Energy from Chemical Reactions

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Target Grade: 6-8

Time Required: 90 minutes in a series of three lessons

Standards:

- MS-PS1-6 Undertake a design project to construct, test, and modify a device that either releases or absorbs thermal energy by chemical processes.
- MS-PS3-5 Construct, use, and present arguments to support the claim that when the kinetic energy of an object changes, energy is transferred to or from the object.
- MS-ESS3-4 Construct an argument supported by evidence for how increases in human population and per-capita consumption of natural resources impact Earth's systems.

Lesson Objectives:

Students will:

- Learn about combustion with experiments and observations.
- Students will make predictions about combustion based on data they have previously collected.

Central Focus:

The central focus is all about combustion, and how automobiles produce a large amount of heat generated by the burning of gasoline. Burning gasoline is a chemical reaction that causes a phase change, which is combustible energy. Students will complete a series of experiments to learn about combustion.

Background Information:

Teacher Background Information:

- The chemical formula for hydrogen peroxide is H_2O_2.
- The yeast serves as a catalyst for the chemical reaction. It speeds up the chemical decomposition reaction of the hydrogen peroxide but remains yeast so does not chemically change itself.
- The hydrogen peroxide decomposes to form oxygen gas (O_2) and water (H_2O).
- As the hydrogen peroxide decomposes, energy in the form of heat is released causing the bottle to feel warm. This is an example of an exothermic reaction.
- Therefore, the elephant toothpaste is made up of dish soap, water, and oxygen gas.

Student Background Information:

- **MS-PS1-4 Matter and its Interactions**
  Develop a model that predicts and describes changes in particle motion, temperature, and state of a pure substance when thermal energy is added or removed.
- **MS-PS3-2 Energy**
  Develop a model to describe that when the arrangement of objects interacting at a distance changes, different amounts of potential energy are stored in the system.

Materials:

Day One Materials:

- Safety equipment (chemical splash goggles, aprons, gloves)
- Hydrogen peroxide (40 volume from a beauty supply house)
- Liquid dish soap (1 squirt)
- Food coloring (optional)
- 1 Tbsp. dry yeast
- 20 ml warm water
- Small cup to mix yeast and water
- 16 oz. plastic soda bottle (recycled soda pop bottle)
- Measuring spoon (tsp) or disposable plastic spoon
- Funnel
- Container to "catch" the elephant's toothpaste
- Infrared thermometer
- Student Journal

Day Two Materials:

- Motorcycle or Car
- Student Journal
- Infrared thermometer

Day Three Materials:

- Fully tested balloon car engineered from previous lesson (Last years or teacher tested)
- Safety Equipment (goggles, aprons, gloves)
- 1 level Tablespoon yeast
- 20ml warm water
- Masking tape

- 1 liter bottle
- 100 milliliters 12% hydrogen peroxide (40 volume from beauty supply house)
- Temperature measure (infrared thermometers)
- Rubber stopper and tubing (provided - see materials list)
- Digital scale
- Funnel

Instruction

Day One: (Opening Activity) Elephant Toothpaste for Students: Let's find out about chemical reactions that produce heat!

1. Introduce the Opening Activity by telling the students how will learn about how chemical reactions produce heat. Go over the following bullet points:
   - The chemical formula for hydrogen peroxide is H_2O_2.
   - The yeast serves as a catalyst for the chemical reaction. It speeds up the chemical decomposition reaction of the hydrogen peroxide but remains yeast so does not chemically change itself.
   - The hydrogen peroxide decomposes to form oxygen gas (O_2) and water (H_2O).
   - As the hydrogen peroxide decomposes, energy in the form of heat is released causing the bottle to feel warm. This is an example of an exothermic reaction.
2. Break the class up into groups of 3 to 4 students.
3. Go over all the steps of the experiment that the students will be doing in class that day:
   1. Measure and add 100 ml of hydrogen peroxide to the 16 oz. bottle. Record the temperature.
   2. Add a squirt of dish soap to the bottle and gently swirl to mix the soap with the hydrogen peroxide. (Optional: add food coloring and swirl). Record the temperature
   3. Place the bottle in a container to "catch" the elephant toothpaste.
   4. Add 1 level tablespoon of yeast to the warm water and stir.
   5. Add the dissolved yeast to the bottle and swirl.
   6. Place the bottle on a large tray or in a tub. Immediately record the temperature and record every 15 seconds until the temperature stops rising.
   7. Observe and record.
4. Make sure all students are wearing the appropriate clothing and safety equipment, while passing out a sheet with all the steps to the experiment and questions for the journal entry (Page 1 below).
5. Let the students begin experiment.

