Chemical Reactions

Goals
To observe chemical reactions and balance chemical equations.

Background

Chemical and Physical Changes
Changes in matter are often classified as either physical changes or chemical changes. In a **physical change**, the basic particle or substance remains unchanged, but its appearance may change. For instance, when water freezes, the appearance changes, but the particles in the ice cube are still water. All phase changes are physical changes. Other physical changes include crushing, dissolving, and cutting.

In a **chemical change**, also known as a **chemical reaction**, new substances are formed during the change. Propane burning is an example of a chemical change. Propane and oxygen react to form new substances – carbon dioxide and water. Iron and oxygen forming rust is another example of a chemical change. Chemical changes often (but not always) are difficult to reverse – it is easier to thaw an ice cube than it is to un-rust a nail. Chemical changes may also be accompanied by a change in heat (heat from the reaction of propane is used for cooking). Other things that may indicate a chemical change are a change in color or the formation of a new solid or gas.

Balancing Chemical Equations
Chemists represent reactions in the form of chemical equations. The formulas for the starting materials known as reactants are written on the left. This is followed by an arrow pointing to products of the reaction on the right. Phases of reactants and products are often written next to the formulas as follows (s) – solid, (l) – liquid, (g) – gas, and (aq) – aqueous (dissolved in water). A chemical equation for the reaction of lead and sulfur becoming lead (II) sulfide is shown below.

$$Pb\ (s) + S\ (s) \rightarrow PbS\ (s)$$

Although new substances are formed during chemical reactions, the number and type of elements you start with will be the same as the number and type of atoms you end up with. Atoms are not created or destroyed in a chemical reaction, they are only rearranged. Consider the formation of sodium chloride below:

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

The reaction is not balanced because the reactants have two chlorine atoms and the product only has one. When balancing equations, it is important not to change or add subscripts. You cannot simply change NaCl to $NaCl_2$ so that the atoms balance – $NaCl_2$ cannot exist because the ion charges do not sum to zero. Instead, we put **stoichiometric coefficients** in front of the chemical formulas to balance. If we put the coefficient 2 in front of NaCl, the chorines will balance:

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

However, now the sodium does not balance – we have one sodium as a reactant, two in the product. If we add a coefficient to the sodium, the all atoms finally balance:

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

This trial an error process is how we balance reactions. Keep changing coefficients until you have the same number and type of elements on both sides of the reaction.

Laboratory Activity

Materials:					
	2 pieces Zinc	2 pieces magnesium	1 piece Copper	10 test tubes	
	1 M $CuSO_4$	1 M HCl	Na_2CO_3	test tube rack	matches
	0.1 M $CaCl_2$	0.1 M Na_3PO_4	0.1 M $BaCl_2$	0.1 M Na_2SO_4	0.1 M $FeCl_3$
	0.1 M KSCN	bunsen burner	tongs	Bunsen burner hose	

Procedure

A. Combustion of Magnesium

1. Obtain a small piece of magnesium and record its initial appearance on your data sheet.

2. Grab the end of the magnesium with tongs and hold it in a Bunsen burner flame. As soon as the magnesium begins to react, remove it from the flame. **Do not look directly at the burning magnesium!!**

3. Record your observation of the reaction and the final appearance of the magnesium on your data sheet. Dispose of any residue in the regular trash.

B. Reaction of Zinc with Copper Sulfate

4. Obtain a test tube rack and several clean test tubes (they do not have to be completely dry).

5. Measure 2 mL of water in a graduated cylinder and pour it into one of the test tubes. Use this as a reference for the rest of the lab – instead of measuring 2 mL of reagents, just fill to approximately the same height as your reference test tube.

6. Using the test tube of water as a reference, fill two other test tubes with about 2 mL of 1M $CuSO_4$. (1 M is the concentration). Leave the first test tube as is for a color reference. Add one piece of zinc to the second test tube.

7. Record the appearance of the reference $CuSO_4$ test tube without the zinc. Record the appearance of the test tube with the zinc after 15 minutes and again after 30 minutes.

8. Pour all materials in the **waste jug**. (Not down the sink!) Rinse test tubes with water.

C. Reaction of Metals with Acid

9. Obtain 3 test tubes and put 2 mL of 1 M HCl (hydrochloric acid) in each. Put one small piece of copper in the first test tube, one piece of magnesium in the second test tube and one piece of zinc in the third test tube.

10. Observe and record any changes that occur over the next 5 minutes.

11. Pour all materials in the **waste jug**. (Not down the sink!) Rinse test tubes with water.

D. Reaction of Carbonate with Acid

12. Obtain a test tube and add 2 mL of 1M HCl. Add a small amount of Na_2CO_3 (s) to the test tube.

13. Observe and record any changes.

14. Pour the test tube contents down the sink. Rinse the test tube with water.

E. Reactions of Ionic Compounds

15. Obtain three test tubes. Record any changes after adding the following:

- In test tube 1 put 10 drops of 0.1 M $CaCl_2$ and 10 drops of 0.1 M Na_3PO_4.
- In test tube 2 put 10 drops of 0.1 M $BaCl_2$ and 10 drops of 0.1 M Na_2SO_4.
- In test tube 3 put 10 drops of 0.1 M $FeCl_3$ and 10 drops of 0.1 M KSCN.

