States of Matter

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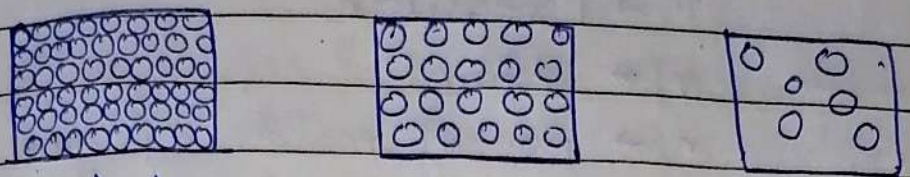
Pharmaceutics is a branch of pharmacy in which we study with the formulation, manufacture, stability and effectiveness of pharmaceutical dosage forms. It is systematic approach to get an effective and stable formulation without disturbing its quality. It deals with technology involve in large scale manufacturing.

Introduction:

Matter are normally exists in the three states i- solid, liquid and gase. However there is no sharp borderline between the various states and in most cases a substance may be made to exists in any of three states. The factor effecting in which matter exist are the intermolecular forces, the temperature and pressure. Solid have strong intermolecular forces and gases have the weakest. When temp. increases solid matter converted to liquid and liquid to gases.

eg. Solid ice liquid water and water vapours.



Solid Liquid Gas.

✱ The Gaseous State

The physical behaviours of gases is independed of chemical nature of the molecules. the molecule in a gas are always in a state of vigorous and rapid motion, these travel are random paths. Collide with one another with the wall of the container. They occupy completely all the space available in the containers.

Ideal and Non-ideal gases:-

The general behaviour of an ideal gas with variations of pressure, volume and temperature can be given by the ideal gas equation.

$$PV = nRT$$

Where,

P → Pressure
V → volume
n → no. of moles of gas
R → Gas constant (0.821)
T → Absolute temp.

The ideal law desived by combining the gas law formulated by Gay Lussac, Boyle's, Charles and Avogadro's.

The ideal gas law is clear that the volumes of a gas is directly proportional to the number of moles of the gas, and absolute temp. is inversely proportional to the pressure.

Non-ideal gas is called Real and actual gases which are not obey the ideal gas law.

Change in the State of Matter.

The molecules, atoms or ions in a solid are strongly held by intermolecular, interatomic or ionic forces respectively. As the temperature of solid substance is raised. The particle acquire

sufficient energy to disrupt the ordered arrangement and pass into the liquid state. On further increasing the temperature, the molecules pass into the ~~gaseous~~ gaseous state. Sometimes, the solid directly converted to the gaseous state. This term is called sublimation.

Latent Heat.

When a change in the state of materials occurs, the temp. usually remains constant but heat is absorbed. This heat will results in the change of matter without increasing the temperature is called latent heat.

When this heat result in the change of state from a solid to a liquid, it is known as the latent heat of fusion.
eg. at 0°c the heat required to change ice to water.

When a liquid change into a vapour form, that latent heat is known as latent heat of vapourisation.
eg:- at 100°c the heat required to change water into vapour.

Vapour Pressure

When temp. applied to a liquid is kept in a closed evacuated container, molecules from its surface continuously leave and keep walking into the free space, this is called vapourisation. Some molecules returns to the surface depending on their conc. in the vapour (condensation). At last a condition of equilibrium gets established when the rate of escape of molecule become equal to the rate of return. The vapour is then said to be saturated and the pressure exerted by the vapour at equilibrium is called the vapour pressure.

The vapour pressure of a liquid depends on the temp. and not on the amount of liquid or vapour as long as both liquid and vapour are present and equilibrium maintained. At the temp. raised, more of the liquid goes into the vapour state and the vapour pressure increase. The density of vapour increase and then liquid density decrease.

The temp. at which this happens is called critical temp. and above this temp. there is no. liquid phase.

Relative Humidity.

Relative humidity may be defined as the ratio of amount of water vapour in air at a specific temp. to the maximum amount that the air could hold at that temp. expressed as a percentage.

$$\text{Relative humidity} = \frac{\text{actual water vapour pressure}}{\text{securated water vapour pressure.}} \times 100\%$$

The amount of water vapour in the air can hold increases with temperature.

★ Eutectic Mixture.

Certain substances such as menthol, thymol, phenol, camphor, sol etc. when mixed in a particular proportion tend to liquify due to reaction in their respective melting points. Mixture of such substances are k/a Eutectic mixture.

The mixture of substance that melts or solidifies at a single temperature that is lower than the melting point of either of the constituents.

Principle

We considered two substances A and B, the point A and B represent the melting point of two components. As increasing quantities of B are added to A, and ~~rice~~ vice-versa. The freezing point A fall as curve ~~A C B~~ AC and B fall as curve BC at the particular composition C, known as Eutectic point.

