Kinetic Theory

Introduction

The **Kinetic Theory of Gases** explains the behavior of gases based on the motion of their molecules. According to this theory, gases consist of a large number of tiny particles that are in **continuous random motion**. The theory helps explain properties such as **pressure, temperature, volume, and internal energy** and forms the basis of the gas laws.

Kinetic Theory of Gases

Basic Postulates

The main assumptions of the kinetic theory are:

- A gas consists of a large number of tiny molecules.
- Gas molecules are in continuous random motion.
- The volume of gas molecules is negligible compared to the volume of the container.
- Molecules move in straight lines between collisions.
- Collisions between molecules and the container walls are perfectly elastic.
- There are no intermolecular forces except during collisions.

Pressure of a Gas

Cause of Pressure

Gas molecules continuously collide with the walls of the container.

The force exerted during these collisions produces **pressure**.

Pressure increases when:

- Temperature increases.
- Number of molecules increases.
- Volume decreases.

Kinetic Energy of Gas Molecules

Average Kinetic Energy

The average kinetic energy of gas molecules depends only on the **absolute temperature**.

Formula:

Average Kinetic Energy = (3/2) kT

where:

- **k** = Boltzmann Constant
- **T** = Absolute Temperature (Kelvin)

Higher temperature means greater molecular kinetic energy.

Root Mean Square (RMS) Speed

Definition

The **Root Mean Square (RMS) Speed** is the square root of the average of the squares of the speeds of gas molecules.

Formula:

Vrms = $\sqrt{}$(3RT/M)

where:

- **R** = Universal Gas Constant
- **T** = Absolute Temperature
- **M** = Molar Mass of the Gas

The RMS speed increases with temperature.

Degrees of Freedom

Meaning

Degrees of Freedom are the number of independent ways in which a molecule can move or store energy.

Types include:

- Translational
- Rotational
- Vibrational

The number of degrees of freedom depends on the type of gas molecule.

Law of Equipartition of Energy

Statement

The **Law of Equipartition of Energy** states that energy is equally distributed among all active degrees of freedom of a molecule.

Each degree of freedom contributes:

(1/2) kT

to the average energy.

Ideal Gas Equation

Equation

The behavior of an ideal gas is represented by:

PV = nRT

where:

- **P** = Pressure
- **V** = Volume
- **n** = Number of Moles
- **R** = Universal Gas Constant
- **T** = Absolute Temperature

Applications of Kinetic Theory

Importance

The kinetic theory is used in:

- Explaining Gas Laws
- Weather Science
- Engineering
- Thermodynamics
- Refrigeration
- Heat Engines
- Chemical Industries

It helps explain the behavior of gases under different conditions.

Key Points

- Gas molecules are in continuous random motion.
- Pressure is produced by molecular collisions with container walls.
- Average kinetic energy depends only on temperature.
- RMS speed increases with temperature.
- Degrees of freedom determine the energy of molecules.
- The law of equipartition distributes energy equally among active degrees of freedom.

- The ideal gas equation is **PV = nRT**.

Chapter Summary

This chapter explains the kinetic theory of gases and the assumptions on which it is based. It covers the causes of gas pressure, average kinetic energy, RMS speed, degrees of freedom, the law of equipartition of energy, and the ideal gas equation. These concepts provide a microscopic explanation of the behavior of gases and form the foundation of thermodynamics and heat transfer.