Decomposition of Baking Soda

Mole Relationships and the Balanced Equation

Concepts

- Decomposition reactions
- Balancing chemical equations
- Stoichiometry

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 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) → sodium hydroxide (s) + carbon dioxide (g)

sodium bicarbonate (s) → sodium oxide (s) + carbon dioxide (g) + water (g)

sodium bicarbonate (s) → sodium carbonate (s) + carbon dioxide (g) + water (g)

Materials

Baking soda, 2 g
Balance, 0.01-g precision
Bunsen burner
Clay triangle
Crucible
Crucible tongs
Ring stand
Ring support
Spatula, micro
Spoon
Weighing dish

Safety Precautions

Exercise caution when using the Bunsen burner and when handling objects that have been heated. Do not touch the crucible or any metal that may remain hot. Use heat-resistant gloves if necessary. Wear safety goggles while performing this demonstration. Please review all Material Safety Data Sheets for additional safety, handling and disposal information.

Experiment Overview

The goal of this lab is for you to experimentally determine which of these three reactions is correct. Students will need to use stoichiometry to determine which reaction is actually occurring inside the crucible.

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Procedure

1. Throughout this demonstration instruct students to record all necessary masses.
2. Measure the mass of the empty crucible.
3. Place the empty crucible on the balance pan and then press the tare/reset button.
4. Measure 2.00 g of baking soda into the crucible. Report the exact measurement to students. *Note:* Do not turn off the balance. Since the balance was zeroed with the mass of the crucible the final balance should also not include the mass of the crucible.
5. Assemble the ring stand with a circular ring support. Place the clay triangle on top of the ring support and place the crucible containing the baking soda on top of the clay triangle (see Figure 1).
6. Heat the crucible and its contents with the Bunsen burner for ten minutes. Use a spatula to carefully break up any "clumps" that form during heating. Clumps need to be broken only once during heating.
7. Mass the crucible and its contents. Report the mass of the product to the students.

Suggested Student Activities

Each person would be required to submit a lab report containing the items listed below in separate sections with the following headings:

1. Purpose
2. Potential Chemical Reactions
   a. Balanced chemical equations with proper chemical formulas for all three possible decomposition reactions.
3. Data Table
   a. Containing all laboratory measurements with proper units.
4. Calculations
   a. Stoichiometric mass predictions for each possible reaction.
5. Conclusions
   a. As based upon individual results. How did the student rule out the other two chemical reactions?

Lab Hints

- Students may ask how much of the baking soda they should use. In keeping with the general practice of not filling a crucible more than half-full, there is no "correct" mass of baking soda to use. This avoids situations where students believe they must use 2.00 g of baking soda or else the experiment "won't work."
- Some students will subtract the wrong masses. These students will usually try to subtract the crucible and product mass from the crucible and starting material mass. These students will almost certainly believe that the second reaction is occurring.
- If the starting mass of the baking soda is known, then the students should be able to calculate the mass of the solid product in each possible chemical reaction.

Sample Data and Calculations

Sample calculations if 2.00 g of baking soda are used:

First Possible Reaction

$$\frac{2.00\text{ g NaHCO}_3}{1} \times \frac{1\text{ mole NaHCO}_3}{84.0\text{ g NaHCO}_3} \times \frac{1\text{ mole NaOH}}{1\text{ mole NaHCO}_3} \times \frac{40.0\text{ g NaOH}}{1\text{ mole NaOH}} = 0.952\text{ g NaOH}$$

Second Possible Reaction

$$\frac{2.00\text{ g NaHCO}_3}{1} \times \frac{1\text{ mole NaHCO}_3}{84.0\text{ g NaHCO}_3} \times \frac{1\text{ mole Na}_2\text{O}}{2\text{ moles NaHCO}_3} \times \frac{62.0\text{ g Na}_2\text{O}}{1\text{ mole Na}_2\text{O}} = 0.738\text{ g Na}_2\text{O}$$

Third Possible Reaction

$$\frac{2.00\text{ g NaHCO}_3}{1} \times \frac{1\text{ mole NaHCO}_3}{84.0\text{ g NaHCO}_3} \times \frac{1\text{ mole Na}_2\text{CO}_3}{2\text{ moles NaHCO}_3} \times \frac{106\text{ g Na}_2\text{CO}_3}{1\text{ mole Na}_2\text{CO}_3} = 1.26\text{ g Na}_2\text{CO}_3$$

Connecting to the National Standards

This laboratory activity relates to the following National Science Education Standards (1996):

Unifying Concepts and Processes: Grades K–12
Evidence, models, and explanation
Content Standards: Grades 5–8
Content Standard B: Physical Science, properties and changes of properties in matter
Content Standards: Grades 9–12
Content Standard B: Physical Science, structure of atoms, structure and properties of matter, chemical reactions

References

Figueira, A. R.; Coch, J.; Zepica, M. *J. Chem. Educ.* **1988**, *65*, 1060.

McCamish, M. *J. Chem. Educ.* **1987**, *64*, 710.

Flinn Scientific—Teaching Chemistry™ eLearning Video Series

A video of the *Decomposition of Baking Soda* activity, presented by Jeff Bracken, is available in *Mole Relationships and the Balanced Equation*, part of the Flinn Scientific—Teaching Chemistry eLearning Video Series.

Materials for *Decomposition of Baking Soda* are available from Flinn Scientific, Inc.

Catalog No.	Description
AP1277	Weighing Dishes, Disposable, ½ g
S0042	Sodium Bicarbonate, 500 g
AP8239	Crucible, Porcelain, High Form, Coors, 10 mL
AP8230	Ring, Support, with Rod Clamp, 2″

Consult the Flinn Scientific website for current prices.