

Acids & Bases – Magic Liquids

Purpose: To observe pH indication of various liquids using red cabbage juice as the indicator.

- Key Concepts: Acidic, neutral, and basic solutions; indicators; pH scale; pH range; denaturation of proteins.

Standards :

Biology/Life Sciences – Cell Biology

- Students know enzymes are proteins that catalyze biochemical reactions without altering the reaction equilibrium and the activities of enzymes depend on the temperature, ionic conditions, and the pH of the surroundings affect on enzymes.*

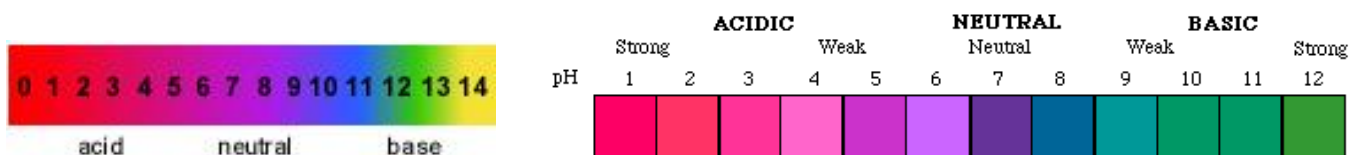
Chemistry - Acids and Bases

5. Acids, bases, and salts are three classes of compounds that form ions in water solutions. As a basis for understanding this concept:
 - a. Students know the observable properties of acids, bases, and salt solutions.
 - b. Students know acids are hydrogen-ion-donating and bases are hydrogen-ion-accepting substances.
 - d. Students know how to use the pH scale to characterize acid and base solutions.

Materials:

Activity 1 - Secret Message (just for fun)– paper, Q-tip, acid or base (vinegar, lemon juice, ammonia, etc.), spray bottle with red cabbage juice

Activity 2 - pH Determination of Household Products (student lab activity) – red cabbage (any food store has it), tools to cook red cabbage for 15 minutes, red cabbage juice, red cabbage juice pH scale, pH paper (coffee filter dipped in cabbage juice: see video how to make: <http://video.about.com/chemistry/Cabbage-pH-Indicator.htm>) apple juice, lemon soda, white vinegar, baking soda, shampoo (preferably clear), conditioner (preferably clear), hand sanitizer, large spoons or pipettes, 50 mL or smaller plastic cup or beaker for each substance being tested, three more common house products in liquid form of your choice (for example: lemon juice, glass cleaner, soap, bleach, drain cleaner, bleach, etc.), and beaker or receptacle for waste.



Red Cabbage Indicator - pH Scales



red cabbage



red cabbage juice

Activity 3 – denaturation of milk by an acid: Milk, lemon juice or vinegar, clear glass or bowl

Activity 4 – tasting an acid & a base: lemon juice or vinegar, baking powder, Q-tips

Procedure:

Activity 1 - Secret Message → do just for fun if you choose after you've made your cabbage juice with a squirt bottle.



1. Dip cotton swab into the vinegar & use it to write your secret message on the paper
2. Allow about 1-2 min for the message to dry completely
3. Read the “invisible ink” message by misting it lightly with the spray bottle filled with red cabbage juice

Activity 2 - pH Determination of Household Products (student lab activity)

- In this activity:
 - If the indicator turns the solution red or pink, the solutions are acids.
 - A purple solution indicates that it is neutral, neither an acid nor a base.
 - If the indicator turns the solution blue, green, or yellow, the solutions are bases.

pH Determination of Household Products

Lab # 4

1. Predict the pH value of substances & estimate the pH value by using the red cabbage juice indicator
2. Use the indicator to identify acidic, basic, and neutral substances found in any home
3. Classify household items as acids and bases
4. Collect and analyze data
5. Organize and analyze results in tables and graphs
 - a. **Hypothesis/prediction:** All items used to clean will be more like (acids/bases) because _____ and items used as foods will be more like (acids/bases) because _____.
 - b. The **indicator** being used is _____.
 - c. The **independent variable** is _____ and the **dependent variable** is _____.

PROCEDURE

Preparation of red cabbage indicator (done by the teacher the night before)

1. Cut ½ of a cabbage into small pieces.
2. Cook cabbage in 2 liters of water for about 15 minutes
3. Separate the bluish-purple liquid from the cabbage and let it cool

Estimating pH values with red cabbage indicator – complete data table!

