Solution Properties

The Solution Process

A. A true solution is homogeneous, the solute is evenly dispersed into the solvent by atoms, ions, or molecules (depending on the bonding)

B. The solute and solvent can be solids, liquids, or gases. Thus there are 9 types of solutions. In this chapter we will focus on solids, liquids and gases dissolved in liquids.

C. An energy change may take place when a solute is dissolved in a liquid. This energy change is called the heat of solution and can involve 3 steps.

1. Separate the solute into individual particles. This process is always endothermic for a solid or liquid. For a gas the particles are already separated and no additional energy is required.

2. Expand the solvent to make room for the solute. This process is endothermic.

3. Surround the solute particles with solvent. This process is exothermic and is called solvation in general and hydration if water is involved.

The total heat of solution is the sum of these three processes and may therefore be endothermic or exothermic.

D. Predicting the possibility of solution occurring

Like dissolves like

- Ionic and polar solutes dissolve in polar solvent.
- Nonpolar solutes dissolve in nonpolar solvents.

E. How much will dissolve? Solubility

Solubility Terms

Unsaturated - can dissolve still more

Saturated - can't normally dissolve more solute, the amt that gives a saturated solution is called the solubility

Supersaturated - due to lack of crystallization sites, the solution holds more solute than it should

Miscible - liquids that dissolve

Immiscible - liquids that don't dissolve

F. Predicting variation of solubility with temp

- Many ionic solids have a +DH of solution so solubility increases with increasing temperature
- Many gases have a -DH of solution so solubility decreases with increasing temperature

G. Predicting variation of solubility with pressure

- Little change with solid and liquid solutes
- Gas solubility increases with pressure (Henry's Law)

II. Units of Solution Concentration

A. Molarity = moles of solute per liter of solution

B. Molality - moles of solute per kg of solvent

C. Weight or volume fractions

$\dfrac{\text{weight of solute}}{\text{weight of solution}}$ solids in liquids

$\dfrac{\text{weight of solute}}{\text{volume of solution}}$ solids in liquids

$\dfrac{\text{volume of solute}}{\text{volume of solution}}$ liquids in liquids

These fractions are the basis for % (parts per hundred), ppt, ppm, ppb. Simply multiply the fraction by 100 for %, 10^3 for ppt, 10^6 for ppm, 10^9 for ppb.

D. Mole fraction of component

MF_x = moles of x___

total moles of solution

III. Colligative properties

Properties of solutions which are determined by the number of solute particles present, not the type . These properties include VP and its influence on FP, BP, and osmotic pressure.

A. Suppose we dissolve nonvolatile O's in a solution of volatile x's. The VP decreases due to the fact that less volatile x's are on the surface. This will then affect the FP and BP.

[Diagram of VP graph]

It is evident that when we add a nonvolatile solute to a volatile solvent the FP (MP) goes down and the BP goes up.

This can be quantified by the following equation

$$DT_{FP} = m \ I \ K_{FP}$$

- DT_{FP} is the change in the freezing point and is also equal to

    Temp of solution FP - Temp of pure solvent FP

- m is the molality of the solution

- i is the van Hoff factor, the number of particles per formula unit

- K_{FP} is the freezing point depression constant

IV. Osmotic Pressure

A. Osmosis is the movement of a solvent through a semipermeable membrane from an area of greater concentration (of solvent) to an area of lesser concentration. This equalizes the concentrations of particles in solution. The osmotic pressure is the pressure that must be exerted to one of the solution to prevent water flow into it.
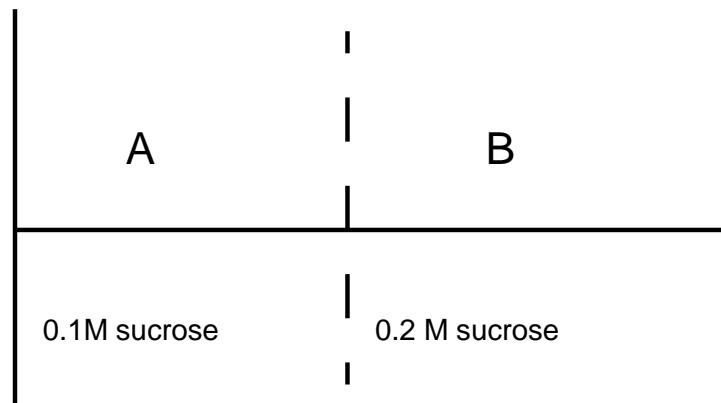
Water flows from A to B to equalize the concentrations of particles.

B. The osmolarity of a solution gives the concentration of particles and is equal to the product of molarity and the van Hoff factor (i).

$$\text{Osmolarity} = M\ (i)$$

C. Applications to Medicine

1. Red blood cells in a hypertonic solution (greater osmolarity) . Water flows outward, cells shrivel - crenation.
2. Red blood cells in hypotonic solution (lesser osmolarity). Water flows inward, cells burst - hemolysis.
3. Isotonic - same osmolarity (blood is about 0.30 Osmol, about 0.15 M NaCl)

D. Calculation of osmotic pressure

$$p = Dc\ R\ T$$

p = osmotic pressure in pressure units contained in R
   (if R=.0821 Atm-l/mole-K then p is in Atm)

Dc = difference is osmolarity of solutions

R = ideal gas constant

T = temperature in Kelvin

V. Colloids

A. Colloids are an intermediate phase between true solutions and suspensions. The following are rough approximations.

Type of mixture	Size	Light scattering	"Settles out" because of gravity
solution	<10 nm	no	no
colloids	10-1000 nm	yes	no
suspensions	>1000 nm	yes	yes

B. Gels, emulsions, aerosols and foams are all types of colloids. These categories include mud, pudding, jelly, smoke, fog and even styrofoam.

C. The interaction of light with colloidal particles is interesting. If the particle size is less than the wavelength of light, a scattering mechanism occurs and results in the object appearing to be blue - cigarette smoke, blue haze in the country, blue eyes.

As the particle size gets larger the regular rules of reflection and refraction take place and the colors that we associate with an object occur - a red rose, a blue shirt, a white cloud.