Exploding Bags

Section CHEMICAL REACTIONS *Topic* ACIDS & BASES

Estimated Time Setup: 5 minutes; Procedure: 5 minutes

OVERVIEW

Students will mix two substances to observe how an 'explosive' new substance is formed through a chemical reaction.

In this activity, students mix baking soda, warm water, and vinegar in a plastic bag and watch as reactants suddenly turn into products: a liquid and a gas. As the reaction proceeds and produces more gas, the plastic bag will inflate and then 'explode' open. Students can explore how matter changes form in chemical reactions, an acid-base reaction, that gases take up space, and that chemical reactions often coincide with thermal energy changes.

INQUIRY QUESTIONS

Getting Started:

- How do we know a chemical reaction has taken place?

Learning More:

- What physical, chemical, and thermal changes happen in this reaction?

Diving Deeper:

- Why do vinegar and baking soda react with one another, and what products do they form?

CONTENT TOPICS

This activity covers the following content topics: chemical reactions, acids and bases, energy, chemical changes, properties of matter, endothermic reactions, chemical formulas

This activity can be extended to discuss: 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:

- Vinegar
- Baking soda
- Warm water
- Sandwich or quart-size sealable plastic bag
- 2 squares of Charmin® toilet paper
- ¼ cup liquid measurer
- Spoon

ACTIVITY NOTES

This activity is good for:

- Pairs
- Small groups

Safety Tips & Reminders:

- We recommend doing this activity over a sink, pan, bin, or outside since the contents in the bag may spill.
- While the 'explosion' is more of a 'pop' and is contained in the bag, safety goggles are recommended.
- The water should be warm, not hot! If it is too hot it could melt the plastic bag.
- Review the Safety First section in the Resource Guide for additional information

ENGAGE

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

- For 'explosive' experiments like this, sometimes the best engagement is the demo itself! Try it as described in the procedure or use a volcano to make it more fun.
- There are great videos of similar reactions, but on a much larger scale! Find videos of 'explosive' reactions that others have tried but may be too big to do in the classroom.

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

Notes

EXPLORE

Procedure:

1. Scoop two large spoonfuls of baking soda to the center of a square of Charmin® toilet paper.
2. Wrap the toilet paper around the baking soda.
3. Wrap a second square of Charmin® toilet paper around the first so the baking soda is held in the paper.
4. Have one student hold the plastic bag open, and another student add ¼ cup vinegar and ¼ cup warm water to the bag.
5. Seal the bag almost entirely closed and hold the wrapped baking soda over a small opening in the corner.
6. Have one student drop the baking soda into the bag and another student quickly seal the bag.
7. Gently swirl the contents of the bag so the toilet paper soaks up the liquid, then place the bag on the table. Watch as the bag inflates and pops!

DATA COLLECTION & ANALYSIS

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

- Take notes on the content of the bag prior to and after adding the baking soda. Are they the same or different? What are the physical properties?
- What are the reactants in this experiment? Can you write their chemical formulas?
- Make a prediction about the temperature of the product: will they feel warm or cold? After a few minutes, feel the bottom of the bag with your hands. Was your prediction correct? Why does this happen? What does it mean?
- Draw and label diagrams showing each stage of the reaction. Why did the bag 'explode'?
- What are the products in this reaction? Can you write their chemical formulas? What are the physical properties of the products?

Fun Fact #1

In July of 2017, the Oregon Museum of Science and Industry made a 34-foot, super-sized volcano! They filled it with 66 gallons of vinegar, 50 gallons of baking soda, water, and red food dye for effect. You might see it in the Guinness Book of World Records soon, and find the video online!

EXPLAIN

What's happening in this Activity?

First review the Acids & Bases Background section to gain a deeper understanding of the scientific principles behind this activity.

During a **chemical reaction** the **reactants** change into completely new substances known as the **products**, and bonds between atoms are broken or formed. Chemical reactions occur all around us. Each substance reacts in a unique way, depending on what atoms it contains and how they are bonded to each other.

Many substances can be categorized as either acids or bases, each of which reacts in a distinctive way. A substance that gives up hydrogen ions, H^+, is an **acid**. A substance that accepts hydrogen ions is a **base**. An **ion** is a charged particle formed when an atom gains or loses an electron. Ions can be either positive or negative. For example, H^+ is positive and OH^- is negative. Positive ions and negative ions are attracted to each other and form bonds—in other words, opposites attract!

Acids and bases often react with each other in **neutralization reactions**. When vinegar and baking soda are mixed, the two react because vinegar is acidic and baking soda is basic. Vinegar is a solution of acetic acid, CH_3COOH, in water. When acetic acid is in water, it breaks down to release H^+ ions. When something breaks down into positive and negative ions it is called **dissociation**.

Baking soda is made of the compound sodium bicarbonate, $NaHCO_3$. It breaks down in water into Na^+ and HCO_3^-. Since HCO_3^- is negative, it is attracted to the oppositely charged H^+ ions from vinegar.

One of the products is a new acid, carbonic acid. Carbonic acid, H_2CO_3, is unstable and so a second reaction takes place right away. The carbonic acid breaks down into carbon dioxide and water in a **decomposition reaction**. 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 are broken to form two or more products.

Step 1: Vinegar (acetic acid) reacts with baking soda (sodium bicarbonate) to produce carbonic acid

$CH_3COOH + NaHCO_3 \rightarrow H_2CO_3 + CH_3COONa$

Step 2: Carbonic acid decomposes into carbon dioxide gas and water

$H_2CO_3\ (aq) \rightarrow H_2O\ (l) + CO_2\ (g)$

The (aq) means carbonic acid is dissolved in water. (l) means liquid, and (g) means gas.

