Introductory Chemistry Lab: Chemical Reactions

Outcomes

As a result of today's laboratory, you will have:

- Observed a number of chemical reactions.
- Noted the indicators of a chemical reaction.
- Translated word equations into balanced chemical reactions.
- Classified chemical reactions as one of five basic types.

Prelab

Prepare a Title (can use the lab handout for this), Purpose (a concise statement) and a Procedure (short "to do" list … see "Writing a Procedure" in the lab handouts folder). The lab Hand-In contains the data, results, conclusion, and questions portion of the lab report. You will fill this in and staple to your report.

Purpose

To classify and observe a number of chemical reactions, record the signs that indicate a chemical change has occurred, and translate word equations into balanced chemical reactions.

Background Information

Most ordinary chemical reactions can be classified as one of five basic types:

1. Combination Reaction - Two or more substances react to form a single compound.

$$A + Z \rightarrow AZ$$

2. Decomposition Reaction - A single compound breaks down into two or more simpler substances, usually by the application of heat. Note that decomposition reactions are the opposite of combination reactions.

$$AZ \rightarrow A + Z$$

3. Complete combustion reaction of an organic fuel - An organic compound containing C & H or C, H, & O, reacts with oxygen gas to form water and carbon dioxide. Using methane (natural gas) as an example:

$$CH_4 + 2\,O_2 \rightarrow CO_2 + 2\,H_2O$$

4. Single-replacement reaction - One element displaces another from a compound or aqueous solution.

$$A + BZ \rightarrow AZ + B$$

5. Double-replacement reaction - Two substances in aqueous solution switch partners; that is, an anion of one substance exchanges with another.

$$AX + BZ \rightarrow AZ + BX$$

Double replacement reactions can be further classified into:

a) Precipitation reaction - An insoluble product (a precipitate) is formed.

$$AX_{(aq)} + BZ_{(aq)} \rightarrow AZ_{(s)} + BX_{(aq)}$$

b) Gas-forming reaction - The double replacement reaction is immediately followed by a decomposition of one of the products to yield a gas (typically CO_2, SO_3, SO_2, or NH_4). For carbonates:

$$HX + BCO_3 \rightarrow BX + H_2O + CO_{2(g)}$$

c) Neutralization reaction - An acid and a base react to form a salt and water. The hydrogen ion in the acid neutralizes the hydroxide ion in the base to form water. If water is written as HOH, the neutralization is more obvious and the equation may be easier to balance.

$$HX + BOH \rightarrow BX + HOH$$

In this experiment, you will carefully observe and record the evidence that a chemical reaction has taken place. Evidence for a reaction may include:
1. bubbling - indicates a gas is produced
2. cloudiness - indicates a precipitate is formed
3. color change - indicates a new species is formed
4. temperature change - indicates a change in energy associated with formation of new substances
5. light - indicates energy being released

We use various descriptive state symbols in the chemical equation. Table 1 lists some of these.

Table1. Symbols in Chemical Equations

Symbol	*Translation*
→	produces, yields (separates reactants from products)
+	added to, reacts with (separates two or more reactants or products)
Δ	heat (written above →)
NR	no reaction (written after →)
(s)	solid or precipitate
(l)	liquid
(g)	gas
(aq)	aqueous solution

Translating word equations into balanced chemical equations

In order to write an equation, it is necessary to predict the products from a given reaction. Word equations are supplied for each reaction in the results section. The word equations must be translated into balanced chemical equations. The following examples illustrate how this is done.

1. Combination Reaction

$$\text{zinc}_{(s)} + \text{oxygen}_{(g)} \rightarrow \text{zinc oxide}_{(s)}$$
$$2\ Zn_{(s)} + O_{2(g)} \rightarrow 2\ ZnO_{(s)}$$

2. Decomposition Reaction

$$\text{lithium hydrogen carbonate}_{(s)} \rightarrow \text{lithium carbonate}_{(s)} + \text{water}_{(g)} + \text{carbon dioxide}_{(g)}$$
$$2\ LiHCO_{3(s)} \rightarrow Li_2CO_{3(s)} + H_2O_{(g)} + CO_{2(g)}$$

3. Complete Combustion of Organic Fuel Reaction

$$\text{propane}_{(g)} + \text{oxygen}_{(g)} \rightarrow \text{carbon dioxide}_{(g)} + \text{water}_{(g)}$$
$$C_3H_{8(g)} + 5\ O_{2(g)} \rightarrow 3\ CO_{2(g)} + 4\ H_2O_{(g)}$$

4. Single-Replacement Reaction

$$\text{tin}_{(s)} + \text{hydrochloric acid}_{(aq)} \rightarrow \text{tin(II) chloride}_{(aq)} + \text{hydrogen}_{(g)}$$
$$Sn_{(s)} + 2\ HCl_{(aq)} \rightarrow SnCl_{2(aq)} + H_{2(g)}$$

