Part 1: Background Information and Context

Activity
Elephant Toothpaste
Students will get to see an exothermic reaction and an oxidation-reduction reaction all in one. Hydrogen peroxide reacts with soap and a catalyst to create a huge plume of foam that resembles toothpaste being squeezed out of a tube. In the adult version, 10, 20, or 30% hydrogen peroxide reacts with beef liver or sodium iodide as the catalyst; both catalysts cause a fast reaction with beef liver eliminating any chemical waste. In the kid's version, yeast or beef liver act as the catalysts on a household (3%) hydrogen peroxide which is a slower but still effective reaction. The addition of the catalyst allows the hydrogen peroxide to break down into oxygen gas and water. While the reaction is going on, the oxygen gas being released forms bubbles in the soap resulting in a tube of bubbles leaving a graduated cylinder. Dyes can be added for different colors.

Suggested NGSS Dimensions to Address (click on the titles to learn more from the K-12 Framework)

Science and Engineering Practices

- Asking Questions/Defining Problems
  - Students can observe the teacher performing this activity as a demo, record observations, and ask questions.
- Planning and Carrying Out Investigations
  - Students could then develop an experiment to test their ideas or the teacher could develop the experiment, and students could conduct it.
- Constructing Explanations/Designing Solutions
  - After students explore different examples of endothermic/exothermic reactions, and/or the effects of catalysts on reaction rates, the students can explain the demonstration.

Disciplinary Core Ideas

- PS1.B Chemical Reactions
  - **3-5**: When two or more different substances are mixed, a new substance with different properties may be formed. (5-PS1-4)
  - **6-8:** Substances react chemically in characteristic ways. In a chemical process, the atoms that make up the original substances are regrouped into different molecules, and these new substances have different properties from those of the reactants. (MS-PS1-2, MS-PS1-6)
  - **9-12:** Chemical processes, their rates, and whether or not energy is stored or released can be understood in terms of the collisions of molecules and the rearrangements of atoms into new molecules, with consequent changes in the sum of all bond energies in the set of molecules that are matched by changes in kinetic energy. (HS-PS1-4),(HS-PS1-5)

Crosscutting Concepts

- **Cause and Effect**
  - Events have causes, sometimes simple, sometimes multifaceted. A major activity of science is investigating and explaining causal relationships and the mechanisms by which they are mediated. Such mechanisms can then be tested across given contexts and used to predict and explain events in new contexts.
- **Systems and System Models**
  - Defining the system under study—specifying its boundaries and making explicit a model of that system—provides tools for understanding and testing ideas that are applicable throughout science and engineering.
- **Scale, Proportion, and Quantity**
  - In considering phenomena, it is critical to recognize what is relevant at different measures of size, time, and energy and to recognize how changes in scale, proportion, or quantity affect a system's structure or performance.

Part 2: Lesson Facilitation for Phenomenon

Teacher Background

General Explanation:

This experiment is a reaction between hydrogen peroxide and yeast. First, we add warm water to the yeast to activate it and essentially wake it up so it can work. Then we mix the hydrogen peroxide with the soap, nothing happens at this point because neither is reactive with the other. When we add the activated yeast mixture to the container, it immediately creates a foam that shoots out of the container. During this reaction, the hydrogen peroxide is being broken down and split apart by the yeast, which is acting as a catalyst. The hydrogen peroxide breaks down into water and oxygen gas. To show that the hydrogen peroxide breaks down into water and oxygen gas, we add soap which can catch the gas and create bubbles. We use a soda bottle or a triangular flask (known as an Erlenmeyer flask) to force the bubbles out of a small opening that creates a funnel like effect. This funneling action causes the mix to shoot out of the bottle with much more force then if it spilled over a larger rim or area.

