Aqueous Chemical Reactions

Introduction

Many chemical reactions occur in water and therefore they are considered aqueous chemical reactions. The reagents are typically dissolved or diluted in water and then the reactions are carried out. Three main types of reactions that typically occur as aqueous reactions are single replacement reactions, double replacement/precipitation reactions, and acid-base neutralization reactions.

In this lab, these three types of reactions will be carried out and detailed observations will be made to help distinguish them from one another.

For more information: *Chemistry: Atom's First* by OpenStax section 7.2 – "Classifying Chemical Reactions"

Materials:

small test tubes
test tube rack
test tube clamp
copper wire
3M HCl
3M NaOH
3M HNO_3
3M H_2SO_4
zinc pieces
1M $CuSO_4$
litmus paper
watch glass
glass stir rod
phenolphthalein
0.1M of the following $Ba(NO_3)_2$, $Pb(NO_3)_2$, $NaNO_3$, KI, HCl, NaOH
saturated Na_2CO_3.
1M Na_2SO_4, 1M $AgNO_3$, 1M NaCl
well-plate
Q-tips
DI water bottle

Procedure

Observations:
Record observations for **all** of the chemical reactions carried out during the lab in your report sheet. These observations should include:

- observations of the reactant(s) before the reaction
- observations of the reaction mixture during the reaction
- observations of the product(s) after the reaction.

Your observations of a material should contain the color, clarity and state of matter, plus any useful descriptions of the material (for example, a sample of magnesium might be described as a smooth, shiny, silver, opaque solid).

Your observations of the reaction in progress should include anything of potential interest, such as "the color changed from green to blue", "a pungent odor is present now", "the test tube is getting warmer" or "bubbles are forming on the surface of the magnesium".

Part I – Single Replacement Reactions.

1. Place a piece of copper wire in a test tube with enough 1 M $AgNO_3$ to cover it.
   ***CAUTION*: $AgNO_3$ will stain skin and clothes!**

2. Allow the test tube to stand for 5-10 minutes.

3. Write down observations noting changes in the appearance of both the wire and the solution.

4. Obtain a new, clean test tube and place a small piece of zinc metal in a test tube.

5. Add 2 mL of 3M HCl.
   ***CAUTION*: 3M HCl(aq) can damage skin and clothing on contact. Rinse any spills on skin immediately with plenty of water for 10 minutes. Neutralize all spills on the lab bench with water or $NaHCO_3$ solution, and rinse your hands thoroughly.**

6. Record your observations.

7. Obtain a new, clean test tube and place a small piece of zinc metal in a test tube.

8. Add enough 1M $CuSO_4$ to cover the zinc metal.

9. Record your observations.

Part II – Acid-Base Neutralization Reactions

1. Line up three small pieces of red litmus paper and 3 small pieces of blue litmus paper on a watch glass leaving plenty of space between each.

2. Place a drop of 0.1M HCl(aq) on one piece of red and one piece of blue litmus paper using a stirring rod and record your observations.
   CAUTION! NaOH, HCl, HNO_3 and H_2SO_4 can damage skin, eyes and clothing on contact. Rinse off any spills immediately with plenty of water for 10 minutes. In the event of a spill in the laboratory, notify your instructor immediately.

3. Place a drop of 0.1M NaOH(aq) on new, fresh pieces of blue and red litmus paper and record your observations.

4. Place a drop of deionized water on new, fresh pieces of blue and red pieces of litmus paper and record your observations.

5. Place 10 drops of 3M NaOH in a clean test tube.

6. Now add ten drops of 3M HNO_3 to the same test tube holding the NaOH. Feel the outside of the test tube and write down any observations.

7. Write the balanced equation for the reaction of NaOH with HNO_3 on your lab report in the observations section for part II.

8. Place 10 drops of 3M NaOH in a new, clean test tube.

9. Add 2 drops of phenolphthalein and stir with a clean stir rod. Record your observations.

10. Add 3M H_2SO_4 slowly drop wise to the NaOH in the test tube. Count how many drops it takes to neutralize the NaOH.

11. Record your results.

12. Write the balanced equation for the reaction of NaOH with H_2SO_4 on your lab report in the observations section for part II.

