EXPERIMENT 11 (2 Weeks) **Chemistry 110 Laboratory**

TYPES OF CHEMICAL REACTIONS

PURPOSE: The purpose of this experiment is perform, balance and classify chemical reactions based on observations. Students will determine the relative activity of several metal elements and the identity of an unknown ionic compound based on its chemical properties.

PART I INTRODUCTION

It is useful to classify reactions into different types, because products of reactions can be predicted. No one classification scheme can accommodate all known reactions but the following classification of reactions is based on the fact that many reactions can be classified as combination (composition), decomposition, combustion, single replacement, double replacement , and replacement reactions.

Classifying Chemical Reactions

A. Combination reactions

1. Simple combination of two elements to form a binary compound

$2\ Na(s) + Cl_2(g) \rightarrow 2\ NaCl(s)$

2. Combination of elements and/or compounds

a. $CaO(s) + CO_2(g) \rightarrow CaCO_3(s)$

b. Metal oxides react with water to form bases

$Na_2O(s) + H_2O(l) \rightarrow NaOH(aq)$

c. Nonmetal oxides react with water to form acids

$SO_3(g) + H_2O(l) \rightarrow H_2SO_4(aq)$

B. Decomposition reactions (often promoted by heat or light)

$$2\ HgO(s) \xrightarrow{\text{heat}} 2Hg(l) + O_2(g)$$

$$2\ NO_2(g) \xrightarrow{\text{light}} 2\ NO(g) + O_2(g)$$

C. Single replacement reactions

1. A more active metal will replace a less active metal

$2\ AgNO_3(aq) + Cu(s) \rightarrow 2Ag(s) + Cu(NO_3)_2(aq)$

2. A more active halogen will replace a less active halogen.

$Cl_2(aq) + 2\ NaI(aq) \rightarrow NaCl(aq) + I_2(aq)$

D. Double Replacement

The products of a double replacement reaction are

1. a precipitate

$AgNO_3\ (aq) + NaCl\ (aq) \rightarrow AgCl\ (s) + NaNO_3\ (aq)$

2. a gas

$Na_2S\ (aq) + HCl\ (aq) \rightarrow H_2S\ (g) + NaCl\ (aq)$

3. a less ionized substance (weak acid or water)

$NaF\ (aq) + HNO_3\ (aq) \rightarrow HF\ (aq) + NaNO_3\ (aq)$ HF is a weak acid

E. Combustion Reactions

A combustion reaction is the reaction of an organic compound with oxygen producing carbon dioxide and water. This reaction gives off heat and light.

An organic compound will contain carbon and hydrogen in its formula, with possibly oxygen or other nonmetals present.

Examples: C_3H_8 C_6H_6 CH_3OH $(C_2H_5)_2O$

Organic compounds react with oxygen to produce water and carbon dioxide at high temperature

$C_3H_8 + 5\ O_2(g) \rightarrow 4\ H_2O(g) + 3\ CO_2(g)$

$2\ C_6H_6 + 15\ O_2(g) \rightarrow 6\ H_2O(g) + 12\ CO_2(g)$

$2\ CH_3OH + 3\ O_2(g) \rightarrow 4\ H_2O(g) + 2\ CO_2(g)$

Safety goggles **must** be worn at all times

$AgNO_3$ will stain your hands black. Rinse your hands with tap water after handling.

NaOH solutions are corrosive to the skin.
Dilute hydrochloric acid (HCl) and sulfuric acid (H_2SO_4) can harm eyes, skin, and clothing. Handle with care. Any acid or base spilled on the skin, clothes, or splashed into your eyes must be rinsed with a large volume of water. Wash your eyes at the eye wash station.

PART II PROCEDURE

[Remember: DO NOT PUT ANY EXCESS REAGENTS BACK INTO THE REAGENT BOTTLES!]

PART A. COMBINATION REACTIONS

1. Take a glass plate from your locker. Obtain a "gas bottle" from the side shelf and a metal "Deflagrating spoon" from under the hood. Your instructor will put a very small amount of sulfur into the spoon. UNDER THE HOOD, your instructor will light the sulfur in the flame of a burner. Set your gas bottle into the fume hood and your instructor will lower the spoon with the burning sulfur into the bottle.

CAUTION: Do not touch the bottle with the hot spoon.

Remove the spoon and use the glass plate to keep the smoke inside the bottle. Whicle in the fume hood. Add 1 ml of deionized water to the bottle Quickly cover then shake well.
Test the solution with blue and red litmus paper.

Is the solution acidic or basic?_____

The white smoke that formed when the sulfur burned in the presence of air is sulfur trioxide. Write the chemical equation for this reaction

Chemical Equation: _____

2 continued.....

When the sulfur trioxide dissolves in water an acid forms .
Write the equation for this reaction.

Combination Equation: _____

2. a. With a crucible tong, hold a strip of magnesium and heat it with a Bunsen burner.
*WARNING! Hold it away from your face. The magnesium will flare up and emit a bright blinding light!! Do not look directly at the light.

