**Activation Energy Determination**

Introduction

C6H8O7(aq) + 3 NaHCO3(aq) → 3 H2O(l) + 3 CO2(g) + Na3C6H5O7(aq)

[citric acid](http://en.wikipedia.org/wiki/Citric_acid) + [sodium bicarbonate](http://en.wikipedia.org/wiki/Sodium_bicarbonate) → [water](http://en.wikipedia.org/wiki/Water) + [carbon dioxide](http://en.wikipedia.org/wiki/Carbon_dioxide) + [sodium citrate](http://en.wikipedia.org/wiki/Trisodium_citrate)



www.alkaseltzer.com

Supplies (assuming five groups of students)

5 125-mL Erlenmeyer flasks

4 1-L beakers

1 2-L or greater graduated cylinder

1-5 thermometers

> 6 balloons

3 hot plates

1-5 timers capable for measuring 10 seconds

>5 Alka Seltzer tablets

Ice

Tap water

Procedure

Each group is assigned a temperature at which to perform their portion of the experiment: (ice bath temperature (~0 oC), room temperature (~25 oC), 50 oC, 75 oC, and temperature of boiling water (~100 oC). For the ice bath, 1 1-L beaker should be more than half-filled with ice. Three water baths, each comprised of 1-L beakers (more than half-filled with water) and a hotplate, need to be adjusted to ~50 oC, ~75 oC, and ~100 oC with the temperature measured accurately with a thermometer. The temperatures do not need to be exact. Record the temperature.

Each group receives a 125-mL Erlenmeyer flask and a balloon. Tap water (75 mL) should be added to the flask. Each group should then receive an Alka Seltzer tablet. The tablet should be broken in half so that it will fit into the flask. A timer needs to be ready to measure a ten second interval.

Except for the group working at room temperature, the flask should be held in the bath until the flask and water are the same temperature as the bath. Add the broken Alka Seltzer tablet to the water in the flask and place a balloon over the lip of the flask as quickly as possible. Ten seconds after adding the balloon, the ballon (just above the base of the balloon but leaving room to tie the balloon) should be twisted and pinched with one’s fingers so that no gas will escape from the balloon. The balloon then needs to be removed from the flask and tied. Allow the gas in the balloon to come to room temperature.

Fill the graduated cylinder with about 1.6 L of tap water. Record the initial volume. Submerge the balloon in the graduated cylinder filled measure the new volume in the cylinder. The difference between this reading and the initial reading corresponds to the total volume of the gas in the balloon and the balloon.

The volume in the balloon should also be corrected for the vapor pressure of water and he volume of the balloon itself. To do this, stretch a balloon over the room temperature Erlenmeyer flask containing 75 mL of water. After 10 seconds, the balloon (just above the base of the balloon but leaving room to tie the balloon) should be twisted and pinched with one’s fingers so that no gas will escape from the balloon. The balloon then needs to be removed from the flask and tied. The volume of this balloon should then be determined as above with the graduated cylinder. Subtract this volume from the volume of the five balloons from the Alka Seltzer experiments to give the volume of CO2 in each balloon.

Plot *ln*(volume of CO2) versus 1/*T* (K-1). The slope of the line is –*Ea*/*R* where *R*=8.314 J/mol.K. Calculate *Ea*.

Data

**Volume of balloon and water vapor**

Volume of water in graduated cylinder \_\_\_\_\_\_\_\_\_\_\_mL

Volume of water and balloon in graduated cylinder \_\_\_\_\_\_\_\_\_\_mL

Volume of balloon and water vapor \_\_\_\_\_\_\_\_\_\_mL

**Group 1 (~0 oC)**

Temperature \_\_\_\_\_\_\_\_\_\_\_oC

Temperature \_\_\_\_\_\_\_\_\_\_\_K

1/Temperature \_\_\_\_\_\_\_\_\_\_\_\_1/K

Volume of water in graduated cylinder \_\_\_\_\_\_\_\_\_\_\_mL

Volume of water and balloon in graduated cylinder \_\_\_\_\_\_\_\_\_\_mL

Volume of gas in balloon and balloon \_\_\_\_\_\_\_\_\_\_mL

Volume of CO2 \_\_\_\_\_\_\_\_\_\_\_\_mL

*ln*(volume of CO2) \_\_\_\_\_\_\_\_\_\_\_

**Group 2 (~25 oC)**

Temperature \_\_\_\_\_\_\_\_\_\_\_oC

Temperature \_\_\_\_\_\_\_\_\_\_\_K

1/Temperature \_\_\_\_\_\_\_\_\_\_\_\_1/K

Volume of water in graduated cylinder \_\_\_\_\_\_\_\_\_\_\_mL

Volume of water and balloon in graduated cylinder \_\_\_\_\_\_\_\_\_\_mL

Volume of gas in balloon and balloon \_\_\_\_\_\_\_\_\_\_mL

Volume of CO2 \_\_\_\_\_\_\_\_\_\_\_\_mL

*ln*(volume of CO2) \_\_\_\_\_\_\_\_\_\_\_

**Group 3 (~50 oC)**

Temperature \_\_\_\_\_\_\_\_\_\_\_oC

Temperature \_\_\_\_\_\_\_\_\_\_\_K

1/Temperature \_\_\_\_\_\_\_\_\_\_\_\_1/K

Volume of water in graduated cylinder \_\_\_\_\_\_\_\_\_\_\_mL

Volume of water and balloon in graduated cylinder \_\_\_\_\_\_\_\_\_\_mL

Volume of gas in balloon and balloon \_\_\_\_\_\_\_\_\_\_mL

Volume of CO2 \_\_\_\_\_\_\_\_\_\_\_\_mL

*ln*(volume of CO2) \_\_\_\_\_\_\_\_\_\_\_

**Group 4 (~75 oC)**

Temperature \_\_\_\_\_\_\_\_\_\_\_oC

Temperature \_\_\_\_\_\_\_\_\_\_\_K

1/Temperature \_\_\_\_\_\_\_\_\_\_\_\_1/K

Volume of water in graduated cylinder \_\_\_\_\_\_\_\_\_\_\_mL

Volume of water and balloon in graduated cylinder \_\_\_\_\_\_\_\_\_\_mL

Volume of gas in balloon and balloon \_\_\_\_\_\_\_\_\_\_mL

Volume of CO2 \_\_\_\_\_\_\_\_\_\_\_\_mL

*ln*(volume of CO2) \_\_\_\_\_\_\_\_\_\_\_

**Group 5 (~100 oC)**

Temperature \_\_\_\_\_\_\_\_\_\_\_oC

Temperature \_\_\_\_\_\_\_\_\_\_\_K

1/Temperature \_\_\_\_\_\_\_\_\_\_\_\_1/K

Volume of water in graduated cylinder \_\_\_\_\_\_\_\_\_\_\_mL

Volume of water and balloon in graduated cylinder \_\_\_\_\_\_\_\_\_\_mL

Volume of gas in balloon and balloon \_\_\_\_\_\_\_\_\_\_mL

Volume of CO2 \_\_\_\_\_\_\_\_\_\_\_\_mL

*ln*(volume of CO2) \_\_\_\_\_\_\_\_\_\_\_

Note: This can readily be modified to measure the effects of surface area (using ground alka seltzer), concentration (adding different numbers of tablets or amounts of powder), or even pressure (closed vs. open plastic soda bottle as container). Can also use citric acid and baking soda and then look at concentration effects of each reactant.

For ideas, Alka Seltzer actually has student experiments on its website: <http://www.alkaseltzerplus.com/asp/student_experiments.html>