Part III – Double Replacement/Precipitation Reactions

1. Clean the well-plate with warm soapy water and Q-tips. Allow to air dry.

2. Obtain solutions of 1M $AgNO_3$, 1M NaCl, 0.1M $Ba(NO_3)_2$, 3M $HNO_3(aq)$ and 0.1M $Pb(NO_3)_2$. Following the grid outline in your data section of this lab report, drop 3 drops of each solution into the appropriate wells of the well-plate.
   ***CAUTION*: $AgNO_3$ will stain skin and clothing! Pb containing compounds are toxic and should not be ingested. HCl, HNO_3 and NaOH are corrosive and can cause chemical burns and damage clothing.**

3. To EACH of these previous well spots in the well-plate, now add 3 drops of the solutions of 0.1M $NaNO_3$, 1M NaCl, 1M Na_2SO_4, 0.1M NaOH, 0.1M KI, and saturated Na_2CO_3. Carefully look at the data table to make sure your are placing the solutions in the correct locations.

4. Record observations for each well of the well-plate that the two solutions were mixed. If no reaction occurred write "NR" on your data table.

5. For each of the following combinations, mix 10 drops of each solution in a clean test tube, so any reactions that take place can be observed on a larger scale:

   - 0.1M $Ba(NO_3)_2(aq)$ and 0.1M NaOH(aq)
   - 3M $HNO_3(aq)$ and saturated $Na_2CO_3(aq)$
   - 0.1M $Pb(NO_3)_2(aq)$ and 1M NaCl(aq)

6. Have your lab instructor sign off on your Double Replacement/Precipitation reaction observation table.

7. Write a balanced chemical equation and clearly identify the solid product for any precipitation reactions that you observe.

Please refer to the Laboratory Techniques Document on the CHM151LL Course Website for more detailed techniques and images of lab equipment.

Clean-Up: Dispose of the contents from all of the test tubes and well-plate in the waste jar in the hood. Rinse everything well with soapy tap water followed by a quick DI water rinse. Clean your benchtop. Put all equipment back exactly where you found it.

Name: _____ Partners: _____

Aqueous Chemical Reactions Lab Report

Turn in Pages 4-6 for Your Lab Report

Data:

Data Table 1: Part I Single-Replacement Reaction Observations

	Copper Metal	$AgNO_3$ solution
Before reaction		
During reaction		
After reaction		

Balanced Chemical Reaction: _____

	Zinc Metal	HCl Solution
Before Reaction		
During Reaction		
After Reaction		

Balanced Chemical Reaction: _____

	Zinc Metal	$CuSO_4$ solution
Before reaction		
During reaction		
After reaction		

Balanced Chemical Reaction: _____

Data Table 2: Part II Acid-Base Neutralization Reaction Observations

	Red litmus paper	Blue litmus paper
Before reaction		
Reaction with 0.1M HCl		
Reaction with 0.1M NaOH		
Reaction with H_2O		

<u>Balanced Chemical Reaction 1</u>: ___HNO_3(aq) + ___NaOH(aq) →_____

Observations:

<u>Balanced Chemical Reaction 2</u>: ___H_2SO_4(aq) + ___NaOH(aq) →_____

Observations:

Observed color of NaOH Before Adding Phenolphthalein	Observed color of NaOH After Adding Phenolphthalein	Number of drops of H_2SO_4 needed to neutralize the NaOH

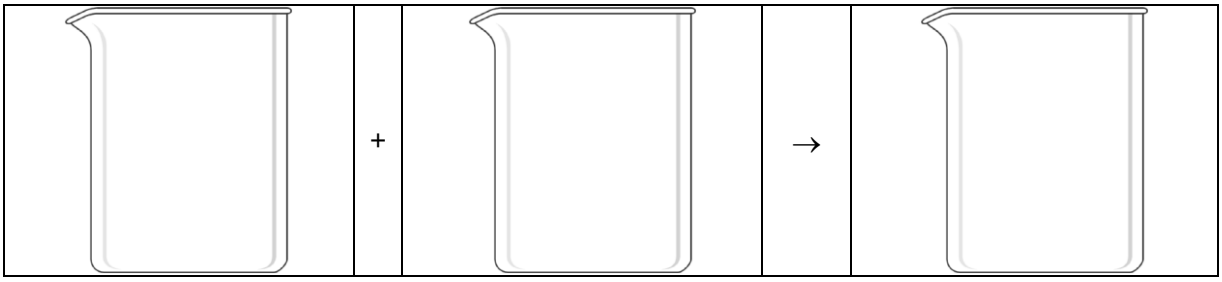
Data Table 3: Part III Double Replacement/Precipitation Reaction Observation

