Potato Catalysis of Hydrogen Peroxide

Authors

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Activity Summary

In this activity, students are investigating a catalysis reaction and practicing experimental design. Students test how catalase, an enzyme common to many foods, catalyzes the decomposition of hydrogen peroxide and they measure how reaction conditions change the amount of oxygen produced by the reaction. This is intended to introduce students to ideas and practices central to the research that I worked on with members of the Krishna Sustainable Catalysis Lab, where researchers design reaction systems with zeolite catalysts and change parameters to improve the conversion of desired products.

Audience

Middle School Science 7-8 Grade

Time Frame

Set-up: 30 minutes to prep student kits (depending on the number of students)
Activity: 40 minutes
Clean-up: 5 minutes for students, some additional time if reusing materials is desired

Objective(s)

After completing the activity:

1. Students will understand the role of a catalyst in a chemical reaction.
2. Students will be able to explain the conversion and transfer of energy that occurs during a chemical reaction.
3. Students will be able to write and test a hypothesis.

Standards Addressed

Next Gen Science Standards (NRC, 2011)

Cross-Cutting Concepts

- **CC5.m Students understand that energy takes different forms and can be tracked as it flows through a system.**

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Disciplinary Core Ideas

- **PS3.B.m Energy changes to and from each type can be tracked through chemical changes.**

Science and Engineering Practices

- **SEP1.A.m Students ask questions to specify relationships between variables**
- **SEP3.m Students plan and carry out investigations that provide evidence to support explanations or solutions**

Activity Materials

Potato Catalyst

The teacher must provide pre-cut potato pieces for each student kit. The 2 oz cups were used to portion potato (and banana or other possible sources of catalase). Pieces should be cut to 0.5-1 cm^3 size that can easily drop into the test tube. Pieces should be as fresh as possible to promote the most noticeable reaction.

Lab Group Kits

Item	Number per kit
3% hydrogen peroxide	*1 large bottle*
8 oz Water bottle	1
Test tubes	3
Stoppers 14-15mm	1
Micropipette tips	3
Droppers	2
Plastic knives	1
Toothpicks	1
2 oz cups w/ lids	2
12 oz cups	2
Protective glasses*	3
Nitrile gloves (medium)*	1-2
Sharpie	1
Scissors	1

*See notes about safety below

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Activity Materials cont.

Student Experimental Design Materials

Parameter Tested	Suggested Materials	Notes for Teacher
Temperature	• Electric Kettle for hot water bath • Ice for cold water bath	• Fill the water bottle reactor chamber with hot or iced water to create a bath for the test tube. • If using a microwave to heat a water bath, do not microwave the water bottle for longer than 20 seconds to avoid melting.
Concentration	• Food coloring	• Useful to differentiate the hydrogen peroxide from water in the test tubes • Students can see the result of dilution more clearly. Provide a separate vessel to create a 2x and 4x dilution.
Catalyst Surface Area	• Plastic knife included in materials list	• Students can cut the potato pieces in half in one test, and mash the potato in another test
Catalyst Type	• Banana • Carrot • Avocado	• Pre-cut pieces to the 0.5-1 cm^3 size • You may require groups to test this option + another parameter
Recycled Catalyst	None	• Students will need to run the baseline experiment again to test recycling

Safety

The hydrogen peroxide (3% wt) is safe for household use and can be safely disposed of in a sink. Spills can be safely cleaned with a paper towel and disposed of in regular trash. Give directions about appropriate and safe handling of this chemical, including caution about exposure to eyes and skin. Include directions to wash hands or flush eyes with water in case of exposure.

Protective lab glasses and gloves should be provided at the teachers discretion. In the activity, one student has the role to handle the hydrogen peroxide; gloves should be provided to this student. If your classroom does not have an eyewash station, then you may provide glasses out of an abundance of caution.

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Activity Instructions

Set-up
Lab groups should be 3-4 students. Determine the total number of kits needed when planning time to set-up the activity. A standard pencil case works really well to hold all of the materials except for the water bottle. One prep period (40-60 minutes) is plenty of time to prep kits for all classes that the teacher might have in a school day.

Important Steps to prep student kits:

1. If you are using food coloring, add drops to a separate vessel with hydrogen peroxide. Add enough color so that a change will be noticeable with dilution (2-4 drops).
2. Label test tubes with "Water" or "H2O2" with a sharpie. Overall, you will need twice as many H2O2 tubes.
3. Fill test tubes (Day 1: 1 water, 1 H2O2 and Day 2: 2 H2O2) A dropper with measurements is very helpful to fill the test tubes with equal amounts (~3 ml).
4. Prep 1-2 extra kits for demonstration and to replace any damaged pieces. For example, students might struggle to pierce the stopper or bend a pipette and need a new one.

