

Gaseous Mixture.

If two non-reactive gases are enclosed in a vessel of volume V. In the mixture μ_1 moles of one gas are mixed with μ_2 moles of another gas. If N_A is Avogadro's number then

$$\text{Number of molecules of first gas } N_1 = \mu_1 N_A$$

$$\text{and number of molecules of second gas } N_2 = \mu_2 N_A$$

(i) Total mole fraction $\mu = (\mu_1 + \mu_2)$.

(ii) If M_1 is the molecular weight of first gas and M_2 that of second gas.

$$M = \frac{\mu_1 M_1 + \mu_2 M_2}{\mu_1 + \mu_2}$$

Then molecular weight of mixture will be

(iii) Specific heat of the mixture at constant volume will be

$$C_{V_{mix}} = \frac{\mu_1 C_{V_1} + \mu_2 C_{V_2}}{\mu_1 + \mu_2} = \frac{\mu_1 \left(\frac{R}{\gamma_1 - 1} \right) + \mu_2 \left(\frac{R}{\gamma_2 - 1} \right)}{\mu_1 + \mu_2} = \frac{R}{\mu_1 + \mu_2} \left[\frac{\mu_1}{\gamma_1 - 1} + \frac{\mu_2}{\gamma_2 - 1} \right]$$

$$C_{V_{mix}} = \frac{R}{\frac{m_1}{M_1} + \frac{m_2}{M_2}} \left[\frac{m_1 / M_1}{\gamma_1 - 1} + \frac{m_2 / M_2}{\gamma_2 - 1} \right]$$

\therefore

$$C_{P_{mix}} = \frac{\mu_1 C_{P_1} + \mu_2 C_{P_2}}{\mu_1 + \mu_2}$$

(iv) Specific heat of the mixture at constant pressure will be

$$\Rightarrow C_{P_{mix}} = \frac{\mu_1 \left(\frac{\gamma_1}{\gamma_1 - 1} \right) R + \mu_2 \left(\frac{\gamma_2}{\gamma_2 - 1} \right) R}{\mu_1 + \mu_2} = \frac{R}{\mu_1 + \mu_2} \left[\mu_1 \left(\frac{\gamma_1}{\gamma_1 - 1} \right) + \mu_2 \left(\frac{\gamma_2}{\gamma_2 - 1} \right) \right]$$

$$C_{P_{mix}} = \frac{R}{\frac{m_1}{M_1} + \frac{m_2}{M_2}} \left[\frac{m_1}{M_1} \left(\frac{\gamma_1}{\gamma_1 - 1} \right) + \frac{m_2}{M_2} \left(\frac{\gamma_2}{\gamma_2 - 1} \right) \right]$$

\therefore

$$(v) \quad \gamma_{\text{mixture}} = \frac{C_{P_{mix}}}{C_{V_{mix}}} = \frac{\frac{(\mu_1 C_{P_1} + \mu_2 C_{P_2})}{\mu_1 + \mu_2}}{\frac{(\mu_1 C_{V_1} + \mu_2 C_{V_2})}{\mu_1 + \mu_2}} = \frac{\mu_1 C_{P_1} + \mu_2 C_{P_2}}{\mu_1 C_{V_1} + \mu_2 C_{V_2}} = \frac{\left\{ \mu_1 \left(\frac{\gamma_1}{\gamma_1 - 1} \right) R + \mu_2 \left(\frac{\gamma_2}{\gamma_2 - 1} \right) R \right\}}{\left\{ \mu_1 \left(\frac{R}{\gamma_1 - 1} \right) + \mu_2 \left(\frac{R}{\gamma_2 - 1} \right) \right\}}$$

$$\gamma_{\text{mixture}} = \frac{\frac{\mu_1 \gamma_1}{\gamma_1 - 1} + \frac{\mu_2 \gamma_2}{\gamma_2 - 1}}{\frac{\mu_1}{\gamma_1 - 1} + \frac{\mu_2}{\gamma_2 - 1}} = \frac{\mu_1 \gamma_1 (\gamma_2 - 1) + \mu_2 \gamma_2 (\gamma_1 - 1)}{\mu_1 (\gamma_2 - 1) + \mu_2 (\gamma_1 - 1)}$$

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