Title: Concentrating on Acids and Bases

Brief Overview:

Acid and base solutions are an important part of our everyday world. Substances lower than 7 are acidic and give off hydrogen ions (H+). Those over 7 are basic and give off hydroxide ions (OH-). Water is made up of both H+ and OH- and is considered neutral with a pH of 7. Various substances will be tested using pH paper and cabbage juice indicators. This information will be applied to real-life applications such as the testing of rain and water samples. The effect of dilution on pH will also be investigated.

Links to NCTM 2000 Standards:

- **Mathematics as Problem Solving**
  Students will demonstrate their ability to work cooperatively in groups to collect and graphically display data for testing the pH of samples with pH papers and cabbage juice indicators, identifying unknowns, and predicting % concentrations.

- **Mathematics as Reasoning and Proof**
  Students will make predictions about how a substance can be neutralized. They should make conjectures, test them, and make modifications based on new results.

- **Mathematics as Communication**
  Students will investigate pH values in common substances. They should then be able to communicate how this applies to everyday life.

- **Mathematics as Connections**
  Students will examine acids, bases, and neutral solutions found in common substances and some reasons for their use. Students will analyze data from testing water and rain samples.

- **Mathematics as Representation**
  Students will create and use data tables, box and whiskers plot and graphs to represent data.

Links to National Science Education Standards:

- **Unifying Concepts and Processes**
  Students will collect and organize data into charts and graphs.

- **Science as Inquiry**
  Students will be conducting scientific experiments involving calculating pH values and concentrations. They will collect data and compare it to various substances.

- **Earth and Space Science**
  They will test and compare rain water and standing water collected from different sites.

- **Science and Technology**
  Students can use TI-83 calculators or simple spreadsheet programs.

Grade/Level:

Grades 6-8

Duration/Length:

5- 7 class periods (45 minutes per period)

Prerequisite Knowledge:

Students should have working knowledge of the following skills:

- Basic knowledge of graphing calculator
- Calculating percentages

Student Outcomes:

Students will:

- be able to use indicators to identify unknown substances, i.e., acid, base, or neutral.
- calculate the percent concentration of solutions.
- apply this knowledge to real-life situations.

Materials/Resources/Printed Materials:

- pH paper
- TI-83 calculator
- Activity sheets

Development/Procedures:

Discussion prior to the activities should include pH, acid, bases, neutralization, solutions and percent concentration. Students should begin collecting water and rain samples approximately two weeks before starting this activity. Safety issues, such as wearing goggles and lab aprons and disposal of solutions, should be addressed. Sources of error should be emphasized, such as not rinsing glassware out and inadvertent sources of contamination.

Buffered solutions could be used for determining the unknowns. Students will devise their own experiment to try to neutralize the unknown. Cooperative lab groups are suggested. For neutralization, you may decide to use pH papers and not just cabbage indicators.

For Activity II, other colored acidic juices could be substituted or food coloring added to help show dilution. If TI-83 calculators are not available, consider using Claris Works or similar spreadsheet program for the graphing.

Assessment:

Using the cabbage indicator, students will determine the pH of their unknown substance and neutralize it. Students will be able to calculate percent concentration of solutions and make predictions from the data that apply to other concentrations.

In Activity IV, students will be using a small sample of acidic pond water to test for neutralization with a base solution. They will then calculate how much base solution must be used to neutralize the whole pond.

Extension/Follow Up:

- Titrations
- Using natural materials for dying cotton fabric
- Use CBL and pH meter

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Activity I **Name_____________**
Acids and Bases and pH indicators

Part A - Cabbage Juice Indicator
Purpose: To make cabbage juice to use as a pH indicator.

Materials: red cabbage leaves, water, 250 mL beaker, hot plate

Procedures:
1. Tear enough cabbage pieces to fill 100 mL in beaker.
2. Fill with water to 125 mL.
3. Heat using hot plate until liquid becomes dark purple.
4. Drain liquid into another beaker.

Part B - pH Readings
Materials: small test tubes, stirring rod, pH papers, colored pencils, various substances such as: aspirin, vinegar, soda, lemon juice, baking soda, orange juice, detergent, shampoo, milk, antacid tablets, distilled water (for rinsing), paper towels

Procedures:
1. Make predictions first for each substance tested.
2. Using stirring rod, put a small amount of substance to be tested on pH papers to determine actual pH range. Record results.
3. Using stirring rod, place drop of substance to be tested in a clean test tube and the same amount of cabbage indicator. Record results by coloring in data chart .

