Effervescence Laboratory Experiment

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Date of Experiment:

OBJECTIVES

- Students will perform a basic mass balance on an effervescence reaction in pharmacology
- Students will conduct theoretical stoichiometric calculations and compare to experimental results
- Students will learn about the equilibrium constants and other fundamental aspects of reactions

INTRODUCTION

Alka-Seltzer® is an effervescent antacid ($NaCO_3$, KCO_3 plus anhydrous citric acid) containing acetylsalicylic acid (aspirin), which is an analgesic, antipyretic, and anti-inflammatory drug. Simply put, Alka-Seltzer® relieves upset stomach, provides pain relief, breaks fevers, and reduces inflammation.

Figure 1. Standard original strength packet

The effervescence allows for a faster rate of drug dissolution into a liquid medium (water in this case) by increasing the surface area of the drug exposed to solution and by "bubbling" the mixture, causing a stirring effect. The effervescence reaction is:

$$C_6H_8O_7(aq) + NaHCO_3(aq) \rightarrow H_2O(l) + CO_2(g) + Na_3C_6H_5O_7(aq) \qquad (1)$$

Figure 2. Weighing the tablets

In this lab you will determine how much CO_2 is generated and released to the atmosphere by taking the initial and final weights of an Alka-Seltzer® solution. This is an introduction to mass balances, an important concept for engineers. This experimental value will then be compared to the theoretical amount of CO_2 mass generated, found through stoichiometry.

MATERIALS NEEDED

- 2 Alka-Seltzer® tablets (1 packet)
- Analytical scale (+/- 0.0001 g)
- Weigh boat
- Graduated cylinder
- 200 mL plastic beaker
- Timer

PROCEDURE

1. Make sure safety glasses and examination gloves are on before entering the lab.
2. Remove both Alka-Seltzer® tablets from the packet. If the tablets are broken, be careful to not lose any pieces. How do you think a broken tablet will affect the rate of the tablets dissolving?
3. Place a weigh boat on the scale. Tare the instrument so it calibrates to zero with the added weight of the boat.
4. Weigh the Alka-Seltzer® tablets and record in your notebook.
5. Alka-Seltzer® is supposed to be dissolved in 4 oz. (118.3 mL) of water according to the manufacturer's directions. Using deionized water, measure out this volume of water with a graduated cylinder and add it to the beaker.
6. Weigh the beaker plus the added water and record it in your notebook. This weight plus the weight of the Alka-Seltzer® tablets is your initial weight.

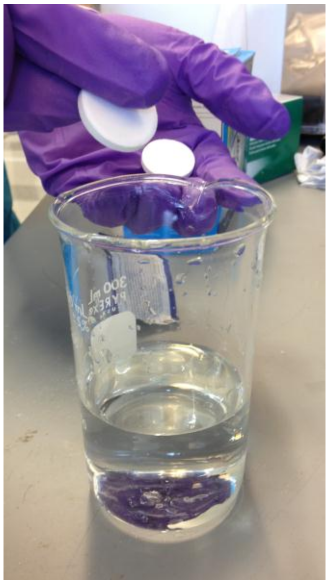

Figure 3. Creating the solution

7. Drop both tablets into the beaker.
8. For the first five minutes, take a weight every 60 seconds. After five minutes have passed, measure the weight every five minutes until an hour has elapsed. Tap the bubbles off of the sides of the beaker as they form.
9. Dispose of the solution down the sink.

PART II

10. Fill the beaker back up with the same amount of deionized water and weigh the water and the beaker.

11. On a weigh boat, measure out 2.0 g citric acid and 3.832 g sodium bicarbonate.
12. Drop the powder into the beaker and record weights at the same time intervals as Part I.
13. Dispose of the solution down the sink and clean up the lab area.

QUESTIONS

1. Fill in the tables shown on the next page:

Solution over time	**Weight**	**Time**
Initial:		0 m
		1 m
		2 m
		3 m
		4 m
		5 m
		10 m
		15 m
		20 m
		25 m
		30 m
		35 m
		40 m
		45 m
		50 m
		55 m
Final:		60 m

Solution over time	**Weight**	**Time**
Initial:		0 m
		1 m
		2 m
		3 m
		4 m
		5 m
		10 m
		15 m
		20 m
		25 m
		30 m
		35 m
		40 m
		45 m
		50 m
		55 m
Final:		60 m

2. You should notice that the initial weights of the two solutions are different.
    a. What may cause this?
    b. To fix this, take the difference between the two sets, find the difference between the two initial points. This difference will need to be subtracted from the solution with the higher weights. Find the new weights and record them in the table below.

