pH

Overview

The concentration of hydrogen ions in solution, as expressed in terms of pH, is of great importance to living systems. Hydrogen bonds—and other weak forces generated by small differences in charge—play a crucial role in shaping large, biologically important molecules. How molecules fold or interact with one another often depends on the concentration of hydrogen ions. So it is not surprising that changes in the balance of positive and negative ions in the watery environment of the cell can affect the shape, and thus the function, of biological molecules. For example, the pH of your blood can change with strenuous activity. Among other things, a change in blood pH affects the shape of hemoglobin molecules, which can increase or decrease their capacity to deliver oxygen to cells.

Although hemoglobin functions by responding to changes in pH, as with all biological molecules, hemoglobin can function properly only within a limited range of pH. Levels of pH that are too high or too low can damage the structure and thus interfere with the function of hemoglobin. The body has mechanisms for maintaining a range of pH that allows molecules, cells, and organs to function properly.

Changes in pH can have major effects not only on molecules and cells, but also on entire ecosystems. For example, rain is usually slightly acidic; unfortunately, because of increased levels of carbon dioxide and other pollutants in our atmosphere, some rain, especially in industrialized regions, has a very high concentration of hydrogen ions, that is, it is very acidic. Because everything from the uptake of nutrients by roots to the delicate membranes surrounding the eggs of fish and amphibians is affected by pH, "acid rain" is slowly destroying our forests and depleting the fish and frog populations in our lakes.

Molecules that are dissolved in water may separate (dissociate or ionize) into charged fragments or ions. Often one of these fragments is a hydrogen ion (H^+). The pH of a solution is a measure of the concentration of hydrogen ions. Because enormous variations in ion concentrations are possible, pH is calculated in powers of 10, using the mathematical device of logarithms (base 10). The alkalinity or acidity of a solution is determined by its concentration of H^+ ions, that is, by its pH.

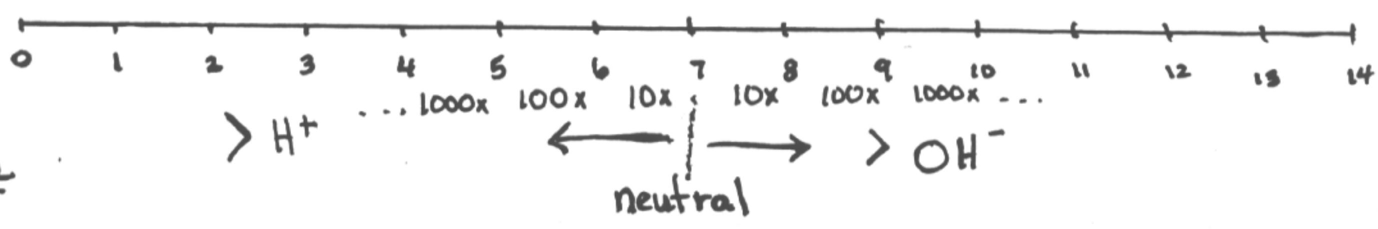
A water molecule ionizes when one of its two hydrogen atoms leaves its electron behind and, as a hydrogen ion (H^+), joins a different water molecule. Two ions are produced by this reaction, a hydroxide ion (OH^-) and a hydronium ion (H_3O^+). We can express this reaction as follows:

$$2\,H_2O \Leftrightarrow H_3O^+ + OH^-$$

Convention, however, allows us to express the ionization of water more simply as

$$H_2O \Leftrightarrow H^+ + OH^-$$

If there are more H^+ ions than OH^- ions per mole, the solution is **acidic.** If there are more OH^- ions than H^+ ions, the solution is **basic.** If the concentration of H^+ ions equals the concentration of OH^- ions, the solution is **neutral**



pH scale

Having conquered pH, you are now ready to appl.y your knowledge. How acidic or basic are the soft drinks you drink or the water you bathe in? How acidic or basic is the soil in your front yard? What is the pH of the rain in your area? All of these questions can be answered by a few simple tests.