This reaction also creates steam and heat. The mixture heats up do to the reaction between the yeast and hydrogen peroxide, this means our reaction is exothermic. An exothermic reaction creates heat by shifting energy from the reaction to the surrounding area. In contrast, an endothermic reaction takes heat away from the surrounding environment. When bonds between different atoms are broken or built, the bonds require energy. When a bond is broken, it requires a lot of energy and it will pull energy from surrounding reactions to get it. This means the area around the reaction will cool down because it is losing energy. For exothermic reactions, more bonds are being built than broken. It requires much less energy and thus will release energy that it doesn't need. That means the surrounding area will heat up from the new energy it is receiving.

When you pour hydrogen peroxide on a cut you see the bubbles that form as soon as the liquid makes contact with the cut. The creation of bubbles is a direct result of the hydrogen peroxide and an enzyme in your tissue called catalase breaking down the bacteria in the cut. Catalase is a catalyst that helps break down the hydrogen peroxide but also helps speed up the reaction. Although nothing extra happens due to a catalyst, it makes the reaction go faster by lowering the energy needed to react known as the activation energy. We use beef liver instead of yeast for this experiment because it is a better catalyst and makes the reaction happen much faster.

Materials

1. Large basin (something to catch the foam)
2. Catalyst
    a. 20 g beef liver and 500 mL 0.1 M potassium phosphate buffer (31 mL of 1M K_2HPO_4 and 19 mL of 1M KH_2PO_4), or
    b. yeast
3. Blender
4. Coffee filters
5. Graduated cylinder or Erlenmeyer flask
6. Dish soap
7. 200 mL of 20% hydrogen peroxide. Note: you might set up three concentrations of hydrogen peroxide: 3%, 10%, and 20%. 20% hydrogen peroxide can be obtained from a beauty supply shop. Make sure that you get pure hydrogen peroxide and not a hydrogen peroxide containing cream used to bleach hair. A higher concentration hydrogen peroxide (30%) can also be used but it is extremely dangerous and should only be used by a trained chemist.

Procedures

1. Blend buffer and liver until finely pureed
2. Pass the mixture slowly through a double thickness of coffee filters and into the cylinder or flask.
3. Add 10 mL of soap, swirl to ensure it's mixed.
4. Carefully but quickly add the hydrogen peroxide.
5. Stand back and watch it foam!

With yeast as a catalyst

1. Add yeast and water in a container or cup, stir then let it sit for a few minutes.
2. Place the plastic bottle in the cake pan or overflow box and pour approximately 1⁄2 cup of hydrogen peroxide into the plastic bottle/container.
3. Add 2-3 squirts of dish soap to hydrogen peroxide to the bottle/container. Swirl the mixture in the container to mix it up a bit.
4. Quickly add the yeast mixture to the bottle/container.
5. Foam will begin to shoot up and out of the bottle and into the container. The kids can place their hands on the bottle to feel the change in temperature and can also play with the suds.
6. This mixture can be rinsed down the sink afterwards and wiped up with paper towels.

Links worth checking out!

https://sciencebob.com/fantastic-foamy-fountain

http://chemdemos.uoregon.edu/demos/Elephants-Toothpaste

Safety Concerns

This is an exothermic reaction, so stand back to avoid burns from the heat. The audience should be kept back to prevent them from getting any of the foam on them and to protect from the heat. Also, be careful of the solution in the bottom of the container/flask and the foam as there could be unreacted hydrogen peroxide present.

Hydrogen peroxide is a strong oxidizer and is a very corrosive solution. Wear gloves, goggles and a lab coat at all times. Keep audience members away from the solutions and use extreme caution when cleaning up. Also, do not inhale fumes or use in an enclosed area. This solution can cause serious burns or irritation if it comes into contact with the eyes or skin and can cause respiratory issues if inhaled.

*For the full MSDS please visit this link: http://www.sciencelab.com/msds.php?msdsId=9924299

3-Dimensional Questions

1. What did you notice during the demonstration?
2. What did you wonder during the demonstration?
3. What effect would changing the amount of yeast used in the reaction have on the results?
4. How would changing the amount hydrogen peroxide affect the amount of foam created or how quickly it formed? How would you test this hypothesis?
5. What role does the soap play in the reaction? What would happen if you didn't add soap to the mixture?

