TEACHER GUIDE

CHEMISTRY'S RAINBOW: THE POWER OF pH

MATERIALS PER GROUP:

- Water
- Citric acid ($C_6H_8O_7$)
- Sodium carbonate (Na_2CO_3)
- Universal indicator
- Universal indicator color chart
- Nine small (3 oz.) clear plastic cups
- Two mini-scoops
- Two plastic pipettes
- Plastic beaker (90 mL)
- One quart-sized Ziploc® bag
- Alka-Seltzer® tablet

TOTAL DURATION:

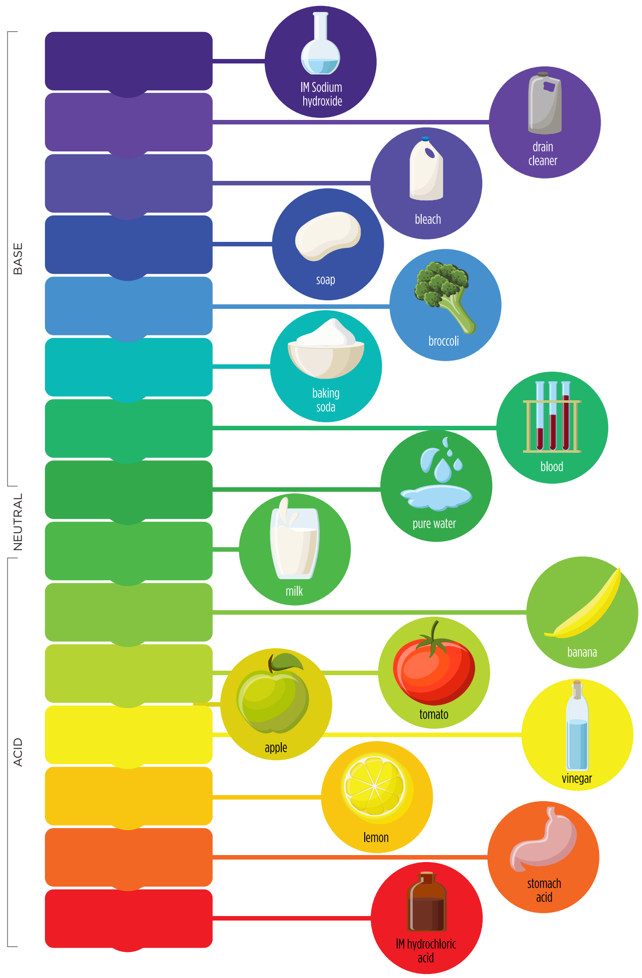
20-30 min. pre-lab prep time;
40-50 min. class time

LESSON OBJECTIVES:

Students will be able to:

1. Use the pH scale to classify solutions as acids or bases.
2. Neutralize an acid and a base.
3. Determine the relative concentrations of hydrogen ions in a solution.

An education and outreach program of:
NOBLE RESEARCH INSTITUTE



LESSON OVERVIEW:

In **chemistry,** pH is a measure of the acidity or basicity of an **aqueous** solution. The concentration (or amount) of hydrogen **ions** (H+) present in a **solution** determines whether the solution is **acidic** or **basic**; acidic solutions have more H+ and basic (or **alkaline**) solutions have fewer H+.

ESSENTIAL QUESTION:

What is the relationship of acids and bases in nature?

TOPICAL ESSENTIAL QUESTION:

Can the pH of a solution be altered?

Noble Research Institute, LLC • 2510 Sam Noble Parkway • Ardmore, OK 73401 • www.noble.org • 580-223-5810

STANDARDS:

Middle School

MS-PS1-2

Students who demonstrate understanding can:
Analyze and interpret data on the properties of substances before and after the substances interact to determine if a chemical reaction has occurred.

High School

HS-PS1-2

Students who demonstrate understanding can:
Construct and revise an explanation for the outcome of a simple chemical reaction based on the outermost electron states of atoms, trends in the periodic table, knowledge of the patterns of chemical properties, and formation of compounds.

