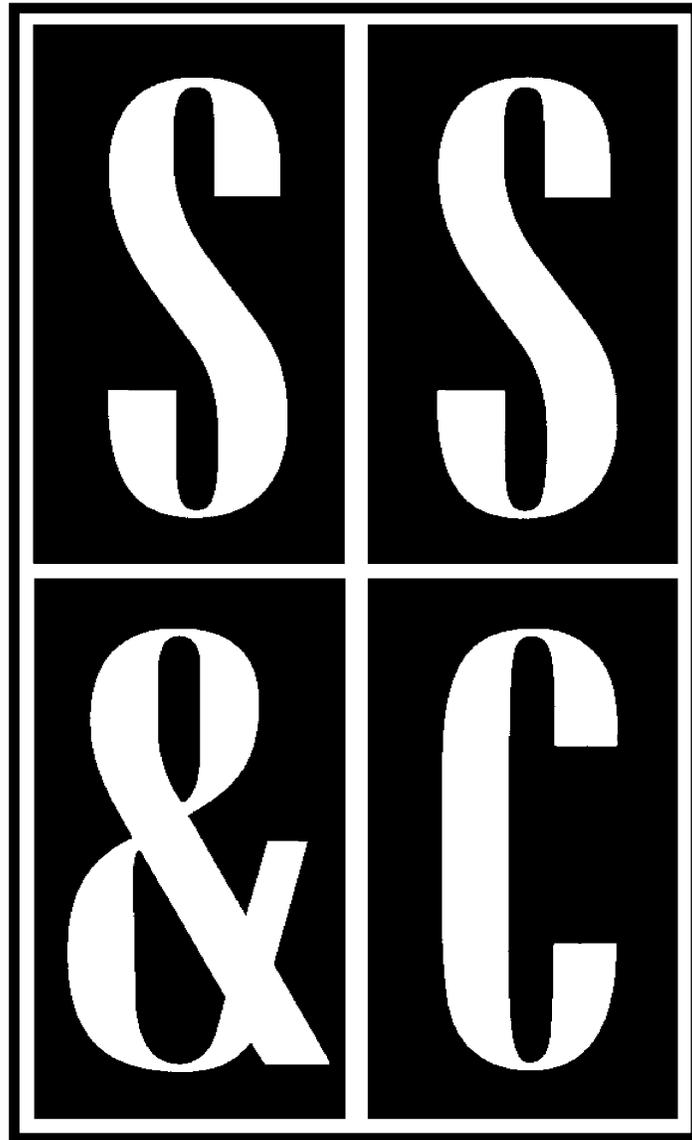


Scope, Sequence & Coordination

A National Curriculum Development and Evaluation Project for High School Science Education



A Project of the National Science Teachers Association



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**National Science Education Standard—Physical Science
Chemical Reactions**

A large number of important reactions involve the transfer of either electrons (oxidation/reduction reactions) or hydrogen ions (acid/base reactions) between reacting ions, molecules, or atoms. In other reactions, chemical bonds are broken by heat or light to form very reactive radicals with electrons ready to form new bonds. Radical reactions control many processes such as the ozone and greenhouse gases in the atmosphere, burning and processing of fossil fuels, the formation of polymers, and explosion

Teacher Materials

Learning Sequence Item:

959

An Introduction to Acids and Bases

March 1996

Adapted by: Mike Brown

Oxidation/Reduction, Acid/Base, and Radical Reactions. Students should determine an operational definition of acid and base by classifying common household substances that are acids and bases according to their chemical and physical properties. They should observe that adding a base will alter the nature of an acid solution and adding an acid will alter a basic solution. (*Chemistry, A Framework for High School Science Education*, p. 68.)

Contents

Matrix

Suggested Sequence of Events

Lab Activities

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

Assessment

1. KBr
2. Vinegar
3. Properties of an Acid
4. Acids
5. Acids
6. Acids and Bases: Properties and Analysis
7. Pollution of Atmosphere
8. Acid-Base Chemistry

959

Learning Sequence

Oxidation/Reduction, Acid/Base, and Radical Reactions. Students should determine an operational definition of acid and base by classifying common household substances that are acids and bases according to their chemical and physical properties. They should observe that adding a base will alter the nature of an acid solution and adding an acid will alter a basic solution. (*Chemistry, A Framework for High School Science Education*, p. 68.)

