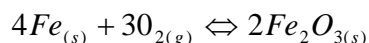


# A DIFFERENT LOOK AT KINETICS

Chancey, K. , Gordon, J. (2005). "Steel Wool and Oxygen: A look at Kinetics". Journal of Chemical Education, v82 n7.

## INTRODUCTION

The purpose of this experiment is to determine how the rate of a reaction depends on the concentration of one of the components. The reaction of interest is between the iron in steel wool and molecular oxygen:



As the reaction proceeds in a test tube, the iron in the steel wool will react with the molecular oxygen and the pressure inside the tube will decrease. In the Vernier oxygen pressure sensor's electrochemical cell, the partial pressure of oxygen is determined. The corresponding voltage is converted to the units of percent oxygen. In this way, the change in concentration of oxygen will be tracked as the change in the percent of gaseous oxygen. The oxygen pressure sensor is connected to a TI-CBL or Vernier LabPro data acquisition system which is interfaced to and controlled by a TI-83 calculator running the DataMate software.

Various percent of oxygen versus time graphs will be made to determine the order of the reaction with respect to the oxygen. One of the following graphs will determine the order of the reaction. As a reminder:

<b>Zero Order</b>	<b>First Order</b>	<b>Second Order</b>
<b>General Rate Law:</b> $-\frac{d[O_2]}{dt} = k[O_2]^0$	<b>General Rate Law:</b> $-\frac{d[O_2]}{dt} = k[O_2]^1$	<b>General Rate Law:</b> $-\frac{d[O_2]}{dt} = k[O_2]^2$
A plot of <b>percent oxygen vs. time</b> will yield a straight line with a negative slope.	A plot of <b>ln percent oxygen vs. time</b> will yield a straight line with a negative slope according to the following equation:	A plot of <b>1/percent oxygen vs. time</b> will yield a straight line with a positive slope according to the following equation:
<b>Integrated Rate Law:</b> $(\%O_2)_t = -kt + (\%O_2)_o$	<b>Integrated Rate Law:</b> $\ln(\%O_2)_t = -kt + \ln(\%O_2)_o$	<b>Integrated Rate Law:</b> $1/(\%O_2)_t = kt + 1/(\%O_2)_o$

## MATERIALS

Vernier Oxygen sensor  
TI83+silver with Datamate  
Acetone  
Paper towels

Lab Pro  
Steel Wool (00) 4.00g  
White vinegar (5 %; 0.83M Acetic acid)  
Test tube (150 x 25)

## **SAFETY**

Acetone – CAS #67-64-1

Acetone is an extremely flammable liquid and vapor. The vapor may cause a flash fire. It is harmful if swallowed and causes irritation to the skin, eyes, and respiratory tract and can affect the central nervous system.

Steel Wool- CAS #7439-89-6 (iron 98%)

Steel wool is generally safe but care must be taken to avoid its contact with open flames and electricity as the wool can be a fire ignition source. In contact with mineral acids, steel wool can produce flammable hydrogen gas. It can cause eye irritation and upper respiratory disease.

Vinegar – CAS #64-19-7

Vinegar is generally safe, but exposure can cause irritation to the nose, throat and lungs. It can also cause damage to the corneal membranes of the eyes.

## **PROCEDURE**

1. Weigh out a single piece of steel wool that is about 2.0 g. Wash the steel wool in acetone for about 30 seconds. Thoroughly dry the wool and then swirl it in about 50 ml of vinegar for about 30 seconds. Remove the steel wool from the vinegar and **THOROUGHLY** dry it with a paper towel. Repeat the washing with the dilute vinegar (10 mL of vinegar diluted to 100 mL with deionized water). After drying, **QUICKLY** place the steel wool into the test tube (150 x 25 mm) ensuring that it is not forced all the way to the bottom of the test tube. It should be spread out as possible to ensure the greatest surface area, which will decrease the reaction time. (NOTE: If the steel wool is not thoroughly dried of the acid, there is a possibility that hydrogen gas will be generated as a result of the reaction of the steel wool with the excess acid rather than the desired reaction with gaseous oxygen. Even thorough drying with paper towels leaves enough residual acid to catalyze the reaction.)
2. Launch the Datamate software on the calculator and connect the oxygen gas sensor to channel one of the LabPro.
3. Use the following procedure to setup the DataMate software to collect data:
  - Press “1” for setup.
  - Move the cursor arrow so that it points at “Channel 1” and ensure that the oxygen gas sensor (NOT dissolved oxygen sensor) is shown. If it isn’t, press “enter” and select “oxygen gas” list of sensors. Choose the option of “oxygen gas (PCT)” to display the information in percent oxygen (NOTE: *The oxygen gas sensor should NOT be used to measure dissolved oxygen content in solutions.*)  
Return to the setup menu and move the cursor arrow so that it points at “Mode”. Press “enter” to select the desired mode for this experiment. Choose “time graph”. Select “change time settings” in the “time graph” menu and enter “30” as the between samples in seconds and “60” for the

number of samples. This will set the program to collect data for 30 minutes.

- Select “OK” until you return to the “Main Screen”
4. Once the steel wool is slid into the test tube, place the pressure sensor into the mouth of the test tube. It should fit very snugly. Be careful not to press the sensor in so tightly that it breaks the test tube. Press “2” to begin the data collection. (NOTE: *The sensor should be operated and stored in the upright position to extend the life of the sensor.*)
  5. Copy the data from the lists of percent oxygen and time data from the calculator. Construct the graphs as indicated in the introduction section. Include the graphs in your lab report.

## DATA/CALCULATIONS

1. Using the TI 83<sup>+</sup> calculator or other instruments, construct a table that can be taped into your lab book.
2. From the data, make 3 graphs: percent oxygen vs. time, in (percent oxygen) vs. time, and 1/ (percent oxygen) vs. time (with time always being the x-axis). Once all three graphs are made they should be printed and neatly taped into the lab notebook.

## CONCLUSION

Write a brief conclusion paragraph indicating the order of the reaction with respect to the oxygen. Be sure to justify your answer using Your graphs.