Science and Engineering Practices:

1. **Asking questions**
2. **Developing and using models**
3. **Planning and carrying out investigations**
4. **Analyzing and interpreting data**
5. **Using mathematics and computational thinking**
6. **Constructing explanations and designing solutions**
7. Engaging in argument from evidence
8. Obtaining, evaluating and communicating evidence

Crosscutting Concepts:

1. **Patterns**
2. **Cause and Effect: Mechanisms and explanations**
3. **Scale, Proportion and Quantity**
4. Systems and System Models
5. Energy and Matter: Flows, cycles and conservation
6. **Structure and Function**
7. **Stability and Change**

KEY VOCABULARY:

Chemistry	Aqueous	Solution
Indicator	Base	Buffer
Acid	Alkaline	
Ion	Neutralize	

SAFETY PRECAUTIONS:

- Avoid contact of all chemicals with eyes and skin. When performing the experiment, always wear safety glasses, and if available, lab coat and gloves.
- Sodium carbonate, citric acid and the universal indicator are not considered hazardous. However, prudent safety procedures should always be observed when handling chemicals in the laboratory.
- Do not eat, drink or chew gum while in the laboratory.
- Wash hands thoroughly with soap and water before leaving the laboratory.

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

LAB BACKGROUND INFORMATION:

NOTE: This is background information for the teacher to assist in facilitating learning and will be explained to the students after the Explore section.

Figure 1

In **chemistry,** pH is a measure of the acidity or basicity of an **aqueous** solution. The concentration (or amount) of hydrogen **ions** (H+) present in a **solution** determines whether the solution is **acidic** or **basic**; acidic solutions have more H+ and basic (or **alkaline**) solutions have fewer H+.

The pH scale (Figure 1) is a logarithmic scale (each number represents a tenfold change) ranging from 0 to 14, with 7 being **neutral**. A pH below 7 is acidic and above 7 is basic (or alkaline).

Virtually every biological process depends on pH, and even slight deviations from these values may be detrimental to the cell or organism. Therefore, maintaining proper pH is essential for life.

In humans, blood pH is maintained at a value between 7.35 and 7.45. This is the pH at which blood carries the maximum amount of oxygen. If blood pH drops below 6.8 or rises above 7.8, death may occur. Fortunately, we have **buffers** in our blood to help protect against such drastic changes.

There are many agricultural processes that rely on pH in order to occur. Perhaps the most important is related to plants. Plants sustain life on Earth; they produce the oxygen we breathe, the food we eat and the clothing we wear. Plants must have soil to grow; therefore, soil indirectly sustains life as well, and we must take care of it.

Soil pH is very important to a plant's ability to grow. Soil pH is the measure of acidity or basicity in soils. It is considered an important factor in soils as it controls many chemical processes. In the soil, changes in pH can affect a plant's ability to take up essential nutrients and may reduce the population of important soil microorganisms. Fortunately, producers (farmers and ranchers) can monitor their soil by testing its pH and make adjustments to the pH with soil amendments such as limestone (increases pH) and sulfur (decreases pH).

The optimum pH range for most plants is between 5.5 and 7.0; however, many plants have adapted and thrive at values outside this range. Some examples are blueberries, strawberries and hydrangeas, which all need soils below 5.5.

Aquatic organisms are also vulnerable to changes in pH; very high (greater than 9.5) or very low (less than 4.5) pH values are unsuitable for most aquatic organisms. Juvenile fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5 and may not survive at these low pH values. High pH levels (9-14) can harm fish by disrupting cellular membranes. This can have devastating effects on aquatic ecosystems, which impact not only wildlife but also the fishing industry and recreational opportunities for humans.

There are several ways in which one may test the pH of a solution: a pH meter, pH paper or a universal indicator. A universal indicator is a pH indicator composed of a solution of several compounds that exhibit several smooth color changes over a pH value range from 1-14 to indicate the acidity or alkalinity of solutions.

ENGAGE:

Show photos of a pink hydrangea plant and a blue hydrangea plant. Discuss how the flower color is affected by the pH of the soil in which the plant grows. The flowers will be pink if the plant grows in alkaline soil, while they will be blue if the plant grows in acidic soil.

Introduction

In this activity, solutions will be classified as either acidic or basic by using a universal indicator. You will learn how to neutralize those acidic or basic solutions as well as be able to describe the relative amount of acid or base in a solution during a chemical reaction.

