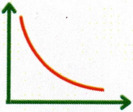
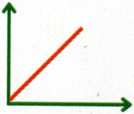
STATES OF MATTER

BOYLE'S LAW

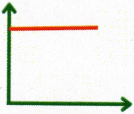
$P \propto \frac{1}{V}$	$PV = k_1$	$P_1V_1 = P_2V_2$



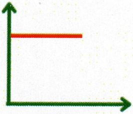
P vs V



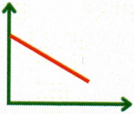
P vs 1/V



PV vs V



PV vs P



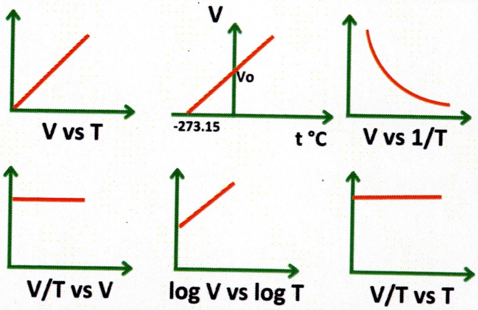
log P vs log V

Graphical View

CHARLES LAW

$V \propto T$	$\frac{V_1}{T_1} = \frac{V_2}{T_2}$	$V_t = V_o + \frac{t^oC}{273.15} V_o$

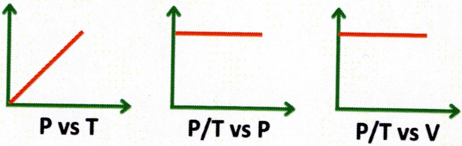
Graphical View



GAY LUSSAC'S LAW

The pressure of a gas increases as its temperature increases, assuming constant mass and volume.

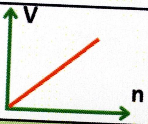
$P \propto T$	$\frac{P_1}{T_1} = \frac{P_2}{T_2}$	$P = k_3 T$



Avogadro's law

Equal volumes of all gases under the same condition of temp and pressure contain equal no of molecules.

$$V \propto n \text{ or } \frac{V_1}{n_1} = \frac{V_2}{n_1}$$



V vs n

Ideal Gas Equation

From all the laws mentioned above	$PV = nRT$

where, R is a gas constant with the following values.

8.314 J $mol^{-1} K^{-1}$	0.0821 L atm $mol^{-1} K^{-1}$	1.98 cal $mol^{-1} K^{-1}$
use (25/3)	use (1/12)	use (2)

Relation of P with density	$PM = dRT$

- No gas is perfectly Ideal.
- Ideal nature is achieved at **High Temp, Low Pressure**

Combined gas laws

For a fixed amount of a gas, if T, P and V changes from initial values P1, V1, T1 to Final P2, V2, T2.

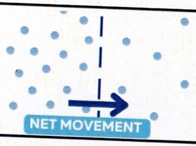
$$\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$$

Grahm's Law of Diffusion

- Rate of diffusion is number of moles of gas diffused per unit time. $r = V/T = n/T$
- The rate of diffusion or effusion of a gas is inversely proportional to the square root of its molar mass.

$$r_1 = \frac{1}{\sqrt{M_1}}$$

$$\frac{r_1}{r_2} = \sqrt{\frac{M_2}{M_1}}$$



- Volume Flow rate

$$\frac{V_1}{V_2} \times \frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$$

- Moles flow rate

$$\frac{n_1}{n_2} \times \frac{t_2}{t_1} = \sqrt{\frac{M_2}{M_1}}$$

Dalton's law of partial pressure

- According to this law, the total pressure of a mixture of non-reacting gas is equal to the sum of partial pressure of each gas.
- Applicable for the mixture of non reacting gases.
- For a mixture of 3 gases A, B, C

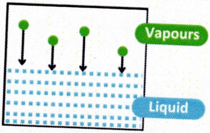
$$P_T = P_A + P_B + P_C \text{ and } P_A = x_A . P_T$$

- The law is not valid for the following mixtures.

$CO + O_2$; $NO + Cl_2$; $CO + Cl_2$; $HCl + NH_3$; $H_2 + F_2$
$NH_3 + Cl_2$ (excess) $SO_2 + Cl_2$; $NO + O_2$; $H_2 + Cl_2$

Vapour Pressure

- The pressure exerted by vapours over the surface of liquid when liquid and vapours are in equilibrium.



