Unit 5 – Reactions

Progress Tracker

Test Date:

Webassign Due *Score*

_____ _____
_____ _____
_____ _____

Packet Progress Checks

_____ _____
_____ _____
_____ _____

Test Readiness Checks:

- ☐ My webassign scores indicate I am ready for the test.
- ☐ I went to ASP for Webassign help when needed.
- ☐ I have completed the unit review AND checked my answers.
- ☐ I am aware that I cannot retake the test unless my webaassign and packet progress checks are all above 80%.

Learning Objectives

5.1 Chemical Equations
5.2 Classifying Reactions
5.3 Net Ionic Equations

5.1 Chemical Equations

- Know the common indicators of a chemical reaction. (production of a gas, unexpected color change, etc.)
- Balance a chemical reaction.
- Demonstrate an understanding of **the law of conservation of mass** by interpreting or drawing **particulate diagrams** of reactions.
- Know the meaning of common chemical symbols and terminology.
  - **(s), (l), (g), (aq)**
  - **→**
  - **Reactant and product**
  - **Precipitate**
  - **Reaction or equation**
- Convert chemical statements into chemical equations with correct symbols.
- Relate lab experiences (visual representations) of reactions to chemical equations.

5.2 Classifying Reactions and Predicting Products

- Classify reactions as one of the common five types:
  - **synthesis**
  - **decomposition**
  - **single displacement**
  - **double displacement**
  - **combustion.**
- Predict products of these 5 types of reactions writing appropriate formulas.
- Predict products of reactions given only the names of the reactants.

5.3 Net Ionic Equations

- Use a **solubility chart** to determine the solubility of ionic substances.
- Draw particulate representations of **soluble** and **insoluble** substance. (In pure form as part of a reaction.)
- Know that covalent substances may dissolve but don't typically dissociate.
- Write a balance **molecular equation**, **total ionic equation** and a **net ionic equation** for reactions that produce:
  - Precipitates
  - Gases (CO_2, SO_2, H_2, etc.)
  - Weak acids
  - Small covalent substances
- Identify **spectator ions** (and know why they are spectator ions.)
- Understand the term **electrolyte** and be able to identify electrolytes in soltion.

Lab: Introduction to Reactions

Part 1

Safety:

- Tie loose hair and clothing back.
- Do not leave the gas on when your Bunsen burner is not lit. Know where the class shut-off valve is.
- Do not leave the Bunsen burner on when you walk away from it.
- Stay with your group unless you are getting materials.

Reaction 1:

Mg (s) + O_2 (g) → _____ (s) (fill in the blank with the formula for magnesium oxide)

To do this reaction:

- Simply heat the metal in a Bunsen burner flame.
- When it is red hot, pull it out.
- DO NOT LOOK DIRECTLY AT IT! (You will know what IT is when you see it!)

Describe what the magnesium looked like before the reaction.

Describe what the oxygen looked like before the reaction.

Describe what the magnesium oxide looked like after the reaction.

After the lab discussion (as a whole class):

What is a **reactant**?

What is a **product**?

Part 2

Safety:

- Calcium: Do not handle the calcium with your hands.
- Wash your hands when you have finished the lab.
- DO NOT DISCARD THE CALCIUM IN THE SINK OR GARBAGE.

Reaction 2:

$Ca\ (s) + H_2O\ (l) \rightarrow$ _____ (aq) + H_2 (g) (fill in the blank with the formula for calcium hydroxide.)

To conduct the reaction:

- Simply place one piece of calcium in one well of your reaction plate.
- Add water to the well and observe what happens.
- Collect the gas in a test tube

What are the <u>reactants</u> in this reaction? (Which chemicals?)

Which <u>product</u> was a <u>gas</u>? (Which chemical?)

After the lab discussion:

Based on these reactions define these symbols and terms. For most, one word will suffice.

