**Stoichiometry Challenge**

**HIGH SCHOOL**

**Green Chemistry & Sustainable Science**

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**Teacher Background Information:**

This lesson replaces a traditional Aluminum to Alum stoichiometry lab with a greener precipitation reaction of sodium carbonate and calcium chloride. It is used to demonstrate how stoichiometry works, showing that if concentrations and amounts of the starting materials are known that the theoretical yield can be calculated from a balanced chemical equation.

**Safety Information:**

* Calcium chloride (CaCl2) and sodium carbonate (NaCO3) are both skin irritants.
* If either chemical comes in contact with skin wash with soap and water.
* If they come in contact with your eyes spend 15 minutes in the eyewash.

**Educational Goal:** Students will understand…

* How to calculate and make molar solutions of CaCl2 and Na2CO3 in order to produce an assigned amount of CaCO3.
* How to research where CaCO3 can be found nature.

**Student Objectives:** Students will …

* Synthesize an assigned amount of calcium carbonate.
* Demonstrate the mass-mass relationship in chemical reactions.
* Calculate the percent yield and analyze sources of error.
* Practice lab safety

**Materials: (per lab group -3 students)**

* 2.2 g CaCl2 (s)
* 2.1 g Na2CO3 (s)
* 40 mL Distilled water
* Three 50-mL or 100-mL beakers
* Filter paper
* Funnel
* Funnel rack
* 125-mL Erlenmeyer flask
* Wax paper or aluminum foil
* Stirring rod
* Spatula
* 2 plastic weigh boats
* Balance

**Time Required:** 1 class period (45 minutes)

**NGSS Standards Met:**

* **HS-PS1-2.** Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, and knowledge of the patterns of chemical properties.
* **HS-PS1-7.** Use mathematical representations to support the claim that atoms, and therefore mass, are conserved during a chemical reaction.
* **HS-PS1-10.** Use evidence to support claims regarding the formation, properties and behaviors of solutions at bulk scales.

**Key terms:** green chemistry principles, stoichiometry

**Prerequisites:** Students should have studied balancing equations, predicting products, stoichiometry and calculating dilutions.

**Teacher Prep:** The students are making solutions and then precipitates from the solutions. Place the Sodium carbonate and Calcium chloride near the balances with appropriate lab ware. Demonstrate to the students how to filter the precipitate. Only an Erlenmeyer flask, a glass filter, rubber adaptor, and filter paper are needed. If a vacuum system is available it is certainly helpful used with a filter flask, though not necessary. A Buchner funnel using vacuum filtration may also be used.

**Disposal Information:** Both calcium chloride and sodium carbonate may be poured down the drain and flushed with water.

**Stoichiometry Student Lab**

**Procedure:**

1. Write out a balanced equation for the reaction of calcium chloride (CaCl2) and sodium carbonate (Na2CO3) on the data sheet.
2. Calculate the amount of calcium chloride and sodium carbonate needed to make 20mL of each 1 M solution.
3. Calculate the amount of 1 M calcium chloride and 1M sodium carbonate in order to produce the assigned amount of product.
4. Obtain two 50-mL or two 100-mL beakers. Label one “1M calcium chloride (aq)” and the other “1 M sodium carbonate (aq)”.
5. Using distilled water, make the 20mL of each 1 molar concentrations of calcium chloride and sodium carbonate using your calculations from step 2.
6. Set-up filtration apparatus as described by your instructor.
7. In a clean 50-mL beaker, combine the 20mL of aqueous calcium chloride and 20mL of aqueous sodium carbonate and stir. Observe.
8. Filter the precipitate.
9. Once all of the solution has been filtered out remove the filter paper and precipitate and let the solid dry overnight.
10. Clean your lab station and lab supplies.
11. Day 2: Mass the solid and calculate the percent yield.

**Data, Questions and Analysis:**

1. Write a balanced chemical equation for the reaction of calcium chloride (CaCl2) and sodium carbonate (Na2CO3).
2. Mass of calcium chloride **needed** = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (show your work below)

**Actual** mass of calcium chloride = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Mass of sodium carbonate **needed** =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (show your work below)

**Actual** mass of sodium carbonate = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Mass of final product = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
2. Calculate percent yield. (Show your work)
3. Name three ways this experiment demonstrates green chemistry?
4. What are some possible sources of error?

**Teacher’s Guide to Questions**

1. **Write a balanced chemical equation for the reaction of calcium chloride and sodium carbonate.**

CaCl2 (aq) + Na2CO3 (aq) 🡪 CaCO3 (s)+ 2 NaCl (aq)

1. **Mass of calcium chloride needed = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (show your work below)**

**Actual** mass of calcium chloride =\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

20mL x 1L x 1mol x 110.98g CaCl2 = 2.22g CaCl2

1000mL 1L 1mol CaCl2

1. **Mass of sodium carbonate needed = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (show your work below)**

**Actual** mass of sodium carbonate = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

20mL x 1L x 1mol x 105.99g Na2CO3 = 2.12g Na2CO3

1000mL 1L 1mol Na2CO3

1. **Mass of final product = \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**
2. **Calculate percent yield. (show your work)**

Percent Yield = \_\_Actual Mass Product \_\_ x 100

Theoretical Mass Product

Theoretical Yield:

2.12g Na2CO3 x 1mol Na2CO3 x1mol CaCO3 x 100.09g CaCO3 = 2.00g CaCO3

105.99g Na2CO3 1mol Na2CO3 1mol CaCO3

Percent Yield= Mass of Final Product x 100

2.00g CaCO3­

1. **Name three ways this experiment demonstrates green chemistry?**

Prevention- very little waste is produced, in fact very little product is produced

Atom Economy - The only waste in the final product is salt water, which is green

Less Hazardous Chemical Syntheses- Both final products are biodegradable and non toxic

Safer Solvents and Auxiliaries – no toxic solvents, only water

Inherently Safer Chemicals for Accident Prevention- no toxic chemicals at all

1. **What are some possible sources of error?** Answers may vary