States of matter

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States of matter

What is matter?

Matter is anything that has a mass and takes up a space. Matter comes in three different states: solid, liquid and gas.

Gases, liquids, and crystalline solids are the three primary states of matter.

1) Solid:

Properties of solid:

1) Solids don´t change shape unless you use your energy to change it.

2) If you put a solid in a container it won’t change its shape. Solids can be hard, soft, bouncy or even fluffy.

3) Solid particles don´t move around.

. Crystalline solids	Amorphous Solids
They have definite shape and geometrical form.	They do not have geometrical shape.
They have sharp melting point.	They melt over wide range temperature.
They are rigid and incompressible.	They too are rigid and can not compressible.
They give clean clevage.	They give irregular clevage.
They have Definite heat of fusion.	They do not have definite fusion.

Polymorphism:

When a substance exists in more than one crystalline form, the different form are designated as polymorphs and the phenomenon as polymorphism.

Polymorphs have different stabilities and may spontaneously convert from the metastable form at a temperature to the stable form.

carbon: diamond in a cubic (tetrahedral lattice arrangement) • Graphite in sheet of a hexagonal lattice.

2)Liquid:

Properties of Liquid:

1) Liquids take the shape of the container they are in.

2) Liquid particules move around.

Vpor pressure of liquid: When the rate of condensation is equal the rate of vaporization at definite temperature, the vapor pressure become saturated.

Boiling:

If a liquid is placed in an open container and heated until the vapor pressure equals the atmospheric pressure, the vapor will form bubbles that rise rapidly through the liquid and escape into the gaseous state.

The temperature at which the vapor pressure of the liquid equals the external or atmospheric pressure is known as the boiling point.

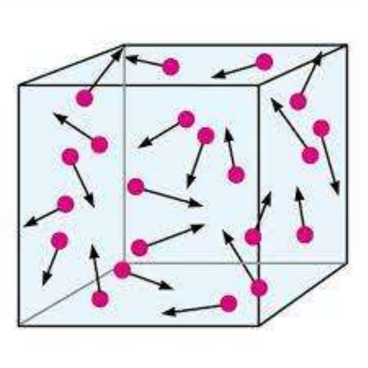
Properties of gases. Gases take the shape of the container they are in.

3) Gases:

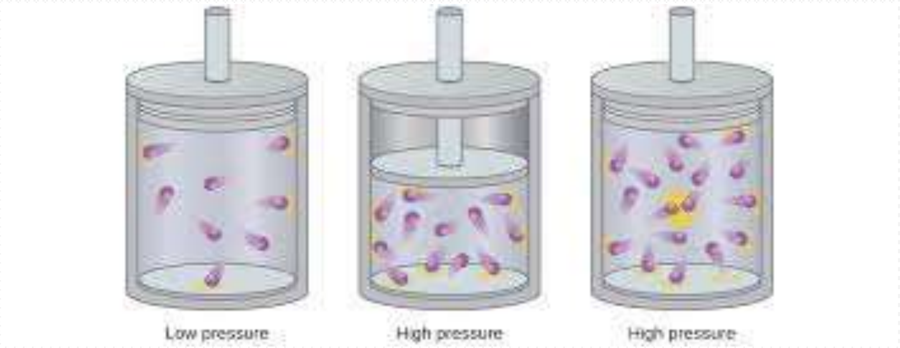
1) Gases have weight.

2) Gases particules move around freely.

1) Ideal Gases



2) Real Gases



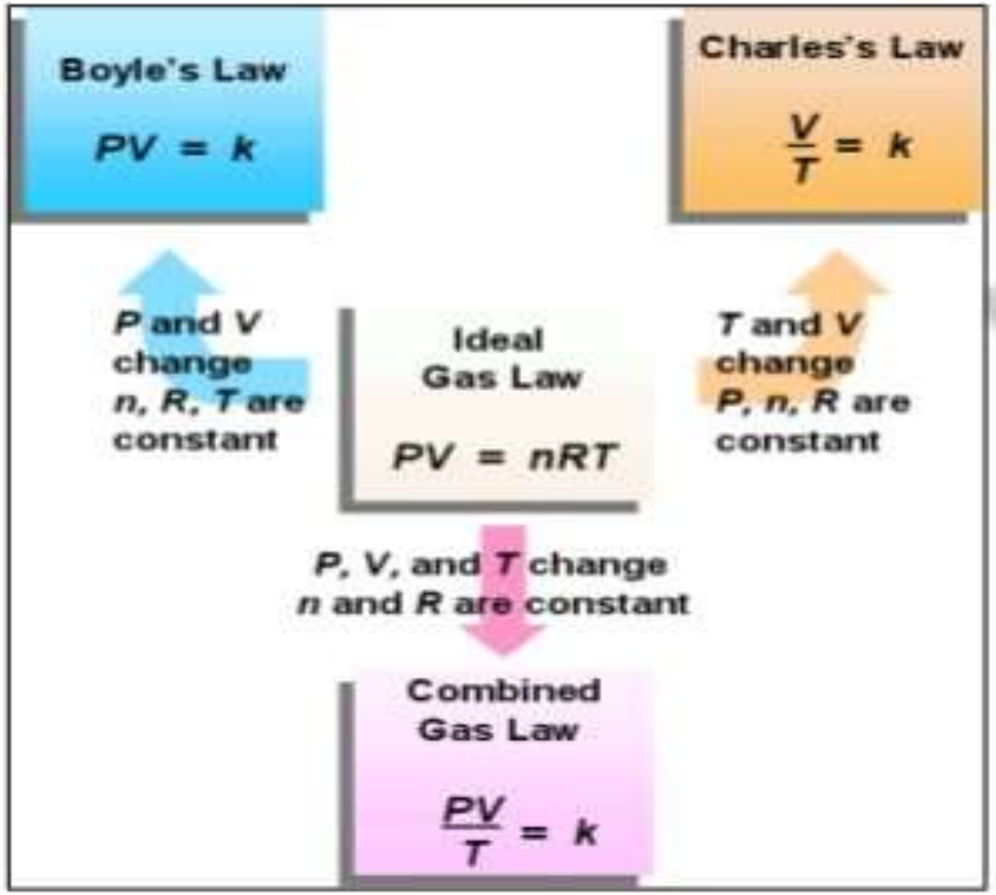
Ideal gas law

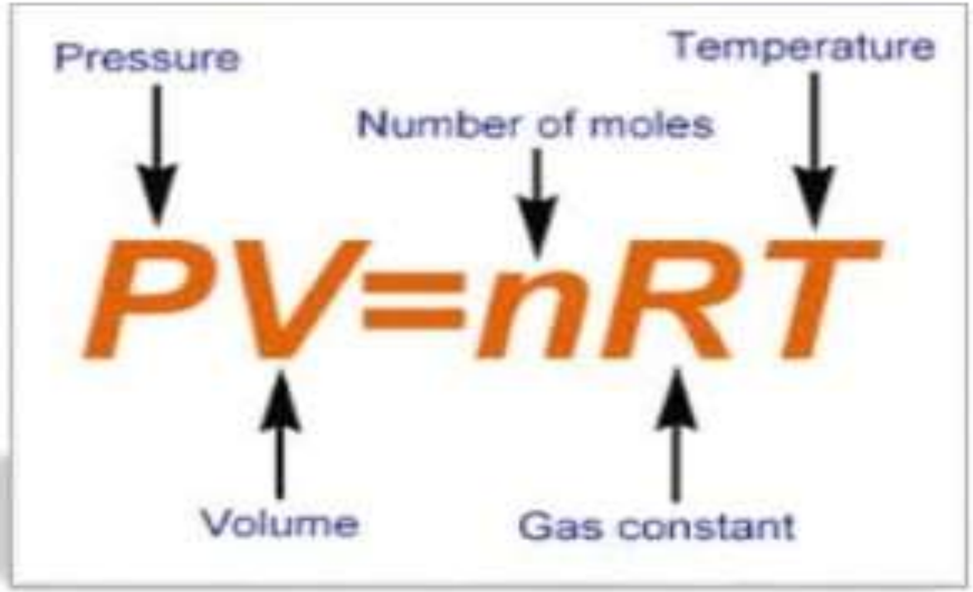
For calculations related to this slide refer to the

