Solutions and Their Properties

Inspired by Paul Groves   **A BLUFFER'S GUIDE**

1. Solutions are homogenous mixtures.
   - Solute = substance dissolved
   - Solvent = the dissolving medium

2. Solutions can be:
   - Unsaturated – less than max solute dissolved at a specific temperature.
   - Saturated – max solute dissolved at a specific temperature.
   - Supersaturated – more than max solute dissolved at a specific temperature.
     - Can be done by heating solvent up, dissolving a lot of solute, then carefully and slowly cooling it back down to the temperature of interest. Unstable, can quickly "crash out" the extra solute if bumped.

3. Solutes can be:
   - Electrolytes – conduct electricity when in an aqueous solution
   - Non-electrolytes – do not conduct electricity when in an aqueous solution

4. Solids and gases can be soluble or insoluble.
   - Solids increase solubility as T increases. Dissolve better when heated, stirred, ground into small particles.
   - Gases increase solubility as T decreases and P increases. Dissolve better when the solution is cold and the pressure is high.

5. Liquids can be miscible or immiscible

6. "Like dissolves like"
   - Polar solutes dissolve/mix best in polar solvents
   - Non-polar dissolve/mix best in non-polar

7. Concentration can be calculated many different ways. Most common ones:
   - $Molarity = M = \left(\frac{moles\ of\ solute}{Liters\ of\ solution}\right)$
   - $Mass\ Percent = \left(\frac{mass\ of\ solute}{mass\ of\ solution}\right) x\ 100$
   - $Mole\ fraction\ of\ A = Xa = \left(\frac{n_A}{n_A + n_B + \cdots}\right)$
   - Don't forget that you can use things like density to find numbers you are missing for concentration calculations
   - See your reference sheet for other ways of calculating concentration!

8. Heat of solution is the amount of heat absorbed or released when a specific amount of solute dissolves in a solvent.
   - $\Delta H_{solution} = \Delta H_{solute} + \Delta H_{solvent} + \Delta H_{mix}$

9. To make a solution you must:
   - Overcome the attractions between solute particles to separate them.
     ΔH_{solute} = endothermic
   - Overcome some attractions between solvent molecules to make room for the solute.
     $\Delta H_{solvent}$ = endothermic
   - Form new attractions between solute particles and solvent molecules.
     ΔH_{mix} = exothermic

Solvent-solute interactions	>	Solvent-solvent and solute-solute interactions	Solution forms
	=		Solution forms
	<		Solution may or may not form, depending on relative disparity

10. Factors favoring solution formation:
    - Negative (exothermic) $\Delta H_{solution}$
    - Positive ΔS, increase in entropy
    - Sometimes an entropy may be negative because the solvent may make "shells" surrounding the solute that results in a decrease in entropy! Often happens with water, referred to as "spheres of hydration"

11. A closed container of liquid will have some vapor gas particles above the surface. This exerts a pressure above the liquid.

12. Raoult's Law states that the partial pressure of each component in an ideal mixture of liquids is equal to the vapor pressure of the pure compound multiplied by its mole fraction in the mixture.
    - $P_{solvent} = X_{solvent}P^{°}_{solvent}$
    - $P_{total} = P_A + P_B = X_A P^{°}_A + X_B P^{°}_B$
    - $\Delta P = P^{°}_{solvent} - P_{solution} = X_{solute}P^{°}_{solvent}$
    - Therefore, presence of a nonvolatile solute lowers the vapor pressure of the solvent.

13. Solutions can deviate from Raoult's Law because they are not ideal

- The higher the IMFs in the liquid, the lower the vapor pressure above, because fewer particles will enter the vapor phase. The lower the IMFs in the liquid, the higher the vapor pressure above, because more particles can enter the vapor phase.
- Negative deviations = lower than predicted vapor pressure, b/c strong IMFs between solute and solvent.
    - Positive deviations = higher than predicted vapor pressure, b/c weak IMFs between solute and solvent.
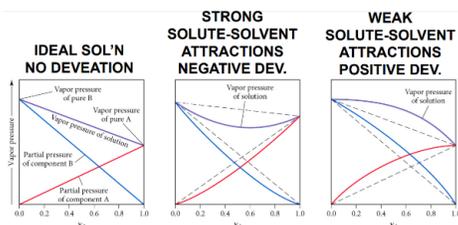
14. Colligative properties are properties that are affected by how many particles are in a solution, not the identity of the particles.

- Boiling point elevation
- Freezing point depression
- Osmotic pressure

15. If a substance dissolves into multiple ions when in solution it will have a larger effect on the colligative properties

- van't Hoff Factor, i, the number of particles that a substances breaks apart into.
    - Example – NaCl = 2, $CaCl_2$ = 3)
- $\Delta T = i \cdot Kf \cdot m_{solute}$
- $\Delta T = i \cdot Kb \cdot m_{solute}$