

MEASUREMENT OF pH

PROBLEM PRESENTATION / EXPLORATION

- A. A couple of days before this experiment begins indicate to the students that we will be working with simulated stomach acid. To impress upon them that it is harmful and care must be used when working with it, drop a little piece of raw hamburger into a flask containing about 100 mL of 0.10 M HCl. Put a small tuft of steel wool in another portion of the 0.10 M HCl. Tell the students that they will be studying the substance in the stomach fluid that causes this type of chemical reaction.
- B. Provide 100 mL portions of 0.10 M HCl to each group. Add to it a few mL of red cabbage extract. (Directions for obtaining this are given in the **CLASS RESPONSE / INVENTION** section of this activity.)
1. Ask the students what happens when they take Roloids[®], Tums[®], or Digel[®] for an upset stomach?
 2. Provide a couple tablets of Roloids[®] and a means for grinding them up (mortar and pestle, or small hammer).
 3. Tell them to add small portions of their Roloids[®] to the "stomach acid" and observe what happens after each addition.
 4. Ask them if they have any idea what is happening to the stomach acid when the antacid substance is being added.

CLASS RESPONSE / CONCEPT INVENTION

- A. The thing that acids have in common is the presence of hydrogen ions, H^+ . It is the excess of this ingredient that causes acid indigestion in our stomachs. The chemical substance in Roloids[®] can use up or destroy these H^+ ions. When we lower the amount of H^+ ions by taking the Roloids[®] we get the concentration of H^+ ions low enough so that our stomach doesn't feel bad any more.
- B. How can we find out how many H^+ ions are in various acid solutions? A convenient way is to know the pH of the solution. The pH scale simply tells us how abundant the H^+ ions are in a solution. Even though this seems backwards, **the lower the pH, the more H^+ ions in the solution.**
1. The pH of stomach fluid is 1
 2. If you would stick an eye dropper into this fluid and draw some out, it would be able to "eat up" a piece of steel wool.
 3. What if you took the container of stomach fluid and added 1000 mL of water to it and then removed an eye dropperfull? Would this solution now be able to eat up the steel wool? No, because there aren't as many H^+ per dropperfull. Maybe a better example is the difference in tasting some frozen orange juice concentrate and tasting it after four cans of water have been added to it. In which tastefull did you get the most orange flavor?
 4. Lets start with 10 mL of stomach acid. (Remember that there are enough H^+ ions per mL in this acid to have a pH = 1.)
 5. Add to this 10 mL of stomach acid 90 mL of water. Now if we took 10 mL of this solution, would it have as many H^+ ion in it as the first 10 mL? No, it would only have 1/10 as many. If your stomach had this mixture, you wouldn't be as sick as if it contained the first mixture. We are going to assign the pH of this new solution to be 2. (Remember, it only has 1/10 as many H^+ as the acid which had pH = 1.)
 6. Take 10 mL of solution #2 and add 90 mL of water to it. If you would take 10 mL of this solution would it have more or less H^+ ions than the second solution? Since it has only 1/10 as many as the second solution we are going to give it a pH of 3. (Remember, the smaller amount of H^+ ions, the bigger the pH.)