6. How would adding dry yeast differ from yeast that was mixed with warm water?
7. Why is there steam coming off of the foam?

5E Model Alignment/Suggestions

Engage:

Consider using this activity as a demonstration and having students ask questions about what they see through a prompt such as "Make 5 observations and 3 questions about the following demonstration". Draw attention to the heat produced and the signs of that (steam) as well as the reaction rate change through the catalyst.

Explore:

1. After students have made preliminary predictions and explanations, they could explore these predictions by conducting an investigation involving reactions that use catalysts or are endothermic/exothermic. Students could either **develop the investigation** or simply **conduct** it using provided procedures.
2. After conducting an investigation, students could *revise* their original thinking about the phenomenon.

Explain:

After the teacher has helped the students make meaning of their activity through direct teaching, video, or text, the students can then explain their learning back to the teacher. Through experience and instruction, students should learn the content relevant to their grade level. 5th graders should focus on the signs of a chemical reaction, middle schoolers can expand into the recombining of atoms to form new molecules, and high schoolers can focus on bond energy differences to give way to exo/endothermic reactions.

The students can **construct an explanation** or write a **Claim-Evidence-Reasoning** on this phenomenon.

Elaborate:

1. Students could **apply their knowledge to a new situation** by predicting/modeling/explaining what would happen in a new scenario that involves endo/exothermic reactions or catalysts. They could test their predictions through an investigation they design and conduct it or simply stop at the design.

- Air-Powered Rockets: Air compressors are used to pressurize a PVC manifold and used to launch a student-built rocket made from cardboard.

- Bath Fizzers: Fizzing bath salts are made using an acid-base reaction.
- Bed of Nails: A volunteer lies down on a bed of nails with an apple between the nail bed and themselves; participants can attempt to pop a balloon on a mini-bed of nails.
- Berry Drops: Sodium alginate and calcium chloride are used to make edible, berry-flavored beads
- Boo Bubbles: Bubbles are generated using carbon dioxide from dry ice leading to bubbles that one can hold using gloves the pop to form a white cloud.
- Build-A-Lung: Students make a working model of a lung.
- Clay-ate the Cardiovascular System: Clay is used to depict the cardiovascular system of humans.
- Colored Flames: Various metal salts are dissolved in ethanol and sprayed into the flame of a butane torch.Colorful Gases: Gas discharge tubes are excited using a high voltage source leading to different colors of light being given off. - use fireworks as phenomenon
- Crime Scene Investigators (CSI): Various activities related to crime scenes including making giant glowing fingerprint helium balloons, blood spatter patterns, and observing fake blood stains using luminol.
- DNA Extraction: DNA is extracted by blending a banana or strawberry and combining the mash with detergent and rubbing alcohol.
- Dr. Glow and Dr. Lumos: Fluorescent dyes are displayed under a black light to show the different colors of light given off, a solution of TCPO (glow stick chemical) reacts with bleach, and luminol reacts with hydrogen peroxide.
- Dry Ice Carbonation: Dry ice is added to punch leading to a bubbly cauldron of carbonated punch.Dry Ice Crystal Ball: A bubble is formed over dry ice mixed with warm water leading to a large bubble forming that resembles a crystal ball.
- Flaming Gummy Bear: A gummy bear burns in molten potassium chlorate.
- Flubber: A mixture of starch and Elmers Glue results in a gooey mass.

