

THINKING AND ACTING LIKE A SCIENTIST

TEACHER'S GUIDE

Rate of Reaction

What is the rate of reaction for the decomposition of hydrogen peroxide using KI for a catalyst?

GRADES 9–12

Physical Science





Rate of Reaction

Grade Level/ Content	9–12/Physical Science
Lesson Summary	In this lesson, students will determine the rate of reaction for the decomposition of Hydrogen peroxide using Potassium iodide as the catalyst. They will apply their knowledge of reaction rate to design and conduct an investigation testing how a chosen variable affects reaction rate.
Estimated Time	3, 45-minute class periods
Materials	6% Hydrogen peroxide (diluted to 3% Hydrogen peroxide), 10% detergent solution, 0.5M Potassium iodide, 100ml graduated cylinder, Investigation Plan , Journal
Secondary Resources	<ul style="list-style-type: none">• Reaction Rate 1• Reaction Rate Video• Decomposition Reaction• Role of a Catalyst• Catalyst• The Decomposition of hydrogen peroxide and the Enzyme Catalase
NGSS Connection	HS-PS1-5 Apply scientific principles and evidence to provide an explanation about the effects of changing the temperature or concentration of the reacting particles on the rate at which a reaction occurs.
Learning Objectives	<ul style="list-style-type: none">• Students will determine the reaction rate for Hydrogen peroxide using KI as the catalyst.• Students will determine how factors (temperature, concentration, etc.) affect the rate of reaction.

What is the rate of reaction for the decomposition of Hydrogen peroxide using KI for a catalyst?

The reaction rate is the speed at which chemical reactions take place. Chemical reactions occur at tremendously different speeds. There are various factors that affect the speed at which a chemical reaction proceeds, such as surface area, temperature, concentration, and presence of a catalyst. A catalyst is a substance that increases the rate of a chemical reaction without itself undergoing any permanent chemical change. In this investigation, students determine the reaction rate of Hydrogen peroxide decomposition using Potassium iodine (KI) as a catalyst. Students will then investigate the effect of changing a variable (temperature, concentration, etc.) on the rate of reaction.

Investigation is based on the Van Andel Education Institute (VAEI) Instructional Model for Inquiry-Based Science.
In all investigations:



Students don't know the "answer" they are supposed to get.



Students play a driving role in determining the process for learning.



Teachers and students construct meaning together by journaling.



Students are working as hard as the teacher.

Part 1

INVESTIGATION SETUP

Students need:

- 3% Hydrogen peroxide (made from 6% H_2O_2 at room temperature)
- 10% detergent solution at room temperature (detergent is used to capture and visualize the release of oxygen bubbles)
- 0.5M Potassium iodide* at room temperature
- 100ml graduated cylinder
- [Investigation Plan](#)
- Journal

* Potato cores can also be used as the catalyst for this investigation. French fry cutters can be used to prepare the potato cores. It is important that the potato pieces are uniform (constant surface area and quantity) and free from potato skin.

Part 2

INVESTIGATION FACILITATION



Question

Introduce the investigation question.

What is the rate of reaction for the decomposition of Hydrogen peroxide using KI as a catalyst?



Personal Knowledge

Students capture what they already know about rates of reaction.

- Ask students to write what they know about the question. Encourage them to think about reactions, reaction rates, Hydrogen peroxide, catalysts, and decomposition reactions.
- Sample student responses could be: *A chemical reaction occurs when there is a color change, production of gas, and/or change in temperature. The speed with which a reaction occurs is known as the reaction rate. Hydrogen peroxide is often used on cuts and bubbles when it is placed on blood.*

COLLABORATION

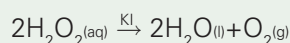
Have students engage in a *Round Robin* group brainstorming activity to ensure everyone participates. Each student is given an index card and personally reflects on the prompt. After the initial independent brainstorm, the group compiles a list from the individual cards and records additional ideas. Each group shares their list with the class.

Investigation Plan

Students conduct trials to determine the rate of reaction for the decomposition of hydrogen peroxide.

