**Experiment 7** Name: _____

# CHEMI 20 Ca L REACTIONS AND EQUATIONS

In this experiment, you will observe changes that occur during chemical reactions. You will also balance the corresponding chemical equations and identify the reaction type. You will also get familiarized to chemical nomenclature while you encounter chemical names and formulas as you work.

In chemical reactions, a set of substances is transformed into another set of substances with different chemical identity. For example, silver tarnishes because it reacts with hydrogen sulfide in air. The chemical reaction taking place is indicated by a change in color. The shiny silver metal turns dull dark-gray because a new is substance, silver sulfide, is formed on the surface. In addition to a change in color, other evidences of a chemical reaction occurring are formation of gas (bubbles or fizzing), formation of a precipitate (insoluble solid) and heat given off or absorbed (change in temperature).

During chemical reactions, atoms of the reactants rearrange into new combinations to form products. By the law of conservation of matter, the total number of atoms of each element in the reactants is equal to the total number of atoms of each element in the products. A chemical reaction is concisely represented by a balanced chemical equation.

In a chemical equation, the reactants are shown on the left side and the products on the right, separated by an arrow. When silver tarnishes, the reactants are solid Ag and gaseous $H_2S$, and the products are solid $Ag_2S$ and gaseous $H_2$. To balance the equation, coefficients must be used so that the numbers of atoms of each element are the same on both sides of the arrow:

**Unbalanced Equation:** $Ag\,(s) + H_2S\,(g) \rightarrow Ag_2S\,(s) + H_2\,(g)$

**Balanced Equation:** $\mathbf{2}\,Ag\,(s) + \mathbf{1}\,H_2S\,(g) \rightarrow \mathbf{1}\,Ag_2S\,(s) + \mathbf{1}\,H_2\,(g)$

Most chemical reactions can be classified into the following types:

1. Combination or Synthesis – **Two or more** simpler substances (compounds or elements) form **one** complex substance

   General Format: A + B → C
   Example: $1\,NH_3\,(aq) + 1\,HCl\,(aq) \rightarrow 1\,NH_4Cl\,(aq)$

2. Decomposition – **One** complex substance is breaks up into **two or more** simpler substances (compounds or elements).

   General Format: C → A + B
   Example: $2\,NaN_3\,(s) \rightarrow 2\,Na\,(s) + 3\,N_2\,(g)$

3. Single displacement – Reaction between **an element and a compound** where one element takes the place of another in the compound.

   General Format: $A + BY \rightarrow B + AY$
   Example: $1\ Ca\ (s) + 2\ HCl\ (aq) \rightarrow 1\ CaCl_2\ (aq) + 1\ H_2\ (g)$

4. Double displacement – Reaction between two compounds in which **ions switch partners**.

   General Format: $AX + BY \rightarrow BX + AY$
   Example: $2\ Al(OH)_3\ (s) + 3\ H_2SO_4\ (aq) \rightarrow 1\ Al_2(SO_4)_3\ (aq) + 6\ H_2O\ (l)$

5. Combustion – Substance **reacts with oxygen** to form an oxide product.
   (Note: Reacting a hydrocarbon (e.g. $CH_4$) with $O_2$ always produces $CO_2$ and $H_2O$, both of which are technically oxide products)

   General Format: $X + O_2 \rightarrow$ oxide
   Examples: $1\ CH_4\ (g) + 2\ O_2\ (g) \rightarrow 1\ CO_2\ (g) + 2\ H_2O(g)$
   $2\ Cu\ (s) + 1\ O_2\ (g) \rightarrow 2\ CuO\ (s)$*

*The reaction of a metal with oxygen forming an oxide can also be classified as combination/synthesis.

**PROCEDURE**

For each of the procedure below, record your observations. Remember that you are looking for the following evidences that a reaction has occurred:

- New substance formed (change in color)
- Formation of gas (bubbles or fizzing)
- Formation of a precipitate (insoluble solid)
- Heat given off or absorbed (change in temperature)
- Light emitted

Consult the chemical equation in the worksheet to confirm your observation is consistent with the expected products. Balance the chemical equation for the reaction that occurs. Identify the reaction type.

