Elements of Chemistry
Acids and Bases
Teacher's Guide

Grade Level: 9–12 | **Curriculum Focus**: Physical Science | **Lesson Duration:** Two class periods

Program Description

Explore the chemistry of acids and bases to see how fundamental they are to the functioning of our world. Students will see how these two classes of compounds combine to produce salts. Then they'll learn about the pH scale, acid rain, and human cells.

Lesson Summary

Students predict if common household products are acids or bases. Then they measure their pH using litmus paper and a pH meter, if available. If time permits, students may use phenolphthalein and note its color change in the presence of an acid and a base. Students will record their results and work in groups to draw conclusions.

Onscreen Questions

Part 1, "Properties of Acids and Bases," "What Makes an Acid," "Weak or Strong?" and "Neutralization Reactions and Buffers"

- What are some differences between an acid and a base?
- How do you measure the strength of an acid or a base?

Part 2, "Digestion," "Aspirin," and "China: Surviving Vinegar"

- What acidic properties does vinegar possess?
- Why might workers need protection from the fermenting vinegar?

Lesson Plan

Student Objectives

- Use supporting evidence to predict if common household substances are acids or bases.
- Determine the pH of the substances.

- Describe the results of the investigation and characteristics of each substance.

Materials

- *Elements of Chemistry: Acids and Bases* program
- computer with Internet access
- paper and pencils
- litmus paper
- pH meter (if available)
- plastic cups (to hold the materials to be tested)
- distilled water
- lemon juice
- vinegar
- baking soda
- ammonia
- phenolphthalein (if available)

Prior to the start of the class, decide how you would like to handle the distribution of the materials for the investigation. One student from each group can come up to a central area to collect the materials, or you can hand out the materials to each group.

Each group will need the following materials:

- 8 strips of litmus paper
- samples of these materials in a cup: distilled water, lemon juice, vinegar, baking soda, and ammonia
- pH meter (if available)

Procedures

1. Begin the lesson by asking students to write on scrap paper materials they can identify as an acid or a base. (If they cannot answer the question, tell them not to worry.) Then ask them to put their papers away until the end of the lesson.

2. Tell students that they are going to measure the pH of common household substances to determine if they are acids or bases. Explain that pH is measured on a scale of 0–14. Substances with a pH lower than 7 are acids; those with a pH higher than 7 are bases; and a

substance with a pH of 7 is neutral. If students would like a little more background information before conducting the investigation, suggest that they watch the first three segments of the program "Elements of Chemistry: Acids and Bases." They can watch the final segment, "China: Surviving Vinegar," to gain an understanding of the important role that chemistry plays in everyday life.

3. Divide students into groups of three. Make sure each group has the materials needed for the experiment and ask the students to predict whether they think these materials are acids or bases. Encourage students to write a reason for their predictions. Then have students put their predictions away until later in the lesson.
4. Give each group a few minutes to read the directions for the investigation, listed below.

Safety note: When working in the lab, always wear goggles, gloves, and an apron. Never touch, sniff, taste, or mix any materials that you are working with as part of a science experiment.

- Have the materials you need in front of you. Then place one end of a strip of litmus paper into each of the materials.
- Compare the color on the strip of litmus paper to the color scale provided by your teacher. Determine the pH of each material. Record the pH on a chart, indicating whether the material is an acid or a base.
- If a pH meter is available, measure the pH of each material with it. Record the pH obtained in this way next to the pH obtained by using litmus paper.

5. Remind students to record their observations as the investigation progresses. They may develop a chart similar to the one shown below. After each group completes the experiment, make sure students clean up.

Material	**pH** **litmus paper**	**pH** **pH meter**	**Observations**
distilled water			
lemon juice			
vinegar			
baking soda			
ammonia			

