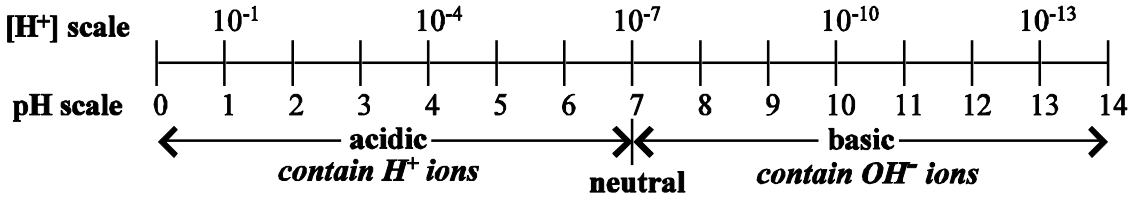
CHM 130LL: pH, Buffers, and Indicators

Introduction

Many substances can be classified as acidic or basic. Acidic substances contain hydrogen ions, H^+, while basic substances contain hydroxide ions, OH^-. The relative acidity or basicity of a substance is indicated by its pH.

pH is a scale ranging from 0-14 and 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 $[H^+]$. The higher the pH, the lower the $[H^+]$.

Substances with a **pH of 7** are **neutral**; for example, pure water and table salt, NaCl, are neutral. Substances with a **pH lower than 7 contain H^+ ions and are acidic**; for example, carbonated soda and lemon juice are both acidic. Substances with a **pH greater than 7 contain OH^- ions and are basic**; for example, soap and drain cleaner are both basic.

pH values can be approximated using substances called ***indicators***. These substances change color over a narrow range of pH values and can be used to determine the pH of different substances or to monitor acid-base neutralization reactions. Red cabbage contains a pigment that varies in color depending on pH; thus, it is a natural indicator that can be used to determine the pH of various substances

Buffer solutions resist changes in pH upon addition of small amounts of acid or base. For example, human blood acts as a buffer to absorb small amounts of acid or base resulting from biochemical reactions while maintaining a pH close to 7.4 because cells can only survive in a narrow pH range around 7.4.

In this experiment, you will use the color of the red cabbage indicator to determine the pH of some common household materials, and to classify the substances as acidic, basic, or neutral. You will also use the cabbage indicator to observe and compare changes in pH when small amounts of acid and base are added to a buffer solution and to water. Next, you will determine the pH of various solutions given their hydrogen ion concentration, $[H^+]$. Finally, you will use pH to classify various substances as strongly acidic (pH<2), weakly acidic (2<pH<7), neutral (pH=7), weakly basic (7<pH<12), or strongly basic (pH>14).

Procedure

A. Red Cabbage Indicator

1. Cut about 8 g of shreds from a head of red cabbage. Put the pieces in a 250-mL beaker. Add 50 mL of deionized water. Place the beaker on the hotplate, and heat at setting 4-5 to a gentle boil. Stir often, until the liquid is ***dark purple*** (~10 minutes). Work on the problems on page 5 while you are waiting for your solution to boil.

   Note: If your solution is **blue**, you used tap water instead of deionized water. Prepare a new solution using deionized water.

2. Turn off the heat and allow the mixture to completely cool for 10-15 minutes. Pour the colored liquid into a 150-mL beaker to use as the indicator.

   Waste disposal: Dispose of the boiled cabbage in the regular trash.

3. Arrange 7 small test tubes in a test tube rack. Number them consecutively with the following pH values: 2, 4, 6, 7, 8, 10 and 12.

4. Add about 20 drops of each pH solution into the test tube matching its number.

5. Use a disposable pipet to add 5-10 drops of the cabbage indicator (enough to determine a color) to each test tube. Tap the tubes with a finger to mix the contents. Record the colors you observe for each pH value. Save these to complete Part B.

B. pH of Household Materials

1. Bring from home at least 3 small ***colorless*** samples of liquids (3-4 mL) and/or solids (size of a pea). Check to make sure that the substances will mix with or dissolve (are soluble) in water. Do NOT bring flammables or alcoholic beverages. (Juices, vinegar, household cleaners, detergents, aspirin are some possibilities.)

2. If your sample is solid, dissolve it in 3-4 mL of deionized water. If your sample is liquid, it may be used as is. Pour about 1 mL or 15 drops of each substance to be tested into separate labeled small test tubes.

3. Add 5-10 drops of cabbage indicator to each test tube (enough to determine a color). Record the color and the pH for each substance. Classify each substance as acidic (pH<7), basic (pH>7) or neutral (pH=7).

