Experiment 15

Identifying Acids, Bases, and Buffers

Purpose

In this experiment you will determine the pH of use household items using a natural indicator and classify them as acids, or bases. You will also test substances to determine if they are buffers.

Background[1]

A pH value is a number, usually between 0 and 14, that represents the acidity or basicity of a solution. The "pH" is always written with a lowercase "p" and an uppercase "H", which stands for "power of hydrogen." pH values are related to hydronium ion [H_3O^+] concentrations.

The mathematical relationship between pH and [H_3O^+] is described by the equation

$$pH = -\log[H_3O^+]$$

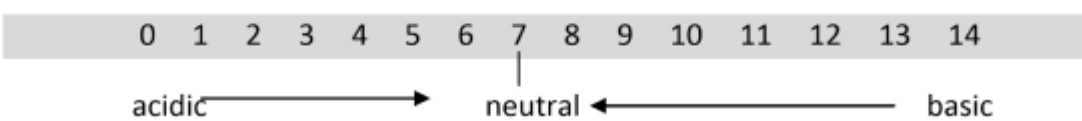
There is an *inverse* relationship between pH and [H_3O^+] ion concentration (in brackets, expressed in units of *molarity*, M). As the H_3O^+ concentration decreases, the pH value increases, and vice versa. When the pH value is a whole number (e.g. pH 7), the number is equal to the negative exponent of the [H_3O^+] ion concentration.

$$[H_3O^+] = 10^{-pH}$$

So for pH 7, the [H_3O^+] ion concentration is 10^{-7} M.

The pH values of everyday chemicals typically range from pH 0 to pH 14. Values between 0 and 7 indicate an acidic solution. Values between 7 and 14 indicate a basic solution. A pH of exactly 7 indicates that a solution is neutral, neither acidic or basic. Pure water is usually pH 7.

The *pH scale* is shown below.



The lower the pH value, the more *acidic* the solution; the higher the pH value, the more *basic* the solution. Basic solutions are also called *alkaline* solutions. It should be noted that the pH scale does extend beyond 0 and 14. Strong laboratory acids typically have pH values less than 0 (negative pH values) and strong laboratory bases typically have pH values greater than 14. Thus, they are considerably more dangerous.

1 Santa Monica College. Accessed 25 May 2018 from <https://chem.libretexts.org/Demos%2C_Techniques%2C_and_Experiments/Wet_Lab_Experiments/Online_Chemistry_Lab_Manual/Chem_9_Experiments/08%3A_Acid%2C_Bases_and_pH_(Experiment)A>

The concept of pH is widely used in all areas of science including agriculture, biology, engineering and medicine. Many commercial products use pH as an advertisement tool, such as shampoo and water; more recently, food and drink of certain pH has been touted as more healthful.

A **pH indicator** is a substance that, when a small amount of it is added to a solution of unknown pH, will change its color. This is a way to determine pH of a solution visually. The indicator used in this lab will be obtained from a natural source, red cabbage. Cabbage indicator produces a particular color depending on the pH of the solution. pH indicators are a good way to easily and quickly show the approximate pH by color when compared to a standard. An everyday example where a pH indicator is used is for testing a water sample from a swimming pool.

While pH indicators are useful for qualitative purposes, when an exact quantitative value is needed, a *pH meter* is used. A laboratory pH meter typically has a special probe capped with a membrane that is sensitive to [H_3O^+] ion concentrations. The meter reading shows an exact pH value of the solution probed.

Living organisms are very sensitive to the effects of acids and bases in their environment. An excess of H_3O^+ or OH^- can interfere with the functioning of biological molecules, especially proteins. Thus, in order to maintain homeostasis and survive, organisms must maintain a stable internal pH.

A **buffer** is a solution whose pH resists change on addition of small amounts of either an acid or a base. To be a good buffer, a solution should have a component that acts as a base (takes [H_3O^+] out of solution) and a component that acts as an acid (puts more H_3O^+ into solution when there is an excess of OH^-).

The buffering capacity of a solution is tested by adding small amounts of acid (for example, HCl) and base (for example, NaOH) and checking the pH after each addition. If the pH changes only slightly, the solution is a good buffer. Eventually its buffering capacity will be exhausted, however, and the pH will change dramatically.

Procedure

Part A Household Items:

Safety: Be sure to wear your safety goggles and take care with strong acids and bases they are corrosive before they are mixed with the cabbage indicator.
Waste: This lab will not generate any hazardous waste.

