Acids and Bases

Organisms are often very sensitive to the effect of acids and bases in their environment. They need to maintain a stable internal pH in order to survive—even in the event of environmental changes. Many naturally occurring biological, geological, and man-made chemicals are capable of stabilizing the environment's pH. This may allow organisms to better survive in diverse environments found throughout the earth. Teams will work in pairs, using one computer and two pH systems. One team will measure the effect of acid on biological materials, while the other team will measure the effect of base on biological materials. Each group will test the biological materials assigned to them, and all groups will share their data at the end of the class.

OBJECTIVES

In this experiment, you will

- Add an acid to a material and note the extent that it resists changes in pH.
- Add a base to a material and note the extent that it resists changes in pH.
- Work with classmates to compare the ability of different materials to resist pH changes.

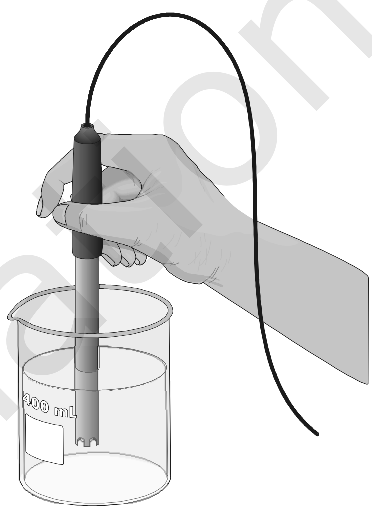

Figure 1

MATERIALS

computer
Vernier computer interface
Logger*Pro*
Vernier pH Sensor (one per team)
Various biological organisms (or parts of an organism), such as yeast, potato, orange juice, or a plant leaf solution.
Various non-biological materials, such as an antacid, buffer, carbonated water or soda, salt, or Alka-Seltzer solution.
two 250 mL beakers
one rinse bottle with distilled water
0.10 M HCl (acid) with dropper
0.10 M NaOH (base) with dropper
50 mL graduated cylinder
goggles
lab apron
two 50 mL beakers
Various simple biological materials, such as egg white, vitamin C, or gelatin solution.

PROCEDURE

1. Obtain and wear goggles.

2. Team A will use the pH probe in CH 1, while Team 2 will use the pH probe in CH 2. Before each use of the pH probe, you need to rinse the tip of the electrode thoroughly with distilled water. To do this, hold the pH electrode above a rinse beaker and use the rinse bottle to thoroughly rinse the electrode tip.

   Important: Do not let the pH electrode dry out. Keep it in a 250 mL beaker with about 100 mL of tap water when not in use. The tip of the probe is made of glass—it is fragile. Handle with care!

3. Connect the probes to the computer interface. Prepare the computer for data collection by opening the file "03 Acids and Bases" from the *Biology with Vernier* folder of Logger*Pro*.

Testing the effect of acid and base on water

4. Label one of the 50 mL beakers *acidic* and label the other *basic*. Place 20 mL of distilled water in each beaker.

5. Rinse the pH probe thoroughly with distilled water, then place it into the beaker to be tested:
   - Team A: Place your probe in the beaker labeled *acidic*.
   - Team B: Place your probe in the beaker labeled *basic*.

6. Click [▶ Collect] to begin making pH measurements.

7. The group will be entering the number of drops of acid or base added to the beaker. Before you begin, determine the initial pH of the solution. Click [Keep], then type **0** in the text box and press ENTER.

8. Add acid or base to the solution. Stir each solution thoroughly after addition. **CAUTION:** Handle the hydrochloric acid with care. It can cause painful burns if it comes in contact with the skin. Sodium hydroxide solution is caustic. Avoid spilling it on your skin or clothing.
   - Team A: Add 5 drops of acid to the beaker labeled *acidic*.
   - Team B: Add 5 drops of base to the beaker labeled *basic*.

9. When the pH readings are stable click [Keep]. Enter the total number of drops of acid or base you have added to the water in the beaker. Type **5** in the text box and press ENTER.

