Relationships FOR MIDTERM #2 CHEMISTRY 163B

definitions for U, H, A, and G (student fills in at exam time):

total differentials for: dU, dH, dA, and dG (student fills in at exam time):

For reversible adiabatic path, ideal gas:

- $T_1^{\frac{\overline{C}_V}{R}} V_1 = T_2^{\frac{\overline{C}_V}{R}} V_2$ (adiabatic reversible path)
- $P_1 V_1^{\frac{\overline{C}_P}{\overline{C}_V}} = P_2 V_2^{\frac{\overline{C}_P}{\overline{C}_V}}$ (adiabatic reversible path, PV $^{\gamma}$ = constant)
- $\dfrac{T_1^{\frac{\overline{C}_P}{R}}}{P_1} = \dfrac{T_2^{\frac{\overline{C}_P}{R}}}{P_2}$ (adiabatic reversible path)

Energy and enthalpy:

- $(\Delta H_{reaction})_T = \Delta U_{reaction} + \Delta n_{gas} RT$
- $\left(\dfrac{\partial H}{\partial T}\right)_P = C_p = n\overline{C}_p; \qquad \Delta H(T_2) = \Delta H(T_1) + \int_{T_1}^{T_2} \Delta C_P dT$

For ideal gas:

- $\Delta U = C_V \Delta T = n\overline{C}_V \Delta T$
- $\Delta H = C_P \Delta T = n\overline{C}_P \Delta T$
- $\left(\overline{C}_P - \overline{C}_V\right) = R$
- $\overline{C}_V = \dfrac{3}{2} R \quad (monatomic\ ideal\ gas)$

For ideal, reversible, Carnot Engine:

- $\varepsilon = \dfrac{-w_{total}}{q_H} = 1 - \dfrac{T_L}{T_H}$

Some entropy relationships:

- $\left(\dfrac{\partial S}{\partial T}\right)_p = \dfrac{C_P}{T} = \dfrac{n\overline{C}_P}{T} \quad ; \quad \left(\dfrac{\partial S}{\partial T}\right)_V = \dfrac{C_V}{T} = \dfrac{n\overline{C}_V}{T}$
- $\Delta S_{mixing,\, ideal\ gasses} = -n_{total} R \sum_i X_i \ln X_i \quad (where\ X_i\ is\ mole\ fraction\ component\ i)$

[see reverse side for more relationships]:

Free energy relationships:

- $\Delta G = \Delta G^\circ + \underline{R}T \ln Q$
- $\Delta G^\circ = -\underline{R}T \ln K_{eq}$
- $\left(\frac{\partial \ln K_{eq}}{\partial T}\right)_P = \frac{\Delta H^\circ}{\underline{R}T^2}$
- $\ln\left[\frac{(K_{eq})_{T2}}{(K_{eq})_{T1}}\right] = \frac{\Delta H^\circ}{\underline{R}}\left(\frac{1}{T_1} - \frac{1}{T_2}\right)$

Partial molar properties:

- $\bar{V}_i = \left(\frac{\partial V}{\partial n_i}\right)_{T,P,n_j \neq n_i}$
- $\bar{G}_i = \mu_i = \left(\frac{\partial G}{\partial n_i}\right)_{T,P,n_j \neq n_i}$
- $V = \sum_i^N n_i \bar{V}_i$
- $X_A \left(\frac{\partial \bar{V}_A}{\partial n_A}\right)_{T,P,n_B} = -X_B \left(\frac{\partial \bar{V}_B}{\partial n_A}\right)_{T,P,n_B}$ **Gibbs-Duhem for volume of two-component system**

Although these relationships for partial molar quantities 'made their way' onto the 'Relationships' page provided on midterm #2, the material on partial molar quantities (lecture 16) **IS NOT INCLUDED ON THIS MIDTERM** *(will see it on CHEM 163B final)*