Egg Dye Solutions

Section **CHEMICAL REACTIONS** *Topic* **ACIDS & BASES**

Estimated Time Setup: 5 minutes; Procedure: 10-15 minutes

OVERVIEW

Students discover how acids and bases can impact the amount of dye an egg shell can absorb through a chemical reaction.

In this activity, students dye three eggs: one in an acid, one in a base, and one in neutral water. Though the dyeing solutions are the same colors at the start, the egg in the acidic solution will be dyed much darker than the other two samples. The acid reacts chemically with the calcium carbonate and protein egg shell, thereby allowing the dye to better bind to the shell.

INQUIRY QUESTIONS

Getting Started:

- Is dyeing an egg a physical or chemical change, or both? How can we create a dye that will color an egg best?

Learning More:

- What chemicals are in the shell of an egg, and how might they react to an acidic or basic solution?

Diving Deeper:

- What chemical reactions take place when an egg is placed in an acidic, basic, or neutral solution, and how do these impact the dyeing process?

CONTENT TOPICS

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

This activity can be extended to discuss the following: nutrition, pH scale, indicators

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.

MATERIALS

For one setup:

- 3 hardboiled eggs
- 3 cups
- 3 plastic spoons
- 1 cup of a household acid (i.e. vinegar, lemon juice, orange juice)
- 1 cup of a household base (i.e. borax, milk of magnesia, ammonia)
    - Note: If your sample is a solid, like borax, first add to one cup of water until no more solid can dissolve. Use this liquid solution for the experiment.
- 1 cup water
- Food coloring
- Masking tape and marker

Optional materials:

- Red and blue litmus paper

ACTIVITY NOTES

This activity is good for:

- Individuals
- Pairs
- Small groups
- Large group
- Demonstration

Safety Tips & Reminders:

- This activity can be a bit messy, so we recommend covering your work surface with newspaper or a plastic tablecloth, and that students wear gloves.
- Be sure to wash eggs with warm, soapy water before using.
- There is no eating or drinking in the laboratory—even when we are working with normally edible materials.
- 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:

- Ask your students if they have ever dyed eggs. If so, how do they do it? What do they think is the best way to get brightly-colored eggs?
- Challenge students to think of the best way to dye an egg. How much time would they leave it in? How much food coloring would they add? What liquid solution do they use? What other factors might make a difference?

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. Test each acid or base sample with litmus paper to determine whether it is an acid or a base. If you do not have litmus paper, ask students to make a guess or look up the values online.
2. Fill one cup with water.
3. Fill each other cup with either an acid or base sample.
4. Label each cup with the name of the acid or base sample used.
5. Add 3-5 drops of the same food coloring to each cup and mix with the spoon. If the samples are not the same color, add more food coloring until they are (i.e. milk of magnesia is white, so more food coloring will have to be added for it to appear the same color as the other samples).
6. Place each egg in its corresponding cup, ensuring that the egg is completely covered by the liquid (add more if it is not!).
7. Let eggs soak for 10 minutes.
8. After 10 minutes, remove each egg and gently rinse under water.
9. Observe and record the appearance of each egg.

DATA COLLECTION & ANALYSIS

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

- Make a prediction at the start: is each liquid an acid, base, or neutral? Why do you think this? Confirm your prediction with pH paper or by looking up the pH of your sample online or in a textbook.
- Do you think each egg will be the same color at the end of the experiment? Why or why not?
- Look closely at the eggs as they are submerged. Do you notice anything? Do the three eggs look like they are responding the same way in the liquids?
- After the eggs have been removed and rinsed, take note of the appearance of each egg. Are they similar or different?
- Examine each egg closely or using a hand lens. What do can you notice up close?
- Which dye solution worked the best? Which worked the worst?
- Are acids, bases, or neutral solutions best for dyeing eggs bright colors? Why might this be the case?

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—for example, when we dye eggs different colors! Each of these reactions is affected by the conditions around it, like temperature and concentration. Changing the conditions could make a reaction happen faster or slower or could make a reaction not happen at all.

Another factor that can affect reactions is pH. The **pH scale** measures how acidic or basic something is. pH can range from 0 to 14. **Acids** are substances with a pH less than 7. **Bases** are substances with a pH greater than 7. Whether something is acidic, basic, or neutral depends on the concentration of hydrogen ions, H^+. In a strong acid, there is a high concentration of H^+ ions floating around. All of these H^+ ions can make other compounds act differently.

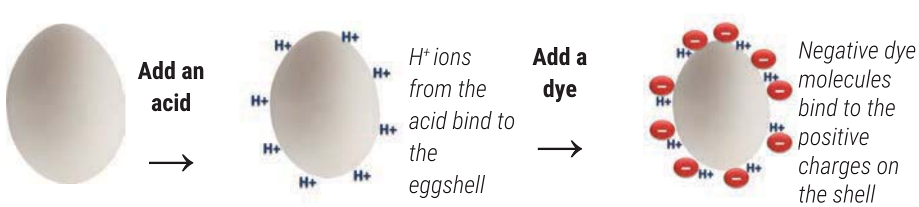
An **ion** is a charged particle formed when an atom gains or loses and electron. Ions can be either positive or negative. For example, H^+ is positive and OH^- is negative. Positive ions and negative ions are attracted to each other and form bonds—in other words, opposites attract!

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, like acetic acid does in water, it is called **dissociation**. This dissociation is why vinegar is acidic.