7. Take 10 mL of solution #3 and add 90 mL of water. What will be the pH of this solution? [4]
 8. Take 10 mL of solution #4 and add 90 mL of water. What will be the pH of this solution? [5]
 9. Take 10 mL of solution #5 and add 90 mL of water. What will be the pH of this solution? [6]
 10. Which solution has the greater amount of H^+ ions, the one with the pH = 4 or the one with pH = 2? [There are how many times more H^+ in the solution with pH = 2 than in the solution with pH = 4? 100 times.]
 11. Save these solutions for the next part of the experiment. Make sure each one of the six solutions is labeled with its pH. You should have 90 mL of the solutions having pH = 1, 2, 3, 4, 5, and 100 mL of the solution having pH = 6.
- C. Each group should take about 100 g of red cabbage and place it in a large beaker. Add to it about 200 mL of water. Heat it until the liquid comes to a boil. Let it boil for about 5 minutes. After cooling for a few minutes, pour off the cabbage juice into another container.
1. Add two dropperfulls to each of the diluted stomach acid solutions that you prepared earlier in steps 5-9 above.
 2. Just as a reference, add to a few mL of a known acid (such as vinegar) 2 dropperfulls of the cabbage juice. Likewise, add to a few mL of a known base (such as ammonia water) 2 dropperfulls of the cabbage juice. Note the color of cabbage juice in the presence of an acid and in the presence of a base. [It is red in the presence of an acid; it is green in the presence of a base.]
 3. The cabbage juice is a type of substance that we call an INDICATOR. By its color it indicates to us the approximate pH of the solution into which it is placed. Note that it doesn't tell us exactly what the pH is, but it does give us a general idea of the pH.
 4. If you have pH Hydrion[®] paper, introduce it at this point to show that the indicator which these papers has been soaked is able to indicate much closer pH values.
 5. A very simple form of indicator is litmus paper. Show the students that below a pH of 7 the litmus paper is red and that if placed in a solution with a pH above seven the litmus paper is blue.
 6. Soak some filter paper in the cabbage juice and set it out to dry. After the paper has dried, cut it up into strips. These "cabbage-paper" strips can now be used to test for the general pH of different substances around the house. If the paper turns red the solution being tested is acid, and if it turns green the solution is basic. (Just like the acid and base in #2 above.)
 7. If you have access to a pH meter show the class that there are very precise ways to measure the pH by using an electronic device called a pH meter.
- D. The pH for a number of common substances can be found in the table below.

SUBSTANCE	pH	SUBSTANCE	pH
Battery Acid	.8	Blood	7.4
Gastric Juice	1.0	Milk of Magnesia	10.6
Lemon Juice	2.2	Windex with Ammonia	11.5
Classic Coke	2.5	Lye	13.0
Vinegar	3.0		
Coffee	5.0		
Cow's Milk	6.5		

CONCEPT EXTENSION

- A. It turns out that there are many substances around us that can be used as acid/base indicators.

1. Try some grape juice (not grape drink or grape soda) in the vinegar and ammonia water solutions.
 2. Grind up some blackberries and soak them in water to make blackberry juice. Try this in the vinegar and ammonia water solutions.
 3. Try different colors of construction paper to see if they act as indicators. Put a strip in vinegar (acid) and in ammonia water (base).
 4. The dye in one particular color of ditto paper is especially good for demonstrating the acid/base character of substances. Wasau Papers Astrobright Galaxy Gold (WAAB57A) is the official name of the goldenrod paper.
 - a. Investigate the color of the paper when it is soaked in a base and in an acid. [Bright red in base; it will remain orange in acid.]
 - b. By using a moistened bar of hand soap (the base) as a crayon the goldenrod paper will magically produce a red message on an orange background.
 - c. Strips of the paper can be soaked in aqueous baking soda and dried. They will turn a deep red. Then these strips, along with strips of untreated orange paper, can be dipped into various solutions to test them for acidity or basicity in a similar fashion to using the cabbage paper strips.
- B. Extract a substance called phenolphthalein from Exlax[®] tablets.
1. Have each group grind up three Exlax[®] tablets (not the chocolate kind)..
 2. Add to this powder about 50 mL of alcohol and heat it gently over a hot plate. (Don't heat with a flame since alcohol is flammable.) Stir frequently.
 3. Place a Mr. Coffee[®] filter in a jar and pour the solution through the filter paper. Allow the solution to cool. Throw away the solid material caught in the filter paper.
 4. Add some of the cooled solution to vinegar and the ammonia water. [It should be colorless in the vinegar solution and pink in the ammonia water solution.]
- C. Have students find out what indicator is used in testing the water in an aquarium or at the local swimming pool.