Kinetics of Catalyzed Decomposition of Hydrogen Peroxide (#8.5)

ACS Chemistry Laboratory Supplement ,Project-Based Labs
Adapted for the MicroLAB 402 Interface by Dale A. Hammond, PhD

Learning Objectives

The objectives of this experiment are to...

- introduce the concepts and units of pressure, catalysts and kinetics.
- experimentally use pressure to monitor the kinetics of the catalytic decomposition of hydrogen peroxide, H_2O_2, using the ***MicroLAB*** interface system to collect and analyze the data.
- experimentally determine which catalyst is most effective, using the ***MicroLAB*** interface system to collect and analyze the data.

Introduction

Students have been asked by a local high school teacher to help develop a lab experiment to investigate the catalyzed decomposition of hydrogen peroxide, H_2O_2. Different conditions and different catalysts, including enzymes and inorganic substances, are to be investigated. The teacher has a limited budget. Student's research shows that catalase, an enzyme that decomposes H_2O_2, is found in many simple biological materials such as yeast, potatoes, turnips, blood, and liver and it also can be decomposed with a variety of inorganic catalysts, such as potassium iodide, manganese dioxide and iron salts. H_2O_2 is inexpensive and readily available in drug stores and supermarkets.

Once students understand the relationships among the different catalysts, different conditions, and the decomposition of hydrogen peroxide, they will be able to help the teacher design an experiment that is suitable for a beginning high school class studying kinetics. Safety and economy are important concerns.

Project Tasks

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

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

Learning and Performance Objectives

1. Assemble appropriate equipment to obtain data.
2. Record data and observations accurately.
3. Collect and record data over specific time intervals.
4. Graphically represent data and develop an equation that describes the curve obtained.
5. Determine the rate of reaction with a gaseous product.
6. Determine the rate equation for the reaction.
7. 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.
8. Compare and contrast enzymatic and inorganic catalytic decomposition of H_2O_2.
9. Write a set of guided inquiry lab directions suitable for a beginning high school class.
10. Write a teacher's guide to accompany the student lab experiment.
11. Suggest extensions suitable for advanced students, such as determining the activation energy of the reaction.

Resources Available

1. Suggestions for measuring the rate of the reaction.
2. Considerations for control of variables.

Reports

1. Planning sheets are to be completed as directed by the instructor.
2. Students will write two reports for this Experiment.
    a. The first report will be written for the laboratory instructor and illustrate their understanding of chemical kinetics. The student's experiment form indicates what it should include:

b. The second report will be written as a separate report to the School Authority requesting the project. Information on what this report includes is also given in the student's experiment form.

Activities

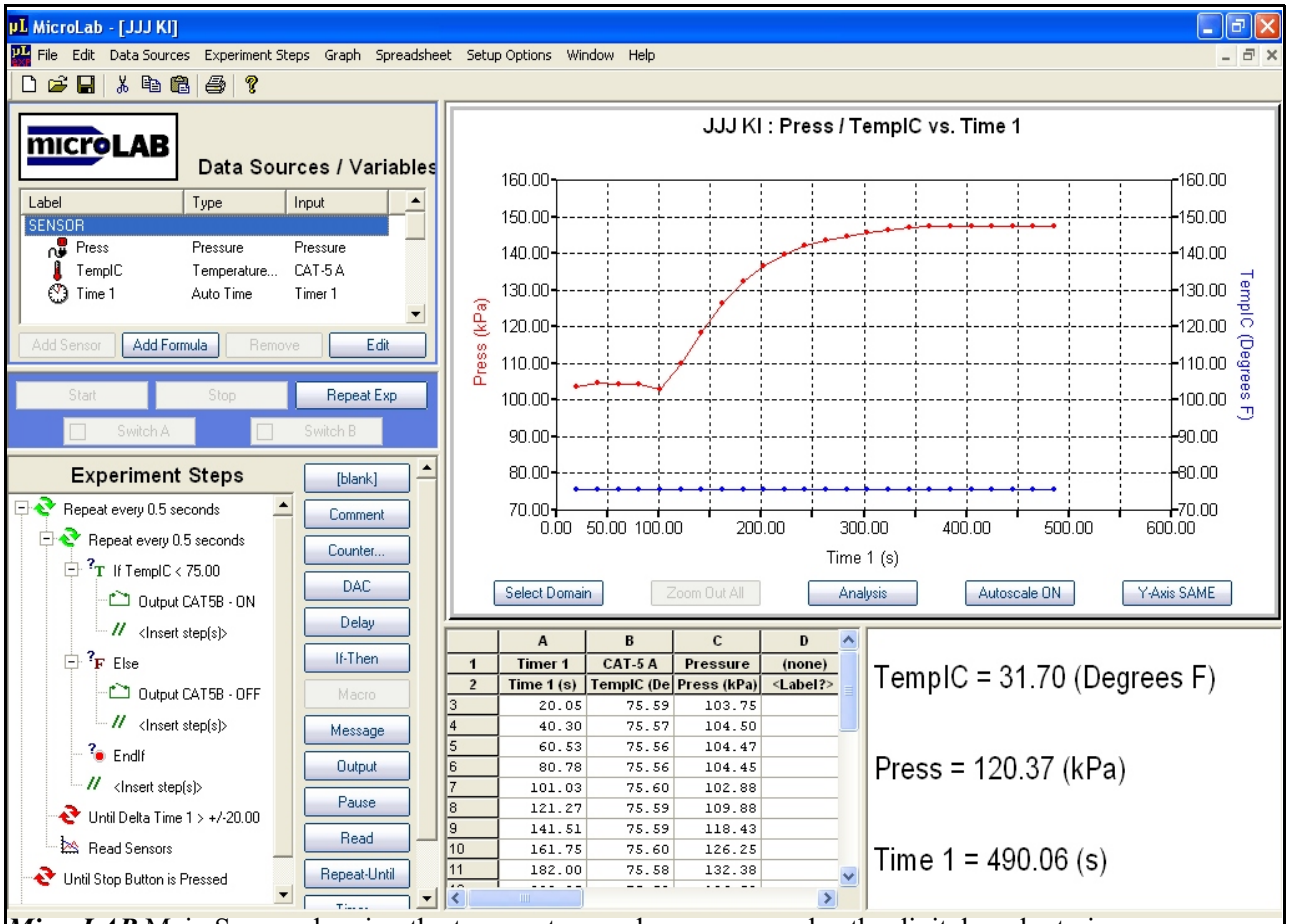
1. Make a table of Initial Rates for various catalysts to show the effectiveness of different catalysts.
2. Make a study of different ways to determine the Reaction Order
3. Show the Effect of temperature on Initial Reaction Rates.
4. Determine the order of the reaction with respect to both the catalyst and the peroxide concentration.

Miscellaneous

A listing of the materials available, safety information, techniques that may be needed, ways of measuring reaction rates, control of variables, use of the ***MicroLAB*** pressure sensor with hints for using it for measuring the rates of reactions and how to use the ***MicroLAB*** for constant temperature control (See Figure 1).

Instructor Resources Provided

5. Sample Report Sheets providing the format to organize the data collection with sample data.
6. Questions to consider, answer and turn-in with suggested answers.
7. Tips and Traps section to assist the instructor with potential problems and solutions.
8. Sample ***MicroLAB*** screen shots and graphs.
9. Laboratory preparation per student station.



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 400 seconds, after which the reaction was essentially completed.

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