Boyle's law: $V \propto \frac{1}{P}$ (constant n, T)

Charles's law: $V \propto T$ (constant n, P)

Avogadro's law: $V \propto n$ (constant P, T)





Molar gas constant: $R = \frac{PV}{T}$

= 0.08205 liter atm/mole K
= 8.314 × 106 erg/mole K
= 1.987 cal/mole deg

The van derWaals Equation for Real Gases

$$\left(P + \frac{an^2}{V^2}\right)(V - nb) = nRT$$

internal pressure per mole resulting from the intermolecular forces of attraction between the molecules

incompressibility of the molecules, that is, the *excluded volume*, which is about four times the molecular volume

Liquefaction of Gases:

- When a gas is cooled, it loses some of its kinetic energy in the form of heat, and the velocity of the molecules decreases.
- Critical temperature: Above which it is impossible to liquefy a gas irrespective of the pressure applied
- Critical pressure: The pressure required to liquefy a gas at its critical temperature which is also the highest vapor pressure that the liquid can have.
- The further a gas is cooled below its critical temperature, the less pressure is required to liquefy it.
- **Aerosols:** Gases can be liquefied under high pressures in a closed chamber as long as the chamber is maintained below the critical temperature.
- When the pressure is reduced, the molecules expand and the liquid reverts to a gas.
- Propellant: material that is liquid under the pressure conditions existing inside the container but that forms a gas under normal atmospheric conditions.
- If the drug is nonvolatile, it forms a fine spray as it leaves the valve orifice; at the same time, the liquid propellant vaporizes off.
- Chlorofluorocarbons and hydrofluorocarbons, nitrogen and carbon dioxide.

Inhalers

An inhaler is a device holding a medicine that you take by breathing in(inhaling).

Inhalers are often used to treat chronic obstructive pulmonary disease (COPD).

There are three types of Inhalers:

1) Metered -dose inhalers

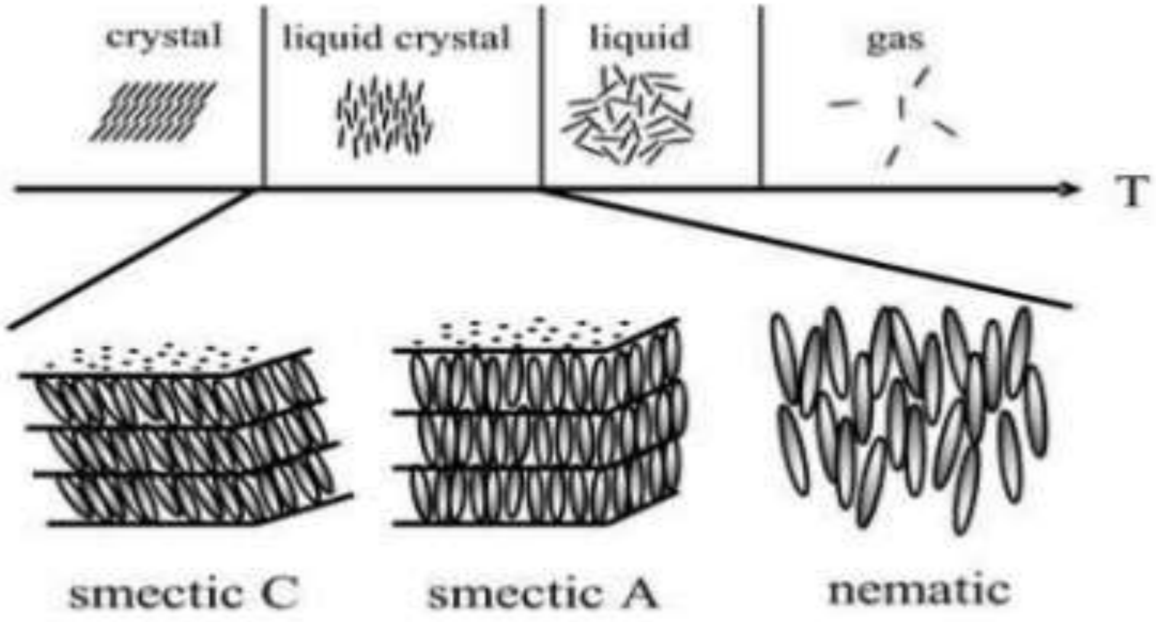
Inhalers

2) Dry powder inhaler

3) Nebulizers

Other Phases of matter

- **The liquid crystalline state: Liquid ⟷ Solid**



Supercritical fluid state

Liquid-Gas Critical temperature and pressure?

High density close to liquids, and low viscosity close to gases

A gas that may have little to no ability to dissolve a compound under ambient conditions can completely dissolve the compound under high pressure in the supercritical range.

They are used for: extraction, crystallization, and preparation of formulations

Advantages of supercritical fluids:

When used as solvents :

The potential for low temperature extractions.

Selectivity of the extracted compounds .

Lower energy requirement and lower viscosity than solvents.

Reduced toxicity and need for hazardous solvents that require expensive disposal .

An example is supercritical CO_2, and the process of decaffeination of coffee.

Changes in the state of matter:

Changes in state Matter also changes when it goes from one state to another. When we heat water, it becomes water vapor. This is gas.

The water has evaporated.

When we freeze water, it becomes ice. This is a solid.

The water has solidified .

When we heat ice, it becomes water. This is a liquid. The ice has melted.

Figure 7.5A Changes of state

Latent heat:

Definition:

The quantity of heat absorbed or released by a substance undergoing a change of state. Also called heat of transformation. In the case of water, 1 gram of ice at 0^oC requires 336 joules of energy to convert it to 1g of water at 0^oC (latent heat of fusion). As matter change from higher kinetic energy to lower one (e.g. stream to water) this latent energy is released. The concept of latent energy has practical applications: Ice milting on the skin takes considerable energy(heat) from the skin, thus cooling it , whereas paraffin wax solidifying on the skin gives out considerable heat to the skin, thus warming it.

