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. Using the pH Sensor, each lab group will measure the effect of an acid and a base in water. Each group will also test the effect of an acid and a base on a biological material assigned to them. 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 to which it resists changes in pH.
- Add a base to a material and note the extent to which it resists changes in pH.
- Work with classmates to compare the ability of different materials to resist changes in pH.

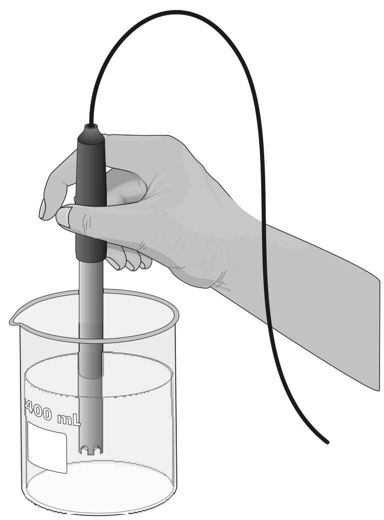

Figure 1

MATERIALS

TI-Nspire handheld **or**
computer and TI-Nspire software
data-collection interface
Vernier pH Sensor
250 mL beaker
50 mL graduated cylinder
50 mL beaker
0.10 M HCl (acid) with dropper
0.10 M NaOH (base) with dropper
rinse bottle with distilled water
graph paper
goggles
lab apron
Various non-biological materials, such as an antacid, buffer, carbonated water or soda, salt, or Alka-Seltzer® solution
Various simple biological materials, such as egg white, vitamin C, or gelatin solution
Various biological organisms (or parts of an organism), such as yeast, potato, orange juice, or a plant leaf solution

PROCEDURE

1. Obtain and wear goggles.

2. Before each use of the pH Sensor, you need to rinse the tip of the sensor thoroughly with distilled water. To do this, hold the pH Sensor above a rinse beaker and use the rinse bottle to thoroughly rinse the sensor tip.

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

3. Connect the pH Sensor to the data-collection interface. Connect the interface to the TI-Nspire handheld or computer.

4. Choose New Experiment from the Experiment menu. Choose Collection Mode ► Events with Entry from the Experiment menu. Enter **Drops** as the Name and leave the Units field blank. Select OK.

Testing the effect of acid on water

5. Label a 50 mL beaker *acidic*. Place 20 mL of distilled water in the beaker.

6. Rinse the pH Sensor thoroughly with distilled water, then place it into the beaker to be tested. Be sure the tip of the probe is totally submerged in the water.

7. Start data collection ( ). Monitor the pH readings displayed to the right of the graph. When the readings are stable, click the **Keep** button ( ).

8. Enter **0** as the number of drops you have added. Select OK to store the first data pair for this experiment.

9. Add 5 drops of acid to the beaker. Stir the solution thoroughly after addition.
   CAUTION: *Handle the hydrochloric acid with care. It can cause painful burns if it comes in contact with your skin. Sodium hydroxide solution is caustic. Avoid spilling it on your skin or clothing.*

10. When the readings are stable, click the **Keep** button ( ). Enter the total number of drops of acid added to the water in the beaker and select OK.

11. Repeat Steps 9–10 adding 5 drops each time until a total of 30 drops has been added.

12. Stop data collection ( ).

13. Click the Table View tab ( ) and record the pH values in Table 1.

14. Rinse the pH Sensor thoroughly and place the sensor into the beaker of tap water.

Testing the effect of base on water

15. Label a 50 mL beaker *basic*. Place 20 mL of distilled water in the beaker. Click the Graph View tab ( ), click the Store Data button ( ), and repeat Steps 6–14 substituting base for acid.

Testing the effect of acid on other materials

16. Clean the 50 mL beaker labeled *acidic*. Place 20 mL of test solution, obtained from your teacher, in the beaker. Click the Graph View tab ( ), click the Store Data button ( ), and repeat Steps 6–14 using acid.

Testing the effect of base on other materials

17. Clean the 50 mL beaker labeled *basic*. Place 20 mL of test solution, obtained from your teacher, in the beaker. Click the Graph View tab ( ), click the Store Data button ( ), and repeat Steps 6–14 substituting base for acid.

18. If time permits, repeat Steps 16–17 for as many materials as you can.

19. Share your data with the rest of the class. 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.

DATA

Table 1

Material tested	Add	pH, after adding this many drops								
		0	5	10	15	20	25	30	ΔpH	Buffer range
	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 in Table 1. Construct the graphs using these guidelines:
   - The horizontal axis has Volume scaled from 0 to 30 drops.
   - The vertical axis has pH scaled from 0 to 12.
   - The acid and base data you obtained for water should be included in every graph.
   - Construct one graph for each material tested in Table 1. The graph should include the acid data and the base data.
2. Calculate the pH change, ΔpH, for each material and record in Table 1. The change in pH can be found using the equation

$$\Delta pH = pH \text{ at 30 drops} - pH \text{ at 0 drops}$$

3. Determine the buffering ability of each substance listed in Table 1. Subtract the Δ*pH* of acid from the Δ*pH* of base for each substance. Record in the Buffer Range column of Table 1.
4. In Table 2, make a list of each material 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 pH at 0 drops of acid or base. This value represents the natural pH of the material.

Table 2		
Material	Initial pH	Rank
		most acidic
		2
		3
		4
		5
		6
		7
		8
		least acidic

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

Biological organisms (tissues or cells)	Biological chemicals	Non-biological chemicals

6. List each material tested with its buffer value in Table 3. Order the materials from worst buffering ability (largest buffer range) to best buffering ability (smallest buffer range).

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

QUESTIONS

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

2. Referring to Question 1, do 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 beneficial 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 tested 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?