WATER IS SO MUCH (PH)UN!

GRADES 9-12

OBJECTIVE

Help students understand the link between water chemistry and pH.

MATERIALS

- Litmus strips – Can be purchased at swimming pool supply stores, pet stores (aquarium section), or online retailers such as Amazon.com
- Distilled water
- Orange juice
- Soda pop (Coke, Pepsi, etc.)
- Soapy water (Dish soap mixed at a water to soap ratio of 10:1)
- Drain cleaner (Drain cleaner mixed at a water to drain cleaner ratio of 10:1)

BACKGROUND

The vast majority of high school students know that the chemical formula for water is H2O; however many students struggle to understand how H (Hydrogen) and O (Oxygen) behave in solution. Understanding the nature of water's constituent elements and the electrical forces that bind them can help students better understand the fundamental concept of pH, preparing them for advanced science courses and a practical understanding of basic chemistry.

Chemical bonding is built upon the fact that opposites attract. Hydrogen has a positive (+) charge and is written as H^+. On the other hand, oxygen has a negative charge (-); in fact oxygen has a double negative charge and is written O_2^-. Opposites attract, or as the song says, there are"attractive forces at work." Atoms are more stable in compounds that have a more balanced charge, so when one H^+ meets one O_2^- they get together to form OH^-. Water is made when the OH- combines with an H^+ to form H_2O, a neutral (zero charge) molecule.

DEFINITIONS

Acid - A chemical that donates extra H^+ to a solution. A substance with a pH below 7 is said to be acidic.

Base - A chemical that donates extra OH^- to a solution. A substance with a pH above 7 is said to be basic.

Buffer - A substance that prevents pH from changing drastically.

Compound - A mixture of two or more different types of chemical elements/atoms.

pH - The measure of how acidic or basic a substance is. pH stands for "power of hydrogen."

Solution - A mixture of two or more substances in a liquid.

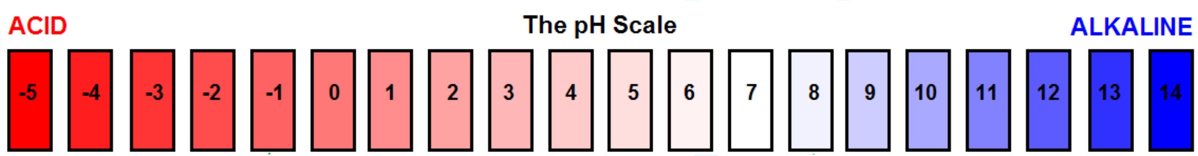
Background (cont.)

Oftentimes there are situations when there are lots of OH^- ions and only a few H^+, or vice versa; lots of H^+ but not enough OH^- to balance out all of the H^+. When this happens H_2O is still formed, but depending on what is left over we may have an acid or a base. For example, if we have extra H^+ left over we just formed an acid. On the other hand, if we have extra OH^- left over we have just formed a base.

The strength of acids and bases are measured on the pH scale. This scale ranges from 0-14, with lower numbers being more acidic and higher numbers being more basic. For example, a pH of 1 indicates a very acidic substance, whereas a pH of 13 indicates a very basic substance. Since 7 is in the middle of 0 and 14, it is neutral. Pure water has a pH of 7 because all of the H^+ has combined with all of the OH^-.

Acids are formed from a solution having extra H^+. Many of us are familiar with acids. Some acids, such as hydrochloric acid, are strong enough to eat through steel, whereas other acids, such as citric acids, are common in our foods. In fact, citric acid is the chemical that gives lemons and oranges their sour taste. Bases are formed from a solution having extra OH^-. Many of us are less familiar with bases, even though we use them on a daily basis (pun intended!). Baking soda and soap are two examples of common chemicals that are bases.

Water has a neutral pH and acts as a buffer to prevent extreme pH fluctuations in the environment. In order for water to best perform this crucial buffering function it is best that it is kept as clean as possible.



Teacher Preparation

Prior to the onset of this exercise, teachers should place each of the materials in a single row to allow student groups to test the pH of each solution using the litmus strips.

Instructions

1. Each group of students will partially insert one strip of litmus paper into a single chemical solution. The litmus paper will turn color, indicating the pH of the chemical solution. Each pH should be recorded; litmus strips are not to be reused.
2. After the initial pH of each chemical solution has been recorded, add one cup of distilled water to each solution. Re-test each solution with litmus paper and record the results.

Discussion Questions

Prompt students to answer the following questions after the experiment data have been recorded:

- Which chemicals were acids (pH below 7) and which were bases (pH above 7)?
- Were any of the chemical solutions at neutral pH (pH 7)? Were these results surprising?
- How can being exposed to something that is very acidic or very basic be dangerous to a person?
- What, if any, changes occurred to the pH of each solution after the distilled water was added?
- What role does clean water play in keeping pH from getting too high or too low?

Challenge Question

Heartburn is a medical condition caused by a person's stomach acid being regurgitated. This condition is often treated by giving the person an antacid which is made up of bicarbonate ($HCO3^-$). Explain how bicarbonate can reduce the acidity of the stomach. Also explain why a person that drinks a lot of water may experience less heartburn.

Additional Resources

http://imnh.isu.edu/digitalatlas/hydr/basics/main/chmtxt.htm (Water chemistry background information)
http://water.usgs.gov/edu/ph.html (Water properties-pH)
http://www.chem4kids.com/files/react_acidbase.html (User-friendly summary of acids and bases)
http://www.youtube.com/watch?v=vrOUdoS2BtQ (pH change demonstration video)
http://www.youtube.com/watch?v=M8tTELZD5Ek (pH scale video)