EXPLORE:

Pre-lab Questions:

1. What pH values are in the acidic range? **(0 to less than 7)** The basic range? **(greater than 7 to 14)**
2. List some examples of common acids and bases. **Acids: Soft drinks, citrus fruits, vinegar, coffee, tea, rainwater. Bases: Lye, oven cleaner, soap/detergent, milk of magnesia, ammonia, bleach**

PROCEDURE:

Activity 1: Preparing the Solutions

Preparing the acid and base solutions

1. Using a beaker, measure 20 mL of water and add it to the cup labeled "Citric Acid Solution."
2. Using a beaker, measure 20 ml of water and add it to the cup labeled "Sodium Carbonate Solution."
3. Add one scoop of citric acid to the cup labeled "Citric Acid Solution (ACID)." Gently swirl the mixture until the citric acid dissolves. This is the citric acid solution.
4. Add two scoops of sodium carbonate to the cup labeled "Sodium Carbonate Solution (BASE)." Gently swirl the mixture until the sodium carbonate dissolves. This is the sodium carbonate solution.

Diluting a universal indicator

1. Use a beaker to add 20 mL of water each to seven clear plastic cups.

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

2. Add 10 drops of universal indicator to each cup and gently swirl to mix thoroughly.
3. Line the cups up horizontally in front of you.

Activity 2: Creating a Rainbow

1. Add one or two drops of citric acid solution to the cup on the far left. Gently swirl the liquid in the cup and observe. Continue adding drops (making sure to keep count of how many drops are added) and swirling until a pH 4 solution is made. What color is a pH 4 solution? In Table 1, record the number of drops of citric acid used to make a pH 4 solution.
2. Add one or two drops of sodium carbonate solution to the cup on the far right. Gently swirl the liquid in the cup and observe. Continue adding drops (making sure to keep count of how many drops are added) and swirling until a pH 10 solution is made. What color is a pH 10 solution? In Table 1, record the number of drops of sodium carbonate used to make a pH 10 solution.
3. Using the remaining cups, make solutions of pH 5, 6, 8 and 9 using the method above. In Table 1, record the number of drops used to create each of these four new solutions.

**If students add too much acid, simply have them add a few drops of base (sodium carbonate). If they add too much base, simply add a few drops of the acid (citric acid) until the proper pH is achieved.*

Table 1. Creating the Rainbow

pH	4	5	6	7	8	9	10
Number of Drops (Citric Acid)				x	x	x	x
Number of Drops (Sodium Carbonate)	x	x	x	x			

Activity 3: Neutralizing the rainbow

1. To neutralize the citric acid solution, add one drop of sodium carbonate solution to the indicator in the cup on the left (red). Observe any changes that occur.
2. Continue to add single drops of sodium carbonate solution until the color is close to the color of the control (the middle cup). In Table 2, record the total number of drops added to the cup.
3. To neutralize the sodium carbonate solution, add one drop of citric acid solution to the indicator in the cup on the right (purple). Observe any changes that occur (if any).
4. Continue to add single drops (it may only take one more drop) of citric acid solution until the color is close to the color of the control (the middle cup). In Table 2, record the total number of drops added to the cup.

Table 2. Neutralizing the Rainbow

pH	4	5	6	7	8	9	10
Number of Drops (Citric Acid)				x			
Number of Drops (Sodium Carbonate)				x			

Activity 4: The Fizzy Finale (Duration: 5 min.)

1. Add 20 mL of water to the Ziploc® bag.
2. Add 10 drops of universal indicator solution to the bag and seal the bag.
3. Record the color of the solution. **Green**
4. Add 10 drops of Citric Acid Solution to the bag, seal and mix.
   a. What is the pH of the solution? **4**
   b. What conditions does the solution mimic in the human body? **Stomach acid**
5. Open the corner of the bag just enough so the Alka-Seltzer® tablet can fit through.
6. Remove as much air as possible from the bag, and drop the tablet into the bag.
7. Seal the bag and shake it.
   a. Describe what happens when the Alka-Seltzer® tablet is placed in the bag.
   b. Explain, using scientific terminology from this lesson, how Alka-Seltzer® helps to relieve pain related to heartburn.
   Alka-Seltzer tablets are a powdered combination of sodium bicarbonate (a base), citric acid (an acid) and aspirin that are stable and unreactive. But when water is added, two compounds interact. When an acid and a base combine, they produce water, gas and a salt. In this reaction, carbon dioxide is released causing the "fizzing." As the carbon dioxide is released, it binds with the excess hydrogen ions in the stomach acid and raises the pH of the solution from a 4 to a 6, essentially neutralizing the acid. In order for this reaction to occur, it takes energy to break the bonds and so the bag feels cold to the touch (endothermic reaction). The aspirin does not have any part in the reaction but is included to help relieve pain associated with heartburn.