6. During the next class period, discuss the investigations and the outcomes. Ask volunteers to share their predictions with the class. Did any groups predict which substances were acids and which were bases? Were the students able to explain their reasons?
7. Continue to discuss the investigation. Ask students why litmus paper can determine the pH of a substance. If necessary, explain that some materials have the characteristic of changing color in the presence of an acid or a base. In general, litmus paper turns from blue to red in the presence of an acid and from red to blue in the presence of a base.
8. Work as a class to further explain the results of the investigation. Which of the substances tested were acids? (*vinegar and lemon juice)* Which were bases? *(baking soda and ammonia)* What was the pH of distilled water, and what does that reading mean? *(Distilled water has a pH of 7, so it is neutral.)*
9. If students also used a pH meter, ask them to compare the results they obtained with that device to their results with litmus paper. Were the results different? *(Students probably obtained more precise results with the pH meter, but the litmus paper is sensitive enough to indicate an acid or base.)*
10. If time permits, give students the option of performing another experiment. Give each group a beaker containing about 100 ml of water; then hand out droppers. Have each group put about three drops of phenolphthalein, another pH indicator, into the water. Tell each group to record their observations. *(The water is now a colorless solution.)*
11. Next, have students add a few drops of ammonia. What happens to the water now? *(It becomes reddish purple.)* Ask students to explain what they think happened. If they are having trouble, have them refer to their experimental results with litmus paper for some clues. *(Ammonia is a base, so adding it to water causes the solution to become basic as well. Phenolphthalein has the property of turning reddish-purple if its pH exceeds 8.3.)* Then tell students that they will be adding a few drops of vinegar to the solution next. Ask them to predict what they think happens. (*The solution becomes colorless again.)* Ask students to explain why. *(The solution is becoming more acidic, causing it to lose its color.)*
12. Conclude the lesson by asking students to revisit their notes from the beginning of the lesson. Ask students to modify their list and add new materials based on what they have learned. Suggest that they write a short paragraph summarizing what they learned as a result of completing these investigations.

Assessment

Use the following three-point rubric to evaluate students' work during this lesson.

- 3 points: Students were able to predict whether five common household materials are acids or bases; demonstrated a clear understanding of how to measure the pH of substances; and could explain clearly and accurately the results of the experiment.

- 2 points: Students were able to predict whether three household materials are acids or bases; demonstrated a satisfactory understanding of how to measure the pH of substances; and could explain satisfactorily the results of the experiment.
- 1 point: Students had difficulty predicting whether any household materials are acids or bases; demonstrated a weak understanding of how to measure the pH of substances; and had difficulty explaining the results of the experiment.

Vocabulary

acid

Definition: A substance that can donate hydrogen ions

Context: Lemon juice and other acids usually have a sour test, sting when touched, and react strongly when combined with metals.

base

Definition: A substance that can accept hydrogen ions

Context: Soap and other bases have a bitter taste, feel slippery to the touch, and do not react when combined with most metals.

indicator

Definition: A material that has the property of changing color in the presence of an acid or a base

Context: Litmus paper is an indicator; it turns from blue to red in the presence of an acid and from red to blue in the presence of a base.

neutralization reaction

Definition: The chemical reaction between an acid and a base that results in both substances losing their distinctive properties

Context: One substance that usually results from a neutralization reaction is a salt, an example of an ionic compound.

pH

Definition: A scale that measures the concentration of hydrogen ions in a solution

Context: In general, acids have a pH below 7; bases a pH above 7; and neutral solutions a pH of 7.

Academic Standards

National Academy of Sciences

The National Academy of Sciences provides guidelines for teaching science in grades K–12 to promote scientific literacy. To view the standards, visit this Web site: http://books.nap.edu/html/nses/html/overview.html#content.

This lesson plan addresses the following national standards:

- Physical Science: Chemical reactions
- Physical Science: Structure and properties of matter

DVD Content

This program is available in an interactive DVD format. The following information and activities are specific to the DVD version.

How To Use the DVD

The DVD starting screen has the following options:

***Play Video*—** This plays the video from start to finish. There are no programmed stops, except by using a remote control. With a computer, depending on the particular software player, a pause button is included with the other video controls.

***Video Index*—** Here the video is divided into sections indicated by video thumbnail icons; brief descriptions are noted for each one. Watching all parts in sequence is similar to watching the video from start to finish. To play a particular segment, press Enter on the remote for TV playback; on a computer, click once to highlight a thumbnail and read the accompanying text description and click again to start the video.

***Curriculum Units*—** These are specially edited video segments pulled from different sections of the video (see below). These nonlinear segments align with key ideas in the unit of instruction. They include onscreen pre- and post-viewing questions, reproduced below in this Teacher's Guide. Total running times for these segments are noted. To play a particular segment, press Enter on the TV remote or click once on the Curriculum Unit title on a computer.

***Standards Link*—** Selecting this option displays a single screen that lists the national academic standards the video addresses.

***Teacher Resources*—** This screen gives the technical support number and Web site address.

Video Index

I. Properties of Acids and Bases (2 min.)
Discover the general properties of acids and bases and see why water is an important factor in determining whether a substance is an acid or a base.

