Lab 3.7
Chemical Reactions

Background

Due to the widespread use of sodium bicarbonate (commonly called baking soda) in many food products, the thermal decomposition reaction has been studied extensively by food chemists. Baking soda is used to prepare cakes in order to ensure that cakes "rise" as they bake.

As the temperature of the cake batter reaches approximately 50°C, the baking soda decomposes and carbon dioxide gas is released. The use of baking soda is especially popular in pancakes and waffles since the high cooking temperatures of 350 - 450°F (175-230°C) cause the carbon dioxide to be liberated before the dough has set. Thus, the batter rises before it sets, and we get a light and tasty finished product.

There are three possible chemical reactions that could be occurring during the baking process. All three of these reactions shown below are theoretically possible, yet only one reaction actually occurs.

Possible Decomposition Reactions

Sodium bicarbonate (s) $\rightarrow$ sodium hydroxide (s) + carbon dioxide (g)
Sodium bicarbonate (s) $\rightarrow$ sodium oxide (s) + carbon dioxide (g) + water (g)
Sodium bicarbonate (s) $\rightarrow$ sodium carbonate (s) + carbon dioxide (g) + water (g)

Safety

- Exercise caution when using the Bunsen burner and when handling objects that have been heated. Do not touch the test tube or any other object that may remain hot until it has cooled.
- Goggles and aprons must be worn.

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AP Chemistry

I. PURPOSE

Part A - The goal is for you to experimentally determine which of three reactions for the decomposition of sodium bicarbonate is correct. You will need to use stoichiometry to determine which reaction is occurring inside the test tube.
Part B - You will be provided a mixture of Na_2CO_3 and $NaHCO_3$. The goal is for you to experimentally determine the percentage of Na_2CO_3 and the percentage of $NaHCO_3$ found in that mixture.
Part C - You will combust the iron found in steel wool using a 9V battery to determine if the product of the reaction is composed of Iron (II) or Iron (III).

II. MATERIALS

1. Baking Soda ($NaHCO_3$)
2. $NaHCO_3$/Na_2CO_3 Mixture
3. Steel Wool
4. Balance, 0.001 g precision
5. Bunsen burner
6. Chemical Scoop
7. Evaporating Dish
8. Test Tube Tongs
9. Test tube
10. Red Solo Cup
11. 9V Battery

III. PROCEDURES

Part A – Decomposition of Sodium Bicarbonate

1. Place the Red Solo cup on the balance and tare (zero) the balance. Place a clean, dry test tube in the Red Solo Cup and determine the mass. Record this mass in your data table.
2. Remove the test tube from the Red Solo Cup. Using the scoop, place approximately 4 cm (one to two finger-widths) of baking soda in the test tube.
3. Make sure the outside of the test tube is clean and dry. Return the test tube with baking soda to the Red Solo Cup and determine the mass. Record this mass in your data table.
4. Holding the test tube at a 45º angle with the tongs, heat the bottom of the tube. DO NOT heat near the tongs, or they will become hot.
5. *Heat the test tube for 5 minutes. **Observe the test tube carefully during the heating process** for signs of a reaction – you should see a clue. After 5 minutes have passed, remove the flame and allow the test tube to cool until you can hold it. Agitate the contents of the test tube (be careful not to spill any of the contents). Return the flame and continue heating for 5 more minutes.
   ***While one partner heats the test tube and contents the other partner(s) should begin work on Question 1**.
6. Allow the test tube to cool to the point that you can comfortably hold it. Place the Red Solo cup on the balance and tare (zero) the balance. Return the test to the cup and determine the mass. Record this mass in your data table.
7. Place the final product (contents of your test tube) in the container provided by your teacher. We will use that product in Part 2. Do not throw it away! Clean and dry the test tube.

Part B - Percent of Na_2CO_3 and $NaHCO_3$ in a mixture.

1. Repeat the procedures from Part A using the sample of unknown provided by the instructor.
2. Start heating the mixture and collect necessary data. While heating discuss with your partners how you will figure out the percentages of the two components. You will need to use what you learned in Part 1 to figure this out. This is not easy but not impossible.
3. Create a **calculation section** and show all calculations while clearly indicating how you found the percentages from the collected data.
   (We will spend our next class going over everyone's method for finding their answers so do your best. You can go back and redo calculations tomorrow night if necessary. Just do your best.)

Part C - The Iron in Steel Wool

1. Watch the demonstration given by your teacher. You will duplicate this with your partner(s).
2. Create a data table. After the demonstration given by the teacher and the data tables you copied in parts 1 and 2, you should be able to determine what information you need to record.

IV. PRE-LAB QUESTIONS

1. Explain the differences between a chemical change and a physical change.
2. List three examples of a physical change and three examples of a chemical change. Explain why you think each example is chemical or physical.
3. What are the indicators of a chemical change? Include an example of each indicator.

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V. DATA & CALCULATIONS

A. DATA

Part A Data Table	
Mass of test tube	
Mass of test tube + sodium bicarbonate	
Mass of sodium bicarbonate	
Mass of test tube + final product	
Mass of final product	

Part B Data Table	
Mass of test tube	
Mass of test tube + mixture	
Mass of mixture	
Mass of test tube + final product	
Mass of final product	

Design a Data Table for Part C

B. CALCULATIONS

Part A

1. Write out each reaction choice and stoichiometrically determine how much solid product should be left.
2. What is the correct reaction?
3. What is your percent yield? Show all work.

Part B

1. Write out and explain all calculations necessary to determine the percentage of $NaCO_3$ in the mixture.

Part C

1. Write the combustion of iron reaction two different ways. In the reactions, you should show the production of two different oxides based on the knowledge that iron's oxidation state can be $^{2+}$ or $^{3+}$.
2. Show the necessary stoichiometry and calculations needed to prove which of the two possible products you produced. Did the product contain Fe^{2+} or Fe^{3+}? *(Two separate stoichiometric calculations needed here.)*

VI. QUESTIONS & DISCUSSION OF ERROR

A. QUESTIONS

Part C

1. Why did the mass of the steel wool increase when it was combusted?
2. Which oxidation number of iron was proven to be the one in the product? Fe^{+2} or $Fe^{+3?}$
3. If not all the steel wool was oxidized (you missed some when applying the battery), how would the final mass of your evaporating dish be affected? Too high, too low, or no effect? EXPLAIN! Draw a picture depicting what happens to the elements and molecules when solid Mg ribbon reacts with hydrochloric acid. Describe what is happening.

B. DISCUSSION OF ERROR

VII. CONCLUSION