Lab #7 Mass Relationships in Chemical Reactions

General Discussion

In general, we say that a reaction will go to completion (be quantitative) if one of the reactants is completely consumed by the reaction. There are several ways that a reactant may be consumed. This will occur if (a) a precipitate is formed, (b) a weakly dissociated substance such as water or a weak acid is formed, and (c) a gas (volatile substance) is formed.

In this experiment you will allow sodium bicarbonate (baking soda) to react with hydrochloric acid for the purpose of obtaining a high yield of sodium chloride.

$$NaHCO_3 + HCl \text{ ---------> } NaCl + H_2O + CO_2(g)$$

You will use an accurately measured mass of $NaHCO_3$ and enough dilute HCl to completely react with it. You will then isolate the NaCl from the other products and determine its mass. The theoretical yield can be calculated by using the mole and mass ratios obtained from the balanced equation for the reaction. The percentage yield can then be determined by comparing the experimental yield with the theoretical yield.

Objectives

1. To prepare and determine the percentage yield of sodium chloride.
2. To gain an understanding of mass relationships in chemical reactions.

Materials: Evaporating dish, watch glass, balance, sodium bicarbonate, hydrochloric acid, wire guaze, ring stand, wash bottle.

Procedure

1. Clean and dry an evaporating dish and watch glass, and weigh the combination to the nearest 0.01 g. The watch glass is the cover for the evaporating dish. Record the data in the data table.
2. Put about 2 g of pure sodium bicarbonate into the dish. Weigh the dish, contents, and cover to the nearest 0.01 g.
3. Cover the dish with the watch glass. Place the convex side down and the glass slightly off center so that the lip of the dish is uncovered. Add dilute hydrochloric acid dropwise down the lip of the dish to the bicarbonate in the dish. Continue this procedure until no more reaction takes place when a drop of acid is added. Gently swirl the contents of the dish so that all of the solid contacts the liquid. Do not add excess hydrochloric acid.
4. Carefully rinse the underneath side of the watch glass with distilled water, a few drops at a time, and collect the washings in the dish.
5. Heat the evaporating dish, contents and cover with a low flame until the salt is *completely* dry. If the contents of the dish pop and spatter, reduce the flame.
6. Allow the dish to cool to room temperature and weight it, along with the watch glass cover to the nearest 0.01 g. Repeat Steps 5 and 6 to be sure constant weight has been obtained. Two consecutive mass readings should agree within 0.02 g.

Data Table

	Trial 1	Trial 2
Mass of evaporating dish, watch glass, and $NaHCO_3$	_____ g	_____ g
Mass of evaporating dish and watch glass	_____ g	_____ g
Mass of $NaHCO_3$ used	_____ g	_____ g
Mass of evaporating dish, cover, and NaCl 1st	_____ g	_____ g
2nd	_____ g	_____ g
3rd	_____ g	_____ g
Mass of salt obtained (experimental)	_____ g	_____ g

Calculations

1. Calculate the theoretical mass of NaCl that should have been obtained. Show mathematical calculations in your report.
2. Determine the percentage yield.

Followup Discussion

The reaction which you used to prepare the salt in this experiment should have proceeded to completion. This type of reaction is also used to prepare weakly dissociated acids. It can be seen from the equation that the reactants are a stong acid and the salt of a weak acid. One product of such a reaction is a weak acid. We can assume that when a strong acid reacts to form a weak acid that ions of the strong acid are removed from the solution. Hence, the reaction proceeds essentially to completion. In this reaction, the weak acid formed as a product was carbonic acid. H_2CO_3. However, carbonic acid decomposes into CO_2 and H_2O.

One of your objectives in this experiment was to compare the experimental and calculated yield of product. The following example is provided to assist you in making the required calculations. The theoretical yield is calculated as follows:

Calculation

Followup Problems

1. What was the cause of the effervescence which you used as an indication of the progress of the reaction?
2. Give two reasons why the reaction in this experiment should have gone to completion.
3. How can you be sure that your product was completely dry?
4. If you had added excess hydrochloric acid to the sodium bicarbonate and then evaporated the solution, you would have detected an irritating gas. What do you think its name and formula would be?
5. List all the sources of error which you think may have influenced the accuracy of your experimental results. Wherever possible, indicate whether each error would have made your result higher or lower.
6. Consider the following balanced equation and answer parts (a) through (f). Show calculations for each part.

$$3\ Ag(s) + 4\ HNO_3(aq) \text{-------}> 3\ AgNO_3(aq) + NO(g) + 2\ H_2O(l)$$

(a) State the number of moles of $AgNO_3$ produced by the reaction of 3 moles of Ag with excess HNO_3.

(b) State the number of moles of $AgNO_3$ produced by the reaction of 108 grams of Ag with excess HNO_3.

(c) State the number of grams of $AgNO_3$ produced by the reaction of 108 grams of Ag with excess HNO_3.

(d) State the number of moles of NO produced as a byproduct of the reaction of 108 grams of Ag with excess HNO_3.

(e) State the number of grams of NO produced as a byproduct starting with 108 grams of Ag and excess HNO_3.