Data chart

substance	**prediction (acid, base, neutral)**	**pH papers**	**cabbage juice color**

Construct a pH scale and label where each substance ranks. Also, label acid, base, and neutral.

0 **7** **14**

Part C Unknown Substances **Name_________________**

Purpose: Determine the pH of the unknown using cabbage juice indicator.

Materials: unknowns, cabbage indicator

Unknown substance _____________ has a pH of ___________ and it is a(n)____________.
Unknown substance _____________ has a pH of ___________ and it is a(n)____________.
Unknown substance _____________ has a pH of ___________ and it is a(n)____________.

Part D Neutralization

Purpose: To neutralize one of the unknowns.

Materials: cabbage indicator, various substances tested in Activity I, small test tubes graduated cylinder, eyedroppers, pH papers(optional)

Procedures: List the steps you are going to use to neutralize this substance. Be sure to take measurements.

Data Chart: Construct a data chart. Use a separate sheet of paper.

____mL of unknown _______ was neutralized with ______ml of _____________________.

Conclusions and Analysis:

1. A closed mine sits next to a stream. Many plants have died along the stream. The pH has been found to be 4. Devise a plan that the USGS might use to help this situation.

2. Based upon what you know about the pH of soaps and detergents, make a hypothesis as to what the pH of your skin /sweat is. Describe how you could test this.

3. If a patient had a problem with excess stomach acid, speculate about several foods (that we did not test) that should be avoided.

Activity II **Name____________**
Concentrations

Increasing Liquid

Purpose: To determine what effect adding water has to the pH and how adding water effects the concentration.

Materials: graduated cylinder, lemon juice, pH papers, beaker, eyedropper

Procedures:
1.Take 5 mL of lemon juice and mix with 10 mL of water. Take the pH reading and record. Determine the % concentration of lemon juice. Record volume, pH and % concentration on the data chart you construct.

2. Continue adding more liquid to the solution nine (9) more times to make a total of 10 trials.

Data Chart:

Water	Lemon Juice	Total Volume	% Concentration	pH
10 mL	5 mL	15 mL		

Conclusions and Analysis:

1. Use the TI-83 calculator to construct a line graph of percent concentration vs. water amount using data from each trial.

To enter data, press STAT, then EDIT and ENTER. In the L1 column, type in corresponding values for lemon juice amount and ENTER. L2 will represent the amount of water volume for each trial and ENTER. In the L3 heading, type the formula for determining the percent concentration (L1/L1+L2) *100. L4 is the pH of each trial and type ENTER.

To graph data, select STAT and CALC, then 1:1-Var Stats. Select Plot 1 ENTER. Use L4 for X value and L3 for Y value. To plot the data press ZOOM, the 9:ZOOM STAT to set viewing window to correct settings and show your graph. Draw your graph here.

Make a general statement about the relationship between adding more water and the percent concentration of the solution. Defend your answer.

2. Construct a line graph of the pH value vs. water amount for each trial.
To graph data, select STAT and CALC, then 1:1-Var Stats. Select Plot 1 ENTER. Use L5 for X value and L3 for Y value. To plot the data press ZOOM, the 9:ZOOM STAT to set viewing window to correct settings and show your graph.
Draw your graph here.

Make a general statement about the relationship between adding more water and the pH value of the solution. Defend your answer.

3. Predict what the % concentration would be for 7.5 mL of water. ________ Select STAT, CALC and EXP REG for the formula. To paste this data, select Y=, VARS, STATISTICS, EQ and REG EQ. Now select TRACE and ENTER. Use the up arrow to move until y= 7.5 What is the x value? ____________

4. If you wanted to clean the tarnish from pennies using the lemon juice-water solution, which concentration that you tested would be best for this? Explain your answer.

Activity III **Name____________**
Testing Water and Rain Samples

Purpose: To test and compare water and rain samples from different sites.

Materials: glass containers will lids, pH papers, various water and rain samples, acid rain diagram

Procedures:
Test pH of various samples and record data.

Data Chart:

Conclusions and Analysis:
1. For the rain samples, construct a box and whiskers plot using the TI-83 calculator. Select STAT, then EDIT and hit ENTER. Type values for rain samples in L1 column and hit ENTER. Type in values for water samples in L2. To graph select 2nd STAT PLOT and highlight Plot 1 and hit ENTER. Select Box and Whiskers Plot. and select X=L1 and hit ENTER. Press WINDOW Xmin = 0 and X max = 14 and press ENTER. Press GRAPH. Select ZOOM:9.
Copy the box and whiskers plot for rain samples here.