1. (s) _____
2. (l) _____
3. (g) _____

4. (aq)

_____

_____

5. → _____

6. + _____

Reactants and Products

For each of these reactions, count the number of reactants and products:

		Number of Reactants	Number of Products
1	$H_2 + O_2 \Rightarrow H_2O$		
2	$H_3PO_4 + KOH \Rightarrow K_3PO_4 + H_2O$		
3	$K + B_2O_3 \Rightarrow K_2O + B$		
4	$HCl + NaOH \Rightarrow NaCl + H_2O$		
5	$Na + NaNO_3 \Rightarrow Na_2O + N_2$		
6	$C + S_8 \Rightarrow CS_2$		
7	$Na + O_2 \Rightarrow Na_2O_2$		
8	$N_2 + O_2 \Rightarrow N_2O_5$		
9	$H_3PO_4 + Mg(OH)_2 \Rightarrow Mg_3(PO_4)_2 + H_2O$		
10	$NaOH + H_2CO_3 \Rightarrow Na_2CO_3 + H_2O$		
11	$KOH + HBr \Rightarrow KBr + H_2O$		
12	$H_2 + O_2 \Rightarrow H_2O_2$		

When answering these questions, use specific chemicals for the answer.

Example: Which **product** in reaction #3 is a compound? Answer:___K_2O_____

14. Which **reactant** in reaction #3 is an element? _____

15. Which **reactant** in reaction #4 contains a polyatomic ion? _____

16. Which **reactant** in reaction #5 is an element? _____

17. Which **reactant** in reaction #11 contains a polyatomic ion? _____

18. In reaction #12, which chemicals will be completely gone when the reaction is over? _____

Chemical Reaction Notes

Example:

"Solid magnesium metal is reacted with chlorine gas to make solid magnesium chloride."

When drawing a chemical reaction, you need to remember 2 important rules:

1. _____
   _____
   _____

2. _____
   _____
   _____

For each of these sentences:

- Underline all chemicals in the reaction.
- Circle the words that represent the arrow (→) in a chemical reaction.
- Put a square around words that represent the "and" (+) sign.
- Then write the chemicals on the correct side of the reaction.

1. Aluminum metal is added to liquid bromine to produce a powder of aluminum bromide.

2. Solid potassium chlorate is decomposed into solid potassium chloride and oxygen gas.

3. Oxygen gas is passed over a chunk of potassium metal resulting in the formation of solid potassium oxide.

4. Copper metal is added to a container filled with chlorine gas resulting in the formation of copper (II) chloride.

5. Methane gas (CH_4) is burned in the presence of oxygen gas to produce carbon dioxide and water vapor.

6. There are many ways to describe a reaction. Write a sentence that describes the reaction shown. You can find a similar reaction that we have already done and use similar language.

$$Na\ (s) + F_2(g) \rightarrow NaF\ (s)$$

_____

_____

_____

_____

Balancing Equations Notes

Na + Cl_2 → NaCl

The Law of Conservation of Mass says:

_____

_____

_____

Important reminder:

_____

_____

__ HgO → __ Hg + ___ O_2

__ H_2O → __ H_2 + ___ O_2

___ Zn + ___ HCl → ___ $ZnCl_2$ + ___ H_2

___ $KClO_3$ → ___ KCl + ___ O_2

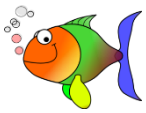
___ Cu + ___ $AgNO_3$ → ___ $Cu(NO_3)_2$ + ___ Ag

___ $Al(NO_3)_3$ + ___ H_2SO_4 → ___ $Al_2(SO_4)_3$ + ___ HNO_3

___ Cl_2 + ___ LiI → ___ $LiCl$ + ___ I_2

___ $AgNO_3$ + ___ $MgCl_2$ → ___ $AgCl$ + ___ $Mg(NO_3)_2$

___ P_4 + ___ O_2 → ___ P_4O_6



Identifying Single and Double Displacement Reactions

Key Skill: Identifying the Number of Reactants and Products in a Reaction

Look at each reaction drawn below. The number of reactants and products are labeled

$$\underbrace{Na + H_2O}_{\textit{2 reactants}} \rightarrow \underbrace{NaOH}_{\textit{1 product}}$$

$$\underbrace{NH_4OH}_{\textit{1 reactants}} \rightarrow \underbrace{NH_3 + H_2O}_{\textit{2 products}}$$

$$\underbrace{Na_2SO_3 + HNO_3}_{\textit{2 reactants}} \rightarrow \underbrace{NaNO_3 + SO_2 + H_2O}_{\textit{3 products}}$$

For each of these reactions, fill in the blanks with the number of reactants and products, using the examples above as a guide.