EXPLAIN: (SEE LAB BACKGROUND)

The Lab Background information from the Teacher Guide is repeated in the Explain section of the Student Guide.

Activity 4 is designed to simulate what happens in your stomach when you take an antacid. Heartburn (acid reflux) happens when stomach acid enters the esophagus, which is not buffered (or protected) from the low pH level of the acid. The antacid is alkaline, or basic, and will neutralize the acid. Many antacids act as buffers and will continue working for an extended time after ingestion.

ELABORATE:

Optional Extension Activities

Acidic and basic substances have different characteristics. Have students investigate the properties of acids and basics.

- Characteristics of an acidic substance can include being corrosive, conductive and having a high concentration of hydrogen. Acidic foods and beverages will taste sour.
- Characteristics of an alkaline or basic substance can include having a slippery feel, being caustic and having a low concentration of hydrogen ions. Alkaline food and beverages will taste bitter.

Make a homemade pH indicator solution

- With adult supervision, try making and testing the red cabbage pH indicator solution below.
- It is recommended that proper safety practices be used (wear gloves, lab coat and safety glasses) whenever performing experiments, both in the laboratory and at home.

Materials

- Red cabbage
- Food processor or blender
- Water (boiling)
- Large glass beaker or other glass container
- Six 250 mL beakers or other small glass containers
- Filter paper or coffee filter

Procedure

1. Using a food processor, chop cabbage into small pieces until about 2 cups of chopped cabbage is prepared.
2. Place the chopped cabbage in a large beaker or other glass container, and add boiling water to cover the cabbage. Allow at least 10 minutes for the color to leach out of the cabbage. (Alternatively, you can place about 2 cups of cabbage in a blender, cover it with boiling water and blend it.)
3. Filter out the plant material to obtain a purple liquid. This is your red cabbage pH indicator, and it has a pH of approximately 7. (The color depends on the pH of the water.)
4. Pour 50 to 100 mL of the red cabbage indicator into each of the 250 mL beakers.
5. To test the pH of various household solutions, add them drop by drop to your indicator until a color change is obtained. Use separate containers for each household solution (do not mix household solutions).
6. Using the chart below as a guide, determine the pH of the tested household solutions.

Red Cabbage pH Indicator Colors

pH	2	4	6	8	10	12	14
Color							

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

Follow this link for a kitchen chemistry pH game:
http://pbskids.org/zoom/games/kitchenchemistry/virtual-start.html

Testing pH of substances

- Test the pH of common household substances.
- Record and share your observations with an adult.

Testing soil pH

Many plants require a specific pH range to thrive. You can test the soil around where you live. You can also research what types of plants grow best in acidic or basic soils.

1. Collect a small amount of soil in a container.
2. Add enough water to the sample to cover the soil.
3. Mix the soil/water mixture and let it sit so the soil particles will settle back to the bottom.
4. Using a dropper, remove the water from the soil sample and place it in a separate container.
5. Add the indicator solution to the water from the soil sample, and observe the pH of the sample.
6. Record and share your observation with an adult.