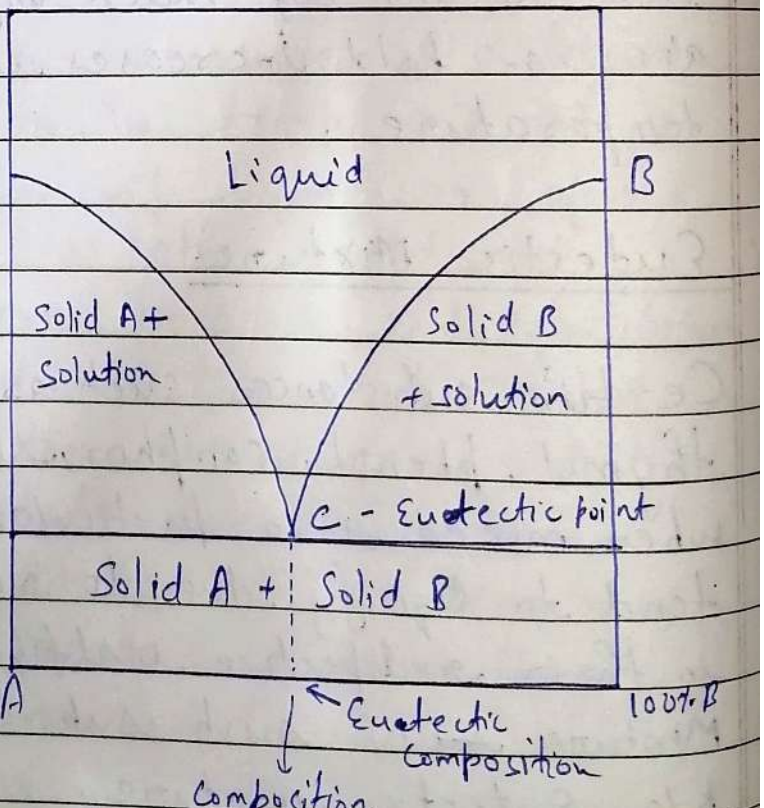


Fig:- Phase diagram of Eutectic system.

The mixture of the two substances has the lowest melting point. This composition of the two substance is k/a. Eutectic mixture.

The phenomenon of Eutectic formation has been used in pharmaceutical practice to improve the dissolution behaviour of certain drugs.

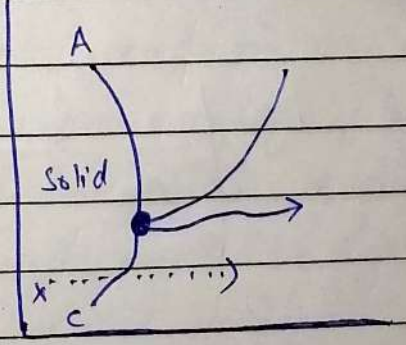
eg:- Aspirin - acetaminiphen (37% and 63%)
Urea - acetaminophen (46% and 54%) and
griseofulvin - succine (55% and 45%)

✱ Sublimation

It is defined as the process of transformation of solid directly into the vapour phase without passing the intermediate liquid phase.

eg. Camphor, menthol, napthalene, ice is also.

Principle:-



The curve AD represents the melting point of the solid phase of the substance at different pressure. Along ~~long~~ the curve AO, the solid exists in equilibrium with its liquid phase. The BO represents the liquid exist form and liquid exists in equilibrium with its vapour.

The curve CO represents the vapour pressure of the solid at various temp. and k/a sublimation curve. There is exist one point (O) where all the three phases of the materials are in equillibrium with each other and this is k/a Triple point.

The point x below the table point where substance is present in the form of a solid, if heat is applied to the substance at the point it will pass directly in the vapour phase without passing through the liquid state. This process is called sublimation.

✱ Aerosols :-

Liquification of gas can be achieved by applying pressure on it and keeping the temperature below the critical temperature. When the pressure is reduced, the molecule expand and the liquid reverts back to the ~~glass~~ gaseous state. Aerosols are based on this principle of reversible change of state on the application and release of pressure.

In pharmaceutical aerosols, drug is classified or suspended in a propellent, a material which exists as a ~~solid~~ liquid under the pressure conditions inside the container but gets converted to a gas under normal atmospheric conditions. The container is designed in such a manner that on depressing a valve, some of the drug-propallent mixture is expelled out due to the excess pressure inside the container. The propallent used ~~on~~ on such products are generally fluorinated Hydrocarbons. Although gases such as Nitrogen and carbon dioxide also used.

The Aerosol containers are filled either by cooling the propellant and dry to a low temp. within the container which is then sealed with the valve. The drug is sealed in the container at Room temp. and the required quality of propellant is forced into the container under pressure.