(1) $NaClO_3 \rightarrow NaCl + O_2$

___ *reactants* ___ *products*

(2) $CH_4 + O_2 \rightarrow CO_2 + H_2O$

___ *reactants* ___ *products*

(3) $NH_3 + HBr \rightarrow NH_4Br$

___ *reactants* ___ *products*

Key Skill: Identifying Synthesis and Decomposition Reactions

Synthesis reactions: 2 *reactants* combine into 1 *product*.

Example: $K + Cl_2 \rightarrow KCl$

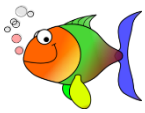
Decomposition reactions: 1 *reactant* splits into 2 *products.*

Example: $K_2CO_3 \rightarrow K_2O + CO_2$

Look at this list of reactions and write "synthesis" or "decomposition" next to each one. When your done, balance each reaction.

	Reaction Type
1. _____ C + _____ O_2 → _____ CO_2	_____
2. _____ $KClO_3$ → _____ KCl + _____ O_3	_____
3. _____ Fe + _____ O_2 → _____ Fe_2O_3	_____
4. _____ Mg + _____ O_2 → _____ MgO	_____
5. _____ Na + _____ Cl_2 → _____ $NaCl$	_____
6. _____ $SiCl_4$ → _____ Si + _____ Cl_2	_____
7. _____ H_2 + _____ O_2 → _____ H_2O	_____
8. _____ CO + _____ O_2 → _____ CO_2	_____
9. _____ CaO + _____ H_2O → _____ $Ca(OH)_2$	_____
10. _____ N_2 + _____ O_2 → _____ NO_2	_____
11. _____ Al + _____ O_2 → _____ Al_2O_3	_____
12. _____ Ti + _____ N_2 → _____ Ti_3N_4	_____
13. _____ $NaBr$ → _____ Na + _____ Br_2	_____
14. _____ C_3H_7I → _____ C_3H_6 + _____ HI	_____
15. _____ $NaHCO_3$ → _____ $NaOH$ + _____ CO_2	_____

Predicting Products of Double Displacement Reactions



Key Skill: Identifying the cation and anion of each compound and swapping them!

All ionic compounds have a cation and anion. In a double displacement reaction we "swap" the ion partners. In this example, the cations have been bolded to make them stand out.

Example 1: **Na**Cl + **K**Br → **Na**Br + **K**Cl

In these equations a blank has been left for the two anions. Fill in the blanks. Remember to swap partners!

Practice 1: **Cs**F + **Li**I → **Cs**__ + **Li**__

RbBr + **Na**F → **Rb**__ + **Na**__

Notice something: Cs is a cation! Cations are always written on the _____(left or right) side of a compound.

Try predicting the products when you also write the cations:

Practice 2: MgO + CaS → ___ ___ + ___ ___

Key Skill: Writing correct formulas after swapping ions.

In most cases, your new products will need to have their formulas "corrected"

<u>Example 2</u>: $MgO + NaF \rightarrow NaO + MgF$

We swapped partners correctly but NaO can't be correct. Let's fix the formula.

While were at it, let's fix MgF as well. Look at the charges for :

The correct equation: $MgO + NaF \rightarrow Na_2O + MgF_2$

<u>Example 3</u>: $CaCl_2 + Rb_3N \rightarrow RbCl + CaN$

Notice: No subscripts when we first swap!

$CaCl_2 + Rb_3N \rightarrow RbCl + Ca_3N_2$ *Corrected formulas*

Write the correct formulas for the blanks in these double displacement reactions.