EVALUATE:

__**C**__ 1. What does pH measure in solutions?
A. The concentration of O^{-2}
B. The concentration of Fe^{+3}
C. The concentration of H^{+}
D. The concentration of H_2O

__**C**__ 2. What is the range of the pH scale?
A. 0-7
B. 0-10
C. 0-14
D. 0-20

__**A**__ 3. What are pH indicators?
A. Solutions that allow us to visually determine the pH of a solution
B. Solutions that allow us to determine how much water is present
C. Solutions that allow us to determine how much oxygen is present
D. None of the above

__**D**__ 4. What is an example of an everyday acidic substance?
A. Water
B. Milk
C. Bleach
D. Lemon juice

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

__**D**__ 5. Why is it important to test the pH of soil?
A. Plants require a specific pH to survive.
B. Soil microorganisms require a specific pH to survive.
C. It's fun.
D. All of the above

6. The pH of a solution is a measurement of what?
The concentration of hydrogen ions (H+)

7. If a solution has a pH of 3, is it considered acidic, basic or neutral? Explain.
Acidic, because it has a higher concentration of hydrogen ions (H+)

8. What do pH indicators help us determine?
How acidic or basic a solution is and/or the concentration of hydrogen ions (H+) in a substance

9. What is an example of an everyday basic substance?
Lye, oven cleaner, soap/detergent, milk of magnesia, ammonia, bleach

10. Read the scenario and answer the related questions using what you now know about acids, bases and the pH scale.
The school is preparing to plant a vegetable and fruit garden. Blueberries will be one of the plants in the garden. Blueberries grow best in acidic soils. In preparation for planting, a soil sample was taken and tested for nutrient content and pH. Below are the results of the soil test:
Soil sample results: pH = 7.8

Will blueberries grow and thrive in this soil? If so, explain. If not, explain what can be done to modify the soil so blueberries will thrive.
Blueberries will not grow well in this soil as it is. Blueberries grow best in acidic soils. A pH of 7.8 is too basic for blueberries to thrive and produce fruit. An acid, such as sulfur, coffee grounds, pine needles or other appropriate acidic substance, would need to be added to the soil to lower the pH.

The Noble Research Institute would like to thank the following people for their contributions to this lesson:
- Quentin Biddy
- Susie Edens
- Kay Gamble
- Janie Herriott
- Fiona McAlister
- Julie Smiley-Foster

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

STUDENT GUIDE

CHEMISTRY'S RAINBOW: THE POWER OF pH

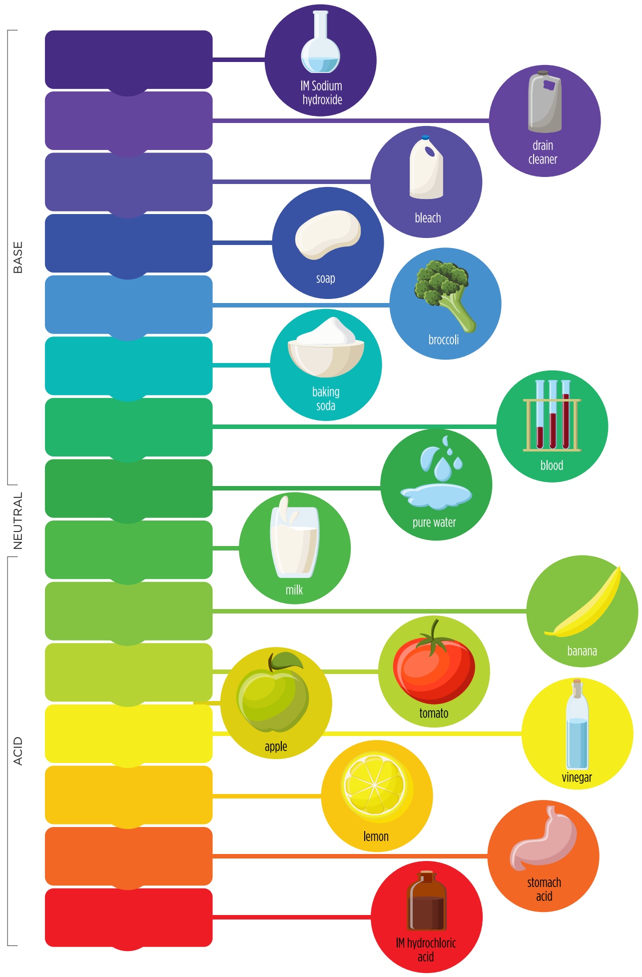
MATERIALS PER GROUP:

- Water
- Citric acid ($C_6H_8O_7$)
- Sodium carbonate (Na_2CO_3)
- Universal indicator
- Universal indicator color chart
- Nine small (3 oz.) clear plastic cups
- Two mini-scoops
- Two plastic pipettes
- Plastic beaker (90 mL)
- One quart-sized Ziploc® bag
- Alka-Seltzer® tablet

LESSON OBJECTIVES:

Students will be able to:

1. Use the pH scale to classify solutions as acids or bases.
2. Neutralize an acid and a base.
3. Determine the relative concentrations of hydrogen ions in a solution.



