Experiment 8

Types of reactions

Purpose

The goal of this lab is to observe some chemical reactions, to learn to recognize signs of a chemical reaction, classify chemical reactions and finally to balance chemical equations in order to represent what happened in a chemical reaction.

Background

Substances in our world can undergo physical changes and chemical changes. A physical change is a process where something might look a little different, but is really the same substance before and after the change. The substance will therefore have the same formula before and after the change. An example of physical change is melting ice. The formula for ice and liquid water are both H_2O. On the other hand, chemical changes create new substances which will have different formulas before and after the change. We represent chemical changes by writing chemical equations as you will see today.

In this experiment we will also be observing five major types of reactions. These are:

1. combination or synthesis
2. decomposition
3. single replacement
4. double replacement
5. combustion

Combination

In a combination reaction, two or more substances (elements or compounds) combine to form a more complex substance. Equations for synthesis reactions have the general form **A + B → AB**. For example, the formation of water from hydrogen and oxygen is written

$$2H_2 + O_2 \rightarrow 2H_2O$$

Other examples of combination reactions are

$$Mg + Br_2 \rightarrow MgBr_2$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Decomposition

A decomposition reaction is the opposite of a synthesis reaction. In a decomposition reaction, a compound breaks down into two or more simpler substances (elements or compounds). Equations for decomposition reactions have the general form **AB → A + B**.
Examples include

$$2H_2O \rightarrow 2H_2 + O_2$$

$$Ca(HCO_3)_2 - CaCO_3 + H_2O + CO_2$$

Single Replacement Reaction

In a single replacement reaction, one substance in a compound is replaced by another. Equations for single replacement reactions have two general forms since either the metal or nonmetal part of the compound can be replaced. In reactions in which one metal replaces another metal, the general equation is **X + YB → XB + Y**. In those in which one nonmetal replaces another nonmetal, the general form is **X + AY → AX + Y**. The following equations illustrate these types of reactions:

Zinc metal replaces copper (II) ion:

$$Zn + CuSO_4 \rightarrow ZnSO_4 + Cu$$

Chlorine (a nonmetal) replaces bromide ions:

$$Cl_2 + 2KBr \rightarrow 2KCl + Br_2$$

Double Replacement Reaction

In a double replacement reaction, the metal ions of two different ionic compounds switch places. Equations for this type of reaction have the general form **AB + CD → AD + CB**. Examples include:

$$ZnS + 2HCl \rightarrow ZnCl_2 + H_2S$$
$$AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$$

Combustion

In a combustion reaction, a compound is reacting with O_2 (oxygen gas). For example, the rusting of iron can be considered a combustion reaction

$$4Fe + 3O_2 \rightarrow 2Fe_2O_3$$

Often the compound reacting with oxygen is a carbon-containing compound which results in the production carbon dioxide (CO_2) and water (H_2O) energy is released as a product in the form of heat

The combustion of methane (natural gas);

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O + \text{energy}$$

The combustion of propane:

$$C_3H_8 + 5O_2 \rightarrow 3CO_2 + 4H_2O + \text{energy}$$

Summary of Reaction Types	
Combination A + B → AB	$2Na + Cl_2 \rightarrow 2NaCl$
Decomposition AB → A + B	$2KClO_3 \rightarrow 2KCl + 3O_2$
Single Replacement A + BC → AC + B	$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$
Double Replacement AB + CD → AD + CB	$BaCl_2$ + K2SO4 → $BaSO_4 + 2KCl$
Combustion ______ + O_2 →	$2Ca + O_2 \rightarrow 2CaO$

All of the types of reactions discussed here may be represented by balanced equations. In a balanced equation, the number of atoms of any given element must be the same on both sides of the equation. Multiplying the coefficient and the subscript of an element must yield the same result on both sides of the balanced equation.

In this investigation you will observe examples of the five types of reactions described above. You will also be expected to balance the equations representing the observed reactions.

Evidence of chemical reaction

If a chemical reaction occurs, one or more of the following observations should be visible. You should look for these as you do each experiment a record your observations on page

1. Formation of a **gas** (bubbles)
2. A **precipitate** forms (solid). Often this is observed as cloudiness in your test tube.
3. **Heat** is produced. This means it is an exothermic reaction.
4. A **color change** occurs.

