Chem 111 – Experiment 3 – Simulation – Alka Seltzer Strength

Background

How Much Base Is in an Antacid Tablet?

Heartburn is caused by excess acid in the stomach. Antacid tablets taken to reduce heartburn contain a specific amount of base that reduces the acid level in the stomach but does not fully deplete it. The different over-the-counter antacids such as Alka-Seltzer©, Tums©, and Pepto-Bismol© have a different formulation and each contains a variety of bases and quantities used in each tablet. The amount of base in each tablet can be determined by reacting the antacid tablets with an acid.

Stoichiometry

The law of conservation of mass states that matter can neither be created nor destroyed. Therefore, the number of atoms of each element on the reactants side must be the same as the number of atoms on the products side. This quantitative study of chemical reactions is called stoichiometry. The substances in a balanced reaction are related to each other by stoichiometric molar ratios. For example, magnesium reacts with hydrochloric acid in a 1:2 stoichiometric ratio in the balanced equation below.

$$\mathbf{Mg(s) + 2\ HCl(aq) = MgCl_2(aq) + H_2(g)}$$

The molar ratios can be used as conversion factors to find the amount (in moles) of one substance given the amount of another. For example, given the number of moles of HCl, the amount of $MgCl_2$ can be determined as shown below.

$$\mathbf{\#\ moles\ MgCl_2} = \mathbf{\#\ moles\ HCl} \times \frac{\mathbf{1\ mole\ MgCl_2}}{\mathbf{2\ moles\ HCl}}$$

The molar ratios are used to determine the amount in moles. However, the amount of reactant or product is often measured in grams. Mass can be converted to moles and vice versa as shown below.

$$\mathbf{\#\ moles} = \frac{\mathbf{Mass\ (g)}}{\mathbf{Molar\ Mass}}$$

Simple rearrangement of this equation and we get

$$\mathbf{Mass(g) = \#\ moles \times Molar\ Mass}$$

Limiting Reactants

Reactants are rarely mixed in exact stoichiometric ratios when performing reactions. The amount of product that can be obtained depends on the reactant that will be entirely consumed in the reaction. This reactant is called the limiting reactant (reagent). The limiting reactant is determined either by calculating the maximum amount of product that can be formed from each reactant or by comparing the reactants with each other. The reactant that will produce the least amount of product is the limiting reactant, whereas the other reactant is present in excess.

Quantitative Studies of Chemical Reactions

Quantities of substances can be predicted by examining the amount of substance involved in a chemical reaction. For example, carbonates and bicarbonates can be quantified using a neutralization reaction with an acid. This reaction releases carbon dioxide gas as shown below in the reaction of bicarbonate with hydrochloric acid.

$$Mg(s) + 2HCl(aq) = MgCl_2(aq) + H_2(g)$$

Alka-Seltzer tablets contain citric acid and sodium bicarbonate. They produce gas (fizzing) when dissolved in water. This is due to the reaction between citric acid and sodium bicarbonate, two ingredients in the Alka-Seltzer tablets. Water dissolves these two substances and allows them to react and form carbon dioxide gas as shown below.

$$C_6H_8O_7(aq) + 3NaHCO_3(aq) = Na_3C_6H_5O_7(aq) + 3CO_2(g) + H_2O(l)$$

The molar ratio between the carbon dioxide produced in the reaction and the bicarbonate is 1:1. Therefore, the amount of sodium bicarbonate in the tablet can be determined from the amount of CO_2 released. When dissolving Alka-Seltzer in water, there is enough acid to start the reaction but not enough for all of the $NaHCO_3$ to react. By adding additional acid to the solution, more $NaHCO_3$ will react. Adding excess acid will result in complete reaction of the $NaHCO_3$. At this point the Alka-Seltzer will become the limiting reactant. Because the amount of $NaHCO_3$ is fixed in the tablet, no additional CO_2 will be generated.

About This Lab

In this lab, you will dissolve Alka-Seltzer tablets in different water/vinegar solutions. Vinegar contains acetic acid, so each solution will contain a different quantity of acid that reacts with the sodium bicarbonate in the antacid. For each sample, you will measure the amount of mass lost by the solution and calculate the amount of $NaHCO_3$ that has reacted. You will then graph the calculated mass of $NaHCO_3$ in the tablet against the volume of vinegar in the water/vinegar solution to determine the amount of $NaHCO_3$ in the Alka-Seltzer tablet.

Open the simulation by clicking on the virtual lab icon shown on the left on the Hayden-McNeil Web Site. The simulation will launch in a new window.

You may need to move or resize the window in order to view both the Procedure and the simulation at the same time.

Follow the instructions in the Procedure to complete each part of the simulation. When instructed to record your observations, record data, or complete calculations, record them for your own records in order to use them later to complete the post-lab assignment.

Procedure

1. Take **six 50 mL beakers** from the **Containers shelf** and place them on the **workbench**. *You may want to label each beaker by double-clicking on the container and renaming it.*

2. Take a **balance** from the **Instruments shelf** and place it on the **workbench**.

3. **Weigh each beaker** and **record its mass** to reference later.
   Note: In a classroom laboratory, the beakers will not all have the same mass. It is therefore important to weigh each beaker independently.

4. The **Materials shelf contains** a bottle of **vinegar solution that is 5% acetic acid**. This **bottle is labeled "5% vinegar"**. Take water and 5% vinegar from the Materials **shelf** and measure the amount of each liquid as specified in the following table into the corresponding beaker.

Liquids to Combine		
Beaker	**Water (mL)**	**5% Vinegar (mL)**
1	**30**	**0**
2	**28**	**2**
3	**26**	**4**
4	**24**	**6**
5	**22**	**8**
6	**20**	**10**

5. **Weigh each beaker** again **after the addition of the 5% vinegar and water**. Record the mass of each.
   Note: This is not the full initial mass, but the Alka-Seltzer© reacts too quickly to measure it with the balance. To find the total initial mass, you will have to add the mass of Alka-Seltzer© added to this mass.

6. **Take another 50 mL beaker** from the **Containers shelf**. Place this beaker on the balance, and click the Zero button to tare the mass of the beaker.

7. **Add 3 g Alka-Seltzer© from the Materials shelf to the beaker on the balance**, recording the actual mass dispensed from the balance display. The approximate weight of one tablet is 3 g. **Transfer this Alka-Seltzer© to Beaker 1**. **Wait** until **all of the bubbling stops**. This indicates that the reaction has finished and all CO_2 has been released. Repeat this process for Beakers 2–6.

8. **Weigh Beakers 1–6 again** and record the total mass of each. **This is the final mass**.

9. Clear the bench of all materials, containers, and instruments, then use the **Report File** that you downloaded from the **General Chemistry web site**. When completed **send it to your TA.**