooled Liquids
- Example : Glass, Rubber, Wax etc.



Difference Between Crystalline & Amorphous Solids

Crystalline	Amorphous
• Regular arrangement of Particles	• Irregular arrangement of Particles.
• Long order arrangement.	• Short order arrangement.
• They are called True Solids	• They are known as Pseudo Solids or Super Cooled Liquids.
• They have Sharp Melting Point	• They have long range of Melting Point.
• They are Anisotropic in nature (Different Physical properties in different directions)	• They are Isotropic in nature. (Same Physical Properties in different directions)
• They are Practically Incompressible	• They are practically Compressible.
• They have less Aqueous solubility	• They have high aqueous solubility.
• They have High Rigidity	• They have less rigidity.
• On cutting with a knife they give sharp & smooth edges	• On cutting with knife they give irregular edges.
• Example : Salt, Iron, Gold	• Example : Glass, Rubber, Wax

POLYMORPHISM

- The word Polymorphism is derived from Greek Word Poly means 'many' and Morph means 'forms'
- When a substance exist in more than 1 crystalline form & each form has different physical properties, then these type of substances are known as Polymorphs.
- And the ability or phenomenon of substances to exist in more than 1 crystalline form is known as Polymorphism.
- Polymorphism is elements is known as 'Allotropy'
- Polymorphs have same chemical but different Physical properties due to different structural arrangement of atoms.
- Example : Carbon, Phosphorus, Sulpher etc.

TYPES OF POLYMORPHS

Polymorphs are of usually two types :

① Enantiotropic
② Monotropic

ENANTIOTROPIC

- Those polymorphs in which one form can be converted into another form at a transition point & can be reversed again are known as Enantiotropic Polymorphs.
- Sulphur exist as Monoclinic & rhombic sulphur & these forms can be interchange into each other at a certain point called Transition Point
- Hence, Sulphur is an example of Enantiotropic Polymorphs.

MONOTROPIC POLYMORPHS

- Polymorphic forms which do not undergo reversible transformation into one another are known as Monotropic Polymorphs.
- Carbon exist in many forms out of which Graphite & Diamond are two forms.
- Diamond can be converted into Graphite at a transition point but Graphite can not be converted back into Diamond even after cooling.
- Hence, Carbon is an example of Monotropic Polymorphs.

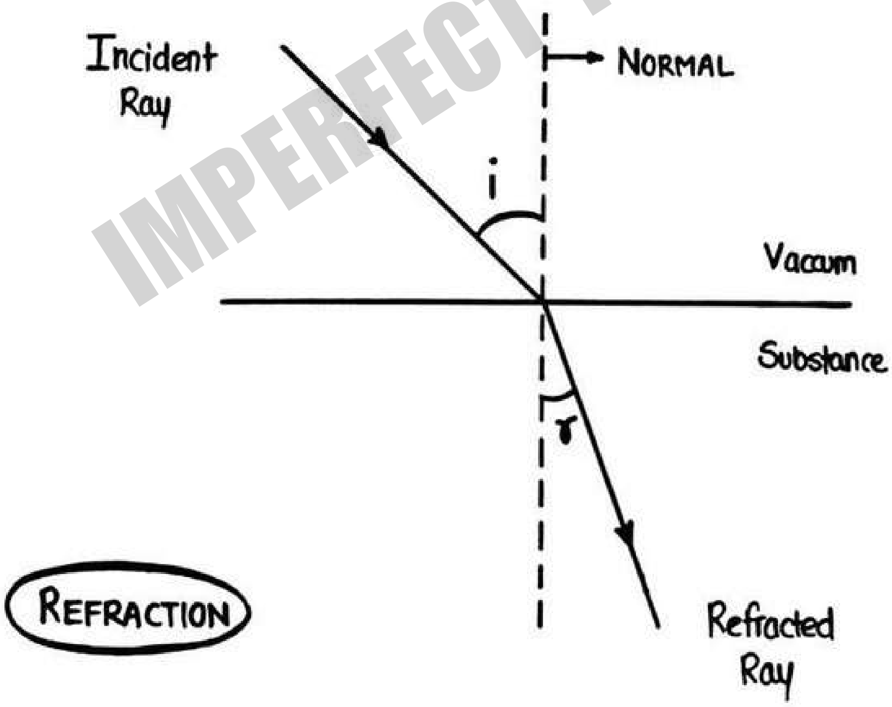
PHYSICOCHEMICAL PROPERTIES OF DRUGS

There are various physicochemical properties of drugs which have been discussed below :

1. Refractive Index
2. Optical Rotation
3. Dielectric Constant
4. Dipole Moment
5. Dissociation Constant

REFRACTIVE INDEX

- Refractive Index is defined as ratio of speed of light in vaccum (or air) to the speed of light in that substance.
- It is denoted by n.
- It can also be defined as Optical Density.



$$n = \frac{\text{Speed Of Light In Vacuum}}{\text{Speed Of Light In Substance}}$$

