

Enzyme Kinetics: How Do Catalyzed Reaction Rates Change with Substrate Concentration?

A Hands-on Learning Activity for Undergraduate Biology Students

Purpose

Teachers should teach briefly about enzymes and Michaelis-Menten enzyme kinetics. Students should then conduct a series of short reactions to see how substrate concentration impacts reaction rates when enzymes are present. The purpose of this experiment is to demonstrate the process and limitations of enzyme-catalyzed reactions by allowing students to collect data for a catalyzed reaction on a microscale. Potatoes have an enzyme, catalase, that degrades hydrogen peroxide (the substrate) into oxygen and water (the products); this reaction will be used in class to demonstrate Michaelis-Menten enzyme kinematics. Afterward, students will answer experiment-application questions.

This toolkit supports learning by providing students with hands-on learning activities alongside lectures. This allows for a greater connection of abstract ideas, engagement of multiple senses and long-term information retention in students.

This experiment can be made accessible by using only the provided theoretical data and graph, depending on time constraints and resource availability within the classroom.

Time: 20-30 mins

Enzymes & Michaelis-Menten Enzyme Kinetics

Enzymes are biological protein catalysts that speed up reactions by providing an alternative reaction pathway with a lower Energy of Activation (Ea). These proteins do not change the overall energy of a reaction or get consumed in the process of the reaction.

However, enzymes can only increase a reaction to a certain speed (Vmax). At high substrate concentrations, many enzyme active sites are unoccupied. This increases the chance of enzyme-substrate complexes, increasing the reaction rate. But once all of those active sites are occupied, adding more substrate cannot increase the reaction rate because the number of substrate-enzyme complexes is limited by the available substrate. Without substrate to react with, enzymes are useless. The Michaelis constant (Km) is the substrate concentration at which the reaction velocity is half of its maximum.

Without enzymes, biological reactions would occur too slowly to sustain life.

1. Pearson. Biochemistry study guide: Enzyme kinetics & Michaelis-Menten: Notes. Biochemistry Study Guide: Enzyme Kinetics & Michaelis-Menten | Notes. 2025 Oct 6 [accessed 2026 Oct 21]. <https://www.pearson.com/channels/biochemistry/study-guides/enzyme-kinetics-michaelis-menten-equation-and-its>

2. Robinson PK. Enzymes: Principles and biotechnological applications. Essays in Biochemistry. 2015 [accessed 2026 Oct 21]. <https://pmc.ncbi.nlm.nih.gov/articles/PMC4692135/>

3. Sullivan A. Top 10 benefits of hands-on learning. SmartLab Learning. 2026 Jun 15 [accessed 2026 Oct 21]. <https://www.smartlablearning.com/benefits-of-hands-on-learning/>

4. ©2008 CIBT A Study of catalase – Teacher Section page 1, Cornell Institute for. [accessed 2026 Oct 22]. <https://cpb-us-e1.wpmucdn.com/blogs.cornell.edu/dist/3/1009/files/2015/05/Catalase-Teacher-Edition-CIBT-23hhtk6.pdf>

5. Education.com. Catalase and hydrogen peroxide experiment: Activity. Activity | Education.com. 2025 Aug 29 [accessed 2026 Oct 21]. <https://www.education.com/activity/article/activator/>

