Formulario[1]	$m_m = \sum_{i=1}^{N} m_i$	$n_m = \sum_{i=1}^{N} n_i$	$m_i = n_i M_i$	$M_m = \dfrac{m_m}{n_m}$
$y_i = \dfrac{n_i}{n_m}$	$\sum_{i=1}^{N} y_i = 1$	$g_i = m f_i = \dfrac{m_i}{m_m}$	$\sum_{i=1}^{N} g_i = 1$	$R_m = \dfrac{R}{M_m}$
$y_i = \dfrac{\%V_i}{100}$	$M_m = \sum_{i=1}^{N} y_i M_i$	$g_i = y_i \dfrac{M_i}{M_m}$	$\%m_i = 100 g_i$	$R_m = \dfrac{1}{\sum_{i=1}^{N} \dfrac{y_i}{R_i}}$
$g_i = \dfrac{\%m_i}{100}$	$M_m = \dfrac{1}{\sum_{i=1}^{N} \dfrac{g_i}{M_i}}$	$y_i = g_i \dfrac{M_m}{M_i}$	$\%V_i = 100 y_i$	$R_m = \sum g_i R_i$

Dalton: $\boxed{P_m = \sum_{i=1}^{N} P_i}$ $\boxed{y_i = \dfrac{P_i}{P_m}}$ **Amagat**: $\boxed{V_m = \sum_{i=1}^{N} V_i}$ $\boxed{y_i = \dfrac{V_i}{V_m}}$ $\boxed{T_i = T_m \text{ para ambos modelos}}$

$\boxed{U_m = n_m \bar{u}_m = \sum_{i=1}^{N} n_i \bar{u}_i = m_m u_m = \sum_{i=1}^{N} m_i u_i}$ $\boxed{\bar{u}_m = \sum_{i=1}^{N} y_i \bar{u}_i}$ $\boxed{u_m = \sum_{i=1}^{N} g_i u_i}$

$\bar{C}_{v0}$ variable: $\boxed{\begin{cases} \bar{u}_i(T) : \text{valor leído en las Tablas A-12 a A-19} \\ \bar{u}_i(T) = 100 \int_{\theta_{ref}}^{\theta_T} \bar{C}_{p0,i}(\theta)\, d\theta - \bar{R}T \text{ (Tabla A-9) (hidrocarburos)} \\ \bar{u}_i(T) = C_{v0,i} M_i (T - T_{ref}) \text{ (Tabla A-8) (gases monoatómicos)} \end{cases}}$

$\bar{C}_{v0}$ constante: $\boxed{\bar{u}_m = \bar{C}_{v0_m} T_m}$ $\boxed{\bar{C}_{v0_m} = \sum_{i=1}^{N} y_i \bar{C}_{v0,i} = \sum_{i=1}^{N} y_i C_{v0,i} M_i \text{ (Tabla A-8) (todos los gases)}}$

$\boxed{H_m = n_m \bar{h}_m = \sum_{i=1}^{N} n_i \bar{h}_i = m_m h_m = \sum_{i=1}^{N} m_i h_i}$ $\boxed{\bar{h}_m = \sum_{i=1}^{N} y_i \bar{h}_i}$ $\boxed{h_m = \sum_{i=1}^{N} g_i h_i}$

$\bar{C}_{p0}$ variable: $\boxed{\begin{cases} \bar{h}_i(T) : \text{valor leído en las Tablas A-12 a A-19} \\ \bar{h}_i(T) = 100 \int_{\theta_{ref}}^{\theta_T} \bar{C}_{p0,i}(\theta)\, d\theta \text{ (Tabla A-9) (hidrocarburos)} \\ \bar{h}_i(T) = C_{p0,i} M_i (T - T_{ref}) \text{ (Tabla A-8) (gases monoatómicos)} \end{cases}}$

$\bar{C}_{p0}$ constante: $\boxed{\bar{h}_m = \bar{C}_{p0_m} T_m}$ $\boxed{\bar{C}_{p0_m} = \sum_{i=1}^{N} y_i \bar{C}_{p0,i} = \sum_{i=1}^{N} y_i C_{p0,i} M_i \text{ (Tabla A-8) (todos los gases)}}$