2. For the water samples, construct a box and whiskers plot using the TI- 83 calculator. Select STAT, then EDIT and hit ENTER. Type values for rain samples in L1 column and hit ENTER. Type in values for water samples in L2. To graph select STAT PLOT and highlight Plot 1 and hit ENTER. Select Box and Whiskers Plot. and select X=L1 and hit ENTER. Press WINDOW Xmin = 0 and X max = 14 and press ENTER. Press graph. Select ZOOM:9.
Copy the box and whiskers plot for the rain samples here.

3. Compare and contrast the two different samples. If they are dissimilar, give possible reasons for this.

4-8. Read the article from USGS, **What is Acid Rain?**
(http://pubs.usgs.gov/gip/acidrain/2.html)

4. What are some of the reasons for these low pH values?

5. How does Maryland compare with the values you tested?

6. Which states have the least problem with acid rain?

7. Which states have the least problem with acid rain?

8. Write a good paragraph describing the effect of pH on soil, lakes, buildings and living organisms.

Name______________

Rubric
Identifying Unknowns and Neutralization

4 Points
1. The pH range is correct by a value of one either way.
2. Substance is correctly identified as an acid, base, or neutral.
3. Procedures for neutralization are clear, concise, and complete.
4. Data chart contains important observations or measurements.
5. All three questions are answered correctly and completely.

3 Points
1. The pH range is correct by a value of one either way.
2. Substance is correctly identified as an acid, base, or neutral.
3. Procedures for neutralization are unclear or incomplete.
4. Data chart contains most of the important observations or measurements.
5. Two questions are mostly correct and complete.

2 Points
1. The pH range is correct by a value of two either way.
2. Substance is incorrectly identified as an acid, base, or neutral.
3. Procedures for neutralization are unclear and incomplete.
4. Data chart is incomplete.
5. Only one question is answered correctly or completely.

1 Point
1. The pH range is correct by a value of three either way.
2. Substance is incorrectly identified as an acid, base, or neutral.
3. Procedures for neutralization are unclear, incomplete, or missing.
4. Data chart is very incomplete or missing.
5. No questions are answered correctly or completely.

Activity IV **Name____________**
Assessment - Pond Water Neutralization

Purpose: Your neighbor has a small rectangular pond 2m x 3m x 2m. The pH of the pond water tested has been found to be 5. You have been asked to neutralize the pond water sample and predict how much base solution would be required to neutralize all of the pond water.

Materials: eyedroppers, small test tubes, test tube rack, buffered solutions of pond water pH5 and base solution pH10, pH papers, graduated cylinder, and glass stirring rod.

Procedures:
Put 10 drops of "pond water" sample into a test tube. Add one (1) drop of base solution and test pH using the glass stirring rod. Record data. Continue adding one drop of base solution at a time until pond water sample is neutralized.

Data Chart:

Drops of Pond Water	Drops of Base	pH
10	0	5

Volume of 10 drops of pond water in graduated cylinder ________ mL

If 1 mL = 1 cm^3, calculate the volume of the pond in cm^3. Show calculations.

Based on your testing, how much of the base solution would you need to neutralize the pond water assuming that the pond was filled? Show calculations.

Conclusions and Analysis:

Write a summary explaining how you determined the volume of the base solution that was used to neutralize the whole pond.

Name_______________

Rubric
Pond Water Neutralization

4 Points
1. Data chart is complete.
2. Volume of pond and units are correct.
3. Calculations for base solution volume and units are correct.
4. Summary is complete including pH testing and relationship to pond neutralization.
5. Grammar and spelling for summary are correct.

3 Points
1. Data chart is complete or mostly complete.
2. Volume of pond and units are correct or mostly correct.
3. Calculations for base solution volume and units are correct or mostly correct.
4. Summary is mostly complete including pH testing and relationship to pond neutralization.
5. Most grammar and spelling for summary are correct.

2 Points
1. Data chart is mostly complete.
2. Volume of pond and units are mostly correct.
3. Calculations for base solution volume and units are mostly incomplete.
4. Summary is mostly incomplete or incorrect for pH testing and relationship to pond neutralization.
5. There are many errors in grammar and spelling for summary.

