Solution Stoichiometry

Ch 4

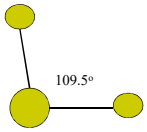
Homework

- Due with test
- Pg 162 Chapter 4 review
- 19-87 odd (there will be test questions from these)

Water and the Nature of Aqueous Solutions

- Water is the foundation of all life on Earth.
- Each O-H covalent bond is highly polar because the electronegativity of oxygen is so much greater than hydrogen.
- The dipole moment creates a slightly negative O and a slightly positive H as the electrons are pulled strongly toward O.

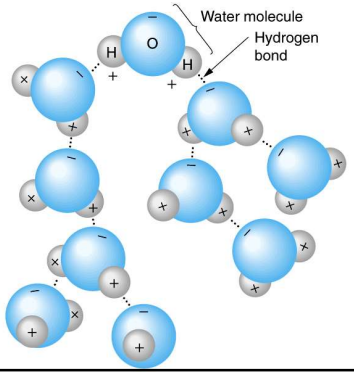
Water is a bent molecule with a bond angle of 109.5°



Hydrogen bond

- Polar molecules are attracted to one another by dipole attractions.
- In water, it is hydrogen bonding.
- The molecules can't easily slide past one another, they are held in place.
- The strength of the hydrogen bonds accounts for water's high surface tension, its low vapor pressure, its high specific heat, its high heat of vaporization, and its high boiling point.

Hydrogen bonding in water



Solvents and Solutes

- Chemically pure water never exists in nature because water dissolves so many substances
- * An **aqueous solution** is one in which water samples contain dissolved substances.
- Components of a solution.
- A **solvent** is the dissolving medium.
  A **solute** is the dissolved particles.

Solutions

- Solutions are homogeneous mixtures in which solute particles are usually less than 1 nm in diameter. The solute and solvent are not capable of being separated by filtration.
- Substances that dissolve most readily in water include ionic compounds and polar covalent molecules.
- Nonpolar molecules do not dissolve in water (a polar molecule).

The Solution Process

- Water molecules are in constant motion as a result of their kinetic energy.
- The molecules collide with solute particles.
- The solvent molecules attract the solute particles.
- The solute particles leave their current state and move with the solvent.
- If it is a salt, the ionic crystal breaks apart by the action of the solvent.
- **Solvation** is the process that occurs when a solute dissolves.
- http://mw2.concord.org/public/student/solution/dissolve.cml

The rule is like dissolves like.

- However, don't like dissolves like as a justification on the AP test. They won't accept it.
- The reason like dissolves like is because polar molecules are more attracted to other polar molecules so they are more capable of pulling polar molecules away (dissolving).
- When I have polar and nonpolar molecules the polar will "clump" together leaving the nonpolar separate (oil and water layer)

Continuing…polar nonpolar

- Since the polar is excluded from the nonpolar, it can't dissolve it.
- Nonpolar **may** be capable of dissolving something that is nonpolar simply because it is around it.
- It is important to note that every nonpolar thing doesn't dissolve easily in nonpolar solvents.
- They just have a chance to dissolve.

Insoluble

- In some ionic compounds, the attractions between the ions in the crystal are stronger than the attractions exerted by water.
- * These compounds are *insoluble*.
- Nonpolar substances form a solution because there are no repulsive forces between them, not because the solute and solvent are attracted.

Electrolytes and Nonelectrolytes

- Compounds that conduct an electric current in aqueous solution or the molten state are called **electrolytes**.
- All ionic compounds are electrolytes.
- Soluble ionic compounds conduct electricity in both a solution and in the molten state.
- Insoluble ionic compounds only conduct electricity in the molten state.

Nonelectrolytes

- Compounds that do not conduct an electric current in either aqueous solution or the molten state are called **nonelectrolytes**.
- Many molecular compounds are nonelectrolytes because they do not contain ions.
- Most compounds of carbon are nonelectrolytes.
- Some very polar molecular compounds are nonelectrolytes in the pure state, but are electrolytes when they dissolve in water.
- This occurs because such compounds ionize in solution.

Weak Electrolytes

- Not all electrolytes conduct electricity to the same degree.
- A **weak electrolyte** conducts electricity poorly because only a fraction of the solute exists as ions.
- * Most of the compound is in the original form.
- * The most common weak electrolytes are weak acids and weak bases.

Strong Electrolytes

- A **strong electrolyte** conducts electricity very well because almost all of the solute exists as separated ions.
- * Very little of the original compound remains intact.
- * Classes of electrolytes include soluble salts, strong acids and strong bases.

The Composition of Solutions

- To perform stoichiometric calculations when two solutions are mixed, two things must be known.
- The nature of the reaction, which depends on the exact forms the chemical takes when dissolved.
- The amounts of chemical present in solution, usually expressed as concentrations.

Molarity

- **Molarity** (*M*) is defined as the moles of solute per volume of solution in liters.
- M = molarity = $\frac{\text{moles of solute}}{\text{liters of solution}}$
- Calculate the molarity of a solution prepared by dissolving 11.5 g of solid NaOH in enough water to make 1.50 L of solution.

Calculation of Molarity II

- Calculate the molarity of a solution prepared by dissolving 1.56 g of gaseous HCl in enough water to make 26.8 mL of solution.

Concentrations of Ions

- Give the concentration of each type of ion in the following solutions:
  - a. 0.50 *M* $Co(NO_3)_2$
  - b. 1 *M* $Fe(ClO_4)_3$

Concentrations of Ions II

- Calculate the number of moles of Cl^- ions in 1.75 L of 1.0 x 10^{-3}*M* $ZnCl_2$.
- Concentration and Volume I.
- Typical blood serum is about 0.14 *M* NaCl. What volume of blood contains 1.0 mg NaCl?

Solutions of Known Concentration

- .To analyze the alcohol content of a certain wine, a chemist needs 1.00 L of an aqueous 0.200 *M* $K_2Cr_2O_7$ (potassium dichromate) solution. How much solid $K_2Cr_2O_7$ must be weighed out to make this solution?

Dilution

- .To save money and space in a laboratory, solutions are often in concentrated form. Water is added to achieve the molarity desired for a particular solution.
- This process is called **dilution**.
- Dilution with water does not alter the numbers of moles of solute present.

Concentration and Volume

- Another way to express the dilution process is: $M_1V_1 = M_2V_2$
- This equation is not on the equation sheet
- What volume of 16*M* sulfuric acid must be used to prepare 1.5 L of a 0.10 *M* H_2SO_4 solution?
- What volume of 14.8*M* ammonia must be used to prepare 0.75 L of a 1.5 *M* NH_3 solution?

Stoichiometry of Precipitation Reactions

- 1. Identify the species present in the combined solution, and determine what reaction occurs.
- 2. Write the balanced net ionic equation for the reaction.
- 3. Calculate the moles of reactants.
- 4. Determine which reactant is limiting.
- 5. Calculate the moles of reactants or products, as required.
- 6. Convert to grams or other units, as required.

Determining the Mass of Products Formed

- Calculate the mass of solid $CaCl_2$ that must be added to 1.50 L of a 0.100 *M* $AgNO_3$ solution to precipitate all the Ag^+ ions in the form of AgCl.