Si C_{v0} y C_{p0_m} se consideran constantes: $\boxed{C_{v0_m} = \sum_{i=1}^{N} g_i C_{v0,i}}$ $\boxed{C_{p0_m} = \sum_{i=1}^{N} g_i C_{p0,i}}$

$\boxed{\Delta S_m = \sum_{i=1}^{N} n_i \Delta \bar{s}_i}$ $\boxed{\Delta \bar{s}_i = \bar{s}_i(T_{m2}, P_{m2}) - \bar{s}_i(T_{m1}, P_{m1}) = \bar{s}^0_{i,2} - \bar{s}^0_{i,1} - \bar{R} \ln \dfrac{P_{m2} y_{i,2}}{P_{m1} y_{i,1}}}$

$\boxed{S_m = \sum_{i=1}^{N} n_i \bar{s}_i(T_m, P_m)}$ $\boxed{\bar{s}_i(T_m, P_m) = \bar{s}^0_i(T_m) - \bar{s}^0_i(T_{ref}) - \bar{R} \ln \dfrac{P_m y_i}{P_{ref}}}$

$\bar{C}_{p0}$ variable: $\boxed{\begin{cases} \bar{s}^0_i(T_m) : \text{valor leído en las Tablas A-12 a A-19} \\ \bar{s}^0_i(T_m) = \displaystyle\int_{\theta_{ref}}^{\theta_{T_m}} \frac{\bar{C}_{p0,i}(\theta)}{\theta} d\theta \text{ (Tabla A-9) (hidrocarburos)} \\ \bar{s}^0_i(T_m) = C_{p0,i} M_i \ln\left(\dfrac{T_m}{T_{ref}}\right) \text{ (Tabla A-8) (gases monoatómicos)} \end{cases}}$

$\bar{C}_{p0}$ constante: $\boxed{\bar{s}^0_i(T_m) = C_{p0,i} M_i \ln\left(\dfrac{T_m}{T_{ref}}\right) \text{ (Tabla A-8) (todos los gases)}}$

GAS REAL $\boxed{P_m V_m = Z_m m_m R_m T_m}$ $\boxed{P_m v_m = Z_m R_m T_m}$ $\boxed{P_m \bar{v}_m = Z_m \bar{R} T_m}$

Regla de Kay $\boxed{Z_m = Z(P_{r_m}, T_{r_m})}$ $\boxed{P_{c,m} = \sum_{i=1}^{N} y_i P_{c,i}}$ $\boxed{P_{r,m} = \dfrac{P_m}{P_{c,m}}}$ $\boxed{T_{c,m} = \sum_{i=1}^{N} y_i T_{c,i}}$ $\boxed{T_{r,m} = \dfrac{T_m}{T_{c,m}}}$

$\boxed{v_{r,i,m} = \dfrac{V_m P_{c,m}}{n_m \bar{R} T_{c,m}}}$ **Tablas:** $\boxed{H_m = \sum n_i \bar{h}^*_i - n_m D \bar{h}_m \bar{R} T_{c,m}}$ $\boxed{U_m = H_m - P_m V_m}$ $\boxed{S_m = \sum n_i \bar{s}^*_i - n_m D \bar{s}_m \bar{R}}$

[1] Prof. José Luis Rodríguez Pérez - jlrodriguez@ieee.org - julio del 2003

Repaso Termodinámica I

$$\boxed{\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{n-1}{n}} = \left(\frac{v_1}{v_2}\right)^{n-1}} \qquad \boxed{C_p - C_v = R} \qquad \boxed{k = \frac{C_p}{C_v}} \qquad \boxed{k_m = \frac{C_{p,m}}{C_{v,m}}}$$

$$\boxed{\delta w_{rev} = Pdv} \qquad \boxed{\delta q_{rev} = Tds} \qquad \boxed{(\delta q - \delta w = du)_{sistema}}$$

$$\boxed{W_{(n=1)} = mRT \ln\left(\frac{P_1}{P_2}\right)} \qquad \boxed{W_{(n\neq 1)} = \frac{P_2V_2 - P_1V_1}{1-n} = mR\frac{T_2 - T_1}{1-n}}$$

Mezclas Reales de Gases: Proceso de Llenado

Asumiendo que se tiene un tanque en el cual es posible cualquier tipo de interacción mecánica (W) y térmica (Q).

