The University of Texas at Austin
Department of Chemistry
College of Natural Sciences

Elephant's Toothpaste: Temperature Variation

Performer's Version

Safety Hazards

- Personal Protective Equipment:
    - Safety glasses/goggles
    - Nitrile gloves
    - Chemical & flame retardant lab coat
- Physical Hazards:
    - Extremely exothermic and may cause skin burns.
    - Hydrogen peroxide is extremely flammable and may intensify fire.
- Chemical Hazards:
    - Hydrogen peroxide is harmful if swallowed or inhaled and may irritate skin and eyes.
    - Potassium iodide causes damage to thyroid through prolonged and repeated exposure.

Materials

- 3x Erlenmeyer flask (volume varies)
- 3x 30% hydrogen peroxide (volume varies)
- 3x Potassium iodide (mass varies)
- Deionized water (volume varies)
- Dawn dish soap (volume varies)
- Food coloring

Safety Data Sheet(s)

- Potassium iodide
- Hydrogen peroxide

Procedure

1. Pour the entire aliquot of 30% hydrogen peroxide into each flask.
2. Add the dish soap to the flasks. Securely hold each flask by the neck and gently swirl the liquids to mix them.
3. Add several drops of your desired food coloring to each flask. Add the drops down the sides of the flask (four equally spaced lines down the inside of the flask) to allow the foam to stripe as it comes out.
4. Pour the correct volume of deionized water into each container of solid potassium iodide. Tightly close the lid and shake vigorously. The bottles should feel cold to the touch.
5. When you are ready and the potassium iodide seems fully dissolved, pour the entire potassium iodide solution into the flask and quickly step back and out of the way. As the hydrogen peroxide decomposes, oxygen gas is released and transforms the soapy solution to a colored foam resembling toothpaste that will expand rapidly out of the container.
    a. Suggested order: cold peroxide + half catalyst, warm peroxide + half catalyst, warm peroxide + full catalyst

Flask Size	Volume of 30% Hydrogen Peroxide	Mass of Potassium Iodide	Volume of DI Water for Catalyst	Volume of Dish Soap
2 L	125 mL	50 g (25 g for half cat.)	40 to 50 mL	40 mL
4 L	250 mL	100 g (50 g for half cat.)	80 to 100 mL	80 mL
6 L	375 mL	150 g (75 g for half cat.)	125 to 150 mL	125 mL

Pedagogy & Supplemental Information

The Elephant's Toothpaste demonstration is a dramatic and visually engaging experiment that showcases the catalyzed decomposition of hydrogen peroxide (H_2O_2). In this reaction, potassium iodide (KI) serves as a catalyst to rapidly decompose hydrogen peroxide into water and oxygen gas:

$$2H_2O_2\ (\ell) \xrightarrow{KI} 2H_2O\ (\ell) + O_2\ (g)$$

The iodide ion (I^-) accelerates the reaction by lowering the activation energy and forming transient iodine-containing intermediates that break down hydrogen peroxide more efficiently. The generated oxygen gas becomes trapped in soap or detergent, producing a thick column of foam that shoots from the container, resembling an oversized stream of toothpaste.

In this variation of the classic demonstration, both the temperature of the hydrogen peroxide and the amount of catalyst are manipulated to illustrate how these factors influence reaction rate. Three flasks are prepared: one with cold peroxide (around 0ºC) and a half-saturated catalyst, another with warmed peroxide (around 50ºC) and the same half-saturated catalyst, and a third with warmed peroxide and a fully saturated catalyst solution. The reaction proceeds slowly in the cold mixture due to reduced molecular motion and a lower rate of collisions. The warmed peroxide with the same catalyst concentration reacts noticeably faster, demonstrating how temperature increases the kinetic energy of the system and accelerates the reaction. However, the most vigorous reaction occurs in the third flask – where both high temperature and maximum catalyst availability work together to push the reaction rate to its peak.

This experiment is a vivid illustration of fundamental chemical kinetics. The Arrhenius equation, shown below, describes how the rate of a chemical reaction depends on temperature and activation energy. In this expression, *k* is the rate constant, *A* is the frequency factor, *Ea* is the activation energy, *R* is the gas constant, and *T* is the temperature in Kelvin. The equation shows that reaction rates increase with higher temperatures or lower activation energies. According to the Arrhenius equation, reaction rate increases exponentially with temperature due to more molecules exceeding the activation energy barrier. At the same time, increasing the concentration of catalyst boosts the number of available reactive sites, further speeding up the reaction.

$$k = Ae^{\frac{-Ea}{RT}}$$

These principles are critical in real-world chemical engineering and industrial processes where precise control of temperature and catalysts can drastically improve efficiency. The decomposition of hydrogen peroxide has applications in wastewater treatment, disinfection, aerospace propulsion, and even chemical synthesis, where rapid oxygen release or oxidative power is needed. This demonstration connects classroom concepts to real-world chemistry in a dynamic and memorable way.

VOLUNTEERS ALLOWED

Volunteers can prepare and pour the catalyst while wearing proper personal protective equipment (PPE).

Volunteers must be closely supervised.