Science as Inquiry	Science and Technology	Science in Personal and Social Perspectives	History and Nature of Science
<p>Acids or Bases? Activity 1</p> <p>Home Inventory with Homemade Indicators Activity 2</p> <p>Natural Indicators Activity 3</p> <p>KBr Assessment 1</p> <p>Vinegar Assessment 2</p> <p>Properties of an Acid Assessment 3</p> <p>Acids Assessments 4, 5</p> <p>Acids and Bases: Properties and Analysis Assessment 6</p> <p>Acid-Base Chemistry Assessment 8</p>	<p>Pollution of Atmosphere Assessment 7</p> <p>Acid Rain Reading 1</p> <p>Roach Busters Reading 2</p>	<p>Aspirin Reading 3</p>	

Suggested Sequence of Events

Event #1

Lab Activity

1. Acids or Bases? (40 minutes)

Event #2

Lab Activity

2. Home Inventory with Homemade Indicators (30 minutes)

Alternative or Additional Experiments:

3. Natural Indicators (50 minutes)

Event #3

Readings from Science as Inquiry, Science and Technology, Science in Personal and Social Perspectives, and History and Nature of Science

Students should select two from the following list:

- | | |
|-----------|---------------|
| Reading 1 | Acid Rain |
| Reading 2 | Roach Busters |
| Reading 3 | Aspirin |

The above readings can be found in the student version of this publication.

Assessment items can be found at the back of this volume.

Assessment Recommendations

This teacher materials packet contains a few items suggested for classroom assessment. Often, three types of items are included. Some have been tested and reviewed, but not all.

1. Multiple choice questions accompanied by short essays, called justification, that allow teachers to find out if students really understand their selections on the multiple choice.
2. Open-ended questions asking for essay responses.
3. Suggestions for performance tasks, usually including laboratory work, questions to be answered, data to be graphed and processed, and inferences to be made. Some tasks include proposals for student design of such tasks. These may sometimes closely resemble a good laboratory task, since the best types of laboratories are assessing student skills and performance at all times. Special assessment tasks will not be needed if measures such as questions, tabulations, graphs, calculations, etc., are incorporated into regular lab activities.

Teachers are encouraged to make changes in these items to suit their own classroom situations and to develop further items of their own, hopefully finding inspiration in the models we have provided. We hope you may consider adding your best items to our pool. We also will be very pleased to hear of proposed revisions to our items when you think they are needed.

Science as Inquiry

Acids or Bases?

What are some easily observed physical and chemical properties that can be used to identify acids and bases?

Materials:

- lemon juice (citric acid)
- white vinegar (acetic acid)
- cream of tartar (tartaric acid)
- vitamin C (ascorbic acid)
- sodium bicarbonate (baking soda, a base)
- sodium carbonate (baking powder, a base)
- soap or detergent (lye or sodium hydroxide, a base)
- stirring rod
- test tubes and test tube rack
- small, clean, shiny pieces of zinc
- red and blue litmus paper strips
- beakers for solutions
- safety goggles

Procedure:

First, caution students that the acids and bases in this lab are concentrated. Tasting and touching concentrated acids and bases can be hazardous because these solutions are usually corrosive, caustic, and often poisonous. Demonstrate to students how to use a stirring rod to get a small amount of acid or base solution for a litmus or taste test. Remind them to always rinse the stirring rod between tests. Make sure you have clean zinc strips. The reaction you are looking for with zinc is the release of bubbles of hydrogen gas in the solution.

There are other metals that react in acid in the same way, but they may react with the water in a base solution and confuse the student. Use sandpaper or emery cloth to clean the zinc. Pretest the solutions. As you mix these solid substances with water, make sure the acids and bases are not too unpleasant to taste and that the acids are concentrated enough to show a reaction with the zinc.

These solutions can be disposed of in the sink with water. *Safety goggles need to be worn.*

Background:

Use the words concentrated and dilute in this activity to describe the substances being used. Strong and weak refer to the degree of ionization, a concept we are not yet ready for. Encourage the students to discuss their descriptions of the taste and feel of acids and bases. We often say acids taste sour and bases bitter, while bases feel slippery and acids do not have that slippery feel (some may say they feel squeaky clean).

Adapted from materials prepared at the CRISTAL training workshop, Price Laboratory School, University of Northern Iowa, 1993.

Science as Inquiry

A Home Inventory with a Homemade Indicator

Surveying substances in the home by reading labels and using natural indicator testing strips.