Practice 3: $Li_2O + BeCl_2 \rightarrow BeO +$ _____

$AlBr_3 + MgO \rightarrow Al_2O_3 +$ _____

$K_3N + MgF_2 \rightarrow$ _____ $+ Mg_3N_2$

Swap partners in these reactions <u>and</u> write correct formulas for both products.

Practice 4: BF_3 + SrO → _____ + _____

Mg_3N_2 + SrF_2 → _____ + _____

Na_3P + BeO → _____ + _____

Key Skill: Double displacement products when <u>polyatomic</u> ions are involved.

The steps are the same when polyatomic ions are involved. Just remember write the polyatomic exactly as it is written on your sheet.

<u>Example 4</u>: $Ca(\mathbf{NO_3})_2$ + $AlCl_3$ → CaCl + $Al(\mathbf{NO_3})$ *swapped*

$Ca(\mathbf{NO_3})_2$ + $AlCl_3$ → $CaCl_2$ + $Al(\mathbf{NO_3})_3$ *formulas fixed*

<u>Example 5</u>: SrO + $K_2\mathbf{SO_4}$ → $Sr\mathbf{SO_4}$ + KO *swapped*

SrO + $K_2\mathbf{SO_4}$ → $Sr\mathbf{SO_4}$ + K_2O *formulas fixed*

Now it's your turn. Swap the ions and fix the formulas using the examples above as a guide.

Practice 5: Na**CN** + Li_2O → _____ + _____

$B(\mathbf{OH})_3$ + $MgCl_2$ → _____ + _____

KBr + $Ca_3\mathbf{(PO_4)_2}$ → _____ + _____

$\mathbf{(NH_4)}F$ + $Sr\mathbf{SO_3}$ → _____ + _____

$Mg(\mathbf{ClO_3})_2$ + Cs**OH** → _____ + _____

Key Skill: Double displacement reactions when <u>water</u> is involved.

The formula for water is H_2O. When we see water in a double displacement reaction, it is easier to re-write it as H**OH**. We are pretending like it is a molecule with a **hydroxide** as a polyatomic ion.

<u>Example 6</u>: KBr + $\mathbf{H_2O}$ → *change water first!*

KBr + **H*OH*** → K*OH* + HBr

<u>Example 7</u>: $\mathbf{H_2O}$ + $Ca(NO_3)_2$ → *change water first!*

H*OH* + $Ca(NO_3)_2$ → HNO_3 + $Ca(OH)_2$

Your turn. Predict the products of these reactions.

Practice 6: H_2O + $SrCl_2$ → _____ + _____

$Mg(CN)_2$ + H_2O → _____ + _____

$LiC_2H_3O_2$ + H_2O → _____ +_____

$(NH_4)_3N$ + H_2O → _____ + _____

Key Skill: Double displacement reactions when <u>transition metals</u> are involved.

There is nothing new in what we are going to do here! But we have a challenge when we write the products of these reactions. Take a look:

<u>Example 8</u>: $FeCl_3 + K_2O \rightarrow ?$

Step 1: swap partners $FeCl_3 + K_2O \rightarrow FeO + KCl$

Step 2: Fix the formulas $FeCl_3 + K_2O \rightarrow Fe_2O_3 + KCl$

But what is the charge of Fe**? Its charge will be the same as it was before we swapped**!

$FeCl_3$ Fe must have a charge of +3!

This one is no problem:

K^{+1} Cl^{-1}

Step 3: Since Fe^{+3} and O^{-2} $FeCl_3 + K_2O \rightarrow$ **Fe_2O_3** $+ KCl$

Example 9: $CuO + NaNO_3 \rightarrow CuNO_3 + NaO$ *swapped*

$CuO + NaNO_3 \rightarrow Cu(NO_3)_2 + Na_2O$ *formulas fixed*

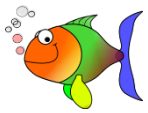
Predict the products of these reactions.

Practice 7: $TiBr_4 + SrF_2 \rightarrow$ _____ + _____

$CoI_2 + NaCN \rightarrow$ _____ + _____

$CuNO_2 + MgS \rightarrow$ _____+ _____

$NaClO_3 + ScSO_4 \rightarrow$ _____ + _____



Predicting Products of Single Displacement Reactions

Key Skill: Identifying the single atom as a cation or anion.

