**Aqueous Solutions**

**- Properties of Water:**

- Water – H2O

 - one O and 2 H atoms connected by COVALENT bonds



 - exists as a liquid at STP

 - water has a LOW vapor pressure (does not evaporate easily)

 - pure water is odorless and tasteless

 - since O is more EN than H, the electrons spend more time with O than H

 - O is δ- and H is δ+

 - bent shape geometry (AB2E2)

 - POLAR molecule (because of its shape)



 - water undergoes extensive HYDROGEN BONDING (H of one molecule

 bonds to the lone pair of electrons on the O of another molecule) (HIGH

 ATTRACTION between 2 water molecules!!)



 - high surface tension – surface of a LIQUID resists an external force

  

 - COHESION – molecules of water “stick” together

 - ADHESION – molecules of water “stick” to container walls

 - capillary action – water has a tendency to move up a narrow tube

 AGAINST the force of gravity

  

 - water is a very good SOLVENT for most polar and ionic substances

 (hydrophilic = water LOVING)

 - water does NOT dissolve oil based substances (hydrophobic = water

 FEARING)

 - PURE water does NOT conduct electricity very well (poor conductor)

 (but with ions, minerals or other things dissolved in it, it DOES conduct

 electricity)

 - water has the 2nd HIGHEST specific heat (ammonia is the 1st) (this means

 it HOLDS LOTS of heat before changing its temperature)

 - water has a maximum density of 1.00 g/cm3 at 3.98oC making it one of

 the ONLY substances whose solid form FLOATS in its own liquid



**- Solutions:**

 - solution—a homogeneous mixture of a substance dissolved in another

 substance

 - solute—substance that is dissolved

 - solvent—the dissolving medium (what the solute is dissolved in)

 - aqueous solution—a solution where the solvent is water

 - water is known as the “universal solvent”

 - that does NOT mean that water dissolves everything!!

 - hydrophilic (ionic and polar) will dissolve in water (MOSTLY!!)

 - hydrophobic (nonpolar) will NOT dissolve

 - solvation—the process by which solute particles become surrounded by

 solvent molecules as they go into solution

  

 - NaCl dissolves in water because the interaction between water and

 the dissociated ions in solution is MORE STABLE and LOWER

 ENERGY than when NaCl is bonded together as a compound

 - solubility—the amount of solute that will dissolve in a particular amount

 of solvent

 

 - soluble—indicates that a SOLID substance will dissolve in another

 substance (usually a liquid like water)

 - insoluble—indicates that a SOLID substance will NOT dissolve

 - technically it is not “insoluble”…a small amount actually

 DOES dissolve but it is so small of an amount it is considered

 to be “insoluble”

 - miscible—indicates that a LIQUID will dissolve in another liquid

 - immiscible—indicates that a LIQUID will NOT dissolve in another

 liquid

**- Factors Affecting Solution Formation:**

 1) particle size – smaller particles

 tend to dissolve faster 2) heat (temperature)

 3) stirring/agitation

 4) “like dissolves like”

- **Factors Affecting Solubility:**

 1) as temperature INCREASES, the solubility of a SOLID in a liquid increases

 2) as temperature INCREASES, the solubility of a GAS in a liquid decreases

 3) as pressure INCREASES, the solubility of a GAS in a liquid increases

 - Henry’s Law: *the solubility of a gas in a liquid at a given*

 *temperature is DIRECTLY proportional to the PRESSURE of the gas*

 *above the liquid*



- **Types of Solutions:**

 **-** concentrated—has a LARGE amount of solute particles in a given amount

 of solvent

 - dilute—has a SMALL amount of solute particles in a given amount of

 solvent

 - unsaturated—contains LESS THAN the maximum amount of solute in a

 particular amount of solvent

 - saturated—contains the maximum amount of solute in a particular

 amount of solvent

 - supersaturated—contains MORE THAN the maximum amount of solute in

 a particular amount of solvent



- **Solution Concentration:**

 - concentration—how much solute is dissolved in a particular amount of

 solvent or solution

 1) Percent by Volume – the grams of solute per mL of solution (expressed

 as a percentage)

  **grams SOLUTE**

 **Percent by Vol. = ---------------------------------- x 100**

 **mL SOLUTION**

 - *How many grams of glucose would be needed to make 500mL of a*

 *20% solution?*

$$\%= \frac{g Solute}{mL Sltn} x 100= \frac{x g sucrose}{500 mL sltn} x 100=20\%$$

$$.20= \frac{x g}{500 mL}$$

$$x=\left(500 mL\right)\left(.20\right)=100. g sucrose$$

 *- What is the percent by volume of 25 g NaCl dissolved in 700 mL*

 *total solution?*

$$\%= \frac{g solute}{mL sltn} x 100= \frac{25 g NaCl}{700 mL} x 100=3.6 \% NaCl$$