Day Two: Observation and discussion of actual combustion engine

1. Review safety precautions with the students before going outside.
2. Go outside to observe a motorcycle or car engine; instruct students to engage and make observations (make notes in journal) using their senses - sight, sound, smell, feel (feel the heat coming off engine but do NOT touch), no tasting.
3. Using an infrared thermometer measure and record the temperature of the engine before starting, and every 30 seconds after starting until the temperature levels off. Write down

all temps in journal.

4. Turn off engine and return inside. Create a chart of temperature readings in journal to make a line graph of the temperature changes over time on a separate sheet of paper.
5. Discuss observations and data in small groups and record in science journal. Suggestions: Have students put on post-it notes, or on a shared electronic document, verbally, or on white boards. Idea coaching: Give students sentence frames to aid in their discussion. Or have students write down their answers to the discussion in their journal.
    - I observed...
    - I think...because...
    - Evidence that supports my argument includes...
    - I think this is supporting evidence because...
    - The scientific idea that this supports is...
    - From my observations, I think this vehicle may affect the environment by ... because...
    - The energy transformation in the engine included.... to..
    - A question I have is... (post these for all to share).
    - The next day compare/contrast the temperature data from all classes.

Day Three: Balloon Car

1. Today students will utilize their previously designed balloon cars along with what they have discovered about combustion engines and exothermic reactions to demonstrate the direct conversion of heat generated by an exothermic reaction to power their cars.
2. Each group of 3-4 students will need goggles, aprons, and gloves to handle the hydrogen peroxide. Each group will also need the other supplies listed above.
3. Without touching the supplies given, students will visually inspect the supplies and connect them with the Elephant Toothpaste launch. Students will think about and discuss how they might use the supplies to make their car move. Allow time for students to generate ideas.
4. Then inform students that we have found that 100 milliliters of 12% (40 volume) hydrogen peroxide and 1 level Tablespoon of yeast will power the car.
5. Have them precisely measure these supplies and talk about how at this time, these amounts may not be adjusted. These amounts are the control. Teacher note: students will not make multiple runs with their cars at this phase. Multiple trials and redesign happened in the previous car design lab. Students will need to be precise in their connection of the inflated balloon to their car. Clipping the twisted end of the balloon may help to prevent gas leakage while attaching it to the car. If necessary, teachers can decide if students can repeat the process with new chemicals.
6. Before combining yeast and hydrogen peroxide, have a discussion about and write in journal:
    - What we expect might happen?
    - What are some things that might interfere with powering our car?
    - What safety precautions need to be observed?
    - What is the mass of the hydrogen peroxide and yeast before the reaction, and the bottle?
    - What is the mass of after the reaction?

- Predict how you think the before and after masses will compare
- What role does the balloon play?
- How does this temperature device work? What safety measures should be taken with use?
- How often should we take measurements for the temperature?