Materials:

- red cabbage
- 250 mL beaker
- hot plate or Bunsen burner
- stirring rod
- white absorbent paper towels

Procedure:

In this lab, students make a cabbage juice indicator to use in a home investigation of acids and bases. Have them shred red cabbage leaves and fill a 250 mL beaker with them. They should add about 100 mL of water to the beaker and bring the water to a boil on a hot plate. After boiling for 3–5 minutes, they should let the leaves cool and squeeze any remaining juice from them into the water. They should then test a small amount of the juice with an acid or a base to see how it changes color. Have them then soak strips of paper towels in the juice. After drying, these strips can be taken home to use in their home inventory.

Include in your discussion the possibility that some students may come across substances at home that could be toxic or flammable, etc. Caution them to read labels first and stay away from hazardous materials.

Acids are easy to find on food labels, but discuss where students should look to find bases. Cleaning compounds often contain bases; they usually show up on the label as a hydroxide. Bases also have a use in antacids to neutralize the effect of acids in the stomach.

After students have done their data collecting at home, make a master list on the board or on posters of all the different substances in their home that contain acids or bases. This can lead to a discussion of the importance of acids and bases in our lives.

Science as Inquiry

Natural Indicators**Materials:**

12 small beakers for pH solutions 1–12
1 spot plate
clean dropper pipettes
universal indicator
natural indicators selected from blueberry, red cabbage, cherry, grape,
red onion, peach, pear, plum, radish, red apple, rhubarb, tomato,
roses, petunias, violets, iris, tulips, gladiolas, geraniums
pH standards 1–12 (can be purchased in capsules from chemical
supply house)

Procedure:

In this lab, students investigate the acidity or basicity of various solutions using natural indicators prepared from common foods. Try to use each row of wells on the spot plate for a series of tests on a particular pH so the student has rows to compare to other rows above or below it.

You should try out any of the natural indicators you may not be sure of before class to see how well they work. In making natural indicators, do not use too much water in the preparation; the concentration of the indicator is important in seeing good results. That is why commercial indicators do such a good job—they tend to be more concentrated than the natural indicators you or your students will prepare.

Besides universal indicators, cabbage and blueberry are good general indicators. You could also let students prepare other commercial indicators, such as methyl orange, methyl red, bromothymol blue, phenolphthalein, alizarin yellow, indigo, carmine, etc., that you have available in your supply room.

Mix the pH 1–12 solutions and put them into labeled beakers.

Background

This may be a good time to introduce the term alkali. The term base replaces alkali in most cases today. Alkali can be associated with the alkali metals on the periodic chart; these metals form hydroxides (bases) when reacted with water. In one of the readings, there is evidence that the term alkali has arabic origins.

Adapted from Ehrenkranz, D.F. and John J. Mauch, John J. *Chemistry in Microscale*, pp. 12–14. Dubuque, Iowa: Kendall/Hunt Publishing Co., 1990.

Science as Inquiry

KBr**Item:**

KBr is an example of:

- A. an acid
- B. a base
- C. an indicator
- D. a salt

Justification:

Acids ionize in water to form H, and bases produce OH. What are the ions formed when KBr is dissolved in water?

Answer:

Science as Inquiry

Vinegar**Item:**

Vinegar is a solution of acetic acid in water. A solution of ammonia in water can neutralize the acidity of vinegar. From this it can be concluded that ammonia is:

- A. an acidic solution
- B. a basic solution
- C. a salt solution
- D. a neutral solution

Justification:

Design an experiment that would demonstrate ammonia's ability to neutralize the acidity of vinegar.

Answer:

B. A substance that can neutralize an acid is a base.

Science as Inquiry

Properties of an Acid**Item:**

Which one of the following is an exception to the properties of an acid (hydrogen-containing substance) when dissolved in water?

- A. It will react with Zn to give $H_2(g)$.
- B. It will be a nonelectrical conductor.
- C. It will turn litmus paper red.
- D. It will taste sour.

Justification:

Explain why the exception is incorrect from your previous experiences using acids.

Answer:

Depending on the acid it will dissociate to a certain degree. This will produce ions, which are necessary for a substance to be an electrical conductor.

Science as Inquiry

Acids**Item:**

Which one of the following would be classified as an acid?

- A. NaOH
- B. CH₃Cl
- C. HNO₃
- D. C₆H₁₂O₆

Justification:

Explain why your selection would act as an acid when dissolved in water as compared to the other choices.

