LESSON 33: Elephant Toothpaste

ESTIMATED TIME Setup: 5–10 minutes | **Procedure:** 10–15 minutes

• DESCRIPTION

Mix hydrogen peroxide with liquid dish soap and active yeast to initiate an "elephant size" chemical reaction.

• OBJECTIVE

This lesson demonstrates a type of chemical reaction called decomposition and explores catalysts. Students observe as yeast, hydrogen peroxide, and soap initiate an astonishing chemical reaction. The lesson can be simplified to address physical and chemical changes.

• CONTENT TOPICS

Scientific inquiry; elements and compounds; chemical reactions (decomposition); energy

Jump ahead to page 409 to view the Experimental Procedure.

• MATERIALS

- ❑ Empty 16-oz plastic soda pop bottle
- ❑ Foil cake pan with 2-inch sides
- ❑ 20-volume hydrogen peroxide (6% solution)
- ❑ Liquid dish soap
- ❑ Active yeast
- ❑ Funnel
- ❑ Warm water
- ❑ Cup or bowl
- ❑ Food coloring (optional)

Always remember to use the appropriate safety equipment when conducting your experiment. Refer to the *Safety First* section in the *Resource Guide* on pages 421–423 for more detailed information about safety in the classroom.

NATIONAL SCIENCE EDUCATION STANDARDS SUBJECT MATTER

This lesson applies both *Dimension 1: Scientific and Engineering Practices* and *Dimension 2: Crosscutting Concepts* from "A Framework for K–12 Science Education," established as a guide for the updated National Science Education Standards. In addition, this lesson covers the following Disciplinary Core Ideas from that framework:

- PS1.A: Structure and Properties of Matter
- PS1.B: Chemical Reactions
- ETS2.B: Influence of Engineering, Technology, and Science on Society and the Natural World (see ***Analysis & Conclusion***)

OBSERVATION & RESEARCH

BACKGROUND

All matter is made up of basic elements. **Elements** are pure substances that cannot be broken down further by normal chemical means. They are known as the building blocks of matter. A **compound** is a pure substance made up of two or more elements joined in a defined ratio. For example, water is a compound made up of the elements hydrogen and oxygen in a 2:1 ratio. Two hydrogen atoms and one oxygen atom join together, giving water the chemical formula H_2O. Hydrogen peroxide is a similar compound made up of hydrogen and oxygen. However, hydrogen peroxide has two hydrogen atoms attached to two oxygen atoms (H_2O_2).

Matter often changes, and these changes can be either physical or chemical. A **physical change** is any change in a substance's form that does not change its chemical makeup. The chemical formula of the substance stays the same before and after the change. A **chemical change** or **chemical reaction** occurs when atoms of a substance are rearranged, and the bonds between the atoms are broken or formed. During a chemical reaction, the structure or composition of the materials changes. When a chemical change is complete, the resulting substance(s) is/are different from the original substance(s). As a result of a chemical reaction, new substances with new properties are formed.

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The starting material or materials for a chemical reaction are referred to as the **reactants**. The substance or substances produced from a chemical reaction are called **products**. Sometimes a secondary product, a **byproduct**, can also be created at the same time as the desired product(s).

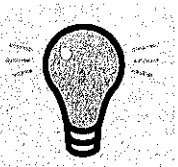
Not every chemical reaction occurs in the same way. There are different types of chemical reactions, including synthesis reactions, decomposition reactions, and displacement reactions. In this experiment, a decomposition reaction takes place. During a **decomposition reaction**, a compound breaks apart into two or more products. Most decomposition reactions need an outside source of energy in order to take place.

Hydrogen peroxide is not a very stable compound, so it slowly decomposes into water and oxygen gas under normal conditions. In this reaction, yeast is used as a catalyst. A **catalyst** is a substance that helps to change the rate of a reaction. During the reaction, the catalyst is not consumed. As a result, the yeast makes the reaction occur much faster; it causes the hydrogen peroxide to break down and release the oxygen gas much faster.

The soap is used to help us "see" the reaction. Bubbles of oxygen become trapped in the soap, creating foam. The reaction occurs so quickly, releasing so much gas and creating so much foam, that the foam begins to flow out of the bottle. The result of this reaction looks like toothpaste being squeezed out of a tube.

In addition, the bottle will feel warm to the touch because the reaction is exothermic. An **exothermic reaction or process is one that gives off energy.** In contrast, an **endothermic reaction** or process is one that requires or absorbs energy.

HYPOTHESIS



▶Adding yeast to hydrogen peroxide will cause the hydrogen peroxide to decompose quickly into water and oxygen gas, creating foam as the gas becomes trapped in liquid dish soap and pushes upward out of the bottle.

FORMULAS & EQUATIONS

Hydrogen peroxide is a relatively clear liquid substance. It is soluble in water and is often sold as a mixture of H_2O_2 in water. The hydrogen peroxide used in this experiment is actually a 6% solution of H_2O_2 in water.

The chemical formula for hydrogen peroxide is $\mathbf{H_2O_2}$.