**For Parts I, III, and V, use small quantities and note that the quantities need not be exact.** For solids, use the amount that fills the tip of a spatula. For liquids, use ~3 mL. (Tip: Use a graduated cylinder to measure 3 mL water. Transfer to a test tube to see and estimate about how much liquid to use each time the procedure calls for 3 mL).

IMPORTANT: Dispose wastes as soon as you finish a reaction or part so you can keep track of the test tube contents and place them in their designated containers.

## I. Zinc and Copper(II) Sulfate

1. Place ~3 mL 1 M solution of copper (II) sulfate ($CuSO_4$), into each of two test tubes.
2. Obtain a small piece of zinc metal.
3. Observe and record the appearance of both $CuSO_4$ solution and zinc metal.
4. Add the zinc to the $CuSO_4$ solution in one test tube. The $CuSO_4$ in the other test tube serves as reference for initial color.
5. Observe after 15 minutes. Observe again after another 15 minutes (30 minutes total).

## II. Magnesium and Oxygen

1. Obtain a small strip of magnesium ribbon and make initial observations.
2. Hold the end of the magnesium ribbon with tongs. Ignite it using a Bunsen burner flame.

> CAUTION: Remove the magnesium from the flame as soon as it ignites. Do not look directly at the flame because the bright light can damage your eyes.

3. Record the changes that occur.

## III. Metals and Hydrochloric Acid

1. Place ~3 mL 1 M solution hydrochloric acid (HCl) in each of three separate test tubes.

> CAUTION: HCl is corrosive. Clean up spills immediately. If it spills on the skin, put affected area under running water for at least ten minutes.

2. Obtain a piece of copper and zinc. Record the appearance of the metals.
3. Add one metal to the acid in each of the test tubes.
4. Record any changes that occur.
5. Obtain a piece of magnesium and a wooden splint. Record the appearance of the metal.
6. Ignite the wooden splint, then immediately place the magnesium into the third test tube with HCl. Wait a few seconds, then insert the burning wooden splint into the top of the test tube (do not place it in the liquid).

> CAUTION: Dispose of the wooden splints in the designated waste container. Do not place it in the trashcan.

## IV. Reactions of Ionic Compounds

The procedure that follows is for mixing 0.1 M solutions of:

A. calcium chloride ($CaCl_2$) and sodium phosphate ($Na_3PO_4$)
B. barium chloride ($BaCl_2$) and sodium sulfate ($Na_2SO_4$)
C. iron (III) chloride ($FeCl_3$) and potassium thiocyanate (KSCN)

1. Record initial observations for each solution you are mixing.
2. Obtain three separate test tubes, one for each pair of solutions (A, B and C) above.
3. To each test tube, add 20 drops of both solutions. Record any changes that occur. Watch for changes in color and formation of gas or solid.

## V. Sodium Carbonate and Hydrochloric Acid

1. Place ~3 mL of 1 M HCl in a test tube.

> CAUTION: HCl is corrosive. Clean up spills immediately. If it spills on the skin, put affected area under running water for at least ten minutes.

2. Add 0.5 g of solid sodium carbonate ($Na_2CO_3$) to the test tube. Record your observations.
3. Light a wood splint and insert the flame in the neck of the test tube. Note what happens to the flame. Explain your observation.

> CAUTION: Dispose of the wooden splints in the designated waste container. Do not place it in the trashcan.

## CLEAN-UP

- Dispose of wastes in designated containers in the front hood.
- Place wooden splints in the designated waste container. Do not place it in the trashcan.
- Wash all glassware used. Return materials where they belong. Shake off excess water from washed test tubes and return to the test tube racks on your work station.
- Make sure the Bunsen burner and gas valve are off, disconnect the tubing from the gas valve.

**Name:** _____ **Date:** _____

**Partner's Name:** _____

# CHEMICAL REACTIONS AND EQUATIONS

## DATA AND OBSERVATIONS

When balancing the equations, write down all coefficients, including 1.
Use the appropriate terms (see pg 2) for describing the evidence of a chemical reaction, include colours where appropriate.

