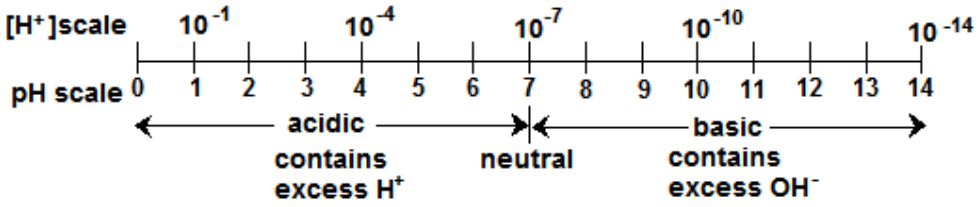
Experiment: Acids, Bases, and Buffers*

Introduction

Many common household solutions contain acids and bases. Acid-base indicators, such as litmus and red cabbage juice, turn different colors in acidic and basic solutions. They can, therefore, be used to show if a solution is acidic or basic. An acid turns blue litmus paper red, and a base turns red litmus paper blue.

The pH scale is a measure of the relative acidity (or basicity) of a solution.
pH is defined as **$- \log[H^+]$** where $[H^+]$ is the molar concentration (or molarity) of the hydrogen ion, H^+.

The following scale shows the relationship between pH and $[H^+]$:



Note: The lower the pH, the higher the $[H^+]$, and the higher the pH, the lower the $[H^+]$. Solutions of low pH are more acidic and those of high pH are more basic.

Litmus and red cabbage juice can give some idea of the pH value, but not precisely. A pH sensor will measure the pH in a more quantitative way (that is, it will give you the pH value).

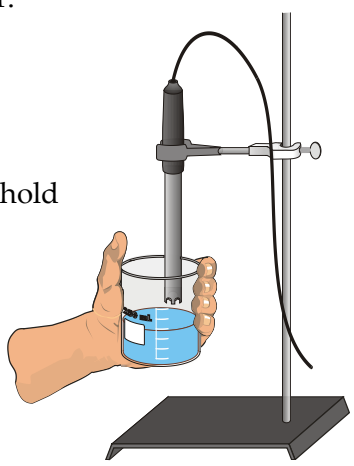
In this experiment, you will use litmus and a computer-interfaced pH sensor to determine the pH values of household substances. After adding red cabbage juice to the same substances, you will determine the different red cabbage juice indicator colors over the entire pH range.

Often it is important, as in the human body, to keep the pH of a solution relatively constant. A ***buffer*** is a combination of substances that act together to prevent a large change in the pH of a solution. A buffer system can absorb small amounts of acids or bases without significant changes in pH. You will also use a pH sensor to observe pH changes when acids and bases are added to a buffer.

Objectives

In this experiment, you will

- ✓ Use litmus paper and a pH sensor to determine the pH values of household substances.
- ✓ Add cabbage juice to the same substances and determine different red cabbage juice indicator colors over the entire pH range.
- ✓ Add acid and base to a buffer solution and determine the effect on the pH of the solution.



* Adapted with permission from Seattle Central Community College and Vernier Labs

Hazards

☠ Ammonia solution is toxic. Its liquid and vapor are extremely irritating, especially to eyes. Drain cleaner solution is corrosive. Handle these solutions with care. Do not allow the solutions to contact your skin or clothing. Wear goggles at all times. Notify your instructor immediately in the event of an accident.

Procedure

Part A: pH and Color

1. Obtain and wear goggles. **CAUTION:** *Do not eat or drink in the laboratory.*
2. Label 8 test tubes with the numbers 1–8 and place them in a test-tube rack.
3. Measure 4 mL of vinegar into test tube 1.
   Refer to the data table and fill each of the test tubes 2–7 to about the same level with its respective solution. In test tube 8 prepare your sample that you brought from home. If your sample is a solid, dissolve it in 4 mL of deionized (DI) water. If your sample is a liquid, it may be used as is.

Litmus Tests

4. Use a stirring rod to transfer one drop of vinegar to a small piece of blue litmus paper on a paper towel. Transfer one drop to a piece of red litmus paper on a paper towel. Record the results. Clean and dry the stirring rod each time.
5. Test solutions 2–8 using the same procedure. You may use one piece of litmus paper multiple times - at least three samples may be tested using one litmus paper. Be sure to rinse and dry the stirring rod each time.

pH Tests

6. Connect the pH Sensor to the LabQuest and **DO NOT** set the value to zero. You should see a pH value (that is non-zero) displayed on the screen. If you have any questions ask your instructor.
7. Raise the pH Sensor from the sensor storage solution and set the solution aside. Use a wash bottle filled with deionized water to thoroughly rinse the tip of the sensor as demonstrated by your instructor. Catch the rinse water in a 250 mL beaker labeled “waste”.
8. Get one of the 7 solutions in the small container supplied by your sensor. Raise the solution to the pH Sensor and swirl the solution about the sensor. When the pH reading stabilizes, record the pH value in your data table.
9. Prepare the pH Sensor for reuse.
   a. Rinse it with deionized water from a wash bottle.
   b. Place the sensor into the sensor soaking solution and swirl the solution about the sensor briefly.
   c. Rinse with deionized water again.
10. Determine the pH of the other solutions using the same procedure. You must clean the sensor between tests. When you are done, CHECK YOUR pH VALUES WITH YOUR INSTRUCTOR before you proceed.
11. After you have checked your values, rinse the tip of the sensor with deionized water and return it to the sensor soaking solution and place the probe back in the box in an upright position.

