LESSON PLAN: pH Rainbows

Description
This activity is meant to extend your students' knowledge of the topics covered in our Chemicals of Innovation lab. Through this activity, students will learn the difference between acids and bases and will test the pH of some everyday household products.

Grade Levels
5-8

Duration
45-60 minutes

Student Outcomes
Students will:
- Determine if a chemical is an acid or base.

Next Generation Science Standards
- Physical Sciences **Grade 5:** 5-PS1-3, 5-PS1-4
- **Grades 6-8:** MS-PS1-2

Common Core ELA Standards
- **Grade 5:** Speaking and Listening 5.SL.1b-d
- **Grades 6-12:** Speaking and Listening SL.1b-e

Materials (one set per group of 4 students)

- Colored pH scale image
- Paper towels
- 1 disposable pipette or liquid medicine dropper
- 7 coffee stirrers or small straws
- Tablespoon
- 1/2 cup cabbage juice pH indicator (materials and instructions below—must be made ahead of time)
- 7 small clear plastic or paper cups, labeled, each containing one of the following:
  - 1 tsp. baking soda
  - 1 tsp. clear dish soap or powdered soap
  - 1 antacid tablet
  - 2 Tbsp. lemon juice
  - 2 Tbsp. clear soda (Sprite)
  - 2 Tbsp. milk
  - 2 Tbsp. filtered or bottled water

Cabbage Juice pH Indicator Materials

- 1 head of red cabbage
- 4 cups water
- Pot for boiling water
- Glass or ceramic heat-proof bowl
- Re-sealable container

Procedure
1. Boil water. While waiting for the water to boil, cut cabbage into quarters and place in bowl.
2. Once the water boils, carefully pour the water over the cabbage and let it sit for 15-20 minutes.
3. After the water has turned dark purple, strain the cabbage out of the water and pour the water into the re-sealable container and refrigerate until ready to use. If the indicator will not be used for several days, wrap the container in foil to keep light out.

Vocabulary

Familiarity with these terms and concepts will enhance students' experience in the activity.

- **Ion:** An atom that has either lost or gained an electron.
- **Hydrogen ions (H±):** Atoms of hydrogen that have lost their one and only electron.
- **Hydroxyl ions (OH^-):** Molecules of hydroxyl (one hydrogen atom bonded with one oxygen atom) that have gained an extra electron.
- **Acid:** A chemical solution that releases excess hydrogen (H^+) ions when water is added.
- **Base:** A chemical solution that releases excess hydroxyl (OH^-) ions when water is added.
- **Neutral:** A chemical solution that has equal amounts of hydrogen and hydroxyl ions.
- **pH:** The measure of how acidic or basic a solution is.
- **Indicator:** Something that changes color to indicate whether the solution is acidic or basic.

Procedure

1. Students will work in groups of four for this activity. Each group should have one set of the above materials. You can also have your students get their own materials if there isn't time to pre-prepare the cups.
2. Begin with a discussion about acids, bases and the pH scale.
    a. An <u>acid</u> is a solution that, when water is added, releases excess <u>hydrogen ions</u> (H^+).

    $\xrightarrow{H_2O}$

    Ex.: HCl (Hydrochloric acid) $\mathbf{H^+} + Cl^-$ The addition of water does not make a chemical reaction; it dissociates, or breaks up, the acid.
    b. A <u>base</u> is a solution that, when water is added, releases excess <u>hydroxyl ions</u> (OH^-).

    $\xrightarrow{H_2O}$

    Ex.: NaOH (Sodium hydroxide) $Na^+ + \mathbf{OH^-}$ The addition of water does not make a chemical reaction; it dissociates, or breaks up, the base.
    c. Strength of acids and bases is determined using the pH scale. The scale is from 0-14, with 0 being the most acidic (greatest amount of hydrogen ions), 7 being neutral (equal amounts of hydrogen and hydroxyl ions) and 14 being the most basic (highest amount of hydroxyl ions). Acids have a pH from 0-6.9 and bases have a pH from 7.1-14. Show the pH scale so students can see the range of pH and associated color.
    d. Chemists use pH indicators that change color to indicate whether or not the solution is an acid or a base. The pH indicator used in this experiment is made from red cabbage.
3. Experiment: Each team will have their set of materials at their station. All cups should be labeled with the corresponding item in the cup. All cups should be on white paper to see the color change appropriately.
    a. Before using the cabbage juice pH indicator, have students make and record their hypotheses on which solutions/compounds are acids and which are bases.
    b. Have students add one tablespoon at a time of pH indicator to the first cup (it doesn't matter which solution is tested first, but they should only do one at a time). Students should make observations: What color did the solution turn? What does that mean? Compare the color to the pH scale to determine the approximate pH. Make sure students record their findings on their worksheets.
    c. Have students continue until all of the solutions have been tested. Teams can compare their results with another team.
    d. Once teams have tested all of the solutions, have them try combining some of the solutions. Make sure they make hypotheses first: What will the new pH be? What color will it be? Will there be any other observable changes? What will happen when you combine an acid and a base? A base and a base? An acid and an acid? Teams should record their hypotheses and their observations upon experimentation.

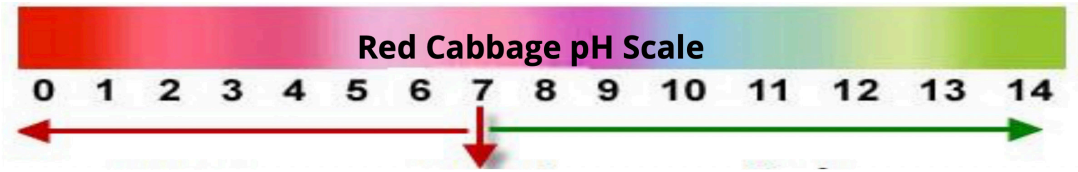
4. Wrap up: Have teams share their observations. Were their hypotheses correct? What were the results of mixing some of the solutions? What was the result of mixing an acid and a base? A base with a base? An acid with an acid?
    a. Combining an acid and a base should have resulted in a neutral solution. Ask students why they think this happened (remind them that acids have excess hydrogen ions (H+) and bases have excess hydroxyl ions (OH-).
        - When the acid and base are combined, they not only react, but the excess hydrogen and hydroxyl ions bond to form H2O, which is neutral.
    b. Combining an acid and an acid should have resulted in an acidic solution, but not a stronger acid, as many students are likely to predict. The strength of the acid is dependent on the concentration of hydrogen ions (# of ions per milliliter or other volumetric measurement). Although the combination of two acidic solutions would increase the amount of hydrogen ions, the volume of the solution has also increased so the concentration remains the same or similar. The same principle applies to the addition of a base to a base.

Extended Learning

Students can test out different brands of bottled water versus different tap waters from around the area. Although water should be neutral, some waters (particularly tap water) may be slightly acidic or basic. Another water type to be tested is rain water (if possible). Rain water is generally slightly acidic, which could be a discussion/tie-in with environmental science.

Acid and Base Rainbows Activity Sheet

Chemical Compound	Hypothesis	pH	Color	Observations



Acidic	Neutral	Basic