Experiment #7 - Types of Reactions and Conservation of Mass

Objectives: To become familiar with several different types of reactions. To study the law of conservation of mass.

Safety glasses are required for this experiment.

Part 1: Types of Reactions
Textbook Reference: pp 407-411

Write down all your observations including the state of matter for each substance.

1) Combination

A. $2Mg + O_2 \rightarrow 2MgO$

B. $2H_2 + O_2 \rightarrow 2H_2O$

2) Single Replacement

A. $Cu + 2AgNO_3 \rightarrow 2Ag + Cu(NO_3)_2$

B. $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

3) Double Replacement

A. $2\ NaHCO_3 + H_2SO_4 \rightarrow Na_2SO_4 + 2\ H_2CO_3$

$$2\ H_2CO_3 \downarrow H_2O + CO_2$$

B. $AgNO_3 + NaCl \rightarrow AgCl + NaNO_3$

C. $2AgNO_3$ + K_2CrO_4 $\rightarrow$ Ag_2CrO_4 + $2KNO_3$

4) Decomposition

$2PbO_2$ $\rightarrow$ $2PbO$ + O_2

5) Gel Formation

$Ca(O_2C_2H_3)_2$ + CH_3CH_2OH

6) Combustion

CH_3CH_2OH + $3O_2$ $\rightarrow$ $2CO_2$ + $3H_2O$

7) Catalyst

$2H_2O_2$ ¾ ¾®$_{KI}$ O_2 + $2H_2O$

8) Exothermic vs. Endothermic

A. $CaCl_2$ (s) $\rightarrow$ Ca^{2+} (aq) + $2Cl^-$ (aq)

B. $Ba(OH)_2$ + $2NH_4SCN$ $\rightarrow$ $2NH_4OH$ + $Ba(SCN)_2$

Part 2: Conservation of Mass

Textbook Reference: pp 353-362, 367-373

Supplies and equipment

Erlenmeyer flask (50 mL), two plastic vials, analytical balance, graduated cylinders, calcium chloride solution, sodium carbonate solution, sulfuric acid solution.

Discussion

In the study of chemical reactions it is important to determine whether the total mass present is the same before and after a reaction has taken place. If the mass remains unchanged throughout the reaction then we say that mass is conserved. To determine if mass is conserved during chemical reactions we will weigh the container with the reactants before the reaction takes place and then weigh the container with the products after the reaction has taken place.

In this experiment we will first study the reaction between aqueous solutions of calcium chloride ($CaCl_2$) and sodium carbonate (Na_2CO_3) to form calcium carbonate ($CaCO_3$) and sodium chloride (NaCl). The calcium carbonate will be evident as a gelatinous precipitate (solid). This is an example of a precipitation reaction:

Reaction 1: $CaCl_2(aq) + Na_2CO_3(aq) \rightarrow CaCO_3(s) + 2NaCl(aq)$

We will then add aqueous sulfuric acid (H_2SO_4) to the products of Reaction 1 to form calcium sulfate ($CaSO_4$), water, and carbon dioxide (CO_2). The calcium sulfate will be evident as a white precipitate. Carbon dioxide will evolve as a gas:

Reaction 2: $CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + H_2O(l) + CO_2(g)\uparrow$

The arrow written next to CO_2 indicates that this product escapes as a gas.

Procedure

1. Use the dispensing pumps located in the hoods to dispense the volumes of each solution needed. Make sure that the flask and the vials are clean. Pump 10.0 mL of the sodium carbonate solution into a 10 mL graduated cylinder. Pour this solution into your 50 mL Erlenmeyer flask. Similarly, pour 10.0 mL of the calcium chloride solution into one of the plastic vials and 3.0 mL of dilute sulfuric acid into the second vial. The exteriors of the flask and the vials should be dry. Place all three on the analytical balance and weigh to the nearest 0.0001 g. Your instructor will show you how to use the analytical balance. Note: You do not need to use the caps with the vials. However, if you do use the caps be sure to include them in all weighings. Do not cap the Erlenmeyer flask.

2. Record all masses in the data sheet provided.

3. Carefully pour the solution of calcium chloride ($CaCl_2$) into the flask that contains the sodium carbonate (Na_2CO_3) solution. Gently swirl the flask to mix the solution. Note any changes that occur on the data sheet. Place the flask and the two vials back on the analytical balance. Again, determine the total mass.

4. Add the sulfuric acid (H_2SO_4) solution **dropwise** to the flask. Swirl the solution and note any evidence of a reaction. Continue to swirl until all evidence of a reaction has stopped. Again measure and record the total mass. Continue swirling and weighing the solution every thirty seconds until two consecutive weighings differ by less than 0.010 g. We will consider this to be constant mass meaning that the mixture has lost as much gas as it can (not necessarily all that it contains).

Observations: Indicate what you observe when you perform these steps.

Addition of calcium chloride to sodium carbonate

Addition of sulfuric acid to flask

1. Total mass before mixing			g
2. Total mass after first mixing			g
3. Total mass after second mixing*		g	g
	g	g	g

*Include measurements until the difference between two consecutive measurements is within 0.010 g. Use the lowest mass in step 3 in your calculations.

Calculations and results

Mass loss due to first mixing (1-2)	g
Mass loss due to second mixing (2-3)**	g

** Use the lowest mass measured for step 3.

Compare the two values for mass loss from the calculations above.

1. Why do you think that the mass loss from the second mixing is different from the mass loss from the first mixing?

2. For the mass loss from the first mixing a value of less than 0.01 grams can be considered negligible, meaning it might be due to experimental error. Does the mass difference verify the law of conservation of mass? Explain.

3. Does the mass loss for the second mixing confirm the Law of Mass Conservation? If not, what happened?

Complete the following problems once the concept of moles and stoichiometry is covered in lecture.

The balanced equations for the reactions occurring with the solutions used in this experiment are:

Reaction 1: $CaCl_2(aq) + Na_2CO_3(aq) \rightarrow CaCO_3(s) + 2NaCl(aq)$
Reaction 2: $CaCO_3(s) + H_2SO_4(aq) \rightarrow CaSO_4(s) + H_2O(l) + CO_2(g)$

Assume that 1.06 g of sodium carbonate, 1.11 g calcium chloride, and 0.98 g sulfuric acid were used in the experiment.

For the first mixing:
1. How many moles of sodium carbonate were initially present?

2. How many moles of calcium carbonate were produced?

For the second mixing:
3a. How many moles of sulfuric acid were in the vial?

3b. How many moles of carbon dioxide were produced?

3c. How many grams of carbon dioxide were produced?

4. Does your answer to question 3c agree with your observation of the mass change in the reaction?

Yes ____ No _____
If "no," suggest a reason for this discrepancy