Proposed Reaction

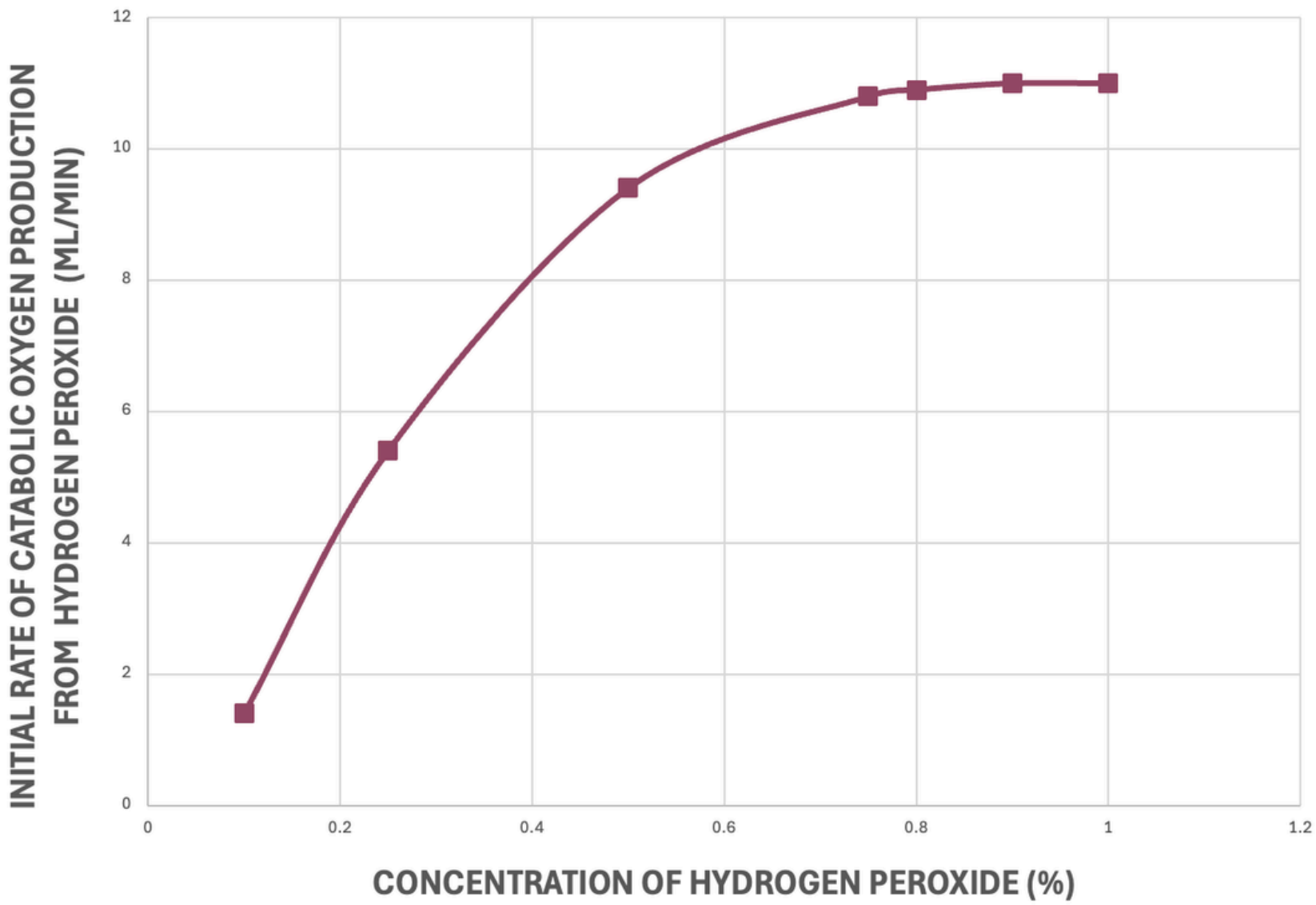
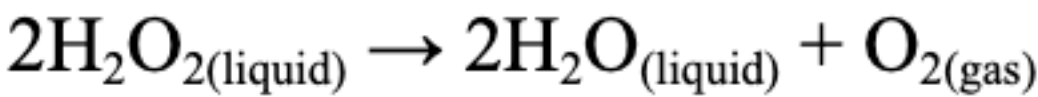


Figure 1. Relationship between the concentration of enzymes (%) and the change in initial reaction rate (mL/min) using catalase for the catabolic reaction of hydrogen peroxide to oxygen and water over one minute (Schopp, 2026).

test tube	H2O2 concentration (%)	O2 at 10 s (mL)	O2 at 20 s (mL)	O2 at 30 s (mL)	initial rate (mL/min)
1	0.1	0.23	0.7	0.9	1.4
2	0.25	0.9	1.6	2.1	5.4
3	0.5	1.57	2.8	3.7	9.4
4	0.75	1.8	3.9	5.2	10.8
5	0.8	1.81	4.8	6.66	10.9
6	0.9	1.83	4.91	6.5	11
7	1	1.83	4.8	6.5	11

Table 1. Tabulated theoretical values for the change in reaction rate when hydrogen peroxide is reacted with varied concentrations of catalase, measuring the amount of oxygen produced over time in discrete intervals (Schopp, 2026).

