pH Mystery: A pH Investigation

Grade: 7

Time Allotted: 2 class periods

Teachers: Stewart Hengeveld and Diana Sanchez

Goal: The students will investigate pH of common substances. Each student will determine if the common substances are an acid or base and estimate the respective pH; therefore, the given unknown substance can be identified and the affects of acids and bases can be observed.

Objective:

- pH is the measurement of Hydrogen concentration in a solution.
- Identify solutions as acidic, neutral or basic.
- Estimate the pH of solutions.
- Identify an unknown solution.
- Predict the affects of acids and bases upon minerals.
- Describe and compare acidic, neutral and basic solutions.

NJCCCS (2009): 5.1.8.A, 5.1.8.B.1-3, 5.1.8.C, 5.1.8.D.1-3, 5.2.8.A.5, 5.2.8.A.7
NJCCCS (2008): 4.1.8.A.2, 4.1.6.B.4, 4.1.8.B.1, 4.1.6.C.2, 4.1.8.C.3, 4.2.4.D.1, 5.3.8.B, 5.3.8.C.

Key Vocabulary:
pH, acid, neutral, base, pH scale, pH indicator

Student Materials
Protective Eyewear (at ALL TIMES)

For Each Group	For the Class

• 1 Bottle of Bromthymol blue, pH indicator
• Litmus paper, red and blue
• Universal indicator, w/ pH indicator scale
• pH Mystery Worksheets
	• Protective eyewear
	• Gloves
	• Test tubes
	• Test tube racks
	• Common substances of different and similar pH
	  o Distilled Water
	  o 3 M HCl
	  o 3 M NaOH

	○ Vinegar ○ Bleach • pH meters (optional) • Limestone • Marble • Pipettes • 3 Erlenmeyer flasks • Bromthymol blue, pH indicator • Litmus paper, red and blue • Universal indicator w/ pH indicator scale • Water • Lemon juice • Bleach • Vinegar • Orange juice • Coke

Teacher Preparation

- Know the background information of the following topics: pH, Arrhenius definition of acids and bases, Brønsted-Lowery definition of acids and bases, protons, acid (strong and weak), base (strong and weak), neutralization reaction, salts, pH indicators, pH indicator Bromthymol blue, litmus paper, pH indicator scale, and pH meter, constant equilibrium.
- Setup up the test tube racks for each group (Part A). Each setup should include: one tong, one canister of red litmus paper, one canister of blue litmus paper, one canister of Universal indicator strips, a bottle of Bromothymol blue, and 4 test tubes. Test tube A can have an acidic solution (HCl or vinegar), tube B can have a neutral solution (distill water), and tube C can have a basic solution (NaOH or bleach). The fourth tube will be the unknown. Try to have a different unknown for each group (a replicate of one of the other substances in the same rack). Note: make list of the A,B,C and unknown that corresponds to the group.
- Setup a Part B substance station for the class. This station should include the following: labeled test tubes, test tube racks, and common substances of different and similar pH (vinegar, orange juice, coke, bleach).
- Setup a mineral station for the class (Part B). This station should include pieces of limestone and marble and pipettes. Each group should take several pieces of each material and a hand-full of pipettes.

- Prepare index cards corresponding to the respective test tube rack. The index cards should contain the names of the known substances. Also, the index card labels should match the labels of the test tubes.
- Prepare a Bromthymol blue pH indicator demonstration for the class. The demonstration will show students how pH indicators can be used to identify acids and bases. As so, Bromthymol blue will be an example pH indicator. Add a few drops of Bromthymol blue into three Erlenmeyer flasks containing distill water. The water in each flask will turn pale bluish green, indicating neutrality. Then, add a few drops of lemon juice into one of the flasks. The contents of the flask will turn yellow, indicating acidity. Finally, add a few drops of Clorox bleach to the third flask. The contents of this flask will turn dark blue, indicating basicity.
- Prepare litmus paper (red and blue) demonstration for the class. The demonstration will show how litmus paper is used to identify acidic, neutral and basic solutions. Using the litmus paper, test water for neutrality, lemon juice for acidity, and Clorox bleach for basicity.
- Prepare Universal indicator demonstration for the class. The demonstration will show how the Universal indicator is used to estimate the pH of a solution (using its respective pH indicator scale). Using the Universal indicator paper, test water for neutrality, lemon juice for acidity, and Clorox bleach for basicity.
- Prepare a pH meter demonstration for the class. The pH meter will demonstrate how it is used to accurately measure the pH of a substance. Thus, the students will learn how to use a pH meter. Insert the pH meter into water, lemon juice, and then Clorox. Remember, before using the pH meter, calibrate the meter by immersing the electrode in buffer solutions with known pH. .Also, remember to gently clean the pH meter with distilled water or a 7.0 pH buffer, between each pH reading.