C. Buffers

1. Add about 15 drops of the buffer solution into a clean small test tube, then add 5-10 drops of cabbage indicator to the same test tube. Record the color and pH under Buffer for the "Original (Before HCl added)" row.

2. Next, use the water bottle to add about 1 mL (about 15 drops) of deionized water into another clean small test tube, then add 5-10 drops of cabbage indicator. Record the color and pH under DI Water for the "Original (Before HCl added)" row.

3. Add 1 drop of 0.10M hydrochloric acid, HCl (aq), to each of the test tubes prepared in steps 1 and 2. Use a glass stirring rod to mix the solutions, and record the color and pH for each solution in the second row. Add a second drop of 0.10M HCl (aq), to each of the test tubes, stir the solutions, and record the color and pH of each solution in the third row. Add a third drop of 0.10M HCl (aq), to each of the test tubes, stir the solutions, and record the color and pH of each solution in the fourth row.

4. Repeat Step 1, and record the color and pH under Buffer for the "Original (Before NaOH added)" row. Repeat Step 2, and record the color and pH under DI Water for the "Original (Before NaOH added)" row.

5. Repeat Step 3 using drops of 0.10M NaOH (aq), a strong base, in place of the hydrochloric acid, HCl (aq), and recording the color and pH for the Buffer and for DI Water in the table for "Effects of NaOH(aq)".

   Waste disposal: Dispose of all solutions down the drain with plenty of water, and wash and rinse the test tubes.

CHM 130LL:
pH, Buffers, and Indicators

Name: _____

Partner: _____

Section Number: _____

LAB REPORT

A. Cabbage Indicator

pH	Color
2	
4	
6	
7	
8	
10	
12	

B. Household Materials

Substance	Color	pH	Acidic, Basic, or Neutral

1. What is an indicator, and how it is used to determine the pH of solutions?

2. Do you think the cabbage indicator would help us determine the pH of coca-cola? Explain.

C. Buffers

Effects of HCl(aq):	Buffer		DI Water	
	Color	pH	Color	pH
Original (Before HCl added)				
with 1 drop of HCl				
with 2 drops of HCl				
with 3 drops of HCl				

Effects of NaOH(aq):	Buffer		DI Water	
	Color	pH	Color	pH
Original (Before NaOH added)				
with 1 drop of NaOH				
with 2 drops of NaOH				
with 3 drops of NaOH				

Questions:

1. When **HCl(aq)** was added to the **buffer**, its pH _____. (Circle below)

   ↑ a little ↓ a little ↑ a lot ↓ a lot stayed the same

2. When **HCl(aq)** was added to the **water**, its pH _____. (Circle below)

   ↑ a little ↓ a little ↑ a lot ↓ a lot stayed the same

3. When **NaOH(aq)** was added to the **buffer**, its pH _____. (Circle below)

   ↑ a little ↓ a little ↑ a lot ↓ a lot stayed the same

4. When **NaOH (aq)** was added to the **water**, its pH _____. (Circle below)

   ↑ a little ↓ a little ↑ a lot ↓ a lot stayed the same

5. Does the buffer solution and water behave the same when small amounts of acid are added? Explain.

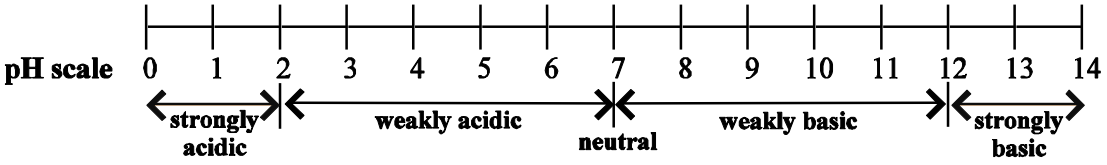
6. Does the buffer solution and water behave the same when small amounts of base are added? Explain.

Questions

1. Determine the pH for each of the solutions below, and state whether the solution is acidic, basic, or neutral. (Refer to page 1.)

Solution	pH	Acidic, Basic, or Neutral
1.0×10^{-3} M HCl		
1.0×10^{-6} M HCl		
0.0001 M HCl		
0.01 M HCl		
Pure water		

2. Consider the following pH scale below:



Categorize each of the following substances as strongly acidic, weakly acidic, neutral, weakly basic, or strongly basic.

Substance	pH	Category
carbonated water	3.9	
stomach acid	1.3	
saline solution	7.0	
tears	7.4	
saliva	6.8	
Codeine	10.3	
carrots	5.1	
drain cleaner	13	
maple syrup	6.0	