Elephant Toothpaste

Section CHEMICAL REACTIONS *Topic* REACTION RATES & CATALYSTS

Estimated Time Setup: 5-10 minutes; Procedure: 10 minutes

OVERVIEW

Students will mix household products to make an 'elephant-size' chemical reaction!

In this activity, students mix hydrogen peroxide, liquid dish soap, and active yeast to create new products through a chemical reaction. Students explore how catalysts work in a decomposition reaction, how reactants change to products in a chemical reaction, and thermal energy changes in this fun, colorful experiment.

INQUIRY QUESTIONS

Getting Started:

- How do we know a chemical reaction or change has occurred?

Learning More:

- What is the purpose of a catalyst and how does it work?

Diving Deeper:

- What happens in a decomposition reaction? What role does each reactant play in forming the products?

CONTENT TOPICS

This activity covers the following content topics: chemical reactions, chemical changes, catalysts, energy, exothermic reactions, decomposition reactions

This activity can be extended to discuss: chemical formulas, balancing equations

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards::

- **5-PS1-4:** Conduct an investigation to determine whether the mixing of two or more substances results in new substances.
- **MS-PS1-2:** Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

MATERIALS

For one setup:

- Empty, 16-oz. plastic soda pop bottle
- Foil cake pan with 2-inch sides (or a bin, sink)
- 3% or 6% Hydrogen peroxide
- Dawn® Ultra dishwashing liquid
- Active yeast
- Funnel
- Warm water
- Cup or bowl
- ½ cup liquid measurer
- Spoon
- Food coloring

ACTIVITY NOTES

This activity is good for:

- Large groups
- Demonstrations

Safety Tips & Reminders:

- Do this experiment in a bin, pan, sink, or outside since it can get messy!
- Safety goggles are recommended.
- If the water you use is too hot it will kill the yeast and the experiment will not work as well. Be sure to follow the instructions on the yeast container or packet.
- The reaction works much better with 6% hydrogen peroxide solution, though stores usually sell 3%. You can get 6% solution online or from a hair salon for a bigger reaction.
- Review the Safety First section in the Resource Guide for additional information

ENGAGE

Use the following ideas to engage your students in learning about chemical reactions:

- There are tons of fun, exciting videos of this reaction – many using more powerful ingredients than in this experiment. Check out some online and show them to students before they try the experiment themselves.
- For 'explosive' experiments like this, sometimes the best engagement is the demo itself!

See more ideas for engagement in the Reaction Rates & Catalysts Background section! You can also look at the Elaborate section of this activity for other ideas to engage your students.

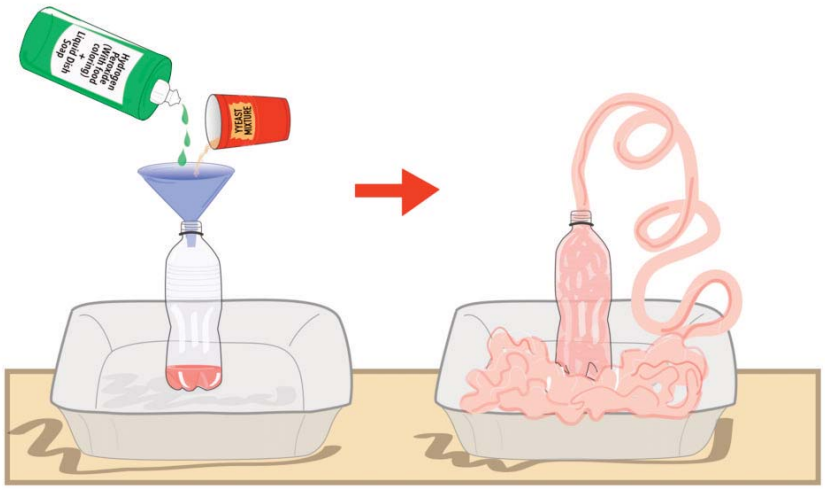
Fun Fact #1

Hydrogen peroxide naturally decomposes over time, especially if it is exposed to light or high temperatures. For this reason, hydrogen peroxide is stored in opaque bottles and is often refrigerated.