12. *After* you have finished the litmus tests and the pH measurement, add 3 mL of red cabbage juice indicator to each of the 8 samples. Record your observations. Place these solutions in the waste container. (Do not put paper towels or litmus paper into the waste container.)

Part B: Buffers

1. Use the markings on a clean, dry 50 mL beaker to measure out about 10 mL of DI water in the beaker. Add about 10 mL of a "buffer" solution into another clean 50 mL beaker (NOTE: Usually you will have choice between pH 4, 7, or 10 buffer solutions). Record the pH of each solution. Add 1 mL of red cabbage juice to each, to track the pH changes by color (add more cabbage juice if you can't see any color but use the same amount for your buffer as for your DI water. Record the color you observe for each solution.
2. Clamp the pH probe into the **DI water** prepared previously (in Part A) – **DO NOT** zero the pH! Add 1 drop **of 0.10M HCl*(aq)***. Use a clean glass stirring rod to mix the solution and record the pH of the solution. Continue adding one drop at time, and record the pH of the solution after each drop: 1, 2, 3, 4, and 5 total drops of HCl*(aq)* added to the same solution.
3. Before you proceed, check your pH values with your instructor.
4. Wash and dry the glass stirring rod and rinse the pH probe with DI water. Repeat step 2 but add drops of **0.10M HCl*(aq)*** to the **buffer solution** instead of DI water. Record the pH of the solution after adding 1, 2, 3, 4, and 5 of drops of HCl*(aq)*.
5. Repeat steps 1 through 3 using **0.10M NaOH*(aq)*** instead of 0.10M HCl to test in DI water and buffer solution in place of the 0.10M HCl*(aq)*.

Pour all liquid waste into the labeled waste container. (Do not put paper towels or litmus paper into the waste container.)

TROUBLESHOOTING: WHAT IF I HAVE TROUBLE READING pH VALUES?

My pH probe seems to read strange values!
In case you accidentally zero your pH probe, you will need to perform a calibration. Follow these steps and/or ask your instructor for guidance:

a. Obtain a pH 4 solution. Place the pH probe in the solution and tap on the red box on the display and choose "calibrate". When the voltage reading stabilizes, enter "4" for pH and click "keep".

b. Rinse the pH probe. Obtain a pH 7 solution. When the voltage reading stabilizes, enter "7" for pH and click "keep".

NOTE: if you plan to take measurements at the upper end of the pH scale, then use pH 10 buffer instead of pH 4.

Report

Acids, Bases, and Buffers

Name _____Section_____

Lab Partner _____

Data

Part A

Test Tube	Solution	Blue Litmus (color)	Red Litmus (color)	pH values	Red Cabbage Juice (color)
1	vinegar				
2	ammonia				
3	lemon juice				
4	soft drink				
5	drain cleaner				
6	detergent				
7	baking soda				
8					

Part B

Total Number of Drops of HCl*(aq)* Added	**DI Water**		**Buffered Solution**	
	Color	**pH**	**Color**	**pH**
0				
1				
2				
3				
4				
5				

Total Number of Drops of NaOH*(aq)* Added	**DI Water**		**Buffered Solution**	
	Color	**pH**	**Color**	**pH**
0				
1				
2				
3				
4				
5				

Post-Lab Questions

Part A

1. Which of the household solutions tested are acids? What do they have in common?

2. Which of the solutions are bases? What do they have in common?

3. What color(s) is red cabbage juice indicator in acids? In bases?

4. State at least one advantage and disadvantage for each of the following methods for determining pH.

	Advantages?	Disadvantages?
Litmus Paper		
Red Cabbage Juice		
pH probe		

Part B

1. Briefly explain any differences observed for DI water compared to a buffered solution when HCl (aq) was added to each. Look at all your data, including pH values and color.

2. Briefly explain any differences observed for DI water compared to a buffered solution when NaOH (aq) was added to each. Look at all your data, including pH values and color.

3. Consider a buffer solution that consists of the weak acid, HF*(aq)*, and its conjugate base, F^{-1}.

   a. Write the reaction that occurs when a strong acid (H^+ or H_3O^+) is added to the buffered solution.

   b. Write the reaction that occurs when a strong base (OH^{-1}) is added to the buffered solution.

Prelab

Name _____Section_____

Acids, Bases, and Buffers

1. Of the compounds you will be testing, which do you predict are…
    a. acids?

    b. bases?

2. A solution has a pH of 9. Is the solution acidic, basic, or neutral?

3. What is the purpose of using the pH sensor?

4. What information does it provide that the litmus paper or cabbage juice does not provide?

5. Refer to the Acids and Bases Chapter of your textbook. Look for the section on **buffer** solutions. (Use the index and search for "buffers".)

    a. What is the normal pH range of blood?

    b. At what minimum and maximum pH levels do cells start to die?

    c. What is the buffer system that regulates blood pH? (weak acid = ?; anion = ?)

    d. What do the terms acidosis and alkalosis mean with respect to blood pH?

6. Bring from home at least 1 sample of a colorless liquid (10 mL) and/or solids (size of a grape). Check to make sure that the substances will mix (miscible) with or are soluble (dissolve) in water. Do NOT bring flammables or alcoholic beverages. Juices, vinegar, household cleaners, detergents, or aspirin are some possibilities. You will test your sample in this lab.