- Have students work in teams of 2.
- Review the materials with the class.
- Have students follow the [Investigation Plan](#).
- Have students record in their journals the temperature of all materials before placing them in the graduated cylinder. Having a starting temperature will be important for students who choose to test the effect of temperature on reaction rates in the follow-up investigation.
- Instruct students to take their time “0” reading as soon as all of the materials are together in the graduated cylinder.
- Students will record the level of foam every 15 seconds for 5 minutes. They will conduct at least 3 trials.

Note: Discuss with students that they are measuring the appearance of oxygen gas as they cannot easily measure the decomposition of H_2O_2 . The decomposition reaction is:



CRITICAL THINKING

Use the [Fair Test](#) checklist to help students think critically about the investigation plan. Help them understand that a good investigation plan must include a test that is repeatable, generates quality data, and minimizes error. The more critically students think about their investigation plan, the more confident they can be in their results.

COLLABORATION

Students will work in pairs. Once all the materials are in the graduated cylinder, one student will need to take a quick reading on the graduated cylinder (for time 0) and the other student will need to start the timer.

INVESTIGATION PLAN	
RATE OF REACTION	
1.	Record the temperature of the Hydrogen peroxide, detergent solution and KI in your journal.
2.	Obtain 20mL of 3.0% Hydrogen peroxide in a 100mL graduated cylinder.
3.	Add 10 drops of 10% detergent solution to the graduated cylinder.
4.	Using a plastic pipette, add 1.0mL of 0.5M KI to the graduated cylinder.
5.	Immediately record the initial volume (time 0) of the Hydrogen peroxide mixture.
6.	Record the level of foam (in ml) every 15 seconds for 5 minutes.
7.	Put the Hydrogen peroxide down the drain in the sink and rinse out the graduated cylinder.
8.	Repeat Steps 1-6 until you have completed 3 or more trials.

Be sure to follow your teacher's safety guidelines and procedures throughout this investigation.

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Investigation Plan



Observation

Students record their data.

Ask students to create a data table to record the level of foam on the graduated cylinder (in ml) every 15 seconds for 5 minutes. Encourage them to include qualitative observations as well. For example: *The bubbles formed a cone in the middle so readings were made from the top of the cone.*

CURIOSITY

This investigation will spark curiosity in the students as it is interesting to see how long the reaction will continue. The bubbles also change appearance as the reaction moves along.

3% Hydrogen Peroxide				
Time (min)	Trial 1 level (ml)	Trial 2 level (ml)	Trial 3 level (ml)	Qualitative Observations
0 (no bubbles)	24	22	23	
.25	25	28	27	
.50	29	30	30	
.75	29	33	32	
1.0	29	34	33	
1.25	35	35	35	
1.5	36	37	38	
1.75	38	39	42	
2.0	40	43	47	The bubbles formed a cone in the middle so readings were made from the top of the cone.

Sample student data table



Data Analysis

Students make sense of their data by organizing it and representing it visually.

- Have students analyze their data. They may wish to use the [Data Analysis](#) prompt as a guide.
- Have students **evaluate** their data for trustworthiness.
- Then have them analyze their data to find patterns and trends. They may **organize** the data and/or **represent** it visually to construct meaning. Have students calculate the rate of reaction using:

$$\frac{\text{change in concentration of O}_2 \text{ (measured in ml of foam created)}}{\text{time}}$$

- Have students **interpret** what the identified patterns or trends mean.
- Ensure they have enough data that it can be used as evidence to support a claim.

SELF-DIRECTION

The students need to collect and use an appropriate amount of data. It must also consist of high quality data. To obtain data from three trials, students must focus on their investigation. They must also be consistent in their measurement technique.



Secondary Knowledge

Students use secondary sources to understand rate of reaction, decomposition reactions, and a catalyzed reaction.

Provide students with the following resources (or your own) to learn more about rate of reaction, decomposition reactions, and a catalyzed reaction. Students will use this information in the reasoning portion of their explanation.