EXPLORE

Procedure:

1. Place empty soda pop bottle in the center of the cake pan with the funnel in the opening of the bottle.
2. Pour ½ cup of hydrogen peroxide through the funnel and into the bottle.
3. Add about one tablespoon of Dawn® Ultra dishwashing liquid to the bottle along with a few drops of food coloring.
4. In the cup or bowl, mix one packet of yeast with warm water (be sure to follow the activation instructions on the yeast label).
5. Pour the yeast mixture into the bottle, quickly remove the funnel, and step back!



Notes

DATA COLLECTION & ANALYSIS

Analyze and discuss the results of this activity using the following questions:

- Describe each reactant and their physical properties. What do you think is the purpose of each reactant in this experiment?
- Describe the products. Did a chemical reaction or change occur? Use evidence to explain why or why not.
- Feel the bottle at the end of the experiment. Does it feel warm or cool? What does that mean?
- Draw a diagram of the reaction in process and label the components.

Notes

EXPLAIN

What's happening in this Activity?

First review the Reaction Rates & Catalysts Background section to gain a deeper understanding of the scientific principles behind this activity.

During a chemical reaction the reactants change into new substances known as the products, and bonds between atoms are broken or formed. This is true of all chemical reactions, but not all reactions occur the same way. Some types of chemical reactions are synthesis reactions, decomposition reactions, and displacement reactions.

During a **decomposition reaction**, a larger molecule breaks down into two or more smaller molecules. There is only one reactant, and bonds in the reactant compound are broken to form two or more product compounds.

$$AB \rightarrow A + B$$

In this experiment, we see the decomposition of hydrogen peroxide, H_2O_2. This reaction produces water, H_2O, and oxygen gas, O_2.

$$2H_2O_2\ (l) \rightarrow 2H_2O\ (l) + O_2\ (g)$$

Because breaking chemical bonds requires energy, the decomposition of hydrogen peroxide happens very slowly under normal conditions. If you go to a grocery store, you can find bottles of hydrogen peroxide solution sitting on shelves—the hydrogen peroxide stays as hydrogen peroxide and doesn't react to turn into water and oxygen gas.

One way to make hydrogen peroxide decompose faster is to add a catalyst. A **catalyst** is a substance that changes the rate of a reaction but doesn't get used up during the reaction. In this case, we use yeast as a catalyst to make the hydrogen peroxide break down faster. This produces a lot of oxygen gas very quickly, which we can see in a big explosion of foam!

We can see the oxygen gas because we added soap to the hydrogen peroxide. The bubbles of oxygen that are produced are trapped in the soap, creating a foam. A **foam** is made of tiny bubbles of gas spread throughout a liquid or a solid. In this case, the foam is oxygen gas spread throughout soapy water. Some other examples of foams are seafoam, whipped cream marshmallows, and sponges.

With yeast, hydrogen peroxide decomposes so quickly and releases so much gas that pressure builds up inside the bottle, and foam explodes out of the top—just like toothpaste being squeezed out of a tube. The yeast makes the reaction happen more quickly by helping to position the reactants so that when they collide, they have the right orientation to react. This means the reaction doesn't need as much energy to get started—it has a lower **activation energy**.

During this experiment, the bottle feels warm to the touch because the decomposition of hydrogen peroxide releases energy. Any reaction that releases energy is an **exothermic reaction**. The products (in this case, water and oxygen gas) are lower in energy than the reactants (hydrogen peroxide). On the other hand, an **endothermic reaction** requires or takes in energy. In an endothermic reaction, the products are higher in energy than the reactants. Energy is put into the reaction, and stored in the chemical bonds that are formed.

The overall change in energy during a chemical reaction is different than the amount of energy the reaction needs to get started. We need to put in energy to get hydrogen peroxide to start decomposing, but once the reaction starts it produces energy. Another example is the combustion reaction that causes burning. You need a spark to start a fire. This spark provides the activation energy. Once the fire starts, it gives off energy in the form of heat because it is an exothermic reaction.

EXPLAIN continued

Differentiation for Younger or More Advanced Students

You can differentiate this activity for students of different grade levels by focusing on the concepts outlined below.

