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:

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

Energy and enthalpy:

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

For ideal gas:

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

For ideal, reversible, Carnot Engine:

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

Some entropy relationships:

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

[see reverse side for more relationships]:

Free energy relationships:

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

Partial molar properties:

- $\bar{\boldsymbol{V}}_i = \left(\frac{\partial \boldsymbol{V}}{\partial \boldsymbol{n}_i}\right)_{T,P,n_j \neq n_i}$
- $\bar{\boldsymbol{G}}_i = \boldsymbol{\mu}_i = \left(\frac{\partial \boldsymbol{G}}{\partial \boldsymbol{n}_i}\right)_{T,P,n_j \neq n_i}$
- $\boldsymbol{V} = \sum_{i}^{N} \boldsymbol{n}_i \bar{\boldsymbol{V}}_i$
- $\boldsymbol{X}_A \left(\frac{\partial \bar{\boldsymbol{V}}_A}{\partial \boldsymbol{n}_A}\right)_{T,P,n_B} = -\boldsymbol{X}_B \left(\frac{\partial \bar{\boldsymbol{V}}_B}{\partial \boldsymbol{n}_A}\right)_{T,P,n_B}$ ***Gibbs-Duhem for volume of two-component system***