Part 1: Using Alkacid Test Paper (pH paper)

Exercise A

1. You will be testing the following solutions: Solution A (deionized/distilled water), solution B (milk), C orange juice), and D (sparkling water).
2. In your lab journal, predict the pH of each solution A-D
3. Obtain a vial of test papers.
4. Use forceps to remove one test paper at a time (do not touch the paper with your fingers).
5. Hold one test paper over a paper towel. Use a clean stirring rod/stick to apply a drop solution A to the test paper.
6. While the paper is still set, compare its color with the standard pH color scale on the label of the alkacid paper's container. Record "color" and "number" in your journal
7. Repeat the procedure for solutions B, C, and D. Record in your journal.
8. Write a brief statement concluding your results, including arranging the solutions in order of increasing H+ concentration.

Part 2: Determining the pH of some Common solutions

1. Each lab group will be assigned to one of the following exercises B, or C.
2. Be prepared to share data with the class by filling in the chart on the overhead transparency.

Exercise B: pH of Beverages

1. Follow the correct procedure for handling the alkacid test papers outlined in Exercise A.

2. You will be testing the following: apple juice black coffee 7-up sport drink (All Sport)

3. In your lab journal, predict the pH of each of the solutions. You might be able to use some of the data obtained in exercise A as background information.
4. Test each of the solutions and record data in your lab journal.
5. Record your data on the overhead transparency.
6. Write a brief statement concluding your results, including arranging the solutions in order of increasing H+ concentration.

Exercise C: pH of some common medicines

1. You will be using an indicator solution produced from boiled red cabbage .

Background information : Anthocyamins, the plant pigments responsible for red, blue, and purple colors in flowers, fruits, and autumn leaves, can be used as a pH indicator. At a low pH, solutions of anthocyanins turn red, and at a high pH, they turn blue. **Your teacher has prepared 8 test tubes ~~tat~~ that will be used as your "pH/Color chart".** The anthocyanins solution is used because some of the solutions we are testing are white or opaque, making it difficult to read the color on a piece of pH paper.

2. Obtain a dropper bottle of red cabbage juice from the supply area.
3. You will be testing the following : #1 aspirin dissolved in deionized water, #2 Milk of Magnesia/$Mg(OH)_2$, , #3 Alka-Seltzer/ $NaHCO_3$ #4 Maalox
4. In your lab journal, predict the pH of each of the solutions. You might be able to use some of the data obtained in exercise A as background information.
5. You have 4 clean test tubes in a rack. Label the test tubes 1-4 . Use clean pipette to measure 3 ml of cabbage juice to each of the test tubes.
6. Use a clean pipette to measure 5ml of solution #1 aspirin in test tube number one. Cover the top of the test tube with a square of parafilm and invert to mix well.
7. Carefully carry this test tube to the supply table to compare to the sample "pH/color chart". Record color and number in your journal.
8. Repeat for the remaining solutions #2-#4.
9. Pour the contents of each test tube down the sink, flush with water, and use the brush to scrub inside, rinse well, and invert into the test tube rack. It is not necessary to remove the labeling tape.
10. Record your data on the overhead transparency.
11. Write a brief statement concluding your results, including arranging the solutions in order of increasing H+ concentration.

Lab Follow-up: Answer each of the following questions on binder paper.

1. It is often recommended that aspirin be taken with a large glass of milk or water. Based on your results in these lab exercises, do you agree with this suggestion? Explain.
2. Would apple juice or orange juice be a good accompaniment to aspirin? Explain why or why not?
3. Enzymes function best at particular pH values. In the normal human stomach, a pH of 2.0 to 3.0 provides the environment required for the proper functioning of the digestive enzymes found there. Which of the medicines you tested are often used for treatment of "acid indigestion"? Based on your results, how would you explain the action of these medicines?
4. What, if any, effect would these medicines have upon digestion? Explain.
5. In some flowers, soil pH affects the uptake of certain metals that can complex (join) with the anthocyanin pigment and prevent its normal color expression, pink . For instance, in hydrangeas,, high soil pH values prevents the uptake of aluminum, and the flowers appear blue. Is the soil more acidic or basic in this situation? What color would hydrangeas be if grown in a heavily industrialized region. Explain.