TRANSMISION OF HEAT

1) Conduction: if one end of a solid metal is heated, the energy added cause an increase vibration of molecules. This vibration is transmitted to adjacent molecules and in this way heat is conducted along the bar, some materials are good conductors of heat (metal) others are not (wood).
2) Convection: it take place on a liquid or a gas. If one part of the fluid is heated, the kinetic energy of the molecules in that part is increases they move further apart and this part becomes less dens → it rises, displacing the more dense fluid above, which descends to take it's place. the current so produced called convection current.
3) Radiation: heat may be transmitted by infra-red electromagnetic radiation, the heating of certain atoms cause an electron to move a higher electron shell. As it returns to its normal shell, the energy is released as a pulse of infra-red electromagnetic energy.

Vapour pressure

When sample of liquid is introduced into a container, the liquid will tend to evaporate.

The molecules will escape from the relative confinement of the liquid state in the gaseous state.

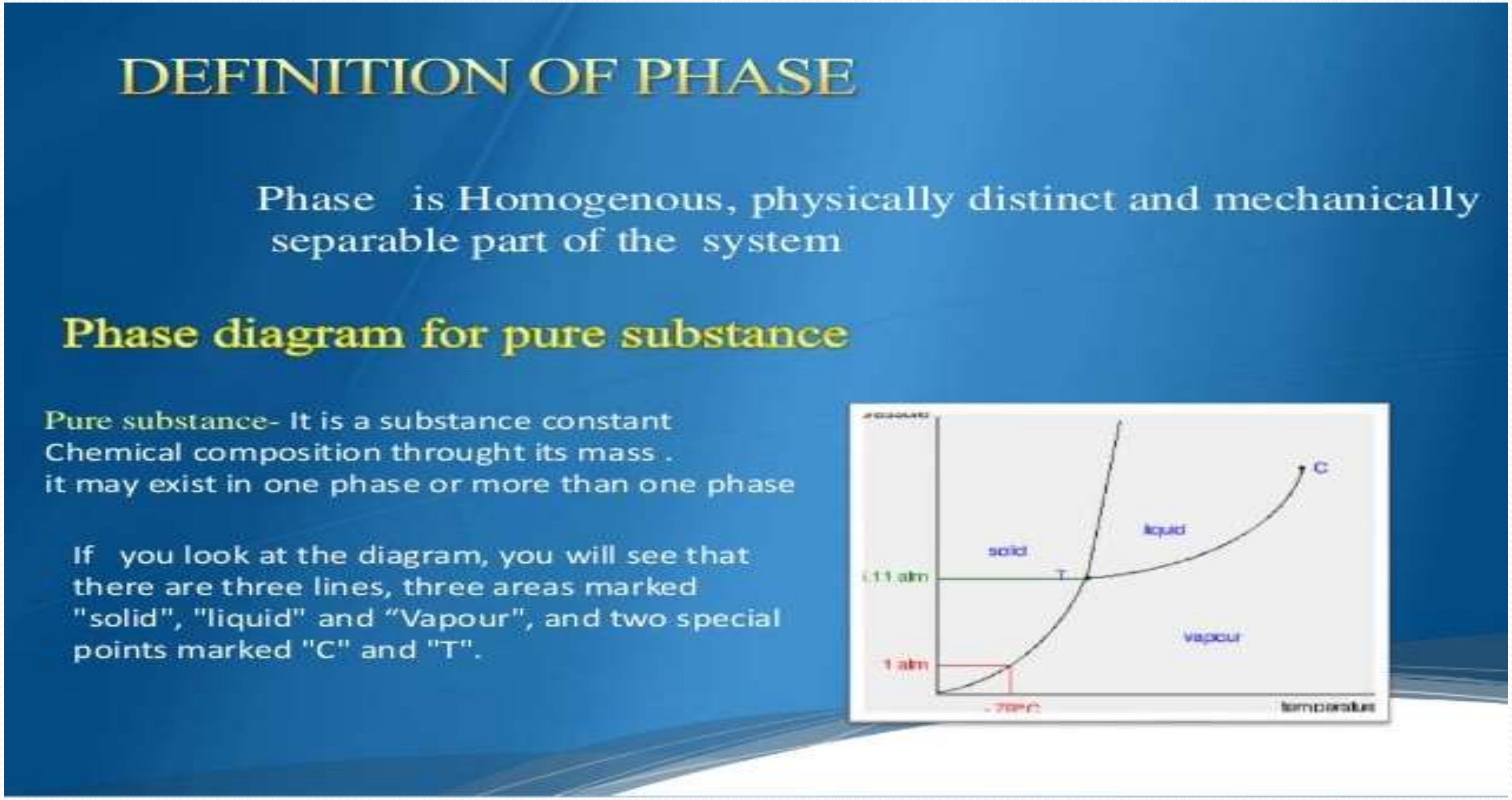
If container is closed, this conversion seems to stop when equilibrium is reached.

Under equilibrium condition, the rate of evaporation is equal to the rate condensation.

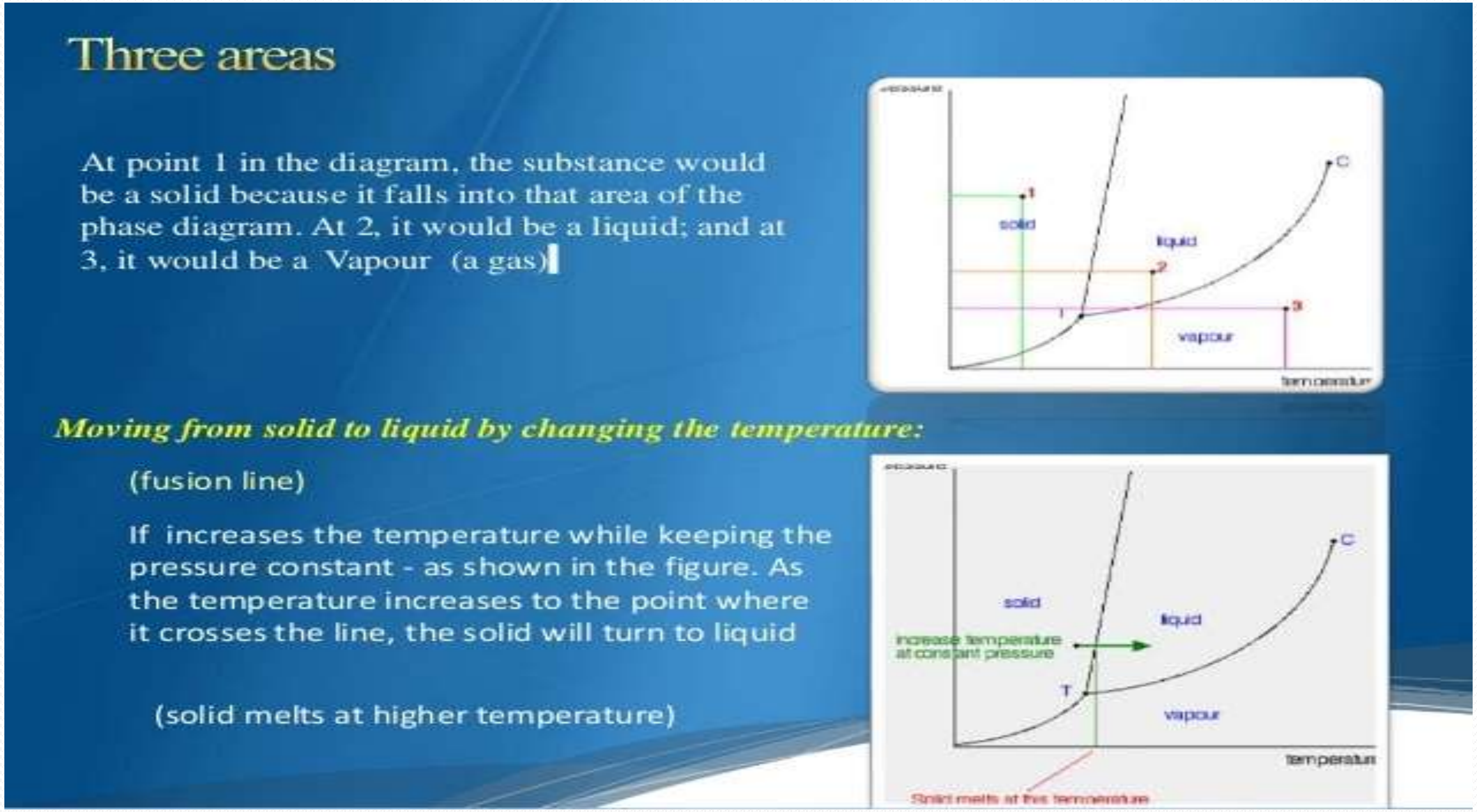
The pressure exerted by the vapours of liquid in equillibrium state with pure at a given temperature is called vapour pressure of the liquid.

