**OBJECTIVE**:

Determine and compare the theoretical and experimental yields of a reaction between aqueous calcium chloride, CaCl2 (aq), and aqueous sodium carbonate, Na2CO3 (aq) , to produce calcium carbonate precipitate, CaCO3 (s), and aqueous sodium chloride, NaCl (aq).

CaCl2 (aq) + Na2CO3 (aq) → CaCO3 (s) + 2 NaCl (aq) EQ1

**BACKGROUND**:

It is important to be able to determine the **quantities** of reactants and products consumed and produced by a given reaction.

A **balanced chemical equation**, such as EQ1, is the starting point for any quantitative determination regarding a chemical reaction. It communicates critical information about a reaction, including:

* The chemical formula of each reactant and product of a reaction
* The physical state (aq, s, l, g) of each reactant and product
* The mole relationships between the reactants and products

**Stoichiometry** is “chemical arithmetic” that is used to determine chemical quantities. Stoichiometry is based on the mole-to-mole relationships that exist between the elements of compounds, and between the compounds of reactions. Calculations are carried out such that the target quantity is determined through systematic unit cancellation.

**Examples of stoichiometric calculations**:

**Example 1**: 100. g of Au = \_\_\_\_\_\_\_\_\_\_\_\_ moles of Au?

**Example 2**: 3 moles of Fe = \_\_\_\_\_\_\_\_\_\_\_\_\_ g of Fe.

**Example 3**: 5 moles of H2O is composed of \_\_\_\_\_\_\_\_\_ moles of H

**Example 4**: Given EQ1, The complete reaction of 4 moles of CaCl2 results in the production of \_\_\_\_\_\_\_ moles of NaCl.

**Example 5**: Given EQ1, the complete reaction of 4.500 g of CaCl2 results in the production of \_\_\_\_\_\_\_\_ moles of CaCO3.

**Example 6**: Given EQ1, the complete reaction of 1.500 g Na2CO3 results in the production of \_\_\_\_\_\_\_ g of CaCO3.

**Example 7**: Given EQ1, how many grams of CaCO3 are formed from the reaction of 5.000 g of Na2CO3 and 2.000 g of CaCl2 ? Which reagent is the limiting reagent in this reaction?

Lay out the calculation for each of the 2 given quantities, and solve separately. The starting reagent that produces the least amount of product is the limiting reagent.

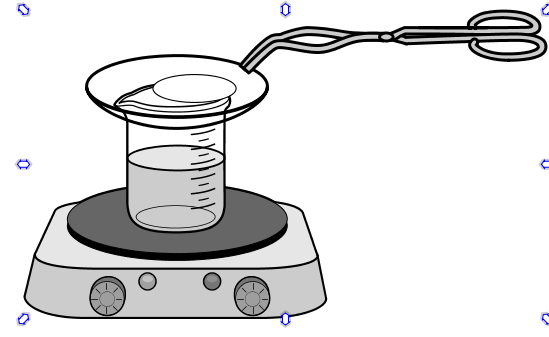
The lesser of the two quantities is produced: 1.804 g of CaCO3

In this case, CaCl2 is the “limiting reagent”

PROCEDURE

1. Label a clean, dry, 250 mL beaker, “CaCl2 (aq)”.
2. To the beaker …
   1. Add about 0.5 g of CaCl2 (Record actual mass of CaCl2 in Table 1)
   2. Add *about* 50 mL of distilled water
3. Stir the contents of the beaker until the CaCl2 is completely dissolved in the water.
4. What does the resulting solution look like?
5. Label a clean, dry, 250 mL beaker, “Na2CO3 (aq)”.
6. To the beaker …
   1. Add about 0.5 g of Na2CO3 (Record actual mass of Na2CO3 in Table 1)
   2. Add about 50 mL of distilled water to the beaker
7. Stir the contents of the beaker until the Na2CO3 is completely dissolved in the water.
8. What does the resulting solution look like?
9. Slowly, pour the Na2CO3 solution into the CaCl2 solution (record observations). Stir the mixture for about half a minute.
10. Weigh and record the mass of a dry piece of filter paper in Table 1. Place weighed filter paper into the filter basket and moisten the paper. Then, apply gentle vacuum to the moistened paper to stick it down to the surface of the filter basket.
11. Gently vacuum-filter the precipitate from the solution, using the filter paper that you weighed in the previous step.
12. Run the vacuum for an additional 5 minutes to partially dry the filter paper and precipitate.
13. Further dry the filter paper and precipitate on a watch glass over steam for 10 minutes. To do this, use a beaker / watch glass combination in which the watch glass is a bit larger in diameter than the beaker. Put about 50 mL of water in the beaker, set the beaker on a hot plate and cover the beaker with the watch glass (concave side up). Set the filter paper and filtrate on the watch glass. Bring the water to a boil. The steam gets very hot and will dry the paper. Do not boil the beaker dry. If necessary, add water to the beaker. Carefully remove the watch glass and its dried contents from the top of the beaker, using tongs to avoid the steam.

**CAUTION**: **HOT!!!** Use tongs to remove the watch glass from the steam. Remember, boiling water is 100C. The steam inside the “head space” of the beaker can get much hotter than 100C.



1. Weigh and record (in Table 1) the combined mass of the filter paper and precipitate.

**Table 1** – Mass data from precipitation reaction.

|  |  |
| --- | --- |
| Mass of CaCl2 (g) |  |
| Mass of Na2CO3 (g) |  |
| Mass of filter paper + precipitate (g) |  |
| Mass of filter paper |  |

**Calculations** (Be neat and thorough)

1. Calculate the theoretical yield of the CaCO3 precipitate formed by the reaction, and identify the limiting reagent in the reaction. Neatly show all of your work, as in Example 7.
2. Record the experimental yield of CaCO3 formed by the reaction.
3. Calculate the % yield of CaCO3 formed by the reaction.

**Table 2** – Results

|  |  |
| --- | --- |
| Theoretical Yield of CaCO3 |  |
| Experimental Yield of CaCO3 |  |
| % Yield of CaCO3 |  |

1. Discard waste in the designated waste container.