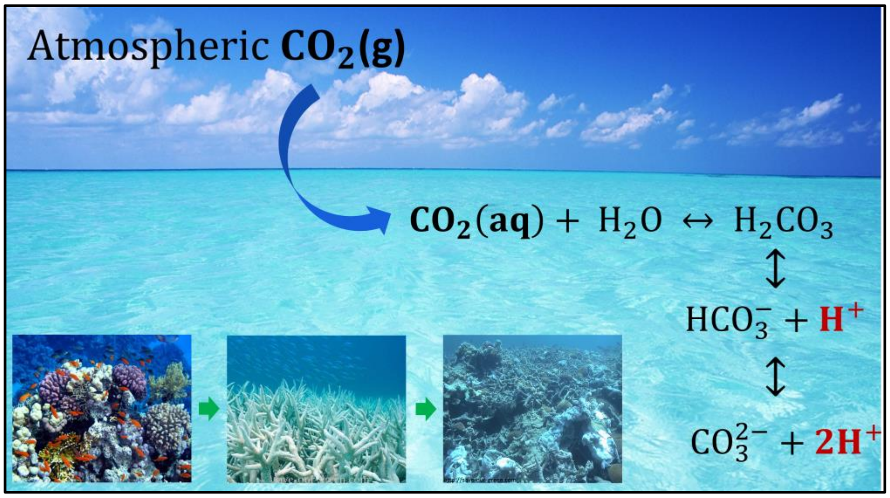
Ocean Acidification

Overview



Over the last 200 years, the release of carbon dioxide (CO_2) from personal, industrial and agricultural activities has rapidly increased the amount of CO_2 in the atmosphere. The oceans absorbs about a quarter of the CO_2 we release into the atmosphere every year, so as atmospheric CO_2 levels increase, so do the levels in the ocean. CO_2 absorbed by the ocean is increases the acidity (or the concentration of H^+) of seawater. This contributes to ocean acidification. Over the last 250 years, ocean pH has reduced from 8.25 to 8.14. At slightly lower pH (i.e. more acidic conditions) animals with calcium-containing shells, like oysters, clams, and corals are at risk of their shells dissolving.

Target Audience: grades 4+, STEM fair or short classroom/home kitchen activity.

Vocabulary

- An acid is a chemical that increases the acidity of a solution.
- A base decreases the acidity of a solution and increases its basicity.
- A neutral solution is neither acidic nor basic.

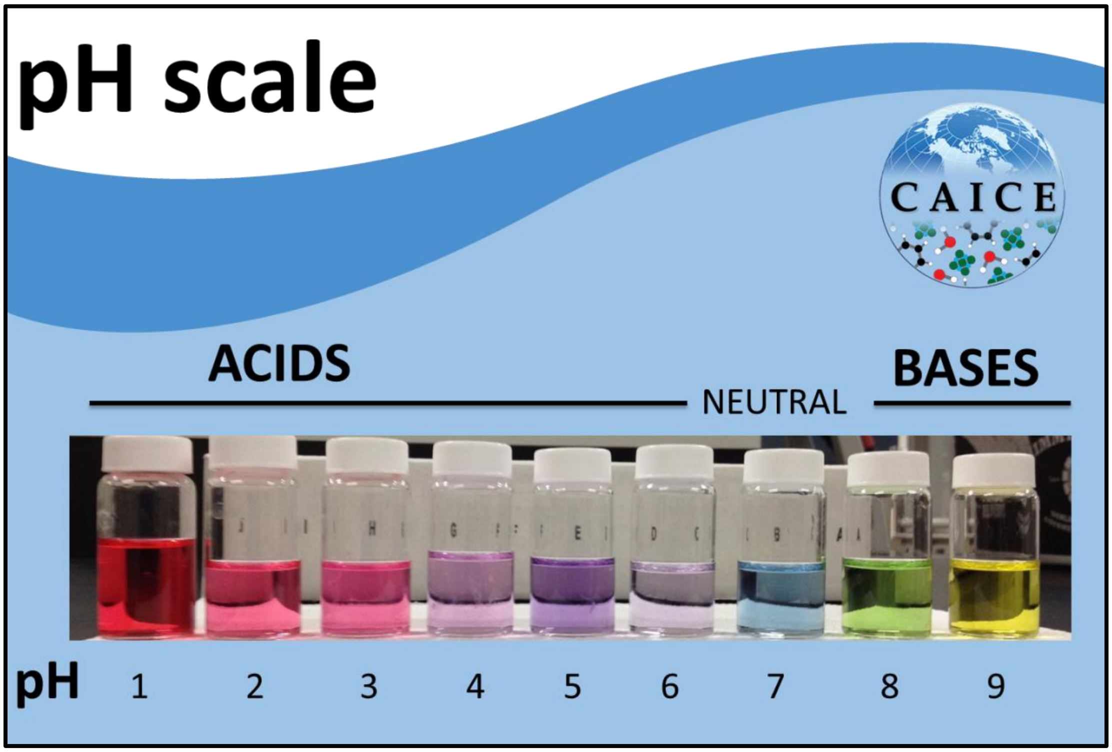
Learning Objectives

- To transfer liquids using a pipet
- To identify acids and bases using a colorimetric indicator
- To observe that acids dissolve shells

