

INSTRUCTOR RESOURCES

ACS Chemistry Laboratory Supplement Project-Based Labs

An Open Inquiry Experiment

Adapted for the MicroLAB 402 Interface by Dale A. Hammond, PhD

PROJECT TASKS

(This experiment requires a minimum of two lab periods)

Some of these tasks will be accomplished experimentally and some by library or web-based research in appropriate resources.

- Investigate the effects of different catalysts, different concentrations and different temperature conditions on the decomposition of hydrogen peroxide.
- Write a guided-inquiry lab experiment suitable to use with beginning high school students studying kinetics.
- Write a teacher's guide that gives possible procedures, expected outcomes, and suggested grading scales for student lab reports.
- Suggest suitable extensions to the experiment that could be used with advanced high school chemistry students.

PROCEDURE OVERVIEW

- Students will research, design and carry out experiments to determine the effect of several of the following on the rate of decomposition of H_2O_2 : potassium iodide, iron(III) chloride, manganese(IV) oxide, bovine liver catalase, dry Baker's yeast, potatoes, turnips, fresh calf's liver or other materials by request
- Students will write an initial report summarizing their knowledge of kinetics, and in particular, the kinetics of the catalytic decomposition of H_2O_2 , as outlined in the experiment.
- Students will write a final report written as a separate report to the School Authority requesting the project, as outlined in the experiment.

LEARNING AND PERFORMANCE OBJECTIVES

- Assemble appropriate equipment to obtain data.
- Record data and observations accurately.
- Collect and record data over specific time intervals.
- Graphically represent data and develop an equation that describes the curve obtained.
- Determine the rate of reaction with a gaseous product.
- Determine the rate equation for the reaction.
- Determine those factors affecting the rate of reaction, including the nature of the catalyst, the pH of the reaction mixture, the mixture's temperature, and others of your choosing.
- Compare and contrast enzymatic and inorganic catalytic decomposition of H_2O_2 .
- Write a set of guided inquiry lab directions suitable for a beginning high school class.
- Write a teacher's guide to accompany the student lab experiment.

NOTICE: THIS EXPERIMENT REQUIRES THE USE OF EXTERNAL TEMPERATURE CONTROLLERS SET AT THE DESIRED TEMPERATURES. See TIPS AND TRAPS # 4.

Kinetics of Catalyzed Decomposition of Hydrogen Peroxide
Experiment Planning Sheets

Classroom Kinetics: Planning Sheet 1 Group _____ Name _____

To be completed and turned in before starting experimentation. Some projects you may want to accomplish this lab period are:

1. The validity of the Ideal Gas Law expression.
2. The order of the reaction with respect to the concentration of the reactant.
3. The order of the reaction with respect to the concentration of the catalyst.

State the overall purposes of this project in your own words.

1. Write the chemical equation for the decomposition of hydrogen peroxide.
2. How do you initially plan to follow the course of the reaction? Explain what equipment you plan to use and what data you plan to gather during your initial trial decompositions?
3. The high school teacher has asked for an experiment that involves comparing and contrasting enzymatic and inorganic catalysts for the decomposition of hydrogen peroxide. How do you expect these types of catalysts to differ in their effect on the decomposition? How will these expected differences influence your experimentation?
4. There are several terms that you will need to use correctly throughout this project. Give a brief explanation of what is meant by each of these terms. If appropriate, also give the units that could be used to express the term's value.
 - a. Catalyst
 - b. enzyme
 - c. reaction rate
 - d. reaction time
 - c. rate constant
 - f. rate law
 - g. activation energy
5. What do you think the term "guided-inquiry" mean as applied to the experiment you will write up for the high school students? How does it compare to the project-based laboratory experiments in this ACS Chemistry Laboratory Supplement?
6. Explain how you will calculate the rate of the reaction.
7. Explain how you will determine the order of the reaction.

Kinetics of Catalyzed Decomposition of Hydrogen Peroxide
Experiment Planning Sheets

Classroom Kinetics: Planning Sheet 2 **Group:** _____ **Name:** _____

To be completed and turned in before starting this period.

Some projects you may want to accomplish this lab period are:

1. The order of the reaction with respect to the concentration of the reactant.
2. The order of the reaction with respect to the concentration of the catalyst.
3. The effect of various catalysts on the rate of the reaction.

State the purposes of this week's lab in your own words.

1. What experimental approaches were used last period to study the decomposition of hydrogen peroxide? Include a sketch of the equipment to be used.
2. Organize and report in tabular form the experimental data you gathered last period. Be sure to label all data clearly.
3. What qualitative and quantitative conclusions did you draw from the data gathered last period? Explain the supporting evidence for your conclusions.
4. Are there any modifications to your procedures that you will implement in this week's lab?
5. Explain what variables will be controlled in your experiments today?
6. What additional data will you need before you are ready to write up the experiment for both the students and the teacher?

