#### UNIT VII. Solutions.

**READING ASSIGNMENT 1**: Read Ch. 17. pg 474-493. Answer review questions 1-7 & Do the Discover It! activity on page 474 and answer the questions in complete sentences.

### I. Water as a Solvent

- A. Characteristics of the Water Molecule
  - 1. Shape: sp<sup>3</sup> hybridization- AX<sub>2</sub>LP<sub>2</sub>- "Bent"

#### DIAGRAM: Structure of Water.

- 2. Bond Polarity:  $\Delta$  e.n. = 1.3
- 3. Dipole Moment:  $\mu_D > 0$ , due to asymmetry of electric charge
- 4. Surface Properties of Water
  - a. Surface Tension- inward pull of water due to Hydrogen Bonding of water molecules -demonstrates high order- very structured
  - i. Surfactant- lowers the order of the water by reducing surface tension ex. soaps & detergents (wetting agents)
  - b. Low Vapor Pressure- caused by hydrogen bondingIncreases the energy required for vaporization
  - c. Heat Capacity of Water- Water resists changes in temperature due to high specific heat -Specific Heat of Water- 1 cal/g  $^{\rm o}C$
  - d. Vaporization of Water- Water has a high boiling point relative to its mass
     -Latent Heat of Vaporization- 540 cal/g
  - e. Fusion (Ice formation)- Water decreases density when it freezes -highest density of water is @ 4  $^{o}\!C$

READING ASSIGNMENT 2 : Read Ch. 11 p311-313. Review Questions: 37, 39, 46, 52, 53a&c, 54, 76 & 82.

### **II. Solution Formation**

- B. Aqueous Solutions
  - 1. Solution-homogeneous mixtures of 2 or more separate substances
    - a. solvent- the dissolver : aqueous solutions- solvent is water
    - b. solute- the dissolvee : aqueous solution- solute is usually ionic or polar compounds
  - 2. Dissociation (Solvation, Dissolution)

-ions separate by the interactions of water- solute/solvent attractions have to be comparable to solvent/solvent or solute/solute attractions.

## DIAGRAM: Solvation Process

a. Enthalpy driven: Enthalpy- measure the change in heat at constant temperature. 1.Enthalphy of Solvation- The heat changes associated with solution formation

 $\Delta H_{soln} = \Delta H_{(forming)} - \Delta H_{(breaking)}$ 

- 2. Exothermic- processes which releases energy ExNaOH<sub>(aq)</sub> has a  $\Delta$ H equal to -44.48 kJ/mol Nature prefers exothermic reaction.
- 3. Endothermic- processes which requires an input of energy- dissolving insoluble materials Ex. NHNO<sub>3(aq)</sub> has a  $\Delta$ H equal to 26.4 kJ/mol

 $\Delta G = \Delta H - T \Delta S$ 

- b. Entropy driven: Entropy- measure of disorderness Nature tends to greater entropy. -ideal solution- solution where no energy is lost during dissociation
- c. Gibbs-Helmholtz Free Energy Equation- Determines the spontaneity of a process.

READING over Entropy, Free Energy, & Spontaneity. Ch 19.1 & 19.3

3. \_Rules of Solubility in water

In general, the cut-off for solubility is 0.1 M.

a. For the anions

- 1.Most nitrates, acetates, perchlorates & chlorates are soluble; silver acetate, chromium(II)acetate, andmercury(I)acetate are slightly soluble.
- 2.All chlorides (bromides & iodides) are soluble except mercury(I), silver, lead(II), and copper(I); lead(II) chloride is soluble in hot water

3.All sulfates except those of Sr, Ba, and Pb(II); Ca & Si sulfates are slightly soluble

- 4.Carbonates, phosphates, borates, arsenates, and arsenites are insoluble, except those of ammonium and alkali metals
- 5. The hydroxides of the alkali metals and of barium and strontium are soluble, and other hydroxides are insoluble; calcium hydroxide is slightly soluble.
- 6.Most sulfides are insoluble, except for the sulfides of the alkali metals which react with water to give solutions of the hydroxide and hydrogen sulfide ion, HS-.
- b. For thecations

1. All alkali metal (lithium, sodium, potassium, rubidium, and cesium) and ammonium compounds are soluble. 2. Silver, lead, andmercury(I) compounds are insoluble.

4. Miscibility- Liquid/Liquid solutions which mix in any proportions -for aqueous solutions, solutes must be polar to be able to form hydrogen bonds

## C. Water of Hydration

Sphere of hydration - water found in a crystalline structure- Hydrate: caused by ion-dipole interactions

- 1. Effloresce- when the hydrate evaporates: caused when vapor pressure is greater than water vapor pressure of the surrounding
- Hygroscopic- compounds that remove moisture from the air

   a.dessicants- those that are used as drying agents b.deliquescent- hygroscopics that can form solutions by removing moistures from the air.
- D. Electrolytes & Non-electrolytes
  - Electrolyte- compounds that conduct electricity when either dissolved in water or molten state

     a.strong electrolyte- ionic substances that exhibit a high degree of solubility or molecular substances that ionize strongly
     ionization- when molecular substances react with water to form ions
     b.weak electrolytes- compounds that only partially dissociate or ionize
  - 2. Non-electrolytes- compounds that do not conduct electricity in the aqueous state/ molten state -Do not possess the ability to form ions.

