CHEM 331
Physical Chemistry
Revision 1.0

Basic Thermodynamic Equations

$$C_v = \left(\frac{\partial U}{\partial T}\right)_V = T\left(\frac{\partial S}{\partial T}\right)_V = -T\left(\frac{\partial P}{\partial T}\right)_V \left(\frac{\partial V}{\partial T}\right)_S$$

$$C_P = \left(\frac{\partial H}{\partial T}\right)_P = T\left(\frac{\partial S}{\partial T}\right)_P = T\left(\frac{\partial V}{\partial T}\right)_P \left(\frac{\partial P}{\partial T}\right)_S$$

$$C_P - C_V = \left[P + \left(\frac{\partial U}{\partial V}\right)_T\right]\left(\frac{\partial V}{\partial T}\right)_P = \frac{\alpha^2 TV}{\varkappa}$$

$$\left(\frac{\partial C_V}{\partial V}\right)_T = T\left(\frac{\partial^2 P}{\partial T^2}\right)_V$$

$$\left(\frac{\partial C_P}{\partial P}\right)_T = -T\left(\frac{\partial^2 V}{\partial T^2}\right)_P$$

$$\gamma = \frac{C_P}{C_V}$$

$$\mu_{JT} = \left(\frac{\partial T}{\partial P}\right)_H = \frac{V}{C_P}(\alpha T - 1)$$

$$\eta = \left(\frac{\partial T}{\partial V}\right)_U = -\frac{1}{C_V}\left(\frac{\alpha T}{\varkappa} - P\right)$$

First Derivatives of T, P, V, and S

$$\left(\frac{\partial T}{\partial P}\right)_V = \frac{\varkappa}{\alpha} \qquad \left(\frac{\partial T}{\partial P}\right)_S = \frac{V\alpha T}{C_P} = \frac{(\gamma-1)\varkappa}{\gamma\alpha}$$

$$\left(\frac{\partial T}{\partial V}\right)_P = \frac{1}{V\alpha} \qquad \left(\frac{\partial T}{\partial V}\right)_S = -\frac{\alpha T}{C_V\varkappa} = -\frac{\gamma-1}{V\alpha}$$

$$\left(\frac{\partial T}{\partial S}\right)_P = \frac{T}{C_P} \qquad \left(\frac{\partial T}{\partial S}\right)_V = \frac{T}{C_V}$$

$$\left(\frac{\partial P}{\partial T}\right)_V = \frac{\alpha}{\varkappa} \qquad \left(\frac{\partial P}{\partial T}\right)_S = \frac{C_P}{V\alpha T} = \frac{\gamma\alpha}{(\gamma-1)\varkappa}$$

$$\left(\frac{\partial P}{\partial V}\right)_T = -\frac{1}{V\varkappa} \qquad \left(\frac{\partial P}{\partial V}\right)_S = -\frac{\gamma}{V\varkappa}$$

$$\left(\frac{\partial P}{\partial S}\right)_T = -\frac{1}{V\alpha} \qquad \left(\frac{\partial P}{\partial S}\right)_V = \frac{\alpha T}{C_V\varkappa} = \frac{\gamma-1}{V\alpha}$$

$$\left(\frac{\partial V}{\partial T}\right)_P = V\alpha \qquad \left(\frac{\partial V}{\partial T}\right)_S = -\frac{C_V\varkappa}{\alpha T} = -\frac{V\alpha}{\gamma-1}$$

$$\left(\frac{\partial V}{\partial P}\right)_T = -V\varkappa \qquad \left(\frac{\partial V}{\partial P}\right)_S = -\frac{V\varkappa}{\gamma}$$

$$\left(\frac{\partial V}{\partial S}\right)_T = \frac{\varkappa}{\alpha} \qquad \left(\frac{\partial V}{\partial S}\right)_P = \frac{V\alpha T}{C_P} = \frac{(\gamma-1)\varkappa}{\gamma\alpha}$$

$$\left(\frac{\partial S}{\partial T}\right)_V = \frac{C_V}{T} \qquad \left(\frac{\partial S}{\partial T}\right)_P = \frac{C_P}{T}$$

$$\left(\frac{\partial S}{\partial P}\right)_T = -V\alpha \qquad \left(\frac{\partial S}{\partial P}\right)_V = \frac{C_V\varkappa}{\alpha T} = \frac{V\alpha}{\gamma-1}$$

$$\left(\frac{\partial S}{\partial V}\right)_P = \frac{C_P}{V\alpha T} = \frac{\gamma\alpha}{(\gamma-1)\varkappa} \qquad \left(\frac{\partial S}{\partial V}\right)_T = \frac{\alpha}{\varkappa}$$