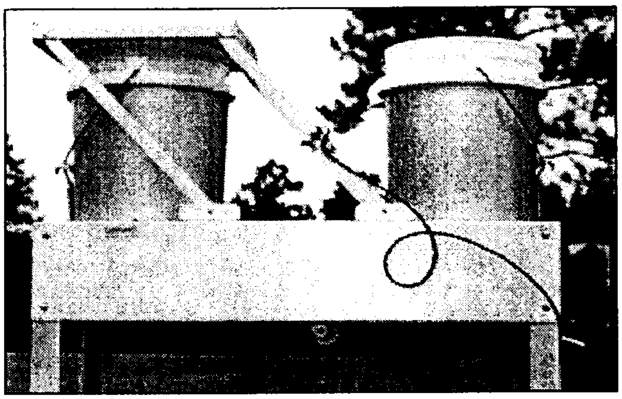
1 Point
1. Data chart is incomplete.
2. Volume of pond and units are incorrect or missing.
3. Calculations for base solution volume and units are incomplete or missing.
4. Summary is very poor for pH testing and relationship to pond neutralization.
5. There are many errors in grammar and spelling for summary.

USGS

What is acid rain?

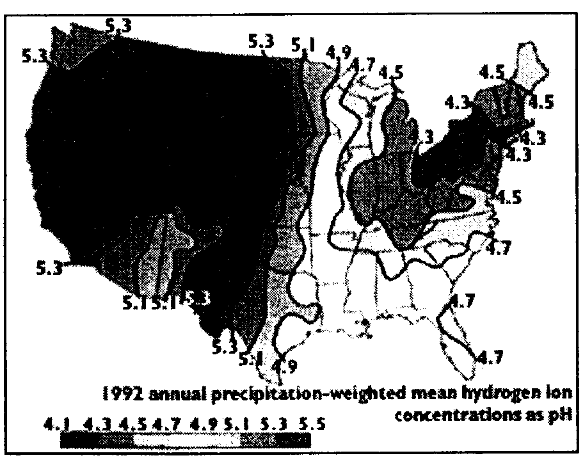
The term "acid rain" is commonly used to mean the deposition of acidic components in rain, snow, fog, dew, or dry particles. The more accurate term is "acid precipitation." Distilled water, which contains no carbon dioxide, has a neutral pH of 7. Liquids with a pH less than 7 are acid, and those with a pH greater than 7 are alkaline (or basic). "Clean" or unpolluted rain has a slightly acidic pH of 5.6, because carbon dioxide and water in the air react together to form carbonic acid, a weak acid. Around Washington, D.C., however, the average rain pH is between 4.2 and 4.4.

The extra acidity in rain comes from the reaction of air pollutants, primarily sulfur oxides and nitrogen oxides, with water in the air to form strong acids (like sulfuric and nitric acid). The main sources of these pollutants are vehicles and industrial and power-generating plants. In Washington, the main local sources are cars, trucks, and buses.



Wet and dry bucket collector, used to collect samples for measuring rainfall acidity.

Acidity in rain is measured by collecting samples of rain and measuring its pH. To find the distribution of rain acidity, weather conditions are monitored and rain samples are collected at sites all over the country. The areas of greatest acidity (lowest pH values) are located in the Northeastern United States. This pattern of high acidity is caused by the large number of cities, the dense population, and the concentration of power and industrial plants in the Northeast. In addition, the prevailing wind direction brings storms and pollution to the Northeast from the Midwest, and dust from the soil and rocks in the Northeastern United States is less likely to neutralize acidity in the rain.



A pH distribution map shows areas in the continental United States of greatest acidity in the rain.

When you hear or read in the media about the effects of acid rain, you are usually told about the lakes, fish, and trees in New England and Canada. However, we are becoming aware of an additional concern: many of our historic buildings and monuments are located in the areas of highest acidity. In Europe, where buildings are much older and pollution levels have been ten times greater than in the United States, there is a growing awareness that pollution and acid rain are accelerating the deterioration of buildings and monuments.

Stone weathers (deteriorates) as part of the normal geologic cycle through natural chemical, physical, and biological processes when it is exposed to the environment. This weathering process, over hundreds of millions of years, turned the Appalachian Mountains from towering peaks as high as the Rockies to the rounded knobs we see today. Our concern is that air pollution, particularly in urban areas, may be accelerating the normal, natural rate of stone deterioration, so that we may prematurely lose buildings and sculptures of historic or cultural value.

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Last modified 07.21.97