The unites for vapour pressure are:mm Hg, atmosphere, bars, pascals, kilopascals etc.

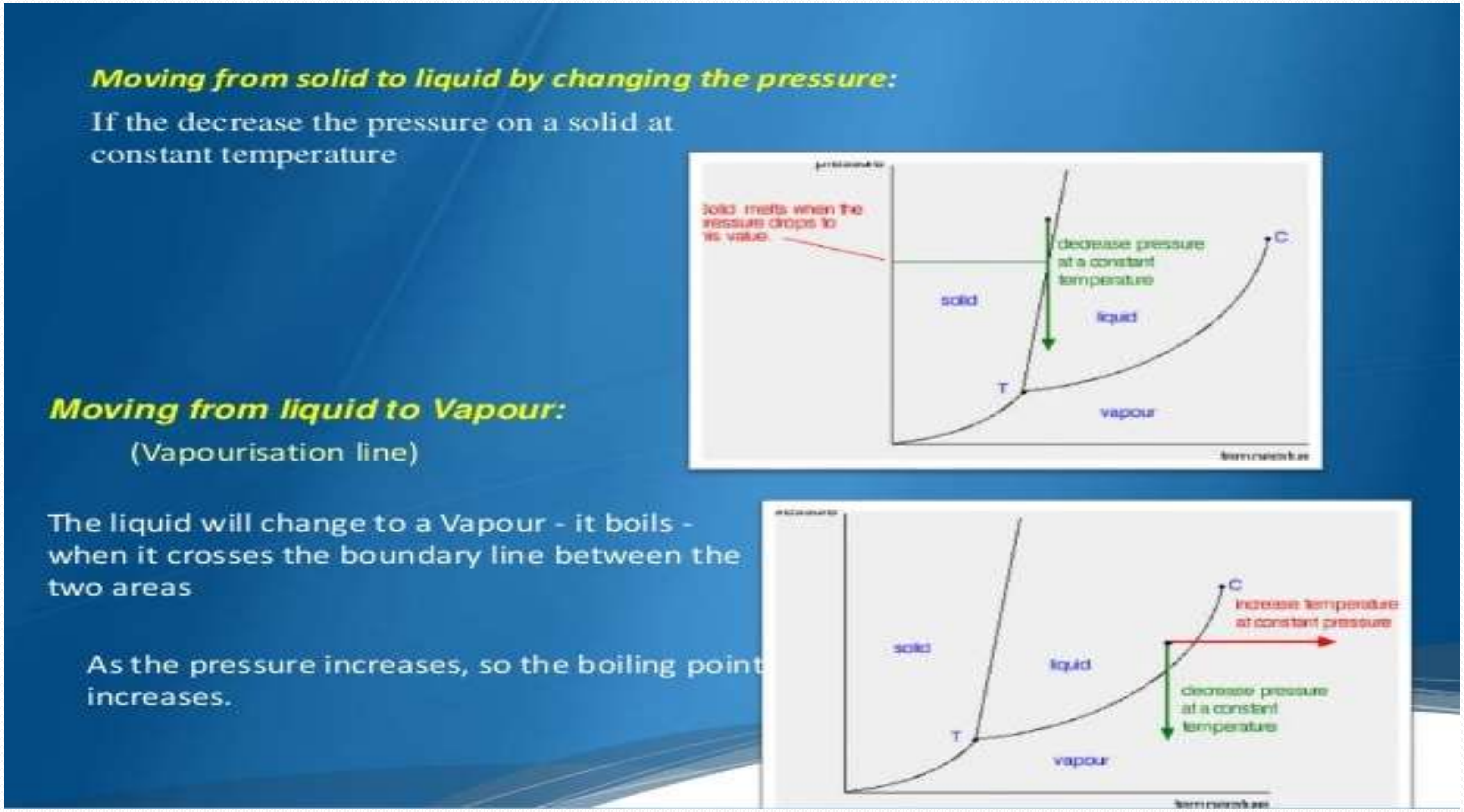
Sublimation critical point



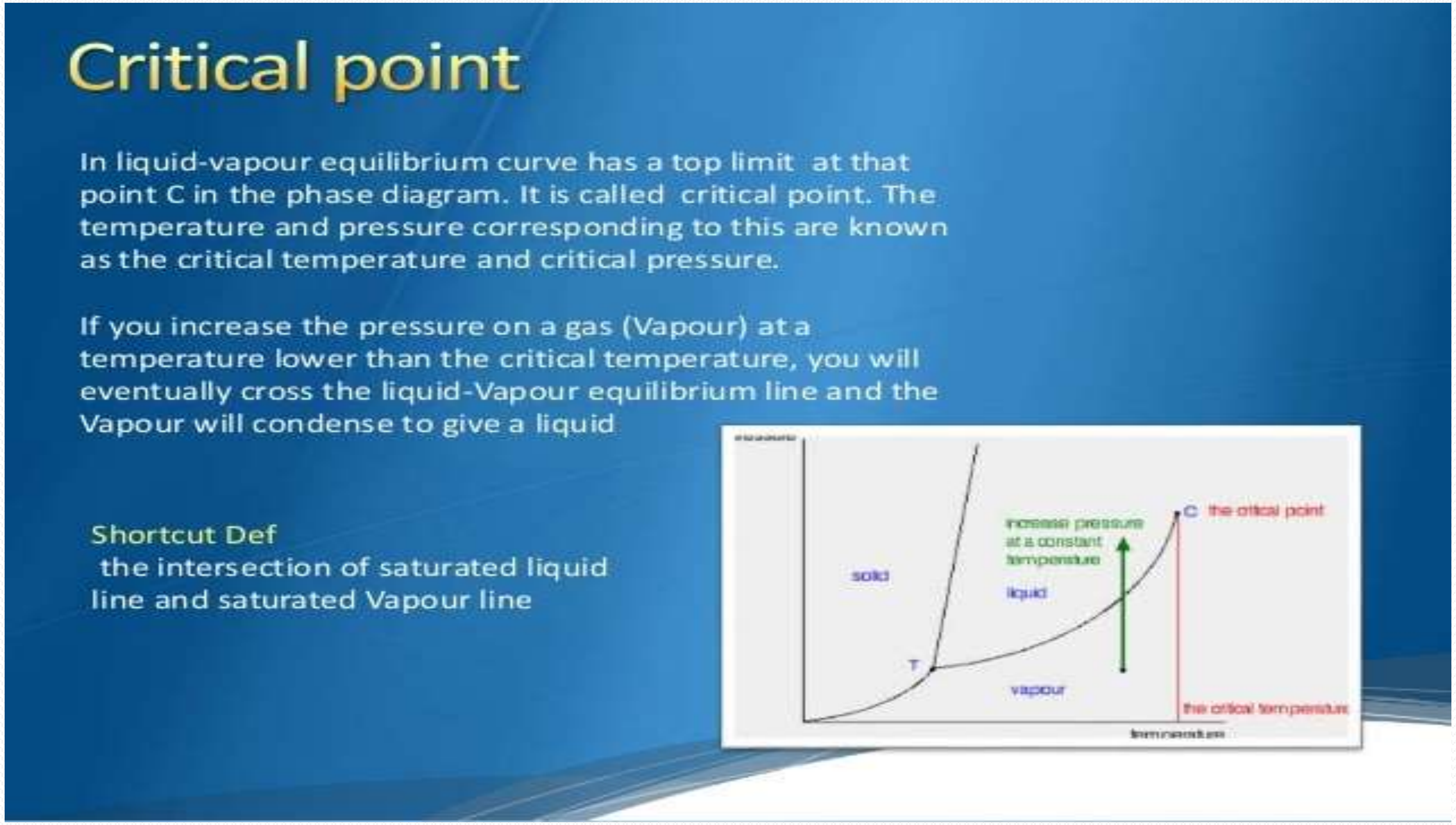
Sublimation critical point



Sublimation critical point



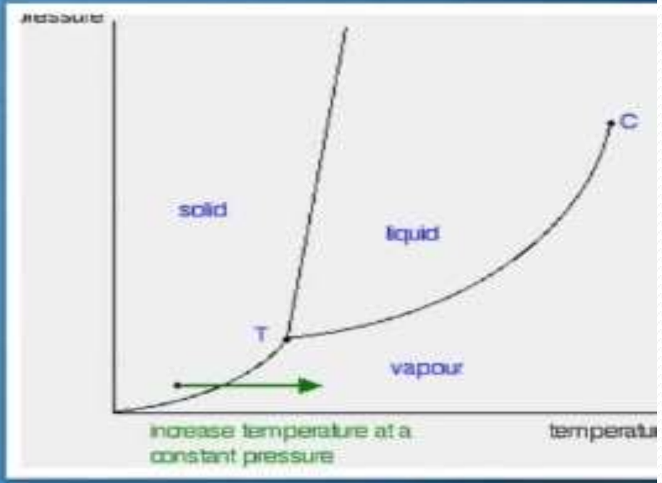
Sublimation critical point



Sublimation critical point

Moving from solid to Vapour (sublimation line)

If the temperature and pressure fell exactly on same line, there would be solid and Vapour in equilibrium with each other - the solid would be subliming. (Sublimation is the change directly from solid to Vapour or vice versa without going through the liquid phase.)



The triple point

At point T on the diagram is called the triple point.

