AP Chemistry
Ms. Ye

Name ______________________________
Date ____________________ Block ______

Solutions:

- ____ of two or more pure substances.
- The ____________________ is dispersed uniformly throughout the ____________________

State of Solution	State of Solvent	State of Solute	Example
Gas	Gas	Gas	Air
Liquid	Liquid	Gas	Oxygen in water
Liquid	Liquid	Liquid	Alcohol in water
Liquid	Liquid	Solid	Salt in water
Solid	Solid	Gas	Hydrogen in palladium
Solid	Solid	Liquid	Mercury in silver
Solid	Solid	Solid	Silver in gold

Formation of Solutions

- The _________________________________ between ____________________________ particles

  must be _____________________________ to compete with and overcome those

  ________________________________ and those _______________________________________.

  If not, your solute particles won't dissociate/dissolve; they will stick to other solute particles instead of interacting with the solvent.

- **Solvation** = the process in which a ____

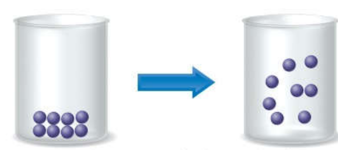
  ____(a PHYSICAL change!)

- **Hydration** = The process of solvation when water is the solvent

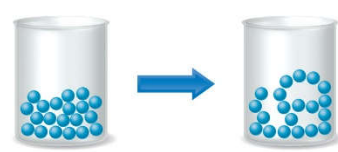
Steps and Energy Changes in Solution Formation

1. ____
2. ____

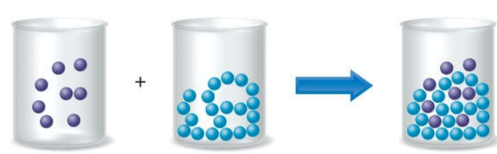
   to accommodate and form spaces the solute particles will occupy
3. ____



ΔH_1: Separation of solute molecules



ΔH_2: Separation of solvent molecules



ΔH_3: Formation of solute-solvent interactions

- **Overall energy change** for the solvation process can be _____________________________ some solutes will release energy when dissolved in water, some will absorb energy when dissolved in water.

Calculating Freezing Point Depression and Boiling Point Elevation

- Recall that adding a solute to a pure substance will always decrease the freezing point and increase the boiling point.

TABLE 13.4 ■ Molal Boiling-Point-Elevation and Freezing-Point-Depression Constants

Solvent	Normal Boiling Point (°C)	K_b (°C/m)	Normal Freezing Point (°C)	K_f (°C/m)
Water, H_2O	100.0	0.51	0.0	1.86
Benzene, C_6H_6	80.1	2.53	5.5	5.12
Ethanol, C_2H_5OH	78.4	1.22	−114.6	1.99
Carbon tetrachloride, CCl_4	76.8	5.02	−22.3	29.8
Chloroform, $CHCl_3$	61.2	3.63	−63.5	4.68

- The change in boiling point is proportional to the molality of the solution:

$$\Delta T_b = i \bullet K_b \bullet m$$

** ΔT_b is *added to* the normal boiling point of the solvent.

- The change in freezing point can be found similarly:

$$\Delta T_f = i \bullet K_f \bullet m$$

** ΔT_f is *subtracted from* the normal freezing point of the solvent.

ΔT_b = change in normal boiling point
K_b = molal boiling point elevation constant
ΔT_f = change in normal freezing point
K_f = molal freezing point depression constant

m = molality
i = van't Hoff constant = # particles into which the solute dissociates (i=1 for covalent solutes since they do not dissociate into ions).

- Note that in both equations, ΔT does not depend on *what the solute is*, **but only on *how many particles* are dissolved.**

Practice:

1. List the following aqueous solutions in order of their expected freezing point: 0.050m $CaCl_2$, 0.15m NaCl, 0.10m HCl, 0.050m CH_3COOH, 0.10m $C_{12}H_{22}O_{11}$

Substance	i (# dissociated particles)	m (molality)	total
$CaCl_2$			
NaCl			
HCl			
$C_{12}H_{22}O_{11}$			

2. Which of the following solutes will produce the largest increase in boiling point upon addition to 1kg of water: 1mol $Co(NO_3)_2$, 2mol KCl, 3mol ethylene glycol ($C_2H_6O_2$)

3. Automotive antifreeze consists of ethylene glycol, $CH_2(OH)CH_2(OH)$, a nonvolatile nonelectrolyte. Calculate the boiling and freezing point of a 5.37 m ethylene glycol solution in water.

4. Calculate the freezing point of a solution containing 0.600kg of $CHCl_3$ and 42.0g of eucalyptol ($C_{10}H_8O$), a fragrant substance found in the leaves of eucalyptus trees.

Extension:

1. 1. A solution of an unknown nonvolatile nonelectrolyte was prepared by dissolving 0.250g of the substance in 40.0g of CCl_4 . The boiling point of the resultant solution was 0.357° C higher than that of the pure solvent. Calculate the molar mass of the unknown.

2. Camphor ($C_{10}H_{16}O$) melts at 179.8° C, and it has a particularly large freezing point depression, K_f = 40.0° C/*m* . When 0.186g of an unknown organic substance is dissolved in 22.01g of liquid camphor, the freezing point is found to be 176.7° C. What is the molar mass of the solute?