II. What Makes an Acid? (4 min.)
Examine the three defining theories about how acids and bases operate.

III. Weak or Strong? (4 min.)
Explore how the pH scale is used to measure the differences between substances and determine the strength of an acid or a base.

IV. Neutralization and Buffers (4 min.)
Discover the important role that the chemistry of acids and bases plays in real life.

V. Digestion (6 min.)
Examine the human digestive system and explore the role that acids play in digestion.

VI. Aspirin (4 min.)
Examine the history and properties of acetylsalicylic acid, a common chemical compound we call aspirin.

VII. China: Surviving Vinegar (22 min.)
Explore the ancient techniques used to produce traditional Chinese vinegar, an acid.

Curriculum Units

1. Acids, Bases, and Water
Pre-viewing question
Q: Give examples of acids and bases.
A: Answers will vary.

Post-viewing question
Q: How does an electrolyte affect water?
A: Acids and bases are electrolytes, which means they improve water's ability to conduct electricity.

2. Defining Theories
Pre-viewing question
Q: How would you define an acid?
A: Answers will vary.

Post-viewing question
Q: What is the Bronsted-Lowry definition of an acid and a base?
A: According to the Bronsted-Lowry definition, an acid is any substance that can donate a proton or hydrogen ion, and a base is any substance that can accept a hydrogen ion.

3. Measuring pH
Pre-viewing question
Q: Do you know the pH value of any substances?
A: Answers will vary.

Post-viewing question
Q: Describe the pH scale.
A: The relationship between acids and bases and the concentration of hydronium ions in a solution provides the basis for measuring acid and phase strength using the pH scale. The pH scale is a logarithmic scale based on the hydronium ion concentrations in a solution. The scale runs from 1 to 14, with 1 representing the strongest acids and 14 representing the strongest bases.

4. Chemistry of Acids and Bases
Pre-viewing question
Q: What biological or chemical processes help keep your body running smoothly?
A: Answers will vary.

Post-viewing question
Q: What is a buffer? How do buffers operate?
A: To maintain a healthy pH, many organisms employ a chemical system called a buffer. A buffer is a solution of weak acid or weak base and its corresponding acid. Something as simple as exercise could cause a drastic change in body pH. Buffers act as cushion to neutralize excess hydronium or hydroxide ions and maintain a constant pH.

Buffers are reliable for regulating the pH of a solution but they can become overwhelmed by a severe influx of an acid or a base. Because they act on a molecule-by-molecule basis, their effectiveness is tied to their concentration.

5. Human Digestive System
Pre-viewing question
Q: What healthful foods do you like to eat?
A: Answers will vary.

Post-viewing question
Q: Describe the human digestive process.
A: The human body digests a meal within 12 to 24 hours. As a person chews food, the saliva in the mouth begins to break the food into simple sugars. After being swallowed, the food travels down the esophagus into the stomach, where strong layers of muscle contract and create a

churning motion. The churning mixes food with acidic digestive juices. The food becomes chime, a liquefied mixture. The chyme leaves the stomach and enters the small intestine, where nutrients are absorbed through the intestinal walls by villi, small fingerlike structures. The digested food moves through the large intestine, where water is absorbed into the bloodstream and the remaining material is eliminated from the body.

6. The History of Aspirin
Pre-viewing question
Q: What are some uses of aspirin?
A: Answers will vary.

Post-viewing question
Q: How did aspirin come to be used as a remedy?
A: Willow bark was historically used to cure aches and pains, but it had a very bitter taste and caused gastric upset. Trying to alleviate his father's arthritis, German chemist Felix Hoffman discovered in the late 1800s that adding acetyl acid to the isolated salicylic acid from the willow could create a chemical composite, now known as aspirin, that blocked pain without willow's side effects.

7. Ancient Chinese Vinegar
Pre-viewing question
Q: Are there any special or unique foods eaten in your household or culture?
A: Answers will vary.

Post-viewing question
Q: Describe the traditional Chinese method of ba gang.
A: Ba gang is an ancient Chinese churning method used to make vinegar. It is crucial to determining vinegar taste during the fermentation process. Two or three times a day for 14 days, workers use their hands to churn and loosen the vinegar mixture for fermentation. They wear special finger protection when churning the fermenting vinegar and must be careful about breathing in the harsh fumes.

8. Marketing a Unique Vinegar
Pre-viewing question
Q: Would you pay more money for a better product?
A: Answers will vary.

Post-viewing question
Q: What successful products made in a traditional manner?
A: Answers will vary.