

## LAW OF CONSERVATION OF MASS

### OBJECTIVES FOR THE EXPERIMENT

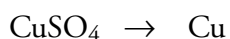
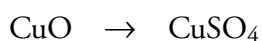
The student will be able to do the following:

1. Write or identify a description of the Law of Conservation of Mass.
2. Given formulas for the reactants in a double displacement reaction, write the complete balanced equation for the reaction.
3. Write or identify a description of double displacement reactions.
4. Given a formula for a substance, identify whether it is an ionic compound.
5. Given a formula for an ionic compound, write the formulas for each ion in the compound.
6. Write formulas for ionic compounds from the formulas of the ions.
7. Convert between the formula and name for the following polyatomic ions: carbonate, nitrate, hydroxide, sulfate, sulfite, acetate, perchlorate, and ammonium.
8. Convert between the name and formula for nitric acid and sulfuric acid.
9. Write the formulas for the products of the reaction of the carbonate ion with acid.
10. Write or identify the definitions of net reaction and single-step reaction.
11. Write or identify the definition of ion complex.
12. Identify the states and colors of reactants and products based on experimental observation, experience, and logic.
13. Separate solids from liquids using gravity filtration.
14. Test solutions to see if they are acidic or basic using litmus paper.

### BACKGROUND TO THE EXPERIMENT

The main purpose of this experiment is to help you gain a greater understanding of chemical equations. You will learn to visualize a chemical reaction just from looking at its chemical equation.

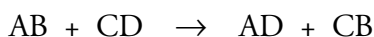
A secondary purpose of this experiment is to illustrate the Law of Conservation of Mass. You carry copper through a series of reactions:



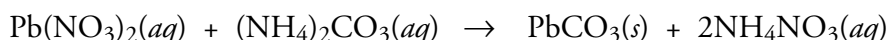
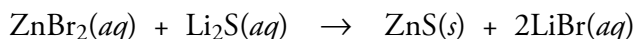
According to the Law of Conservation of Mass, the mass of metallic copper reclaimed at the end of the series should be the same as the initial mass.

## PRELAB ASSIGNMENT

Before coming to the lab, write out balanced equations for each reaction on the report sheet provided. Some of them are given to you in the procedure and on the data sheet. Almost all the reactions are double displacement reactions. Double displacement reactions have the following general formula.



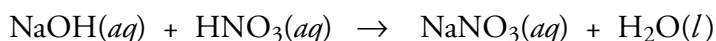
The AB and CD in double displacement reactions are often ionic compounds. The following are examples of double displacement reactions.



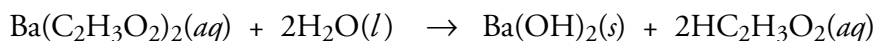
The AB and CD can be acids. The following are common acids used in this experiment.

$\text{HNO}_3$  - nitric acid

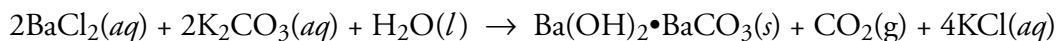
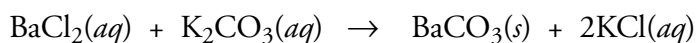
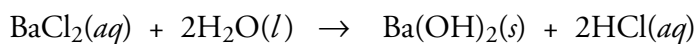
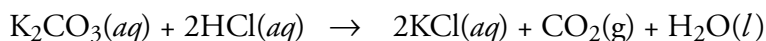
$\text{H}_2\text{SO}_4$  - sulfuric acid



When water reacts in a double displacement reaction it acts as if it were hydrogen hydroxide, H-OH.



Chemical equations can describe net reactions that are a sum of two or more single step reactions. Ionic compounds can combine to form ion complexes like the barium hydroxide-barium carbonate complex below.



Note that in the first equation above, carbonic acid,  $\text{H}_2\text{CO}_3(aq)$  spontaneously decomposes to carbon dioxide and water. If you get  $\text{H}_2\text{CO}_3$  as a product in your equation, replace it with  $\text{CO}_2$  and  $\text{H}_2\text{O}$ .

You will be asked to identify the states and colors of each reactant and product. Ionic formulas are followed by (s) if pure or water insoluble and by (aq) if water soluble and water is present. The solubility rules from lecture will be useful. Acids are aqueous unless indicated otherwise.

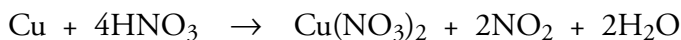
You will identify the colors in the following ways. Some colors you will observe, e.g. nitric acid,  $\text{HNO}_3(aq)$ , is colorless. Some colors you will figure out. For example, nitric acid is colorless, so hydronium ions and nitrate ions are colorless. A solution of table salt, NaCl, is colorless, so sodium ions and chloride ions are colorless. Therefore, sodium nitrate which includes sodium ions and nitrate ions is colorless.