Supóngase también que los componentes involucrados en el proceso se dividen en:

A) Componentes que inicialmente están en el tanque y también en la línea de llenado.

B) Componentes que inicialmente solo están en el tanque.

C) Componentes que inicialmente solo están en la línea de llenado.

Ecuaciones de continuidad: $\boxed{\sum n_{e,A} = \sum n_{2,A} - \sum n_{1,A}}$, $\boxed{\sum n_{2,B} = \sum n_{1,B}}$ y $\boxed{\sum n_{2,C} = \sum n_{e,C}}$

Primera Ley de la Termodinámica:

$$\begin{aligned} Q_{1\to 2} - W_{1\to 2} &= \sum n_{2,A}\left(\bar{h}_{2,A} - \bar{h}_{e,A}\right) - \sum n_{1,A}\left(\bar{h}_{1,A} - \bar{h}_{e,A}\right) + && \text{(1a)}\\ &\quad \sum n_{2,C}\left(\bar{h}_{2,C} - \bar{h}_{e,C}\right) + \sum n_{1,B}\left(\bar{h}_{2,B} - \bar{h}_{1,B}\right) - && \text{(1b)}\\ &\quad \bar{R}\left(n_2 D\bar{h}_2 T_{c,2} - n_1 D\bar{h}_1 T_{c,1} - n_e D\bar{h}_e T_{c,e}\right) - && \text{(1c)}\\ &\quad (P_2V_2 - P_1V_1) && \text{(1d)} \end{aligned}$$

Donde: $\bar{h}_b - \bar{h}_a = \begin{cases} MCp_o\left(T_b - T_a\right) & Cp_o \text{ constante, Tabla A-8} \\ M\left(h_b - h_a\right) & \text{Tabla A-10} \\ \bar{h}_b - \bar{h}_a & \text{Tablas A-12} \to \text{A-19} \\ 100\int_{\theta_a}^{\theta_b} \bar{C}p_o\left(\theta\right) d\theta & \text{Tabla A-9} \end{cases}$

Segunda Ley de la Termodinámica:

$$\begin{aligned} \Delta S_U &= \sum n_{2,A}\left(\bar{s}_{2,A} - \bar{s}_{e,A}\right) - \sum n_{1,A}\left(\bar{s}_{1,A} - \bar{s}_{e,A}\right) + && (2)\\ &\quad \sum n_{2,C}\left(\bar{s}_{2,C} - \bar{s}_{e,C}\right) + \sum n_{1,B}\left(\bar{s}_{2,B} - \bar{s}_{1,B}\right) - && (3)\\ &\quad \bar{R}\left(n_2 D\bar{s}_2 - n_1 D\bar{s}_1 - n_e D\bar{s}_e\right) - \frac{Q_{vc}}{T_o} && (4) \end{aligned}$$

Donde:

$$\bar{s}_b - \bar{s}_a = \begin{cases} MCp_o \ln\left(\dfrac{T_b}{T_a}\right) - \bar{R}\ln\left(\dfrac{P_{m,b}y_b}{P_{m,a}y_a}\right) & Cp_o \text{ constante, Tabla A-8} \\ M\left(s_b^o - s_a^o\right) - \bar{R}\ln\left(\dfrac{P_{m,b}y_b}{P_{m,a}y_a}\right) & \text{Tabla A-10} \\ \bar{s}_b^o - \bar{s}_a^o - \bar{R}\ln\left(\dfrac{P_{m,b}y_b}{P_{m,a}y_a}\right) & \text{Tablas A-12} \to \text{A-19} \\ \int_{\theta_a}^{\theta_b} \dfrac{\bar{C}p_o\left(\theta\right)}{\theta} d\theta - \bar{R}\ln\left(\dfrac{P_{m,b}y_b}{P_{m,a}y_a}\right) & \text{Tabla A-9} \end{cases} \qquad (5)$$