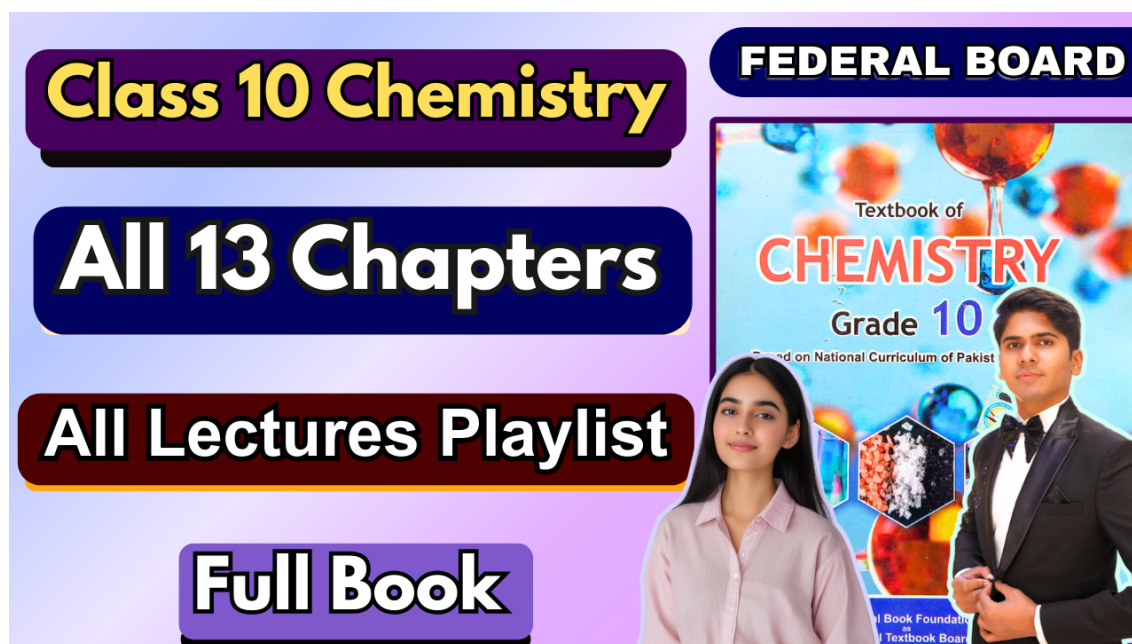


Chapter 2: Matter

All Lectures Uploaded on YouTube:

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2.1 Changes of States of Matter

A change of state (also called phase transition) refers to the transformation of matter from one physical state to another such as solid, liquid, and gas without a change in temperature. These changes are explained by Kinetic Particle Theory and internal energy. Internal energy consists of kinetic energy (related to temperature) and potential energy (related to intermolecular forces). During a phase change, temperature remains constant because the energy supplied or released changes the potential energy of particles rather than their kinetic energy.

Melting (Solid to Liquid)

In a solid, particles are tightly packed in fixed positions and vibrate about their mean positions. When heat is supplied at the melting point, the particles absorb energy. This energy increases their potential energy, weakening the intermolecular forces that hold them in fixed positions. The kinetic energy does not increase, so the temperature remains constant. Once the forces are overcome, the solid melts and changes into a liquid where particles can move freely.

Boiling (Liquid to Gas)

In liquids, particles are close together but can slide past one another. When a liquid is heated to its boiling point, particles gain sufficient energy to overcome the attractive forces between them. The added energy increases potential energy, allowing particles to escape the liquid surface. The kinetic energy does not increase, so the temperature remains constant. The liquid boils and changes into a gas, where particles are far apart and move randomly at high speeds.

Freezing (Liquid to Solid)

When a liquid is cooled to its freezing point, particles lose energy. This loss of energy decreases the potential energy of the particles, which strengthens the intermolecular forces. The particles lose their ability to move freely and settle into fixed positions, causing the liquid to change into a solid. The temperature remains constant during the phase change.

Condensation (Gas to Liquid)

When a gas is cooled at its condensation point, particles lose energy. The loss of energy reduces the potential energy of the particles, which strengthens the intermolecular forces. The particles are drawn closer together and the gas changes into a liquid. The temperature remains constant during the phase change.

2.2 Vapour Pressure

The vapour pressure of a liquid is the pressure exerted by its vapour when it is in dynamic equilibrium with its liquid phase in a closed container at a specific temperature.