The combination of temperature and pressure where all three phases are in equilibrium together. That's why it is called a triple point.

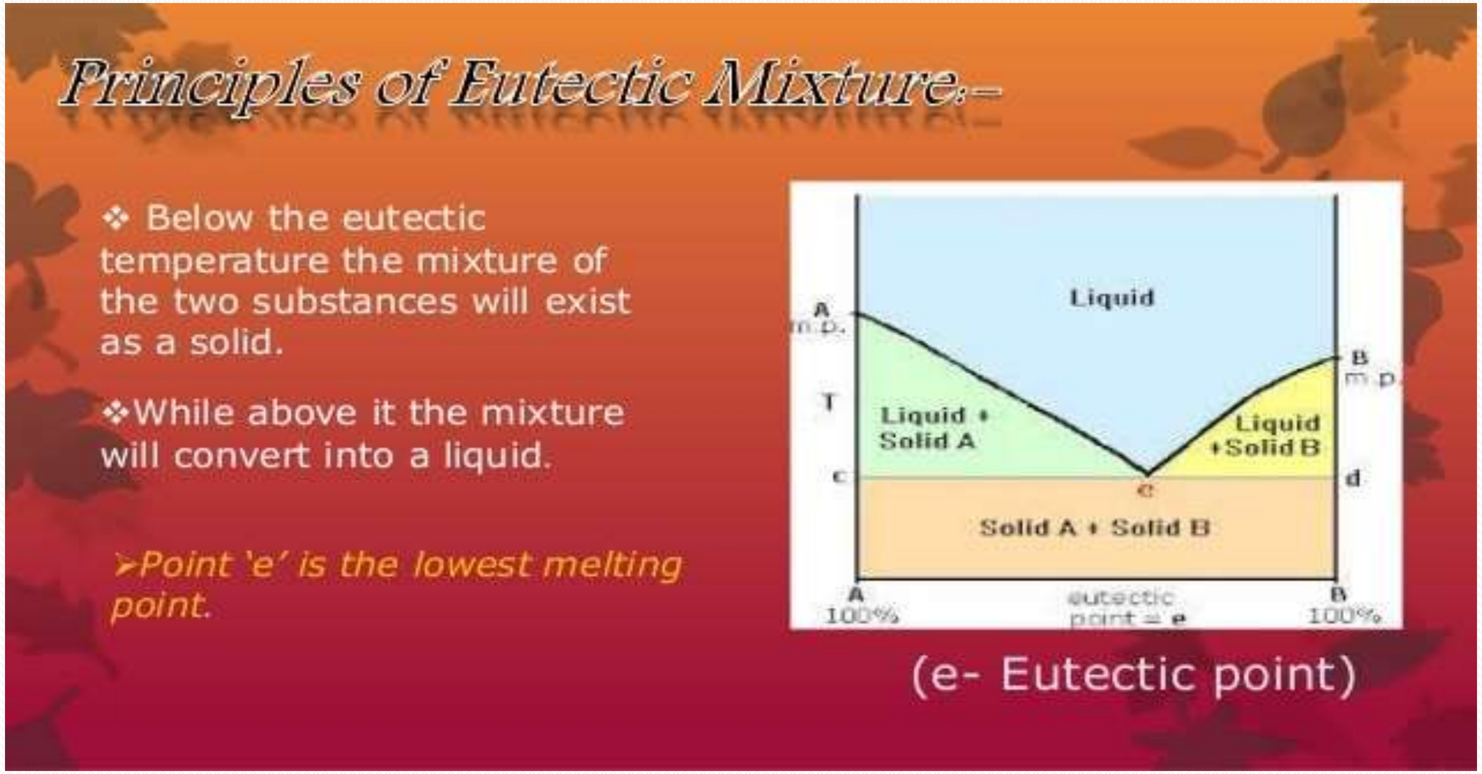
Def-
The intersection of fusion line, Vapourisation line and sublimation line
Is called triple point

Definitions:

1) Sublimation: Sublimation is the process where a solid changes from a solid to a vapor without passing through the liquid state.
2) Triple point: The point at which pressure and temperature at which all three phases are present at equilibrium.
3) Critical temperature: It is the temperature above which the liquid state of a substance no longer exist regardless of pressure.
4) Critical pressure: It is pressure required to bring about liquifaction at the critical temperature.