- [Reaction Rate 1](#)
- [Reaction Rate Video](#)
- [Decomposition Reaction](#)
- [Role of a Catalyst](#)
- [Catalyst](#)
- [The Decomposition of Hydrogen Peroxide and the Enzyme Catalase](#)

CONSTRUCTION OF MEANING

Conduct a *Jigsaw* to help students work collaboratively. Place students in a “home” group and have each student choose a different article/video. After reading or viewing, the groups divide into new “expert” groups consisting of students who looked at the same resource. The information is discussed and then students re-form into their home group and share in the construction of meaning.

SELF-DIRECTION

Encourage students to find additional secondary knowledge sources such as; their textbook, other website articles, or videos. Ask students to record what they have learned in their journals.



Explanation

Students write a claim and provide evidence and reasoning to support it.

- Have students use what they've discovered from their analyzed data to write an explanation that answers their investigation question. Students may wish to use the [Explanation](#) prompt as a guide. Have them write their claim in their journal.
- Have students develop a **Claim** to answer the question: What is the rate of reaction for the decomposition of Hydrogen peroxide using KI as the catalyst?
- Then, have them add **Evidence** (the analyzed data) to support their claim.
- Finally, have them add **Reasoning** to their claim. Reasoning should include the information obtained from this investigation as well as science principles they have learned.

Claim

The data shows the decomposition of Hydrogen peroxide produces 15 ml of O₂ per minute under our experimental conditions.

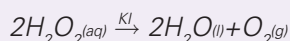
Evidence

As the reaction proceeds the rate of the reaction appears to remain fairly constant as is evidenced by the straight line when the graph of bubble height vs time is created.

Reasoning

Investigation: We followed the investigation plan carefully and conducted 3 trials. The data is fairly consistent in all of the trials and there are no outliers. Therefore, we believe our data is valid and reliable.

Science: From our class discussions and readings, we learned that a catalyst makes a reaction happen faster as it provides a pathway for the reaction that is at a lower activation energy. Activation energy is the energy required to break bonds so that new bonds may form. The Potassium iodine (KI) serves as a catalyst in the decomposition of Hydrogen peroxide. According to our information, the gas in the bubbles must be oxygen because water and oxygen gas are the products of the decomposition of Hydrogen peroxide:



Evaluation

Students reflect on the investigation.

- Ask students how confident they are in their data.
- Ask students what question they would like to investigate next.

Part 4

INVESTIGATION ASSESSMENT AND EXTENSION



Application

Students demonstrate their understanding of reaction rate by designing and conducting their own investigation.

- Have students brainstorm variables they can change and measure to design and conduct their own reaction rate investigation.
- Instruct students to use the investigation they just completed as the control. Have them change a reaction variable to determine the effect of that on the rate of reaction.
- Have students present their explanations using a [Present and Defend](#).

Some suggested variables:

- Concentration: Change the concentration of the Hydrogen peroxide or Potassium iodide.
- Temperature: Increase or decrease the temperature of the Hydrogen peroxide. (Assuming that the temperature was recorded in the first investigation as a control.)
- Students may suggest other variables. **However, the NGSS Performance Expectation, HS-PS1-5, specifically states that concentration and temperature should be studied.**

DISCOURSE

Have students conduct a [Present and Defend](#) to develop presentation and audience participation skills. Research teams present a summary of their investigation to the class. The class analyzes the information presented and asks clarifying questions, challenges and/or supports the arguments made, and even presents alternative explanations as appropriate. Research teams defend their explanation with evidence and reasoning.

Assessment

Determine how well students:

- Provide an explanation (**claim, evidence, and reasoning**) that shows the reaction rate for the decomposition of Hydrogen peroxide using KI as a catalyst.
- Design and conduct their own investigation to determine the effect of changing a variable (temperature, concentration, etc.) on the rate of reaction.

For additional lessons or to customize this lesson, go to www.nexgeninquiry.org.

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INVESTIGATION PLAN

RATE OF REACTION

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