7. Students will measure the temperature of the bottle and record. Remind students to collect the temperature at 5 points (empty bottle, right before swirling, during swirl, after balloon is fully inflated, after stopper/balloon apparatus is removed)
8. Students will use a digital scale to mass the bottle, hydrogen peroxide, water and yeast prior to reaction.
9. In your groups decide the role for each student. Suggestions include bottle filler, bottle mixer, balloon fillers, pourer, balloon fastener, thermal measurement, observer/data collector, etc. Rehearse roles before mixing chemicals.
10. Students attach stretched out balloon to tubing/stopper apparatus. (Suggestion: Use a balloon pump to inflate the balloon to stretch it out before inflating with the chemical reaction.)
11. Students combine the hydrogen peroxide and yeast/warm water solution in the bottle and immediately attach stopper.
12. Students gently swirl the bottle to promote reaction.
13. Reminder that temperatures are being collected at multiple phases.
14. Students rapidly and precisely transfer inflated balloon to car, observe, and record.
15. Students mass the bottle containing the mixture
16. Students clean up experiment
17. Students discuss their observations in their group
18. Students evaluate and interpret their temperature data. Students will choose a method to display their temperature data and write a brief summary of the experiment.

Extension:

Day One: (Opening Activity) Elephant Toothpaste for Students: Let's find out about chemical reactions that produce heat!

Have students brainstorm problems to solve using the materials from this demonstration. Examples might include variables to test such as bottle size, amount of yeast, amount of hydrogen peroxide, strength of hydrogen peroxide, not using warm water, etc.

Day Two: Observation and discussion of actual combustion engine

In groups – Observe and operate a combustion engine model. In your science journal sketch what you see, use arrows to show the flow of energy, and label each step. Research and explain how observing the model is alike and different than observing a real engine.

Highlights: A type of chemical reaction known as combustion takes place in the combustion engine.

1. Things that happen in a combustion engine:

- Fuel
- Air
- Spark

The fuel, air, and spark combine in the chamber to force the piston down. This rotates the crankshaft.

2. Chemical energy is transformed to mechanical energy and heat energy.
3. Heat and chemicals are given off. The chemicals are water and hydrocarbons.

Assessment

Day One:
Journal Entry (Formative): Students will answer questions from handout that will be answered into their journal.

Day Two:
Journal Entry (Formative): Students will record observations and temperature of engine combustion.
Temperature Graph (Formative): Students will create a line graph based on the temperatures they recorded from the experiment.

Day Three:
Journal Entry (Formative): Students will answer questions from handout that they will be answered into their journal.
Combustion Quiz (Summative): Students will take a quiz over combustion, using there data from their journals.

Name/Group Number:_____

Elephant Toothpaste Experiment

1. Measure and add 100 ml of hydrogen peroxide to the 16 oz. bottle. Record the temperature.
   Temp:_____
2. Add a squirt of dish soap to the bottle and gently swirl to mix the soap with the hydrogen peroxide. (Optional: add food coloring and swirl). Record the temperature.
   Temp:_____
3. Place the bottle in a container to "catch" the elephant toothpaste.
4. Add 1 level tablespoon of yeast to the warm water and stir.
5. Add the dissolved yeast to the bottle and swirl.
6. Place the bottle on a large tray or in a tub. Immediately record the temperature and record every 15 seconds until the temperature stops rising.
7. Observe and record.

_____
_____
_____

When complete with the experiment answer the following questions in your journal.

1. Record your observations: see, hear, touch, smell, but do NOT taste?
2. What ideas do you have about what may have caused each of these observed characteristics?
3. What was the purpose of the yeast?
4. How does the container feel? What type of reaction is this and why?
5. How does the elephant's toothpaste feel?
6. What are the products of this chemical reaction (What was left at the end?)

Name/Group Number:_____

Combustion Quiz

1. How does the combustion engine work?

   _____
   _____
   _____
   _____

2. How do combustion engines affect our lives: pros and cons?
   Pros:

   Cons:

3. What is your argument and evidence that when the kinetic energy of the car changed, the energy was transferred to or from the car? Give details

   _____
   _____
   _____
   _____

4. What is your argument and evidence for how the environment is affected by the combustion engine? Give details

   _____
   _____
   _____
   _____

5. What ideas do you have to improve any of these things? Original thinking outside the box! Give details

   _____
   _____
   _____
   _____