You should be aware of what you have in your reaction vessel at each stage in the procedure. For example, if you were asked what is in the concentrated nitric acid bottle, you would not say nitric acid. You would say water, hydronium ions, and nitrate ions.

The copper or copper compound is the limiting reactant for each step. The other reactants are in excess. The reactant in excess is still in the product mixture after the reaction is complete. Some reactants or products from previous steps are still in the container in later steps.

## PROCEDURE

**Step 1** - The following is the procedure for the formation of copper nitrate by oxidation of copper with nitric acid.



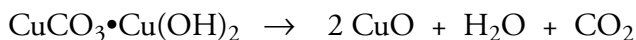
- Weigh about 0.5 g of copper (not more than 0.6g) to the nearest 0.001 g.
- Put on gloves and your goggles. Place the Cu in a 150 mL beaker, and IN THE HOOD, add 3 mL of concentrated HNO<sub>3</sub> slowly and carefully. There will be a vigorous evolution of brown gas. If you spill any nitric acid, tell your instructor.
- After the initial reaction has subsided, swirl the HNO<sub>3</sub> around in the beaker until all evolution of gas has ceased. Do not remove the beaker from the hood until there is no sign of brown gas.
- Add 5 mL deionized H<sub>2</sub>O to the beaker.
- Warm the mixture on the hot plate in the hood for 3-4 minutes.
- If your copper is not completely dissolved, don't worry.
- Record the states and colors of each reactant and product.
- Describe what is in the product mixture after Step 1 is complete. Your description should include a drawing that shows the particles present and the attractions between them.

**Step 2** - The following is the procedure for the formation of the ion complex CuCO<sub>3</sub>•Cu(OH)<sub>2</sub> by double displacement. This step can be done outside of the hood.



- Dilute the solution of Cu(NO<sub>3</sub>)<sub>2</sub> with 40 mL of deionized H<sub>2</sub>O.
- Next add 3 g of anhydrous Na<sub>2</sub>CO<sub>3</sub> slowly with stirring. There will be a large evolution of carbon dioxide. The bluish-white precipitate is the basic salt CuCO<sub>3</sub>•Cu(OH)<sub>2</sub>.
- Stir the suspension thoroughly, and test to see if it's basic with litmus paper.
  - Stir your solution with your stirring rod, remove it from the mixture with a half drop on the end, and touch it to a piece of red litmus paper.
  - Basic solutions turn red litmus paper blue.
- If the supernatant liquid is not basic, consult your instructor.
- Record the states and colors of each reactant and product.
- Describe what is in the product mixture after Step 2 is complete. Your description should include a drawing that shows the particles present and the attractions between them.

**Step 3** - The following is the procedure for the formation of CuO by decomposition of CuCO<sub>3</sub>•Cu(OH)<sub>2</sub>.



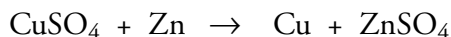
- Add 5 mL of 6 M NaOH to your beaker.
- Heat your solution with your Bunsen burner, while stirring rapidly, until the blue-white precipitate turns black. Heat as strongly as possible without boiling.
- Describe what was in the mixture. Be specific.
- This is one good place to stop for week 1. Let your solution cool, put a piece of Parafilm over the top of your container, and put it in your drawer until next week.
- Separate the solid from the solution (called the filtrate) by gravity filtration.
- Wash the precipitate on the filter twice with 5 mL of water. (Use this water to wash the last traces of CuO from your beaker onto the filter. There will be some CuO that will stick to the bottom of the beaker. Do not worry about this, but be sure to use this beaker in Step 4.)

- g. *Discard the filtrate.*
- h. Record the states and colors of each reactant and product.

**Step 4** - The following is the procedure for the formation of  $\text{CuSO}_4$  by double displacement.

- In the beaker containing trace amounts of  $\text{CuO}$  from step 3, place 25 mL of 3 M  $\text{H}_2\text{SO}_4$ .
- After you have dissolved the  $\text{CuO}$  in the beaker, dissolve the  $\text{CuO}$  on the filter paper by pouring the  $\text{H}_2\text{SO}_4$  onto the filter paper.
- If all the  $\text{CuO}$  is not dissolved when the  $\text{H}_2\text{SO}_4$  has passed through the filter paper the first time. Pour the filtrate, now containing  $\text{CuSO}_4$ , back over the precipitate on the filter paper. Repeat this procedure until all the  $\text{CuO}$  is dissolved.
- After all the  $\text{CuO}$  has dissolved, rinse off the filter paper with about 10 mL water. Collect this wash water with the copper sulfate solution. The filter paper should be colorless when all the  $\text{CuO}$  and  $\text{CuSO}_4$  are removed.
- Record the states and colors of each reactant and product.
- Describe what is in the product mixture after Step 4 is complete. Your description should include a drawing that shows the particles present and the attractions between them.

