Rubber Eggs

Section CHEMICAL REACTIONS *Topic* ACIDS & BASES

Estimated Time Setup: 5-10 minutes; Procedure: 3-5 days

OVERVIEW

Students soak an egg in vinegar and within a few days the shell seems to disappear!

In this activity, students place a raw or hardboiled egg in a cup of vinegar. The basic calcium carbonate in the egg shell reacts with the acidic acetic acid in vinegar, and the shell dissolves into carbon dioxide, water, and calcium acetate. After a few days, the shell-less egg is all that is left, and students can easily see inside the egg and experiment further!

MATERIALS

For one setup:

- 1 hardboiled egg
- 1 cup of vinegar
- Clear cup
- 1 cup measurer

INQUIRY QUESTIONS

Getting Started:

- Are the changes in this activity due to a chemical or physical change?

Learning More:

- What changes occur when an egg is left in vinegar?

Diving Deeper:

- What type of chemical reaction occurs between an egg shell and vinegar?

CONTENT TOPICS

This activity covers the following content topics: acids and bases, chemical reactions, chemical changes, physical changes

This activity can be extended to discuss the following: human anatomy, nutrition, indicators, pH, animal life cycle and development

NGSS CONNECTIONS

This activity can be used to achieve the following Performance Expectations of the Next Generation Science Standards:

- **2-PS1-1:** Plan and conduct an investigation to describe and classify different kinds of materials by their observable properties.
- **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.

ACTIVITY NOTES

This activity is good for:

- Individuals
- Pairs
- Small groups
- Demonstrations

Safety Tips & Reminders:

- The activity can be performed with a raw egg, but be sure that an adult handles it or closely supervises young students since they will have to handle it gently.
- Be sure to wash eggs with warm, soapy water before using.
- There is no eating or drinking in the lab, even when we are working with normally edible materials.
- The vinegar and egg may have a strong odor. We recommend conducting this experiment in a well-ventilated area.
- Review the Safety First section in the Resource Guide for additional information.

ENGAGE

Use the following ideas to engage your students in learning about chemical reactions and acids and bases:

- Start with the final product: show some eggs with the shells removed. Ask students to brainstorm how you might have removed the shell. This is more entertaining with raw eggs, but could be much messier!
- For more of a life sciences focus, start with the anatomy of an egg. Students can dissect, label, and learn about each part and its function in development or protection. Use this activity as a way to examine the membrane and intact insides of the egg more closely.

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.

Fun Fact #1

The membrane of an egg is actually made of two separate layers: the internal and the external shell membranes. The egg shell is also filled with pores, allowing gases to move between the environment and the growing chick in the egg.

EXPLORE

Procedure:

1. Add one cup of vinegar and add it to the clear cup.
2. Place the egg in the vinegar, ensuring it is completely submerged (add more vinegar if it is not!).
3. Let the set up sit in a well-ventilated area (i.e. near a window) for 3-5 days. Record your observations daily.
4. After 3-5 days, carefully remove the egg from the vinegar and rinse. Observe and record your observations.

DATA COLLECTION & ANALYSIS

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

- What are the physical properties of the egg at the start?
- Observe the setup at the start of the experiment and every day. What do you notice?
- Why do you see bubbles? Where might they be coming from? What gas is in the bubbles?
- Draw a picture of the egg each day and note and changes.
- What are the physical properties of the egg at the end of the experiment?
- What is the chemical formula for vinegar? What chemical makes up an egg shell? Look these chemicals up online or in a textbook. What can you find about their properties?
- Is what you saw in this reaction a chemical or physical change? What is your evidence?

Notes

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 an egg is placed in vinegar, there is an acid-base reaction between the vinegar and the eggshell. Vinegar is a solution of acetic acid, CH_3COOH, in water. Most of the eggshell—around 95%—is calcium carbonate, $CaCO_3$. The rest of the eggshell is made of proteins.

