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^3 hybridization- AX_2LP_2- "Bent"

DIAGRAM: Structure of Water.

2. Bond Polarity: Δ 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 ^oC

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 ^oC

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

Ex$NaOH_{(aq)}$ has a ΔH equal to -44.48 kJ/mol

Nature prefers exothermic reaction.

3. Endothermic- processes which requires an input of energy- dissolving insoluble materials

Ex. $NH_4NO_{3(aq)}$ has a ΔH equal to 26.4 kJ/mol

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.

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

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
2. 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
1. 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: Molarity

GUIDE: Making Solutions

GUIDE: Molarities of Common Acids & Bases

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

$$M_1 \times V_1 = M_2 \times V_2$$

ASSIGNMENT 3: ~~Dilutions~~

2. Percent solute concentration

a. Mass Percentage - Typically for solid/liquid solutions

$$\% \text{ solute} = \text{mass of solute} / \text{mass of solution}$$

1. Parts per million (ppm) = mass percentage x 10^6
2. Parts per billion (ppb) = mass percentage x 10^9

Liquid/Liquid solutions-

$$\% \text{ solute} = \text{volume of solute} / \text{volume of solution}$$

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

$$P_{solv} = X_{solv} \times P^o_{solv}$$

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

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

IN-CLASS PRACTICE: ~~Raoult's Law~~.

2. ~~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

$$\Delta T = i K_b m$$

$$K_b \text{ for water} = 0.512\ ^oC/m$$

ΔT - 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

$$m = \text{moles of solute} / \text{1 kg of solvent}$$

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

ON-YOUR-OWN PRACTICE: Boiling Point Elevation
ON-YOUR-OWN PRACTICE: Molality

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.

$\Delta T = i\ K_f\ m$
K_f for water = 1.86 $^oC/m$

IN-CLASS PRACTICE: Freezing-Point depression & Boiling-Point Elevation
ON-YOUR-OWN PRACTICE: Freezing Point Depression

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: Bad Chemistry. Avoiding misinterpretations about water and solutions.