SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Student Materials

Learning Sequence Item:

960

Acids, Bases and Indicators

March 1996
Adapted by: Patsy Janda and George Miller

Contents

This micro-unit was adapted by **Patsy Janda** (University H.S., Irvine), and
George Miller (University of California, Irvine)

Student Sheet

Science as Inquiry

Acid-Base Indicators

Label two beakers A and B. Place 100 mL of water into beaker A. Add 10 drops of universal indicator. Add, drop by drop, a solution of dilute sodium hydroxide until some change occurs appears. Stir the solution between drops to make sure the solution is stable and the drops are evenly dispersed. Fill beaker B with crushed dry ice to the 100 mL mark. Carefully pour the solution from beaker A into beaker B. Observe what happens to the solution, and carefully record your observations.

Don't wait for all the dry ice to dissolve. Now pour the solution back into beaker A. Again, carefully observe what happens to the solution. Return the color to purple by adding drop by drop the sodium hydroxide solution, mixing between drops.

Repeat the procedure by pouring the solution back and forth between the beakers until the dry ice is completely dissolved.

1. How did the sodium hydroxide affect the water in beaker A?

2. How did the dry ice affect the solution in beaker A?

3. Use the following chart to determine when the solution was acidic and when it was basic.

purple	basic
blue	basic
green	basic
yellow	acidic
orange	acidic
red	acidic

4. Dry ice is solid carbon dioxide at about $^{-}78$ ^{o}C. What compound is contained in the bubbles that rise when water is added to the dry ice? How do you know?

5. Explain what color a clear carbonated beverage would be if universal indicator is added to it and why?

6. When the solution was first returned to beaker A, how did it change?

Student Sheet

Science as Inquiry

Using the Best Indicator for pH Determination

Label eight test tubes 1A, 1B, 2A, 2B, 3A, 3B, 4A, and 4B, or label the wells in a reaction plate. Place 5 mL of water into each test tube or 10 drops in each well. Add two drops of thylophthalein to test tubes 1A and 1B (or one drop in wells 1A and 1B), two drops of phenolphthalein to test tubes 2A and 2B (one drop in wells 2A and 2B), two drops of phenol red to test tubes 3A and 3B (one drop in wells 3A and 3B), and two drops of bromthymol blue to test tubes 4A and 4B (one drop in wells 4A and 4B).

Add two drops of ammonia to each test tube (one drop to each well). Be sure the thymolphthalein turns blue; if it doesn't add more drops of ammonia.

Break the effervescent tablet into small pieces. Add one piece to test tube A (well) of each pair. Look for a color change as the effervescent tablet dissolves. Compare the color in each test tube A (well A) with the corresponding test tube B (well B).

Use the table below to determine the pH of each solution:

Indicator	Initial Color	Changes to	pH Range
thymolphthalein	blue	colorless	10.6–9.4
phenolphthalein	pink	colorless	10.0–8.2
phenol red	red	yellow	8.0–6.6
bromthymol blue	blue	yellow	7.6–6.0

1. How did the test tubes or wells change?

2. Solutions that are more acidic have a lower pH value, and solutions that are more basic have a higher pH value. Which of the indicators would you choose to determine the pH of a very basic solution?

3. Some plants prefer a soil environment with a pH of 8.0. Which of the indicators used in this experiment would be the best to use for testing the soil around basic-loving plants?

Student Sheet

Science as Inquiry

The Gardener's Chemistry

Label the beakers 1, 2, 3, and 4. Be sure the beakers are dry. Place a strip of pH paper on the bottom of each beaker. Cover the pH paper with a piece of filter paper. Loosely fill each beaker with a different soil sample to the 100 mL mark.

Pour approximately 100 mL of preboiled water on the soil. The water should diffuse through the soil sample and filter paper, moistening the pH paper but not soaking it. Turn the beaker over onto a piece of newspaper or paper towel. Observe the change in color of the pH indicator paper. Repeat this procedure for the other soil samples.

To be sure the change in color is due to the soil and not the water, place a piece of pH paper in the water and observe. The pH of this water control sample should be neutral, with a pH of 7.0.

1. Explain what variables can cause differences in the acid content of soils?

2. Explain why the pH of the water sample was determined?

3. What kinds of plants grow best in acidic and basic soils?

4. Design an experiment to test the effect of soil pH on plant health or plant growth. Write out a proposed procedure.

Student Sheet

Science as Inquiry

Voice-Activated Chemical Reactions

Two colored solutions have been prepared. Try speaking into the flasks containing these solutions. Look for any changes during this activity.

1. The solutions began with a basic pH. What compound was introduced into these solutions when the student volunteers spoke into the flask?