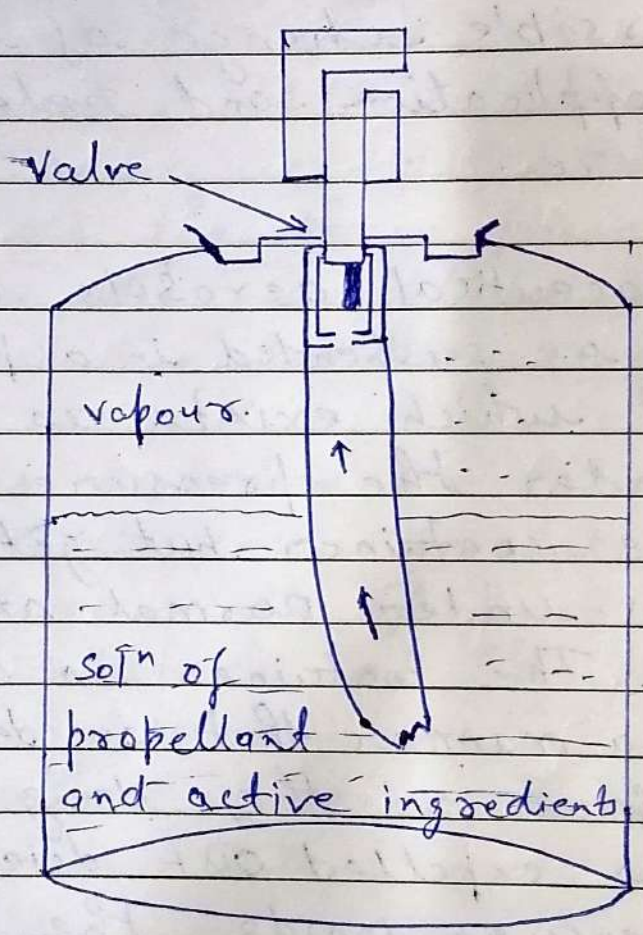


Fig :- An Aerosol System

The Solid State

Solid have the stoongest intermolecular forces. Their ~~stuu~~ structure may be crystalline and lattice-like or non-crystalline such as glass which are not lattice like structure. The molecules of a solid are held together by stoong bonds which impart a high melting point to these substances.

Crystalline solids:-

crystalline solids generally exhibit a definite shape and an orderly arrangement of units, it arranged in fixed geometric patterns or lattice. The crystalline solids have been divided into seven distinct forms including cubic form (eg- NaCl), tetragonal form (eg.- Urea), hexagonal form (eg.- iodoform), orthorhombic form (eg- iodine), monoclinic form (eg.- sucrose), Trigonal form (eg.- calamine) and triclinic form (eg- boric acid).

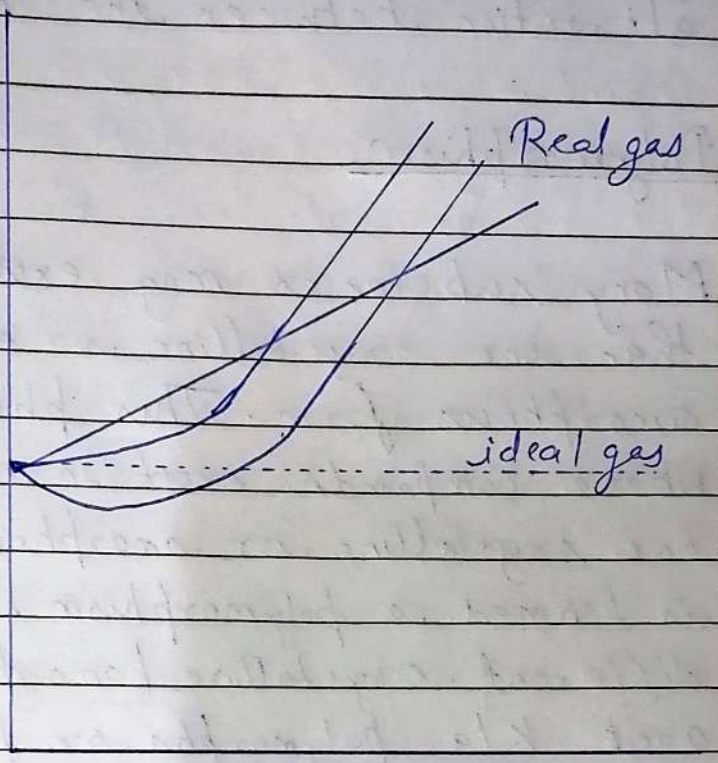
☆ The Liquid State.

