Handout 6-A
The Ion Balancing Act of pH

Name _____ Date _____

- CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS -

We are affected every day by the pH of liquids in and around us. The food we eat and liquids we drink have pH levels, and our body organs require specific pHs to keep us healthy. Some people's bodies are sensitive to acids, so they may choose to not drink colas, orange and apple juices, coffee, and beer. Doctors sometimes suggest that women not drink cola (pH 2.5) because its phosphoric acid removes essential calcium from their bones. But strong acids are perfectly normal in the stomach, where gastric acids (pH 1.5–2.0) are essential for digesting foods.

The cleaning power of certain products is related to pH. Cleaners like ammonia and bleach are strong bases (pH over 11.5) while milder hand soaps have lower pHs (9.0 and 10.0). But these strong basic cleaners can also destroy the clothes or objects they are meant to clean if not used properly. When is a neutral or nearly neutral pH preferred?

Even water is not the same, in terms of pH values. Acid rain (pH 5.0 or less) from industrial air pollution harms plants and wildlife, but we can swim in seawater with a basic pH of 8.0. If chemicals with strong pHs are spilled into an unpolluted (pH 5.0–8.0) lake or river, the dramatic pH rise or drop could change a healthy water ecosystem into a dead zone by killing all life. Only after the water's pH returns to a healthier, more neutral, pH level would animals and plants return.

Representative pH Values

Substance	pH	Substance	pH
Hydrochloric acid, IOM	-1.0	Tea or healthy skin	5.5
Battery acid	0.5	Milk	6.5
Gastric acid	1.5–2.0	Pure water	7.0
Lemon juice	2.4	Healthy human saliva	6.5–7.4
Cola	2.5	Blood	7.34–7.45
Vinegar	2.9	Seawater	7.7–8.3
Orange or apple juice	3.5	Hand soap	9.0–10.0
Beer	4.5	Household ammonia	11.5
Acid rain	<5.0	Bleach	12.5
Coffee	5.0	Household lye	13.5

Retrieved July 18, 2007 from *en.wikipedia.org/wiki/PH*

Handout 6-A
The Ion Blancing Act of pH

What Does the Forensic Scientist Need to Know?

Forensic scientists must be able to choose and run appropriate lab tests to identify the pH of a solution collected as evidence. If pH indicators are used, scientists will select several different indicators to narrow down the pH range. Since all solutions have a pH, any taken as evidence could be tested to help solve a crime. Investigators can also take the pH of liquids or powders on a suspect's or victim's body to determine if they are factors in a crime.

Scientists must know the meaning of the pH scale and values, how to identify acids and bases, how acids and bases are formed chemically, and how they react when mixed. Scientists can then use this knowledge to relate the pH of the solution to possible effects it would have on living things and the natural habitat at the crime scene.

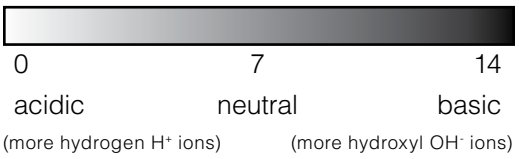
What's the Difference Between Acids and Bases?

The term *pH* was coined long after scientists categorized acids and bases. For hundreds of years scientists observed that some solutions had common characteristics. If something tasted sour, corroded metals, and turned blue litmus paper red, it was called an acid (*acidus* is Latin for "sour"). If something tasted bitter, felt slippery, and changed red litmus paper to blue, it was called a base.

It was later discovered that acids, such as lemon juice, vinegar, and carbonated drinks, all release hydrogen ions (H^+) when mixed with water. Hydrogen ions are protons (positively charged atomic particles), so acids are also called proton donors. Bases, like ammonia and soap, release hydroxyl ions (OH^-) when mixed with water and are called proton acceptors because OH^- attracts H^+ (proton). A hydroxyl ion is really just an H_2O molecule that lost a proton.