Hydrogen peroxide naturally decomposes into water and oxygen gas. The reaction is shown by the following equation:

$$\mathbf{2H_2O_2\ (aq) \rightarrow 2H_2O\ (l) + O_2\ (g)}$$

The rate of the reaction can be increased by introducing a catalyst. In this experiment, the catalyst is yeast. Yeast is a microorganism that is part of the fungi family. Therefore, in the equation below, the catalyst is indicated above the arrow.

$$\mathbf{2H_2O_2\ (aq) \xrightarrow{yeast} 2H_2O\ (l) + O_2\ (g)}$$

The hydrogen peroxide used in the experiment is actually a mixture of water and hydrogen peroxide.

CONNECT TO THE *YOU BE THE CHEMIST* CHALLENGE

For additional background information, please review CEF's Challenge study materials online at http://www.chemed.org/ybtc/challenge/study.aspx.

- Additional information on elements, compounds, and physical and chemical changes can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry*.
- Additional information on chemical reactions can be found in the Chemical Reactions section of CEF's *Passport to Science Exploration: Chemistry Connections*.

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DIFFERENTIATION IN THE CLASSROOM

LOWER GRADE LEVELS/BEGINNERS

DESCRIPTION

Mix hydrogen peroxide with liquid dish soap and active yeast to initiate an "elephant size" chemical reaction.

OBJECTIVE

This lesson explores the differences between physical and chemical changes.

OBSERVATION & RESEARCH

Matter is often classified as either a pure substance or a mixture. All matter is made up of basic elements. **Elements** are pure substances that cannot be broken down further by normal chemical means. They are known as the building blocks of matter. A **compound** is a pure substance made up of two or more elements joined in a defined ratio. For example, water is a compound made up of the elements hydrogen and oxygen in a 2:1 ratio. Two hydrogen atoms and one oxygen atom join together, giving water the chemical formula H_2O. Likewise, hydrogen peroxide is a similar compound, made up of hydrogen and oxygen. However, hydrogen peroxide has two hydrogen atoms attached to two oxygen atoms (H_2O_2). Hydrogen peroxide is often mixed with water for household use. It is a mixture! A **mixture** is made of two or more substances that are combined physically.

Matter often changes, and these changes can be either physical or chemical. A **physical change** is any change in a substance's form that does not change its chemical makeup. The chemical formula of the substance stays the same before and after the change. Examples of physical changes are breaking a stick or melting ice. The stick is still a stick, and the ice and water are both still H_2O after those changes. A **chemical change** or **chemical reaction** occurs when atoms of a substance are rearranged, and the bonds between the atoms are broken or formed. During a chemical reaction, the structure or composition of the materials changes. When a chemical change is complete, the resulting substance(s) is/are different from the original substance(s). As a result of a chemical reaction, new substances with new properties are formed. An example of a chemical change is baking a cake. After the batter is heated, a new substance (the cake!) is formed.

Not every chemical reaction occurs in the same way. In this experiment, hydrogen peroxide breaks down into water and oxygen gas. This reaction occurs naturally, but yeast is used as a catalyst. A **catalyst** is a substance that helps to change the rate of a reaction. (During the reaction, the catalyst is not consumed.) As a result, the yeast makes the reaction occur much faster.

The soap is used to help us "see" the reaction. Bubbles of oxygen released by the reaction become trapped in the soap, creating a foam. The reaction occurs so quickly, releasing so much gas and creating so much foam, that the foam begins to flow out of the bottle. The result of this reaction looks like toothpaste being squeezed out of a tube.

HIGHER GRADE LEVELS/ADVANCED STUDENTS

Perform the experiment as described on page 409, but discuss the product of the reaction further. Oxygen gas is a product of the reaction and creates bubbles in the liquid dish soap. The gas becomes trapped in the liquid and creates a foam. A foam is a type of **colloid**. Discuss homogeneous mixtures, heterogeneous mixtures, and colloids.

Another option is to discuss other types of reactions. Give examples of **synthesis**, **displacement**, and **double displacement** reactions.

CONNECT TO THE *YOU BE THE CHEMIST* CHALLENGE

For additional background information, please review CEF's Challenge study materials online at http://www.chemed.org/ybtc/challenge/study.aspx.

- Additional information on elements, compounds, mixtures, and physical and chemical changes can be found in the Classification of Matter section of CEF's *Passport to Science Exploration: The Core of Chemistry.*
- Additional information on chemical reactions can be found in the Chemical Reactions section of CEF's *Passport to Science Exploration: Chemistry Connections.*

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EXPERIMENTATION

As the students perform the experiment, challenge them to identify the independent, dependent, and controlled variables, as well as whether there is a control setup for the experiment. (Hint: If you do not add yeast, does the foam still form?) Review the information in the ***Scientific Inquiry*** section on pages 14 –16 to discuss variables.

