

Acid Rain

Acid rain is a topic of much concern in today's world. As carbon dioxide gas, CO_2 , dissolves in water droplets of unpolluted air, the following reaction occurs:



H_2CO_3 is a weak acid that causes the rain from unpolluted air to be slightly acidic. This source of "acid rain" is not usually considered to be a pollutant, since it is natural and usually does not alter the pH of rain water very much. Oxides of sulfur dissolve in water droplets to cause more serious problems. Sulfur dioxide dissolves to produce sulfurous acid, H_2SO_3 , by the equation:



This source of sulfur dioxide can occur naturally, as from volcanic gases. More often, however, sulfur dioxide is considered a pollutant, since it is a by-product of fossil-fuel combustion.

The acidity of a solution can be expressed using the pH scale, which ranges from 0 to 14. Solutions with a pH above 7 are basic, solutions with pH below 7 are acidic, and a neutral solution has a pH of 7. In Part I of this experiment, you will study how the pH of water changes when CO_2 is dissolved in water. In Part II, you will study the effect sulfuric acid has on the pH of different water types.

A *buffer* is a mixture of a weak acid and its conjugate base, or a weak base and its conjugate acid. A buffer's function is to absorb acids (H^+ or H_3O^+ ions) or bases (OH^- ions) so that pH changes very, very little. The bicarbonate-carbon dioxide *buffer system*, for example, keeps the pH of blood in humans between 7.3 and 7.5.

OBJECTIVES

In this experiment, you will

- Use a computer to measure pH.
- Study the effect of dissolved CO_2 on the pH of distilled water.
- Study the effect on pH of dissolving H_2SO_4 in various waters.
- Learn why some bodies of water are more vulnerable to acid rain than others.

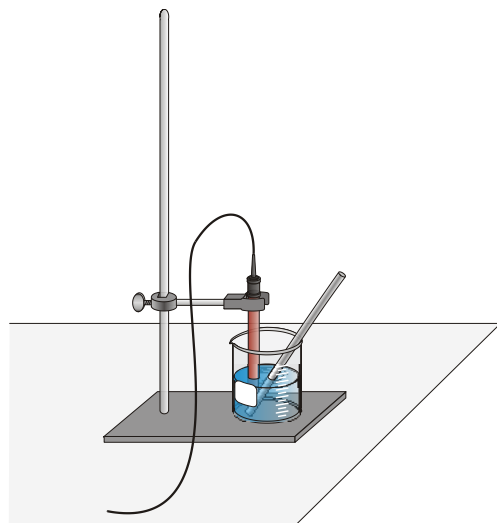


Figure 1

MATERIALS

computer
Vernier computer interface
Vernier pH Sensor
LoggerPro
250 mL and 100 mL beaker
buffer solution

dilute H_2SO_4
ring stand and utility clamp
straw
wash bottle with distilled water
water from a lake
water from the ocean (optional)

PROCEDURE

Part I CO_2 and Water

As carbon dioxide gas, CO_2 , dissolves into water droplets suspended in the atmosphere, it changes the rainwater's pH. Here you will test to see if CO_2 will affect the pH of distilled water. The source of CO_2 will be your breath.

1. Obtain and wear goggles.
2. Connect the pH Sensor to the computer interface. Prepare the computer for data collection by opening the file "18a Acid Rain" from the *Biology with Vernier* folder of *LoggerPro*.
3. Use a rinse bottle to thoroughly rinse the pH electrode as shown by your teacher. Catch the rinse water in a beaker.
4. Wash a 100 mL beaker with tap water and dry it with a paper towel. Note: All glassware must be clean in this experiment! Put 50 mL of distilled water into this clean beaker. Lower the pH electrode into the distilled water and swirl the water around the electrode briefly.
5. Begin data collection by clicking . After the computer registers the initial pH, use a straw to blow your breath into the distilled water for 1 minute. Your breath contains CO_2 . The computer will save readings as you blow.
6. Click the Statistics button, , to determine the maximum and minimum pH values. Record

the maximum and minimum pH in Table 1.