Lemon juice and orange juice also contain acids that dissociate to release H^+. Lemon juice contains citric acid, and orange juice contains multiple kinds of acids. The pH of the acid solution in this experiment depends on which acid you use, and on how much you dilute it with water.

When an egg is placed in an acidic solution, where there are lots of loose hydrogen ions floating around, the hydrogen ions bind to proteins in the egg's shell. All of these H^+ ions crowding around the eggshell give it a positive charge.

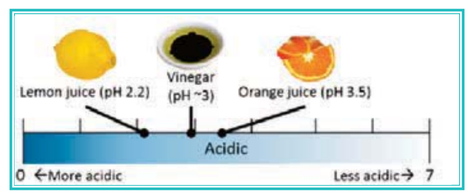
The dye that we use to color eggs also dissociates in water. Dye molecules have a positive part and negative part. The negative part is what gives the dye its color. In water, the positive and negative parts break apart from each other. Since opposites attract, the negative dye molecules floating around bind to the positive charges on the eggshell.



Without the acid present, the dye molecules don't chemically bind to the eggshell. We can see this by comparing how well each of dye solutions colored the egg. In neutral and basic solutions, some dye molecules may get stuck in the pores of shell and color it slightly, but there are no extra H^+ ions to help bind the dye to the shell. More dye molecules will be attached to the shell in the acidic solution, giving it a more intense color.

Fun Fact #1

Did you know: hens with white ear lobes typically produce white eggs, and hens with colored ear lobes usually produce brown eggs – though there is no nutritional difference between white or brown-shelled eggs.



EXPLAIN continued

The dye molecules binding isn't the only thing that happens when the egg is placed in acid. The proteins that bind to H^+ are only a small part of the eggshell. Most of the shell—around 95%! —is calcium carbonate, $CaCO_3$. Acid reacts with calcium carbonate and makes it dissolve, producing bubbles of carbon dioxide gas. This is why small bubbles form on the egg's surface in acid solution. If the solution is too acidic, the shell will dissolve.

So how can we tell whether the solution is not acidic enough, too acidic, or just right? An **indicator** is a substance that changes color at different levels of acidity. **Litmus paper** is commonly used as an indicator. Some litmus paper turns a different color for each number on the pH scale. Other litmus paper just indicates acid or base. For example, blue litmus paper turns red when it is in an acidic solution. Red litmus paper turns blue in a basic solution.

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:

- Different types of chemical reactions
- Properties and characteristics of acids and bases
- Reactions are affected by conditions like temperature and pH
- Opposite charges attract

DIVING DEEPER

For more advanced students, emphasize the following concepts:

- Neutralization reactions
- Ions – cations and anions
- Aqueous solutions
- Substances can dissociate in solutions

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.

- Want to check out another fun experiment with eggs and vinegar? Go to the Rubber Eggs Activity Guide!
- Does temperature matter? Try the experiment again using three samples: hot water, half hot water and half room temperature vinegar, and half room temperature water with half room temperature vinegar. Do the results differ?
- Use a wax crayon to write or draw on the eggs at the start of the experiment. The dye will not adhere to the wax-covered parts of the egg. Why do students think this might be?
- Want more vibrant colors? Soak the eggs for an hour or two to see more drastic results.
- How does the concentration of the acid change the results? Try the experiment again but with solutions of varying concentration: 1 cup water, 1 cup water plus 1 tsp. vinegar, 1 cup water plus 2 tsp. vinegar, etc. Check the pH and see how well each works!
- There are an endless number of acid-base reactions in the natural world around us, and even in our own bodies. Task students with looking up some examples online and presenting them to their peers. Or, can they make a list of acids and bases in their environment? If they are unsure, provide pH paper and ask them to test at least 3 substances and report back to the class.

Notes

CHEMISTRY IN ACTION

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

Real-World Applications

Egg-dyeing kits that can be bought at the store also recommend adding vinegar to water to get the most colorful eggs!

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.

Careers in Chemistry

- Developing dyes is a serious science, and one that has been around for centuries. Chemists and artists often work together to develop the perfect colors for various industries and uses.
- Color scientists in the food industry are tasked with producing dyes that are edible, taste good (or have no taste!), easy to manufacture, are specific colors, and approved by the Food and Drug Administration.

Notes

EVALUATE

- Provide groups of students with various household acids, or vinegar diluted to different concentrations. Ask them to test the pH or look it up if they know the name of the sample. Based on the original experiment, students should make a prediction as to how well the food coloring will be absorbed into the egg shell. What evidence do they have? They can test it out and see how close their predictions were.
- Have individual students draw a diagram of what is happening at the molecular level in this acid-base reaction. Can they make a single or multi-panel cartoon or image that visually represents what is happening? Or can they create an advertisement for an egg dye company with recommendations on best practices for dyeing eggs?
- At the end of class, have each student fill an exit ticket about the experiment. It could ask them to explain which substance – the acid, base, or neutral liquid – worked best for dyeing eggs bright colors and why. Or provide them with mystery substances with known pH measurements and ask them to write or draw and label what they think will happen if those samples are used to dye a series of eggs.

Fun Fact #2

Depending on the breed of chicken, hens might lay their own 'dyed' eggs that are white, pink, brown, blue, green, speckled, striped, and more! The color of the egg is based on the genetics of the hen, and chickens can be bred to produce chicks that lay eggs of specific colors.