Chemical Equation: _____

b. Drop the ash (Magnesium oxide) from the above experiment onto a glass plate. Add a few drops of deionized water. Mix with a stirring rod to partially dissolve the ash. Press pieces of both blue and red litmus paper into the mixture.

Is the solution neutral, acidic or basic? _____

Chemical Equation: _____

PART B. DECOMPOSITION REACTIONS

1. Put about 3 ml of fresh hydrogen peroxide solution into a small test tube. Add a small amount (match head size) of manganese dioxide (MnO_2) , a catalyst.

Observation: _____

Chemical Equation: _____

*** DISPOSAL:** Dispose of the hydrogen peroxide reaction mixture in the waste container labeled "Manganese dioxide/Hydrogen peroxide mixture".

2. Put a small amount (pea size) of solid copper (II) carbonate into a crucible and gently warm for one minute followed by 3 minutes of high heat

Observation: _____

Decomposition Equation: _____

PART C. SINGLE REPLACEMENT REACTIONS

1. Activity Series for metals and hydrogen gas

Clean your spot plates. Place a paper towel under the plates.

For each reaction place about 5 drops of solution with one piece of metal in individual wells of the spot plate. Label each reaction. Examine each reaction mixture and record your observations. If there is no reaction, write N.R.

NOTE: Some reactions are slow. If a reaction does not occur immediately, go back and examine the well after ten to fifteen minutes. Be sure to observe the surface of the metal as well as the solution for any color changes, bubbles or new solid forming.

Spot Plate #1

a. Cu metal + aqueous silver nitrate solution

Observations: _____

Chemical equation: _____

Which is more active copper or silver ? Arrange them in order of activity

_____ > _____

more active less active

***DISPOSAL:** Dispose of the $AgNO_3$ reaction mixture into the silver nitrate waste container when the reaction is completed

Spot Plate #2

b. Cu metal + DIL sulfuric acid (above your lab bench)

Observations: _____

Chemical equation: _____

Which is more active copper or H_2 ? Arrange them in order of activity

_____ > _____

more active less active

c. Mossy zinc + DIL sulfuric acid (above your lab bench)

Observations: _____

Chemical equation: _____

Which is more active zinc or H_2 ? Arrange them in order of activity

_____ > _____

more active less active

d. Mossy zinc + aqueous magnesium sulfate

Observations: _____

Chemical equation: _____

Which is more active zinc or magnesium ? Arrange them in order of activity

_____ > _____

more active less active

e. Calcium metal + water

Observations: _____

Chemical equation: _____

Which is more active calcium or H_2 ? Arrange them in order of activity.

_____ > _____

more active less active

f. Place 1 strip of magnesium metal and 3 ml of water into a test tube. Set the test tube into a hot water bath. Make your observations after 1 minute (no longer).

Observations: _____

Chemical equation: _____

Which is more active magnesium or H_2 ? Arrange them in order of activity.

_____ > _____

more active less active

Which is more active magnesium or calcium ? (See the results from part "e"). Arrange them in order of activity. (A **very** active metal will displace H_2 from cold water)

_____ > _____

more active less active

*** DISPOSAL: Dispose the Solid calcium metal into the waste container labelled " Waste Calcium metal"**

For reactions b-->d, and f, dispose of the liquids in the sink and the metals in the trash can

List the six elements, Ag, Cu, Zn, Mg, Ca, and H_2 in order of activity

ACTIVITY SERIES FOR METALS AND HYDROGEN

_____ > _____ > _____ > _____ > _____ > _____

most active least active

PART D. COMBUSTION REACTIONS

1. Each time you light a "gas" burner, you burn methane, CH_4. Write the chemical equation for the combustion of methane:

   Chemical Equation: _____

2. Octane C_8H_{18} is the main part of the mixture you put in your car called gasoline. Write the chemical equation for the combustion of octane:

   Chemical Equation: _____

PART E. DOUBLE REPLACEMENT REACTIONS

Clean both spot plates. Place a paper towel under the spot plate and write the reaction mixture next to each well. Mix equal volumes of solutions (4-5 drops) and then look for evidence of a chemical reaction. Record any precipitate that forms and its color. If there is no reaction write N.R. Write the balanced equation for those reactions that do occur. Identify the unknown by mixing 4-5 drops of each solution with 4-5 drops of your unknown. Record all observations. **Each reaction is to be performed only once. Use a separate plate for the reactions involving silver nitrate. Dispose of silver nitrate in the Waste container labeled "silver waste."** Boxes are shaded to remind you not to perform the same reaction twice. But it might be helpful in determining the identity of your unknown if you filled in the shaded boxes with observations as well as the non shaded boxes.