2) Molarity (M)—moles of solute per LITER of solution

  **Moles SOLUTE**

 **MOLARITY (M) = -----------------------------**

 **Liters SOLUTION**

 - *What is the molarity of a solution of 2.00 moles glucose in 5.00 L of*

 *total solution?*

$$M= \frac{mol solute}{L sltn}= \frac{2.00 mol glucose}{5.00 L}=0.400 M glucose$$

 *- How many grams of NaCl are needed to make 2.50 L of a 0.100 M*

 *NaCl solution?*

$$M= \frac{mol solute}{L sltn} = \frac{x mol NaCl}{2.50 L} =0.100 ^{mol NaCl}/\_{L}$$

$$x=\left(\frac{0.250 mol NaCl}{1}\right)\left(\frac{58.5 g NaCl}{1 mol NaCl}\right)=14.6 g NaCl$$

 3) Molality (m)—moles of solute per kg of solvent

  **Moles SOLUTE**

 **Molality (m) = ---------------------------**

 **kg SOLVENT**

 - *How many grams of KI must be dissolved in 500.0 g of water to*

 *make a 0.45 m KI solution?*

$$m= \frac{mol solute}{kg solvent} = \frac{x mol KI}{.5000 kg} =0.45 ^{mol KI}/\_{kg solvent}$$

$$x=\left(\frac{0.225 mol KI}{1}\right)\left(\frac{166 g KI}{1 mol KI}\right)=37.4 g KI$$

- **Dilutions:**

 - to dilute a solution (make it LESS concentrated) you need to INCREASE

 the amount of SOLVENT!!! (“water down”)

 - since the TOTAL number of MOLES of solute still remains the same in

 solution (only the amount of solvent and total solution changes) then the

 following is true:

 Volume in LITERS x MOLARITY (mol/L) = moles solute

 Since the moles of solute before and after are the same:

**V1C1 = V2C2**



 - *How much of a 2.00 M MgSO4 stock solution would be needed to*

 *make 100.0 mL of 0.400 M MgSO4?*

$$V\_{1}C\_{1}=V\_{2}C\_{2}\rightarrow V\_{1}= \frac{V\_{2}C\_{2}}{C\_{1}}= \frac{\left(100.0 mL\right)(0.400 M)}{2.00 M}=20.0 mL$$

- serial dilutions—dilutions are done in a SERIES (one after the other) in

 order to make a very small concentration that would not be convenient to

 make in one step



**- Colligative Properties:**

- colligative property—depends ONLY on the number of particles of solute

 dissolved in a given mass of solvent (not on the identity of the solute!!)

 1) Boiling Point Elevation (ΔTb)

 - the boiling point of a solution is always HIGHER than the boiling

 point of a pure solvent

 - as a solute dissolves in a solvent the particles of the solute become
 “solvated” (surrounded by water molecules in a particular

 formation) and there is an ATTRACTION from solute—solvent.

 - the more the attraction is, the HARDER it is to separate the solvent

 from the solute (so the boiling point INCREASES!!)

 - **ΔTb = *i* Kb m**

 *i* is the # of particles per molecule or formula unit of solute

 C6H12O6 🡪 C6H12O6(aq) [1 particle]

 NaCl 🡪 Na+(aq) + Cl-(aq) [2 particles]

 CaCl2 🡪 Ca2+(aq) + 2 Cl-(aq) [3 particles]

 AlCl3 🡪 Al3+(aq) + 3 Cl-(aq) [4 particles]

 Kb is the molal boiling point depression constant

 Kb for water is +0.51 Co·kg H2O/mol solute

 m is the molality (mol solute/kg H2O)



 2) Freezing Point Depression (ΔTf)

 - the freezing point of a solution is always LOWER than the freezing

 point of a pure solvent

 - as a solute dissolves in a solvent the particles of the solute become
 “solvated” (surrounded by water molecules in a particular

 formation) the solute particles take up space that is normally

 occupied by water molecules forming a crystalline structure so it

 makes it more difficult for that solid structure to form

 - **ΔTf = *i* Kf m**

 *i* is the # of particles per molecule or formula unit of solute

 Kf is the molal freezing point depression constant

 Kf for water is -1.86 Co·kg H2O/mol solute

 m is the molality (mol solute/kg H2O)

