Analyzing the Reaction between Baking Soda and Citric Acid

Background
Baked goods are leavened (to leaven means to raise or make light) with a variety of natural and chemical raising agents. They produce gases that are responsible for the increased volume when a mixture is placed in the oven to bake. Raising agents such as baking soda are responsible for producing and expanding the millions of bubbles trapped in the batter. The reaction is triggered by moisture and or heat. When the batter sets into a firm structure during baking the aeration is preserved, observed as a soft cushion-like texture with miniscule air pockets.

Raising agents also contribute to the taste, texture and color of baked foods. For a successful leavening system, balancing the chemical ingredients minimizes the risk of a bitter flavor, or a too moist or too dry texture. Baking soda requires an acid and moisture to react and neutralize the bitter taste and produce the carbon dioxide air bubbles to lighten the texture.

In this experiment we will use our understanding of chemistry to investigate the reaction between baking soda and citric acid and determine the amount and ratio of each reactant we would need for a complete and balanced reaction.

Objective
To determine the amount of baking soda and citric acid required in a balanced chemical reaction

Part 1: Prelab Warm-up and Questions

1. Balance the following equation with reactants of baking soda and citric acid producing carbon dioxide, water and sodium citrate:

   \[ \text{____H}_3\text{C}_6\text{H}_5\text{O}_7 + \text{____NaHCO}_3 \rightarrow \text{____CO}_2 + \text{____H}_2\text{O} + \text{____Na}_3\text{C}_6\text{H}_5\text{O}_7 \]

2. Calculate the molar mass for citric acid:

3. Calculate the molar mass for baking soda:
4. According to the balanced equation in question 1, for a complete reaction to occur how many grams of each of the reactants would be required?

5. You will be conducting a lab using 0.1 moles of citric acid. Calculate the mass of citric acid that you would need to weigh:

6. Based on the ratio of moles: How many moles of baking soda are required to react with 0.1mole of citric acid?

7. Calculate the number of grams of baking soda required for the lab reaction.

Part 2: Experiment

Materials
- Analytical balance
- Citric acid (H$_3$C$_6$H$_5$O$_7$)
- Baking soda (NaHCO$_3$)
- Weighing paper or weighing dish
- 50 mL beaker
- Deionized water/distilled water
- 25mL graduated cylinder

Safety
- Always wear safety goggles when handling chemicals in the lab.
- Wash your hands thoroughly before leaving the lab.
- Follow teacher instructions for clean-up of materials and disposal of chemicals.
- Immediately alert your teacher if any solution gets on your skin, and thoroughly flush their skin with water.
- Wear protective gloves when working with strong acids
**Procedure**

Use your Pre-lab data and the following recording space at each step as you go through the procedures.

1. Use weighing paper and the analytical balance to measure the required amount of citric acid *Prelab Question 6* and baking powder *Prelab Question 7*. Place them both into the beaker. Write down your observation of this mixture:

2. Measure 10mL of water and gently pour it into the beaker with citric acid and baking soda. Write down your observation:

3. Measure an additional 10mL quantity of water and gently pour it into the beaker with citric acid and baking soda. Write down your observation:

4. Between 1-2 minutes later add another 10mL of water and swirl the beaker. Write down your observation:

5. Place the beaker on the lab table until there is no further observable reaction. Describe the remaining liquid:

6. Explain the result of your remaining liquid:
7. You are assigned to bake a cake for a celebratory event and are tasked with finding a recipe that is most likely to create a moist and light (well raised) cake texture. Outline some of the key factors you will be analyzing when making your recipe selection, with evidence and reasoning.

Part 3: Analysis

1. Review your observation of Procedure step 1. Explain this in terms of the chemical reaction taking place.

2. Was the quantity of reactants used in this experiment balanced according to the theoretical equation? Explain why or why not.

3. If an additional 10mL of water was added in the reaction, what would you hypothesize would happen? Explain your reasoning.