SCOPE, SEQUENCE, and COORDINATION

A National Curriculum Project for High School Science Education

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Student Materials

Learning Sequence Item:

959

An Introduction to Acids and Bases

March 1996
Adapted by: Mike Brown

Contents

Lab Activities
1. Acids or Bases?
2. Home Inventory with Homemade Indicators
3. Natural Indicators

Readings
1. Acid Rain

This micro-unit was adapted by **Mike Brown** (North Scott H.S., Eldridge, Iowa)

Student Sheet

Science as Inquiry

Acids or Bases?

A major task in chemistry is to identify and classify substances. This process is called qualitative analysis and can be accomplished by the observation of certain chemical and physical properties. Physical properties such as touch, taste, and color change of an indicator are useful in classifying acids and bases. Chemical reactions with other substances can also be used in classifying.

Begin by comparing the taste and feel of two household substances. Once you are able to describe how lemon juice (a dilute acid) and baking soda (a dilute base) taste and feel, go to the other solutions and try to classify these as acids or bases.

Indicators are substances that change color in the presence of an acid or a base. Litmus paper strips are indicators and they change color when placed in an acid or base solution. Use the red and blue litmus with the lemon juice and baking soda and decide which litmus is an indicator for an acid and which indicates a base. Then use the litmus to help in the classification of the other household substances.

Chemical reactions with metals can also be useful in classifying. Get two small, clean pieces of zinc metal and observe them in the lemon juice and baking soda. After you establish the way zinc reacts in these two solutions, try other substances with zine and see if all the data you have collected allows you to classify the common household substances as acids or bases.

1. Which substances did you classify as acids?

2. Which substances did you classify as bases?

3. Explain why you classified these substances in the manner you did.

Science as Inquiry

A Home Inventory with a Homemade Indicator

Not all indicators are commercial. Many natural substances can serve as acid-base indicators. To make cabbage juice indicator, simply shred some red cabbage leaves and fill a 250 mL beaker with them. Add about 100 mL of water to the beaker and bring the water to a boil on a hot plate. After 3–5 minutes of boiling, let the cabbage leaves cool and squeeze any remaining juice from the leaves into your water. Test a small amount of cabbage juice with an acid or a base to see how it changes color.

Cut paper towels into long strips and soak them in the juice. After they dry, cut them into shorter strips to use in your home investigation.

Take some of these strips home and find various liquids in your refrigerator, cupboards, or other storage places and read their labels to see if you can find any that have acids or bases in them. Make a list and test them with your indicator strips to verify what the label says. Some things you test may not have a label, after testing do you think they are acid or base?

1. Why are the acids put into foods or drinks?

2. Are acids that are found in foods or drinks generally concentrated or dilute acids?

3. Some acids do not have governmental approval for use in foods. Why do you suppose this is so?

4. What kinds of substances do you find bases in? What characteristics of bases make them good for these uses?

Science as Inquiry

Natural Indicators

Indicators that you have used in other activities, such as litmus paper and universal indicators are obtained from natural pigments in plants and even lichens. These acid-base indicators work because particles from the plants change color according to the concentration of hydrogen ions in the solution being tested.

Investigate the acidity or basicity (another term for basicity is alkalinity, from the word alkali) of solutions provided by using some natural indicators that you will prepare from common foods.

In the labeled beakers you will find substances with a pH of 1, 2, etc., through pH 12. Put five drops of pH 1 in a well on the spot plate, and fill additional wells so that each indicator you are going to test will be tested in its own well.

Add two drops of each natural indicator to each well and record the color of the mixture. In the final well for that pH, use two drops of universal indicator.

Repeat this process using all indicators and all twelve pH solutions.

To prepare a natural indicator shred the skin or flower petals and put them into a 250 mL beaker (use enough of the skin or petal to fill the beaker fairly full). The beaker needs to be about 1/2 full of water. Boil the water and use the water solution as an indicator. You may be able to squeeze additional juice out of the leaves or petals into the water after boiling.

1. What is the significance of the color changes in each row?

2. Which indicator(s) would be good for general use?

3. Why don’t natural indicators produce as dark a color as the commercial indicators that you used?

Science and Technology

Acid Rain

Acid rain is defined as precipitation that is more acidic than "normal" background precipitation, regardless of its cause-either natural or manmade. The acidity of precipitation can be determined accurately using well designed analytical procedures, and it has been measured in a number of geographical locations in Scandinavia, Canada, and the U.S. The acidity of rain varies across the continental U.S., generally being higher in the East and lower in the West.