Procedure

Safety

Be sure to wear your safety goggles and take care with hot glassware.

Burning magnesium produces a very bright, hot flame. Make sure you do not look directly at it. Remember never to smell a chemical directly.

Do not allow $AgNO_3$ solution to contact your skin as it can produce a chemical burn and stain your skin.

Dispose of all chemicals as directed in the instructions below.

Do not dispose of wooden splints or metal pieces in the sink.

1. **Instructor Demonstration:** Place 2 mL of saturated calcium acetate, $Ca(C_2H_3O_2)_2$, in an evaporating dish. Add 15 mL absolute ethanol and swirl or stir the mixture. Pour off any excess liquid and ignite the solid residue. While the mixture is burning, sprinkle some solid boric acid or lithium chloride into the flame. You will be balancing the reaction for the burning of the ethanol

2. **Instructor Demonstration:** Gently heat a pea size amount of table sugar in a small test tube over a Bunsen burner flame.
Discontinue heating when the sugar turns brown.
Discard the test tube and its contents in the broken glass box.

3. Obtain a 1 inch piece of magnesium ribbon. Using crucible tongs, hold the sample of magnesium in the flame of a Bunsen burner until the magnesium starts to burn. **DO NOT LOOK DIRECTLY AT THE FLAME.** After the magnesium finishes burning, examine the product thoroughly and record your observations.
Dispose of the product in the trashcan.

4. Place 2 mL (40 drops) of 0.05 M $AgNO_3$ in a small test tube., Add a short piece of Cu wire.
Allow the reaction to sit for at least 10 minutes before recording your observations.
Dispose of the mixture in the waste container.

*Note: In experiments 5-7, you will be testing the flammability of a gas produced in a chemical reaction using a wooden splint. To make a **burning splint**, place the wooden splint in the flame of a Bunsen Burner until it ignites. To make a **glowing splint,** place the wooden splint in the flame of a Bunsen Burner until it ignites and then blow out the flame on the splint to form a red hot ember.*

5. Place 3 mL of 9 % hydrogen peroxide (H_2O_2) in a small test tube. Add a pea size amount of manganese dioxide (MnO_2) to the test tube. Stopper the test tube for one minute to let the gas build up inside of the test tube. Then remove the stopper and quickly insert a glowing (not burning) wood splint into the top of the test tube (approximately 1 inch down inside the test tube) .
Record what happens to the glowing splint.
Note that manganese dioxide is a catalyst in this reaction and is not a reactant or product in the reaction.
Dispose of the mixture in the waste container.

6. Place 3-4 mL of 3.0 M HCl in a clean, dry test tube. Add a piece of mossy zinc. After about half a minute and while the mixture is still bubbling, bring a burning splint to the mouth of the test tube to see if the gas will ignite (approximately 1 inch down inside the test tube). A popping sound indicates the gas is flammable.
Dispose of the mixture in the waste container.

7. Mix 1 mL of 3.0 M HCl with 1 mL of 1.0 M Na_2CO_3 in a small test tube. While the mixture is still bubbling, test the gas produced by bring a burning splint to the mouth of the test tube to see if the evolving gas is combustible (approximately 1 inch down inside the test tube). Note that one of the products of this reaction is H_2CO_3, which will decompose spontaneously into carbon dioxide and water.
Dispose of the mixture in the sink.

8. Mix about 1 mL (20 drops) of 0.1 M $CaCl_2$ and 1mL (20 drops) of 0.1 M Na_3PO_4 in a small test tube. Record your observations.
Dispose of the mixture in the sink.

9. Mix about 1 mL (20 drops) of 0.1 M $FeCl_3$ and 1mL (20 drops) of 0.1 M KSCN in a small test tube. Record your observations.
Dispose of the mixture in the waste container.

10. Place 2 mL of 3.0 M H_2SO_4 in a test tube and add 2 drops of phenolphthalein indicator. Then add 5 mL of 3.0 M NaOH to the test tube. Touch the bottom of the test tube to determine if the reaction is exothermic. If no color change is observed, add another 1-2 mL of NaOH solution.
Dispose of the mixture in the sink.

