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Class 11
Chemistry

Chapter 5
States & Phases of Matter
Handwritten Notes

CH 05: STATES & PHASES OF MATTER

Liquid

A liquid is a type of matter with specific properties that make it less rigid than a solid but more rigid than a gas. It can flow and doesn't have a specific shape. Istead it takes the shape of the contains in which it is held.

- Kinetic molecular interpretation of liquids

The postulates of the kinetic molecular theory of liquids are given below:

- Molecules touch one another.
- Molecules are in constant motion, but the motion of the molecules is limited by their close packing.
- The attractive forces of liquid molecules are greater than gases. However, these attractive forces are not sufficient to hold the molecules in a fixed position. Liquid molecules can slide past each other.
- The average kinetic energy of liquid molecules is ~~equal to~~ directly propotional to the absolute temperature.
- At constant temperature, the average K.E of the molecules is equal to the K.E of the vapours of the liquid.

Physical properties of liquids

- Evaporation

The spontaneous change of a liquid into its vapours at the surface of liquid at given temperature is called evaporation. The molecules in liquid are in motion and move with the liquid volume. The energy of molecules is not equally distributed. High energy molecules move faster then low energy molecules. When the high speed molecules reach the surface of liquid it may escape the attraction of its side molecules and leave the surface of liquid. Evaporation takes place at all temperatures. Evaporation causes cooling. When high energy molecules leave the liquid during evaporation, low energy molecules are left behind, the average K.E of molecules of liquid decreases and temperature of the liquid falls so heat moves from surrounding to the liquid and temperature of surrounding falls. Evaporation is controlled by different factors. For surface area, Rate of Evaporation $\propto$ Surface area. Greater the surface area greater no. of molecules escape from the surface. For intermolecular forces, greater the attraction of molecules less molecules will escape. Rate of evaporation $\propto$ 1/force of attraction. For temperature, Rate of Evaporation $\propto$ Temperature. Higher temperature means higher K.E so more molecules will escape.

-Vapour Pressure

The pressure exerted by the vapours on the surface of the liquid in equilibrium with the liquid at a given temperature is called vapour pressure. If the surface of the liquid is covered and the system is closed the molecules of the liquid evaporate and start gathering above the surface of liquid. These evaporated molecules collide with the surface of liquid and also with walls of container. Molecules are recaptured by surface of liquid. Vapours turning back to liquid is called condensation. After some time the rate of vapourization will become equal to rate of condensation. This state is called dynamic equilibrium and pressure exerted in this state is called vapour pressure. Vapour pressure is not affected by amount of liquid, Volume of the container, surface area of liquid. Vapour pressure is affected by intermolecular force, Vapour pressure $= 1/$intermolecular forces. Greater attraction forces means less molecules will escape. Vapour pressure is also effected by temperature, Vapour pressure α Temperature, greater temperature means higher K.E which leads to greater amount of molecules escaping the surface.

- Boiling point

The temperature at which vapours pressure of the liquid becomes equal to the external atmospheric pressure is called boiling point. At this temperature boiling starts. The K.E of molecules increases by heating and temperature of the liquid also increases. When the K.E of the molecules become maximum than further heat supplied will not increase temperature (temperature remains constant at boiling point) beacause the further heating will break the intermolecular forces and the liquid is converted into vapours. Boiling point is affected by intermolecular forces, Boiling point α Intermolecular forces, this means the boiling point increase if the intermolecular forces are strong. Boiling point is also affected by atmospheric pressure, Boiling point α Atmospheric pressure, higher atmospheric pressures means higher ~~p~~ boiling point.

-Viscosity

The resistance to flow of a liquid is called viscosity. The higher the viscosity, slower the liquid flows. It measures how easily molecules slide past each other. It is represented by greek letter η (eta). Resistance is caused by friction b/w layers of molecules. The layer next to the walls has the lowest speed. SI unit of viscosity is Pascal Second (Pa.S) and non-SI unit is poise

1 poise $= 0.1\, kgm^{-1}s^{-1}$ or $gcm^{-1}s^{-1}$

1 Pa.S $= 1\, kgm^{-1}s^{-1} = 10$ poise.

The size and shape of molecules strongly influences viscosity. Such as water, acetone, methanol, whose molecules are small and compact have a low viscosity. Liquids with large and irregular molecules, such as honey, glycerin tends to tangle with each other, leading to high viscosity. The stronger the intermolecular forces, the higher the viscosity.

- Surface tension

A force in dynes acting right angles to a unit length of liquid surface is called surface tension. It can also be defined as the amount of energy required to expand the surface of a liquid per unit area. Surface tension is the property of the surface of liquids to behave as if a membrane were stretched over it. All molecules below the surface of a liquid are surrounded by other molecules in all directions. Thus, the force exerted by such molecules is balanced in all directions, while at the surface of a liquid there are molecules beside and below but none above it. This results in an unbalanced force that pulls the surface molecules inward. Molecules on the surface of a liquid are less stable than inside it, so a liquid is stable if it has the fewest molecules on its surface. This happens when the surface of the liquid is the smallest. The surface tension of a liquid directly depends on the strength of the intermolecular forces. SI unit of surface tension is joule per square meter, Jm^{-2} or Newton per meter Nm^{-1}. It is represented by Gamma γ.

- Hydrogen Bonding

Hydrogen bonding in water contributes to its unique properties.