All the gas that this decomposition reaction produces makes the bag inflate. Even though we can't see it, the extra gas particles flying around take up more space in the bag than the liquid and solid reactants did. If the reaction produces enough gas, the bag will explode!

Baking is soda is used in cooking things like bread, muffins, and cake. When bread rises in the oven, it is because the baking soda is reacting to produce carbon dioxide gas.

During this experiment, the bag feels cold to the touch. This is because the reaction is **endothermic**, meaning that it takes in or absorbs energy from its surroundings. Other reactions release energy and feel warm to the touch. These are **exothermic reactions**.

Notes

EXPLAIN continued

Any feeling of "hot" or "cold" is because of the transfer of energy. The type of energy related to temperature is called **thermal energy**. When you touch something and it feels hot, thermal energy is flowing from the object to your hand. When something feels cold, thermal energy is being transferred from you to the object. If you hold the bag during this experiment, it feels cold because you lose some thermal energy to the reaction mixture.

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:

- During a chemical reaction new substances with different properties are formed
- Many substances can be characterized as acids or bases based on how they behave
- Opposite charges are attracted to one another
- Acids and bases react with one another

DIVING DEEPER

For more advanced students, emphasize the following concepts:

- The pH scale is used to measure how acidic or basic a substance is
- Acids donate H^+ ions and bases can accept H^+ ions
- Ions have a charge, which can be either positive or negative
- Many things dissociate, or break down into ions, in water
- Some chemical reactions absorb energy and others release energy

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.

- You might have seen this reaction before at a local science fair as an exploding volcano! Help students make this into a more explosive and creative project by building a volcano, adding food coloring and liquid dish soap, and researching how real volcanos work in nature.
- Another modification for a more explosive reaction is to do the experiment in a bottle with Dawn® Ultra dishwashing liquid soap. What might the purpose of the dish soap be? (Hint: what is captured in the soapy bubbles? How does this make the reaction more visible compared to the original Exploding Bags procedure?)
- If a student's bag did not 'explode,' ask them to brainstorm the reasons why. What can they do to ensure the bag will 'explode?' Help them write out the potential variables they could adjust and test a variety of solutions to see what works best.
- Does the size of the bag matter? Try the experiment again with a snack, sandwich, quart, and gallon bag using the same amount of reactants and see what happens.
- What is the purpose of the toilet paper? Try the reaction again with dropping the baking soda directly into the bag. Do you have enough time to seal the bag and experience the full reaction?
- 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?
- See what difference the temperature of the water makes. Ask students to make a prediction, then try the experiment again with cold, room temperature, and warm water. Are there any differences? What might be the purpose of the warm water? What if you do the experiment without water?
- Explore whether this is a physical or chemical reaction. What defines each type of reaction? What are some examples? What is the evidence that shows what type of reaction this is? Hint: write or draw the reactants and products. Are they the same or different?
- For more advanced students: write out the chemical formulas for the reactants and products. Ask students to balance the equation.
- Ask students to draw a diagram showing the movement of energy in the system. Where does the energy (heat) go in the reaction? Can they add this to their chemical equation? (Hint: if the products felt cold, energy is flowing into the reaction and it is endothermic, so heat is one of the inputs.)
- Doing this activity in the fall? Try it out in a jack-o-lantern! Place a small cup in the pumpkin and add in your liquids. You can be generous: ½ cup warm water, ½ cup vinegar, big squirt of Dawn® Ultra dishwashing liquid soap, a couple drops of food coloring (optional). Drop a heaping spoonful of baking soda into the cup, stir, and watch it foam out of the jack-o-lantern!

CHEMISTRY IN ACTION

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

Real-World Applications

You have already experienced this reaction dozens of times, especially if you are a baker or eat baked goods! Baking soda is a common ingredient in baked goods because when it reacts with acidic ingredients like vinegar, yogurt, buttermilk, or cream of tartar it produces carbon dioxide bubbles and makes dough rise!

Both vinegar and baking soda are common cleaning, deodorizing, and disinfecting products. Baking soda is commonly added to toothpaste, all-purpose cleaners, and various soaps and shampoos. It also absorbs odors, which is why people sometimes put open boxes of baking soda in their refrigerators and why it is added to kitty litter. Vinegar is often added to liquid cleaning or disinfecting products. There are lots of recipes for make-your-own cleaners using baking soda, vinegar, or both since they are such inexpensive, effective products!

Careers in Chemistry

- Developing, testing, manufacturing, and selling cleaning products is a big industry! Chemists work hard to create products that work best on specific surfaces, for certain types of stains or impurities, that are safe to use in the home, and good for the environment. Inexpensive and accessible products like baking soda and vinegar are common components in these products.
- How do you make the chewiest cookie? The fluffiest? One that doesn't spread out too much in the oven? Food scientists test dozens of different recipe tweaks to make sure baked goods you buy in the grocery store or make in your home are the best they can be.

EVALUATE

- 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.
- The reaction in this experiment is an acid-base reaction. Design a research project for students to explore other acid-base reactions in the world around them. What are some common acids and bases? What types of acid-base reactions happen in your body? In nature? In the school? What are the products of these reactions? Have each student or student pair/group share their findings with the class and see what commonalities or differences they note between their discoveries.