17 Acid-Base Indicators
Color Changers

Acid/base indicators are chemicals that help you compare or estimate the strength of an acid or base by changing color depending on the pH value of a tested liquid. The lower the pH value, the more acidic the liquid. The higher the pH value, the more basic, or alkaline, the liquid.

In this project, you will make indicators from foods, such as red cabbage and various plants. You will determine the affect of acids and bases on the color of indicators and create color scales for the different indicators. You will also investigate the effect of soil pH on the color of flowers containing an acid-base indicator.

GETTING STARTED

Purpose: To determine the effect of acids and bases on red cabbage indicator.

Materials

pen
masking tape
1-tablespoon (15-ml) measuring spoon
white vinegar, 5%
distilled water
½ teaspoon baking soda
three 10-ounce (300-ml) clear plastic cups
sheet of white copy paper
red cabbage indicator (see Appendix 6)
4 stirring spoons

Procedure

1. Use the pen and tape to label the cups "Acid," "Base," "Neutral."
2. Add 1 tablespoon (15 ml) of vinegar to the Acid cup, 1 tablespoon (15 ml) of distilled water and ½ teaspoon (2.5 ml) baking soda to the Base cup, and 1 tablespoon (15 ml) of distilled water to the Neutral cup. *Note:* Wash the spoon in distilled water and dry it after each use so that you do not contaminate or dilute the contents of the different cups.
3. Set the cups on one of the sheets of white paper so that it will be easier to detect color changes.

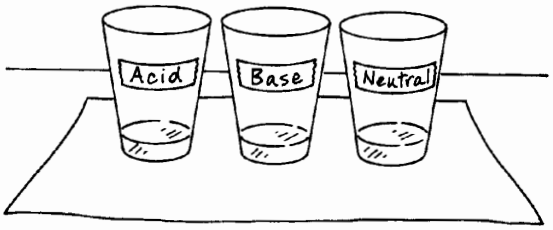

Figure 17.1

4. Add 1 tablespoon of red cabbage indicator to each cup. Using different spoons, stir the contents of each cup. Then observe and record their color in a Red Cabbage Indicator Data table like Table 17.1.

TABLE 17.1 RED CABBAGE INDICATOR DATA

Solution	Color of Indicator
Acid (vinegar, 5%)	red
Water (distilled)	purple
Base (baking soda)	blue

Results

The red cabbage indicator turns red in vinegar, remains purple in water, and turns blue in baking soda.

Why?

Chemicals are substances made of a combination of **elements** (basic chemical substance of which all things are made). Each element is made of **atoms** (building blocks of matter), and only one kind of atom makes up each specific element. Indicators are natural or synthetic chemical substances that change color in response to other chemicals. **Acid/base** indicators change colors in the presence of acids or bases. **Acids** are aqueous solutions containing hydronium ions—H_3O^{+1} and **bases** are aqueous solutions containing hydroxide ions—OH^{-1}. Generally the characteristics of acids and bases are opposite. The special

15. Place all the plants together in a spot where their environment (temperature, amount of sunlight, and so on) is the same.
16. Keep the soil moist, but not dripping wet, consistently using the liquid indicated on the plant container's label. Add the same amount of liquid to each plant, and water them all at the same time.
17. Observe and record the growth of the plants for four or more weeks.

Results

Your results may vary, but the author found that at the end of four weeks the nutrient-fed plants had stronger stems and greener leaves.

Why?

Many nutrients needed for plant growth are **soluble** (able to break up and thoroughly mix with another substance) in water. Thus, when mixed with water they form an **aqueous solution,** which is a mixture in which one or more substances are dissolved in water. (**Dissolve** means to break into very small particles and mix thoroughly with a liquid.) Nutrients in soil can be removed by a process called leaching. **Leaching** is the removal of soluble chemicals from a material, such as soil, by filtering water through the material so that water-soluble substances are extracted. In this experiment, the cheesecloth acts as a **filter** (material that allows a liquid, but not solids, to pass through) and the liquid passing through the cheesecloth is called the **filtrate** (liquid that passes through a filter). The filtrate collected by leaching is rich in nutrients. Plants grown with this nutrient liquid grow better than plants grown in the washed soil without nutrients. Plants without soil nutrients continue to make food in their leaves by photosynthesis, but photosynthesis alone is not enough to sustain the plants. The nutrients taken in by the roots are necessary for proper growth and maintenance of plant cells. Lack of nutrients results in many problems, including yellow leaves, wilting, thin foliage, small leaves, and generally poor growth.

Try New Approaches

Do all soils contain the same nutrients? Repeat the experiment using samples of soils taken from different locations. Remove any ground covering, grass, and/or plants growing in the soil. Be sure to label the soil samples and make notes of the types of plants growing in the soil and in the general area from which each sample is taken (see Figure 16.2). This information can be used later to determine the nutrients needed by these plants. Use leached water from the different soil samples to grow plants. Determine which nutrient filtrate is the best for the plants used.