- Surface tension: Water has hydrogen bonding which is strong intermolecular force, due to this, it creates high surface tension.
- Vapour Pressure: Vapour pressure of a liquid is affected by intermolecular attractive forces. Strong force of attraction makes the evaporation slow. Due to the hydrogen bonding in water which is a strong intermolecular attractive forces decreases evaporation so water has low vapour pressure.
- High heat of vapourization of water: Heat of vapourization of water is high as compared to other liquid. It is because of strong molecular force of hydrogen bonding in water. More heat is required to overcome these attractive forces to vapourize water as a result ~~show~~ water show high heat of vapourization than other liquids.
- High boiling point: Due to strong hydrogen bonding water has low vapour pressure. More heat is required to enhance the evaporation and produce more vapours pressure equal to external pressure. Water has high boiling point.

Energy Changes and Intermolecular forces

As a result of melting of a solid, small change in intermolecular distance and potential energy takes place in atoms, molecules or ions. On other hand on evaporation of a liquid atoms, molecules or ions undergo large changes in their intermolecular distance and potential energy. Therefore, heat of vaporisation is much greater than that heat of fusion.

Properties of Gases

- Gases do not have definite shape and volume. Gas molecules move freely and randomly. Volume of the gas is the volume of its container.
- Intermolecular space in gas molecules is more due to which gases show low densities. Gases bubble and rise up through liquid due to its low densities than liquids and solids.
- Intermolecular spaces in gases are more enough to accomodate other gases molecules and show ppropertics of diffusion and effusion.
- When gases are heated the velocity of molecules increases and volume of gases increases. Similarly, if volume is available then gases expand and occupy the available volume.

- Compressibility

Gases are highly compressible because the particles in gases are far apart and large spaces exists b/w them, so gases can be compressed into small volume by applying pressure. Due to this property of gases large volume of a gas can be placed in small cylinder by compression. For example, oxygen gas in cylindes are supplied to hospitals. Compressed Natural Gas (CNG) is used in vehicles. Liquid Petroleum Gas (LPG) is used for cooking.

- Expandability

Gases expand to fill its container. Expandability of gases is spontaneous and gases occupy the available volume. The gas molecules are in random motion having K.E and there is empty space b/w gas molecules. The air contained in a balloon fills up the whole ballon. If the gas in balloon is let into the room it will spread in the room. In balloon, gas has high pressure and in room, gas has low pressure. Compressed gas can also expand if volume is available.

- Pressure exerted by the Gases

Molecules of a gas are in constant random motion and collide against walls of the container. Due the collisions with the walls of container, the walls experiance a containous force. Due to this force gases exert pressure. Pressure is force per unit area.

Properties of Solids

- Solid have definite mass, volume and shape. It has a compact arrangement of constituent particles. There is a short distance b/w molecules and forces of attraction b/w its particles is very strong. Due to this reason solid are non-compressible and they cannot diffuse into each other. Solid particle only has vibrational motion.
- Solids is a collection of atoms or molecules held together in a definite shape under constant conditions. Substances which are rigid hard, cannot flow and have definite volume under constant conditions.
- They have definite size under constant conditions, because of strong force of attraction b/w atoms/molecules. Particles cannot move randomly.
- There exists a well-ordered arrangement in solids.

- Kinetic Molecular Interpretation of Solids

- Solids show maximum forces among their particles due to very close packing of arrangement
- Particles are closely packed as a result they occupy minimum volume and show high density.
- Particles do not show translational motion therefore there is no collision b/w particles.
- The particles of solid can only vibrate and posses only vibrational K.E.
- Crystalline solids have definite, distinctive geometric shape due to orderly arrangement of particles in three-dimensional shape.

Types of Solids

- Crystalline solids

Have definite, regular and three-dimensional geometric shapes. Atoms, ions or molecules are arranged in a definite three-dimensional geometric shapes. Examples are, diamond, ice, glucose, $ZnSO_4$ etc.

- Amorphous solids

Constituent particles (atoms, ions or molecules) lack regular arrangement. No definite geometric shape. Lack ordered crystalline structure. Can have small regions of orderly arrangement (crystallites). No sharp melting point. Particles soften over high temperature and can be molded. Also known as "super cooled liqueds". Examples, glass, ~~stone~~ plastic and rubber. Amorphous solids can be formed by melting and rapidly cooling crystalline solids.

Properties of Crystalline solids

- Goemetrical shape

Crystals have a geometric shape. The particles of solids are arranged in three-dimensional space. The internal angles of a crystal are always the same, no matter in what form they are grown.

- Melting point

Crystalline solids have sharp melting points. At the melting point, their vibration energies become so high that they start leaving fixed positions simultaneously and the solid turns into a liquid.

- Cleavage planes

When pressure is applied to it along the cleavage plane, it changes into small crystals of the same size and shape as that of the original crystal. For a crystalline solid, the cleavage plane are bent towards each other.

- Habit of a crystal

The shape of a crystal in which it usually grows is called habit of a crystal. Crystals slowly form when a saturated solution is cooled. Crystal form by growing in different directions. If the growth condition remain the same, crystals of the same shape will form. If the conditions are changed, the shape of crystals also changes. Cubic crystals of sodium chloride are obtained from its aqueous solution. If 10% urea is present in aqueous solution of sodium chloride, octahedral crystals are obtained.