	1M $AgNO_3$	1M NaCl	0.1M $Ba(NO_3)_2$	3M HNO_3	0.1M $Pb(NO_3)_2$
0.1M $NaNO_3$					
1M NaCl					
1M Na_2SO_4					
0.1M KI					
0.1M NaOH					
saturated Na_2CO_3					

Part III Observations of the test tube reactions on a larger scale:

0.1M $Ba(NO_3)_2$(aq) and 0.1M NaOH(aq)	3M HNO_3(aq) and saturated Na_2CO_3(aq)	0.1M $Pb(NO_3)_2$(aq) and 1M NaCl(aq)

For the third reaction, 0.1M $Pb(NO_3)_2$(aq) and 1M NaCl(aq), fill in the beaker drawings:



<u>Part III Double Replacement Reactions:</u>

(7 pts) Write out the products for each of the precipitation reactions in Part III that you observed a reaction for.

1. _____ + _____ → _____ + _____
2. _____ + _____ → _____ + _____
3. _____ + _____ → _____ + _____
4. _____ + _____ → _____ + _____
5. _____ + _____ → _____ + _____
6. _____ + _____ → _____ + _____
7. _____ + _____ → _____ + _____
8. _____ + _____ → _____ + _____
9. _____ + _____ → _____ + _____
10. _____ + _____ → _____ + _____
11. _____ + _____ → _____ + _____
12. _____ + _____ → _____ + _____
13. _____ + _____ → _____ + _____
14. _____ + _____ → _____ + _____

Conclusion: (5 pts) Summarize the three types of aqueous reactions studied in the lab report and cite examples along with evidence of how you know these types of reactions occur. Make sure you use specific chemical reactions and observations from this lab experiment to demonstrate each type of reaction and how it is recognizable as that type of reaction.

Post-Lab Questions – These questions will not be graded as part of your lab report grade. You will be responsible for the information in these questions and able to answer these or similar questions on the post-lab quiz at the start of next week's lab period. Questions will also be similar to your lab report data, observations, calculations, and results.

Part II and III Acid-Base Neutralization Reactions and Double Replacement/Precipitation Reactions

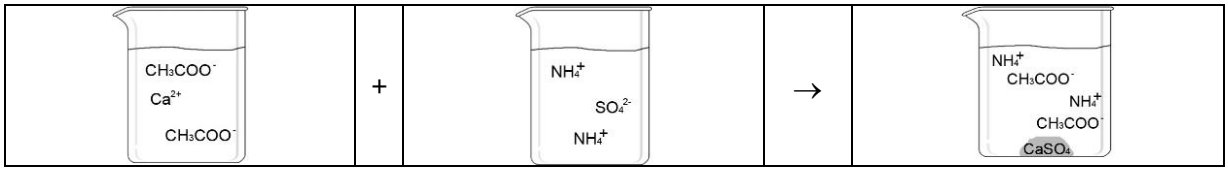
Refer to your data table for the following selected sets of reactants and fill in the following blanks and beaker drawings. An example **NOT** from this experiment is presented first.

Example: **calcium acetate and ammonium sulfate** Reaction type: ____**precipitation**

Molecular: $Ca(CH_3COO)_2(aq) + (NH_4)_2SO_4(aq) \rightarrow CaSO_4(s) + 2\ NH_4CH_3COO(aq)$

Ionic: $Ca^{2+}(aq) + 2\ CH_3COO^-(aq) + 2\ NH_4^+(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s) + 2\ CH_3COO^-(aq) + 2\ NH_4^+(aq)$

