Name ________________________________ Date ________ Period ________

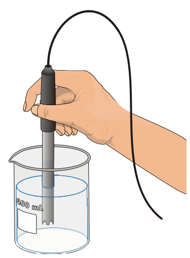
ACIDS AND BASES

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.



HYPOTHESIS

1. If drops of ACID are added to a pH buffer, then the pH of the buffer will ________________________________ [increase / decrease / stay the same].

2. If drops of BASE are added to a pH buffer, then the pH of the buffer will ________________________________ [increase / decrease / stay the same].

MATERIALS

INDIVIDUAL/TEAM MATERIALS:

- MacBook Air computer
- LabQuest (Vernier computer interface)
- Logger*Pro* software
- 2 Vernier pH Sensors
- 100 mL 0.10 M HCl (acid) with dropper
- 100 mL 0.10 M NaOH (base) with dropper
- 2 stickers, labeled ACID and BASE
- 2 100 mL flasks
- 1 50 mL graduated cylinder
- 1 500 mL beaker with water (HOH)

SHARED CLASS MATERIALS:

- 1 L 2% albumin (egg white) solution
- 1 L 0.10 M bicarbonate solution
- 1 L 0.10 M citric acid solution
- various buffer solutions

PROCEDURE

1. Obtain and wear goggles. Connect a Vernier pH probe into CH 1 and CH 2 of the LabQuest.

2. One person from each lab team will use the pH probe in CH 1. This probe will be used when adding ACID to the different solutions. The other person from each lab team will use the pH probe in CH 2. This probe will be used when adding BASE to the different solutions. Thoroughly rinse the two probes and place them into a 500 mL beaker that contains approximately 300 mL of water.

   Important: Do not let the pH electrodes dry out. Keep them in a 500 mL beaker with about 300 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 100 mL flasks *ACID* and label the other *BASE*. Place 30 mL of water in each flask.

5. On the data table, click on the labels "pH 1" and "pH 2". Change "pH 1" to "ACID" and "pH 2" to "BASE".

6. Select "Graph Options…" from the "Options" menu. First click on "Axes Options". Label the Y-Axis "pH of Water". Then click on "Graph Options" in the dialogue box that appears. Select the option that says "Connect Points". Also select the option that says "Legend".

7. Rinse the pH probe thoroughly with water. Then place it into the beaker to be tested:

   - Person A: Place your probe in the beaker labeled *ACID*.
   - Person B: Place your probe in the beaker labeled *BASE*.

8. Click ▶ Collect to begin making pH measurements.

9. 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.

10. 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.

    - Person A: Add 5 drops of acid to the beaker labeled *ACID*.
    - Person B: Add 5 drops of base to the beaker labeled *BASE*.

11. 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.

12. Repeat Steps 10 11, adding 5 drops at a time until each person has added a total of 30 drops.

13. Click ■ Stop when you have added a total of 30 drops.

14. Select “Print Graph…” from the “File” menu. Press “OK” when the “Printing Options” box appears. Follow the prompts to save the graph as a PDF. Save the graph to the Desktop. Include your name(s) and WATER in the title.

15. Rinse the pH probe thoroughly and place the probe into the 500 mL beaker of tap water. Rinse and dry the two 100 mL beakers.

Testing the effect of acid and base on bicarbonate solution

16. Place 30 mL of bicarbonate solution in each beaker.

17. Select “Graph Options…” from the “Options” menu. First click on “Axes Options”. Label the Y-Axis “pH of Bicarbonate”. Set the X-axis “Scaling options” for the graph to go from 0 to 100 drops. Then click on “Graph Options” in the dialogue box that appears. Select the option that says “Connect Points”. Also select the option that says “Legend”.

18. Click ▶ Collect to begin making pH measurements. Select the option to “Erase and Continue”.

19. Repeat steps 9-12 for the bicarbonate solution, but add 10 drops of ACID or BASE at a time instead of 5 drops. Click ■ Stop when you have added a total of 100 drops.

20. Select “Print Graph…” from the “File” menu. Press “OK” when the “Printing Options” box appears. Follow the prompts to save the graph as a PDF. Save the graph to the Desktop. Include your name(s) and BICARBONATE in the title.

21. Rinse the pH probe thoroughly and place the probe into the 500 mL beaker of tap water. Rinse and dry the two 100 mL beakers.

Testing the effect of acid and base on a buffer solution

22. Place 30 mL of a buffer solution in each beaker. Record the pH of the buffer solution that you chose.

23. Select “Graph Options…” from the “Options” menu. First click on “Axes Options”. Label the Y-Axis “pH of Buffer Solution”. Set the X-axis “Scaling options” for the graph to go from 0 to 100 drops. Then click on “Graph Options” in the dialogue box that appears. Select the option that says “Connect Points”. Also select the option that says “Legend”.

24. Click ▶ Collect to begin making pH measurements. Select the option to “Erase and Continue”.

25. Repeat steps 9-12 for the buffer solution, but add 10 drops of ACID or BASE at a time instead of 5 drops. Click ■ Stop when you have added a total of 100 drops.