LESSON OVERVIEW:

In **chemistry,** pH is a measure of the acidity or basicity of an **aqueous** solution. The concentration (or amount) of hydrogen **ions** (H+) present in a **solution** determines whether the solution is **acidic** or **basic**; acidic solutions have more H+ and basic (or **alkaline**) solutions have fewer H+.

ESSENTIAL QUESTION:

What is the relationship of acids and bases in nature?

TOPICAL ESSENTIAL QUESTION:

Can the pH of a solution be altered?

An education and outreach program of:

NOBLE RESEARCH INSTITUTE

KEY VOCABULARY:

Chemistry	Aqueous	Solution
Indicator	Base	Buffer
Acid	Alkaline	
Ion	Neutralize	

SAFETY PRECAUTIONS:

- Avoid contact of all chemicals with eyes and skin. When performing the experiment, always wear safety glasses, and if available, lab coat and gloves.
- Sodium carbonate, citric acid and the universal indicator are not considered hazardous. However, prudent safety procedures should always be observed when handling chemicals in the laboratory.
- Do not eat, drink or chew gum while in the laboratory.
- Wash hands thoroughly with soap and water before leaving the laboratory.

ENGAGE:

Look at the photos of a pink hydrangea plant and a blue hydrangea plant. In hydrangeas, flower color is affected by the pH of the soil in which the plant grows. The flowers will be pink if the plant grows in alkaline soil, while they will be blue if the plant grows in acidic soil.

INTRODUCTION:

In this activity, solutions will be classified as either acidic or basic by using a universal indicator. You will learn how to neutralize those acidic or basic solutions as well as be able to describe the relative amount of acid or base in a solution during a chemical reaction.

EXPLORE:

Pre-lab Questions:

1. What pH values are in the acidic range? The basic range?
2. List some examples of common acids and bases.

PROCEDURE:

Activity 1: Preparing the Solutions

Preparing the acid and base solutions

1. Using a beaker, measure 20 mL of water and add it to the cup labeled "Citric Acid Solution."
2. Using a beaker, measure 20 ml of water and add it to the cup labeled "Sodium Carbonate Solution."
3. Add one scoop of citric acid to the cup labeled "Citric Acid Solution (ACID)." Gently swirl the mixture

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

until the citric acid dissolves. This is the citric acid solution.

4. Add two scoops of sodium carbonate to the cup labeled "Sodium Carbonate Solution (BASE)." Gently swirl the mixture until the sodium carbonate dissolves. This is the sodium carbonate solution.

Diluting a universal indicator

1. Use a beaker to add 20 mL of water each to seven clear plastic cups.
2. Add 10 drops of universal indicator to each cup and gently swirl to mix thoroughly.
3. Line the cups up horizontally in front of you.

Activity 2: Creating a Rainbow

1. Add one or two drops of citric acid solution to the cup on the far left. Gently swirl the liquid in the cup and observe. Continue adding drops (making sure to keep count of how many drops are added) and swirling until a pH 4 solution is made.

   What color is a pH 4 solution? ____

   In Table 1, record the number of drops of citric acid used to make a pH 4 solution.

2. Add one or two drops of sodium carbonate solution to the cup on the far right. Gently swirl the liquid in the cup and observe. Continue adding drops (making sure to keep count of how many drops are added) and swirling until a pH 10 solution is made.

   What color is a pH 10 solution? ____

   In Table 1, record the number of drops of sodium carbonate used to make a pH 10 solution.

3. Using the remaining cups, make solutions of pH 5, 6, 8 and 9 using the method above. In Table 1, record the number of drops used to create each of these four new solutions.

