TYPES OF CHEMICAL REACTIONS

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, single replacement, double replacement , and replacement reactions. combustion

Classifying Chemical Reactions

A. Combination reactions
   1. Simple combination of two elements to form a binary compound
      $2\ Na(s)\ +\ Cl_2(g)\ \text{--->}\ 2\ NaCl(s)$
   2. Combination of elements and/or compounds
      a. $CaO(s)\ +\ CO_2(g)\ \text{---->}\ CaCO_3(s)$
      b. Metal oxides react with water to form bases
         $Na_2O(s)\ +\ H_2O(l)\ \text{---->}\ NaOH(aq)$
      c. Nonmetal oxides react with water to form acids
         $SO_3(g)\ +\ H_2O(l)\ \text{---->}\ H_2SO_4(aq)$

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
      $2\ AgNO_3(aq)\ +\ Cu(s)\ \text{--->}\ 2Ag(s)\ +\ Cu(NO_3)_2(aq)$
   2. A more active halogen will replace a less active halogen.
      $Cl_2\ (aq)\ +\ 2\ NaI\ (aq)\ \text{--->}\ NaCl\ (aq)\ +\ I_2\ (aq)$

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

$C_3H_8\ +\ 5\ O_2(g)\ \text{--->}\ 4\ H_2O(g)\ +\ 3\ CO_2(g)$

$2\ C_6H_6\ +\ 15\ O_2(g)\ \text{--->}\ 6\ H_2O(g)\ +\ 12\ CO_2(g)$

$2\ CH_3OH\ +\ 3\ O_2(g)\ \text{--->}\ 4\ H_2O(g)\ +\ 2\ CO_2(g)$

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

Safety

$AgNO_3$ 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. 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. Balance the equation

   Chemical Equation: $Mg + O_2 \rightarrow MgO$

   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: $MgO + H_2O \rightarrow Mg(OH)_2$

2. 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 red phosphorus into the spoon. UNDER THE HOOD, light the phosphorus in the flame of a burner. Lower the spoon with the burning phosphorus 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. 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 phosphorus burned in the presence of air is diphosphorus pentoxide Write the chemical equation for this reaction

   Chemical Equation: $P + O_2 \rightarrow$

   # 2 continued........

   When the diphosphorus pentoxide dissolves in water an acid forms .
   Write the equation for this reaction.
   Combination Equation: $+ H_2O \rightarrow H_3PO_4$

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: H2O2 $\rightarrow H_2O + O_2$

*** 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: ____________$\rightarrow CO_2 + CuO$

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.

Spot Plate #1

a. Cu metal + aqueous silver nitrate solution

Observations: ______________________________________

Chemical equation: Cu + $AgNO_3 \rightarrow$

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: Cu + $H_2SO_4 \rightarrow$

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: Zn+ $H_2SO_4 \rightarrow$

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: Mg+ $H_2SO_4 \rightarrow$

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

_______ > _______

more active less active

e. Calcium metal + water

Observations: ___________________________________

Chemical equation: $Ca + H_2O \rightarrow$

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: $Mg + H_2O \rightarrow$

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 **<u>very</u>** 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. Finish and balance the chemical equation for the combustion of methane:

Chemical Equation: $CH_4 + O_2 \rightarrow$

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	$Al(NO_3)_3$	K_2CO_3	NaOH
KNO_3							
$AlCl_3$							
$AgNO_3$							
NaCl							
$Al(NO_3)_3$							
K_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.

$KNO_3 + AlCl_3$

$KNO_3 + AgNO_3$

$KNO_3 + NaCl$

$KNO_3 + Al(NO_3)_3$

$KNO_3 + K_2CO_3$

$KNO_3 + NaOH$

$AlCl_3 + AgNO_3$

$AlCl_3 + NaCl$

$AlCl_3 + Al(NO_3)_3$

$AlCl_3 + K_2CO_3$

$AlCl_3 + NaOH$

$AgNO_3 + NaCl$

$AgNO_3 + Al(NO_3)_3$

$AgNO_3 + K_2CO_3$

$AgNO_3 + NaOH$

$NaCl + Al(NO_3)_3$

$NaCl + K_2CO_3$

$NaCl + NaOH$

$Al(NO_3)_3 + K_2CO_3$

$Al(NO_3)_3 + NaOH$

$K_2CO_3 + NaOH$

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

Unknown # ____________Determine the identity of your unknown_______________________

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

Part F. Equilibrium

Balance the following equation:

$FeCl_3$ (aq) + KSCN (aq) $\rightleftharpoons$ FeSCN (aq) + KCl (aq)

Obtain 6 ml each of $FeCl_3$ (aq) and KSCN (aq) in two separate small beakers. Using your 10 ml graduated cylinder measure out exactly 2 ml of each and add them to an Erlenmeyer flask. Then measure out 40 ml of distilled water and add it to the flask.

What are the compounds present after you mixed the two solutions?

1.	2.
3.	4.

What is the color of the solution?________________

What compound caused this color?_______________

Divide the mixed solution into 4 equal parts in 4 different numbered (1-4) test tubes. To:

Tube #	Instructions	Did the color get darker or lighter or stay the same?	Did the equilibrium shift to the right or left or neither?
1	Add 2 ml of distilled water		
2	Add 2 ml of $FeCl_3$ solution		
3	Add 2 ml of KSCN solution		
4	Add 2 ml of distilled water ½ teaspoon of KCl		