- Refractive Index is also explained by Snell's Law
- According to Snell's law, Refractive Index is the ratio of sin of angle of incidence (sin i) to the sin of angle of refraction (sin r).

$$n = \frac{\sin i}{\sin r}$$

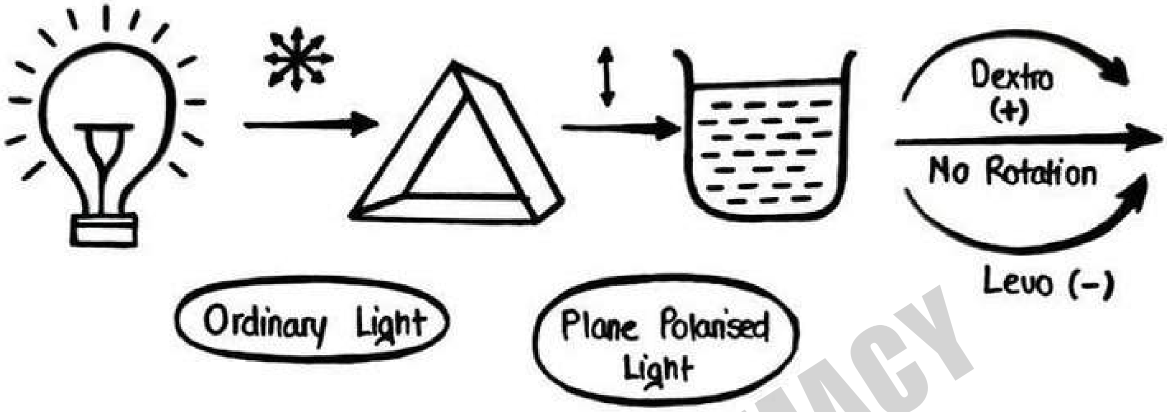
- Refractive Index has no units because it is the ratio of two similar quantities.
- It is usually determined using Abbe's Refractometer.

Application

- It is used for substance identification.
- It is used for measuring purity of substance.
- It is used for determining concentration of a substance.
- It is used for determining Dielectric Constant.

OPTICAL ROTATION

- When a Plane Polarized Light is passed through an Optically Active Substance then it rotates the light in Clockwise or Anti-Clockwise direction and this phenomenon is known as Optical Rotation.



- Now if the compound rotates the light in Clockwise direction, then it is said to be Dextrorotatory (+).
- If the compound rotates the light in Anti clockwise direction, then it is said to be Levorotatory (-).
- And if the light passes undeviatedly, then compound is Optically Inactive.

APPLICATION

- To identify compounds Optical Activity.
- To differentiate between two Optical Isomers.
- To determine the purity of substance.

DIELECTRIC CONSTANT

- Dielectric Constant is defined as the ability of a substance to reduce the force of attraction between charges in a compound.
- In quantitative way it can be defined as ratio between Permittivity of medium to the permittivity of free space.
- It is denoted by ε (Epsilon).

$$\boxed{\varepsilon = \frac{\varepsilon_m}{\varepsilon_0}}$$

- Here ε = Dielectric Constant (Relative Permittivity)
  ε_m = Permittivity of Medium under study
  ε_0 = Permittivity of Free Space.

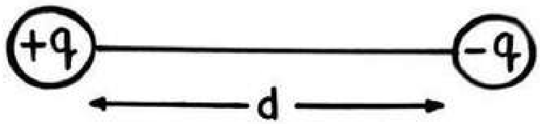
- Dielectric Constant of Water is approx 78·4.

APPLICATION

- It determines polarity of solvent.
- For selection of solvents.
- It also determines dipole moment

Dipole Moment

- The Dipole Moment is defined as product of magnitude of charge (q) and distance (d) between the charges in a polar compound.
- It measures the net polarity of a molecule.
- It is denoted by μ.



$$\boxed{\mu = q \times d}$$

Here μ = Dipole Moment
q = magnitude of charge
d = distance between charges

Application

- To differentiate between Polar & Non Polar Molecules.
- To Predict the degree of Polarity.
- To determine the shape of molecules.

DISSOCIATION CONSTANT

- Dissociation Constant is defined as a Substance's ability or tendency to dissociate into ions.
- It is also known as Ionization Constant.
- It is generally represented by K_a
- Let's say if we determine the dissociation constant for water

$$H_2O \rightleftharpoons H^+ + OH^-$$

DISSOCIATION CONSTANT FOR WATER

Dissociation constant for water can be defined as :

$$\boxed{K_w = \frac{[H^+][OH^-]}{[H_2O]}}$$

- Now If we talk about dissociation constant in case of Acids then it is known as Acid Dissociation Constant denoted by K_a
- And Dissociation Constant in case of base is known as Base Dissociation Constant denoted by K_b.

APPLICATION

- It determines the strength of Acids & Bases.
- It is used to determine the SAR of drugs.
- It is also used in drug discovery & drug development.

THANK YOU

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