Net Ionic: $Ca^{2+}(aq) + SO_4^{2-}(aq) \rightarrow CaSO_4(s)$

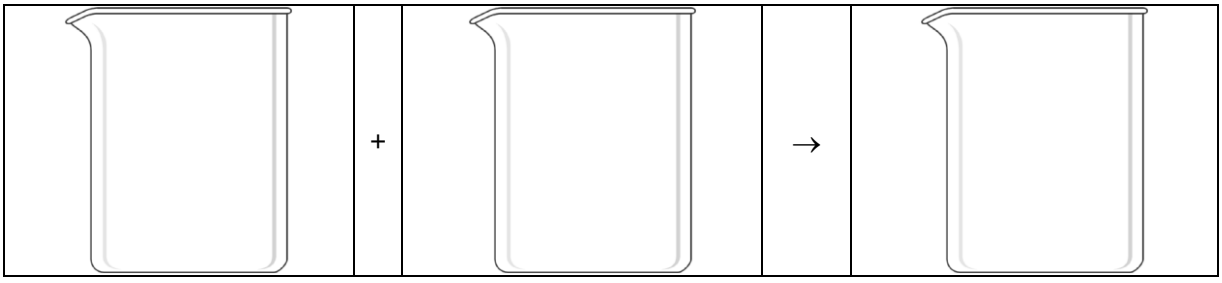


1. **lead (II) nitrate and potassium iodide** Reaction type: _____

Molecular: _____

Ionic: _____

Net Ionic: _____

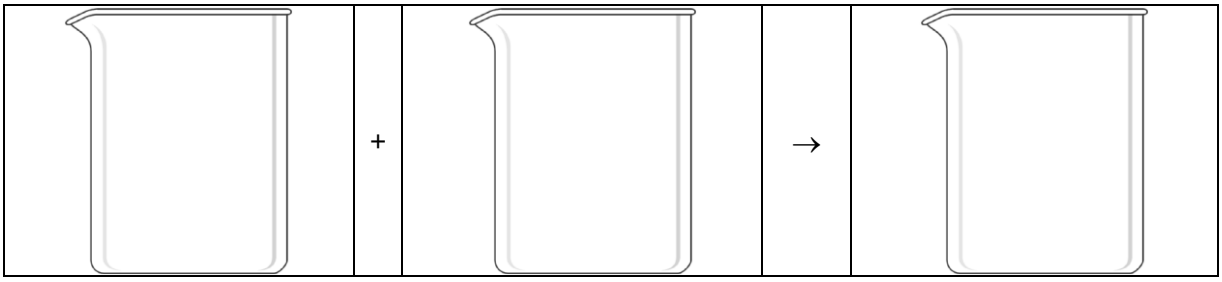


2. **nitric acid and sodium hydroxide** Reaction type: _____

Molecular: _____

Ionic: _____

Net Ionic: _____



Balancing and Categorizing Chemical Equations:
Balance each of the chemical equations given below, and identify each as one of the six types listed below.

Single-Replacement reaction (SR)
Double-Replacement/Precipitation reaction (DR)
Acid-Base Neutralization reaction (N)

TYPE

_____ 1. _____ $Al_{(s)}$ + _____ $NiCl_{2\ (aq)} \rightarrow$ _____ $Ni_{(s)}$ + _____ $AlCl_{3\ (aq)}$

_____ 2. _____ $Ba(OH)_{2\ (s)}$ + ____ $FeCl_{3\ (aq)} \rightarrow$ ____ $BaCl_{2\ (aq)}$ + ____ $Fe(OH)_{3\ (s)}$

_____ 3. _____ $H_2SO_{4\ (aq)}$ + _____ $Mg(OH)_{2\ (s)} \rightarrow$_____ $H_2O_{(l)}$ + _____ $MgSO_{4\ (aq)}$

_____ 4. _____ $Na_3PO_{4\ (aq)}$ + ____ $MgCl_{2\ (aq)} \rightarrow$ ____ $Mg_3(PO_4)_{2\ (s)}$ + ___ $NaCl_{(aq)}$

_____ 5. _____ $H_3PO_{4\ (aq)}$ + ____ $NaOH_{(aq)} \rightarrow$ _____ $H_2O_{(l)}$ + ____ $Na_3PO_{4\ (aq)}$

Discuss two sources of error and how they can be corrected in the future.

1.

2.

Now that you have completed the experiment please write a "Purpose" statement that more accurately reflects the function of this lab.