Materials and Supplies

- Laboratory glasses
- Red cabbage indicator (*see solution preparation below)
- Vinegar (*a weak acid*)
- Baking soda (*a weak base*)
- Tap water
- A cup for dissolving baking soda.
- Egg shells – washed and dried

- Eyedroppers or small plastic pipets (for drop wise transfer of the indicator)
- Small see-through vials
- pH scales (a print copy is provided in these materials, or make your own)



Solution preparation (to be done by an adult in advance)

Red cabbage indicator – Shred ¼ red cabbage in a food processor with 1 cup of water. Heat mixture on stovetop and bring to a boil for 10 minutes uncovered. Remove from heat and let cool. Filter out the solids with a coffee filter. The resulting dark blue solution is the indicator.

Saturate baking soda in water by adding baking soda to a 1 cup of water while stirring until no more baking soda dissolves and the water is in contact with the white solid. This is the "saturated baking soda" solution.

Test solutions **–** Transfer the following liquids to see-through vials. Plan to have one acid and one neutral solution for each student.

- White vinegar
- Saturated baking soda
- Mixtures of vinegar and baking soda (at 1:1, 1:5, or 1:10 dilution ratios)

Ocean Acidification

To make your own color scale – adult chemical handling and additional safety precautions are required. Use strong acids or bases only in a laboratory setting that is well-removed from food consumption. Only an adult should handle the following materials and shall heed the safety instructions on their respective packages:

- A drop-sized amount of powdered dishwasher detergent (*a strong base*) will saturate 10 mL of water, providing an approximately pH 10 solution.
- Approximately 5 mL of shower cleaner designed to remove soap scum (*a strong acid*) transferred safety from the container provides an approximately pH 2 solution.

Color points between the strong acid and vinegar can be obtained by diluting the strong acid. To do the dilution at a 1:10 ratio, slowly adding one part acid to 10 parts of water. The resulting solution is then diluted in a 1:10 ratio until the color of vinegar is reached. The strong base can be likewise diluted, by slowly adding one part strong base to 10 parts of water.

Instructions

1. Introduce students to the pH scale of the red cabbage indicator. Name the acidic, neutral and basic regions.
2. Demonstrate how to use an eyedropper (or plastic transfer pipet).
3. Give test solution to each student. Instruct them to transfer 3-5 drops of red cabbage indicator to these solutions and observe closely. Ask:
   - What do you see when the indicator is added?
   - What color is the color of the final solution?
   - Using the pH scale, is this solution acidic or neutral?

   Come to agreement on the answers to these questions for the blue (basic) and pink (acidic) solutions.

   Observations and explanations: An indicator is a chemical whose color changes in response to solution conditions. Red cabbage contains a number of compounds whose colors change in response to solution pH. The neutral and basic solutions appear blue. The vinegar appears pink. Intermediate pH solutions appear purple. The indicator may fizzle when added to the acid; these bubbles are a product of a fast chemical reaction between and acid and a base that releases a gas.

4. Instruct the students to add a small piece of eggshell to each solution. Using the indicator and pH scale Discuss:
   - What do you observe in the acidic solution?
   - What do you observe in the basic solution?
   - What is happening?

Ocean Acidification

Explanation: Students will see small gas bubbles forming on the surface of the eggshells in acidic solution. This is (CO_2) formed from bicarbonate in the acidic solution. The proton (H^+) from acetic acid is transferred to bicarbonate (HCO_3^-) from the shell forming CO_2 gas and water. As CO_2 leaves the solution, the reaction proceeds, and the shell continues to dissolve. Gas bubbles rise that form on the surface of the eggshell may lift the eggshell. With enough time, the eggshell will disintegrate.

In the ocean marine organisms whose shells contain carbonates are at risk from ocean acidification. As the pH of the ocean becomes more acidic, their shells will not form. This will cause a change in the distribution of marine organisms, towards those that can survive at more acidic pH.

Safety and waste disposal

All participants shall wear safety goggles to protect their eyes from any splashing. If opting to use strong acids and bases in making your own color scale, heed the warnings on the chemical bottles. Dilute acids and bases with excess tap water. The pH should be neutralized to pH 7 before passing down the drain with plenty of excess tap water.