5. Double-Replacement Reaction

A. Precipitation Reaction

$$\text{potassium phosphate}_{(aq)} + \text{calcium chloride}_{(aq)} \rightarrow \text{calcium phosphate}_{(s)} + \text{potassium chloride}_{(aq)}$$
$$2\ K_3PO_{4(aq)} + 3\ CaCl_{2(aq)} \rightarrow Ca_3(PO_4)_{2(s)} + 6\ KCl_{(aq)}$$

B. Gas-Forming Reaction

$$\text{potassium carbonate}_{(aq)} + \text{hydrochloric acid}_{(aq)} \rightarrow \text{potassium chloride}_{(aq)} + \text{carbon dioxide}_{(g)} + \text{water}_{(g)}$$
$$K_2CO_{3(aq)} + 2\ HCl_{(aq)} \rightarrow 2\ KCl_{(aq)} + H_2O_{(l)} + CO_{2(g)}$$

C. Neutralization Reaction

$$\text{hydrochloric acid}_{(aq)} + \text{barium hydroxide}_{(aq)} \rightarrow \text{barium chloride}_{(aq)} + \text{water}$$
$$2\ HCl_{(aq)} + Ba(OH)_{2(aq)} \rightarrow BaCl_{2(aq)} + 2\ HOH_{(l)}$$

Procedure Work in Pairs

The data tables, results, conclusion and questions are in the Hand-In. Complete these and staple to the pages from your lab report.

For each of the reactions below record yours observations on the attached data sheet.
You are looking for the following **signs** for a reaction:

1. **bubbling** - indicates a gas is produce;
2. **cloudiness** - indicates a precipitate is formed
3. **color change** - indicates a new species is formed
4. **temperature change** - indicates an energy change associated with formation of new substances

WEAR YOUR SAFETY GOGGLES!

If you get any chemical on your skin, immediately wash with lots of cold water (do not rub your skin) and notify the instructor.

Combination Reactions—Instructor Demonstration

1. Your instructor will ignite a 2 cm strip of magnesium ribbon using a Bunsen burner flame.
2. Your instructor will place (in separate watch glasses) 6 M HCl near 6 M NH_4OH.

Decomposition Reactions

3. Add approx. 1 mL of hydrogen peroxide to a clean medium test tube. Add a small piece of raw potato to the test tube. Observe the decomposition of hydrogen peroxide. The potato is a source of an enzyme, catalase. The catalase acts as a catalyst for the decomposition. Catalysts are used to increase the rate of chemical reactions without being consumed in the reaction.

Complete Combustion Reactions of Organic Fuels

4. A well adjusted Bunsen burner flame results from the complete combustion of natural gas, methane. Note the color of the flame when combustion is complete compared to when the combustion is incomplete when the air intake on the burner is closed.
5. Place several drops of ethanol on a watch glass and ignite it with a lighted match.

Single-Replacement Reactions

6. Put 20 drops of copper (II) sulfate **solution** into a small test tube and add a small piece of zinc. Observe the reaction for several minutes. Put the test tube aside and observe again after 30 minutes. Look for color changes on the zinc and in the solution. When finished drain off liquid only into the copper (II)sulfate waste container. The metal should be emptied into the Zinc metal waste container. Both containers are under the hood. Do NOT put the Zinc down the drain!
7. Put 20 drops of hydrochloric acid into a test tube and add a small piece of magnesium metal. Carefully touch the outside bottom of the test tube to feel for heat. Record any visual observations.

Double-Replacement Reactions

8.–14. Put 10 drops of reactant A in a small test tube and add 10 drops of reactant B. Mix well by gently flicking the bottom of the test tube. In addition to visual signs of change, feel each test tube for changes in temperature. Look carefully for small bubbles in the gas forming reactions. Some changes are subtle so look carefully.

#	Reactant A	Reactant B
A. Precipitation Reaction		
8	Copper(II) sulfate	Sodium hydroxide
9	Calcium chloride	Sodium sulfate
10	Potassium carbonate	Calcium chloride
B. Gas-Forming Reaction		
11	Potassium carbonate	Hydrochloric acid
12	Sulfuric acid	Sodium carbonate
C. Neutralization Reaction		
13	Nitric acid	Sodium hydroxide
14	Sulfuric acid	Sodium hydroxide

CLEAN UP

1. All chemicals should be placed in the designated waste containers as described in the lab procedure.
2. Metals must never be put down the drain.
3. Rinse out all glassware 3x in tap and 3x in deionized water.
4. Wipe, dry, and return all glassware to proper storage.
5. Wipe down lab table with wet paper towel.