



States of Matter

Gas's Law

Boyle's law:

$$V \propto \frac{1}{P} (n, T = \text{const}) \quad \boxed{P_1 V_1 = P_2 V_2}$$

Charle's law:

$$V \propto T (n, P = \text{const}) \quad \frac{V_2}{V_1} = \frac{T_2}{T_1}$$

Gay lussac's law:

$$P \propto T (n, V = \text{const}) \quad \frac{P_2}{P_1} = \frac{T_2}{T_1}$$

Avogadro's law:

$V \propto \text{moles} \propto \text{number of molecules} (P, T = \text{const})$

Ideal gas equation $PV = nRT$

$R = 0.0821 \text{ L atm mol}^{-1} \text{ K}^{-1}$

$R = 8.314 \text{ J K}^{-1} \text{ mol}^{-1}$

$R = 2 \text{ cal K}^{-1} \text{ mol}^{-1}$, $R = 8.314 \times 10^7 \text{ erg K}^{-1} \text{ mol}^{-1}$

Graham's Diffusion Law

It is applicable for non reacting gases

$$r \propto \frac{1}{\sqrt{d}}; r \propto \frac{1}{\sqrt{VD}}; r \propto \frac{1}{\sqrt{M_w}} (P, T = \text{constant})$$

$$VD = \frac{d_{\text{gas}}}{d_{\text{H}_2}} = \frac{M_w}{2}$$

Rate of diffusion

$$r = \frac{l_{\text{diffused gas}}}{t_{\text{time taken}}}; r = \frac{V_{\text{diffused gas}}}{t_{\text{time taken}}}; r = \frac{n_{\text{diffused gas}}}{t_{\text{time taken}}}$$

(When, l = distance traveled by diffused gas)

Kinetic Gas Equation : $PV = \frac{1}{3} nN V_{\text{rms}}^2$

Dalton's Law of Partial Pressure

$$P_{\text{mixture}} = P_1 + P_2 + P_3 \dots (T \& V \text{ const.})$$

Partial pressure

$$P_{\text{moist gas}} = P_{\text{dry gas}} + P_{\text{water vapours}}$$

It is applicable for non reacting gases.

Methods of determination of partial pressure

(P_A & P_B are partial pressure)

❖ From ideal gas equation

$$P_A V = n_A RT \& P_B V = n_B RT$$

❖ In the form of mole fraction.

$$P_A = X_A P_T = \frac{n_A}{n_T} P_T;$$

$$P_B = X_B P_T = \frac{n_B}{n_T} P_T$$

$$[X_A + X_B = 1]$$

P_T = sum of partial pressure of all gases

Average Kinetic Energy (KE_{av})

$$K.E_{\text{av}} = \frac{3}{2} nRT \quad (n \text{ moles})$$

$$K.E_{\text{av}} = \frac{3}{2} RT \quad (1 \text{ mol or } N_A \text{ molecules})$$

$$K.E_{\text{av}} = \frac{3}{2} KT \quad (1 \text{ molecule})$$

$$K_B = 1.38 \times 10^{-23} \text{ JK}^{-1} \text{ molecule}^{-1}$$

K_B is called Boltzmann constant

$$u_{\text{ü}} = \sqrt{\frac{v_{\text{ü}}^2 + v + \dots v}{N}}$$

$$u_{\text{av}} = \frac{v_1 + v_2 + v_3 \dots v_n}{N}$$

$$u_{\text{rms}} = \sqrt{\frac{3RT}{Mw}}; u_{\text{av}} = \sqrt{\frac{8}{\pi} \frac{RT}{Mw}}; u_{\text{mp}} = \sqrt{\frac{2RT}{Mw}}$$

$$u_{\text{rms}} = \sqrt{\frac{3PV}{Mw}}; u_{\text{av}} = \sqrt{\frac{8}{\pi} \frac{PV}{Mw}}; u_{\text{mp}} = \sqrt{\frac{2PV}{Mw}}$$

$$u_{\text{rms}} = \sqrt{\frac{3P}{d}}; u_{\text{av}} = \sqrt{\frac{8}{\pi} \frac{P}{d}}; u_{\text{mp}} = \sqrt{\frac{2P}{d}}$$

❖ In the form of volume fraction.

$$P_A = \frac{V_A}{V} P_T \text{ \& } P_B = \frac{V_B}{V} P_T$$

❖ If individual pressure and individual volume are given

$$P_A = \frac{V_A}{V} P_1 \text{ and } P_B = \frac{V_B}{V} P_2$$

P_1, P_2 = pressure of gases before mixing

P_A, P_B = pressure of gases after mixing

$$u_{rms} : u_{av} : u_{mp} = \sqrt{3} : \sqrt{\frac{8}{\pi}} : \sqrt{2}$$

$$= 1 : 0.92 : 0.82$$

$$u_{mp} : u_{av} : u_{rms} = \sqrt{2} : \sqrt{\frac{8}{\pi}} : \sqrt{3}$$

$$= 1 : 1.128 : 1.224$$

Compressibility factor

$$(z) = \frac{(V_m)_{obs}}{V_l} = \frac{P(V_m)_{obs}}{RT}$$

IF $z = 1$, the gas show ideal gas behaviour.

IF $z > 1$, the gas show positive deviation.

IF $z < 1$, the gas show negative deviation.

Vanderwaal's Equation

Vanderwaal's Equation

$$\left(P + \frac{an^2}{V^2} \right) (V - nb) = nRT$$

$$P_i = P_R + \frac{an^2}{V^2} \Rightarrow P_i > P_R$$

a increases force of attraction increases

liquification increases;

b increases effective size of molecule increases,

incompressible volume increases,

compressible vol. decreases

❖ At high pressure, Vanderwaal's eqⁿ is

$$PV_m - Pb = RT$$

❖ At low pressure or Moderate pressure vanderwaal's eqⁿ is

$$PV_m + \frac{a}{V_m} = RT$$

❖ At very low pressure, high temp. Vanderwaal's Equation is

$$VP = nRT$$

Ideal gas behaviour.

❖ Gases having higher value of a ; will have higher T_c ; higher rate of liquefaction.