In a single displacement reaction we "swap" ions in the same way, but one reactant does not have a partner to exchange! Oh what to do?!!

Examples: **Na** + KCl → **Na**Cl + K

Single elements with no partners.

Cs + Li_2O → **Cs**$_2$O + Li

In these examples, the single element "bumps out" one of the ions in the other compound. How do we know which one to exchange with?

Na + KCl → **Na**Cl + K

Na metal has no charge. But in a compound it likes to be Na^{+1}

Things that have (+) charges go on the left in formulas, so it takes the place of

$\mathbf{F_2}$ + KCl → K**F** + Cl_2

In a compound fluorine likes to be F^{-1}

Things that have (-) charges go on the right in formulas, so it takes the place of **Cl**.

Try these single displacement reactions. Start by putting a circle around the element that is by itself. Write down its charge so you know which sideof the formula it should go on.

$Rb + MgO \rightarrow$ _____ + _____

$Br_2 + Na_2O \rightarrow$ _____ + _____

$LiF + Mg \rightarrow$ _____ + _____

$HBr + O_2 \rightarrow$ _____ + _____

$KCN + Ca \rightarrow$ _____ + _____

$Be + Al(NO_3)_3 \rightarrow$ _____ + _____

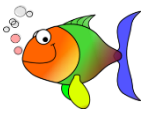
Before you finish, check two things:

- Did you write neutral formulas?
- Did you check for diatomic elements? (H_2, N_2, O_2, F_2, Cl_2, Br_2 I_2.)

In the following group of reactions, identify the reaction type:

- Synthesis S
- Decomposition D
- Double Displacement DD
- Single Displacement SD

1. $H_2 + O_2 \rightarrow H_2O$ _____
2. $Fe + S \rightarrow FeS$ _____
3. $H_2 + Cl_2 \rightarrow HCl$ _____
4. $Al + Fe_2O_3 \rightarrow Al_2O_3 + Fe$ _____
5. $AgNO_3 + Cu \rightarrow Cu(NO_3)_2 + Ag$ _____
6. $H_2 + N_2 \rightarrow NH_3$ _____
7. $NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$ _____
8. $BaCl_2 + Na_2SO_4 \rightarrow NaCl + BaSO_4$ _____
9. $Ca + HCl \rightarrow CaCl_2 + H_2$ _____
10. $FeS + HCl \rightarrow H_2S + FeCl_2$ _____
11. $Pb(NO_3)_2 + H_2SO_4 \rightarrow PbSO_4 + HNO_3$ _____
12. $ZnCl_2 + (NH_4)_2S \rightarrow ZnS + NH_4Cl$ _____
13. $Na + H_2O \rightarrow NaOH + H_2$ _____
14. $NaHCO_3 \rightarrow Na_2CO_3 + H_2O + CO_2$ _____
15. $NaOH + H_2SO_4 \rightarrow Na_2SO_4 + H_2O$ _____

Combustion Reactions Notes 

Requirements for a reaction to be a combustion reaction:

1.

2.

- Gasoline burning in a car:

- Propane burning in a grill:

- Alcohol burning:

- Sugar burning:

Predict the products of these combustion reactions:

1. CH_4 + O_2 → _____ + _____

2. O_2 + C_5H_{12} → _____ + _____

3. C_6H_6 + O_2 → _____ + _____

What is missing in this combustion reaction? (Fill in the blanks)

4. C_3H_8 + _____ → H_2O + _____

Synthesis and Decomposition 2

Name: _____

Identify these as either a synthesis (combination) or decomposition (disassociation) reaction. Write the products and balance the equation.

	Type of Reaction
1. $Cs_{(s)} + Cl_{2\,(g)} \rightarrow$	_____
2. $B_{(s)} + O_{2\,(g)} \rightarrow$	_____
3. $CoBr_{2\,(l)} \rightarrow$	_____
4. $Sr_{(s)} + N_{2\,(g)} \rightarrow$	_____
5. $Al_{(s)} + F_{2\,(g)} \rightarrow$	_____
6. $NI_3 \rightarrow$	_____

Complex Decomposition Notes

What is a **CARBONATE**?