Materials

- 250 mL beaker
- 100 mL beaker
- 14 small test tubes
- 10 large test tubes
- 10 mL Graduated Cylinder
- Household items
- Buffer solutions
- Cabbage Indicator

1) Label a 250 mL beaker as your waste beaker.

2) Label 10 large test tubes with each household item to be tested and predict if you think the solution will be Acidic, Basic, or Neutral.

3) Add 3 mL (60 drops) of each solution to the labeled test tube.
Note: If the sample to be tested is a solid, first crush the solid with a mortar and pestle. Then dissolve a small amount of the solid in 3 mL of water and use this as your sample.

4) Collect ~80 mL of cabbage indicator in a 100 mL beaker.

5) Label 14 small test tubes 1- 14 for your known pH solutions.

6) Put 2 mL (40 drops) of each known pH solution into the labelled small test tubes.

7) Mix 3 mL (60 drops) of cabbage juice with each solution in the big test tubes. Mix 2 mL (40 drops) of cabbage juice with each buffer in the small test tubes.

8) Record the color using as much detail as possible to identify the color. Lime-yellow green, Kermit green, Hulk green, or Green Bay Packers green.

9). Determine the pH pf each household item based by comparing to the known pH samples and its color.

9) Save the known pH samples (small test tubes) and any cabbage indicator solution in the 100 mL beaker for Part B. All other waste can be dumped into the sink.

Procedures Part B Buffers

1) Label 5 large test tubes with each buffer solution to test (water or acetic acid/sodium acetate buffer, pH 2 buffer)

2) Add 3 mL (60 drops) of each solution to the labeled test tube.

3) Collect more cabbage indicator in a 100 mL beaker or use the indicator you still have in the 100 mL beaker from part A.

4) Add 3 mL (60 drops) of cabbage juice to each of the 5 large test tubes.

4) Add 10 drops of HCl to water. Add 10 drops of HCl to Acetic Acid/Sodium Acetate buffer

5) Add 10 drops of NaOH to water. Add 10 drops of NaOH to Acetic Acid/Sodium Acetate buffer.

6) Add 10 drops of pH 2 buffer solution (used in Part A) to the Acetic Acid/Sodium Acetate buffer.

6) Record the color using as much detail as possible to identify the color. Lime-yellow green, Kermit green, Hulk green, or Green Bay Packers green.

7) All solutions can be disposed of in the sink.

Name ___________________________

Data Table

Colors of Known pH Samples with Cabbage Juice

pH of Sample	Color		pH of Sample	Color
1			8	
2			9	
3			10	
4			11	
5			12	
6			13	
7			14	

Household Items

Household Item	Prediction: Acid, Base, or Neutral	Color of Solution when mixed with Cabbage Indicator	Estimated pH value	Acidic, Basic, Neutral based on estimated pH
Cleaners				
Drano				
Laundry Detergent				
Dish Soap				
Personal Care Products				
Shampoo				
Body wash				

Household Item	Prediction: Acid, Base, or Neutral	Color of Solution when mixed with Cabbage Indicator	Estimated pH value	Acidic, Basic, Neutral based on estimated pH
Beverages				
Soda				
Apple Juice				
Lemon Juice				
Over the Counter Medicine				
Aspirin				
Antacid				
Mouthwash				
Other Items				

Effect of Buffers on pH

Test Tube	Contents	Initial pH	Final pH	Did the solution resist a pH change? *= Good Buffer*
1	Water + HCl			
2	Water + NaOH			
3	Acetic Acid and Sodium Acetate + HCl			
4	Acetic Acid and Sodium Acetate + NaOH			
5	Acetic Acid and Sodium Acetate + Buffer pH 2			

Post Lab Questions

1. When the H_3O^+ ion concentration is expressed in brackets $[H_3O^+]$, what are the units of the for H_3O^+ ion concentration?

2. Does a solution with pH 10 have equal, less or more H_3O^+ ions than of a solution with a pH 6?

Calculate the $[H_3O^+]$ for both solutions. Include units in your answer:

For pH 10, $[H_3O^+]$ = _________________

For pH 6, $[H_3O^+]$ = _________________

Name ______________________

Pre-Lab Assignment for Identifying Acids, Bases and Buffers

1. What is an acidic solution?

2. What is a basic solution?

2. What is an alkaline solution?

3. What is a pH indicator? What are common uses of pH indicators?

4. Write the mathematical equation that relates pH value and [H_3O^+] ion concentration:

5. Circle correct choice:

   Acids have (***high OR low***) pH, and (***high OR low***) [H_3O^+] ion concentration.

   Bases have (***high OR low)*** pH, and (***high OR low***) [H_3O^+] ion concentration.