## E. Suspensions & Colloids

mixtures that differ in the size of solute particles than those in solutions

- 1. Suspension- aqueous milieu where the particles will settle out due to larger size, easily filtered
- 2. Colloids- aqueous milieu where particles are smaller than suspension, but are not truly dissolved, rather are simply dispersed through water due to random movement of molecules
  - a. Tyndall effect- scattering of light due to particle size
  - b. Brownian movement- random motion of colloid particles due to motion of water
  - c.Emulsions- colloids made of immiscible substances using an emulsifying agent (soap/detergent)

ASSIGNMENT 1: Ch 17 Review Questions: p496: 19, 20, 21, 27, 33, 35, 36, 38, 40, 55, 56, & 62 ASSIGNMENT 2: Ch. 17 Standardized Test Prep. p.499 1-12

**READING ASSIGNMENT 3**: Read Ch. 18. pg 500-525; Perform the Analysis calculations for the Small-Scale Lab on page 516. The given masses are: dry bottle = 15.98 g, bottle + NaCl = 22.88g, bottle + NaCl + water = 69.09g.

### III. Characteristics of Solutions

- F. Characterization of Solution Formation
  - 1. Solubility- a measure of a solvents ability to dissolve another substance.
    - a.Ratio of solute to solvent

1.saturated- the point where the maximum amount of solute is dissolved per solvent

at saturation point a dynamic equilibrium is established

2.unsaturated-less solute than saturation point

3.supersaturated- solute amounts exceeding saturation point.

-occurs only by cooling saturated solutions

- b. Factors affecting solubility
  - 1. Temperature- solubility of solids and liquids are directly proportional to temperature Solubility of gases are inversely proportional to temperature
  - 2. Pressure- solubility of a gas is directly proportional to the pressure above the solvent @ constant temperatures Henry's Law-

$$^{S}1 / P_1 = ^{S}2 / P_2$$

2. Solubility rate- a measure of how fast a solute is dissolved stirring, heating, solutes surface area to volume ratio all affect solubility rates

G. Concentration of Solutions- Quantitative Description

1. Molarity - the number of moles dissolved in 1 L of solution

Molarity =	moles/volume (solution)
	Units are in mol/L

Remember: The density of water is 1 g/mL

IN-CLASS PRACTICE: <u>Molarity</u> GUIDE: <u>Making Solutions</u> GUIDE: <u>Molarities of Common Acids & Bases</u>

a. Dilution- A process of reducing concentration by adding solvent, the moles of solute is constant

$$M_1 \ge V_1 = M_2 \ge V_2$$

ASSIGNMENT 3: Dilutions

2. Percent solute concentration

a. Mass Percentage - Typically for solid/liquid solutions

% solute = mass of solute / mass of solution

- 1. Parts per million (ppm) = mass percentage x  $10^6$
- 2. Parts per billion (ppb) = mass percentage x  $10^{\circ}$

Liquid/Liquid solutions-

% solute = volume of solute / volume of solution

H. Colligative Properties of Solutions

- solution properties which are dependent upon solute concentrations
- 1. Vapor pressure- nonvolatile solutes decrease the vapor pressure of a solution compared to a pure solvent -decrease is proportional to the number of particles of solute in the solution

a.Raoult's Law- The vapor pressure of a solvent in an ideal solution is equal to the product of the mole fraction of the solute and vapor pressure of the pure solvent

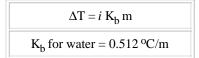
$$P_{solv} = X_{solv} x P_{solv}^{o}$$

$$X_{solv} = \frac{\text{moles of solvent}}{\text{total moles in solution}}$$

-Mole fraction  $(X_{solv})$  is the ratio of moles of solvent to total moles.

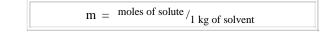
IN-CLASS PRACTICE: Raoult's Law.

 Boiling point elevation - The boiling point of a solution increases over pure solvent based on the amount of solute. Due to additional intermolecular attractions which increases the needed energy to vaporize the solvent particles



 $\Delta T$  - change in boiling point,  $K_b$  - molal boiling point elevation constant, m - molality

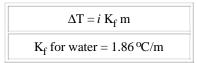
a. Molality - the moles of solute dissolved in 1 kg of solvent



b.van't Hoff Factor (i)- this is a number that refers to the number of dissolved particles in solution.

# ON-YOUR-OWN PRACTICE: <u>Boiling Point Elevation</u> ON-YOUR-OWN PRACTICE: <u>Molality</u>

3. Freezing point depression- The freezing point of a solution decreases over the freezing point of a pure solvent- due to the disruption of crystal formation of the pure solvent.



IN-CLASS PRACTICE: <u>Freezing-Point depression & Boiling-Point Elevation</u> ON-YOUR-OWN PRACTICE: <u>Freezing Point Depression</u>

## ASSIGNMENT 4: Calculating concentrations

ASSIGNMENT 5: Ch. 18 Review Questions. 44, 47, 48, 50, 54, 58, & 81. Plus the Standardized Test Prep. p531 1-17

Additional Links.

Practice Quizzes. Solutions. These are practice quizzes from Ohio State University.

Food for Thought <u>Bad Chemistry</u>. Avoiding misinterpretations about water and solutions.