Table 1. Creating the Rainbow

pH	4	5	6	7	8	9	10
Number of Drops (Citric Acid)				x	x	x	x
Number of Drops (Sodium Carbonate)	x	x	x	x			

Activity 3: Neutralizing the rainbow

1. To neutralize the citric acid solution, add one drop of sodium carbonate solution to the indicator in the cup on the left (red). Observe any changes that occur.
2. Continue to add single drops of sodium carbonate solution until the color is close to the color of the control (the middle cup). In Table 2, record the total number of drops added to the cup.
3. To neutralize the sodium carbonate solution, add one drop of citric acid solution to the indicator in the cup on the right (purple). Observe any changes that occur (if any).
4. Continue to add single drops (it may only take one more drop) of citric acid solution until the color is close to the color of the control (the middle cup). In Table 2, record the total number of drops added to the cup.

Table 2. Neutralizing the Rainbow

pH	4	5	6	7	8	9	10
Number of Drops (Citric Acid)				x			
Number of Drops (Sodium Carbonate)				x			

Activity 4: The Fizzy Finale (Duration: 5 min.)

1. Add 20 mL of water to the Ziploc® bag.
2. Add 10 drops of universal indicator solution to the bag and seal the bag.
3. Record the color of the solution. ____
4. Add 10 drops of Citric Acid Solution to the bag, seal and mix.
   a. What is the pH of the solution? ____
   b. What conditions does the solution mimic in the human body? _________________________________
5. Open the corner of the bag just enough so the Alka-Seltzer® tablet can fit through.
6. Remove as much air as possible from the bag, and drop the tablet into the bag.
7. Seal the bag and shake it.
   a. Describe what happens when the Alka-Seltzer® tablet is placed in the bag.
   b. Explain, using scientific terminology from this lesson, how Alka-Seltzer® helps to relieve pain related to heartburn.

____

____

____

____

____

____

EXPLAIN:

In **chemistry,** pH is a measure of the acidity or basicity of an **aqueous** solution. The concentration (or amount) of hydrogen **ions** (H+) present in a **solution** determines whether the solution is **acidic** or **basic**; acidic solutions have more H+ and basic (or **alkaline**) solutions have fewer H+.

The pH scale (Figure 1) is a logarithmic scale (each number represents a tenfold change) ranging from 0 to 14, with 7 being **neutral**. A pH below 7 is acidic and above 7 is basic (or alkaline).

Virtually every biological process depends on pH, and even slight deviations from these values may be detrimental to the cell or organism. Therefore, maintaining proper pH is essential for life.

In humans, blood pH is maintained at a value between 7.35 and 7.45. This is the pH at which blood carries the maximum amount of oxygen. If blood pH drops below 6.8 or rises above 7.8, death may occur. Fortunately, we have **buffers** in our blood to help protect against such drastic changes.

There are many agricultural processes that rely on pH in order to occur. Perhaps the most important is related to plants. Plants sustain life on Earth; they produce the oxygen we breathe, the food we eat and the clothing we wear. Plants must have soil to grow; therefore, soil indirectly sustains life as well, and we must take care of it.

Soil pH is very important to a plant's ability to grow. Soil pH is the measure of acidity or basicity in soils. It is considered an important factor in soils as it controls many chemical processes. In the soil, changes in pH can affect a plant's ability to take up essential nutrients and may reduce the population of important soil microorganisms. Fortunately, producers (farmers and ranchers) can monitor their soil by testing its pH and make adjustments to the pH with soil amendments such as limestone (increases pH) and sulfur (decreases pH).

The optimum pH range for most plants is between 5.5 and 7.0; however, many plants have adapted and thrive at values outside this range. Some examples are blueberries, strawberries and hydrangeas, which all need soils below 5.5.

Aquatic organisms are also vulnerable to changes in pH; very high (greater than 9.5) or very low (less than 4.5) pH values are unsuitable for most aquatic organisms. Juvenile fish and immature stages of aquatic insects are extremely sensitive to pH levels below 5 and may not survive at these low pH values. High pH levels (9-14) can harm fish by disrupting cellular membranes. This can have devastating effects on aquatic ecosystems, which impact not only wildlife but also the fishing industry and recreational opportunities for humans.

