Lab: Baking Soda Stoichiometry

FOR THE TEACHER

Summary
In this lab, students will decompose baking soda and use stoichiometry to determine the proper balanced chemical equation of its decomposition.

Grade Level
High school

Objectives
By the end of this lesson, students should be able to
- Use stoichiometry to confirm the reaction they observe.
- Witness a decomposition reaction.

Chemistry Topics
This lesson supports students’ understanding of
- Stoichiometry
- Decomposition
- Percent yield

Time
Teacher Preparation: 30 minutes
Lesson: one class period

Materials
- Hot plate
- Baking soda
- Balance
- Stirring rod
- 50-mL beaker

Safety
- Exercise caution when using a heat source. Hot plates should be turned off and unplugged as soon as they are no longer needed.
- Always wear safety goggles when handling chemicals in the lab.
- Students should wash their hands thoroughly before leaving the lab.
- When students complete the lab, instruct them how to clean up their materials and dispose of any chemicals.

Teacher Notes
- The three possible balanced equations are: (reaction #3 is how it decomposes)
  1. \( \text{NaHCO}_3(s) \rightarrow \text{NaOH}(s) + \text{CO}_2(g) \)
  2. \( 2 \text{NaHCO}_3(s) \rightarrow \text{Na}_2\text{O} (s) + 2 \text{CO}_2(g) + \text{H}_2\text{O}(g) \)
  3. \( 2 \text{NaHCO}_3(s) \rightarrow \text{Na}_2\text{CO}_3 (s) + \text{CO}_2(g) + \text{H}_2\text{O}(g) \)
• Usually the apparatus consists of a crucible over a Bunsen burner, but this is a less precarious set up and heats the baking soda to an appropriate temperature for the decomposition reaction to take place. It’s a safer alternative.

**FOR THE STUDENT**

**Lesson**

**Prelab Questions**

Baking soda (sodium bicarbonate) is a common ingredient in baked goods. What state is baking soda?

When baking soda is heated, it breaks down into new compounds. This is an example of what kind of reaction?

If you omit baking soda from a recipe, the final product’s texture isn’t as light and fluffy as you would expect it to be. What does that tell you about the state of at least one of the products from the reaction?

**Background**

In this experiment, you will use stoichiometry to determine which of the three reactions takes place when baking soda is heated.

1. Sodium bicarbonate $\rightarrow$ sodium hydroxide + carbon dioxide
2. Sodium bicarbonate $\rightarrow$ sodium oxide + carbon dioxide + water
3. Sodium bicarbonate $\rightarrow$ sodium carbonate + carbon dioxide + water

Before completing the experiment, determine the complete balanced equation for each of the possible reactions, including the states of each compound involved.

1. 
2. 
3. 

**Materials**

- Hot plate
- Baking soda
- Balance
- Stirring rod
- 50-mL beaker

**Procedure**

1. Obtain the necessary materials. Make sure the beaker is clean and dry.
2. Find the exact mass of the beaker. Record its mass.
3. Mass about 4 grams of baking soda. Be sure to record the exact mass you obtain. Do not tare the balance so you know the mass of the beaker and baking soda.
4. Place the beaker on the hot plate and heat for about 10 minutes. You can use the stirring rod to stir the powder and break up any clumps you see form.
5. Remove the beaker from the hot plate and allow it to cool for a few minutes. Find the mass of the beaker and “baking soda.” Record this mass.
6. Place the beaker back on the hot plate and allow it to heat for another 10 minutes. Again, use the stirring rod to stir and break up clumps.
7. Remove the beaker from the hot plate and allow it to cool for a few minutes. Find the mass of the beaker and “baking soda.” Record this mass.
8. If the mass in step seven is more than 0.1 g different than the mass in step five, place the baker back on the hot plate and allow it to heat for 5 minutes, stirring and breaking up clumps.
9. Remove the beaker from the hot plate and allow it to cool for a few minutes. Find the mass of the beaker and “baking soda.” Record this mass.
10. If the mass in step nine is more than 0.1 g different than the mass in step seven, place the baker back on the hot plate and allow it to heat while stirring for 5 minutes.
11. Repeat the reheating and remassing until you obtain two masses that are less than 0.1 g different.
12. Once the beaker is cool to the touch, wash the contents down the sink with lots of water. Clean and dry the beaker and stirring rod and return the materials to where you found them.

Data

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<th>Material(s)</th>
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Calculations
1. From the background, what are the three possible reactions you could have witnessed in this experiment?
   1.
   2.
   3.
2. According to your data, which equation properly expresses how baking soda decomposes? Show your calculations as evidence.
3. Check with your teacher to find the actual reaction that took place. Calculate your percent yield.
4. If you repeated this experiment, would you expect to get similar results? Explain why or why not.
5. In procedure steps 5, 7, and 9, why is it referred to as “baking soda” and not baking soda?
6. What were some possible sources of error?
7. How could you improve this experiment to obtain closer to 100% yield?

Conclusion
What did you learn from this experiment?