Introduction (5 min)
Introduce the activity with a discussion exercise(see Turn&Talk) to recall what students have learned about energy transfer/ conversion/ and storage. Students should be familiar with the concept of a chemical reaction, but the concept of a catalyst may be new and must be described.

Necessary background information is reviewed in Student Facing Slides and included on the Handout for each day.

Activity Day 1 - Building Apparatus and Baseline Experiment (35 min)

Student Facing Slides (slides 1-19)
Day 1 Handout / Handout Sp.
Day 1 Instructions for the Apparatus

1. Turn & Talk: Energy Transfer/Convert/Store (5 min)
2. Introduce Catalysis (5 min)
3. Build the Apparatus (10 min)
4. Baseline Experiments - Control and H2O2 (15 min)
5. Work on Discussion Questions (5 min)
6. Clean up (5 min)

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Activity Day 2 - Writing and Testing a Hypothesis (45 min)

Student Facing Slides (slides 20-29)
Day 2 Handout / Handout Sp.

1. Turn & Talk - Recall the purpose of the experiment (5 min)
2. Class discussion - Where does the energy come from? (5 min)
3. Groups decide on a test parameter and Write a Hypothesis (10 min)
4. Students Experiment (20 min)
5. Clean up (5 min)

Activity Day 3 - Assessment (35 min)

Student Facing Slides (slides 20-29)
Day 3 Assessment / Assessment Sp.

Optional: make a few experiment stations/kits available to groups that need to finish their trials

1. Arrange groups and distribute needed materials from the previous class period.
2. Turn&Talk: What happened in your experiment? (5 min)
3. Class discussion - Reflect on learning targets (5 min)
4. Assessment:
   Students create a bar graph comparing their experimental trials. Then answer some questions about the results and energy transfer/conversion. (20 min)
5. Clean up (5 min)

Post Activity (30 min)
If reusing materials, test tubes should be rinsed with soap and water and allowed to dry before storage. Hydrogen peroxide should be stored away from light and at room temperature.

Refer to Safety Data Sheet for handling and storage.

Assessment

Formative assessment questions
Activating prior knowledge:

1. What is one example of energy transfer?
2. What is one example of energy being converted into a different type?
3. What is one example of energy being stored* to be used later? *hold/keep

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Formative assessment questions

After activity:

1. How do you know that energy is in the system? What type of energy do you notice?
2. Did the oxygen (bubbles) come from the Hydrogen Peroxide (H2O2) or the Water (H2O)? How do you know?
3. Where did the energy that you observed come from? (Hint: was it transferred from somewhere? or converted from one form into another?)

Summative assessment, including presentation of student data:
Assessment / Assessment Sp.

After student-designed experiment:

1. Was your hypothesis correct?
2. If you wanted the reaction to produce more energy, what would you recommend for a future experiment?

Background/Prior Knowledge

No special background or prior knowledge is needed to prepare, construct, or facilitate this activity. The materials needed are accessible, affordable, and safe.

Supplemental Materials

Student Facing Slides
Day 1 Handout / Handout Sp.
Day 1 Instructions for the Apparatus
Day 2 Handout / Handout Sp.
Day 3 Assessment / Assessment Sp.

Scaffolding

Before doing this activity, an introductory lesson could be added to allow more time for students to learn/review vocabulary. Previous understanding of reactions and catalysts can help middle school students grasp the purpose and significance of the experiment.

An important scaffold during the activity is a teacher's kit to demonstrate the techniques and construction of the apparatus. Scaffolding of the experimental design steps is important and included in the "Day 2" Materials. Writing a hypothesis and gathering needed materials can be a good checkpoint where the teacher can offer guidance before students begin their own experiment.

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Extensions

Another way to conclude the activity and assess student learning would be through short oral presentations about the group's results. Students could create different products to use in their presentations (i.e. poster, slides, one-page memo, comic strip, zine) .

It is possible to adapt the experiment apparatus to allow for collection of the oxygen gas by bubbling it through water (See Additional Resources below). Measuring the volume of gas produced would allow for students to practice a variety of analysis techniques.

Additional Resources

Activate:

A Catalyst and the Rate of Reaction

This lesson outline includes demonstrations like the Elephant's Toothpaste that the teacher can use to introduce the topics and specific reaction in this activity.

Extend:

Gas Collection (9th or 10th grade)

The novel apparatus used in this activity can be combined with some plastic tubing and parafilm to collect the oxygen gas that is produced in the hydrogen peroxide decomposition reaction. After measuring the volume of oxygen produced, High School chemistry students could perform stoichiometric, mass balance, and percent conversion calculations.

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