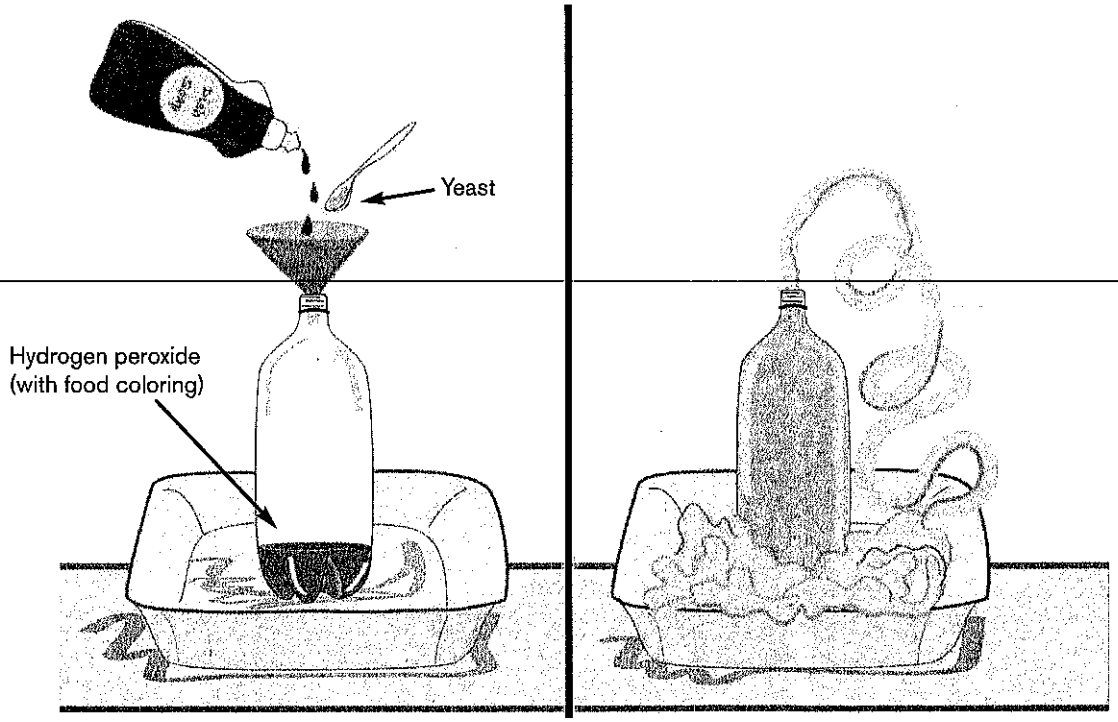
EXPERIMENTAL PROCEDURE

1. Place the empty soda pop bottle in the center of the cake pan. Put the funnel in the opening of the bottle.
2. Pour ½ cup of hydrogen peroxide through the funnel into the soda pop bottle.
3. Add about one tablespoon of liquid dish soap to the hydrogen peroxide in the bottle.
4. In a separate cup or bowl, mix one packet of yeast with warm water. (Follow the instructions on the packet of yeast when adding water.)
5. Pour the yeast mixture into the bottle, and then quickly remove the funnel.
6. Observe the reaction! (Along with observing with their eyes, students can also be allowed to touch the bottle to feel any changes taking place, and touch the foam that forms from the reaction.)

DATA COLLECTION

Have students record data in their science notebooks or on the following activity sheet. What happens when the soap is added to the hydrogen peroxide? What happens when the yeast is added? You can use the chart in the activity sheet (or a similar one of your own) for students to record their data.

NOTES



LESSON 33 ACTIVITY SHEET: Elephant Toothpaste

OBSERVE & RESEARCH

Introduce elephant toothpaste with PowerPoint: How do we create stuff?

1. Write down the materials you observe. _____

_____

_____

2. Predict how these materials may be used. _____

_____

_____

3. Define the following key terms. Then, provide an example of each by writing the example or drawing/pasting an image of the example.

Term	Definition	Example (write or add image)
Chemical reaction		
Reactant		
Product		
Catalyst		

4. Consider what effects the addition of yeast might have on a mixture of hydrogen peroxide and liquid dish soap and why.

▶**Write your hypothesis.** _____

_____

ANALYZE & CONCLUDE

Add one physical property for each column.

1. List some of the physical properties of each substance in the chart below.

Liquid Dish Soap	Hydrogen Peroxide	Active Yeast

2. What is the purpose of adding liquid dish soap? _____

_____

_____

3. What purpose does the yeast have in the experiment? Explain. _____

_____

_____

4. Write the equation of the chemical reaction that occurs. What are the products of the reaction? _____

_____

_____

5. Compare and contrast exothermic and endothermic reactions. _____

_____

_____

6. Is your hypothesis valid? Why or why not? If not, what would be your next steps? _____

_____

7. Does this chemical reaction support the law of conservation of mass? Why? $2H_2O_2 \rightarrow 2H_2O + O_2$

_____

_____

8. What are the reactants in this experiment? _____

_____

9. What are the products in this experiment? _____

_____

10. How do you know that a chemical reaction occurred during this experiment?

_____

_____

11. How did we speed up the rate at which this chemical reaction occurred?

_____

_____

12. How do you know that the yeast was a catalyst used in this chemical reactions?

_____

$2H_2O_2 + \text{Yeast} \rightarrow 2H_2O + O_2 + \text{Yeast}$