### I. Zinc and Copper(II) Sulfate

| | Observations | |
|---|---|---|
| Time elapsed | Solid | Solution |
| Initial | | |
| After 15 min | | |
| After 30 min | | |
| | Metal formed: | Solution formed: |

Balance: ____ $Zn(s)$ + ____ $CuSO_4(aq)$ → ____ $Cu(s)$ + ____ $ZnSO_4(aq)$

Reaction type: _____

### II. Magnesium and Oxygen

Observations:

Initial _____

During Reaction _____

Balance: ____ $Mg(s)$ + ____ $O_2(g)$ → ____ $MgO(s)$

Reaction type: _____

## III. Metals and Hydrochloric Acid

| | Observations | | |
|---|---|---|---|
| | Cu | Zn | Mg |
| Initial | | | |
| Reaction with HCl | | | |

Balance: ____ $Cu(s)$ + ____ $HCl(aq) \rightarrow$ ____ $CuCl_2(aq)$ + ___ $H_2(g)$

____ $Zn(s)$ + ____ $HCl(aq) \rightarrow$ ____ $ZnCl_2(aq)$ + ___ $H_2(g)$

____ $Mg(s)$ + ____ $HCl(aq) \rightarrow$ ____ $MgCl_2(aq)$ + ___ $H_2(g)$

Reaction type: _____

What caused the noise when the splint was inserted into the test tube? _____

_____

## IV. Reactions of Ionic Compounds

| | Observations | | | | | |
|---|---|---|---|---|---|---|
| | A. $CaCl_2$ and $Na_3PO_4$ | | B. $BaCl_2$ and $Na_2SO_4$ | | C. $FeCl_3$ and KSCN | |
| Initial | | | | | | |
| Reaction | | | | | | |

Balance:

A. ____ $CaCl_2(aq)$ + ____ $Na_3PO_4(aq) \rightarrow$ ____ $Ca_3(PO_4)_2(s)$ + ____ $NaCl(aq)$

B. ____ $BaCl_2(aq)$ + ____ $Na_2SO_4(aq) \rightarrow$ ____ $BaSO_4(s)$ + ____ $NaCl(aq)$

C. ____ $FeCl_3(aq)$ + ____ $KSCN(aq) \rightarrow$ ____ $Fe(SCN)_3(aq)$ + ____ $KCl(aq)$

Reaction type: _____

## V. Sodium Carbonate and Hydrochloric Acid

Observations:

Initial: $NaCO_3$ _____ HCl _____

Reaction with HCl: _____

Splint: _____

Balance: ____ $Na_2CO_3(s)$ + ____ $HCl(aq) \rightarrow$ ____$NaCl(aq)$ + ____ $CO_2(g)$ + ____ $H_2O(l)$

* The reaction can be considered as occurring in two steps:

Step 1: $Na_2CO_3(s) + HCl(aq) \longrightarrow NaCl(aq) + H_2CO_3(aq)$

Step 2: $H_2CO_3(aq) \longrightarrow CO_2(g) + H_2O(l)$

Reaction type: Step 1: _____ Step 2: _____

Why did the flame of the burning splint go out? _____

_____

## POST-LAB QUESTIONS

1. What evidence that a chemical reaction is taking place might you observe when:

   a. Bananas ripen _____

   b. Milk turns sour _____

   c. An Alka-Seltzer tablet is added to water _____

   d. Burning a candle _____

2. Balance the following equations, then classify as combination, decomposition, single displacement, double displacement, or combustion:

   Reaction Type

   a. ___ $Al(s)$ + ___ $HBr(aq) \rightarrow$ ___ $AlBr_3(s)$ + ___ $H_2(g)$ _____

   b. ___ $H_2(g)$ + ___$Cl_2(g) \rightarrow$ ___ $HCl(g)$ _____

   c. ___ $P_4(s)$ + ___ $O_2(g) \rightarrow$ ___ $P_4O_{10}(s)$ _____

3. Write a balanced chemical equation for the following reactions – write the formulas of the reactants and products, then balance. Identify the reaction type.

   a. Ammonium nitrate forms nitrogen, oxygen and water.

      Equation: _____

      Reaction Type: _____

   b. Zinc chloride and sodium hydroxide form sodium chloride and zinc hydroxide.

      Equation: _____

      Reaction Type: _____

4. Predict the products, then **balance** the chemical equations. Identify the type of reaction.

   Reaction Type

   a. __ Al + __ $O_2$ → ___ _____ _____

   b. __ AgCl + __ Zn → ___ _____ + ___ _____ _____

   c. __ $Pb(NO_3)_2$ + __ KI → ___ _____ + ___ _____ _____