Minneapolis Community and Technical College
Introductory Chemistry Laboratory

Experiment: Acids, Bases and Indicators

Objectives:

- To prepare indicator solution from red cabbage.
- To identify the characteristic colors of red cabbage indicator at different pH values.
- To use the red cabbage indicator to determine the pH of various household chemicals.

Text references:

Arrhenius acids and bases, indicator solution, pH, hydronium ion, hydroxide ion.

Discussion:

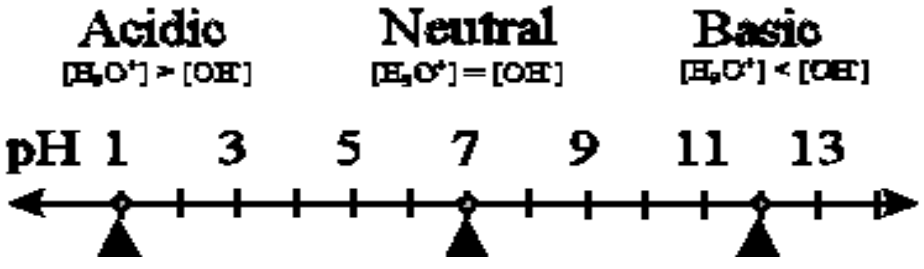
Acids and Bases

According to the Arrhenius theory, *an acid is a substance that can generate a hydrogen ion (H^+) in aqueous solution*. More realistically, an isolated hydrogen ion in an aqueous (water) environment attaches itself to a water molecule creating what is called a hydronium ion (H_3O^+). Consequently, $H^+(aq)$ and H_3O^+ are used interchangeably and really mean the same thing, that is, a hydrogen ion in solution.

Examples of acids include binary acids such as hydrohalic acids (HF, HCl, HBr, HI) and ternary acids such as sulfuric acid (H_2SO_4), phosphoric acid (H_3PO_4), and nitric acid (HNO_3).

An Arrhenius *base is a substance that can release hydroxide ions (OH-) in aqueous solution*. Examples of bases include calcium hydroxide, $Ca(OH)_2$ and sodium hydroxide, NaOH.

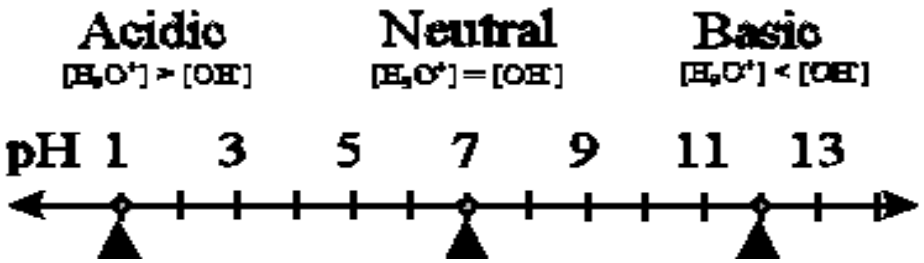
An acidic solution contains more hydronium than hydroxide whereas the opposite is true for bases. Let's consider this idea in the form of a number line:



pH

pH is used to determine the degree of acidity of a solution. Smaller the pH, greater is the acidity (higher is the concentration of hydronium ions as compared to that of OH^- ions). Higher the pH, lower is the acidity (smaller is the concentration of hydronium ions as compared to that of OH^- ions).

For acidic solutions, pH is less than 7.0.
For neutral solutions, pH = 7.0.
For basic solutions, pH is greater than 7.0.



Indicators

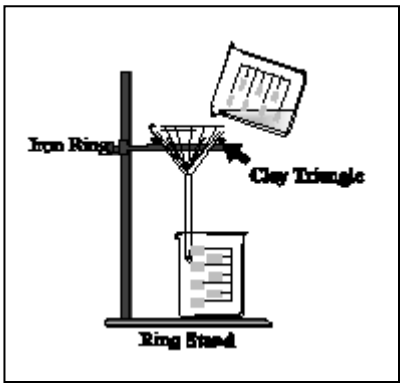
Indicators are chemicals whose color depends on the pH. One example of an indicator, phenolphthalein, is clear and colorless in an acidic environment where the pH is less than 8. When the pH is greater than 8 the color changes to pink.

The indicator we will use today is the juice extracted from red cabbage. Unlike phenolphthalein, red cabbage juice has a range of characteristic colors that depend on the pH of the solution. It is an example of **universal indicator**. Universal indicators display a continuous range of colors over a wide range of pH values. Your goal will be to determine the characteristic color of the red cabbage indicator at different pH values and then to use this information to determine the pH of several common household chemicals.

