Lab Investigation: Chemical Reactions

**Which chemical equation best represents the thermal decomposition of baking soda?**

**Introduction:** The law of conservation of mass says that mass is conserved in ordinary chemical changes. The law of definite composition states that atoms combine in specific ways to form compounds. John Dalton(1820) justified these laws with his **Atomic Theory**:chemical changes occur when there is a predictable rearrangement of atoms with no atoms being destroyed and no new atoms being produced. Balanced chemical equations are how we represent chemical reactions.

**Your Task:** Use mass to determine the rearrangement of atoms in a chemical reaction.

The guiding question of this investigation is: **Which chemical equation best represents the thermal decomposition of sodium hydrogen carbonate (NaHCO3)?**

NaHCO3 🡪 NaOH + CO2

(solid) (solid) (gas)

2NaHCO3 🡪 Na2CO3 + CO2 + H2O

(solid) (solid) (gas) (gas)

NaHCO3 🡪 NaH + CO + O2

(solid) (solid) (gas) (gas)

2NaHCO3 🡪 Na2O + 2CO2 + H2O

(solid) (solid) (gas) (gas)

**Materials:** You may use any of the following materials during your investigation.

Solid NaHCO3

Triple-beam balance

Periodic table

Gas burner

Crucible

pipe-stem triangle

ring stand

**Safety Precautions:** Follow normal lab safety rules.

**Getting Started:**

To determine **what type of data to collect,** think about what masses you will need to measure to answer the guiding question. *To begin your investigation it is suggested that you use between 2 and 3 grams of NaHCO3.*

To determine **how you will collect your data**, think about:

* How will you **empirically** determine when the decomposition of the NaHCO3 is complete?
* How will you reduce error?

Your group should allow about five minutes for your first heating.

To determine **how you will analyze your data** think about:

* What type of calculations will you need to make?
* How will your group use the precision of the balance in your analysis?

**As you work through this activity, be sure to think about the difference between laws and theories in science and the predictive power of each.**

**ADI Report: Chemical Reactions**

**Introduction:**

The law of conservation of mass states that mass is conserved in a chemical reaction. John Dalton’s atomic theory explains that this happens because individual atoms are not created or destroyed, but simply rearranged in a predictable way. The rearrangement of atoms in a chemical reaction is represented in the form of a chemical equation. Our task was to examine the chemical reaction that occurs when sodium hydrogen carbonate (aka sodium bicarbonate, aka baking soda) is heated in hopes of answering the guiding question: Which chemical equation best represents the thermal decomposition of sodium hydrogen carbonate (NaHCO3)?

**Methods:**

We used quantitative data to determine which of the four given equations best fit the thermal decomposition of baking soda. Our plan to conduct the chemical reaction was to begin with 2g of baking soda in a crucible, place it over a flame from a Bunsen burner for 5 minutes (until the chemical reaction was complete), then measure the mass of the resulting product. Our plan to analyze our data began with making predictions. We started by finding the molar mass of each compound in each equation. Then, we found the ratio of the molar mass of the solid reactant to the molar mass of the solid product in each equation (ignoring the molar mass of the gas products since they would not be measurable in an open system such as our setup). This ratio allowed us to make a prediction about the mass of the solid product based on the mass of the solid reactant for each of the four equations. We could then compare the measured mass of the product to the four predictions to determine which prediction best matched the data.

**Claim:**

Our claim is that the chemical equation 2NaHCO3 🡪 Na2CO3 + CO2 + H2O best represents the thermal decomposition of sodium hydrogen carbonate.

**Evidence:**

Figure 1 shows the predicted mass of the solid product in each of the four possible chemical equations using the methods described above.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Figure 1: Predicted Mass of Solid Product for Each Possible Chemical Equation** | | | | |
| **Possible Chemical Equations** | **Molar Mass of Solid Reactant** | **Molar Mass of Solid Product** | **Ratio of**  **Molar Mass of Solid Reactant**  **To**  **Molar Mass of Solid Product** | **Predicted Mass of Solid Product**  **(Given 2g of Solid Reactant)** |
| 1. NaHCO3 🡪 NaOH + CO2 | NaHCO3 = 84 g/mol | NaOH = 40 g/mol | 2.1 | **0.95 g** |
| 1. 2NaHCO3 🡪 Na2CO3 + CO2 + H2O | NaHCO3 = 84 g/mol | Na2CO3 = 106 g/mol | 1.585 | **1.26 g** |
| 1. NaHCO3 🡪 NaH + CO + O2 | NaHCO3 = 84 g/mol | NaH = 24 g/mol | 3.5 | **0.57 g** |
| 1. 2NaHCO3 🡪 Na2O + 2CO2 + H2O | NaHCO3 = 84 g/mol | Na2O = 62 g/mol | 2.71 | **0.738 g** |

Figure 2 shows the measurements we made during our investigation.

|  |  |  |
| --- | --- | --- |
| **Figure 2: Measurements of Mass** | | |
| Mass of Crucible | Mass of Crucible with Reactant  (before heating) | Mass of Crucible with Product  (after heating) |
| 21.25 g | 23.25 g | 22.55 g |

By subtracting the mass of the crucible, we found the initial mass of the reactant (the baking soda) to be 2.0 g. In the same way, we found the mass of the product after the chemical reaction had taken place to be **1.3 g**. When we compared this result with our predictions shown in Figure 1, we found that it matched very closely with the prediction made from equation 2. Equation 2 predicted a solid product mass of 1.26 g. Our result of 1.3 g gives us a percent error of only 3.17%.

**Justification:**

Our evidence supports our claim because the law of conservation of mass states that mass is conserved during a chemical reaction. Atomic theory explains this by stating that matter (atoms) is not created or destroyed, only rearranged during a chemical reaction. Based on this theory, we are able to predict the mass of the solid product using the mass of the solid reactant. We made that prediction for each of the four possible equations and our results best matched the prediction made by the second equation, 2NaHCO3 🡪 Na2CO3 + CO2 + H2O.