Eutectic Mixtures

Eutectic mixture is a mixtrure of several component in particular ratio, which melt sharply below the melting point of any indivisual component.



Relative humidity

It is ratio of the airs actual water content to its potential water vapor content at a given temperature.

Relative Humidity= weight of water vapor in air / Weight of potential water vapor in air at saturation

Liquid complexes :

"Complex fluids and soft matter are materials intermediate between conventional liquids and solids, displaying fluid-like as well as solid-like behavior".

OR

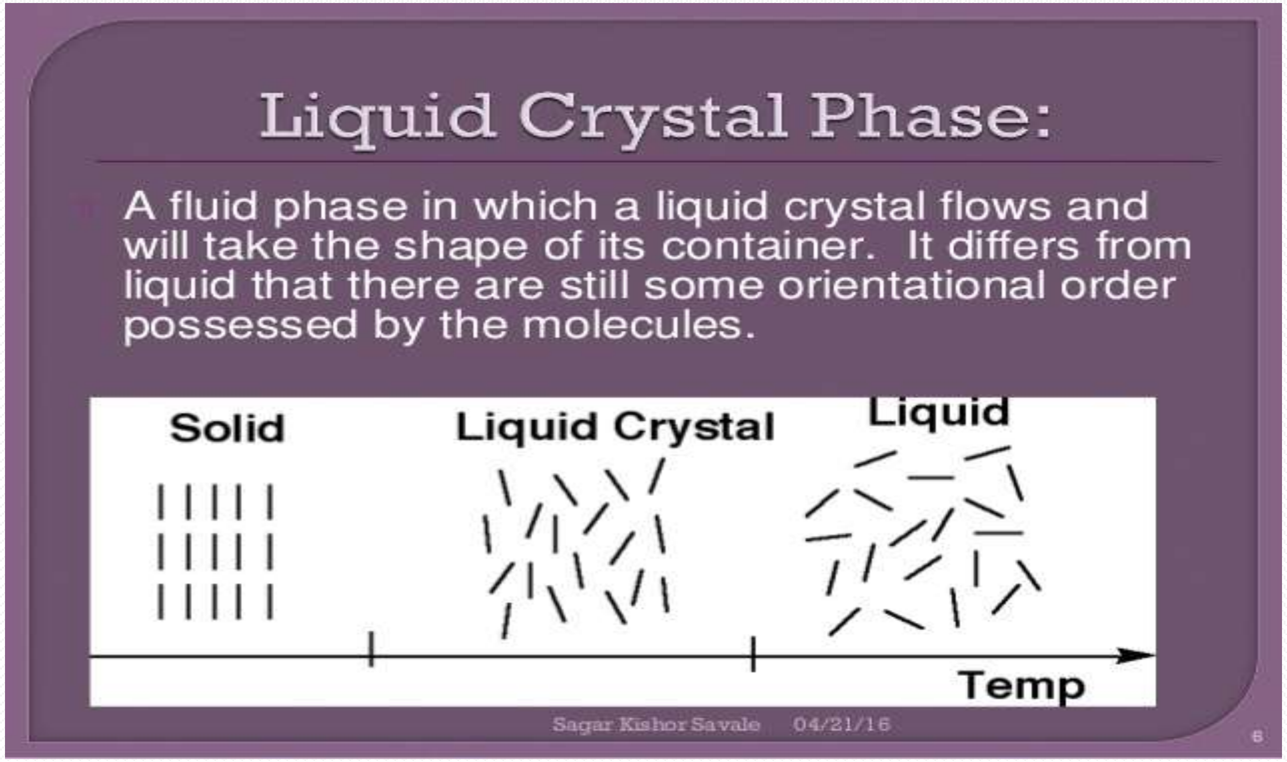
"Complex fluids are binary mixtures that have a coexistance between two phases: solid- liquid (suspensions or solutions of macromolecules such as polymers), solid-gas (granular), liquid- gas (foams) & liquid- liquid (emulsions).

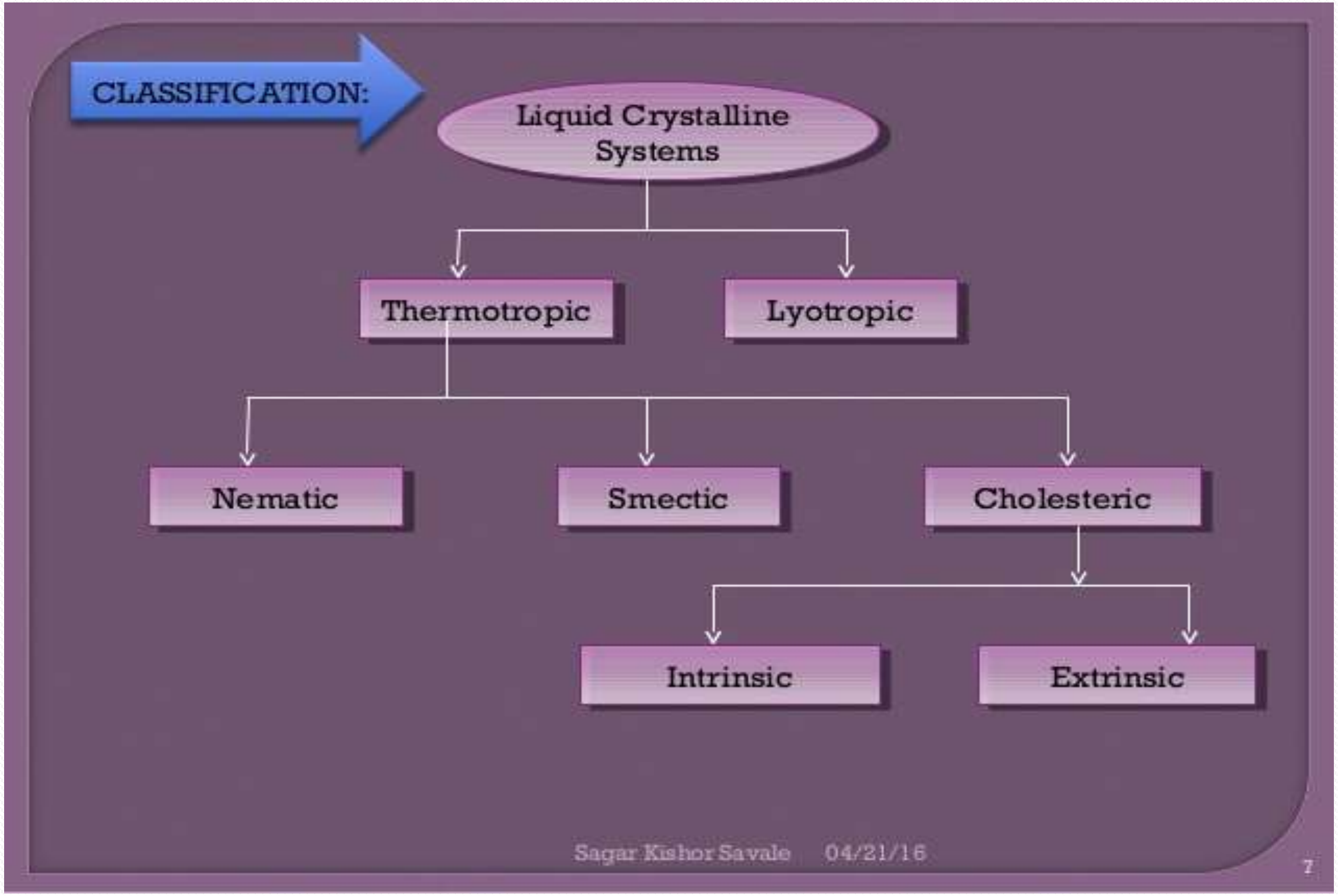
Examples are polymeric melts or solutions, glasses, gels, foams and granular matter.

