Solutions

Introduction

What is a solution?

- A homogeneous mixture of two or more substances
- A **solute** is dissolved in a **solvent**
  - Salt (solute) dissolved in water (solvent)
- A solution may exist in any phase

Types of Solutions

- Solid in Solid
  - Copper in silver (sterling silver)
  - Zinc in copper (brass)
- Solid in Liquid
  - Salt in water (ocean water)
  - Iodine in alcohol (tincture)
- Solid in Gas
  - Microscopic particulates in air
  - Mothball particles in air

- Liquid in Solid
  - Mercury in silver amalgams (tooth fillings)
- Liquid in Liquid
  - Ethylene glycol in water (engine antifreeze)
  - Methanol in water (gas line antifreeze)
- Liquid in Gas
  - Water vapor in air

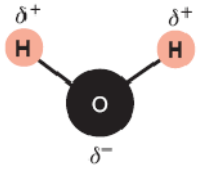
- Gas in Solid
  - Hydrogen in palladium (purification of hydrogen)
  - Gases absorbed in carbon (carbon filter)
- Gas in Liquid
  - Carbon dioxide in beverages (carbonated beverages)
  - Oxygen in water (supporting aquatic life)
- Gas in Gas
  - Oxygen in nitrogen (air)

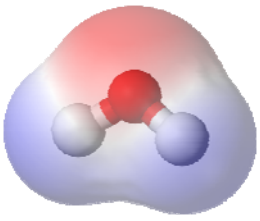
Electronegativity

- Electronegativity is a measure of the tendency of an atom to attract a bonding pair of electrons.
  - Fluorine has the highest electronegativity
    - It attracts electrons the best
  - Cesium and Francium have the lowest electronegativity
    - They attract electrons the least

Polar Bond

- A polar bond is a covalent bond in which there is a separation of charge between one end and the other.
  - in other words in which one end is slightly positive and the other slightly negative
  - The hydrogen-oxygen bonds in water are polar





Solvation

- Why are some substances soluble in one another whereas others are not?
  - To form a solution, solute particles must separate from one another and the solute and solvent particles must mix
- When a solid solute is placed in a solvent, the solvent particles completely surround the surface of the solid solute

- If the attractive forces holding the solute particles together, the solvent particle pull the solute particles apart and surround them
- These surrounded solute particles then move away from the solid solute, out into the solution
- This process is called **solvation**
- Solvation in water is called hydration

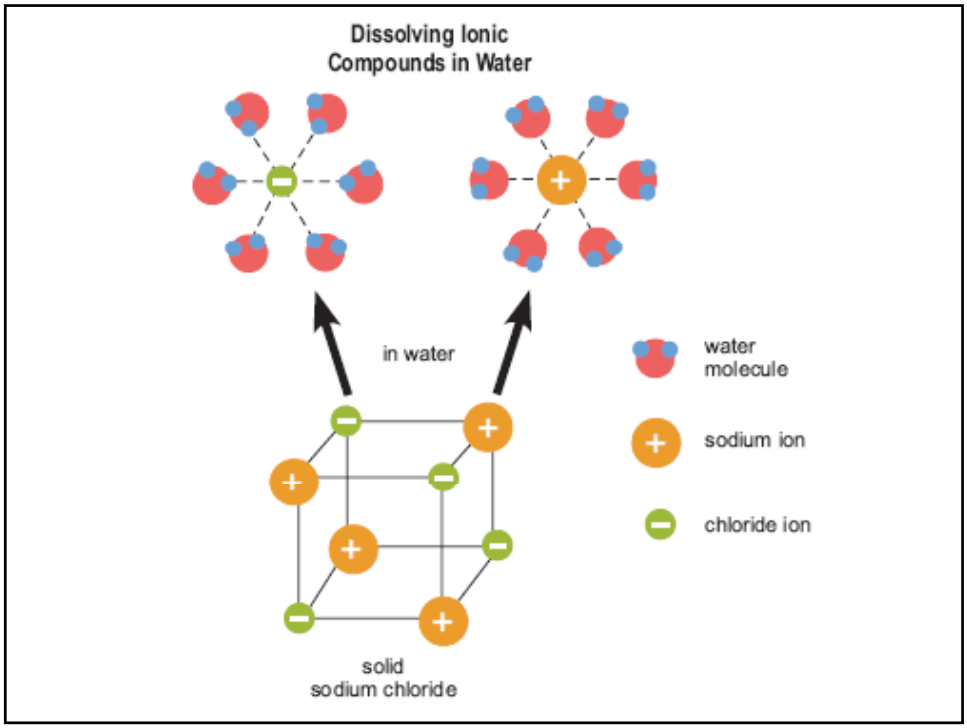
“Like Dissolves Like”

- General rule used to determine whether solvation will occur in a specific solvent
  - Ionic and polar solutes will dissolve in polar solvents
  - Nonpolar solutes will dissolve in nonpolar solvents
- If a solute and solvent are mutually soluble in all proportions they are both said to be **miscible.**

Ionic Solvation

- When a crystal of an ionic compound, such as NaCl, is placed in water, the water molecules collide with the surface of the crystal
- The charged ends of the water molecules attract the positive sodium ions and negative chloride ions

- This attraction between the dipoles and the ions is greater than the attractions among the ions in the crystal
- So the ions break away from the surface
- The water molecules surround the ions and the solvated ions move into solution
- Solvation continues until the entire crystal has dissolved and all ions are distributed throughout the solvent



Molecular (Covalent) Solvation

- In a molecular (covalent) solution, entire molecules are pulled away from the solid structure as it goes into solution
- Once again, the attractive forces between the solute and the solvent must be greater than the attractive forces between the molecules in the crystal structure

Equations

$$NaCl_{(s)} \xrightarrow{H_2O_{(l)}} Na^+_{(aq)} + Cl^-_{(aq)}$$

$$C_{12}H_{22}O_{11(s)} \xrightarrow{H_2O_{(l)}} C_{12}H_{22}O_{11(aq)}$$

Heat of Solution

- When attractive forces are broken, energy is required
- Therefore, the separation of solute particles from one another and the separation of solvent particles from one another are both endothermic processes
- The attraction between solute and solvent particles during the solvation process is exothermic

- Whether energy is absorbed or released in the overall net process of solution formation depends on the balance between these two processes
- The net energy change is called the heat of solution

- If the amount of energy absorbed is greater than the amount of energy released, then the overall solution becomes *endothermic*
  - Cold packs

$$NH_4NO_{3(s)} + \text{heat} \rightarrow NH^+_{4(aq)} + NO^-_{3(aq)}$$

- If the amount of energy absorbed is less than the amount of energy released, then the overall solution becomes *exothermic*
  - Hot packs

$$CaCl_{2(s)} \rightarrow Ca^{+}_{2(aq)} + 2Cl^{-}_{(aq)} + heat$$