GETTING STARTED

For younger students, emphasize the following concepts:

- There are different types of chemical reactions
- A decomposition reaction breaks down a larger molecule into smaller ones
- Catalysts change the rate of a chemical reaction without being used up

DIVING DEEPER

For more advanced students, emphasize the following concepts:

- Exothermic reactions release energy, and endothermic reactions absorb energy
- A reaction's overall change in energy is different than the amount of energy it needs to get started

Fun Fact #2

Yeast is a living organism – a single-celled fungus – which is why it is important to not use water that is too hot, which could kill the sample.

ELABORATE

Elaborate on your students' new ideas and encourage them to apply them to different situations. The section below provides some alternative methods, modifications, and extensions for this activity.

- The foam produced is not toxic or dangerous, so students can touch and feel it (though if you added food dye this might get messy!). This is one way to feel the temperature difference.
- Want rainbow or glittery toothpaste? Add a few drops of different colors or glitter in step 3!
- Ask students whether the amount of each reactant matters in this experiment. Try the experiment a few more times, each time changing the amount of each reactant. Do they see a pattern? Which reactant limits the amount of product that can be made?
- Explore whether Elephant Toothpaste is a physical or chemical change. What is the definition of a physical change? Chemical change? What are some examples? What is the evidence that shows what type of change occurred?
- What happens if the experiment is done in a smaller bottle? What about a graduated cylinder? We find the experiment works best with a bottle that has a narrow neck. Why might that be the case? Make predictions and try the experiment using different containers.
- Lead a discussion about what each reactant does in this reaction. Which one could we increase (in amount of concentration) to make the reaction bigger? Record their predictions and then test a few of their ideas.
- What happens if some of the reactants are removed? For example, would the reaction happen without the yeast catalyst? Or without the soap to see the gas released? Lead a discussion of what students' predictions are and then try some out!
- Yeast is used as a catalyst in this reaction, but there are lots of other catalysts in the world around us! Design a research project for students to investigate catalysts in their body, home, school, environment, and more. Students can share their findings with the class.
- There are tons of videos of this reaction online! Ask students to find the most "elephant"-sized ones to share with the class. What did the experimenters do differently in their procedure? What might that have changed about the reaction?
- The catalyst in this reaction, yeast, is a living organism that is used in a number of different ways at home and in the laboratory. Ask students to find some fun facts about yeast, including how we use it in our everyday lives and in science research.
- For more advanced students: write out the chemical formulas for the reactants and products. Ask students to balance the equation.
- For more advanced students: a way to test for the presence of oxygen – which is a product in this reaction – is by bringing a glowing split near the foam. If oxygen is present, it will reignite.

CHEMISTRY IN ACTION

Share the following real-world connections with your students to demonstrate how chemistry is all around us.

Real-World Applications·

Hydrogen peroxide has many uses, including acting as a bleaching agent, disinfectant, and in high concentrations it has even been used as a propellant for rockets!

Yeast is used to leaven bread, ferment food and drink, as a nutritional supplement, and as a way to study genetics in the laboratory since it is easy to grow, maintain, and manipulate. Yeast is even being studied as a potential biofuel!

Humans need catalysts! Your body burns fuel (in the form of food), just like a car's engine burns fuel. The reactions in our bodies that digest food and turn it into fuel require energy. There are special catalysts in the body called enzymes that help these reactions to start. The slowest known biological reaction would take 1 trillion years without an enzyme. With enzymes, the reaction can occur in just 10 milliseconds

Careers in Chemistry

- Thinking of a career in the automotive industry? The invention of airbags relies on rapid decomposition reactions to save lives! Sodium azide ($Na(N_3)_2$) decomposes rapidly into nitrogen gas (N_2) and sodium (Na) upon impact, which causes airbags to instantly fill with gas.

EVALUATE

- Add some art and creativity to the experiment: ask students to make a video, comic, or advertisement selling Elephant Toothpaste. In their work they should explain how the product is made. You can also add in other sections like safety warnings, recommended usage, and more!
- Can students prove whether a chemical reaction took place? Provide vocabulary words learned throughout this unit and ask students to write what they observed and whether a chemical or physical change took place using new vocabulary and evidence from their experiences. They can present their writing to a peer to review and provide feedback, or share their thoughts orally with the class.
- Ask students to plan a presentation to younger students in the school. They should be prepared to introduce the experiment, perform it, explain what is happening, and answer questions from the audience.

Notes