Red Cabbage Indicator Extraction:

1. To prepare the indicator you will use today, red cabbage shredded into smaller pieces is heated in distilled water for approximately 15 minutes at 85ºC, taking care **NOT TO BOIL the mixture as this may decompose the indicator and render it useless**.

2. After the solution has been sufficiently heated to extract the indicator molecules from the cabbage, your instructor will filter and cool the mixture (using the apparatus shown at right) – to separate the leaves from the filtrate. You will use this filtrate for your experiment.



Introductory Chemistry Laboratory
Experiment: Acids, Bases and Indicators

Pre-lab exercise: ***Complete and check answers before coming to lab***

1. According to Arrhenius Theory, what is an acid and what is a base? Give an example for each.

2. What is an indicator? Which indicator will you use in this experiment?

3. How will you dispose of wastes for this week's lab?

4. Classify the solutions with the following pH values as neutral, basic or acidic:

    a. pH = 2.4

    b. pH =7.0

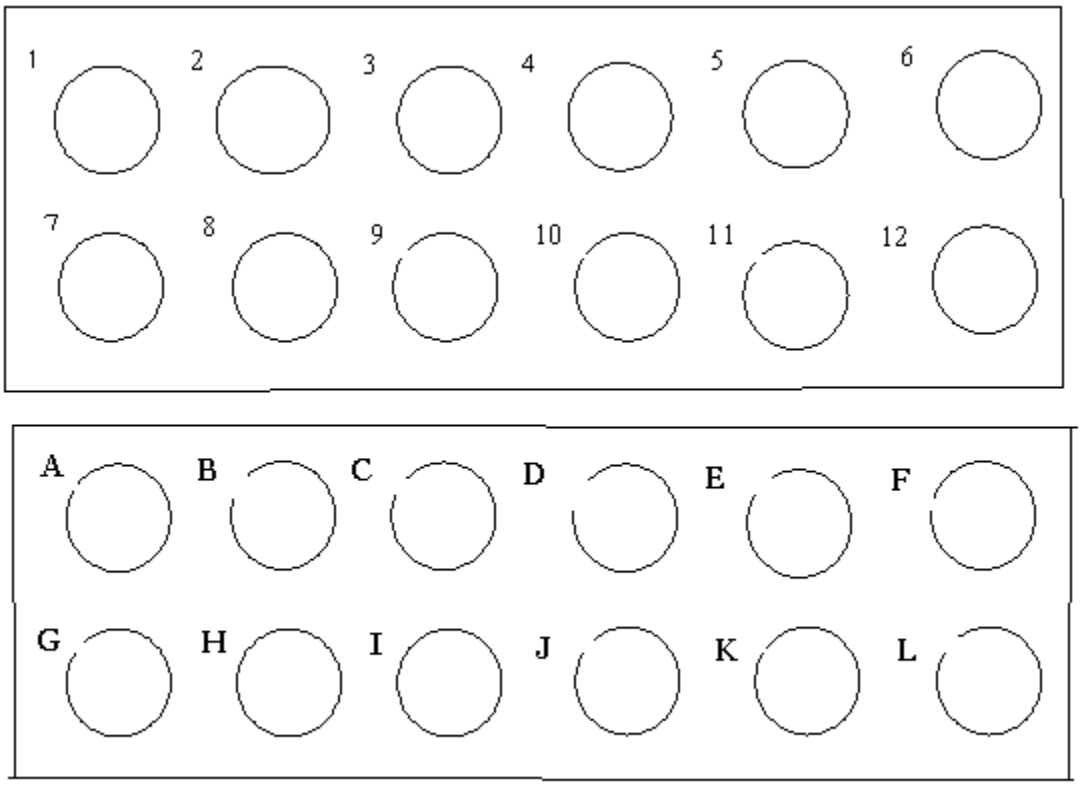
    c. pH = 10.6

Procedure:

Obtain about 30 mL of cabbage juice indicator extract as directed by your instructor.

<u>Part I</u>: *Determination of Characteristic Colors of Red Cabbage Indicator:*

1. Obtain two pre-marked (one with numbers and one with letters) 12-well plates.



1. First, using the dropper provided to you, dispense 15 drops (15 drops = 1mL) of the cabbage juice solution into each of the 12 wells from **both** well plates (24 wells total).

2. **Next, Start with the well plate that is labeled with numbers.** Locate the twelve pH standard solutions (standard solutions are solutions of known pH) as instructed. Add 10 drops of EACH standard solution to the APPROPRIATE WELL in the plate (i.e. add 10 drops of solution of pH = 1 to the well labeled "1", solution of pH =2 to the well labeled "2" and so on). **Be very careful not to cross-contaminate the well.**

To avoid waiting in line for the solutions, you can start with any of the pH standard solutions, as long as you keep track of which well received which pH standard.