4. line up all substances to be tested on top of white paper
5. write each name in your data table → data table!
6. predict each substance as basic, neutral, or acidic → data table!
7. record the color of each substance to be tested - best to use color pencils! → data table!
8. observe the red cabbage indicator, record its color → data table!
9. place a labeled beaker in front of each substance to be tested
10. add about 5-10mL of red cabbage indicator to all labeled beakers
11. to the corresponding cups with indicator, add drop by drop up to 5mL of (1mL = 16 drops) the substance to be tested & record the color change of the indicator → data table!
12. organize all cups from most acidic to most basic using as a guide the pH scale for red cabbage juice
13. estimate the pH value of each substance by using the pH scale for red cabbage juice → record in the data table!
14. classify each product as acid, base, or neutral → record in the data table!
15. slowly pour 2 mL of vinegar into 2 mL of baking powder and write your observations
16. add 2 mL of milk into each cup (A & B). Add 6 drops of water to cup A. After each drop, mix well & record any change. Using vinegar, repeat the procedure with cup B and record any changes.

Be sure to clean up after yourself.

DATA

- DATA table
- Draw cups with indicator
- Draw household products being tested
- Draw all cups after adding the substances being tested with the indicator
- GRAPH your results from the most acidic to the most basic (pH v. item)

Lab Report Guidelines:

See:

http://juanitaquevedo.com/Projects/Project_Types/Lab_Report.htm
or use the one I gave out in class.

ANALYSIS Questions (pH post-lab questions)

Answer the following questions completely in paragraph form in the conclusion of your lab report.

- The main idea of this lab was ...
- It is important to learn about acids and bases because ...
- When you added vinegar to red cabbage indicator, the indicator changed color from _____ to _____.
- Why and when does red cabbage juice changes from purple to other colors?
- When you added vinegar to baking powder, you noticed that ...
- List the substances you tested from most acidic to most basic.
- The data shows that most foods are mostly _____ because ...
- Cleaning supplies are mostly _____ because...
- In this lab investigation, the problem being investigated was ... The dependent variable was _____. The control was _____. My conclusion in this exercise is _____.
- In living things, pH is maintained within a narrow range. Why is pH important in maintaining homeostasis?
- Discuss why enzymes in living systems cannot catalyze reactions as well when they are not in their optimum pH; be sure to include: substrate, active site, and protein denaturation in your discussion. e include in your conclusion how
- how pH and enzymes are relevant to biological systems
- how enzyme function may be altered with varying pH due to protein denaturation (protein unfolding) and the active site is lost, as a result; the substrate can no longer bind and a reaction may not occur.

Conclusion starter (write at least 1 paragraph to explain how your results support or reject your hypothesis, what you learned, and how you can improve your lab)

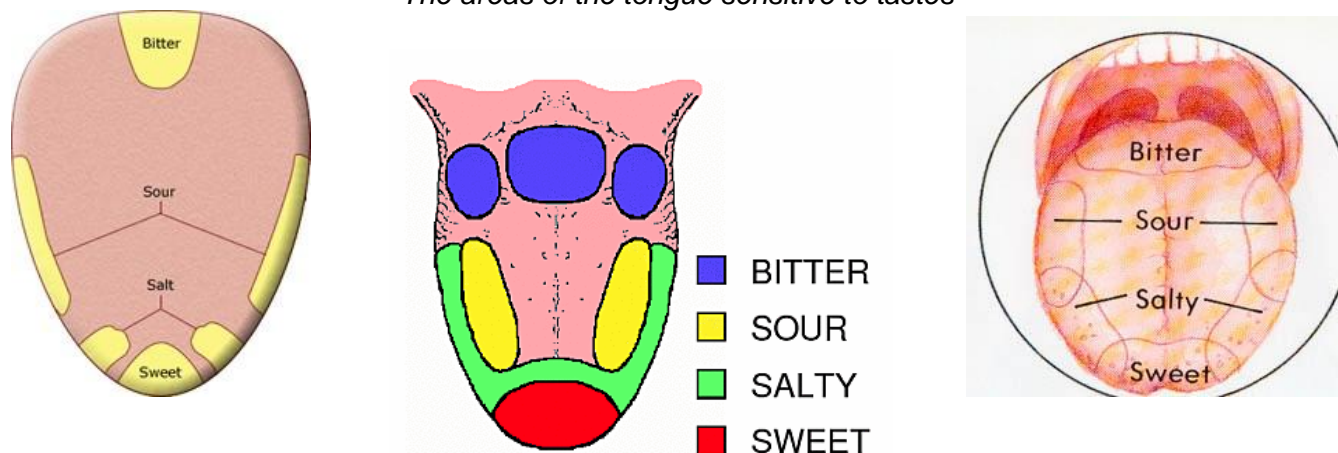
Activity 3 – denaturation of milk (to increase understanding of protein properties)

- slowly pour 2 mL of vinegar into 2 mL of baking powder and write your observations
- add 2 mL of milk into each cup (A & B). Add 6 drops of water to cup A. After each drop, mix well & record any change. Using vinegar, repeat the procedure with cup B and record any changes.

Activity 4 – tasting acids & bases

- Dip a cotton swab in vinegar & place it on different parts of your tongue
 - Where do you taste the acidity?
- Dip another cotton swab in baking soda and place on different part of your tongue
 - Where do you test the bitterness?