Unpolluted or "clean" rain is always slightly acidic, having a pH of 5.6. This is due to carbon dioxide, which dissolves in water in the atmosphere to produce carbonic acid. Carbonic acid is a weak acid also found in soda water and carbonated soft drinks.

$$CO_2 + H_2O - H_2CO_3\ (I)$$
$$H_2CO_3\ (I) \longrightarrow H^+\ (aq) + HCO_3^-\ (aq)$$

Rain or snow is considered "acid" when its pH falls below 5.6. Acidic rain is generally formed by the following steps:

1) Emission into the air of oxides of sulfur and nitrogen, primarily SO_2, NO, and NO_2 from natural and man-made sources.
2) Short and long-range atmospheric transport of the oxides.
3) A series of chemical reactions between oxides, moisture, and other chemicals in the atmosphere to form sulfuric acid, H_2SO_4, and nitric acid, HNO_3, and others (called the transformation step).
4) Rain or snow carrying the acids to the Earth's surface.

Although scientists agree with this general outline, the exact processes that take place from step one to step four are not clearly understood (see section on uncertainties).

Some people also use the term "acid rain" to refer to the process called "dry deposition," even though rain is not carrying the acid. This occurs when the oxides of sulfur and nitrogen are deposited, or absorbed directly onto surfaces. It is believed that these oxides are then converted into acids after contacting water in the form of rain, dew, fog, or mist, or in the internal structure of plants, which have taken in these particles.

Some Causes of Acid Rain

Acid rain probably occurred when the first rains fell on our newly formed planet. Volcanic eruptions, forest fires, and bacterial decomposition of organic matter produce sulfur or nitrogen oxides. Lightning bolts form nitrogen oxides from the nitrogen and oxygen gases in the atmosphere.

However, the Industrial Revolution, which began about two-and-a-half centuries ago, started a surge in the amount of man-made pollutants in the atmosphere. Suddenly, sulfur and nitrogen, which had been stored in fossil fuels for millions of years, were released as rapidly as coal could be burned. Today, the major sources of sulfur and nitrogen compound emissions are power-generating plants, ore smelting, petroleum refining, industrial furnaces, and vehicles of all kinds.

In 1980, more than 26 million tons of sulfur dioxide were released into the air in the U.S. In addition, nearly 22 million tons of nitrogen oxides were produced. By way of comparison, the eruption of

Mount St. Helens in the state of Washington on May 18, 1980, blew out some 400,000 tons of sulfur dioxide, which is just over 1.5% of the total from man-made sources in the U.S. for that same year.

Some Effects of Acid Rain

Lakes and Streams. Most scientists agree that acid conditions affect animals and plants that live in water—in streams, rivers, lakes, ponds, and marshes. The decline in fish populations in some rivers and lakes has been linked to the toxic effect of aluminum, which is leached from soil by acid rain. Aluminum compounds collect in the gills of small fish. To combat the pollution, the fish produce unusually large amounts of mucus, which eventually strangles them.

The decline in fish population in some rivers and lakes has been linked to the toxic effect of aluminum.

A particularly bad time of the year for the aquatic community is spring when the snow melts and runs into streams and ponds. Extensive fish kills in early spring have been attributed to the runoff of the large amount of acid that accumulates on the snow over the winter.

Forests and Crops. Acid rain can dissolve and wash away valuable minerals such as magnesium, calcium, and potassium from the soil. Severe acid rain also can dissolve the waxy covering that protects leaves from fungi and bacteria. It is a well-documented fact that a growing number of forests and crops suffer total or partial damage each year, and there is good reason to suspect that this damage is due, in part, to acid rain. More study is needed to determine the extent to which acid rain is responsible for this damage and to establish the precise cause-and-effect relationship.

Some Acid Rain Uncertainties

The effects of acid rain were first acknowledged in the 1800s, but only in recent decades have these effects been examined in some detail. There are still many uncertainties associated with the issue. Major gaps in our understanding include the following:

- the pH of precipitation in the absence of human activity;
- evidence of a change in the acidity of precipitation over the past several decades;
- the controlling factors (reagents and processes) in the production of sulfur and nitrogen acids;
- the exact mechanism for oxidizing sulfur dioxide and nitrogen oxides; and
- the relationship between the locations(s) of source(s) and the location(s) of the depositions(s).

Materials. Acid rain is believed to be responsible for many forms of damage to buildings, monuments, and other man-made structures. It is also thought to contribute to metal corrosion, to reduce exterior paint durability, and to deteriorate textiles, paper, and leather.

Human Health. Little is known about the effects of acid rain on health. There are, however, several reasons for concern. Sulfur dioxide and sulfates are known to be harmful if inhaled, especially by people who suffer from asthma or other respiratory problems. Food may also be adversely affected by acid rain. Toxic metals, dissolved by acid rain, may be deposited in waters and finally taken up by fish. In addition, an acidic drinking water supply can dissolve such toxic metals as copper or lead. These metals are often present in the pipes or the pipe joints in plumbing.

No one is absolutely certain about all the effects of acid rain, how serious they are, or what controls are necessary to lessen these effects. Research is currently under way to answer these questions. In the meantime, many scientists are recommending across-the-board pollution emission reductions and are working to find methods of countering the effects of acid precipitation after it has fallen.

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