Factors Affecting Vapour Pressure

The magnitude of the vapour pressure is dependent on two factors:

Temperature

- As temperature increases, the kinetic energy of the liquid particles increases.
- More particles gain enough energy to escape the liquid surface and enter the gaseous phase.
- This results in a higher concentration of vapour particles, leading to an increase in vapour pressure.

Intermolecular Forces

- Liquids with **weak** intermolecular forces are considered **volatile**. These particles easily overcome the attractive forces, leading to a high rate of evaporation and a **high vapour pressure**.
- Liquids with **strong** intermolecular forces are considered **non-volatile**. These particles require more energy to escape the liquid surface, leading to a low rate of evaporation and a **low vapour pressure**.

2.3 Boiling Point

The boiling point of a liquid is the temperature at which its vapour pressure becomes equal to the external (or atmospheric) pressure.

Factors Affecting Boiling Point

External Pressure

- When the external pressure is **high**, the liquid needs a **higher temperature** to produce enough vapour pressure to match it. Therefore, the boiling point increases.
- When the external pressure is **low** (e.g., at high altitudes), the liquid needs a **lower temperature** to boil. Therefore, the boiling point decreases.
- The normal boiling point is measured at standard atmospheric pressure (1 atm or 101.3 kPa).

Intermolecular Forces

- Liquids with **strong** intermolecular forces (non-volatile) require a **large amount of energy** to overcome these forces, resulting in a **high boiling point**.
- Liquids with **weak** intermolecular forces (volatile) require a **small amount of energy**, resulting in a **low boiling point**.

2.4 Diffusion

Diffusion is the process where particles move from a region of **high concentration** to a region of **low concentration** until they are uniformly distributed. Diffusion occurs spontaneously in gases and liquids due to the random movement (Kinetic Particle Theory) of their particles.

Diffusion in Liquids

Diffusion occurs in liquids but is much **slower** than in gases. This is because:

- Liquid particles are **more closely packed** than gas particles.
- They have **less kinetic energy** than gas particles.
- The particles move in shorter, more random paths before colliding with another particle (i.e., a shorter mean free path).

Diffusion in Gases

Diffusion in gases is the **fastest** form of diffusion. This is because:

- Gas particles are **far apart** (lower density).
- They have **high kinetic energy** and move at high speeds.
- The particles move in long, straight paths before colliding.

Example: When a container of ammonia is opened, the gas spreads quickly throughout the room due to diffusion.

2.5 Graham's Law of Diffusion

Graham's Law states that the rate of diffusion of a gas is **inversely proportional** to the **square root of its density** (or molecular mass) at constant temperature and pressure.

$$\frac{\text{Rate}_1}{\text{Rate}_2} = \sqrt{\frac{\text{Density}_2}{\text{Density}_1}} = \sqrt{\frac{\text{Molecular mass}_2}{\text{Molecular mass}_1}}$$

Factors Affecting the Rate of Diffusion

Molecular Mass/Density

- Lighter gases (lower molecular mass) diffuse **faster** than heavier gases.
- **Example:** Ammonia (NH_3 , MM = 17) diffuses faster than hydrogen chloride (HCl , MM = 36.5).

Temperature

- Higher temperature increases diffusion rate. At higher temperatures, particles have higher kinetic energy and move faster, so they diffuse faster.

2.6 Sublimation

Sublimation occurs when solids with weak intermolecular forces change directly into gas without passing through the liquid phase.


Application Of Sublimation In Our Life:

- **Air Fresheners:** The solid air fresheners we often use in our cars and homes rely solely on the magic of sublimation. The solid fragrance within slowly transforms into a delightful vapour, filling the entire space with an enticing aroma that lingers in the air.
- **Textile Industry/3D Printing:** Dye sublimation printers are now widely used for the printing process for a reduced cost. Dye sublimation is used to print a variety of objects such as T-shirts, pens, coffee mugs, and bags.
- **Food Industry:** Freeze-drying food items for preservation for a longer duration is due to the process of sublimation.

2.6.1 Importance of Diffusion Rates in Medicine

When you take a drug, whether it's taken by mouth or injected, it needs to diffuse from the injection site into your bloodstream. The diffusion rate determines how quickly a drug reaches its target area in your body. Ultimately, diffusion determines how fast drugs spread in the body. Faster diffusion leads to quicker drug action. The rate of diffusion also depends on the composition of the drug (e.g., liquid, gel, tablet). Generally, liquid drugs move more quickly than solid drugs, as their particles have already dispersed.





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