2. Why were the stoppers kept on the flasks as much as possible during this activity?

3. One of the solutions changed colors with fewer “voices.” How was this accomplished?

4. How could you set up the experiment so it changed only when it reached a specific student in the class?

Student Sheet

Science as Inquiry

Neutralizing Acids

Place 50 mL of water into the beaker. Add two drops of vinegar to the water and mix well. Add two–five drops of phenol red indicator to turn the solution to a yellow color. Drop the antacid tablet into the solution and look for a color change, noting the time it takes for the color to change.

1. Why did the indicator solution change color when vinegar was added?

2. Design an experiment to find out what affects the rate of the color change reaction.

3. Antacids are sometimes used to treat individuals who produce excessive hydrochloric acid in the stomach. How can antacids be effective in this situation?

Science in Personal and Social Perspectives

ANTACIDS

Antacids are "anti" acids, meaning "against" or the "opposite of" acids. In chemical terms, antacids "neutralize" acids to form salts and water. Therefore, antacids are bases. The specific acid in our body for which antacids are designed is hydrochloric acid, HCI. Hydrochloric acid is a component of the gastric juice secreted by the stomach during the process of digestion. The concentration of HCI in gastric juice can vary from 0.0 to 5.4 g/L of gastric juice, but at the upper limit of this range, one would probably feel stomach discomfort. If the stomach secretes too much HCI over a long period, the stomach wall itself is digested, and a craterlike sore or ulcer forms. Antacids can be used to treat ulcers that are not too serious, and for many years this was the only treatment for such ulcer cases.

The most widely used antacids are carbonates and bicarbonates, such as magnesium carbonate, $MgCO_3$, calcium carbonate, $CaC0_3$, and sodium bicarbonate, $NaHCO_3$. Probably the most popular of these is sodium bicarbonate, also known as baking soda. When baking soda reacts with acid, it produces carbon dioxide gas, CO_2.

$$\underset{\text{Hydrogen ion (acid)}}{H^+(aq)} + \underset{\text{Bicarbonate ion (baking soda)}}{HCO_3^-(aq)} \rightarrow \underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Water}}{H_20(l)}$$

In addition to being readily available and low in cost, baking soda dissolves easily and can therefore be effective in a short time. The disadvantage is that if excess baking soda is present, it can pass into the intestine and from there be absorbed by the bloodstream. This can upset the acid-base balance of the body fluids and in extreme cases cause a medical condition known as alkalosis.

Other active ingredients commonly found in antacids include aluminum hydroxide, $Al(OH)_3$, magnesium hydroxide, $Mg(OH)_2$, magnesium oxide, MgO, and magnesium trisilicate, $2Mg0 \bullet 3SiO_2 \bullet H_20$ (variable). Each of these ingredients, as well as magnesium carbonate and calcium carbonate, can be used alone or combined with other ingredients. Since none of these other active ingredients dissolve easily—and are therefore much less likely to be absorbed in the intestine—they are preferable to baking soda. Antacid tablets also contain “filler” materials, usually starch or sugar, to hold the tablet together. These fillers can also mask the flat or even bitter taste of the base. The effectiveness of a given antacid may be judged by the amount of stomach acid it will neutralize. The speed of the neutralization reaction is also important, but a very rapid rate is not necessarily the ideal. A more gradual rate is desirable, since it is less likely to cause the stomach to produce excess gastric juice in response to the antacid’s presence.

Things to Do

1. Inspect the labels of some common antacids and determine the active ingredient(s).

2. Consult your teacher for a method for determining how much acid a given dose of antacid can neutralize.

Antacid Mini Lab #1

If the active ingredient in an antacid tablet is a carbonate, the amount of active ingredient can be determined by reacting the tablet with acid (for example, 6M HCI) and measuring the volume of CO_2 produced. Consult your teacher for an appropriate method to collect the CO_2. The balanced equation for the reaction of a Rolaids® antacid tablet is as follows:

$$NaAl(OH)_2CO_3 + 4HCI \rightarrow NaCI + AIC1_3 + 3H_20 + CO_2$$

Antacid Mini Lab #2

A colorful way of following the effect of an antacid tablet on an acid can be shown by the following home experiment:

Materials

Antacid tablet (suggested: Phillips Milk of Magnesia® tablet), white vinegar, cabbage juice indicator, measuring cup, 1/4 teaspoon, one drinking glass, small saucepan (optional), two teaspoons

Procedure

1. Place about 1/2 cup (about 125 mL) of water in a glass.
2. Add 1/4 teaspoon (about one mL) of white vinegar to the water in the glass and stir to mix thoroughly.
3. Add cabbage juice indicator to the solution in the glass until a definite color is imparted to the solution.
4. Crush the antacid tablet between two teaspoons and add the antacid to the vinegar solution. Stir to mix thoroughly.
5. Observe the color change of the solution over the next 10 to 15 min. stirring occasionally. ***Note:*** This process may be speeded up by heating the solution gently in a saucepan for 1 to 3 min with occasional stirring.

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