Notice that the acetic acid is part of a mixture in vinegar, and the calcium carbonate is part of a mixture in the eggshell. Even though both reactants are part of a mixture, the reaction still takes place. This is because when multiple substances are physically mixed, each substance still retains its own chemical properties. Acetic acid in vinegar reacts the same way that pure acetic acid would react.

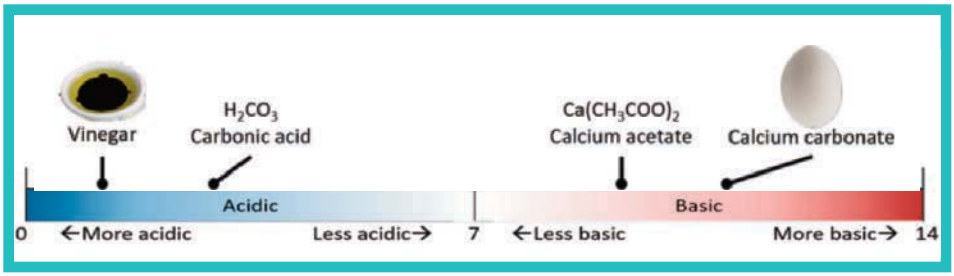
Acetic acid and calcium carbonate react to produce a new acid, called carbonic acid, and calcium acetate.

Acetic acid from vinegar	+	Calcium carbonate from the eggshell	⟶	Carbonic acid	+	Calcium acetate
$2CH_3COOH(l)$	+	$CaCO_3(s)$	⟶	$H_2CO_3(aq)$	+	$Ca(CH_3COO)_2(aq)$

During this step, the acetic acid dissolves the eggshell. It changes the solid calcium carbonate into dissolved carbonic acid and calcium acetate. Once vinegar has dissolved the shell, it leaves behind the soft inside of the egg. Without its shell, the egg is only covered by a thin membrane.

In the equation, the letters to the right of each compound indicate its state of matter. (l) is liquid, (s) is solid, and (g) is gas. Something that is (aq), which stands for **aqueous**, is dissolved in water. We start with solid eggshell and liquid acetic acid, and the products are both aqueous.

The products are all closer to neutral than the reactants. Acetic acid is a stronger acid than carbonic acid, and calcium carbonate is a stronger base than calcium acetate.



Notes

EXPLAIN continued

In addition to being a weaker acid than acetic acid, carbonic acid is unstable. As soon as it is formed, the carbonic acid decomposes. 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.

When carbonic acid decomposes, it produces carbon dioxide gas and water. This is why you might see tiny bubbles on the surface of the egg during this process. The gas bubbles that form on the egg are one way we can tell that a chemical reaction is taking place.

Step 1: Vinegar (acetic acid) reacts with the eggshell (calcium carbonate) to produce carbonic acid

$CH_3COOH + CaCO_3 \rightarrow H_2CO_3 + Ca(CH_3COO)_2$

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

$H_2CO_3 \rightarrow H2O + CO_2$

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	DIVING DEEPER
For younger students, emphasize the following concepts: • Different types of chemical reactions • New substances formed in chemical reactions • Properties and characteristics of acids and bases • Opposite charges attract	**For more advanced students, emphasize the following concepts:** • Neutralization reactions • Ions – cations and anions • Aqueous solutions • Decomposition reactions

Notes

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.

