Acids and Bases

How does pH affect biological solutions?

Learning Objectives
- To relate the pH scale to how acidic or basic a solution is.
- To explain how a buffer affects the pH of a solution.

Process Objectives
- To classify biological solutions as acids or bases.
- To measure the pH of a solution

Materials
For Group of 2
Parts I and II
- Safety goggles

Part I
- 10 Common substances (such as distilled water, vinegar, baking soda, shampoo, orange juice, tomato juice, grapefruit juice, soda water, tap water, cola, fabric softener, household ammonia, bleach, liquid detergent, salt water, milk)
- Full-range pH paper
- 1 spot plate
- Distilled water in wash bottle
- Glass rod

Part II
- Bromothymol blue indicator
- Egg white solution
- 125-mL Erlenmeyer flask
- 0.1 N Hydrochloric acid
- Dilute basic solution
- Medicine dropper
- Full-range pH paper
- Glass rod

Introduction

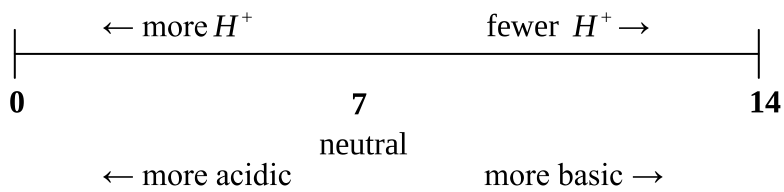
Organisms are very sensitive to how acidic or basic (alkaline) their environment is. For example, some bacteria and fungi can grow only in acidic solutions while some marine organisms can only live in a slightly basic environment. The reason for this insensitivity is that the enzymes used to control metabolic functions can operate only within a narrow range of pH.

How acidic or basic a solution is depends on the number of **hydrogen ions** $\left(H^+\right)$ that it contains. The hydrogen ion forms naturally when a few molecules of water ionize:

$$2H_2O \rightleftarrows H^+ + OH^-$$

Because pure water has the same number of hydrogen ions and **hydroxide ions** $\left(OH^-\right)$, it is considered neutral. If a solution has a greater concentration of H^+ than OH^- it is considered acidic. If a solution has a lesser concentration of H^+ than OH^- it is considered basic.

A special number scale called the pH scale uses numbers to indicate the relative concentration of H^+. Human blood must be a constant pH of 7.4. If the blood pH drops to 7.0 or rises above 7.8, death results.



Prelab Preparation
Review Section 2.3 on acids and bases in your textbook.

1. Why are some substances acids? What are some of their characteristics?

2. Why are some substances bases? What are some of their characteristics?

In this lab you will measure acidity using pH paper. Do not handle the paper strips too much or the chemicals on your fingers will cause the pH paper to react incorrectly. Always wash glassware with distilled water (which is neutral). This will help to give valid and consistent results.

3. What does it mean to say that distilled water is neutral? What pH should it have?

The pH paper is made by combining paper and chemical indicators such as litmus and phenol red. The color of an indicator changes as the pH changes.

4. How is an indicator different from a dye?

In part II you will be working with **buffers**. A buffer is a mixture of chemicals that keeps the pH of a solution relatively constant. A buffer systems acts by taking up or releasing H^+ or OH^- in a

solution so that sudden changes in pH are prevented. Human blood has a buffer system to keep its pH within the narrow range.

5. Where else in the human body might a buffer system be useful or important?

As you work in your groups be sure to label all experimental solutions to avoid confusion. Record your observations and measurements immediately as some of the color changes may fade in a short time. Become familiar with the pH chart so you can easily determine the pH number.

6. For the following solutions, how would you describe the H^+ concentration? Label them as acidic, basic, or neutral.
   Solution A - pH 10
   Solution B - pH 7
   Solution C - pH 3

Strategy for Measuring
In order to maintain consistency, have the same person read each of the strips of the pH paper over the standard spectrum.

Strategy for Classifying
To determine whether the test substances are acids or bases, compare pH and litmus color results. Look for a pattern. Then make a generalization about your criteria for classifying these substances.

Procedure

Part I: Acid-Base Classification
CAUTION: Strong acids and bases are harmful to skin or clothing. Avoid letting them contact your clothing and skin. Be careful about protecting eyes.

A. Obtain a spot plate from your teacher. Add a few drops of each substance to the spot plate.
B. Use a glass rod to touch one drop of a test substance to a strip of pH paper. Hold the strip of pH paper up to the standard pH color chart to determine the pH. If the result is between two numbers, estimate to the nearest 0.5.

7. Record your results in your data chart for Part I.

C. Rinse the glass rod with distilled water and proceed to test the other substances. Test 2 substances per 1 piece of pH paper.