26. Select “Print Graph…” from the “File” menu. Press “OK” when the “Printing Options” box appears. Follow the prompts to save the graph as a PDF. Save the graph to the Desktop. Include your name(s) and BUFFER in the title.

27. Rinse the pH probe thoroughly and place the probe into the 500 mL beaker of tap water. Rinse and dry the two 100 mL beakers.

Testing the effect of acid and base on citric acid solution

28. Place 30 mL of citric acid solution in each beaker.

29. Select "Graph Options…" from the "Options" menu. First click on "Axes Options". Label the Y-Axis "pH of Citric Acid". Set the X-axis "Scaling options" for the graph to go from 0 to 30 drops. Then click on "Graph Options" in the dialogue box that appears. Select the option that says "Connect Points". Also select the option that says "Legend".

30. Click [▶ Collect] to begin making pH measurements. Select the option to "Erase and Continue".

31. Repeat steps 9-12 for the citric acid solution. Remember to add 5 drops of ACID or BASE at a time. Click [■ Stop] when you have added a total of 30 drops.

32. Select "Print Graph…" from the "File" menu. Press "OK" when the "Printing Options" box appears. Follow the prompts to save the graph as a PDF. Save the graph to the Desktop. Include your name(s) and CITRIC ACID in the title.

33. Rinse the pH probe thoroughly and place the probe into the 500 mL beaker of tap water. Rinse and dry the two 100 mL beakers.

Testing the effect of acid and base on albumin (egg white) solution

34. Place 30 mL of albumin (egg white) solution in each beaker.

35. Select "Graph Options…" from the "Options" menu. First click on "Axes Options". Label the Y-Axis "pH of Albumin". Set the X-axis "Scaling options" for the graph to go from 0 to 100 drops. Then click on "Graph Options" in the dialogue box that appears. Select the option that says "Connect Points". Also select the option that says "Legend".

36. Click [▶ Collect] to begin making pH measurements. Select the option to "Erase and Continue".

37. Repeat steps 9-12 for the albumin solution, but add 10 drops of ACID or BASE at a time instead of 5 drops. Click [■ Stop] when you have added a total of 100 drops.

38. Select "Print Graph…" from the "File" menu. Press "OK" when the "Printing Options" box appears. Follow the prompts to save the graph as a PDF. Save the graph to the Desktop. Include your name(s) and ALBUMIN in the title.

39. Rinse the pH probe thoroughly and place the probe into the 500 mL beaker of tap water. Rinse and dry the two 100 mL beakers.

NOTES REGARDING DATA TABLES

1. The Greek symbol "Δ" refers to the change in something. Mathematically, it means to calculate the difference by subtracting the initial value from the final value.

2. The "Total Buffer Range" refers to the range of drops in which the pH level generally stays the same.

3. Your lab report will contain 10 data tables. For each section of this experiment, you will need to include a data table as well as a graph. You will be permitted to cut out or scan data tables 1, 3, 5, 7, and 9 and to paste/insert them into your lab report.

4. If you are unable to print your graphs in color, you are required to indicate which line represents drops of acid and which line represents drops of base. You should trace the lines using colored pencils and make sure that a legend is included.

RESULTS

Data Table #1: ____

Material Tested	Add	pH, after adding this many drops								
		0	5	10	15	20	25	30	ΔpH	Buffer pH (if any)
Water	acid									
	base									

Data Table #2: (Attach a graph that displays the information from Data Table #1.)

Data Table #3: ____

Material Tested	Add	pH, after adding this many drops												
		0	10	20	30	40	50	60	70	80	90	100	ΔpH	Buffer pH (if any)
Bicarbonate	acid													
	base													

Data Table #4: (Attach a graph that displays the information from Data Table #3.)

Data Table #5: ____

Material Tested	Add	pH, after adding this many drops												
		0	10	20	30	40	50	60	70	80	90	100	ΔpH	Buffer pH (if any)
pH _______ Buffer	acid													
	base													

Data Table #6: (Attach a graph that displays the information from Data Table #5.)

Data Table #7: ____

Material Tested	Add	pH, after adding this many drops								
		0	5	10	15	20	25	30	ΔpH	Buffer pH (if any)
Citric Acid	acid									
	base									

Data Table #8: (Attach a graph that displays the information from Data Table #7.)

Data Table #9: ____

Material Tested	Add	pH, after adding this many drops												
		0	10	20	30	40	50	60	70	80	90	100	ΔpH	Buffer pH (if any)
Albumin	acid													
	base													

Data Table #10: (Attach a graph that displays the information from Data Table #9.)

PROCESSING THE DATA

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

2. What was the purpose of collecting the information in data table #1?

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. What was the effect of adding HCl or NaOH to the buffer solution?
   Explain using CLAIM → EVIDENCE → REASONING.

6. Which of the first four solutions acted the most like a buffer solution?
   Explain using CLAIM → EVIDENCE → REASONING.

7. What is the name of the chemical used to buffer blood in most mammals, including humans? Why do you think this chemical is necessary?