Answer:

C. The others will not release H⁺ ions into the solution. This is a general property of an acid.

Science as Inquiry

Acids**Item:**

You can test for acids using a variety of indicators. Rain can be tested using an indicator that will indicate “acid rain” with a change of color. Which of the following statements is true and therefore important to know when doing environmental testing?

- A. The amount of color change always shows how acidic the rain is.
- B. The color of the indicator must start at blue for it to show an acid.
- C. The amount of color is not important—just a color change shows an acid condition.
- D. There is no such thing as acid rain.

Justification:

Explain what your answer would be if you were testing for the presence of a base instead of an acid and using a different indicator.

Answer:

The correct choice is C. This would be true when testing for a basic solution as well. Indicators are sensitive to pH changes and change color within the pH range in which an end point occurs. Indicators alone do not help you determine the concentration of an acid or a base. However, the degree of acidity can be approximated using pH paper.

Science as Inquiry

Acids and Bases: Properties and Analysis**Item:**

Eva carried out one chemical test on each of four separate liquids with the following results:

Substance 1 conducted electricity.

Substance 2 reacted strongly with copper, seeming to “eat it” away and producing fumes.

Substance 3 felt slippery.

Substance 4 changed pH paper and litmus paper blue.

Eva would have been correct in concluding which of the following?

- A. Substance 2 was an acid, and substance 3 was a base.
- B. Substance 1 was an acid, and substance 3 was also an acid.
- C. Substance 3 was an acid, and substance 4 was a base.
- D. Substance 2 was an acid, and substance 4 was also an acid.

Justification:

Explain the results of the reactions with the substances. Why are some results not conclusive?

Answer:

A. Nitric acid reacts with copper to give nitric and nitrogen dioxide fumes. Bases are described as having a slippery feel since they react with surface skin.

1. Both acids and bases conduct electricity.
2. A base reacts with copper very slowly and doesn't produce fumes.
3. Bases feel slippery.
4. Bases turn litmus or pH paper blue.

Science and Technology

Pollution of Atmosphere**Item:**

Depending on where you live, pollution of the atmosphere by different substances may occur. Which of the following correctly describes the major source of acid rain in the two areas of the country?

- | Eastern U.S. | Western U.S. |
|-----------------------|---------------------|
| A. forest trees | burning coal |
| B. automobile exhaust | automobile exhaust |
| C. burning coal | automobile exhaust |
| D. burning coal | desert cactus |

Justification:

Describe the way in which acid gases might be formed and released into the atmosphere in the area where you live.

Answer:

C. Coal with sulfur content is a major source of pollution in the eastern U.S., while little coal is burned in the west. Sulfur dioxide is the main acid gas culprit. Auto exhaust releasing oxides of nitrogen is the main source for acid gases in the west.

Science as Inquiry

Acid-Base Chemistry**Item:**

Chemical analysts carry out tests on substances to check what they are. Each test costs time and money. Customers sometimes want information at the lowest possible cost. Given a variety of substances from a grocery store, perform the following tasks and decide whether each substance is an acid or a base, and whether all substances can be distinguished as a result of these tests. Solid materials can be dissolved in a little water before testing. Test liquids directly.

1. See if the solution conducts electricity.
2. See if it reacts with copper.
3. Does it feel slippery? (*Wash fingers quickly after touching!*)
4. Use red and blue litmus paper and look for the results.
5. Does it have a bitter or sour taste? (*Use only the substances that are marked safe to eat.*)

After running these tests decide whether the substance is definitely an acid, definitely a base, or possibly an acid or a base. Justify your reasoning based on the tests performed.

Make a table showing properties and observations. Are any of the substances not able to be distinguished from one another by this set of tests?

If a customer gave you an unlabeled bottle of any one of the substances and wanted the lowest cost identification, what is the *minimum* number of tests you would need to be sure of the identity? Your teacher may give you such an unknown so you can try out your proposal.

Teacher Hints

Needed are small test tubes or spot plates/well trays, and eye droppers. Even an acetate sheet with a grid drawn on it with a wax pencil can make a well tray. Several inexpensive designs for a conductivity tester (battery and bulbs, or battery, resistor, and LEDs) are readily available. Quantities should be kept at the microscale level.

Possible substances are household vinegar, salt, lemon juice, antacid tablet or powder, milk of magnesia, lime water, carbonated water, soap, borax, detergent solutions and powders, and sugar and syrup solutions.