Liquid crystals

Definition:

Liquid crystals (LCs) are matter in a state that has properties between those of conventional liquid and those of solid crystal. For instance, a liquid crystal may flow like a liquid, but its molecules may be oriented in a crystal-like way.




CLASSIFICATION:
Liquid Crystalline Systems
Thermotropic
Lyotropic
Nematic
Smectic
Cholesteric
Intrinsic
Extrinsic
Sagar Kishor Savale 04/21/16
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Classification:

A) Phase transition depend on temperature. Temp increases, first LCs phase is smectic A &layer like arrangement & rotational motion of molecule. Further increase temp lead to nematic phase , molecule rapidly diffuse out of initial lattice structure & form layer like arrangement . At highest Temp, material become isotropic liquid where motion of molecule changes again.

1) Nematic phase: Long range orientation order but no positional order. Preferred direction is known as director. Phase Structure change in number way e.g.. electric or magnetic field or treatment of surface of sample container.

2) Smectic phase: Occurs at temp below nematic or cholesteric phase.

Not positional order are destroyed when crystal melts to form a smectic LC & these are useful in drug delivery.

Different smectic distinguished on basis of arrangements with varying temp.

3) Cholesteric/chiral nematic LCs : first LC through polarizing microscope is cholesteryl benzoate.eg cholesteric LC at 147° c & isotropic 186° c. It great potential uses following drug delivery, sensors, Thermometer, fashion fabrics that change color with Temp, display devices . In cholesteric phase, there is orientation order & no positional order, but director is in helical order.

Classification:

B) Lyotropic liquid crystals: Phase transition depend on Temp and Conc. When two different substances are mixed together, the mixture can exhibit different phases not only as the temperature is changed, but also as the concentration of one component of the mixture is varied. Example: a molecule that has end groups with different properties (one is hydrophobic and the other is hydrophilic).

Glassy state

All the glass is considered to be a non-conducting transparent solid, it is actually a type of solid matter. It can neither be considered as a typical solid nor a typical liquid. The atoms and molecules in most solids are arranged in an orderly manner whereas in Glassy materials these are highly disorder .Glassy materials however, have some short range order as in the case of polymers. Glassy materials also do not have a specific melting point but these slowly and gradually liquefy on heating. Structurally Glassy materials can be considered to be made up of a random selection of polyhedral molecules linked together at their corners. Certain materials can easily be converted to a Glassy state while other pose great difficulty and certain materials cannot be converted at all. Although the theory behind this behaviour is not very clear, it has been shown that material which can be converted to glassy state have a very high viscosity at their melting point which inhibits the formation of an ordered structure.

Physicochemical properties of drug molecules

A study of physical property of drug molecules is very important for product formulation and it often leads to better understanding of interrelationship between molecular structure and drug action.

Significance

1) Arrangement of an atom in the drug molecules can be obtained.

2) By studying the physical and chemical properties the structure of the drug molecules can be determined.

3) Solubility of a compound can be determined.

4) It gives an idea how a compound can be measures qualitatively and quantitatively.

Classifications

The physical properties can be classified as:

1. Additive property
2. Constitutive property
3. Colligative property

Physicochemical properties of drug molecules

- Additive property: They are derived from the sum of the properties of the individual atoms or the functional groups within the molecules. Example. Molecular weight.
- Constitutive properties: The constitutive property depends on the structural arrangement within the molecules. Example. Optical rotation.
- Colligative properties: The colligative property depends on the number of particles. Example.1.Lowering of volatile point. 2. Elevation of boiling point.3.Depression of freezing point.
- **Refractive index**

The refractive index (n) is one of the physicochemical properties of the substance. The refractive index is dimentionless physical quantity specific to certain medium. It is equal to the velocity of light of given wavelenght in the empty space devided by its velocity in the selected medium.

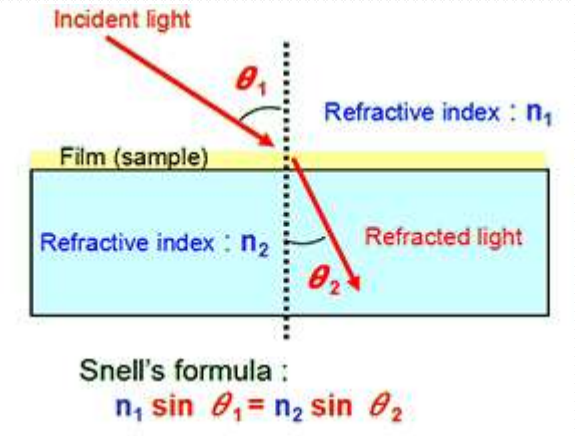
It is expressed as,

$n=c/v$ where, c=velocity of light of a given wavelength in vaccume.

v=velocity of light of a given wavelength in selected medium.

Refractive index

- When the light passes the denser medium, a part of the wave slows down more quickly as it is passes through interface which makes it to bend toward the interface, this phenomena is called as refraction.
- Consider the incident light is in medium one and the refracted light is in medium two if incident light is in vacuum then this value is called the absolute refractive index of medium two.



- **Abbes refractometer**

It is commonly used for the determination of refractive index. Liquids and mixtures of liquids possesses a characteristic refractive index

For example, carbon tetrachloride has a lower refractive index and benzene has a high refractive index. When benzene as added for carbon tetrachloride the refractive index of carbon tetrachloride increases. And the proportion of benzene increasing refractive index also increases linearly.

