# Raoult's Law

$$\mu = \mu^{\ominus} + RT \ln \frac{P}{1 \text{ bar}}$$

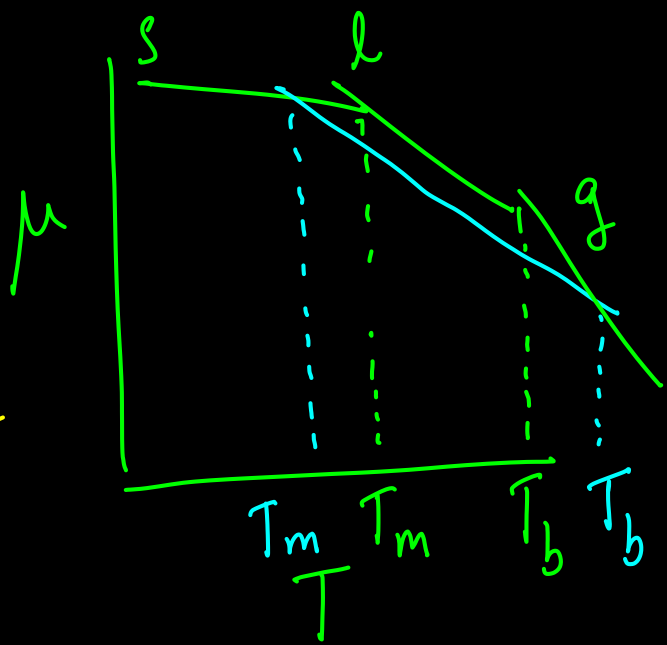
$$\mu_A^*(l) = \mu_A^{\ominus} + RT \ln P_A^*$$

$$\mu_A(l) = \mu_A^{\ominus} + RT \ln P_A$$

$$\mu_A(l) = \mu_A^* + RT \ln P_A/P_A^*$$

$$\mu_A = \mu_A^* + RT \ln x_A$$

$$K = \frac{RT^{*2}}{\Delta H_{trs}}$$




$$\Delta T = K x_B$$

mole fraction of the solute

# Gibbs-Helmholtz Equation

$$\left(\frac{\partial}{\partial T}\frac{G}{T}\right)_p = -\frac{H}{T^2}$$

$$\frac{1}{T}\left(\frac{\partial G}{\partial T}\right)_p + G\,\frac{d\,1/T}{dT}$$

$$\frac{1}{T}\left[\left(\frac{\partial G}{\partial T}\right)_p - \frac{G}{T}\right] = -\frac{1}{T}\left[S + \frac{G}{T}\right]$$

$$= -\frac{1}{T}\left[\frac{H}{T}\right]$$

# Phase Rule

$$\mu_J(\alpha; P, T) = \mu_J(\beta; P, T)$$

$$f = 1$$

$$\mu_J(\alpha; P, T) = \mu_J(\beta; P, T) = \mu_J(\gamma; P, T)$$

$$f = 0$$

3 eqns. 2 unknowns

## General case

$$P \;\&\; T = 2$$

$$P(C-1) + 2$$

At $\mu_J(\alpha) = \mu_J(\beta) = \mu_J(\gamma) = \cdots$

$$C(P-1) \text{ eqns.}$$

$$P(C-1) + 2 - C(P-1)$$

$$PC - P + 2 - CP + C$$

$$\boxed{F = C - P + 2}$$ Phase Rule

Thermal decomposition of $NH_4Cl$

$$NH_4Cl\,(s) \rightleftharpoons NH_3\,(g) + HCl\,(g)$$

$$C = 1$$

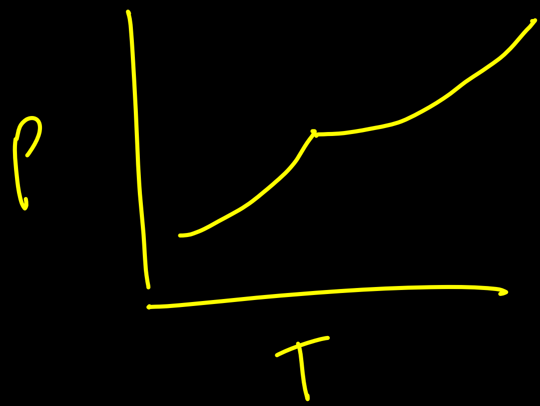
Add $HCl$ ($NH_3$) from outside, $C = 2$

$s \leftrightarrow v$

$$\log p\,(\text{torr}) = 10.5916 - 1871.2/T(K)$$

$l \leftrightarrow v$

$$\log p\,(\text{torr}) = 8.3186 - 1425.7/T(K)$$




$s-v$

$$\log P(\text{mm Hg}) = -6850/T - 0.755 \log T + 11.24$$

$l-v$

$$\log P(\text{mm Hg}) = -6620/T - 1.255 \log T + 12.34$$

At 25°C $C_6H_{12}O_6(s) + 6O_2(g) \longrightarrow 6CO_2(g) + 6H_2O(l)$

$\Delta U = -2808 \text{ kJ mol}^{-1}$

$\Delta S = +182.4 \text{ J K}^{-1}$

$q_p$ ? $w$ (max available) ?

$\Delta A = \Delta U - T\Delta S$

$$dG = V\,dp - S\,dT + f \cdot dl$$

$$f = \left(\frac{\partial G}{\partial l}\right)_{p,T}$$

$$\left(\frac{\partial H}{\partial V}\right)_S = -\frac{\gamma}{\beta} \qquad dH = T\,dS + V\,dp$$

$$\left(\frac{\partial H}{\partial V}\right)_S = V\left(\frac{\partial p}{\partial V}\right)_S \cdot \frac{(\partial V/\partial p)_T}{(\partial V/\partial p)_T}$$

$$= -\frac{\left(\frac{\partial p}{\partial V}\right)_S \left(\frac{\partial V}{\partial p}\right)_T}{\beta} = \frac{-\left(\frac{\partial S}{\partial V}\right)_p \left(\frac{\partial p}{\partial S}\right)_V \cdot \left(\frac{\partial T}{\partial p}\right)_V \left(\frac{\partial V}{\partial T}\right)_p}{\underbrace{(\partial S/\partial T)_p\,(\partial T/\partial S)_V}_{\beta}\ \beta}$$

$\beta$

$$\left(\frac{\partial T}{\partial p}\right)_S = -\left(\frac{\partial S}{\partial p}\right)_T \left(\frac{\partial T}{\partial S}\right)_p$$

$$\left(\frac{\partial V}{\partial T}\right)_p \quad T/C_p$$

$$\alpha V \quad T/C_p$$

$$\begin{array}{ccc}
0^\circ C\,(l) & \underset{\longleftarrow}{\xrightarrow{\Delta H_{fus}}} & 0^\circ C\,(s) \\
\| \; C_{p,l} & & \| \; C_{p,s} \\
-5^\circ C\,(l) & \longrightarrow & -5^\circ C\,(s)
\end{array}$$