Stoichiometry: Mass-mass and percent yield in a precipitate reaction

Prelab Assignment: You will complete the **Title, Purpose, Background information, Storyboard, and BLANK data table** portion of your lab report PRIOR to completing the lab.

Objective

In this lab students will dissolve a known amount of sodium carbonate Na_2CO_3 in water and mix it with a solution containing excess calcium chloride ($CaCl_2$). The chemical reaction that occurs is

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

In the chemical equation above the notation (*aq*) means 'aqueous', that is, dissolved in water. The notation (*s*) means solid. These notations are included to show that a **precipitate** forms in the reaction. A precipitate is a solid compound that results from the reaction of two soluble compounds in a solution. The solid precipitate will be collected, dried and weighed. The mass of calcium carbonate will then be compared with the mass predicted by stoichiometric calculations.

Stoichiometry is the technique of using the molar ratios in balanced chemical equations to calculate the amount of reactants or products. In this lab a sample of sodium carbonate (Na_2CO_3) with a mass of 4 - 5 g is dissolved in distilled water. A solution of $CaCl_2$ will be used in an amount that will ensure that it is in stoichiometric excess over the Na_2CO_3 that will be used. This makes the Na_2CO_3 the limiting reagent and the amount of calcium carbonate ($CaCO_3$) produced will depend only on how much Na_2CO_3 is used.

This lab is designed to provide data which demonstrate the validity of the mathematical techniques of stoichiometry. By both calculating the amount of $CaCO_3$ that forms and measuring it in the lab it will be possible to calculate the percent yield for the reaction. The percent yield is a measure of the efficiency of the reaction in producing products. It is calculated by dividing the amount measured in the lab by the amount predicted using stoichiometry and multiplying by 100%.

Materials

1. 60 mL Calcium chloride solution (1.0 M)
2. 4 - 5 g Sodium carbonate, dried
3. Distilled water
4. Lab Balance
5. 1 250-mL beaker
6. 100-mL graduated cylinder
7. filter paper
8. glass stirring rod
   with rubber policeman
9. wash bottle filled with distilled water

Safety

- If you choose not to wear safety glasses you are choosing to sit out the lab.

Stoichiometry Procedure

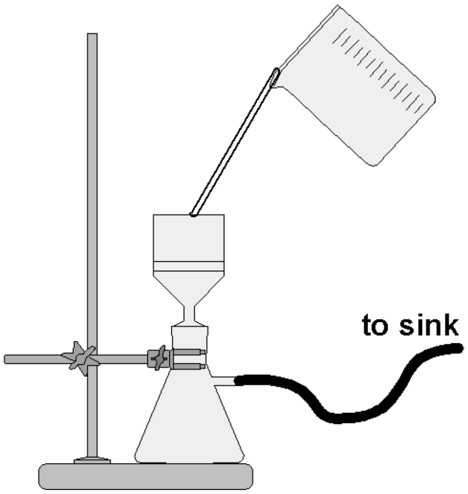
Precipitation Reaction

In this part of the lab you will make a solution of sodium carbonate and mix it with a solution of calcium chloride. Be careful to observe what happens. Read the following step-by-step procedure in its entirety before carrying it out. Before even collecting your materials, plan out the data you will need to collect and make a data table to put it in.

1. Using appropriate equipment, measure out an amount of sodium carbonate from between 4 and 5 grams. Do **not** try to get any exact amount such as exactly 4.00 g or 5.00 g. Instead, simply measure out an amount between these extremes and record its exact mass.
2. Measure 100 mL of distilled water and pour it carefully into the 250-mL beaker.
3. Carefully add the sodium carbonate to the water being sure no solid remains in the container you used to weigh it.
4. Stir the mixture you have made until the sodium carbonate has completely dissolved.
5. Measure 60 mL of the 1.0 *M* calcium chloride solution.
6. Pour it carefully into the 250-mL beaker containing the sodium carbonate solution. Observe the formation of a white precipitate as you do so.

Filtration and Drying Procedure

In this part of the lab you will filter the solid calcium carbonate from the water. Then you will dry the solid material on the filter paper in order to be able to weigh it to find the mass of the precipitate. This will allow you to see whether the mass you measure matches your stoichiometric calculation. **Read the following step-by-step procedure in its entirety before carrying it out.**



1. After completing the previous procedure, allow the precipitate to settle to the bottom of the beaker.
2. Set up the filter flask apparatus as shown at right. Securely clamp the flask upright and connect the vacuum tubing from the flask to the sink aspirator. An aspirator is a device installed in a sink to create low pressure (a 'vacuum') by the flow of water. Your teacher will demonstrate its use. The plastic funnel has two parts: a cylindrical upper part and a funnel-shaped lower part which goes through a rubber stopper. Assemble the funnel and place it securely into the opening in the flask.
3. Obtain and **find the exact mass** of a piece of quantitative filter paper. Record the mass in the data table. The paper you use must fit exactly into the funnel.
4. Place the filter paper into the funnel and use the wash bottle to make it wet with distilled water. Make sure that it is completely flat and has no folds or wrinkles. If it does it may allow the solid material to pass through. Obtain and weigh another piece of filter paper if this is the case.
5. Turn the water for the sink aspirator on full blast. Using a stirring rod to guide the flow of liquid into the filter (as shown in the picture), decant the supernatant (the liquid above the settled precipitate) into the funnel. (To decant means to pour in such a way as to leave the solid material on the bottom of the beaker. Do not let that material collect on the filter paper until almost all of the supernatant has been filtered.) Do not over fill the funnel! Liquid which overflows can no longer be filtered. Also, do not exceed the capacity of the flask: it can hold a maximum of about 250 mL. Finally, keep an eye on the sink: with the water on at full blast it can sometimes fill right up to the top. Do not allow it to spill over.
6. When all but about 10 mL of the liquid has been filtered swirl the beaker to suspend the solid. Transfer this to the funnel.
7. Use the wash bottle to gently wash any remaining solid into the funnel while holding the beaker upright so it drains directly into the funnel while you wash. Your teacher will demonstrate this technique for you.
8. Rinse the solid three times with small amounts of distilled water from the wash bottle. This will remove dissolved sodium chloride from the solid calcium carbonate. Once finished, turn off the faucet.

9. Obtain a weighing boat. Using forceps (tweezers), remove the filter paper from the funnel and place it in the weighing boat. Be careful not to tear the filter paper or to lose any of the solid material.
10. Place the weighing boat with the filter paper on it into your drawer and allow it to dry overnight.
11. Weigh the filter paper with the $CaCO_3$ and **record it in your data table.**
12. The filter paper can be thrown in the trash.
13. Carefully wash all lab equipment with water containing detergent.

Post lab assignments…

Calculations:

1. Use the mass of sodium carbonate to predict the mass of calcium carbonate that will form in your experiment (mass-mass calculation).
2. What mass of $CaCO_3$ did you measure in your lab work?
3. Calculate the percent yield for your reaction.

Analysis:

1. Would the mass of calcium carbonate that you measure be made larger or smaller if it were not completely dry? Explain.
2. Explain any differences between your measurement and the stoichiometric calculation of the mass of calcium carbonate. In particular, comment on why the percent yield was (likely) not 100%.

Conclusion:

How did this lab help you to learn and apply the skills involved in understanding stoichiometry?