***DISPOSAL:** Dispose of the $AgNO_3$ reaction mixture into the silver nitrate waste container when the reaction is completed

	KNO_3	$AlCl_3$	$AgNO_3$	NaCl	$Zn(NO_3)_2$	Na_2CO_3	NaOH
KNO_3							
$AlCl_3$							
$AgNO_3$							
NaCl							
$Zn(NO_3)_2$							
Na_2CO_3							
NaOH							
Unknown #							

Write the balanced equations for only those reactions that occurred. Be sure to show all states. To help you determine the precipitate that formed, it would be helpful to refer to the boxes in which the products were both soluble. For example you should have obtained a precipitate for the reaction between silver nitrate +sodium chloride → sodium nitrate + silver chloride. Only one of these products is a precipitate. Looking at the observation (no reaction) for the mixing of sodium chloride + aluminum nitrate reveals that both products, sodium nitrate and aluminum chloride are soluble. Therefore, the precipitate in the reaction between sodium chloride and silver nitrate is silver chloride and not sodium nitrate.

List the identities of the precipitates that formed. These ionic compounds are insoluble (or very slightly soluble) in water.

Unknown # _____Determine the identity of your unknown_____

Give an explanation for how you determined you unknown. Give evidence.

Below is a list of all of the ions that you mixed in the above experiment. Look at your observations and the list of precipitates that formed. Try to find a pattern for each ion . Make a general statement about compounds that might contain the particular ion. For example, you could write " This ion is always soluble", or " This ion is generally soluble except with hydroxide."

K^+
NO_3^-
Al^{+3}
Cl^-
Na^+
Ag^+
OH^-
CO_3^{2-}

PRACTICE:

Single Replacement Reactions: Complete the chemical equations for the reactions below. For those that do not react, write N.R.

1. Calcium and water _____
2. Magnesium and silver nitrate _____
3. Potassium bromide and iodine _____

Decomposition, Combination and Combustion Reactions:

4. Decomposition of potassium oxide

_____

5. Combustion of butane, C_4H_{10}

_____

6. Sulfur dioxide combines with water

_____

7. Combustion of benzene, C_6H_6

_____

Double Replacement Reactions

8. Sulfuric acid solution is mixed with sodium hydroxide

_____

9. Calcium nitrate solution is mixed with a solution of sodium carbonate

_____

10. Solutions of potassium sulfide and cupric sulfate are mixed

_____

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Chem. 110 Lab Report Date _____

Name _____ Initials_____

Lab Section _____

EXPERIMENT 11

TYPES OF REACTIONS

A. SINGLE REPLACEMENT REACTIONS

1. a. Cu metal + aqueous silver nitrate solution

Chemical equation: _____

Which is more active?_____ > _____

more active less active

b. Cu metal + DIl sulfuric acid (above your lab desk)

Chemical equation: _____

Which is more active?_____ > _____

more active less active

c. Mossy zinc + Dil sulfuric acid

Chemical equation: _____

Which is more active?_____ > _____

more active less active

d. Mossy zinc + aqueous magnesium sulfate

Chemical equation: _____

Which is more active?_____ > _____

more active less active

e. Calcium metal + water

Chemical equation: _____

Which is more active?_____ > _____

more active less active

f. Magnesium metal + hot water

Chemical equation: _____

Which is more active?_____ > _____

more active less active

Which is more active magnesium or calcium ?

_____ > _____

more active less active

ACTIVITY SERIES FOR METALS AND HYDROGEN

_____ > _____ > _____ > _____ > _____ > _____

most active least active

PART B. Decomposition Reactions:

1) Observations: _____

Equation_____

2) Observations: _____

Decomposition equation_____

PART C. Combination:

1) Equation for ash: _____

Acidic or Basic? _____

Equation for ash + water: _____

2) Acidic or Basic? _____

Equation for smoke: _____

Equation for smoke + water: _____

PART D. Combustion: 1) Equation : _____

2) Equation : _____

PART E. DOUBLE REPLACEMENT REACTIONS

Write the balanced equations for only those reactions that occurred. Be sure to show all states.

Unknown # _____Determine the identity of your unknown_____

Write a paragraph stating the identity of your unknown dissolved ionic compound. Make a claim as to its identity and back up that claim with very clear and specific evidence.

PRACTICE:

Single Replacement Reactions: Complete the chemical equations for the reactions below. For those that do not react, write N.R.

1. Bromine and potassium chloride _____
2. Aluminum bromide and chlorine _____
3. Copper and zinc sulfate _____
4. Zinc and silver sulfate _____
5. Copper and silver nitrate _____
6. Zinc and sulfuric acid _____

Decomposition, Combination and Combustion Reactions:

Complete the chemical equations for the reactions below:
For those that do not react, write N.R.

10. Sulfur + oxygen, forming sulfur dioxide

_____

11. Silver "tarnishes" (reacts) in the presence of sulfur

_____

12. Iron rusts, forming ferric oxide

_____

Double Replacement Reactions

11. Sulfuric acid solution is mixed with sodium hydroxide

_____

12. Calcium nitrate solution is mixed with a solution of sodium carbonate

_____

13. Solutions of potassium sulfide and cupric sulfate are mixed

_____