Properties of Gas Mixture :-

The Various properties of gas mixture such as pressure, Volume temperature, internal energy, enthalpy, entropy and special heats.

i) Pressure :-

Using Dalton's law of partial pressure, the pressure of a mixture is the sum of pressure of each component at the temperature and volume of the mixture.

ii) Volume :-

Using Amagat's law of partial volumes, the volume of mixture is the sum of Volume of each component at the temperature and pressure of the mixture.

iii) Temperature :-

At any uniform mixture, the temperature is the same for each component of the mixture.

$$T_m = T_A = T_B = T_C .$$

iv) Internal Energy :-

For a mixture of ideal gases, the internal energy is given by.

$$U_m = U_A(N_A, T_m) + U_B(N_B, T_m) + U_C(N_C, T_m) .$$

$$= \sum_{i=1}^{K} U_i$$

(6)

$$= \sum_{i=1}^{k} m_i u_i$$

$$\boxed{U_m = \sum_{i=1}^{k} N_i \bar{u}_i}$$

Internal energy of a gas mixture per unit mass is given by,

$$u_m = \frac{U_m}{m_m} = \frac{U_A + U_B + U_C}{m_m}$$

$$u_m = \frac{m_A u_A + m_B u_B + m_C u_C}{m_m}$$

$$u_m = \frac{m_A}{m_m} u_A + \frac{m_B}{m_m} u_B + \frac{m_C}{m_m} u_C$$

$$u_m = x_A u_A + x_B u_B + x_C u_C$$

$$\boxed{u_m = \sum_{i=1}^{k} x_i u_i}$$

where,

mass function, $x_i = \frac{m_i}{m_m}$

v) Enthalpy :-

For a mixture of ideal gases, enthalpy is given by,

$$H_m = H_A(N_A, T_m) + H_B(N_B, T_m) + H_C(N_C, T_m)$$

$$H_m = \sum_{i=1}^{k} H_i$$

$$H_m = \sum_{i=1}^{k} m_i h_i$$

$$\boxed{H_m = \sum_{i=1}^{k} N_i \bar{h}_i}$$

Enthalpy for a gas mixture per unit mass is given by,

$$h_m = \frac{H_m}{m} = \frac{m_A h_A + m_B h_B + m_C h_C}{m_m}$$

$$h_m = \frac{m_A}{m_m} h_A + \frac{m_B}{m_m} h_B + \frac{m_C}{m_m} h_C$$

$$h_m = x_A h_A + x_B h_B + x_C h_C$$

$$\boxed{h_m = \sum_{i=1}^{k} x_i h_i}$$

vi) Specific heats :-

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For a mixture of ideal gases, specific heats are given by,

volume, $C_{v_m} = \frac{m_A C_{v_A} + m_B C_{v_B} + m_C C_{v_C}}{m_m}$

$= \frac{m_A}{m_m} C_{v_A} + \frac{m_B}{m_m} C_{v_B} + \frac{m_C}{m_m} C_{v_C}$.

$= x_A C_{v_A} + x_B C_{v_B} + x_C C_{v_C}$.

$$C_{v_m} = \sum_{i=1}^{k} x_i C_{v_i}$$

Similarly, Pressure, $C_{p_m} = \frac{m_A}{m_m} C_{p_A} + \frac{m_B}{m_m} C_{p_B} + \frac{m_C}{m_m} C_{p_C}$.

$$C_{p_m} = \sum_{i=1}^{k} x_i C_{p_i}$$

vii) Gas Constant :-

$$R_m = \frac{m_A}{m_m} R_A + \frac{m_B}{m_m} R_B + \frac{m_C}{m_m} R_C.$$

The gas constant of the mixture can also be obtained by,

$$R_m = \frac{\bar{R}}{M_m}$$

M_m = molar mass of the mixture.

viii) Entropy :-

Gibbs theorem states that the total entropy of a mixture of gases is the sum of the partial entropies.

$$S_m = (S_A(N_A, P_A, T_m) + S_B(N_B, P_B, T_m) + S_C(N_C, P_C, T_m))$$

$$S_m = \sum_{i=1}^{k} S_i .$$

$$S_m = \sum_{i=1}^{k} m_i \bar{s}_i$$

$$S_m = \sum_{i=1}^{k} N_i \bar{s}_i$$

Entropy for a gas mixture per unit mass is given by.

$$s_m = \frac{S_m}{m_m} = \frac{m_A s_A + m_B s_B + m_C s_C}{m_m}.$$

$$= \frac{m_A}{m_m} s_A + \frac{m_B}{m_m} s_B + \frac{m_C}{m_m} s_C .$$

$$= x_A s_A + x_B s_B + x_C s_C .$$

$$s_m = \sum_{i=1}^{k} x_i s_i$$

Gibbs Function :-

(4)

Gibb's theorem states that the total energy of a mixture of gases is the sum of the partial entropies.

By Gibb's functions,

$$G = h - Ts.$$

$$dg = dh - d(Ts) \qquad \because d(uv) = udv - vdu.$$

$$dg = dh - Tds - sdT. \qquad \because h = u + PV.$$

$$dg = T\cancel{ds} + Vdp - T\cancel{ds} - sdT. \qquad dh = Tds + V\,dp.$$

$$\boxed{dg = Vdp - sdT.}$$