Experiment 6
Chemical Reactions

OUTCOMES

After completing this experiment, the student should be able to:

- be familiar with a variety of reactions including precipitation, acid-base, gas forming, and oxidation-reduction reactions.
- identify the products formed in these reactions.
- write balanced chemical equations and net ionic equations.
- identify the species being oxidized and reduced in oxidation-reduction reactions.

DISCUSSION

Chemical equations represent what occurs in a chemical reaction. For example, the equation

$$HCl(aq) + NaOH(aq) \rightarrow NaCl(aq) + H_2O(l)$$

describes an acid-base reaction, a type of **exchange reaction** in which the driving force is the formation of water. In an exchange reaction, the anion of one reactant changes places with the anion of the other reactant. Other types of exchange reactions include precipitation and gas forming reactions where the driving force is the formation of either a solid or gas, respectively. Most of these exchange reactions take place in aqueous solutions.

One important aspect of exchange reactions is being able to accurately represent what is happening in solution using balanced "molecular" and net ionic equations. Writing these equations involves many steps including writing correct chemical formulas, using solubility rules to identify aqueous and solid products, and balancing the equations.

As an example of this process, when a solution of lead(II) nitrate is mixed with a solution of sodium sulfate, a precipitate is formed. To determine the identity of the products, the cations are paired up with the anions of the other reactant. Once the **CORRECT FORMULAS** have been established, the unbalanced chemical equation can be written as follows:

$$Pb(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow PbSO_4 + NaNO_3$$

At this point, one can use solubility rules to determine which of the products was the solid. Solubility rules, including those found in your textbook, are tables that describe the tendency of certain ions to remain in solution or to form precipitates. When looking at the tables, it can be determined that $PbSO_4$ is an insoluble salt while $NaNO_3$ is always soluble. Consequently, one can fill in the phase labels for the products of the reaction as follows:

$$Pb(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow PbSO_4(s) + NaNO_3(aq)$$

After determining the phases of the products, the equation must be balanced to satisfy the Law of Conservation of Mass. The result is the following balanced "molecular" chemical equation:

$$Pb(NO_3)_2(aq) + Na_2SO_4(aq) \rightarrow PbSO_4(s) + 2\ NaNO_3(aq)$$

To obtain the net ionic equation, the "molecular" equation should be written as a complete ionic equation with all *strong electrolytes* (ie: aqueous salts and strong acids) broken apart into their corresponding ions. Compounds that are *weak electrolytes* (ie: insoluble salts and weak acids and bases, consult your textbook for examples) or *nonelectrolytes* (ie: molecules such as H_2O) do not form significant amounts of ions in solution and therefore retain their "molecular" formula in ionic equations. For the reaction between $Pb(NO_3)_2$ and Na_2SO_4, the complete ionic equation would be as follows:

$$Pb^{2+}(aq) + \cancel{2\ NO_3^-}(aq) + \cancel{2\ Na^+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s) + \cancel{2\ Na^+}(aq) + \cancel{2\ NO_3^-}(aq)$$

By eliminating ions that are identical on both sides of the equation (known as spectator ions and crossed out above), the net ionic equation is obtained.

$$Pb^{2+}(aq) + SO_4^{2-}(aq) \rightarrow PbSO_4(s)$$

Oxidation-reduction (redox) reactions are another important class of chemical reactions. In redox reactions electrons are transferred from one substance to another. For example, if a copper wire is placed in a solution of silver nitrate, a redox reaction occurs and silver metal is formed along with copper(II) nitrate.

Oxidation numbers: (0) (+1) (+2) (0)

"Molecular" equation: $Cu(s) + 2\ AgNO_3(aq) \rightarrow Cu(NO_3)_2(aq) + 2\ Ag(s)$

(0) (+1) (+2) (0)

Net ionic equation: $Cu(s) + 2\ Ag^+(aq) \rightarrow Cu^{2+}(aq) + 2\ Ag(s)$

The oxidation numbers for the metallic elements in these equations can be obtained from oxidation number rules found in your textbook. These numbers show us that copper metal is being oxidized (it is losing electrons) while the silver ion is being reduced (it is gaining electrons). Copper is therefore the *reducing agent* while silver nitrate is the *oxidizing agent*.