4. Visualize the colors of the above mixtures by keeping the plate on a sheet of white paper such as your paper-template. Record the observations in Part I of the Data-report sheet, generally describing the color trends from pH=1 through pH =12 with the cabbage juice.
5. **KEEP these solutions in the wells** for comparison later with the household chemicals in the next part of the experiment.

Part-II. Determining the pH of Household Chemicals

You will perform this part of the experiment in the fume hood

1. **Now use the well plate that is labeled with letters.** Place 15 drops (1mL) of the cabbage juice into each well.
2. Take your plate to the fume-hood, and for the wells from A through L, add the appropriate household chemical labeled A through L, respectively. If the house-hold chemical is a liquid, **use ONLY 2 drops** of liquid, if it is a solid use **a VERY SMALL amount** on the tip of the micro-spatula. **If you use too much of the household chemical, you will not get good comparison with the standards.**
3. Upon returning to your work area, observe whether the household products have mixed well with the cabbage juice. If not, use a glass stirring rod to gently mix them. Make sure to clean off the stirring rod when moving between two different household products.
4. Observe the color generated in each well and compare it with the colors of the standard solutions in the wells 1 through 12, to determine the corresponding nearest pH. Record this pH value of your household chemical in the data sheet. Based on the pH, decide of the product is acidic, neutral or basic.
5. **<u>If the color of a certain household product does not match any of the 12 standard solutions, determine its pH by using a broad-range pH paper.</u>** A broad-range pH paper is coated with a universal indicator (different from the cabbage juice extract) and allows *semi* quantitative estimation over a pH range of 1-14.

   Put a piece of broad-range pH paper on a clean, dry watch glass. Use a clean glass rod to place a small amount of the product (TWO DROPS OF LIQUID HOUSEHOLD PRODUCT, or A SUSPENSION OF SOLID HOUSEHOLD PRODUCT IN DIOIONIZED WATER) on the pH paper. Compare the color of the pH paper to the color and pH scale on the paper container. **NO CABBAGE JUICE IS NEEDED FOR THIS PROCEDURE.**

Disposal

All wastes from this activity can go down the sink. Pour the contents of the wells into the sink, wash the plate at least three times with tap water, finally rinse once with distilled water and place the plate upside down on a paper towel at your station.

Report Sheet: **Experiment: Acids, Bases and Indicators**

Name_____Date_____ Lab Section_____

Part-I: pH standards:

1) What color(s) generally describe the standards between pH = 1 and pH = 4?

_____

2) What color(s) generally describe the standards between pH = 5 and pH = 9?

_____

3) What color(s) generally describe the standards between pH = 10 and pH = 12?

_____

Part-II. Determination of pH of Household Chemicals:

Sample Number	Household Chemical Name Remember! Only 2 drops of liquid or tiny amount of solid!	pH determined from comparison of colors with standards	Is this product: acidic neutral, or basic?
A	Vinegar		
B	Egg White		
C	Window Cleaner (Ammonia)		
D	"Sprite" (or some brand of colorless soda pop)		
E	Milk		
F	Lemon Juice		
G	Coffee		
H	"Drano" Kitchen crystals		
I	Cola		
J	"The Works" Drain Opener		
K	Wine		
L	Aspirin		

Post-Lab Questions:

1. Refer to your observations of the standards on Part One of the data sheet to answer these questions.

   a) What color would you predict for the cabbage indicator in a strongly basic solution?

   b) Describe the colors that would appear (in order) as acid is continually added to the base solution – until it becomes very acidic.

2. List ALL the household chemicals that you tested, starting with the most acidic and ending with the most basic. If two are of the same pH, just indicate that they are equal to one another.

3. With the cabbage indicator, you noticed a gradual color change with increasing pH value and different colors with different pH values. However, certain indicators give only one color with all acidic pH values and only one color with all basic pH values. Also the color change is abrupt (sudden) instead of gradual. For example:

Indicator	**Acidic Solutions**	**Basic Solutions**
Bromothymol Blue	yellow	blue
Phenolphthalein	colorless	pink
Neutral Red	red	yellow

For the following household chemicals determine whether it will be acidic or basic, based on your experimental observations. Then, based on the information for the indicators in the above table, list the color you expect with each of these indicators.

		Colors Expected With:		
	Acidic/Basic	Bromothymol blue	Phenolphthalein	Neutral Red
Aspirin				
Egg White				
Vinegar				
"Drano"				