Introduction to Thermodynamics Name\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Kinetics- Rate of Reaction

**Overview-** The rate of a chemical reaction can be depend on several variables including:

1. Nature of the reagents
2. Concentration of the reagents
3. Surface area of the reagents
4. Catalysts
5. Temperature

**Definitions**

Nature of the reagents-the physical state the reactants occupy (solid, liquid, gas)

Catalyst-a substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change.

Endothermic-a reaction or process accompanied by or requiring the absorption of heat.

Exothermic-a reaction or process accompanied by the release of heat.

In today’s experiment you will be studying energy exchange (exo/endothermic), and the effect of temperature and surface area on the rate of reaction. You will be using Alka-Selzer (or a generic equivalent) dissolved in water. As the tablet dissolves and the principle components react carbon dioxide gas is released. This is due to the reaction between sodium bicarbonate (NaHCO­3) and citric acid (H3C3H5O7) in the tablet, you are also producing water and sodium citrate (Na3C3H5O7 aq.) which remain in solution..

The balanced equation is as follows:

3 NaHCO3(aq) + H3C3H5O7(aq) 🡪 Na3C3H5O7(aq)+ 3 CO2(g) + 3 H20(l)

Relevant outside information- Why do you take Alka-Seltzer which is marketed as an antacid when it contains citric acid (a mild acid)?

The sodium citrate is a buffer (meaning it is resistant to change in pH), and it can neutralize stomach acid HCl (Hydrochloric acid) by the following reaction:

Na3C3H5O7(aq)+ 3 HCl(aq) 🡪 H3C3H5O7(aq) + 3 NaCl(aq)

**Supplies**

Styrofoam cup

Antacid tablets (6)

Water

Ice

Thermometer

Reaction vessel (35mm film canister, or other container holding ~10mL with lid that can pop off)

Graduated cylinder

250mL beaker

Stopwatch

Mortar and pestle

**Part I-Thermodynamics**

In this experiment you will determine if the reaction that occurring between the sodium bicarbonate and the citric acid is exothermic or endothermic.

1) Place 100mL of water that is near room temperature in a styrofoam cup, place the cup inside a larger beaker to help insulate it from the bench. Measure and record the temperature of the water to the nearest tenth of a degree.

2) Place an alka-seltzer tablet in the water and allow the reaction to proceed until completion (no bubbles or fizzing). Record the final temperature of the solution to the nearest tenth of a degree.

3) Clean up this solution and proceed to part II.

**Part II-Kinetics**

Temperature vs reaction rate-

1) Obtain a film canister or other clean and dry reaction vessel, place an antacid tablet in the vessel.

2) Obtain about 100mL of warm water, place it in a styrofoam cup inside the beaker to isolate it from the bench, and measure the temperature of the water.

3) After the temperature of the water has been determined immediately measure 10mL of water in a graduated cylinder and pour the water into the film canister. As soon as the water has been mixed with the tablet close the lid on the canister and start your stopwatch. Record the time it takes for the lid to pop off.

4) clean and dry your reaction vessel, and place another alka-seltzer tablet in the film canister.

5) Prepare an ice water bath in a beaker, and measure and record the temperature. Quickly measure out 10mL and place it in the film canister, and again record the time it takes for the lid to fly off.

6) Repeat step 4, now prepare a solution of water with a temperature in between your warm and cold water. Record the temperature of the water, place 10mL in your reaction vessel and record the time it takes for the lid to pop off once again.

Particle size vs reaction rate-

7) Clean and dry your reaction vessel. Using a mortar and pestle crush an alka seltzer tablet into a fine powder, try to avoid stirring up excessive dust.

8) Carefully transfer all of the powder into your reaction vessel, choose one of your water solutions (hot, cold, or medium), measure and record the temperature and quickly transfer 10mL of water into your reaction vessel. Close the lid and measure and record the time of reaction.

**Post experiment analysis:**

1) Did the temperature of the water increase or decrease in part I? Is this reaction exothermic or endothermic?

2) Given that the heat capacity of water is 4.18 Joules / gram °C how many joules did the reaction give off or take in? (Hint: recall the density of water is ~0.99 grams/cm3 at 25°C)

3) Prepare a graph of your three data points from part II. Temperature vs time of reaction. (a grid is attached on the next page for your convenience)

4) Describe how the temperature affects the rate of reaction?

5) Compare your points for the same temperature and different surface areas? Did the fine powder react faster or slower? Could you determine any rate of reaction difference by increasing the surface area?

If you could not measure a difference in the speed of the reaction do you think trying it a different [lower] temperature would make surface area more or less significant?