Kinetics of Catalyzed Decomposition of Hydrogen Peroxide
Experiment Planning Sheets

Classroom Kinetics: Reflection and Planning Sheet 3 Group _____ Name: _____

To be completed and turned in before starting this lab period.

Some projects you may want to accomplish this lab period are:

1. The effect of temperature on the rate of the reaction.
2. The determination of activation energy.

State the purposes of this week's lab in your own words.

3. Organize and report in tabular form the experimental data you have gathered so far. Be sure to label all data clearly.
4. What qualitative and quantitative conclusions can you draw from the data gathered so far? Explain the supporting evidence for your conclusions.
5. What will you will include in the experimental write up for the high school students? How will you organize the write up? Outline your group's ideas.
6. What will you include in the experimental write up for the high school teacher? How will you organize the write up? Outline your group's ideas.
7. Explain how you will calculate activation energy.

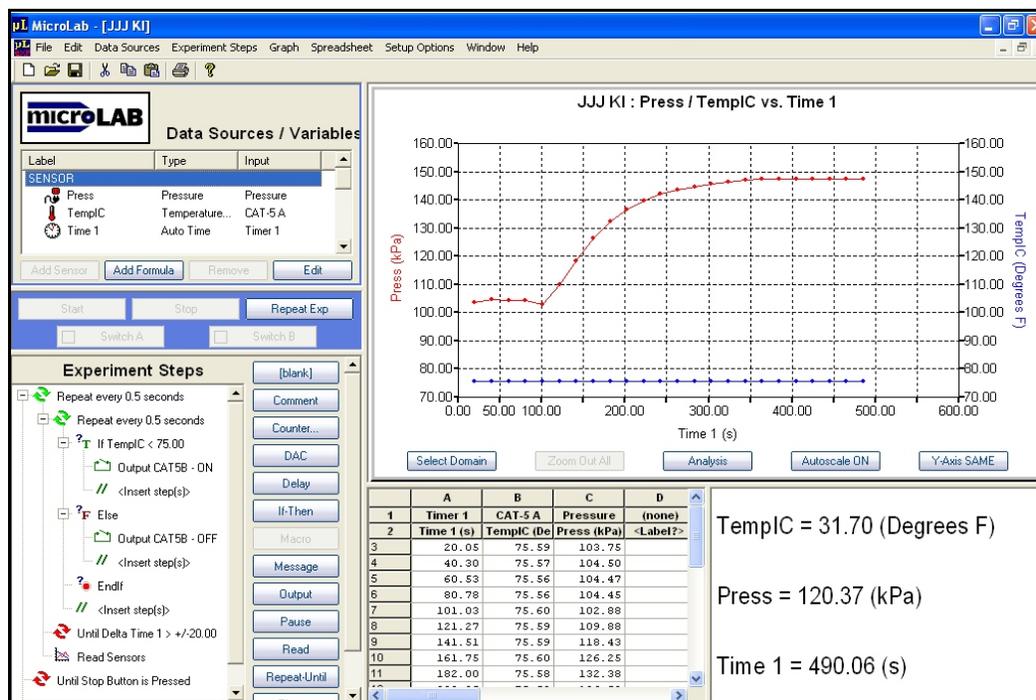
Kinetics of Catalyzed Decomposition of Hydrogen Peroxide

