Lab 27: Stoichiometry and Chemical Reactions: Which Balanced Chemical Equation Best Represents the Thermal Decomposition of Sodium Bicarbonate?

**Introduction**

The *law of conservation of mass* states that mass is conserved during a chemical reaction. The *law of definite proportions* states that a compound is always made up of the exact same proportion of elements by mass. John Dalton was able to explain these two fundamental laws of chemistry with his *atomic theory*, which states that a chemical reaction is simply the rearrangement of atoms with no atoms being destroyed and no new atoms being produced during the process. Chemists use a balanced chemical equation to represent what happens on the submicroscopic level during a chemical reaction.

The *stoichiometric coefficient* is the number written in front of atoms, ions, or molecules in a chemical equation. These numbers are used to balance the number of each type of atom found on both the reactant and product sides of the equation. Stoichiometric coefficients are also useful because they identify the mole ratio between reactants and products. The mole ratio is important because it allows chemists to determine how many moles of a product will be produced from a specific number of moles of a reactant or how many moles of reactant are needed to produce a specific amount of a product.

Molar mass serves as a bridge between the number of moles of a substance and the mass of a substance. The molar mass is the mass of a given substance divided by one mole of the substance. The molar mass of a given substance can be calculated by summing the atomic mass for each atom found in a molecule of that substance. For example, the atomic mass of hydrogen is 1.01 g/mol, and the atomic mass of oxygen is 16.00 g/mol, so the molar mass of H2O is 18.02 g/mol (1.01 g/mol + 1.01 g/mol + 16.00 g/mol). Once the molar mass of a substance is known, the mass of a sample can be used to determine the number of moles of a substance or the moles of substance can be used to determine the mass of a sample. For example, a 40-gram sample of H2O consists of 2.2 mol of H2O (40 g of H2O ÷ 18.02 g/mol = 2.2 mol of H2O) and a 3.0 mol sample of H2O has a mass of 54.03 g (3.0 mol of H2O x 18.02 g H2O = 54.06 g of H2O). In this investigation, you will have an opportunity to use atomic theory, molar mass, and stoichiometry to determine how atoms are rearranged during a chemical reaction.

**Your Task**

There are at least four different balanced chemical equations that could explain how atoms are rearranged during the thermal decomposition of sodium bicarbonate (NaHCO3). The first potential explanation is that the sodium bicarbonate decomposes into sodium hydroxide (NaOH) and carbon dioxide (CO2) when it is heated. The balanced chemical equation for this reaction is

NaHCO3(s) 🡪 NaOH(s) + CO2(g)

The second potential explanation is that the sodium bicarbonate decomposes into sodium carbonate (Na2CO3), carbon dioxide (CO2) and water when it is heated. The balanced chemical equation for this reaction is

2NaHCO3(s) 🡪 Na2CO3(s) + CO2(g) + H2O(g)

The third potential explanation is that the sodium bicarbonate decomposes into sodium oxide (Na2O), carbon dioxide, and water when it is heated. The balanced chemical equation for this potential reaction is

2NaHCO3(s) 🡪 Na2O(s) + 2CO2(g) + H2O(g)

The fourth potential explanation is that the sodium bicarbonate decomposes into sodium hydride (NaH), carbon monoxide (CO), and oxygen when it is heated. The balanced chemical equation for this potential reaction is

NaHCO3(s) 🡪 NaH(s) + CO(g) + O2(g)

Your goal is to determine which of these four balanced chemical equations best represents how atoms are rearranged during the thermal decomposition of sodium bicarbonate.

The guiding question of this investigation is: **Which balanced chemical equation (of the four written above) represents the thermal decomposition of sodium bicarbonate?**

**Materials:**

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

|  |  |
| --- | --- |
| **Consumables**  Solid NaHCO3 (Baking Soda) | **Equipment**   * Hot Plate * Spatula * Spoon * Electronic Balance * Periodic Table * Aluminum Foil |

**Safety:**

Follow all normal lab safety rules. Your teacher will explain relevant and important information about working with the chemical associated with this investigation. In addition, take the following precautions:

* Wear goggles at all times.
* Use caution when working with hot plates. They can burn skin. If you are removing objects off of the hotplate, use caution because it will still be hot. If you have long hair, tie it back behind your head.
* Wash your hands with soap and water before leaving the laboratory.

**Getting Started:**

As part of your investigation, you will need to use a hotplate and a tray made of aluminum foil to increase the temperature of sodium bicarbonate enough for it to decompose. The thermal decomposition of sodium bicarbonate will occur rapidly at 200°C, but the product of the decomposition reaction will begin to decompose at temperatures over 850°C.

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Group Members\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Stoichiometry and Chemical Reactions: Which Balanced Equation Best Represents the Thermal Decomposition of Sodium Bicarbonate? (45 points)**

**LAB INVESTIGATION REPORTING SHEET-YOU MAY USE EXTRA PAPER IF NECESSARY.**

**Guiding Question: Which balanced chemical equation best represents the thermal decomposition of sodium bicarbonate?**

**Task One:** What type of data do you need to collect? Hint: Think about how much NaHCO3 will you need to use? What will you need to measure? Please come up with at least three pieces of data you will need to answer the guiding question. (3 pts- 1 pt per piece of data)

**Task Two:** List specific steps for how you plan to collect the data. (Like a procedure.) Hints: What type of equipment will you need to reduce error? How long will you need to heat the NaHCO3? How will you empirically determine when the decomposition of the NaHCO3 is complete? How will you measure how much reactant you start with and how much product you make? (4 pts for listing equipment and designing a method for tracking data.)

**Task Three:**  What type of calculations will you need to make? How will your group take into account the precision of the balance in your analysis? (2 pts for planning how you will organize and use the data in calculations.)

In the space below, create your data table. Also, perform any calculations here that you may need to begin to solve your problem. (3 pts data table-title, headings, units/proper sig figs. 5 points misc. calculations- work, ans/unit, sig figs)

In the space provided below, neatly work out the calculations to determine the correct chemical equation for your unknown. (Hint: You will need to do four different stoich calculations.) (20pts- 5 pt each problem- setup (2pts), answer, unit, sig fig)

1. NaHCO3(s) 🡪 NaOH(s) + CO2(g)
2. 2NaHCO3(s) 🡪 Na2CO3(s) + CO2(g) + H2O(g)
3. 2NaHCO3(s) 🡪 Na2O(s) + 2CO2(g) + H2O(g)
4. NaHCO3(s) 🡪 NaH(s) + CO(g) + O2(g)

**Our Claim:** What is the answer to the guiding questions for your unknown? (2 pts –stated, correct)

**Our Evidence:** What is the analysis of the data and your interpretation of what the analysis means? Provide evidence that proves without a doubt that your claim is true. (3 pts)

**Our Justification:** What is the scientific concept or principle that explains why the evidence you decided to use is relevant and important? Explain the science behind why and how your claim is valid. (3 pts)