8. Record these results in the data chart.

D. After all substances have been tested with pH paper, test each substance with red and blue litmus paper. The pH paper indicates the range of the pH with a corresponding range of colors. The litmus paper has only two colors: red and blue. Red litmus turns blue in the presence of bases; blue litmus turns red in the presence of acids.

9. Record the litmus results in the data chart.

10. Why would some substances not change the color of the litmus paper?

11. Use the diagram of the pH scale in the Introduction to rate each substance in your data chart as having a high, low, or medium concentration of H^+ and to classify each substance as an acid or a base.

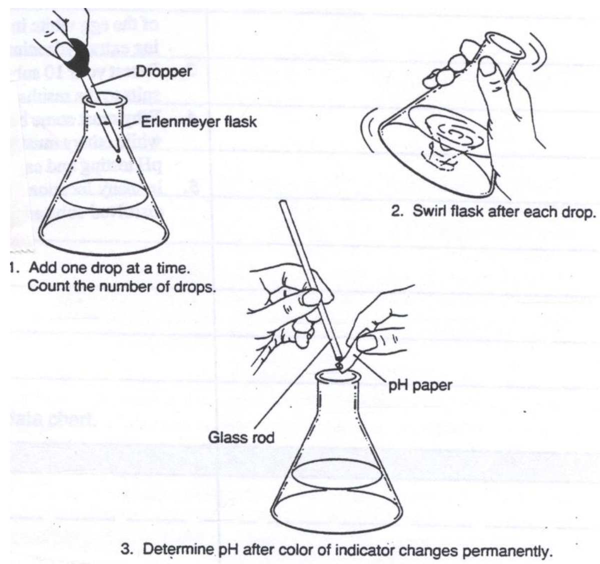
Part II: Buffers

E. Fill a 125-mL Erlenmeyer flask with 25 mL of the dilute basic solution (water adjusted to a pH equivalent to that of egg white). Add 5 drops of bromothymol blue indicator and swirl the flask until the indicator is completely dissolved. Use pH paper as in Step B above to determine the initial pH.

12. Record this in your data chart for Part II.

F. Slowly add 0.1 N HCl drop-by-drop to the solution in the flask, keeping count of the drops. NOTE: Be extremely careful that you add one drop at a time and that each drop enters the solution and does not adhere to the inner surface of the flask. Swirl after each drop to completely mix. Stop when there is a significant color change that does not disappear after 30 seconds. Use pH paper to determine the new pH. Record how many drops of HCl were required to make this change. CAUTION: Do not allow the HCl to contact your skin or clothing.

13. Enter observations and measurements on your data chart.



G. Wash out the flask with distilled water. Each lab table should now get one egg. Break the egg into a beaker. Be careful only to allow egg white into the beaker. Pour the egg white into a graduated cylinder. Add deionized water to the graduated cylinder until the volume reaches 50 mL. Pour the solution back into your beaker and stir it. After stirring, pour the solution back into the graduated cylinder. Pour 25 mL of the egg white solution into one group's Erlenmeyer flask, and 25 mL into the other group's Erlenmeyer flask. Add 5 drops of bromothymol blue indicator to the egg white and swirl the flask until it is completely dissolved. Use pH paper to determine the initial pH. Repeat step F.

14. Enter all new observations and measurements on your data chart. Record the initial and final pH of egg white as well as the number of drops of HCl required to make a significant color change.

15. Which solution, the weakly basic one or the egg white, required the most drops of HCl to change its color and pH? Which solution required the least?

Postlab Analysis

16. From the data you collected in Part I, what generalizations can you make about the pH of a solution and the effect of a solution on litmus paper?

17. Using data from Part I, make a list of those substances you tested that are acidic, in the order from strongly acidic to weakly acidic. Make a similar list for the basic substances, in the order from strongly basic to weakly basic. What do acids have in common? What do bases have in common?

18. In Part II, look for a delay in pH change when adding HCl. Which substance would you consider a buffer?

19. What biological purpose can buffering serve?

Name____Class____________________Date__________________

Acids and Bases

1. ____

2. ____

3. ____

4. ____

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5. ____

6. ____

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7 - 9. Enter your answers on the data chart.

Part I Data Chart

substance										
pH										
Red Litmus										
Blue Litmus										
H^+ Concentration										
Acid or Base										

10. ____

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11. Enter your answers on the data chart above.

12 - 14. Enter your answers on the data chart.

Part II Data Chart

	Initial pH	Number of Drops of HCl	Final pH
weakly basic solution (plus indicator)			
egg white solution (plus indicator)			

15. ______________________________

16. ______________________________

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17. ______________________________

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18. ______________________________

19. ______________________________

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