The principle is used to find the percent composition of benzene in carbon tetrachloride. Refractive index of the unknown mixture can be determined experimentally

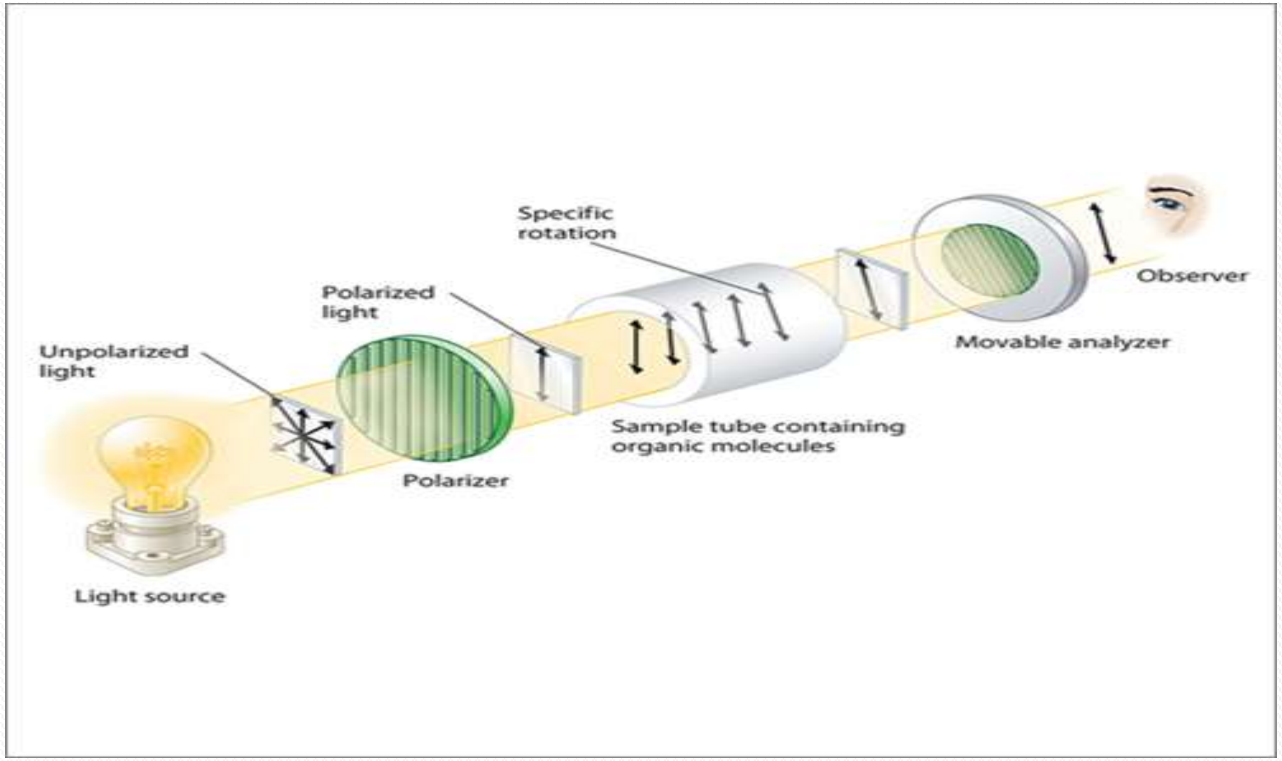
Applications

Refractive index can be used to identify a substance, to measure its purity and to determine the concentration of one substance dissolved in another.

Optical rotation

- Ordinary light consist of different wavelengths which vibrate evenly distributed in all direction in a plane perpendicular to the direction of propagation. This light is called as unpolarised light.
- When the vibration of the light are restricted only to a single plane, the light is said to be polarized light.
- Polarized light from monochromatic light source is called Plane Polarized Light (PPL).
- The substances which rotate the plane of plane polarized light, are called optically active substance and this property of rotation of plane polarized light is called as optical activity .
- The substance which rotates the plane of polarized light to right are called dextro rotatory and those which rotate it to left are called as levorotatory
- Angle through which PPl is rotated is angle of rotation.

Optical rotation



- Specific rotation is the angle of rotation of the plane of polarised light caused by 1 decimeter columns of solution containing 1 gram of the substance per cubic centimeter.
- **Applications**

1) The value of specific rotation can be used to identify the compound

2) Used in sugar industry, chemical industry, food and pharmaceutical industry.

$$[\alpha]_{\lambda}^{t} = \frac{\alpha}{cl}$$

$[\alpha]$ = observed rotation
t = temperature
λ = wavelength of emitted light
α = observed rotation in degrees
c = concentration in g/ml
l = pathlength (length of tube in decimeters)

Dielectric constant

- Dielectric constant: The capacitance of the answer filled with some materials CX divided by the reference standard Co is referred as the dielectric constant (ε) $\varepsilon = C_X / C_o$
- Dielectric constant can be determined by Oscillometry in which the frequency of a signal is kept constant by electrical changing the capacitance between the parallel plates.
- The liquid whose dielectric constant is being measured is placed in glass container between the two plates during the experiment.
- The dielectric constant of solvent mixture can be related to drug solubility Dielectric constant of drug molecules can be related to drug plate's concentration.
- **Application**

1. The ease of solution of salt soluble like water & glycerin bi explain based on high dielectric constant.
2. More polar is the solvent higher the dielectric constant.
3. Dielectric constants are related dipole-dipole interactions and full induced dipole-dipole interaction.
4. Solvents with large dipole moment will have large dielectric constant.
5. As the temperature increases the dielectric constant of dipolar solvent will tend to decrease.

Dipole moment

- **Dipole moment :**An electric dipole is a system of positive and negative charge separated by a finite distance. If positive and negative charges are + Q and -Q are separated by a distance 1 then the dipole moment is given as: μ= QI Debye is the unit of dipole moment=10-18 esu x cm Where esu indicates electrostatic unit of charge
- **Applications**

1. To confirm the structure of the molecule. Examples: a) Benzene and carbon tetrachloride are symmetrical molecules and the dipole moment is zero. b) Water molecule has a dipole moment of 1.85 D. So there is an angle of 108O between the OH bonds of the water molecules. c) Dipole moment of carbon dioxide is zero and this shows that it is a linear molecule. [O=C=O]
2. Dipole moment can be used to distinguish between the cis and trans forms.
3. The insecticidal activity can be measured from dipole moment. Lower the value greater will be lipoidal solubility and greater will be the toxicity.
4. Dipole moment can be used to determine the percentage ion character of a covalent bond.

- **Dissociation constant**

Acid and bases can ionize in water to give their respective conjugate base and conjugate acid. According to law of mass action a ratio of ionized molecule to unionized molecule can be given. This ratio is called as ionization constant or dissociation constant.

For an acid H A + H2O <======>A-- +H3O+

Ka =acidity constant= [A-][H3O+]/ [H A]

For a base B + H2O <==> BH++ OH–

Kb = basicity constant = [OH-](BH+)/[B]

Ionization of water H2O +H2O<====>H3O+ + OH—

Kw= [H3O+] [OH--]/[H2O]

Kw= KbxKa It is also called as ionic product of water.

Applications

Dissociation constant are related to physiological and pharmaceutical activities, solubility, rate of the solution, side of binding (protein binding) and rate absorption of the drug.

Determination of dissociation constant

- There are various methods like conductivity method, visible or UV absorption spectrometer, potentiometer etc.Potentiometeric pH is most widely used
- Dissociation constant of acid
- Ka= [H3O+] [A--]/ [HA]
- When equimolar concentration of salt A- and an acid [HA] are present, the Ka--- dissociation constant is numerically equal to the hydronium ion concentration.
- Ka= [H3O+] when [A-] = [HA]