Student In-class Prep and Procedure (Part A)

- Arrange the students into groups of three and hand out the pH Investigation worksheets.
- Introduce the term pH. Ask the students: Have you ever heard the term pH? What is pH? Why is it important to know the pH of a substance? Define pH as is in chemistry.
- Introduce acid and base. Ask the students: Can you give examples of acids? Can you give examples of bases? Define acids and bases as is in chemistry. Keep the definition simple; however, if the students have learned about electrons and ions, then define the Arrhenius and the Brønsted-Lowery definition of acids and bases.
- Introduce the pH scale (with examples).
- Ask the students: What are some ways we can measure and identify the pH of a substance? Introduce the term pH indicators and define as is in chemistry. Demonstrate how a litmus paper is used to identify acidic, neutral, and basic solutions (red to blue = basic; blue to red = acid). Demonstrate how Universal indicator strips are used to estimate the pH of a solution. Using the litmus paper, test water for neutrality, lemon

juice for acidity, and Clorox for basicity. Repeat the demonstration with the Universal indicator strips, using its respective pH indicator scale. Demonstrate, with the pH indicator Bromthymol blue, how pH indicators are used to identify acidic, basic, and neutral substances. Add a few drops of Bromthymol blue into three Erlenmeyer flasks containing water. The water in each flask will turn pale bluish green, indicating neutrality. Then, add a few drops of lemon juice into one of the flasks. The contents of the flask will turn yellow, indicating acidity. Finally, add a few drops of Clorox to the third flask. The contents of this flask will turn dark blue, indicating basicity. Demonstrate how a pH meter is used to accurately measure the pH of a substance. Thus, the students will learn how to use a pH meter. Insert the pH meter into water, lemon juice, and then Clorox. Compare the Universal indicator results with the pH meter results.

- Ask the students about the importance of pH in medicine, chemistry, biology, environmental science, etc. Give hints such as: medication, lab safety reasons, etc.
- Tie the lesson to my research: Why is it important for me to test the pH of any lake, pond, or stream before I step in to collect snails (specifically the *Helisoma trivolvis*)? Why is it important to check the pH of the media I will expose to the embryos?
- Introduce the pH investigation: pH Mystery PowerPoint presentation.
- Review the materials and procedure for the investigation (pH Mystery worksheet, Part A). Inform the students to share the work of pH testing. One person can use the Bromthymol blue, another student can use litmus paper, and the other student can use the pH strips.
- Notify the students about the various stations setup around the classroom for Part A of the investigation.
- Clean up.

Student In-class Prep and Procedure (Part B)

- Keep the students in the same groups. Make sure the students will be following Part B of the pH Investigation.
- Ask the students: What affect would acids and bases have upon matter?
- Introduce Part B of the pH Investigation: Affects of Acids and Bases upon Limestone and Marble. Have the students predict what would happen if limestone was exposed to vinegar, orange juice, coke, lemon juice, and bleach. Have the students predict what would happen if marble was exposed to vinegar, orange juice, coke, lemon juice, and bleach.
- Review the materials and procedure for the investigation (pH Mystery worksheet, Part B). Remind the students to test the pH for each substance before and after adding the limestone or marble.
- Notify the students about the various stations setup around the classroom for Part B of the investigation.

- Clean up
- Discuss the results from Part A and B of the investigation.

Student In-class Prep and Procedure (Part C)

- Discuss the questions in the pH Mystery Worksheet.
- Complete the Math section of the lesson.

Accommodations

- ESL students can be paired with or grouped where a bilingual student who excels in the English language, thus helping to explain and carry out the investigations. If no other student can speak the ESL student's native language, then pair or group the student with another student who excels in the English language. Also, assess these pairs or groups to some extent be assessed more frequently, without avoiding the needs of the other pairs or groups. Furthermore, demonstrate how to use the different instruments to measure the pH of a substance.
- The pairs or groups that include students who have learning disabilities (helping to explain and carry out the investigations) can to some extent be assessed more frequently, without avoiding the needs of the other pairs or groups. Also, if it is necessary, during the session or the following session review the investigation using techniques, such as multimedia, that would additional help the students with learning disabilities better carry out the investigation. As so, demonstrate how to use the different instruments to measure the pH of a substance.