Examples of carbonate decompositions:

What is a **CHLORATE**?

Examples of carbonate decompositions:

What is a **HYDROXIDE**?

Examples of carbonate decompositions:

What is a spontaneous decomposer?

Examples of Spontaneous Decompositions:

1.

2.

3.

Decomposition Practice Problems

Most of these reactions involve complex decompositions.

- Circle the question numbers for those that are binary salts. (simple ones)
- Put a heat symbol above the reaction arrow for those that require heat.
- Write correct formulas for the products of all of these decomposition reactions, then balance the equations.

1) $Ni(ClO_3)_2$ --->

2) Ag_2O --->

3) LiBr --->

4) $Fe(OH)_3$ --->

5) NH_4OH --->

6) Cs_2CO_3 --->

7) H_2SO_3 --->

8) $SrCO_3$ --->

9) $RbClO_3$ --->

10) $RaCl_2$ --->

11) $ZnCO_3$ --->

12) H_2CO_3 --->

13) $Al(OH)_3$ --->

14) H_2O --->

Double Displacements with Decomposition Practice

Write the products for these reactions. Remember to look for decomposing products and convert them to their final state.

1. Na_2CO_3 + H_2SO_4 --->

2. $Cr_2(SO_3)_3$ + H_2SO_4 --->

3. $CaCO_{3(s)}$ + $HCl_{(aq)}$ --->

4. NH_4Br + KOH -->

5. HNO_3 + Cs_2SO_3 --->

6. $HF + Li_2CO_3 \rightarrow$

7. $Ca(OH)_2 + (NH_4)_2S \rightarrow$

8. $HCl + CuCO_3 \rightarrow$

Types of Reactions #1

Fill in the product for each reaction.
What type of reaction are these?

I. DECOMPOSITION

a. $BaCO_3 \xrightarrow{\Delta}$ _____ + _____
b. $Ba(OH)_2 \xrightarrow{\Delta}$ _____ + _____
c. $PbO_2 \xrightarrow{\Delta}$ _____ + _____
d. $NaClO_3 \xrightarrow{\Delta}$ _____ + _____
e. KCl (elect.) _____ + _____
f. $H_2CO_3 \xrightarrow{\Delta}$ _____ + _____

What type of reaction are these?

b. $Mg + O_2 \rightarrow$ _____
c. $H_2 + F_2 \rightarrow$ _____

e. $Ca + O_2 \rightarrow$ _____

What type of reaction are these?

a. $Mg + CuSO_4 \rightarrow$ _____ + _____
b. $K + H_2O \rightarrow$ _____ + _____
c. $Mg + HCl \rightarrow$ _____ + _____
d. $Br_2 + KI \rightarrow$ _____ + _____

What type of reaction are these? _____

a. $AgNO_3 + NaCl \rightarrow$ _____ + _____
b. $Sr(NO_3)_2 + Na_2CO_3 \rightarrow$ _____ + _____
c. $Na_2CrO_4 + Pb(NO_3)_2 \rightarrow$ _____ + _____
d. $Na_2CO_3 + HCl \rightarrow$ _____ + _____ (_____ + _____)
e. $HCl + NaOH \rightarrow$ _____ + _____
f. $Zn(NO_3)_2 + Na_3PO_4 \rightarrow$ _____ + _____
g. $NH_4NO_3 + NaOH \rightarrow$ _____ + _____ (_____ + _____)

What type of reaction are these? _____

a. $C_2H_6 + O_2 \rightarrow$ _____ + _____
b. $CH_4 + O_2 \rightarrow$ _____ + _____
c. $C_2H_2 + O_2 \rightarrow$ _____ + _____
d. $C_{12}H_{22}O_{11} + O_2 \rightarrow$ _____ + _____

Predicting Products in Word Problems

Directions: Predict the products and balance the following reactions. Use abbreviations to indicate the phase of reactants and products where possible (s, l, g, aq). Remember to check solubility rules for all products.

