STATES OF MATTER

THE LIQUID STATE

In a liquid the molecules are contact with each other and forces of attraction between molecules are strong.The molecules of a liquid are in randomness.

Most of the physical properties of liquids like vapour pressure, surface tension, viscosity ect.are influenced by the strength of attractive forces.

VAPOUR PRESSURE:-

1. Evaporation is the process of converting molecules of liquid to the vapour state. It is a surface phenomenon.
2. The kinetic energy of molecules of a liquid depends upon temperature. Rapid evaporation causes cooling due to escape of molecules having higher kinetic energy.
3. In an open vessel the liquid keeps on evaporating. The process of evaporation continues till the liquid disappears.
4. The number of molecules escaping from the liquid surface in unit time is known as rate of evaporation. The rate of evaporation depends on :
   a) nature of liquid,
   b) surface area of the liquid,
   c) temperature and
   d) flow of air current over the liquid surface.
5. In a closed vessel, with some free space above the liquid, the evaporated molecules can not escape to the atmosphere. The molecules of the vapour colloids with other molecules, with the walls of the container and the surface of the liquid. Some of these molecules having lesser kinetic energy are converted back into the liquid state,which is called condensation. Number of molecules condensing on the liquid surface in unit time is known as rate of condensation.

6. At a given temperature both evaporation and condensation process take place simultaneously. After certain time, the rate of evaporation is equal to rate of condensation. This state is called equilibrium state of liquid and vapour.

7. The pressure exerted by vapour molecules of a liquid in equilibrium, on the surface of the liquid at a given temperature is called vapour pressure of the liquid.

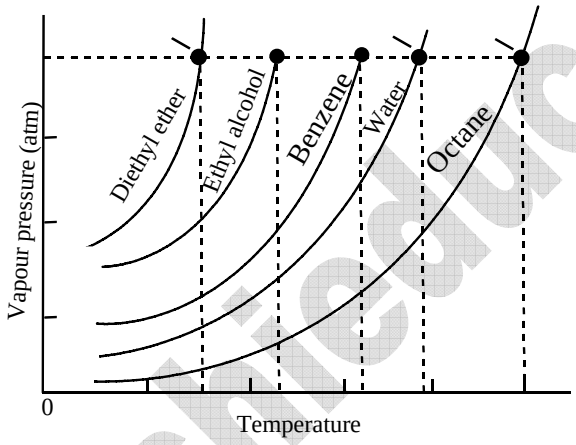
8. Vapour pressure of a liquid depends upon :

   a) nature of liquid b) temperature and c)purity of the liquid

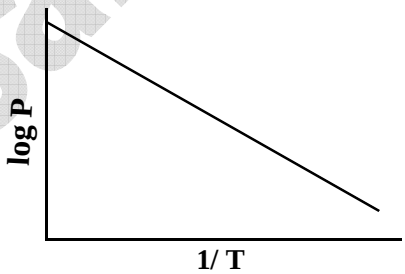
9. Vapour pressure of a pure liquid at a given temperature is independent on the quantity of liquid, the shape of the vessel and the surface area of the liquid.

10. When the temperature of a pure liquid is raised the average kinetic energy of the molecules increases. Therefore the rate of evaporation increases. As a result the vapour pressure increases.

11. with increase in temperature, vapour pressure of a liquid increases exponentially but not linearly,



The graph drawn between log p on Y-axis and 1/T on X-axis is known as ClausiusClapeyron curve.



12. The temperature at which the vapour pressure of the liquid becomes equal to the atmospheric pressure is called normal boiling point of the liquid.

13. The temperature at which the vapour pressure of the liquid becomes equal to one bar pressure is called standard boiling point of the liquid.

14. The temperature of the boiling liquid remains constant until all the liquid has been vaporised. Evaporation occurs spontaneously at all temperatures, but boiling occurs at the boiling point only. The boiling point of a liquid changes with the change in external pressure. Moving higher altitudes pressure decreases .Thus water boils at low temperature on hills

16. Liquids with very weak intermolecular forces of attraction have high rates of evaporation, high vapour pressures and lower boiling points. They are called volatile liquids.

17. liquids with relatively stronger intermolecular forces have lower vapour pressures and higher boiling points. They are called non-volatile liquids. Diethyl ether is a typical volatile liquid and mercury is a non-volatile liquid.

