A Catalyzed Reaction: Elephant Toothpaste

A Carolina Essentials™ Demonstration

Overview

This quick demonstration showing the decomposition of hydrogen peroxide, catalyzed by iodide ions, provides students with visual evidence of a chemical reaction. Students compare the reaction rate of the catalyzed and uncatalyzed reactions and use their data to sketch an energy diagram for the decomposition reaction. The energy diagram serves as a model of energy flow through the reaction, from reactants to products, with 2 different reaction pathways—catalyzed and uncatalyzed.

Physical Science, Chemistry
Grades: 6–12

Phenomenon

Show students samples of the hydrogen peroxide (H_2O_2) and the potassium iodide (KI). Let them observe the chemicals and predict what will happen. Let them share their predictions and write down a master list.

Essential Question

How does the addition of a catalyst affect reaction rate?

Demonstration Objectives

1. Observe a catalyzed decomposition reaction.
2. Compare the reaction rates of catalyzed and uncatalyzed reactions.

Next Generation Science Standards* (NGSS)

PE HS-PS1-4. Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.

Science and Engineering Practices	Disciplinary Core Ideas	Crosscutting Concepts
Developing and Using Models • Use a reaction time data and potential energy diagram to construct a model of catalyzed and uncatalyzed reactions.	**HS-PS1-4: Matter and Its Interactions** • Develop a model to illustrate that the release or absorption of energy from a chemical reaction system depends upon the changes in total bond energy.	**Energy and Matter** • Changes of energy and matter in a system can be described in terms of energy and matter flows into, out of, and within that system.

Safety Procedures and Precautions

Hydrogen peroxide at 30% is a very strong oxidizer. It is corrosive to clothing and will cause burns if spilled on the skin. Use appropriate personal protective equipment (PPE), such as gloves, chemical splash goggles, and lab coats or aprons, to avoid contact. Know and follow all federal, state, and local regulations as well as school district guidelines for the disposal of laboratory wastes.

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TIME REQUIREMENTS

PREP	ACTIVITY
30 min	20 min

Teacher Prep: 30 min
Demonstration: 20 min

SAFETY REQUIREMENTS

MATERIALS

Dishwashing liquid
Hydrogen peroxide, 30%, 30 mL
Potassium iodide, 1.5 g
Large garbage bag or large tray
Weighing boat or filter paper
2 plastic bottles or large graduated cylinder, 250 to 500 mL
Graduated cylinder, 100 mL
Digital balance
Spatula
Timer (online, smartphone, or stopwatch)
Safety goggles
Gloves

HELPFUL LINKS

Chemistry Activity Video: Elephant Toothpaste
Motivate Students with Chemistry Demos

REFERENCE KITS

Carolina Chemonstrations®: Elephant Toothpaste

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Teacher Preparation and Disposal

Upon completion of this demonstration, the bottles can be rinsed, dried, and put away. Keep PPE on in case the bottle contains any leftover hydrogen peroxide. Unless otherwise prohibited, the foam and catalyst on the trash bag can be carefully rolled up and discarded in the trash.

Teacher Procedure

1. Put on gloves and safety goggles.
2. Crush any lumps of potassium iodide (KI) into fine crystals with a spatula, and then weigh 1.5 g of it onto a weighing boat or filter paper.
3. Lay a large garbage bag flat on a desk, table, or lab bench to protect the demonstration area. A large tray can also be used for this purpose.
4. Prepare both bottles or cylinders at the same time. Label one "Uncatalyzed" and the other "Catalyzed."
5. Place the plastic bottles or large graduated cylinders in the middle of the demonstration area.
6. Measure 15 mL of 30% hydrogen peroxide and pour it into the bottle or cylinder. Repeat for the second bottle or cylinder.
7. Add 25 drops of dishwashing liquid to the hydrogen peroxide in both bottles or cylinders.
8. Swirl the bottles or cylinders to mix the liquid soap and peroxide.
9. Prepare students to begin timing the reactions as soon as the KI is added to the bottle or cylinder labeled "Catalyzed."
10. Quickly add the KI crystals to the bottle or cylinder labeled "Catalyzed" and begin timing.
11. Observe the oxygen gas as it forms bubbles in the soap, creating a plume of foam that is quickly expelled.
12. Stop timing the catalyzed reaction when the foam stops flowing out of the container. Continue timing the uncatalyzed reaction.
13. Direct students to answer the demonstration analysis questions. Check for evidence of a reaction in the uncatalyzed container every 5 minutes until students finish. Stop timing if or when a noticeable volume of bubbles is produced in the uncatalyzed container.

Teacher Preparation and Tips

Make sure the bottles are identical and that students understand both bottles are getting the same amount of the same chemicals. The only difference is the addition of the catalyst.

Dawn dishwashing liquid produces a high volume of bubbles.

Announce for students to get ready to time the reactions. You may want to assign individual students, 2 students per group, or split the room in half so both reactions are timed.

Begin timing as soon as the KI is added. You may want to use a projected online timer.

Announce to students when to stop timing the catalyzed reaction.

Check the uncatalyzed reaction periodically for any evidence of bubbles.

Data and Observations

Reaction	Time (s)	Observations
Uncatalyzed Reaction	*Will vary with temperature*	*May see small bubbles*
Catalyzed Reaction	*Instantaneous—runs for about 2 minutes*	*Large amounts of foam spew out of the bottle*

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Analysis and Discussion

1. What evidence indicates that a reaction took place?
   Bubbles were produced.

2. Explain why dishwashing detergent was added to the hydrogen peroxide.
   The detergent traps the oxygen bubbles, making a foam that allows the bubbles to be more visible and last longer.

3. Explain why the sodium potassium iodide was added to one of the bottles.
   It serves as a catalyst.

4. Compare the times for the 2 reactions. Using the time data, write a statement explaining what catalysis is.
   When a reaction time is relatively slow and needs to be faster, a catalyst can be added. A catalyzed reaction has a shorter reaction time because the addition of a catalyst lowers activation energy. See the explanation of the reaction mechanism below.

   Hydrogen peroxide (H_2O_2) is stable for at least a year if stored in an airtight opaque container at room temperature. Common in first aid kits, a 3% H_2O_2 solution can be applied to minor cuts and abrasions. When the solution contacts tissue and blood, it rapidly decomposes into water (H_2O) and oxygen gas (O_2).

   $$2H_2O_{2\,(l)} \rightarrow 2H_2O_{(l)} + O_{2\,(g)}$$

   The oxygen gas creates a foam that lifts and washes contaminants out of the wound.

TEACHER NOTES

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