Liquid ⇌ Vapours

Rate of Vaporisation = Rate of Condensation

Factors Affecting Vapour Pressure

• Temperature $VP \propto T$	• Intermolecular forces $VP \propto 1/IMF$

$$P_{\text{moist gas}} = P_{\text{dry gas}} + VP_{H_2O}\ (\text{aq. Tension})$$

Kinetic Theory of gases

- NO force of attraction b/w gas molecules.
- Volume of gas molecule is negligible
- Motion is straight line and random (chaotic motions)
- Collision is perfectly elastic.
- Avg. KE ∝ Absolute T

Kinetic Gas Equation

$$PV = \frac{1}{3} mNV^2_{rms}$$

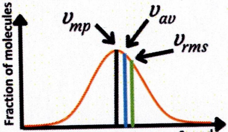
- P in Pa
- Volume in m^3
- Mass in kg
- No. of molecules (N)
- Root mean square velocity (m/s)

Average Kinetic Energy

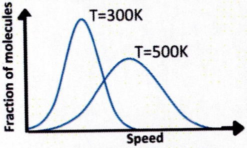
$$K.E. = \frac{3}{2}RT = \frac{3}{2}k_bT$$

Per Mole   Per molecule

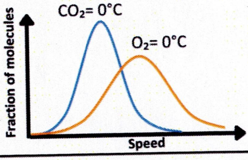
Maxwell Boltzmann distribution of speeds

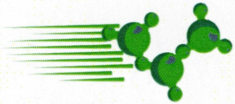


Distribution of Molecular Velocities



Variation with temperature



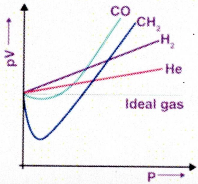


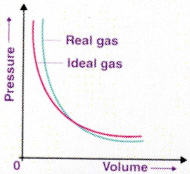
Variation with Molar mass

$$f(v) = 4\pi \left(\frac{m}{2\pi kT}\right)^{\frac{3}{2}} v^2 e^{\frac{-mv^2}{2kT}}$$

RMS	Average	Most probable
$v_{rms} = \sqrt{\frac{3RT}{M}}$	$v_{av} = \sqrt{\frac{8RT}{\pi M}}$	$v_{mp} = \sqrt{\frac{2RT}{M}}$

Relation ($v_{mp} : v_{av} : v_{rms}$) = 1 : 1.128 : 1.224





Deviation from Ideal Behaviour

• Pressure Correction	• Volume Correction
$P_{ideal} = P_{real} + \frac{an^2}{V^2}$	$V_{ideal} = V_{container} - nb$

Equation of State

$\left(p + \frac{n^2a}{V^2}\right)(V - nb) = nRT$	**a** = Force of attraction measure ($atm\ L^2\ mol^{-2}$) **b** = Excluded volume ($L\ mol^{-1}$)

Compressibility factor, Z

$Z = \frac{V_{real}}{V_{Ideal}} = \frac{PV_{real}}{RT}$	Z is a factor to check the deviation of real gas from ideality
For Attraction	$V_{real} < V_{Ideal} \Rightarrow Z < 1$
For Repulsion	$V_{real} > V_{Ideal} \Rightarrow Z > 1$
Boyles temperature	T at which Ideal = Real $T_b = a/Rb$

Collision Parameters

Mean Free Path		Average time between collisions
$\lambda \propto \frac{T}{P}$	$\lambda = \frac{1}{\sqrt{2}\pi\sigma^2 N^*}$	σ = Collision diameter N* = Number Density
Collision Frequency	$z = \sqrt{2}\pi\sigma^2 V_{avg} N^*$	

Liquefaction of gases

Critical Temperature	$T_c = \frac{8a}{27Rb}$	Critical Volume	$V_c = 3b$
Critical Pressure	$P_c = \frac{a}{27b^2}$	Comp. Factor (Zc)	$\frac{P_cV_c}{RT_c} = \frac{3}{8} < 1$

Condition for Liquification

- Liquefaction ∝ a/b (Vander waals constants)
- $He < H_2 < N_2 < O_2 < CO_2 < NH_3 < H_2O$ (For Liquefaction)