Real-World Extension

Lead a class discussion at the end of the entire toolkit as to why substrate and enzyme concentrations matter, and the necessity of catalysts within the body. The goal is to tie the hands-on experiment to real-world applications that might be difficult to explain without the demonstration.

STUDENT WORKSHEET

Enzyme Kinetics: How Do Chemical Reaction Rates Change with Enzymes?

A Hands-on Learning Activity for Undergraduate Biology Students

Purpose

The purpose of this experiment is to demonstrate the process and limitations of enzyme-catalyzed reactions by allowing students to collect data for a catalyzed reaction on a microscale.

Potatoes have an enzyme, catalase, that degrades hydrogen peroxide (the substrate) into oxygen and water (the products); this reaction will be used to demonstrate Michaelis-Menten enzyme kinetics.

Procedure

SAFETY:
Students must wear a proper lab coat, goggles, and gloves.
3% Hydrogen peroxide is a mild eye and skin irritant and should be used in a well-ventilated area with no exposure to heat.

SET UP:
Groups of 3-4 mix the following solutions for the desired concentrations:
Tube 1: 0.33 mL H2O2 + 9.67 mL H2O
Tube 2: 0.83 mL H2O2 + 9.17 mL H2O
Tube 3: 1.67 mL H2O2 + 8.33 mL H2O
Tube 4: 2.50 mL H2O2 + 7.50 mL H2O
Tube 5: 2.67 mL H2O2 + 7.33 mL H2O
Tube 6: 3.00 mL H2O2 + 7.00 mL H2O
Tube 7: 3.33 mL H2O2 + 6.67 mL H2O
** Use 3% hydrogen peroxide and distilled water **

Teachers: Prepare the enzyme by pureeing a small, finely chopped potato with 100 mL distilled water.

Predict the results of each test tube before the experiment.

For each test tube, add 3 drops of enzyme mix and measure the amount of oxygen produced in discrete intervals over a minute.

Time: 20 mins

Procedure Cont.

SAFETY:
Students must wear a proper lab coat, goggles, and gloves.
3% Hydrogen peroxide is a mild eye and skin irritant and should be used in a well-ventilated area with no exposure to heat.

This experiment does not have to be conducted in a science lab, but lab safety must be followed.

SUPPLIES (for classroom):
-3% hydrogen peroxide (amount depends)
-1 small, peeled and chopped potato
-water (amount depends)
-25mL test tubes
-test tube rack
-timer
-dropping pipettes (for catalase mixture)

Theory Application

Before the experiment, predict your results for each test tube. Explain the trend you think you'll see and why you believe that will be the trend.

Use the acquired data to generate a Michaelis-Menten graph. Include Vmax and Km.

Answer the experiment questions using the graph, the teacher's lesson and your predictions.