- Ghost Eggs: Students observe how polymer beads swell to form egg-like objects that “disappear” in water.
- Giant Bubbles: Kids make various bubbles using speciality bubble solution mixtures. Includes standing in a large bubble.
- Glow Powder Drawings: Kids use glue to create a drawing which is then sprinkled with glow powder; the resulting art created will glow in the dark.
- Glue Gak: White glue is mixed with laundry borax leading to the formation of gak.
- Gold and Silver Pennies: A penny is soaked in a a mixture of zinc powder and sodium hydroxide and heated leading to silver and gold pennies.
- How Does Your Garden Grow: Students learn about how seeds sprout and plant their own seeds to watch them grow.
- Instant Snow: Sodium polyacrylate powder can absorb many times its mass in water. Use NaCl to partially shrink the polymer by driving out the water.
- It’s Electrifying: A van de Graaf generator and plasma globe are used to light neon bulbs and fluorescent light bulbs.
- Liquid Nitrogen Dippin Dots: Liquid nitrogen is used to make homemade ice cream dip-N-dots.
- Liquid Nitrogen Effects: Various activities including shrinking of long balloons, spinning of ping pong balls,and freezing oreos, miniature marshmallows, and saltine crackers.
- Magic Pitcher: Solutions of phenolphthaline, dilute sodium hydroxide, and vinegar are mixed resulting in the appearance and disappearance of a pink color.
- Magnetic Goo: Students make a magnetic goo that can be attracted to a magnet.
- Make a Motor: Students wind a coil of copper wire and make a motor that they can take home.
- Make Your Own Hair Gel: Students learn how two solutions can be mixed to make a thick hair gel.
- Make Your Own Lip Balm: Students make lip balm by melting bees wax and mixing it with fragrances and oils.

- Make Your Own Perfume: Students make a perfume by mixing fragrances with ethanol.
- Make Your Own Stress Ball/ Juggling Ball: Kids fill a balloon with sand using a vacuum chamber to inflate the balloon/ demonstrating how the lungs work.
- Makey Makey/ Banana Piano: A Makey Makey keyboard interface is used to play music or flash lights using objects like playdough and bananas.
- Mentos and Diet Coke: Mentos candies are placed in a 2L soda bottle leading to a jet of soda being blasted out of a hole in the lid.
- Money on Fire: A dollar bill is soaked in rubbing alcohol containing water and set on fire; the bill does not burn.
- Oil Spill Clean-Up: Kids learn how oil spills affect the ocean and how they can be cleaned up.
- Oobleck: The fixotropic properties of corn starch can be investigated by trying to punch a hole in it and seeing it dance on a speaker.
- Owl Pellet Dissection: Owl pellets are dissected and the bones found in the pellet are identified.
- Pencil Lead Light Bulb: Electricity is run through a mechanical pencil lead resulting in a glowing light.
- Ping Pong Ball Accelerator: A ping pong ball is placed in a clear PVC tube which is evacuated. A hole is generated at one end of the tube and the ball accelerates to supersonic speeds allowing it to go through a piece of 1/8″ plywood. The speed of the ball is measured to be supersonic.
- Pixie Stix: Students make Pixie Stixs by mixing food grade citric acid and dextrose.
- Prints from the Past: Kids get to make their own cast of a fossil mold using clay.
- Propane Mamba: Butane gas is bubbled through a soap solution resulting in flammable bubbles that are ignited on the demonstrator's hands.
- Rainbow Juice: Food grade citric acid, sodium citrate, red cabbage juice. An acid-base reaction generates a fizzy, color-changing drink.

- Screaming Cup: A wet string is pulled through a hole in the bottom of a plastic cup leading to spooky sounds.
- Self-Carving Pumpkin: A carved pumpkin (removed face pieces still intact) is filled with acetylene gas and a spark source/ flame causes a minor explosion that propels the face pieces out of the pumpkin.
- Selzer Freeze: A bottle of selzer water is chilled in a salt-ice mixture; when opened, the contents of the bottle immediately freeze.
- Slime: A solution of polyvinyl alcohol in water is mixed with laundry borax leading to the formation of slime.
- Smoke Rings: A fog machine is used to fill a trash can with smoke and a smoke ring is generated by tapping the base of the trash can.
- Soap Monster: A small piece of ivory soap placed in a microwave grows into a large mass of soap flakes.
- Sodium Alginate Beads and Worms: A solution of sodium alginate is added to calcium ions resulting in beads or worms, depending on the mode of mixture of the two solutions.
- Tie Dye and Spin Chromatography: Students use water and isopropyl alcohol to separate a mixture of dyes from marking pens, Kool Aid, or candy coatings using filter paper chromatography.
- UV Bracelets: Kids get to make bracelets that change color under UV light.