

Chapter 13- Properties of Solutions**Section 1:**

- **Solutions** involve one substance dispersing uniformly throughout another
- All of the intermolecular forces we've learned operate in between solute and solvent particles within a solution. When a solute is dissolved in a substance it is known as **solvation**, when that solvent is water it is known as **hydration**
- Energy and Disorder are both involved with a solution formation and its spontaneity
- Homogeneous solutions depend on the disorder and entropy to explain why they form

Section 2:

- The dissolving and **crystallization** of solutes both occur simultaneously within a solution's equilibrium
- A solution at equilibrium with undissolved solutes is **saturated**
- The amount of solute needed to make a saturated solution in a given amount of solvent is **solubility**
- Dissolving less solute than needed to saturate is known as **unsaturated**, and when one dissolves more it is **supersaturated**

Section 3:

- Solute-Solvent interactions will have higher solubility if the attraction between solute and solvent molecules are stronger
- With this in mind, polar liquids dissolve readily in polar solvents, or *like dissolves like*
- Liquids that mix at all proportions are **miscible**; those that do not dissolve significantly are **immiscible**
 - Nonpolar liquids tend to be insoluble in polar liquids (Hexane and water)
- Alcohols can form hydrogen bonds, changing polarity and allowing water solubility

Example: Predict which is more likely to dissolve in nonpolar CCl₄ or in water: C₇H₁₆, Na₂SO₄, HCl, I₂.

CCl₄= C₇H₁₆ and I₂ (nonpolar substances)

Water= Na₂SO₄ and HCl (polar and Ionic)

- Solubility of a gas in any solvent increases as the pressure over the solvent increases
 - The solubility of the gas increases in direct proportion to its partial pressure above the solution
 - This is **Henry's Law**: $C_g = kP_g$

Where C_g is solubility of gas in solution phase (Molarity), P_g is partial pressure of gas, and k is *Henry's Law Constant* (varies)

Example: Calculate concentration of CO₂ in a bottle with partial pressure of 4.0 atm at 25°C. Henry's Law constant is 3.1×10^{-2} mol/L-atm

$$(3.1 \times 10^{-2} \text{ mol/L-atm})(4.0 \text{ atm}) = 0.12 \text{ mol/L} = 0.12M$$

- Solubility of solid solutes increase as the temperature increases, while solubilities of gases typically decrease with increasing temperature

Section 4:

- Mass percentage, mole fraction, Molarity, and molality are all ways of expressing **concentration**

$$\text{Mass \% of component} = \frac{\text{Mass of component in soln}}{\text{total mass of soln}} \times 100$$

- Concentrations of dilute solutions are measured in **parts per million (ppm)**

$$\text{Mole fraction of component} = \frac{\text{moles of component}}{\text{total moles of all components}}$$

$$\text{Molarity} = \frac{\text{moles solute}}{\text{liters soln}}$$

$$\text{Molality} = \frac{\text{moles solute}}{\text{kilograms of solvent}}$$

- Molarity is in terms of *volume of solution*, while Molality is in terms of *mass of solvent*
 - M changes with temperature, *m* does not
- Sometimes it is possible to interconvert concentration units:

Section 5:

- A physical property of a solution dependent on the concentration of solute particles is a *colligative property*
- An *ideal solution* obeys *Raoult's Law*

$$P_A = X_A P_A^\circ$$

The partial pressure exerted by vapor pressure above a solution, P_A , equals the product of the mole fraction of the solvent, X_A times the vapor pressure of pure solvent P_A°

- A solution with a nonvolatile solute posses a higher boiling point than the pure solvent
- **Molal boiling-point-elevation constant**, K_b , represents the increase in boiling point for a 1 *m* solution of solute compared to pure solvent; just as the **Molal freezing-point-depression constant**, K_f , measures the lower of a 1 *m* solution
- $\Delta T_b = K_b m$ (same for freezing point but with K_f)

Example: What is the boiling point elevation when 11.4 g of ammonia (NH₃) is dissolved in 200. g of water? K_b for water is 0.52 °C/m.

Determine molality of ammonia

$$\frac{11.4g}{17.031g/mol} = 0.6693676 \text{ mol}$$

$$\frac{0.6693676 \text{ mol}}{200kg} = 3.3468 \text{ m}$$

$$\Delta T = (1) (0.52 \text{ °C/m}) (3.3468 \text{ m})$$

$$\Delta T = 1.74 \text{ °C}$$

- **Osmosis** is the tendency of solvent molecules to move through a semipermeable membrane from a less to more concentrated solution
- **Osmotic Pressure**, π is

$$\pi = \left(\frac{n}{V}\right) RT = MRT \text{ (Where M is Molarity)}$$

Section 6:

- Large molecular particles that are still small enough to remain suspended in a solvent form *colloids*, or *colloidal dispersions*
- Colloids are intermediates between solutions and heterogeneous mixtures