TEACHER REFERENCE PAGES—KINETICS LAB

Introduction

Hydrogen peroxide is a very reactive chemical that is continually formed as a by-product of reactions in living cells. Since it is poisonous, the cells must either get rid of it or change it to something non-poisonous. If they cannot do either of these processes, they may die.

The purpose of this kinetics laboratory is to measure the rate of reaction for the decomposition of hydrogen peroxide. The speed of the reaction is determined by the reactants being consumed or products being formed. This must be determined experimentally by measuring the time rate of change in the concentration of one of the reactants or one of the products. The change of concentration can be measured by such physical properties such as the volume of a gas or color intensity of a solution. The rate may be expressed, for example, as moles per liter of product being formed per minute, milliliters of gas being produced per minute, or moles per liter of reactant being consumed per second.

During this experiment, you will determine the rate of decomposition of hydrogen peroxide with the use of catalysts, various pH values, and various temperatures. The goal in this experiment is to deduce a rate law for the reaction, showing the dependence of the rate on the concentrations of $H_2O_2$ and $I^-$. Your rate law will be of the general form:

$$\text{Rate of oxygen production} = k[\text{H}_2\text{O}_2]^x[I^-]^y$$

where $k$ is the specific rate constant and depends only on temperature. Thus your objective is to determine the numerical values of the exponents $x$ and $y$.

In this experiment, you will determine the rate law for the iodide-catalyzed decomposition of hydrogen peroxide to form water and oxygen (see the equation below). You will study the effect of temperature on the reaction. Then, you will replace KI with commercially available catalase and study the effect of temperature as well as the pH of the reaction medium. Finally, use some tissues from both plant and animal to find whether a similar decomposition reaction takes place or not.

$$I^- \rightarrow 2H_2O_2(aq) \rightarrow 2H_2O(l) + O_2(g)$$
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EQUIPMENT

Magnetic Stirrers

SUPPLIES

Plastic water bath dishes
Stirbars
50ml Erlenmeyer Flasks
50ml Mohr Burets
Buret clamps
Leveling bulbs
Leveling bulb supports
Ring Stands
000-00 stopper sets
00-0 stopper sets
40 mL Beakers
50ml graduate cylinders or
10ml pipets and pumps
50-200μL pipettors for catalase solution
0-100° C. thermometers
Wash bottles for DI water
mortar & pestle to grind sample
food coloring

CHEMICALS

0.25M KI solution
3% H₂O₂ solution
pH 5 buffer solution
pH 6 buffer solution
pH 7 buffer solution
pH 8 buffer solution
stock catalase solution
raw liver or potato
DI Water

KEY TERMS

These terms should be clear to students before running the lab:
Rate of Reaction, Catalyst, pH, Decomposition, Molarity, Concentration, Slope.
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PROCEDURE

Follow the procedure in the student handout. Running all sets of conditions will take 3-4 hours, so assign various sets of conditions to different groups. Specify four tasks per group: 1) Data Recorder 2) Temperature/Time Reader 3) Bulb Leveler/Volume Reader 4) Reagent Mixer. Caution students NOT to turn on the heat of the magnetic stirrers; the plastic water baths will melt. Explain to students the purpose of the leveling bulb, and demonstrate the process to obtain valid readings. Add a few drops of food coloring to the water in the buret and leveling bulb to facilitate reading the level. Place the various reagents and pipets in different locations in the lab to avoid congestion and confusion of pipets and reagents.

You will need to run off several copies of the data tables for each group of students. They will need one data table for each set of conditions and there are two data tables/page. There are ten different sets of conditions but in most cases time will not permit having all students run all conditions.

SAMPLE CALCULATIONS

Calculation of rate of production of \( \text{O}_2 \) in moles/second:

\[
PV = nRT
\]

\[
n = \frac{PV}{RT}
\]

\[
n = \frac{(1.00 \text{ atm} - 0.0313 \text{ atm})(0.001 \text{ L/mL})}{(0.0821 \text{ L} \cdot \text{atm/mol} \cdot \text{°K})(298 \text{°K})}
\]

\[
n = 3.96 \times 10^{-5} \text{ mol O}_2/\text{mL}
\]

\[
\frac{\Delta [\text{O}_2]}{\Delta t} = n \cdot \text{slope}
\]

\[
\frac{\Delta [\text{O}_2]}{\Delta t} = (3.96 \times 10^{-5} \text{ mol O}_2/\text{mL})(\text{slope})
\]

\[
\text{slope units are mL/sec}
\]

Calculation of initial concentration of \( \text{H}_2\text{O}_2 \) in Exp. A-1

\[
M_1V_1 = M_2V_2
\]

\[
M_2 = M_1V_1/V_2 = (0.882 \text{ mol/L})(0.005 \text{ L})/0.030 \text{ L}
\]
\( M_2 = 0.147 \text{ mol/L} \)

Calculation of initial concentration of KI in Exp. A-1

\( M_1 V_1 = M_2 V_2 \)

\( M_2 = \frac{M_1 V_1}{V_2} = \frac{(0.25 \text{ mol/L})(0.010 \text{ L})}{0.030 \text{ L}} \)

\( M_2 = 0.0833 \text{ mol/L} \)

Calculation of rate constants

\[
\frac{\Delta [O_2]}{\Delta t} = k \left[ \Gamma \right]^1 \left[ H_2O_2 \right]^1
\]

\[
k = \frac{\Delta [O_2]/\Delta t}{\left[ \Gamma \right]^1 \left[ H_2O_2 \right]^1}
\]

\[
k = \frac{2.14 \times 10^{-6} \text{ mol O}_2/\text{sec}}{(0.0833 \text{ mol/L})(0.147 \text{ mol/L})}
\]

\( k = 1.7 \times 10^{-4} \text{ L}^2/\text{mol} \cdot \text{sec} \)