16. Pour all materials in the **waste jug**. (Not down the sink!) Rinse test tubes with water.

Waste Disposal

- Refer to the last step of each section A-E.

CHM111 Lab – Chemical Reactions – Grading Rubric

To participate in this lab you must have splash-proof goggles, proper shoes and attire.

Criteria	Points possible
Worked actively in the lab group of 3 or fewer students. Did parts of the experiment. (Just writing down data is not doing part of the experiment!)	2
Part A (accurate observations and reaction balanced)	2
Part B (accurate observations and reaction balanced)	2
Part C (accurate observations and reactions balanced)	2
Part D (accurate observations and reactions balanced)	2
Part E (accurate observations and reactions balanced)	4
Post Lab Q1	3
Post Lab Q2	2
Post Lab Q3	1
Total	20

Subject to additional penalties at the discretion of the instructor.

Chemical Reaction: Data Sheet **Name _____ Team Name _____**

A. Combustion of Magnesium

Initial Appearance of Mg	Reaction observations	Final Appearance

Balance the reaction:

____ Mg (s) + ____ O_2 (g) → ____ MgO (s)

B. Reaction of Zinc with Copper Sulfate

Initial Appearance of zinc and solution	After 15 minutes	After 30 minutes

Balance the reaction:

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

C. Reaction of Metals with Acid

Metal	Initial Appearance	Reaction observations
Copper		
Magnesium		
Zinc		

Balance the reactions:

____ Cu (s) + ____ HCl (aq) → ____ $CuCl_2$ (aq) + ____ H_2(g)

____ Mg (s) + ____ HCl (aq) → ____ $MgCl_2$ (aq) + ____ H_2(g)

____ Zn (s) + ____ HCl (aq) → ____ $ZnCl_2$ (aq) + ____ H_2(g)

D. Reaction of Carbonate with Acid

Initial Appearance	Reaction observations

Balance the reaction:

____ $HCl\ (aq)$ + ____ $Na_2CO_3\ (aq)$ → ____ $CO_2\ (g)$ + ____ $H_2O\ (l)$ + ____ $NaCl\ (aq)$

E. Reactions of Ionic Compounds

Reactants	Initial Appearance	Reaction observations
$CaCl_2$ + Na_3PO_4		
$BaCl_2$ + Na_2SO_4		
$FeCl_3$ + KSCN		

Balance the reactions:

____ $CaCl_2\ (aq)$ + ____ $Na_3PO_4\ (aq)$ → ____ $NaCl\ (aq)$ + ____ $Ca_3(PO_4)_2\ (s)$

____ $BaCl_2\ (aq)$ + ____ $Na_2SO_4\ (aq)$ → ____ $BaSO_4\ (s)$ + ____ $NaCl\ (aq)$

____ $FeCl_3\ (aq)$ + ____ $KSCN\ (aq)$ → ____ $KCl\ (aq)$ + ____ $Fe(SCN)_3\ (aq)$

Q1. Balance the following reactions:

a) ____ $Li\ (s)$ + ____ $N_2\ (g)$ → ____ $Li_3N\ (s)$

b) ____ $HNO_3(aq)$ + ____ $Ba(OH)_2(aq)$ → ____ $H_2O\ (l)$ + ____ $Ba(NO_3)_2(aq)$

c) ____ $PCl_5\ (g)$ + ____ $H_2O\ (l)$ → ____ $H_3PO_4\ (aq)$ + ____$HCl(aq)$

d) ____ $Mg_3N_2\ (s)$ + ____ $H_2O\ (l)$ → ____ $Mg(OH)_2\ (s)$ + ____ $NH_3\ (g)$

e) ____$C_{11}H_{18}\ (l)$ + ____ $O_2\ (g)$ → _____ $CO_2(g)$ + ____$H_2O\ (l)$

f) ____ $FeCl_3\ (aq)$ + ____ $Na_2SO_4\ (aq)$ → ____ $Fe_2(SO_4)_3\ (aq)$ + ____ $NaCl\ (aq)$

Q2. Are the following chemical (C) or physical changes (P)?

a) ____ Sugar dissolves in hot tea

b) ____ baking soda reacts with vinegar to make bubbles.

c) ____ alcohol evaporates.

d) ____ silver tarnishes to make silver oxide.

Q3 List three signs that a reaction occurred in your experiments. (How could you tell by looking at the mixtures that a reaction had occurred?)