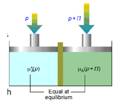
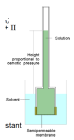
59-240 Lecture 17 Properties of Solutions

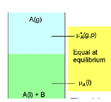
Osmosis

- Tanks
  
- Column/tank
  
- semipermeable membrane
- van't Hoff equation: $\Pi = [B]RT$
- make sure you know the **proof**!
- examples
  - J-tubes
  - reverse osmosis
  - cells
    - hypotonic
    - isotonic
    - hypertonic
- osmometry
  - use column height to determine MW of large molecules
  - $\frac{h}{c} = \frac{RT}{\rho g M}\left(1 + \frac{Bc}{M} + \ldots\right) = \frac{RT}{\rho g M} + \left(\frac{RTB}{\rho g M^2}\right)c + \ldots$

Freezing Point Depression

- $\mu_A^*(s) = \mu_A^*(l) + RT \ln x_A$
- $\Delta T = K' x_B \qquad K' = \frac{RT^{*2}}{\Delta_{fus} H}$
- $\Delta T = K_f b$
- K_f is the cryoscopic constant
- Same proof as for BP elevation
- Note that ΔT comes out positive in calculations but really represents a negative depression in bp

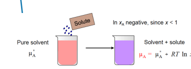
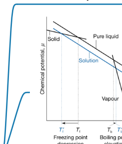
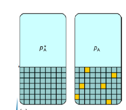
Boiling Point Elevation

- $\mu_A^*(g) = \mu_A^*(l) + RT \ln x_A$
- 
- $\Delta T = K x_B \qquad K = \frac{RT^{*2}}{\Delta_{vap} H}$
- $\Delta T = K_b b$
- K_b is the ebullioscopic constant
- Work on proof: will aid with exercises; no need to memorize for examinations

Liquid Mixtures

- Ideal solutions have similar equations as mixes of gases
  - $\Delta_{mix} G = nRT(x_A \ln x_A + x_B \ln x_B)$
  - $\Delta_{mix} S = -nR(x_A \ln x_A + x_B \ln x_B)$
  - $\Delta_{mix} H = 0$
  - interactions between A and B molecules is same as average interactions A-A and B-B
- Real solutions
  - miscible
  - partially miscible
  - immiscible
  - Composed of molecules for which A-A, A-B, B-B interactions are all different from one another
- Excess functions, X^E
  - Excess entropy, S^E: $S^E = \Delta_{mix} S - \Delta_{mix} S^{ideal}$
  - Can write excess functions for all state function variables that can be written as extensive properties (i.e., *V*, *S*, *H*, *U*, *G* and *A*)
  - Excess enthalpy example, H^E
  - Excess molar volume example, V^E

Colligative Properties

- Assumptions
  - Solute not volatile, no contribution to vapour pressure
  - Solute does not dissolve in solid solute
  - All property changes arise solely from **mixing**
  - 
- Solvents, solutes and entropy
  - Entropy is driving force for lowering chemical potential of solution
  - 
  - Effects of entropy
    - 
    - Solvent: S*, p_A^*
    - Solute: S > S*, $p_A^* < p_A^*$ because there is a weaker tendency to form a gas
    - Results in elevation of boiling point (and also depression of freezing point)

Not covered

- Solubilities
- Activities