18. In a closed vessel a liquid on heating doesn't boil but the vapour pressure increases. As the temperature increases the density of the liquid decreases and that of vapour increases, and very soon the boundary between the liquid and the vapour disappears at critical temperature.

19. vapour pressure of a pure liquid decrease when a non-volatile solute is dissolved in it.

Surface tension

1. Surface tension is one of the characteristic properties of liquids. A molecule in the bulk of liquid experiences equal attractive forces from all sides.

2. There is no resultant force on the molecule which tries to move it in any direction. Where as for a molecule at the surface of the liquid, the net attraction towards the liquid is greater than that towards the vapour state.

3. If the surface area of the liquid is increased, then molecules from the body of liquid state have to be brought to surface of the liquid requiring work to increase the surface area.

4. The energy required to increase the surface area of the liquid by one unit, is defined as its surface tension. Surface tension is also defined as the force acting per unit length perpendicular to the line drawn on the surface. It has the dimensions of

   kg s^{-2} and its unit is expressed as N m^{-1} in the SI unit. It can also be expressed in terms of surface energy per unit area, as J m^{-2}.

5. The liquid surface, in the absence of any other force tends to attain a minimum area. The surface layer, therefore, behaves as a stretched membrane which tends to contract. Mathematically it can be shown that for a given volume, the sphere has the minimum area.

   Ex: i.When a mercury thermometer bulb breaks, mercury spreads in small spherical globules.

   ii.The water drop in vacuum is perfectly spherical. The shape of the water drop is distorted due to the action of gravity.

   iii. Liquid in a capillary tube rises due to its surface tension, and this is one of the methods for the measurement of surface tension.

   iv.On heating the glass melts and the surface of the liquid tends to take the rounded shape at the edges. This makes the edges smooth. This process is called fire polishing of glass.

5. Surface tension decreases with increase of temperature due to decrease in intermolecular forces.

6. **Surface tension of liquids at 20^0C in dynes/cm**

Diethyl ether	**16.9**
Acetone	**23.7**
Carbon tetrachloride	**26.9**
Ethanol	**22.3**
Water	**72.8**

Viscosity

1. The ease with which a fluid can flow is determined by its property called viscosity. Viscosity arises due to the internal friction between layers of fluids as they pass over each other.

When a liquid is steadily flowing over a fixed horizontal surface the layer immediately in contact with the surface is stationary. The velocity of the layers increases with the distance from the fixed surface.

The regular gradation in velocity of layers in passing from one layer to the next is called laminar flow.

Force required to maintain the flow in the three layers described above is directly proportional to the area of contact and velocity gradient.

Force is proportional to area in contact and velocity gradient.

$f \propto A$, where 'f' is force and 'A' is area

$f \propto dv/dx$, where 'dv/dx' is velocity gradient.

$f = \eta A\, dv/dx$,

where 'η' is called the coefficient of viscosity.

Viscosity coefficient is defined as the force when velocity gradient and area of contact each is unity. **Hence η is a measure of viscosity.**

$$\eta = \frac{f \times d}{A \times V} = \frac{\text{dynes} \times \text{cm}}{\text{cm}^2 \times \text{cm} \times \sec^{-1}} = \text{dynes.cm}^{-2}.\text{sec} = \text{g.cm}^{-1}.\text{sec}^{-1} =$$ **1 poise.**

Viscosity coefficient has the units of poise, g $cm^{-1}s^{-1}$.

In SI system it is Pa s or N $m^{-2}s$. Commonly used unit, poise, is one tenth of the SI unit.

The presence of Hydrogen bonding or strong Van der Waals forces cause more viscosity.

E.g:Sulphuric acid has intermolecular hydrogen bonds. Hence, its has greater viscosity .

Glass is highly viscous liquid. Its properties resembles solids. The property of flow of glass can be experienced by measuring the thickness of window panes of old buildings as they become thicker at the bottom than at
the top.

Viscosities of some liquids at 293K

Liquid	**viscosity in milli poise**
diethyl Ether	2.33
Ethyl alcohl	12.0
Acetone	3.29
Acetic acid	12.2
Carbon tetrachloride	9.68
Ethylene glycol	19.9
Water	10.09
Glucinol	8500

Coefficient of viscosity (η) is related exponentially with temperature (T) as,

$$\eta = Ae^{E/RT}$$

Viscosity of liquids decreases with an increase in temperature. This is because of high kinetic energy of molecules that overcome the intermolecular forces to slip past one another between layers.