Part II Simulating Acid Rain Using H₂SO₄

7. Rinse the pH electrode thoroughly with distilled water.
8. Wash and dry the 100 mL beaker. Get a new 50 mL portion of distilled water. Place the pH electrode into the distilled water and secure in place with a ring stand and utility clamp.
9. Prepare the computer for data collection by opening the file “18b Acid Rain” from the *Biology with Vernier* folder of *LoggerPro*.
10. You are ready to begin the measurements. Start measuring the pH by clicking . Note that a new button is available.
11. Click to take a pH measurement. A text box will appear. You should enter the number of drops of acid you add to the water in the beaker. Since you didn't add any acid yet, type **0** in the text box and press ENTER.
12. Add 1 drop of H₂SO₄ (sulfuric acid) to the water. Stir thoroughly, until the pH is stable.
CAUTION: *Handle the sulfuric acid with care. It can cause painful burns if it comes into contact with skin.*
13. Click . Enter the number of drops of acid added to the beaker. Type **1** in the text box and press ENTER.
14. Repeat Steps 12–13, adding 1 drop at a time, until you have added 10 drops of acid.
15. Click when all measurements have been made.
16. From the table, record the pH values in Table 2.
17. Store your data by choosing Store Latest Run from the Experiment menu.

H₂SO₄ and Water from the Ocean

18. Complete these steps:
 - a. Clean the pH electrode.
 - b. Wash and dry the 100 mL beaker.
 - c. Get a 50 mL portion of “Ocean Water” in the 100 mL beaker, lower the pH electrode into this water, and then briefly swirl the water about the electrode.
 - d. Repeat Steps 10–17 for this sample.

H₂SO₄ and Lake Water

19. Repeat Step 18, using “Lake Water” from your teacher.

H₂SO₄ and Buffer Solution

20. Repeat Step 18, using “Buffer Solution” from your teacher.
21. Use the Text Annotation feature from the Insert menu to label each of the plots on the graph with the water type used. Adjust the position of the arrow.
22. Print a graph with the four types of water tested. Enter your name(s) and number of copies of

the graph. Use your graph to answer the discussion questions at the end of this experiment.

PRE-LAB QUESTIONS

1. What is the definition of an acid? What is the definition of a base?
2. When a sensor is used to measure the pH of a solution, what is it detecting in the solution?
3. In what ways is pH important to living things?
4. What is a buffer?
5. Why is it important for an organism to be able to prevent a large change in internal pH?
6. What do you predict will happen to the pH of the solution when the acid, HCl, is added to water? when the base, NaOH, is added?

PROCESSING THE DATA

Part I

| Table 1 Adding CO ₂ from your breath to water | | |
|---|------------|-----|
| Maximum pH | Minimum pH | ΔpH |
| | | |

Part II

| Table 2 | | | | |
|-------------|-----------------------|-------|------|--------|
| Drops | pH of this water type | | | |
| | distilled | ocean | lake | buffer |
| 0 | | | | |
| 1 | | | | |
| 2 | | | | |
| 3 | | | | |
| 4 | | | | |
| 5 | | | | |
| 6 | | | | |
| 7 | | | | |
| 8 | | | | |
| 9 | | | | |
| 10 | | | | |
| Δ pH | | | | |

QUESTIONS

1. Calculate the change in pH (Δ pH) for the water in Part I. Subtract the final pH from the initial pH. What conclusion can you make about your breath?
2. Why does the pH change rapidly at first, and remain stable after a time?
3. Calculate the change in pH (Δ pH) for each of the Part II trials. Subtract the final pH from the initial pH.
4. Compare the Δ pH values. Which test gave the largest pH change? Which test gave the smallest pH change?
5. Water from the ocean is said to be “naturally buffered.” From the result of this experiment, what does this mean?
6. How does water from the ocean become buffered?
7. Many aquatic life forms can only survive in water with a narrow range of pH values. In which body of water—lakes or oceans—would living things be more threatened by acid rain? Explain.

Computer 18

8. There are numerous coal-burning electric power plants along the Ohio River in Southern Indiana, where the river and lake waters are naturally buffered. However, air pollution produced there is more harmful to water life in Upstate New York, where the river and lake waters are NOT buffered like in Southern Indiana. A similar situation exists in Europe where air pollutants from highly industrialized Germany are more harmful to Scandinavian water life than to water life in Germany. Use the results of this experiment to explain these situations.
9. Summarize your conclusions about this laboratory experiment. Use your data to answer the purposes of this experiment.

INQUIRY

1. What other types of water might you test in the same way you tested lake and ocean water. How do they compare and what explanation can you give for why they are different from or similar to the various waters that you tested?
2. Do library research to get more information on the effects of acid rain on streams and lakes.
3. Do library research and prepare a report on “naturally buffered” streams and lakes.