Observations **Name** ____________________

1. Ethanol demonstration

Observation:____

2. Heating of table sugar demonstration

a. Observation:____

b. What is the liquid formed on the upper wall of the test tube in this reaction? __________

3. Burning Magnesium

Observation:____

4. $AgNO_3$ and Cu

Observation:____

5. Hydrogen peroxide reaction

a. Observation:____

b. What gas is produced in the reaction? ________

6. HCl and Zinc

a. Observation:____

b. What gas is produced in the reaction? ________

7. HCl and Na_2CO_3

a. Observation:____

b. What gas is produced in the reaction? ________

8. $CaCl_2$ and Na_3PO_4

Observation:____

9. $FeCl_3$ and KSCN

Observation:____

10. H_2SO_4 and NaOH

Observation:____

Balancing and classifying the reactions performed in this experiment.

Balance the chemical equations for the reactions you performed in this experiment. Also, indicate if the reaction is a synthesis (SY), decomposition (D), single replacement (SR), double replacement (DR) or combustion (CO) reaction.

Reaction		**Classification**
1. _____CH_3CH_2OH + _____O_2 → _____CO_2 + _____H_2O		_________
2. _____$C_{12}H_{22}O_{11}$ → _____C + _____H_2O		_________
3. _____Mg + _____O_2 → _____MgO	(2 answers)	_____ _____
4. _____Cu + _____$AgNO_3$ → _____$Cu(NO_3)_2$ + _____Ag		_________
5. _____H_2O_2 → _____H_2O + _____O_2		_________
6. _____Zn + _____HCl → _____$ZnCl_2$ + _____H_2		_________
7. _____HCl + _____Na_2CO_3 → _____H_2CO_3 + _____NaCl		_________
8. _____$CaCl_2$ + _____Na_3PO_4 → _____$Ca_3(PO_4)_2$ + _____NaCl		_________
9. _____$FeCl_3$ + _____KSCN → _____$Fe(SCN)_3$ + _____KCl		_________
10. _____H_2SO_4 + _____NaOH → _____H_2O + _____Na_2SO_4		_________

Post-Lab Questions

1. Balance and classify the following reactions as a synthesis (SY), decomposition (D), single replacement (SR), double replacement (DR) or combustion (CO) reaction:

a. _____C_2H_6 + _____O_2 → _____CO_2 + _____H_2O __________

b. _____$PbCl_2$ + _____K_2SO_4 → _____ KCl +_____ $PbSO_4$ __________

c. _____K_2CO_3 → _____ K_2O + _____CO_2 __________

d. _____Fe + _____HCl → _____$FeCl_3$ + _____H_2 __________

e. _____Cl_2 + _____NaBr→ _____NaCl+ _____Br_2 __________

2. Write the balance equation for each of the following reactions. You will need to convert the names of each compound to a formula first using the methods you learned in Chapter 5 of your book.

a. Calcium iodide + sodium phosphite → calcium phosphite + sodium iodide

b. potassium + oxygen → potassium oxide

c. sodium + water → sodium hydroxide + hydrogen

d. Iron + oxygen → iron (III) oxide

3. Predict the products of the reactions below. Write the formulas for the products correctly taking into account the charges of the ions. Then, balance the reaction using coefficients.

a. For the single replacement reaction,

_____Zn + _____$Cu(NO_3)_2$ → ___________ + ______________

b. For the combination reaction

____K + _____Cl_2 → ____________

c. For the double replacement reaction

_____$CaCl_2$ + _______K_3PO_4 → ____________ + ______________

Name ________________________

Pre-lab Assignment for Types of Reactions

1. Balance and classify the following reactions as a synthesis (SY), decomposition (D), single replacement (SR), double replacement (DR) or combustion (CO) reaction:

a. _____Ba + _____N_2 → _____Ba_3N_2 __________

b. _____Ag + _____H_2S → _____Ag_2S + _____H_2 __________

c. _____$CaCl_2$ + _____Na_3PO_4 → _____$Ca_3(PO_4)_2$ + _____$NaCl$ __________

d. _____$NaClO_3$ → _____$NaCl$ + _____O_2 __________

2. Chemical equations are typically written to show what is going on in a chemical change. Classify each of the following as an example of a chemical change or physical change.

a. Grinding pepper ____________________

b. Burning wood ____________________

c. Freezing water ____________________

d. Rusting of an iron nail ____________________