PROCEDURE

⚠ ***Wear safety glasses or goggles at all times for this experiment.***

Procedure 1: Precipitation Reactions

1. Obtain 7 small, clean test tubes. For the purposes of this lab, the test tubes need only be clean, not totally dry. A hose connected to the air supply in the hood may be used to quickly remove most water from the test tubes.

2. Place 10 drops of 0.5 *M* $CaCl_2$ into each of the 7 test tubes.

3. Add 10 drops of 0.5 *M* solutions of each of the following solutions to the indicated test tubes and record your observations. Allow at least 5 minutes for reactions to occur before disposing your solutions.

Test Tube	1	2	3	4	5	6	7
	$MgSO_4$	$(NH_4)_2C_2O_4$	KNO_3	Na_3PO_4	KBr	NaOH	K_2CO_3

4. Dispose of the solutions and any precipitates in the waste beakers located in the hoods. Wash your test tubes with soap and water. Rinse with tap water, then deionized water.

Procedure 2: Gas Evolving Reactions

1. Obtain a clean test tube. Add a small scoop (the size of a small pea) of baking soda, sodium hydrogen carbonate, to the test tube. Add 10 to 20 drops of vinegar to the test tube and record your observations. Vinegar is an aqueous solution of acetic acid, $HC_2H_3O_2$.

2. Obtain a clean test tube and take it to the hood. IN THE HOOD, add a small scoop of sodium sulfite, Na_2SO_3, to the test tube. Add 10 to 20 drops of 6 *M* HCl and record your observations.

3. Dispose of the solutions and any unreacted solid in the waste beakers located in the hoods. Wash your test tubes with soap and water. Rinse with tap water, then deionized water.

Procedure 3: Acid-Base Reactions

1. Obtain two clean test tubes. Add 10 drops of 0.5 *M* nitric acid to the first test tube and 10 drops of 0.5 *M* phosphoric acid to the second test tube.

2. Add 1 drop of phenolphthalein to each test tube. Phenolphthalein is an acid-base indicator that is colorless in acidic and neutral solutions, but pink in basic solutions.

3. Add drops of dilute (0.5 *M*) sodium hydroxide solution into each of the test tubes until a permanent color change is observed. Count and record the number of drops of sodium hydroxide needed for the color change.

4. Dispose of the solutions in the waste beakers located in the hoods. Wash your test tubes with soap and water. Rinse with tap water, then deionized water.

Procedure 4: Redox Reactions

1. Obtain two clean test tubes. To the first, add a small piece of zinc metal. To the second, add a 1 inch piece of copper wire.

2. Add 30 drops of 6 *M* HCl to each of the test tubes and record your observations.

3. Dispose of the solutions and any unreacted solid in the waste beakers located in the hoods. Wash your test tubes with soap and water. Rinse with tap water, then deionized water.

4. IN THE HOOD, take a 2 inch piece of magnesium ribbon and hold it with a pair of crucible tongs. Light the magnesium metal with a Bunsen burner and record your observations. DO NOT LOOK DIRECTLY AT THE BURNING MAGNESIUM.

⚠ ***Use the Bunsen burner with care. Do not leave the burner unattended.***
⚠ ***Do not look directly at the burning magnesium.***
⚠ ***Dispose of all chemicals in the proper waste container.***

DATA ANALYSIS

1. Make a table of your experimental observations for each procedure.

2. For all observed reactions, write balanced molecular and net ionic equations. For each reaction, include phase labels after each reactant and product.

3. For observed reactions from procedure 4, determine the oxidation numbers of all reactants and products. Identify which reactant is the oxidizing agent and which is reducing agent.

POSTLAB ACTIVITY

You will be turning in a worksheet for this experiment. It will be completed either individually or in pairs, according to your instructor's directions. The tables and equations that you generated in the data analysis will be incorporated into the worksheet.

Follow your instructor's directions for submitting the worksheet. If you are submitting electronically, please use the following convention for naming your worksheet: *Lastname1 Lastname2 Reactions*. If you are emailing the worksheet, use a subject line of *Chem 1061: Reactions Lab*.