Kinetic Theory of Gases

Gas Laws

Charles Law

$P = const$

$V \propto T$

Boyle's Law

$T = const$

$P \propto \frac{1}{V}$

Gay Lussac's Law

$V = const$

$P \propto T$

Avogadro's Law

$V \propto n$

For ideal Gas, $\boxed{PV = nRT}$

also, $\boxed{P = \frac{d RT}{M_0}}$ → T in kelvin, d in kg/m^3

Postulates of an ideal Gas

- spherical
- collision → Perfectly elastic
- Interatomic force doesn't exist
- No P.E
- K.E → Internal Energy

- Real Gases behaves like a ideal gas at → low pressure and high Temperature.

Pressure

- $P = \frac{1}{3} \rho (V_{RMS})^2$

$V_{MP} < V_{Mean} < V_{RMS}$

$\sqrt{\frac{2RT}{M_0}} < \sqrt{\frac{8RT}{\pi M_0}} < \sqrt{\frac{3RT}{M_0}}$

- $K.E = \frac{1}{2} M (V_{RMS})^2$.

Degree of Freedom

linear, $f = 5$ Non-linear, $f = 6$

Polyatomic

Monoatomic (He/Ne)

DOF = 3

Diatomic

$H_2/N_2/O_2$

Trans^n → 3

Rotational → 2

DOF = 5

Tri-atomic

- linear: CO_2
  - 3 Trans^n
  - 2 Rotational
  - DOF = 5
- Non-linear: 3T, 3R
  - DOF = 6

(*) vibrational degree of freedom = 2 × no. of mode of vibration.

Monoatomic Gas

$$E_{(r\,mol)} = \frac{3}{2} nRT$$

Diatomic Gas

$$E_{(r\,mol)} = \frac{5}{2} nRT$$

Molar Specific Heat Capacity

At const. volume

$$C_v = \frac{nf}{2}$$

At const. Pressure

$$C_p = R\left(\frac{f}{2}+1\right)$$

$$\gamma = \frac{C_p}{C_v}$$

$$\gamma = \frac{f+2}{f}$$

also (*) $\boxed{C_p = R + C_v}$

Mixing of phases

$$(C_p)_{mix} = \frac{n_1 C_{p_1} + n_2 C_{p_2}}{n_1 + n_2}$$

$$(C_v)_{mix} = \frac{n_1 C_{v_1} + n_2 C_{v_2}}{n_1 + n_2}$$

$$\boxed{\gamma_{mix} = \frac{n_1 C_{p_1} + n_2 C_{p_2}}{n_1 C_{v_1} + n_2 C_{v_2}}}$$

Mean Free Path

$$\lambda = \frac{1}{\sqrt{2}\pi n d^2}$$