NAME______________________________________ SECTION___________________________________

Chemistry 118 Laboratory
University of Massachusetts, Boston

STOICHIOMETRY - LIMITING REAGENT

PRELAB ASSIGNMENT

When 25.0 mL of 0.75 M $CdCl_2$ is mixed with 40.0 mL of 0.120 M $(NH_4)_2S$, CdS precipitates from the solution.

a) Write the balance chemical equation for this reaction.

b) How many moles of CdS will form? Show your work.

c) Which reagent is in excess, and how many moles will be left unreacted? Show your work.

INTRODUCTION

This experiment is designed to illustrate the relationship between quantities of reactants and the amount of product produced by a chemical reaction. The principles of stoichiometry and limiting reagents will be used to predict the amount of product that is produced when mixing two solutions to produce an insoluble product. The reaction to be studied is:

$$CaCl_2(aq) + Na_2CO_3(aq) \rightarrow 2\ NaCl(aq) + CaCO_3(s)$$

The balanced chemical equation for this reaction can be expressed in net ionic form as:

$$Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)$$

NAME_______________________________________ SECTION____________________________________

Because $CaCl_2$ contains one mole of calcium (II) ions per mole of calcium chloride and Na_2CO_3 contains one mole of carbonate ions per mole of sodium carbonate, it is a 1-1 reaction. Consequently the reagent with the fewer number of moles will be limiting. For every mole of limiting reagent, a mole of product, $CaCO_3$, should be formed. This is called the theoretical yield (in moles). The theoretical yield (in grams) is obtained by multiplying the theoretical yield in moles by the molar mass of calcium carbonate.

The actual yield of product obtained by weighing the product (which differs from the theoretical yield because of experimental errors), can be compared to the theoretical yield. This comparison, called the percent yield, is calculated as follows:

$$\%\text{ yield} = \frac{\text{actual yield (in grams)}}{\text{theoretical yield (grams)}} \times 100\%$$

Solutions of calcium chloride and sodium carbonate will be combined in four different ratios, and the amount of calcium carbonate produced will be measured. The limiting reagent in each case will be determined and the percent yield calculated.

IN THE LABORATORY

1. Label four 100 mL beakers which are to hold your reaction mixtures.

2. Using two 250 mL Erlenmeyer flasks, obtain about 100 mL each of the two stock solutions. Label the flasks. Be sure to record the concentrations on the attached data sheet.

3. Rinse a burette with the calcium chloride solution. Fill the burette so it reads between 0 and 3 ml. Purge any air bubbles in the tip by draining a small amount of the solution into a waste beaker. Record the initial burette reading to the hundredths place on the data sheet. Using the approximate volumes listed in Table 1; fill each reaction beaker with solution. Record the actual volume to two decimal places on the data sheet.

4. Rinse a second burette with water and then with the sodium carbonate solution. As above, fill the burette with the solution so it reads between 0 and 3 ml, purging any air bubbles into the waste beaker. Record this value to the hundredths place on the data sheet. Using the approximate volumes listed in Table 1, fill each

NAME______________________________________ SECTION___________________________________

reaction flask with solution. Record the actual volume on the data sheet. Rinse the burette with water before proceeding.

Table 1

	$CaCl_2$	Na_2CO_3
Reaction #1	25 mL	25 mL
Reaction #2	28 mL	25 mL
Reaction #3	10 mL	25 mL
Reaction #4	25 mL	10 mL

5. Stir each reaction mixture with a stirring rod. Rinse the rod using a wash bottle containing deionized water, collecting rinsings in the reaction beaker, before transferring to another beaker.

6. The next step will be carried out four times, once for each reaction mixture.

   a) Put a piece of filter paper on a watch glass. Determine the combined mass (filter paper + watch glass) using an analytical balance. Place the watch glasses on a piece of labeled paper so that you can distinguish them. Record the masses on the data sheet.

   b) Using a Buchner funnel and one of your pre-weighed pieces of filter paper, filter the contents of a beaker. Use the spatula and wash bottle to transfer all of the solid into the funnel.

   c) Transfer the filter paper and its contents to the watch glass and dry them under the heat lamp. Place a piece of paper with your name and reaction number under the glass for identification. Check the sample often **making sure the sample doesn't scorch**. While the sample is drying, filter another reaction mixture.

   d) When the contents of the watch glass have completely dried, weigh the watch glass, paper, and reaction product on the analytical balance previously used. Record all masses on the data sheet.

7. Clean all glassware before proceeding with calculations.

8. Complete all calculations and submit them to your laboratory instructor.

NAME________________________________ SECTION________________________________

Data (record units)

for $CaCl_2$	Reaction #1	Reaction #2	Reaction #3	Reaction #4
concentration				
initial burette reading				
final burette reading				
volume delivered				
for Na_2CO_3	Reaction #1	Reaction #2	Reaction #3	Reaction #4
concentration				
initial burette reading				
final burette reading				
volume delivered				
	Reaction #1	Reaction #2	Reaction #3	Reaction #4
mass of watchglass + filter paper				
mass of watchglass + filter paper + product				
mass of product				

Volumes and masses summary	Reaction #1	Reaction #2	Reaction #3	Reaction #4
volume of $CaCl_2$				
volume of Na_2CO_3				
mass of product (actual yield)				

Calculations

	Reaction #1	Reaction #2	Reaction #3	Reaction #4
Moles of $CaCl_2$				
Moles of Na_2CO_3				
Limiting Reagent				
Theoretical Yield (moles)				
Theoretical Yield (mass)				
Percent yield				
Moles of Ca^{2+} in excess				
Moles of CO_3^{2-} in excess				