- Conduct this experiment with a control: have a second egg in water for the duration of the experiment and compare the two at the end.
- Want to see how the experiment progresses each day? Set up the experiment with a few eggs and start them all at the same time. Each day, remove one egg, wash and dry it, set it aside and label with the day it was removed. At the end of the experiment line the eggs up in order to see the progression of how the shell was removed day by day.
- Try other acids, like soda, juices, or different concentrations of acids. Which worked the best? What differences do students see?
- At the end of the experiment, leave the egg sitting out for another day. Do you notice any changes the next day? The egg might feel harder again as it absorbs carbon from carbon dioxide in the air.
- How does the concentration of the acid affect the results? Try making several samples of vinegar and water with various concentrations (i.e. ½ water and ½ vinegar, ¾ water and ¼ vinegar, etc.). Students can plot the pH (test with litmus paper or look up an estimate) versus the amount of time taken for the egg shell to fully dissolve.
- If you used a hardboiled egg, try bouncing it at the end of the experiment! Or, if you used a raw egg, try bouncing it in a sink. How high can it go?
- If you used a raw egg, now that the shell is removed you can use this opportunity to examine the inside of an egg! Turn the lights down and hold the egg in front of a flashlight. What can students see?
- Teach about osmosis and how membranes are permeable in this easy extension. If you used a raw egg for the first part of the experiment, after the shell is removed place the egg in a glass and cover with corn syrup. Let it sit for around three days, and you will notice the egg shrink! The egg membrane lets certain particles – like water – pass in and out. In this case, water leaves the egg and moves into the solution because of osmosis: the movement of water from a less concentrated solution into a more concentrated one to equalize the concentrations on both sides of the membrane. There is more water in the egg than in the corn syrup, so it moves through the membrane, out of the egg, and into the syrup. Place the shrunken egg into a glass of water next and let it sit for a few days. See if the reverse process happens now! (If you want to prove to students that the water is moving in and out, try using food dye to color the water first! You can also weigh the egg before and after each step.) Test out different liquids to see which ones make the egg grow, and which ones make the egg shrink.
- Add in some physics: do the experiment with a dozen raw eggs, then test how strong the membrane is by dropping them from various heights or placing different weights on them. (Warning: this will be messy, so ensure you do this outside or with plenty of space and table coverings inside!)
- Write a secret message or design with a white way crayon on the eggs before putting it in the vinegar. The wax covers and protects the egg shell and does not react with vinegar. At the end of the experiment the shell will be gone everywhere except where you drew with the crayon!

EVALUATE

- Ask students to draw a diagram of the experiment and label each chemical present (both reactants and products) along with a short explanation of what is happening in the experiment.
- Provide groups of students with mystery liquids, which could be acids, bases, or neutral. Students can explore the properties of the liquids and test the pH with an indicator (like litmus paper) or look it up online to check the pH once they know what it is. Have them make a guess: will this react with the calcium carbonate and dissolve the shell? Why or why not? Test it out and see if the predictions were correct!
- Make this a research project! We know that calcium carbonate has many different functions and uses in our world and in our bodies. Have your students do some research and learn more about this compound and what they find most interesting about its functions.

Fun Fact #2

Calcium carbonate is found in our bones, teeth, and in minerals around the world.

CHEMISTRY IN ACTION

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

Real-World Applications

The chemical in the egg shell – calcium carbonate – is the same thing that makes up our bones. You can try this experiment with chicken bones, and even tie them into knots at the end!

Too much acidity can wear away at tooth enamel. The acids in soda pops, fruit juices, and other types of highly acidic foods and beverages can corrode the calcium in your teeth, leading to sensitivity, cavities, or other health problems.

Calcium in the eggshell supports the structure of the shell. People also need calcium. Calcium helps to support bone and tooth structure, which is why we say that calcium keeps bones and teeth strong! Milk and other dairy products are primary sources of calcium in human diets, as are dark-green, leafy vegetables. Many foods have been fortified with added calcium. By eating a wide variety of foods with calcium, you can help ensure that you get the calcium you need each day to stay strong and healthy.

Careers in Chemistry

- Farmers need to ensure that the eggs their hens produce have strong shells that won't break in transit. The strength of the shell (or the amount of calcium carbonate) is related to a variety of factors, such as diet, age, the environment, and more.
- Calcium carbonate is common in pharmaceutical medicine. Tablets of calcium carbonate are used as an antacid, and calcium supplements are used to prevent osteoporosis.
- Many living things in the ocean, such as oysters and clams, have shells made of calcium carbonate. Because of increasing carbon dioxide in the atmosphere from human emissions, the ocean is becoming more acidic. Oceanographers, marine biologists, chemists, and other types of scientists are studying the risk that this poses for calcium carbonate shells that dissolve in strong acids.

.

Notes