The liquid state may be intermodiate state as matter. Liquid can be considered as highly compressed gases or slightly released solids. The molecules of gas are in a state of rotation owing to their kinetic energy which is proportional to the absolute temp. of the gas.

When gas is cooled, its reduced their kinetic energy gradually. As the temp. reduced, a stage is reduced where the molecules almost loose their kinetic energy. As a result, the gas molecules come closer and ultimately the gas gets converted into the liquid state. Liquefication of gas can also by increasing the pressure on the gas, but pressure is effective only, below a certain temp.

Those certain temp. which are gas converted to the liquid states is called critical temp. The critical pressure is the pressure required to liquify a gas at its critical temp. The critical temp. of water is 374°C or 647°K and its critical pressure is 218 atmosphere.

Departure of real gases from ideality can be demonstrated by means of plots such as that shown in figure.



- PV/RT is a function of pressure for 1 mole of each gas.

A better approximation to the real behaviour may be obtained by the using of vander waals equation.

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

Where,
a and b are constants for a particular gas. $\frac{a}{v^2}$ accounts for the internal pressure per mole resulting from the intermolecule force of attraction between the molecules.

☆ Polymorphism.

Many substances may exist in more than one crystalline or ~~amorph~~ amorphous form. This phenomenon where compounds exist in more than one crystalline or amorphous forms is termed a polymorphism and the different crystalline / amorphous forms are K/a polymorphs or polymorphic forms.

Different polymorphic forms of substance usually exhibit different melting points, x-ray diffraction pattern, solubilities, dissolution behaviour, stability and biological activity. A number of pharmacologically active substances such as chloramphenicol, furosemide, sulphonamide, barbiturates, testosterone, Prednisolone, (steroids) etc. have been show to exhibit a number of polymorphic forms differing their solubility, stability and pharmacological

activity. The most stable polymorph. Polymorphism can affect the mechanical properties of drug particles and can therefore affect the ~~manufacturing~~ manufacturability and physical attributes of dosage forms like, tablet.

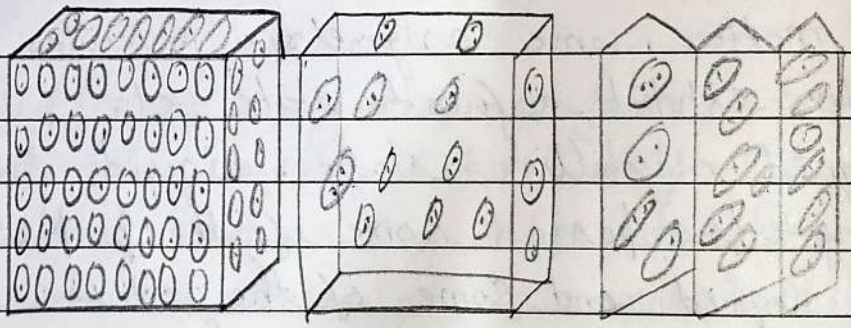
For example: Different polymorphic forms of drug like paracetamol, carbamazepine, phenylbutazone etc. have exhibited different mechanical properties such as compressibility, flowability, hardness, bonding strength etc.

★ Liquid Crystal

In addition to the three states of matter, some assymetric molecules often exhibit a fourth state kla liquid crystalline state. Liquid crystals posses some of the properties of liquid and some of the solids. eg - liquid crystals posses the property of mobility and rotation and can be considered to have the flow properties of liquids. On the other hand, These also posses the property of birefringence, A property associated with solid crystals. In birefringence,

the light passing through a material is divided into two ~~components~~. components with different velocities and different refractive index.

The two main types of structure of liquid crystals are smectic (soap or grease like) and Nematic (thread like). In Smectic state, the molecules are mobile in two directions and show rotation about one axis. In the nematic state, the molecules are mobile in three dimensions. A third type are kla the cholestric crystals exist but may be considered as a special case of the nanematic type.



Smectic Nematic Cholestric

Fig: Liquid crystalline phase

The liquid crystalline state is found widespread in nature in nerve, brain tissue and blood vessels. Atherosclerosis is throughout to result from the deposition of lipid in the liquid crystalline state on the walls of blood vessels. The three components of bile, the cholesterol, the bile salts and water, when present in a definite proportion can result in formation of Smectic crystals and ~~three~~ these may be involved in the formation of gall stones.

Q. Define boiling point, melting point and freezing point.

⇒ When a liquid is heated in a open atmosphere the vapour pressure is increased. On further heating its vapour pressure ~~becomes~~ becomes equal to the atmospheric, the temperature at which the vapour pressure of a liquid equal to the atmospheric is known as boiling point.

Melting point:

The temperature at which a solid passes into a liquid state under atmospheric pressure is known

as its melting point.

Freezing Point:-

The melting point is referred to as freezing point if the liquid passes into the solid state.