Proposed Reaction

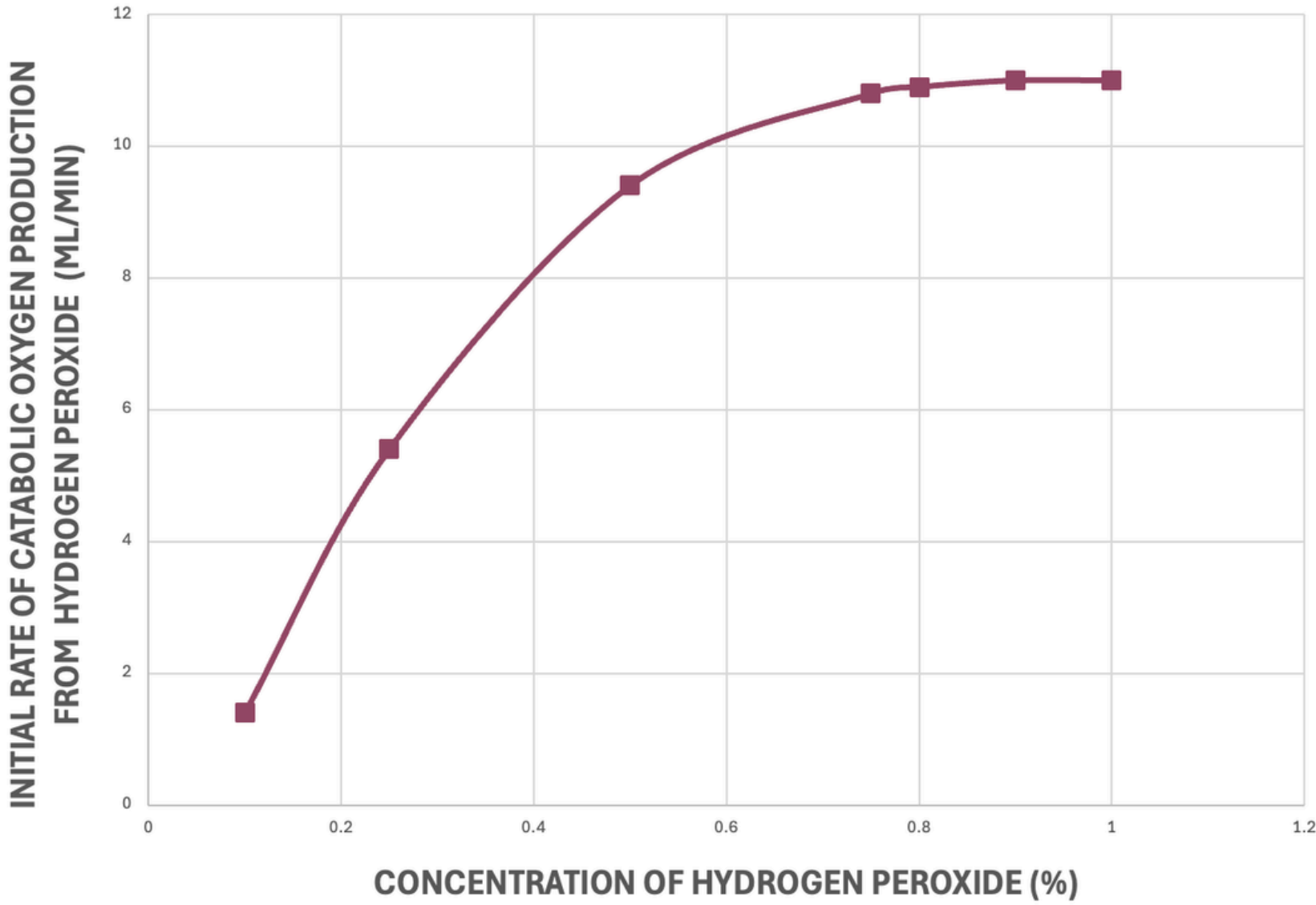
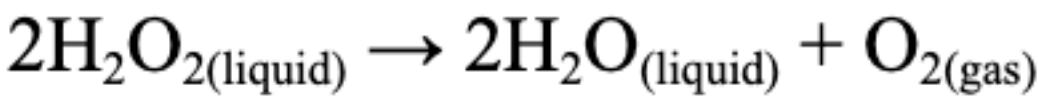


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Questions

1. Were your predictions correct? Why or why not?
 2. What enzyme concentration is suitable for this reaction to proceed at maximum velocity, without excess enzymes?
 2. What are Vmax and Km? Include any relevant calculations.
 3. What experimental factors could prevent the data from showing a perfect Michaelis-Menten curve?
- Time: 8- 10 mins