Solution over time-Fixed	**Weight**	**Time**
Initial:		0 m
		1 m
		2 m
		3 m
		4 m
		5 m
		10 m
		15 m
		20 m
		25 m
		30 m
		35 m
		40 m
		45 m
		50 m
		55 m
Final:		60 m

    c. Please graph the revised data set along with the other set that was not changed.

3. Determine the experimental amount of CO_2 generated and released to the atmosphere by subtracting the initial weight from the final weight.

4. Balance the reaction given in the beginning of the laboratory.

5. According to the manufacturer's website, each tablet contains 1000 mg of citric acid and 1916 mg of sodium bicarbonate. Determine the moles of each reactant.

6. Determine which reactant is the limiting reactant. What is the percent excess? Why do you think there is extra added?

7. Using the effervescence reaction given in the beginning of the lab, determine the moles produced of CO_2 gas.

8. How many milligrams of CO_2 were made in both reactions?

9. What is the theoretical final weight of each solution? Use the weight of the beaker and water measured in the lab.

10. Determine your percent error at each point with the given equation:

$$\%_{Error} = \left(\frac{\left(M_{theoretically\ lost} - \left(M_{experimental}^{inital} - M_{experimental}^{point\ in\ time} \right) \right)}{M_{theoretically\ lost}} \right) x\ 100 \qquad (3)$$

11. What were some sources of error in this lab?

12. Was there if a difference in the way the pure components dissolved versus the tablets? Why do you think they behaved the same/differently? Do you think that the use of milling the powders when forming the tablets adds into the difference in behavior?

13. What is a different way that this experiment can be designed so that the gas released could be directly measured?

14. When designing a reactor, chemical engineers must take into consideration reaction equilibria. The equilibrium constant, Kc, can be used to determine the extent of a reaction at equilibrium. For a given constant temperature reaction at equilibrium:

$$\propto\ A_{(aq)} + \beta B_{(aq)} \leftrightarrow \gamma C_{(aq)} + \delta D_{(aq)}$$

an equilibrium constant can be calculated using the formula:

$$K_c = \frac{[C]^{\gamma}[D]^{\delta}}{[A]^{\propto}[B]^{\beta}}$$

Where [A], [B], [C], and [D] represent the equilibrium concentrations of each component, usually in molarity (mol/L). Pure liquids, like water, and solids are not taken into consideration when determining an equilibrium constant. For example, for the reaction:

$$HCl_{(aq)} + NaOH_{(aq)} \leftrightarrow NaCl_{(aq)} + H_2 0_{(l)}$$

The equilibrium constant, Kc, would be:

$$K_c = \frac{[NaCl]^1}{[HCl]^1[NaOH]^1}$$

Using data collected, an engineer or chemist can determine the value of Kc by using a RICE (Reagent, Initial Concentration, Change in Concentration, Equilibrium Concentration) table. A RICE table shows the initial and equilibrium concentrations of a chemical reaction. For the reaction,

$$\propto\ A_{(aq)} + \beta B_{(aq)} \leftrightarrow \gamma C_{(aq)} + \delta D_{(aq)}$$

a generic rice table would look like

R	A	B	C	D
Initial	X M	Y M	0	0
Change	-(α)x(z M)	-(β)x(z M)	+(γ)x(z M)	+(δ)x(z M)
Equil.	X - (α)x(z) M	Y -(β)x(z M)	+(γ)x(z M)	+(δ)x(z M)

Where X is your initial concentration of component A, Y is your initial concentration of component B, z is the concentration of reactants used up during the reaction, in molarity. For example, using the reaction above, a process starts out with 1 M of HCl and 1 M of NaOH. At equilibrium the concentration of NaCl is .98M. Using a RICE table, the amount of each component can be determined.

R	HCl	NaOH	NaCl
Initial	1.0M	1.0M	0
Change	-(1)x(.98M)	-(1)x(.98M)	+(1)x(.98M)
Equil.	.02M	.02M	.98M

a. If you were designing a reactor for the balanced effervescence reaction from Question 3, what would your equilibrium constant equation look like?

b. Using the data obtained from Part II of the experiment, create a RICE table, assuming that the reaction reaches equilibrium after 1 hour. Assume no water leaves the system.
c. Calculate the Kc at room temperature. Is Kc above or below 1.0? Comment on what that means about which is favored, reactants or products.