**Step 5** - The following is the procedure for the formation of  $\text{Cu}$  from  $\text{CuSO}_4$ .



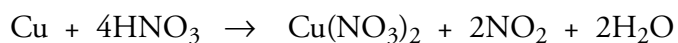
- Weigh out about 1.2 grams of granulated zinc and place the zinc in the  $\text{CuSO}_4$  solution. Do this step in the hood.
  - The zinc will replace the  $\text{Cu}^{2+}$  from the solution, and you will see red copper formed on the bottom of the beaker.
  - The excess zinc will replace the hydrogen ion in the excess acid, and you will see  $\text{H}_2$  bubbling off.
- Stir the mixture breaking up any large pieces of copper that form.
- When the bubbling slows, place the reaction mixture on one of the hot plates in the hood. Gentle warming will speed up the reactions.
- If the evolution of  $\text{H}_2$  has stopped, and if the solution is still blue, add 0.1-0.2 g more Zn. Repeat if necessary.
- When the solution becomes colorless, carefully decant the colorless liquid from the copper. Decant into another beaker. The solution decanted can be discarded in the sink.
- Describe what is in the product mixture after Step 1 is complete? Your description should include a drawing that shows the particles present and the attractions between them.
- Add 10 mL 3 M sulfuric acid to the copper and note if there is any evolution of  $\text{H}_2$ .
- When there is no evolution of gas, your copper will be free of zinc particles. Decant the sulfuric acid.
- Add 10 mL of water to the copper, swirl, allow the copper to settle. Decant the water. Repeat this one more time.
- Next add 10 mL of acetone to the copper, swirl, and allow the  $\text{Cu}$  to settle. Decant the acetone. Repeat this one more time.
- With your spatula, spread the copper out evenly on a watch glass and leave it on your bench to dry for 5-10 minutes.
- Weigh the copper on the weighing paper found in the balance room.
- Turn in your copper to your instructor.
- Record the states and colors of each reactant and product.

NAME: \_\_\_\_\_

**LAW OF CONSERVATION OF MASS REPORT SHEET**

Initial mass of Cu	
Final mass of Cu	
Percent of Cu recovered	

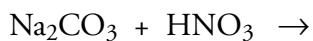
NOTE: You will show the state and color of every reactant and product for each reaction.

**Step 1**

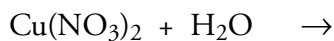
	Cu	HNO <sub>3</sub>	Cu(NO <sub>3</sub> ) <sub>2</sub>	NO <sub>2</sub>	H <sub>2</sub> O
States					
Colors					

What is in the product mixture after Step 1 is complete? Your description should include a drawing that shows the particles present and the attractions between them.

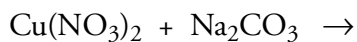
**Step 2** - Complete the following equations before coming to class. They are the single step reactions for the net reaction in the formation of the ion complex  $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$ .



	$\text{Na}_2\text{CO}_3$	$\text{HNO}_3$			
States					
Colors					



	$\text{Cu(NO}_3)_2$	$\text{H}_2\text{O}$		
States				
Colors				



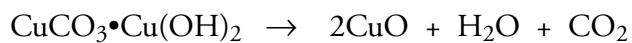
	$\text{Cu(NO}_3)_2$	$\text{Na}_2\text{CO}_3$		
States				
Colors				

Write the states and colors for each reactant and product in this net reaction.



	$\text{Cu(NO}_3)_2$	$\text{Na}_2\text{CO}_3$	$\text{H}_2\text{O}$	$\text{CuCO}_3 \cdot \text{Cu(OH)}_2$	$\text{CO}_2$	$\text{NaNO}_3$
State						
Color						

What is in the product mixture after Step 2 is complete? Your description should include a drawing that shows the particles present and the attractions between them.

**Step 3**

	$\text{Cu(CO}_3\text{)}\cdot\text{Cu(OH)}_2$	$\text{CuO}$	$\text{H}_2\text{O}$	$\text{CO}_2$
States				
Colors				

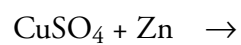
What is in the product mixture after the heating but before the filtration in Step 3? Your description should include a drawing that shows the particles present and the attractions between them.

**Step 4**

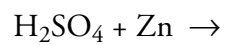
Equation:

States				
Colors				

What is in the product mixture after Step 4 is complete? Your description should include a drawing that shows the particles present and the attractions between them.

**Step 5**

	$\text{CuSO}_4$	Zn		
States				
Colors				



	$\text{H}_2\text{SO}_4$	Zn		
States				
Colors				

What is in the product mixture after the Step 5 reaction has taken place but before the solution is decanted? Your description should include a drawing that shows the particles present and the attractions between them.