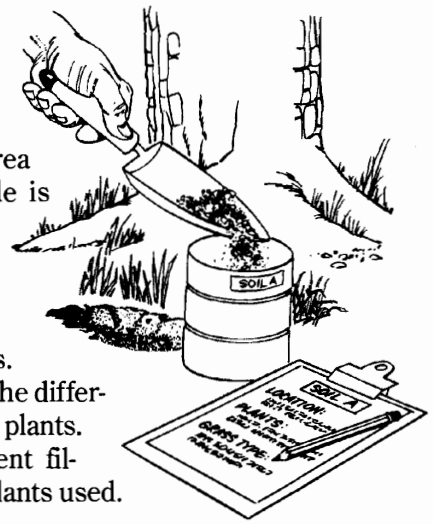

Figure 16.2

Design Your Own Experiment

The types of nutrients in soil can be determined with an inexpensive soil-testing kit. (Your teacher can order this from a plant nursery or a science supply company. See Appendix 9 for a list.) Design an experiment to compare the effect of specific nutrients, such as nitrates and phosphates, on plants. One way is to repeat the original experiment, but test for and identify the presence of some of the nutrients. Record your testing results in a Nutrient Soil Data table like Table 16.1. You may wish to include information in the table about where the soil was found, as shown in Table 16.1.

Table 16.1 Nutrient Soil Data

Soil Sample	Nitrate Test	Phosphate Test	Soil Location
1	yes	yes	potting soil
2	yes	no	open field with only crabgrass growing in it
3			
4			

Get the Facts

Plants look unhealthy when they do not have proper nutrients. Use a gardening book to determine the nutrients needed for proper plant growth for the plants in your experiments and the symptoms that indicate a deficiency of each nutrient.

scale for measuring the acidic or basic nature of a substance is called the **pH scale.** The values on the **pH** (a number used to indicate the acidic or basic nature of a solution) scale range from 0 to 14, with the pH value of 7 being **neutral** (having no acidic or basic properties). Acids have a pH of less than 7 and bases have a pH greater than 7.

Red cabbage contains a chemical that is one of a class of compounds called **anthocyanins** (red pigment found in some foods). The anthocyanin pigment in red cabbage is an acid/base indicator. Vinegar is known to be an acid with a pH of about 2.8 and baking soda is a base with a pH of about 8.5. So from the results of this experiment, cabbage indicator is red at pH of 2.8, purple at pH 7, and blue at pH 8.5. For more information about color changes of anthocyanins in red cabbage due to changes in pH, see pages 10–11 in Dianne N. Epp's *The Chemistry of Food Dyes* (Terrific Science Press: Middletown, Ohio, 1995).

Try New Approaches

Anthocyanins are found in red poppies, blue cornflowers, grapes, beets, blueberries, and apple skin. Repeat the experiment using a different plant and/or fruit to make anthocyanin indicator. How do the colors differ from the colors in the original experiment?

Design Your Own Experiment

1. In the original experiment using red cabbage indicator, only three different testing materials were used. Thus, a pH color scale for the indicator would look like Table 17.2.

Table 17.2 pH Color Scale for Red Cabbage Indicator

Testing Material	pH	Color of Indicator
Vinegar	2.8	red
Water	7	purple
Baking soda	8.5	blue

Design a more comprehensive pH color scale for red cabbage indicator as well as for one or more of the other food or plant indicators previously made. First test each indicator with testing materials of known pH, such as those in Table 17.3. Make an effort to create a scale with colors for the greatest pH range possible. See a chemistry text for the pH of other materials. *Note:* Mix about ½ teaspoon (2.5 ml) of solid materials with 1 tablespoon of water.

Table 17.3 pH Data

Testing Material	pH
Lemon juice	2.3
Apple juice	3.2
Tomato juice	4.4
Bananas	5.3
Distilled water	7
Baking soda	8.5
Milk of magnesia	10.5
Ammonia	12

2. If you have access to a pH meter, design a pH color scale for red cabbage indicator and/or other food or plant indicators. With assistance from an adult, use an acid stronger than lemon juice or vinegar and a base stronger than ammonia to create a color pH scaled from 0 to 14. As you add drops of acid or base to the indicator, test the liquid's pH, then record the pH and color until you have determined colors for pH 0 to 14.

Get the Facts

The color of some flowers is an indication of the pH of the soil they grow in. Hydrangeas have pink flowers in soil with a high pH (basic) and blue flowers in soil with a low pH (acid). Find out more about soil pH by checking with a plant nursery, school agriculture department, or county agriculture department for information. What can be added to soil to change its pH? **Science Fair Hint:** Determine the range of colors of flowers containing acid-base indicators. Do this by growing plants, such as hydrangeas, in soils of various pH. Your control can be soil with a pH of 7.