Figure 1

There are several ways in which one may test the pH of a solution: a pH meter, pH paper or a universal indicator. A universal indicator is a pH indicator composed of a solution of several compounds that exhibit several smooth color changes over a pH value range from 1-14 to indicate the acidity or alkalinity of solutions.

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

ELABORATE:

Make a homemade pH indicator solution

- With adult supervision, try making and testing the red cabbage pH indicator solution below.
- It is recommended that proper safety practices be used (wear gloves, lab coat and safety glasses) whenever performing experiments, both in the laboratory and at home.

Materials

- Red cabbage
- Food processor or blender
- Water (boiling)
- Large glass beaker or other glass container
- Six 250 mL beakers or other small glass containers
- Filter paper or coffee filter

Procedure

1. Using a food processor, chop cabbage into small pieces until about 2 cups of chopped cabbage is prepared.
2. Place the chopped cabbage in a large beaker or other glass container, and add boiling water to cover the cabbage. Allow at least 10 minutes for the color to leach out of the cabbage. (Alternatively, you can place about 2 cups of cabbage in a blender, cover it with boiling water and blend it.)
3. Filter out the plant material to obtain a purple liquid. This is your red cabbage pH indicator, and it has a pH of approximately 7. (The color depends on the pH of the water.)
4. Pour 50 to 100 mL of the red cabbage indicator into each of the 250 mL beakers.
5. To test the pH of various household solutions, add them drop by drop to your indicator until a color change is obtained. Use separate containers for each household solution (do not mix household solutions).
6. Using the chart below as a guide, determine the pH of the tested household solutions.

Red Cabbage pH Indicator Colors

pH	2	4	6	8	10	12	14
Color							

Follow this link for a kitchen chemistry pH game:
http://pbskids.org/zoom/games/kitchenchemistry/virtual-start.html

Testing pH of substances

- Test the pH of common household substances.
- Record and share your observations with an adult.

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

Testing soil pH

Many plants require a specific pH range to thrive. You can test the soil around where you live. You can also research what types of plants grow best in acidic or basic soils.

1. Collect a small amount of soil in a container.
2. Add enough water to the sample to cover the soil.
3. Mix the soil/water mixture and let it sit so the soil particles will settle back to the bottom.
4. Using a dropper, remove the water from the soil sample and place it in a separate container.
5. Add the indicator solution to the water from the soil sample, and observe the pH of the sample.
6. Record and share your observation with an adult.

EVALUATE:

Name: ____

Use knowledge gained from this lesson to complete the questions.

_____ 1. What does pH measure in solutions?

A. The concentration of O^{-2}
B. The concentration of Fe^{+3}
C. The concentration of H^{+}
D. The concentration of H_2O

_____ 2. What is the range of the pH scale?

A. 0-7
B. 0-10
C. 0-14
D. 0-20

_____ 3. What are pH indicators?

A. Solutions that allow us to visually determine the pH of a solution
B. Solutions that allow us to determine how much water is present
C. Solutions that allow us to determine how much oxygen is present
D. None of the above

_____ 4. What is an example of an everyday acidic substance?

A. Water
B. Milk
C. Bleach
D. Lemon juice

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE

_____ 5. Why is it important to test the pH of soil?

A. Plants require a specific pH to survive.
B. Soil microorganisms require a specific pH to survive.
C. It's fun.
D. All of the above

6. The pH of a solution is a measurement of what?

____

7. If a solution has a pH of 3, is it considered acidic, basic or neutral? Explain.

____

____

8. What do pH indicators help us determine?

____

____

9. What is an example of an everyday basic substance?

____

____

10. Read the scenario and answer the related questions using what you now know about acids, bases and the pH scale.

The school is preparing to plant a vegetable and fruit garden. Blueberries will be one of the plants in the garden. Blueberries grow best in acidic soils. In preparation for planting, a soil sample was taken and tested for nutrient content and pH. Below are the results of the soil test:

Soil sample results: pH = 7.8

Will blueberries grow and thrive in this soil? If so, explain. If not, explain what can be done to modify the soil so blueberries will thrive.

____

____

____

____

____

____

ACS Chemistry for Life™

This lesson has been modified from the "Chemistry's Rainbow" lesson from The American Chemical Society.

An education and outreach program of: NOBLE RESEARCH INSTITUTE