Experiment 9
RED CABBAGE INDICATOR

A study of acids, bases and pH

INTRODUCTION

Chemical indicators are weak organic acids or bases, dissolved in water, which change color if the hydrogen ion concentration changes in a solution. By definition, an Arrhenius acid is a substance that increases the concentration of hydrogen ion (H^+) in a solution. An Arrhenius base is a substance that increases the amount of hydroxide ion (OH^-) in a solution. In water and in neutral solutions, the amounts of H^+ and OH^- are the same. The reaction below shows how hydrogen ion and hydroxide ion are formed from water.

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

In pure water and in neutral solutions, the amounts of hydrogen ion and hydroxide ion are very small.

An Arrhenius acid has hydrogen as the first element in its formula. When an acid dissolves in water, the acid releases H^+ into the solution and the solution becomes acidic. An Arrhenius base has hydroxide ion in its formula. When a soluble Arrhenius base dissolves in water, it releases OH^- into the solution and the solution becomes basic. Indicators are used to determine whether a solution is acidic, basic or neutral. Indicators impart different colors depending on how much H^+ or OH^- is in the solution.

The term pH is a simple way of expressing how acidic (or basic) a solution is. The standard pH scale runs from 0 to 14. If the pH is less than 7, the solution has more H^+ than OH^- and the solution is acidic. The lower the pH, the more H^+ is present and the more acidic the solution is said to be. If the pH is greater than 7, the solution has more OH^- than H^+ and the solution is basic. The higher the pH, the more OH- is present and the more basic the solution is said to be. If the pH is equal to 7, the solution has the same amount of OH^- as H^+ and the solution is said to be neutral.

You have already used indicators to predict whether a solution was basic or acidic. Litmus is an indicator that is blue in basic solution (pH > 7) but takes on a red color in acidic solution (pH < 7). Phenolphthalein is an indicator that is pink in solutions with pH values greater than 8, but is colorless in solutions with pH values less than 8.

A buffer solution is a solution that will resist large pH changes upon the addition of an acid or base. Buffers will also maintain the pH when they are diluted. Buffers resist pH change because there is an acid component to neutralize added base and a base component to neutralize added acid. There are many types of buffers, ranging from an acetic acid /acetate solution to natural buffers composed of amino acids and proteins.

The most common type of buffer in the chemistry laboratory is the combination of a weak acid like acetic acid and its conjugate base, an acetate salt. The conjugate acid-base pair differ by an H^+ ion.

In this experiment you will use an organic indicator extracted from red cabbage. You will examine the range of colors it imparts when put into solutions with various pH values. In part A, you will record the colors of the indicators in solutions of known pH, or buffers. In doing so, you will obtain a set of reference standards. In part B, you will investigate the acidity or basicity of various solutions by observing the color the indicator imparts in each solution and comparing these colors to the reference standards you obtained in part C.

PROCEDURE

Part A: Place about 10 - 20 drops of pH 2, 4, 6, 7, 8, 10, 12, 14 standard buffers into separate wells in a spot plate and label them with tape or a marker. To each well containing a buffer solution, add 0.5 mL (about 10 drops) of red cabbage indicator. Thoroughly mix each solution, then observe the color of the solution in each test tube. Record your observations on the report sheet. Do not discard these solutions. Use them for reference for part B.

Part B: Pour about 10 - 20 drops of each solution listed on the report sheet in separate pre-labeled wells in a spot plate. Next add 0.5 mL of cabbage indicator to each tube and mix well. Record your observations. Determine the pH of each solution to the nearest pH unit and enter your value on your report sheet. Also indicate if each solution is an acid, base, or neutral. Calculate the hydronium ion concentration in each solution.

Part C: In a spot plate using the first two rows, place in separate wells one piece each of zinc metal, copper metal, and chalk ($CaCO_3$). In the fourth well position for the two rows, place a small amount of sodium bicarbonate also called baking soda ($NaHCO_3$) in each well. To the first row you should add several drops of 6.0 M HCl acid to each substance. Record you observations on the report sheet. Next add 6.0 M NaOH (a base) to each substance in the second row. Record your observations.

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REPORT SHEET

Part A: Standard Buffer Solutions with Red Cabbage Indicator

	Color of indicator	Acidic, basic, or neutral	$[H_3O^+]$
2			
4			
6			
8			
10			
12			
14			

Part B: pH of Various Solutions

Solution	Color of indicator	pH	Acidic, basic, or neutral
DISH SOAP			
BAKING SODA			
TAP WATER			
0.1M HCl			
0.1M NaOH			
VINEGAR			
AMMONIA			
7-UP/SLICE			
BLEACH			
LEMON JUICE			
ALKA SELTZER			

Part C Reaction of Acids and Bases

Table of observations:

	Zinc metal	Copper metal	Chalk ($CaCO_3$)	Sodium bicarbonate
Addition of HCl				
Addition of NaOH				

GENERAL QUESTIONS

1. Why is it a good idea to add the same amount of indicator to each of the test solutions in part "A" as was added to your reference standards in part "A"?
2. What is the pH of a neutral solution? _________
3. What is the pH range of an acidic solution? _________
4. What is the pH range of a basic solution? _________
5. There are a large number of synthetic and natural indicators available, the pH where color change occurs differs from indicator to indicator. Titration is a technique where a base is added to an acid until the moles of acid equals the moles of base. Once all the moles of acid have been consumed only moles of base remain in solution. Why would it be important to carefully choose your indicator when doing an acid-base titration?
6. Do all metals react with acids? ________
7. Zinc, Chalk, and baking soda only react with ___________________ but not with ____________________.
8. Write an equation for the reaction of hydrochloric acid with zinc.
9. Write an equation for the reaction of hydrochloric acid with chalk.
10. Write an equation for the reaction of hydrochloric acid with baking soda.
11. Write an equation for the reaction of sodium hydroxide with zinc. Why is this equation different from the others written above?