1. A solution of ammonium hydroxide decomposes.

2. A piece of barium metal is added to a solution of sodium sulfate.

3. Solid sulfur is dropped into a solution of copper (II) iodide.

4. Calcium metal is added to a solution of hydrobromic acid.

5. Solutions of lithium sulfite and nitric acid are mixed.

6. Solutions of sodium chromate and iron (III) chloride are mixed.

Precipitate Lab

Goal: To predict when a precipitate will form in a reaction.

Pre-lab:

1. In your own words, what is a precipitate?
   _____
   _____

2. What state symbol do all precipitates have? _____

3. NaBr is not a precipitate. Using your solubility rules, explain how you know that it is not a precipitate.
   _____
   _____
   _____

What you need to do:

Choose 1 chemical from group A and 1from group B. Write their formulas in the table below. Predict the products of the reaction. Assign state symbols to both products using your solubility rules. State if a precipitate will form. After you have predicted the outcome of 10 reactions, try them in lab to see if they are correct.

Example:

Rxn

Beakers

Rxn	**Draw the reaction here. Circle any precipitates that will form.**	**Precipitate observed in lab? (Y/N)**
1	Rxn: Beakers:	
2	Rxn: Beakers:	
3	Rxn: Beakers:	

Rxn	**Draw the reaction here. Circle any precipitates that will form.**	**Precipitate observed in lab? (Y/N)**
4	Rxn: Beakers:	
5	Rxn: Beakers:	
6	Rxn: Beakers:	

ROUND 4

Formation of a Precipitate

In order to predict double replacement reactions yielding precipitates, one must memorize the solubility rules listed on page 48.

Exercise 9–1: Predict and balance the following metathesis reactions based on the solubility of the products. Use the abbreviations (aq) and (s) for the reactants and products. All reactants are aqueous. *Note:* Some of these reactions do not go to completion.

1. silver nitrate + potassium chromate

2. ammonium chloride + cobalt(II) sulfate

3. lithium hydroxide + sodium chromate

4. zinc acetate + cesium hydroxide

5. ammonium sulfide + lead(II) nitrate

6. iron(III) sulfate + barium iodide

7. chromium(III) bromide + sodium nitrate

8. rubidium phosphate + titanium(IV) nitrate

9. ammonium carbonate + nickel(II) chloride

10. tin(IV) nitrate + potassium sulfite

Note: Correct molecular formulas must be written for both the reactants and products before an equation may be balanced.

Chapter 9: Double Replacement (Metathesis) Reactions

Exercise 9–2: Predict and balance the following metathesis reactions. Use the abbreviations (s), (l), (g), and (aq) for the reactants and products. All reactants are aqueous unless otherwise stated.

1. ammonium sulfate and potassium hydroxide are mixed together

2. ammonium sulfide is reacted with hydrochloric acid

3. cobalt(II) chloride is combined with silver nitrate

4. solid calcium carbonate is reacted with sulfuric acid

5. potassium sulfite is reacted with hydrobromic acid

6. potassium sulfide is reacted with nitric acid

7. ammonium iodide + magnesium sulfate

8. solid titanium(IV) carbonate + hydrochloric acid

9. solid calcium sulfite + acetic acid ($HC_2H_3O_2$)

10. strontium hydroxide + ammonium sulfide

Exercise 9–3: Predict and balance the following reactions. Use the abbreviations (s), (l), (g), and (aq) for the reactants and products. All reactants are aqueous unless otherwise stated.

1. carbon dioxide gas is bubbled through a solution of lithium hydroxide

2. sodium nitrite is reacted with hydrochloric acid

3. ammonium bromide + sodium hydroxide

4. carbon dioxide gas is reacted with solid potassium oxide

5. solid magnesium oxide is reacted with hydrochloric acid

6. equal numbers of moles of potassium hydroxide and phosphoric acid react

7. sodium fluoride reacts with dilute nitric acid

8. ammonium carbonate + potassium bromide

9. oxalic acid (0.1 M) reacts with an equal volume of cesium hydroxide (0.1 M)

10. silver nitrate + sodium chromate