Tips and Traps

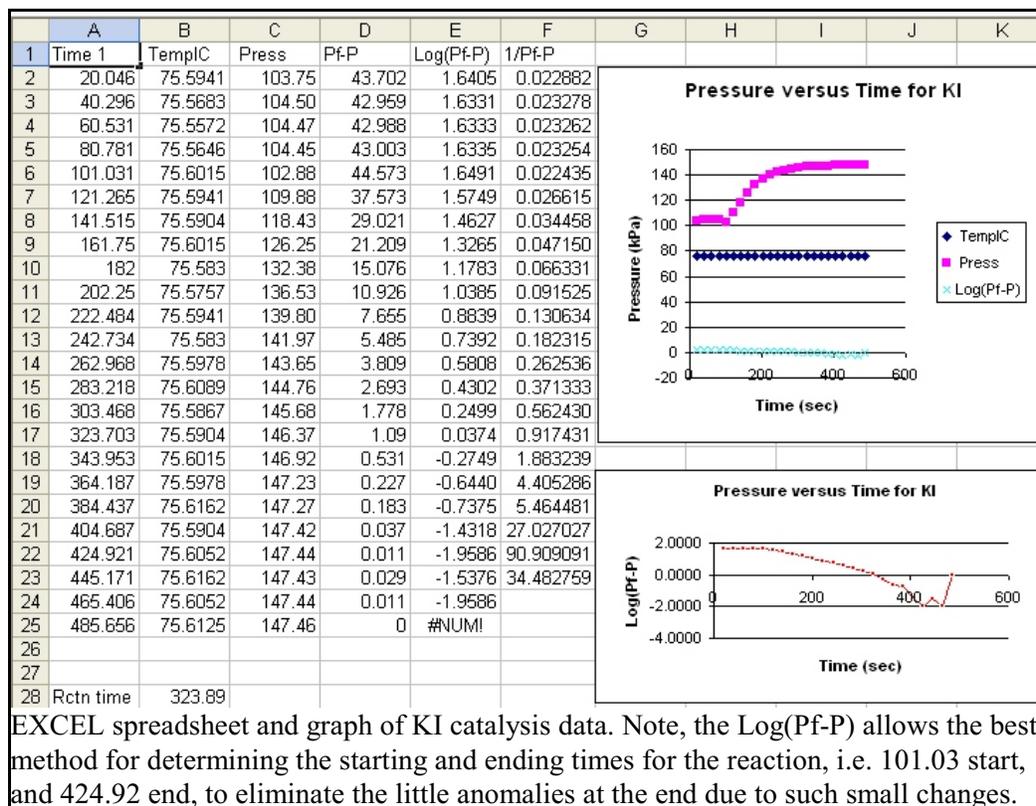
1. Since we are using the pressure measurement simply as a means of monitoring the time of the reaction, a calibration is not really necessary, only the beginning time and the time the pressure levels out, signaling the reaction has ceased. The experiment gives instructions for the calibration of the pressure sensor, and it is a good exercise for the students to learn the importance of calibrating their sensors. All of the *MicroLAB 402* interfaces except the very earliest are factory calibrated and should give good data without calibrating if time is of the essence. Test it out beforehand by measuring the pressure in torr registered by an operating the *MicroLAB* against a barometer. If you decide to have the students do the pressure calibration, it will help to demonstrate this using an LCD projector
2. Students will need much guidance in doing the research, design, carrying out the experiments and writing the reports. Assistance in this can be obtained from **MAKING ORAL & WRITTEN PRESENTATIONS AND ORGANIZING THE RESEARCH & ITS REPORT** contained on the CD available from the *MicroLAB* Inc. at PO Box 7358, Bozeman, MT 59771-7358, web: www.microlabinfo.com.
3. At the beginning of the first lab period, be sure to review the process for modifying the Experiment Steps using an LCD projector, if possible, to help the students better understand how to modify the program to suit their experiment design.
4. **NOTICE: THIS EXPERIMENT REQUIRES THE USE OF EXTERNAL TEMPERATURE CONTROLLERS SET AT THE DESIRED TEMPERATURES,**
The water baths should be set up at the desired temperatures, which are well stirred and large enough for the number of student beakers that will be done at each temperature. The chamber should have shelves such that the 50 ml beakers can be immersed to the level of the solution within them and maintained in a stable condition.

Kinetics of Catalyzed Decomposition of Hydrogen Peroxide

MicroLAB Sample Main Screen



MicroLAB Main Screen showing the temperature and pressure graphs, the digital readout view, Spreadsheet view and the Experiment Steps view with the program to maintain the temperature constant at 75 °F (31.70 °C). Note that the catalyst was added at 100 seconds, and the pressure rose until about 425 seconds, after which the reaction was completed.



EXCEL spreadsheet and graph of KI catalysis data. Note, the Log(Pf-P) allows the best method for determining the starting and ending times for the reaction, i.e. 101.03 start, and 424.92 end, to eliminate the little anomalies at the end due to such small changes.

Kinetics of Catalyzed Decomposition of Hydrogen Peroxide

Laboratory Preparation (per student station)

Materials Required:

Chemicals

- 3% H₂O₂,
- Possible catalysts: 1.0 M potassium iodide, 0.1 M iron(III) chloride,
- manganese(IV) oxide, bovine liver catalase, dry Baker's yeast,
- potatoes, turnips, fresh calves' liver
- (other materials by request).

Equipment

- Glassware or plastic equipment suitable for gas pressure measurement.
- **MicroLAB** interface for monitoring the build up of pressure from the O₂ product of the decomposition of H₂O₂.
- Separate temperature bath units, set at 5 to 10 °C intervals from 5 °C to 50 °C.

Safety and Disposal

- All materials may be safely flushed down the sink with lots of water to dilute them.
- **CAUTION:** Wear gloves if handling 30% H₂O₂ to mix a 3% solution. At this concentration, H₂O₂ is a powerful oxidizing agent and can cause severe burns. Beginning students should not be allowed to use this concentration for their experimentation, and it cannot be used for the high school experiments. For best results the H₂O₂ concentrations should not exceed 0.4 M.