Name: _____

Science Period: ____ Math Period: _____ Date: _____

pH Mystery: Part A

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Materials

Protective eyewear
Gloves (optional)
Tongs
1 Vial rack w/ Known and Unknown solutions
Litmus papers, red and blue
Universal indicator, w/ pH indicator scale
Bromothymol blue

Procedure

1. Put on protective eyewear and gloves.
2. Obtain the rack of supplies (vials, tongs, pH indicators). The number of the Unknown should correspond to the number of your group. Record the names of the known solutions.
3. Quickly dip litmus paper into each known solution. One piece of litmus paper for each known solution. Observe and record (acid or base).
4. Add 3-4 drops of Bromothymol blue into each vial (with known solution). Observe and record (acid, neutral or base).
5. Quickly dip Universal indicator into each known solution. One strip per solution. Observe and record. Estimate pH of each known solution.
6. Optional: Use the pH meter to accurately measure the pH of the unknown and the one or more possible known substances that will identify the unknown.
7. Identify the Unknown. Use the litmus paper, bromothymol blue, and then the Universal indicator to identify your unknown.

Name: _____

Science Period: ____ Math Period: _____ Date: _____

pH Mystery: Part A

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Known Solutions

A	
B	
C	

Red Litmus Paper Results

Solution	Color Change	Acid, Neutral, or Base
A		
B		
C		

Blue Litmus Paper Results

Solution	Color Change	Acid, Neutral, or Base
A		
B		
C		

Bromthymol blue Results

The color changes you should observe:

Acidic	Neutral	Basic

Solution	Acidic, Neutral, or Basic
A	
B	
C	

Universal Indicator Results

Solution	Color	pH Estimate	Acid, Neutral, or Base
A			
B			
C			

What is your Unknown? Identify.

Unknown #:_____

Red Litmus Paper Results

Color Change	Acid, Neutral, or Base

Blue Litmus Paper Results

Color Change	Acid, Neutral, or Base

Unknown #: _____

Bromthymol blue Results

The color changes you should observe:

Acidic	Neutral	Basic

Is your Unknown: Acidic, Neutral, or Basic

Universal Indicator Results

Color	**pH Estimate**	**Acid, Neutral, or Base**

What is your unknown?

Name: _____

Science Period: ____ Math Period: _____ Date: _____

pH Mystery: Part B

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Materials

Protective eyewear
Gloves (Optional)
2 Vial racks w/ known solutions
Tongs
Universal indicator, w/ pH indicator scale
Pieces of Marble, one for each vial
Pieces of Limestone, one for each vial

Procedure

1. Put on protective eyewear and gloves.
2. Test the pH of each solution with the Universal indicator. Observe and record.
3. Add your piece of limestone into each test tube. Observe.
4. Re-test the pH of each solution, with limestone, using the Universal indicator. Observe and record the estimated pH.
5. In a different set of test tubes of the same substances, add your piece of marble into each test tube. Observe.
6. Re-test the pH of each solution, with marble, using the Universal indicator. Observe and record the estimated pH.

pH Mystery: Part B

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Limestone Observation Results

Solution	pH of Solution	Acid, Neutral, or Base	pH of Solution w/ Limestone	Acid, Neutral, or Base
Lemon Juice				
Orange Juice				
Coke				
Bleach				
Vinegar				

pH Mystery: Part B

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Marble Observation Results

Solution	pH of Solution	Acid, Neutral, or Base	pH of Solution w/ Limestone	Acid, Neutral, or Base
Lemon Juice				
Orange Juice				
Coke				
Bleach				
Vinegar				

pH Mystery: Part C

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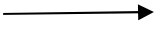
Questions

1. Why is it important to know the pH of a substance, especially for an unknown substance?

2. Is Hydrochloric acid an acid or a base?

3. Is Sodium hydroxide an acid or a base?

4. Balance this equation.

   HCl + NaOH 

   Why is this reaction known as a neutral reaction?

pH Mystery: Part C

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5. If $pH = -\log [H^+]$, then what is the pH of HCl if $[H^+] = 1.00 \times 10^0$ M?

6. If $pH = -\log [H^+]$, what is the pH of NaOH if $[H^+] = 1.00 \times 10^{-14}$ M?

7. If $pH = -\log [H^+]$, what is the pH of lemon juice if $[H^+] = 1.00 \times 10^{-2}$ M?

pH Mystery: Part C

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The most fundamental acid-base reaction is water: $H_2O \leftrightarrows H^+ + OH^-$. In pure water, the equilibrium constant is $K_W = [H^+][OH^-] = 1.00 \text{ X } 10^{-14}$. Where $[H^+] = 1.00 \text{ X } 10^{-7}$ and $[OH^-] = 1.00 \text{ X } 10^{-7}$.

8. What is the $[H^+]$ of a sample of rain water with $[OH^-]$ of $1.00 \text{ X } 10^{-8.6}$ M?

9. What is the $[H^+]$ of a sample of rain water with $[OH^-]$ of $2.00 \text{ X } 10^{-9}$ M?