AP Chemistry
Stoichiometry Target Lab

In this experiment, you will be observing the reaction between citric acid, $H_3C_6H_5O_7$, and sodium hydrogen carbonate (aka sodium bicarbonate). Your goal is to produce an assigned mass of carbon dioxide gas when sodium hydrogen carbonate reacts with excess citric acid monohydrate according to the following chemical equation:

$$3\ NaHCO_3 + C_6H_5O_7 \cdot H_2O \rightarrow Na_3C_6H_5O_7 + 3\ CO_2 + 3\ H_2O$$

Objectives
- Observe evidence of reaction between citric acid and sodium hydrogen carbonate
- Calculate the number of moles of each of the starting materials needed to produce a specified mass of carbon dioxide gas
- Compare the theoretical amount to the actual amount of carbon dioxide and calculate the percent yield

Materials

balance
distilled water
400 mL beaker
wash bottle
stirring rod
25 mL graduated cylinder
weighing boat
solid citric acid monohydrate, $C_6H_5O_7 \cdot H_2O$
solid sodium hydrogen carbonate, $NaHCO_3$

Safety

Wash spills and splashes off your skin and clothing with plenty of water. Wear your safety goggles to keep spills and splashes out of your eyes.

Procedure and Calculations

1. Put on your laboratory apron and safety goggles.
2. Your teacher will assign you a target mass of carbon dioxide gas. Record this in the data table.
3. Add about 25 mL of distilled water to a 400 mL beaker. Record the combined mass of the beaker and water.
4. Starting with your target mass of CO_2, calculate the mass of sodium hydrogen carbonate, $NaHCO_3$, you will need to produce that mass of CO_2.

5. Using a balance and weighing boat, obtain a sample of sodium hydrogen carbonate that equals the mass you calculated in question 4.

6. Add the sodium hydrogen carbonate to the water in the beaker.
7. Starting with your target mass of CO_2, calculate the minimum mass of citric acid monohydrate, $C_6H_5O_7 \cdot H_2O$, you will need to produce that mass of CO_2.

8. Using a balance and weighing boat, obtain a sample of citric acid monohydrate that exceeds the mass you calculated in question 6 by 0.5-1.0 grams. Record the actual mass that you used in the data table.
9. Add the massed citric acid to the beaker with water and sodium hydrogen carbonate.
10. Determine the total mass of the beaker, water, and chemicals BEFORE the reaction. Swirl or stir carefully for several minutes--avoid letting any liquid splash out of the beaker.
11. Using the balance, determine the total mass of the beaker, water, and chemicals AFTER the reaction.

Data and Results

a	Target mass of CO_2(g)	
b	Mass of distilled beaker with water before the reaction (g)	
c	Mass of sodium hydrogen carbonate $NaHCO_3$ used (g)	
d	Mass of citric acid monohydrate $C_6H_5O_7 \cdot H_2O$ used (g)	
e	Total mass of beaker, water and chemicals BEFORE the reaction (g)	
f	Total mass of beaker, water and chemicals AFTER the reaction (g)	
g	Mass of CO_2 (g) produced during the reaction (g)	
h	% yield of CO_2, %	

Analyze and Apply Questions

Answer these questions in complete sentences.

1. Write a net ionic equation for the reaction in this experiment.

2. What mass of carbon dioxide did your group produce? Was this mass higher or lower than the mass of carbon dioxide you were challenged to produce?

3. Confirm that the sodium hydrogen carbonate was the limiting reactant in this experiment. Support your answer with calculations.

4. List and discuss a minimum of TWO possible sources of experimental error which specifically explain your % yield. (Answers such as "human error" are not acceptable.) For each source of error, detail which measurement(s) were affected by this error and use math-based reasoning to explain how this error affected the mass of carbon dioxide released.

5. If you had the opportunity to repeat this experiment, what would you do differently to improve your results?

Teacher information (Do not print this page!)

Answers to questions 4 and 6 based on different CO_2 targets

CO_2 target	g $NaHCO_3$ needed	minimum mass citric acid monohydrate needed*
1.00	1.91	1.59
1.20 g	2.29	1.91
1.40 g	2.67	2.23
1.60 g	3.06	2.54
1.80 g	3.44	2.86
2.00 g	3.82	3.18
2.20 g	4.20	3.50
2.40 g	4.58	3.82

*students should use at least 0.5-1.0 g additional citric acid!

setup instructions
tray of 400 mL beakers or large plastic cups (1 per group) (If you use smaller beakers you will probably have spills as the gas generates)
tray of 25 mL graduated cylinders (1 per group)
electronic balances
at each table or station: small container with 30-35 g citric acid monohydrate & a scoop
at each table or station: small container with 60-65 g sodium hydrogen carbonate and a scoop
weighing boats
distilled water in bottles
stirring rods for each station