Kinetic Theory of Gases

Lecture - 2

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The Pressure of the gas in terms of energy :

$$P = 1/3 \, \rho \, C^2$$

Or , $$P = 2/3 \times 1/2 \, \rho \, C^2$$

$E = ½ \, \rho \, C^2$ is the kinetic energy of the molecules of unit volume .

$$P = 2/3 \, E \qquad (10)$$

Kinetic interpretation of temperature :

$$PV = 1/3 \, MC^2 \qquad (11)$$

$RT = 1/3MC^2$

$C^2 = 3RT / M$ (12)

Therefore , $C^2 \propto T$ (13)

Interpretation of gas laws :

(I) Perfect gas equation :

$PV = 1/3\ MC^2$

Since , $C^2 \propto T$

Therefore , $PV = RT$ (14)

Where R is a universal gas constant , eq.(14) is perfect gas equation .

(ii) Boyle's law :

Since , $PV = 1/3\ MC^2$

And $C^2 \propto T$

Therefore , PV = Constant .

Or, $P \propto 1/V$, where T is constant (15)

Which is Boyle's law .

(iii) **Charle's law :**

Since PV = RT

Hence , $V \propto T$ (16)

Where P is constant . which is Charle's law .

(iv) **Law of pressure :**

Since , $P = RT/V$

At a constant volume R/V is constant .

Therefore , $P \propto T$, which is a law of pressure . (17)

(v) **Graham's law of diffusion** :

Since $P = 1/3\ \rho\ C^2$ .If for the two gases pressure , density and velocity be respectively P_1 ,P_2 , ρ_1 , ρ_2 and C_1 , C_2 Then ,

$P_1 = 1/3\ \rho_1 C_1{}^2$ and $P_2 = 1/3\ \rho_2 C_2{}^2$

At constant pressure ($P_1 = P_2$)

$$1/3\ \rho_1 C_1{}^2 = 1/3\ \rho_2 C_2{}^2$$

$\therefore\ c_1 / c_2 = \sqrt{\rho_1/\rho_2}$ (18)

(vi) **Avagadro's hypothesis :**

For two gases whose pressure and volume are same; then

$P = 1/3\ m_1\ n_1\ c_1^2 / V = 1/3\ m_2\ n_2\ c_2^2 / V$

Or , $m_1 n_1\ c_1^2 = m_2 n_2\ c_2^2$ (19)

If the temperature of the two gases are same then average energy of each molecule will be equal , that is

$1/2\ m_1\ c_1^2 = 1/2\ m_2\ c_2^2$ (20)

Comparing Eq.(19) and (20) , we get

$n_1 = n_2$

Hence at the same temperature and pressure the equal volume of different gases contains equal number of molecules . This is Avagadro's hypothesis .

(vii) **Dalton's law of partial pressure :**

Let there be a mixture of number of gases of densities ρ_1 , ρ_2 ....
And of mean square velocities c_1^2 , c_2^2 ... in the same volume V ,
then the total pressure exerted by mixture is given by

$$P = 1/3\ \rho_1 C_1{}^2 + 1/3\ \rho_2 C_2{}^2 + ...$$

$$= P_1 + P_2 + ... \qquad (23)$$

Thus the pressure exerted by the mixture is equal to the sum of the pressure exerted separately by its components . This is Dalton's law of Partial pressure .