Marwari college Darbhanga

Subject--- physics(Hons)

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Kinetic theory of gases

The **kinetic theory of gases** is a historically significant, but simple model of the thermodynamic behavior of gases with which many principal concepts of thermodynamics were established. The model describes a gas as a large number of identical submicroscopic particles (atoms or molecules), all of which are in constant, rapid, random motion. Their size is assumed to be much smaller than the average distance between the particles. The particles undergo random elastic collisions between themselves and with the enclosing walls of the container. The basic version of the model describes the ideal gas, and considers no other interactions between the particles and, thus, the nature of kinetic energy transfers during collisions is strictly thermal. The kinetic theory of gases explains the macroscopic properties of gases, such as volume, pressure, and temperature, as well as transport properties such as viscosity, thermal conductivity and mass diffusivity. The model also accounts for related phenomena, such as Brownian motion.

Postulates of Kinetic Theory of Gases by

Following are the kinetic theory of gases postulates:

- Space-volume to molecules ratio is negligible.
- There is no force of attraction between the molecules at normal temperature and pressure. The force of attraction between the molecules build when the temperature decreases and the pressure increases.
- There is large space between the molecules resulting in continuous motion.
- The free movement of molecules results in collision which is perfectly elastic.
- The molecules have kinetic energy due to random movement. But the average kinetic energy of these molecules differs with temperature.
- Molecules exert pressure on the walls of the container.

Assumptions of Kinetic Theory of Gases

Following are the kinetic theory of gases assumptions:

- All gases are made up of molecules which are constantly and persistently moving in random directions.
- The separation between the molecules is much greater than the size of molecules.
- When a gas sample is kept in a container, the molecules of the sample do not exert any force on the walls of the container during the collision.
- The time interval of collision between two molecules, and between a molecule and the wall is considered to be very small.
- All the collisions between molecules and even between molecules and wall are considered to be elastic. • All the molecules in a certain gas sample obey Newton’s laws of motion.
- If a gas sample is left for a sufficient time, it eventually comes to a steady state. The density of molecules and the distribution of molecules are independent of position, distance and time.

Kinetic Theory of Gases Formula

Following is the formula of kinetic theory of gas

we get-

$$nRT = \frac{1}{3} N m v^2$$

Boyle's law At constant temperature, the average kinetic energy and hence the average speed of the molecules is constant. The number of molecules present in a given mass of a gas is also constant.

Let the volume of a given mass of a gas be reduced to one half of its original volume. The same number of molecules with their same average speed will now have half the original space to move about. As a result ,the number of molecules striking the unit area of the walls of the container in a given time will be doubled and consequently the pressure is also doubled.

If the volume of a given mass of a gas is doubled at constant temperature the same number of molecules with their same average speed will now have double the space to move about. The number of molecules striking the unit area of the walls of the container in a given time will now become one half of the original value. As a result, the pressure of the gas will be reduced to one half of its original volume.

Deduction from Kinetic Gas Equation

PV = 1/3 mnc^2

PV = 2/3 × 1/2 (Mc^2)

But 1/2 Mc^2 = Kinetic energy of the gas

PV = 2 K.E/ 3

K.E. ∝ T

K.E. = kT

PV = 2kT/3

As 2/3 and k are constant

Hence PV = constant

Charles law

According to kinetic theory of gases, the average kinetic energy and hence the average speed of the gas molecules is directly proportional to its absolute temperature.

When the temperature of a gas is increased at constant volume the average kinetic energy of its molecules increases and hence the molecules would move faster. As a result, the molecules of a gas will strike the unit area of the walls of the container more frequently and vigorously. The pressure of the gas will increase accordingly. Thus, at constant volume the pressure of a gas increases with rise in temperature.

If the pressure of the gas is to be maintained constant, the force per unit area on the walls of the container in a given time must be kept the same. This can be achieved by increasing the volume proportionately. Thus at constant pressure, the volume of a given mass of a gas increases with increase in temperature. This explains Charles law.

Deduction from Kinetic Gas Equation

PV = 2kT / 3

V/T = 2k / 3P

2/3 is constant, k is also constant, hence P is kept constant, V/T =constant. which is Charles law.

Dalton's law of partial pressure

According to the kinetic theory of gases ,the attractive forces between the molecules of the same or different gases are very weak under ordinary conditions of temperature and pressure. Therefore the molecules of a gaseous mixture move completely independent of one another. As a result ,each molecule of the gaseous mixture would strike the unit area of the walls of the container the same number of times per second as if no other molecules were present.

Therefore the pressure due to a particular gas is not changed by the presence of other gases in the container. The total pressure exerted by a

gaseous mixture must be kept equal to the sum of partial pressure of each gas when present alone in that space. Hence kinetic theory explains Dalton's law of partial pressure.

Deduction from Kinetic Gas Equation

$PV = 1/3\ (mnc^2)$

$P = mnc^2 / 3V$

If only the first gas is enclosed in the vessel of volume V, the pressure exerted would be,

$P_1 = m_1n_1c_1^2 / 3V$

If second gas is enclosed in the same vessel ,then the pressure exerted would be

$P_2 = m_1n_2\ c_2^2 / 3V$

$P = m_1n_1c_1^2 / 3V + m_1n_2\ c_2^2 / 3V + \ldots\ldots\ldots$

$P = P_1 + P_2$