

1. Acid Rain and Weathering

Ruined Rocks

Driving Question

- What effect can acid rain have on architectural materials?

Materials and Equipment

For each student or group:

- | | |
|-------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
| <input type="checkbox"/> Data collection system | <input type="checkbox"/> Iron nail |
| <input type="checkbox"/> pH sensor | <input type="checkbox"/> Rock samples, small -marble, limestone , chalk, or similar |
| <input type="checkbox"/> Bottle, 500-mL (or any clean soda bottle 16 oz or smaller) | <input type="checkbox"/> White vinegar, 50 mL |
| <input type="checkbox"/> Graduated cylinder, 50-mL or 100-mL | <input type="checkbox"/> Water |
| <input type="checkbox"/> Beakers (2), 150-mL | <input type="checkbox"/> Spoon |
| <input type="checkbox"/> Pipet or eye dropper | <input type="checkbox"/> Funnel |
| <input type="checkbox"/> Balloon, 10" or 12" in diameter | <input type="checkbox"/> Bromothymol blue indicator solution |
| <input type="checkbox"/> Straw | <input type="checkbox"/> Baking soda, 1.5 Tbsp. |

Safety

Add these important safety precautions to your normal laboratory procedures:

- Wear aprons to protect clothes.
- Wear safety goggles.
- Handle all equipment with care and ensure computers and/or data collection systems are protected from liquids.

Thinking about the Question

Working together with the members of your group, make a list of ten buildings or structures around the world that are well-known, famous, or important. For each building or structure also list the material from which it is made, if you know. If you do not know, leave that part of your list blank. Be prepared to share your list with the rest of the class.

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Structures made of stone, brick, concrete, and metal can be affected by acid rain. Are any of the buildings or structures in your list made of these materials?

As you know, an acid is a substance that has a pH factor lower than 7.0. The pH scale goes from 0 to 14, with those substances whose pH factors are below 7 classified as acids, and those whose pH factors are above 7 are bases, or alkalis. You know the 7 on the pH scale represents neutral.

In this activity, you will be using your knowledge of acids, bases, and the pH scale to help you investigate the effects of acid rain on the materials used to construct buildings and other structures.

Sequencing Challenge

The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.

				
Place several drops of the simulated acid rain onto each sample of material.	Make certain that each member of your lab group is aware of the safety rules and procedures for this activity.	Use a straw to bubble carbon dioxide gas into water, so the gas dissolves in the water, creating simulated acid rain.	Test the pH of the simulated acid rain (the solution of water and carbon dioxide).	React baking soda with vinegar to produce carbon dioxide gas.

Investigating the Question

Note: When you see the symbol "◆" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Making predictions

- Write your prediction for the following:
 - What will happen to the pH of a beaker of distilled water when carbon dioxide is added to it?
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- Complete Table 1 by predicting how acid rain will react with the listed materials.

Table 1: Predicted acid rain reactions

	Chalk	Iron (nail)	Limestone	Marble
Predicted Reaction				

Part 2 – Creating simulated acid rain

3. Pour 50 mL of vinegar into a 500-mL soda bottle.
4. Pour about 40 mL of water into each 150-mL beaker
5. Add a few drops (it may need as much as half a pipet) of the bromothymol blue indicator solution to the water in the beakers. It should turn the water blue or blue-green.
6. Start a new experiment on the data collection system. ♦^(1.2)
7. Connect a pH sensor to the data collection system. ♦^(2.1)
8. Display pH on the y-axis of a graph with Time on the x-axis. ♦^(7.1.1)
9. Insert the pH sensor into one of the beakers.
 - Note:** Remember to remove the storage bottle from the pH sensor tip, and set the bottle aside.
10. Using the funnel, put one heaping tablespoon of baking soda into the balloon.
11. Carefully place the end of the balloon over the top of the bottle, taking care to prevent the baking soda from falling in.
12. Once the balloon is in place, lift it up, allowing the baking soda to fall into the bottle.
13. The carbon dioxide formed in the reaction between vinegar and baking soda should inflate the balloon.
14. Pinch or twist the balloon to save the gas, and while holding the gas in the balloon, remove the balloon from the bottle.
15. Twist the end of balloon around one end of a straw. Then place the other end of the straw in the water in beaker with the previously inserted pH sensor.
16. Start data recording. ♦^(6.2)

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17. *Slowly* release the pinch or twist that is holding the gas in the balloon, allowing the gas to bubble into the water.
18. Once the balloon is empty, stop data recording. ♦^(6.2)
19. Label and print your graph according to your teacher's instructions. ♦^(11.2)
20. What happened to the color of the indicator?

-
21. What is the pH of the water?

-
22. How does acid rain change the pH of water?
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Part 3 – Investigating the effects of acid rain on materials

23. Place several drops of the simulated acid rain water on each of the samples of materials. Observe each sample carefully for signs of reaction.
- Note:** For the nail, you may need to place it in the beaker of simulated acid rain and observe for changes.
24. Complete Table 2 after testing the reaction of your acid rain solution with each of the listed materials.

Table 2: Acid rain reactions

	Chalk	Iron (nail)	Limestone	Marble
Reaction				

Answering the Question

Analysis

1. How did your predictions from Part 1 compare to the results from Part 2 and 3?

2. What factors do you think contributed to your findings?

3. What signs did you observe that indicated that a chemical change was taking place when you tested the acid rain and the material samples?

4. What relationship is there between acid rain levels and changes to certain rocks?

5. Suppose you are visiting a cathedral that was built of limestone blocks several hundred years ago. In walking around and looking at the carvings depicting people and animals, you notice that the finer details such as the facial features of people have become worn and unrecognizable. As you listen to the guide giving the tour, you learn that acid rain is a problem in the area, due to pollution sources upwind. Is it possible that acid rain could be responsible for the damage to the carved stone faces? Explain your thinking.

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6. Weathering refers to any process that decomposes rocks and turns them into loose particles such as gravel, sand, clay or soil. Explain how acid rain could be considered a weathering process.

True or False

Enter a "T" if the statement is true or an "F" if it is false.

- _____ 1. Substances whose pH factors are above 7 are classified as acids.
- _____ 2. Soil consists of weathered rocks and decomposed organic materials.
- _____ 3. Acid rain can be the result of human-caused pollution.
- _____ 4. Acids have no effect on such materials as limestone and chalk.
- _____ 5. Sedimentary rocks are never damaged by acid rain.
- _____ 6. Some structures made of marble have become damaged by acid rain's effects.
- _____ 7. As water passes through the water cycle, it dissolves minerals and gases.
- _____ 8. One substance that can lower the pH of water, when dissolved in it, is carbon dioxide.

Key Term Challenge

Fill in the blanks from the randomly ordered words below:

a chemical reaction	product	pH	weathering
sedimentary	gas	acid	water

1. The process by which rocks are broken down to form smaller particles such as gravel, sand, and clay is called _____.
2. Vinegar and sodium bicarbonate (baking soda) undergo _____ to form a/an _____.

3. When rain absorbs gaseous pollutants in the atmosphere the _____ of the rain is lowered, resulting in _____ rain.

4. Buildings constructed of limestone or other _____ rocks, as well as certain metamorphic rocks such as marble, can be damaged by the weathering that occurs with acid rain.

5. Because of its ability to dissolve so many substances, including solids and gases, _____ is able to carry minerals as well as pollutants as it moves throughout the earth's surface.

6. Carbon dioxide, the _____ of a chemical reaction, produces an acid when dissolved in water.