10. Repeat Steps 8 through 9, adding 5 drops at a time until each team has added a total of 30 drops.

11. Click [■ Stop] when you have added a total of 30 drops.

12. Rinse the pH probe thoroughly and place the probe into the beaker of tap water. Clean the two 50 mL beakers.

13. Move your data to a stored data run. To do this, choose Store Latest Run from the Experiment menu. This will allow the data you obtained for water to be included in every future graph.

Testing the effect of acid and base on other materials

14. Test the effect of acid and base on a material assigned to you by your instructor:
    a. Obtain 20 mL of a solution to test from your instructor.
    b. Repeat Steps 5–12.
    c. Record the volume and pH values from the table in Table 1. Run 1 data will be the data collected using water. The data labeled Latest will be the data for your tested material.
    d. (optional) Print a copy of your graph. Enter your name(s) and the number of copies of the graph. The graph should have four lines on it—water with acid, water with base, your material with acid, and your material with base.
15. If time permits, repeat Step 14 for as many materials as you can. Before starting the next experiment, delete the latest run by choosing Delete Data Set ▸ Latest from the Data menu.
16. Obtain the pH values of any materials you did not test from your classmates. These values should be listed on the board. Record these values in Table 1.
17. Subtract the ΔpH of the acid from the ΔpH of the base to determine the Total Buffer Range. Record these values in Table 1.

DATA TABLE

Table 1										
Material Tested	Add	pH, after adding this many drops								
		0	5	10	15	20	25	30	ΔpH	Total Buffer Range
	acid									
	base									
	acid									
	base									
	acid									
	base									
	acid									
	base									
	acid									
	base									
	acid									
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PROCESSING THE DATA

1. Make a series of graphs of the data obtained from other students. Alternatively, if instructed by your teacher, obtain a printout of each plot from other student teams. Construct the graphs so they appear similar to the plot your team made:
   - The horizontal axis has Volume scaled from 0 to 30 drops.
   - The vertical axis has pH scaled from 0 to 12.
   - The data you obtained for water should be included in every graph.
   - Construct one graph from the data in each row of Table 1.

2. Make a list of each material that was tested by the teams in your class. Place the most acidic material at the top of the list and the most basic material at the bottom of the list. Use the value corresponding to 0 drops of acid or base, as this value represents the natural acidity of the material.

Table 2		
Material	Initial pH	Rank
		most acidic
		2
		3
		4
		5
		6
		7
		least acidic

3. Put the materials tested into the following three categories:

Biological Organisms	Biological Chemicals	Non-Biological Chemicals

4. Calculate the pH change for each material. Record this in Table 1.

5. Make a second list of each material in Table 1. Place the material that had the largest Total Buffer Range at the top of the list in Table 3 and the smallest range at the bottom of the list.

Table 3		
Material	Total Buffer Range	Rank
		greatest change
		2
		3
		4
		5
		6
		7
		8
		least change

QUESTIONS

1. How should the pH of a material to test in the *Acidic* beaker compare to that in the *Basic* beaker before any acid or base is added? Why?

2. Referring to Question 1, does your data support your hypothesis? If not, what might cause the differences?

3. Generally, what was the effect of adding HCl to each solution? Was this true for every solution? Why do you think this happened the way it did?

4. Generally, what was the effect of adding NaOH to each solution? Was this true for every solution? Why do you think this happened the way it did?

5. Compare the various graphs of each substance. Why was it of value to include the plot of water in acid and water in base with every experiment?

6. Which class of materials, biological organisms, biological chemicals, or non-biological chemicals reacted most dramatically to the addition of acid or base? How does this relate to their complexity?

7. Which of the materials in Table 3 is the best buffer? The poorest buffer?

EXTENSION

1. Bring in common materials from home to test. How do you think they will respond? How did their response compare to your predictions?

Vernier Lab Safety Instructions Disclaimer

THIS IS AN EVALUATION COPY OF THE VERNIER STUDENT LAB.

This copy does not include:

- **Safety information**
- **Essential instructor background information**
- **Directions for preparing solutions**
- **Important tips for successfully doing these labs**

The complete *Biology with Vernier* lab manual includes 31 labs and essential teacher information. The full lab book is available for purchase at: http://www.vernier.com/cmat/bwv.html

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