Chemistry Study Materials for Class 11
(NCERT Based Notes of Chapter- 05)
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States of Matter

Liquefaction of gases

Gases can be liquefied by applying pressure at low temperature. The temperature below which a gas can be liquefied by the application of pressure is called **Critical Temperature** (Tc).

The pressure that must be applied at the critical temperature to liquefy a gas is called **Critical Pressure** (Pc).

The volume of 1 mole of a gas at its critical temperature and critical pressure is called **Critical Volume** (Vc).

Tc, Pc and Vc are called **Critical constants**.

A gas below its critical temperature can be liquefied by applying pressure and is called the vapour of the gas. **THE LIQUID STATE**

In liquids the particles are loosely packed and so there is some inter molecular force of attraction. But this force is not strong enough to bind the molecules together. So liquids have a definite volume but no definite shape.

Due to the weak force of attraction, the molecules can move and so liquids can flow. Some of the important properties of liquids are:

1. Vapour pressure

In a liquid, all the molecules do not have the same energy. The molecules having higher energy are escaped to vapour phase. This process is called **evaporation**. As the density of the vapour increases the molecules collide with each other and so their energy decreases and returns to the liquid state. This process is called **condensation**. After some time, the rate of evaporation becomes equal to rate of condensation and the two processes attain equilibrium. At this condition, the pressure exerted by the vapour is called **vapour pressure**.

It is defined as *the pressure exerted by the vapour in equilibrium with its own liquid.* It depends on the nature of the liquid and the temperature.

As the temperature *increases*, the vapour pressure also *increases*.

2. Boiling Point

The vapour pressure of a liquid increases with temperature. At a particular temperature, the vapour pressure becomes equal to atmospheric pressure.

At this temperature, the liquid boils. This temperature is called **boiling point**.

At 1 atm pressure the boiling point is called **normal boiling point**.

If pressure is 1 bar then the boiling point is called **standard boiling point** of the liquid.

The normal boiling point of water is 100 °C (373 K), its standard boiling point is 99.6 °C (372.6 K).

At high altitudes (heights) atmospheric pressure is low. Therefore liquids at high altitudes boil at lower temperatures than at sea level. Since water boils at low temperature on hills, the pressure cooker is used for cooking food.

As depth increases, the atmospheric pressure also increases. So water boils at a higher temperature in a mine than at sea level.

Boiling does not occur when liquid is heated in a closed vessel. On heating continuously vapour pressure increases. At first there is a clear boundary between liquid and vapour phase because liquid is denser than vapour. As the temperature increases more and more molecules go to vapour phase and density of vapours rises. At the same time liquid becomes less dense. When density of liquid and vapours becomes the same; the clear boundary between liquid and vapours disappears. This temperature is called critical temperature. At critical temperature boiling does not occur.

3. Surface Tension

It is defined as the force acting per unit length perpendicular to the line drawn on the surface of liquid. It is denoted by Greek letter γ (Gamma). Its SI unit is N m^{-1}.The energy required to expand the surface of a liquid by unit area is called surface energy. Its SI unit is Jm^{-2}.

Every liquid tries to reduce their energy by decreasing the surface area. For a given volume sphere has the minimum surface area. So liquid drops assume spherical shape

Sharp glass edges are heated for making them smooth. On heating, the glass melts and the surface of the liquid tends to take the rounded shape at the edges, which makes the edges smooth. This is called fire polishing of glass.

The magnitude of surface tension of a liquid depends on the attractive forces between the molecules and the temperature. When the attractive forces are large, the surface tension is large. As temperature increases, surface tension decreases.

The phenomenon like rise (or fall) of a liquid in a capillary tube (Capillary rise/depression) is due to surface tension.

4. Viscosity

When a liquid flows over a fixed surface, we can assume that there are a large number of layers.

The layer of molecules which is in contact with the surface is stationary. The velocity of upper layers increases as the distance of layers from the fixed layer increases. This type of flow in which there is a regular change of velocity in passing from one layer to the next is called **laminar flow**.

Viscosity is a measure of internal resistance offered by the different layers of a liquid.

If the velocity of the layer at a distance dz is changed by a value du, then velocity gradient is given by the amount du/dz. A force is required to maintain the flow of layers. This force is proportional to the area of contact of layers and velocity gradient

i.e. $f \alpha A$

Where A is the area of contact

$f \alpha du/dz$

Where du /dz is the velocity gradient

i.e. the change in velocity with distance

or, $f \alpha A .du /dz$

or, $f = \eta A .du /dz$

The proportionality constant ‘ η ’ is called coefficient of viscosity. It is defined as the force when velocity gradient and the area of contact are unity. Thus ‘ η ’ is measure of viscosity.

SI unit of viscosity coefficient is Newton second per square meter (N s m^{-2}) or Pascal second (Pa sec).

In cgs system the unit of coefficient of viscosity is **poise**.

1 poise = 1 g $cm^{-1}s^{-1}$ = 10^{-1}kg $m^{-1}s^{-1}$.

Greater the viscosity, the more slowly the liquid flows. i.e. viscosity is inversely proportional to fluidity. The presence of Hydrogen bonding and Vander Waals forces, increases viscosity.

Glass is a very viscous liquid. So it has a tendency to flow though very slightly. Hence the windowpanes of old buildings are thicker at the bottom than at the top.

Viscosity of liquids decreases as the temperature rises because at high temperature, molecules have high kinetic energy and can overcome the intermolecular forces.

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