Question: \( y_A \, A + y_B \, B \rightarrow y_C + y_D \)

A, B, C, D are gases

\( \gamma_i \) = stoichiometric coefficients

**mixture**

\[ G = \sum_{i=1}^{m} M_i \, \eta_i \]

\( \eta_i \) = chemical potential of \( i^{th} \) component

? \( M_i < M_i \) (T, P, composition)

**Ideal Gases: Mixture**

What is \( M_A(\text{mixture}, T, P_{\text{tot}}) \)?
\[ M_A(T, P_{\text{tot}}, \text{mixture}) = M_A(T, P_{\text{tot}}, \text{pure}) \]

\[ X_A P_{\text{tot}} = P \quad \text{Pressure exerted by pure A} \]

\[ M_A(T, P_{\text{tot}}, \text{mixture}) = M_A(T, X_A P_{\text{tot}}, \text{pure}) \]

\[ = M_A(T, P^o) + RT \ln \left( \frac{X_A P_{\text{tot}}}{P^o} \right) \]

\[ M_A(T, P_{\text{tot}}, \text{mixture}) = M_A(T, P^o) + RT \ln \left( \frac{P_{\text{tot}}}{P^o} \right) \]

\[ + RT \ln X_A \]

\[ M_A(\text{mixture}) < M_A(\text{pure}) \]

at same \( T \) & \( P_{\text{tot}} \)

So what? relate to \[ G \]
Initially, we have $G$ after $G$ occurs

$G$ initially $G$ occurs $G$ after $G$ occurs

$A \neq B \\
B \neq C \\
A \neq C$

$D + C + B = \frac{1}{3} C + (C + B)$

$G = \frac{1}{3} G \cdot N.$
Initially: \( \mathbf{G}_0 = \Sigma M_i N_i \)

\[
\begin{align*}
M_A \eta_A^0 + M_B \eta_B^0 + M_C \eta_C^0 + M_D \eta_D^0
\end{align*}
\]

After \( \varepsilon \) of rxn.

small \( \varepsilon \) so \( M_A \) remains constant.

\[
\begin{align*}
\eta_A &= \eta_A^0 + \nu_A \varepsilon \\
\eta_C &= \eta_C^0 + \nu_C \varepsilon \\
\eta_B &= \eta_B^0 + \nu_B \varepsilon \\
\eta_D &= \eta_D^0 + \nu_D \varepsilon
\end{align*}
\]

\[
\begin{align*}
G(\varepsilon) &= M_A \eta_A + M_B \eta_B + M_C \eta_C + M_D \eta_D \\
G(\varepsilon) &= M_A(\eta_A^0 + \nu_A \varepsilon) + M_B(\eta_B^0 + \nu_B \varepsilon) + M_C(\eta_C^0 + \nu_C \varepsilon) + M_D(\eta_D^0 + \nu_D \varepsilon)
\end{align*}
\]

\[
\begin{align*}
G(\varepsilon) - G &= \varepsilon \left[ M_A \nu_A + M_B \nu_B + M_C \nu_C + M_D \nu_D \right]
\end{align*}
\]

\[
\begin{align*}
\frac{G(\varepsilon) - G}{\varepsilon} &= \left[ M_A \nu_A + M_B \nu_B + M_C \nu_C + M_D \nu_D \right]
\end{align*}
\]

\[
\begin{align*}
\lim_{\varepsilon \to 0} \frac{dG}{d\varepsilon} &= M_A \nu_A + M_B \nu_B + M_C \nu_C + M_D \nu_D = 0
\end{align*}
\]
\[ M_A = M_A^0 + R T \ln \left( \frac{p_A}{p_0} \right) \quad \rho_A = x_A \rho^0 \]

\[ M_B = M_0 + R T \ln \left( \frac{p_0}{p_0} \right) \quad \rho_B = x_B \rho^0 \]

\[ \nabla_M \left[ M_A^0 + R T \ln \left( \frac{p_A^0}{p_0} \right) \right] + \nabla_B \left[ M_0 + R T \ln \left( \frac{p_0}{p_0} \right) \right] + c-t c-m + D-t c-m \]

\[ = 0 \]

\[ \nabla_M \left[ M_A \left( p_A, T, \rho \right) + 2^a M_0 \left( p_0, T \right) + 2^c M_c \left( p_c, T \right) + 2^d M_d \left( p_d, T \right) \right] \]

\[ \Delta G^0 \]

\[ + R T \ln \left( \frac{p_0}{p_0} \right)^{2^a} + R T \ln \left( \frac{p_0}{p_0} \right)^{2^b} + R T \ln \left( \frac{p_0}{p_0} \right)^{2^c} + R T \ln \left( \frac{p_0}{p_0} \right)^{2^d} \]

\[ \Delta G^0 = -R T \left[ \ln \left( \frac{p_0}{p_0} \right)^{2^a} + \ln \left( \frac{p_0}{p_0} \right)^{2^b} + \ln \left( \frac{p_0}{p_0} \right)^{2^c} + \ln \left( \frac{p_0}{p_0} \right)^{2^d} \right] \]
\[ \Delta G^0 = -RT \ln \left\{ \left( \frac{P_A}{P} \right)^{v_A} \left( \frac{P_B}{P} \right)^{v_B} \left( \frac{P_C}{P} \right)^{v_C} \right\} \]

\[ \Delta G^0 = -RT \ln \left\{ \frac{b_A b_B}{(P_A)^{v_A} (P_B)^{v_B}} \right\} \]

\[ K_p = \frac{P_A^{v_A} P_B^{v_B}}{P_C^{v_C} P_D^{v_D}} \]

Equilibrium Constant