The areas of the tongue sensitive to tastes



Explanation: Acids & Bases

Concentration of Hydrogen ions compared to distilled water		Examples
10,000,000	pH 0	Battery acid
1,000,000	pH 1	Hydrochloric acid
100,000	pH 2	Lemon juice, vinegar
10,000	pH 3	Grapefruit, soft drink
1,000	pH 4	Tomato juice, acid rain
100	pH 5	Black coffee
10	pH 6	Urine, saliva
1	pH 7	"Pure" water
1/10	pH 8	Sea water
1/100	pH 9	Baking soda,
1/1,000	pH 10	Great Salt Lake
1/10,000	pH 11	Ammonia solution
1/100,000	pH 12	Soapy water
1/1,000,000	pH 13	Bleach
1/10,000,000	pH 14	Liquid drain cleaner

<p>Acids: compound that produce hydrogen ions in solution Ex) HCl & acid rain</p> <p>Bases: compounds that produce hydroxide ions in solution Ex) NaOH</p> <p>pH – amount of hydrogen ions in solution</p> <p>The pH scale measures the hydrogen ion concentrations (how acidic or basic substances are).</p> <ul style="list-style-type: none"> - its range is 0 (highly acidic) to 14 (highly basic) - 7 is the neutral pH and that of water - Acid solutions have high concentrations of H⁺ - Basic solutions have high concentrations of OH⁻ <p>Indicators are substances that change color when the pH goes above or below a certain value.</p> <ul style="list-style-type: none"> - used to estimate the pH values of solutions <p><i>Litmus paper</i> → changes red in acids & blue in bases <i>Methyl orange</i> → changes yellow to orange in acidic solutions <i>Phenolphthalein</i> → changes colorless to pink in basic solutions <i>Red cabbage juice</i> → changes from purple to different colors</p>

- **Activity 3 & 4 – protein denaturation & tasting activity** - can be done to summarize the importance of acids & bases in everyday life

Questions & Answers to consider:

1. **Are most house cleaning substances acids or bases? Are most food product acids or bases?** According to the red cabbage juice indicator, cleaning substances are mostly bases. Most foods are acidic, which makes sense because they go to an acidic environment (\sim pH 3) and because acids kill bacteria that cannot be seen in food that is ingested.
2. **What are indicators?** Indicators are substances that change color when the pH goes above or below a certain value. Indicators only have the capacity to approximate the pH value of substances and not indicate the exact pH value. Red cabbage juice is purple because of the pigments or chemical compounds that are called chromophores, which absorb light at different wavelengths. Chromophores structures change and even decompose in the presence of acidic or basic solutions.
3. **How do disinfectants kill pathogens such as bacteria, fungi, and viruses?** Disinfectants kill bacteria by interacting and breaking the bonds in proteins thus disrupting their structure and function. Most disinfectants accumulate around the cell membrane of bacteria thus disrupting their function and causing cell death. Some of those common disinfectants include chlorine used to treat swimming pools, isopropyl alcohol and ethanol to kill bacteria.

Applications to Everyday Life: Acids and bases are all around us causing changes that most people do not pay attention to. Throughout the course of biology, we can explore the presence of acids in bases...

- **Proteins/enzymes have optimum pH levels.** In the mouth (\sim pH 2), the enzyme amylase that breaks down simple sugars. In the stomach (\sim pH 2), pepsin works together with hydrochloric acid to break down foods. In the small intestine (\sim pH 8), pepsin works to break down proteins. **Catalase works throughout the body to break down hydrogen peroxide (waste produced in cells) into water and oxygen.**
 - $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$
- **Indigestion treated with anti-acids.** Many times ingested food produce excess acid in the stomach, causing pain. The pain is stopped by taking anti-acids over-the-counter medications such as Peptobismol or milk-of-magnesia. The anti-acids neutralize the acidity of the stomach to its normal pH level.
- **Acid-Base balance in the blood.** The normal pH of blood is slightly basic, between 7.3 and 7.5. pH below 7.3 (acidosis) can be the cause of carbon dioxide accumulation and carbon monoxide poisoning, loss of bicarbonate in the feces and urine, production of acids from the breakdown of proteins, etc. pH above 7.5 (alkalosis) can be caused by loss of hydrogen ions in vomitus or urine and overuse of hydrogen ions in metabolic reactions.
- **Acid Rain.** In the air carbon dioxide and water react to produce carbonic acid, making normal rain slightly acidic, pH 5.6. However the rain becomes more acidic (even below pH 4.0) due to air pollutants, such as sulfur oxides and nitrous oxides from vehicles and factories, which combine with water thus forming sulfuric acids and nitric acids. Acid rain has completely damaged the biodiversity of mountains and lakes, and even buildings and historic sculptures.

References

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