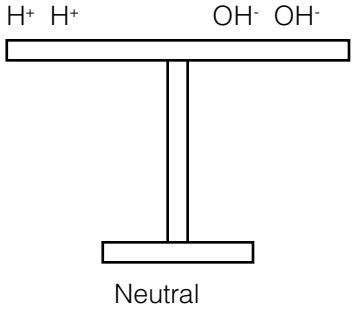
What Is pH?

pH Scale



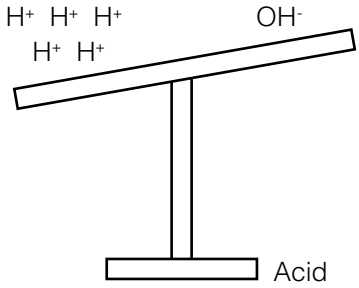
Neutral Scale

The strength of an acid or base is measured on a pH scale. A pH ("power of hydrogen" or the "potential of hydrogen") level indicates the amount of hydrogen



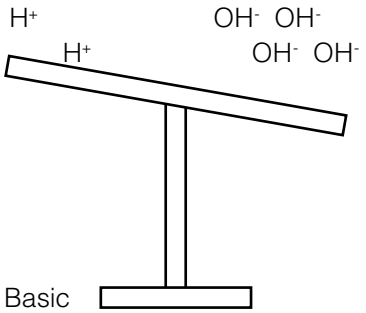
Handout 6-A
The Ion Balancing Act of pH

ions (H^+) in a solution in relation to the amount of hydroxyl ions (OH^-). Pure water has equal amounts of H^+ and OH^-, putting it in the neutral middle of the pH scale with a pH of 7.



Acid Scale

If an acid is mixed with water or another liquid, it will release H^+ (protons). As acids get stronger, the difference between H^+ and OH^- gets larger, with more H^+ in solution. Acid levels span from 0 (strongest) to 6 (weakest).



Basic Scale

If a base is mixed with water or another liquid, it will attach to H^+. As bases get stronger, the difference between OH^- and H^+ gets larger, with more OH^- in solution. Base levels span from 8 (weakest) to 14 (strongest).

What's the Difference Between pH Levels?

The pH scale is a logarithmic scale, which means that each step represents a 10-fold change. What is changing? Remember that pH is measuring the ratios of H^+ and OH^-. So a decrease of one number on the pH scale represents a 10-fold increase in H^+ concentration in relation to OH^-. For example, a pH of 2 has 10 times more H^+ than a pH of 3; a pH of 13 has 100 times less H^+ than a pH of 11.

Strong acids (battery acid, stomach acid) and strong bases (bleach, lye, ammonia) have the highest amounts of H^+ and OH^- respectively. When these very reactive ions contact objects, the chemical changes can burn holes in clothes and other materials, corrode metals, and harm skin. Diluting the strong acid or base with water, or mixing it with a contrasting pH solution, will bring the new solution closer to neutral and make it less reactive.

Handout 6-A
The Ion Blancing Act of pH

Name _____ Date _____

How Do pH Indicators Work?

In the lab, pH can be determined with pH paper, electronic probes, or pH indicators. pH indicators are chemicals that, when mixed with a solution, will change colors according to the pH of the solution. Each color indicates a pH range. For instance, bromthymol blue turns yellow for pH 0 to 6, green for pH 6 to 7.8, and blue for pH 7.8 to 14. Phenolphthalein only changes colors for bases (base indicator), while Congo red only changes colors for acids (acid indicator). Below are four common pH indicators and the colors they show.

Bromthymol blue (BTB):

- yellow for a pH of 0 to 6
- green for a pH of 6 to 7.8
- blue for a pH of 7.8 to 14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Yellow					Green		Blue						

Congo red (CR):

- blue for a pH of 1 to 3
- purple for a pH of 3 to 4.9
- red for a pH of 4.9 to 14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Blue		Purple		Red									

Phenolphthalein (PHT):

- colorless for a pH of 1 to 8
- light pink for a pH of 8 to 10
- hot pink for a pH of 10 to 14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Clear							Light pink		Hot pink				

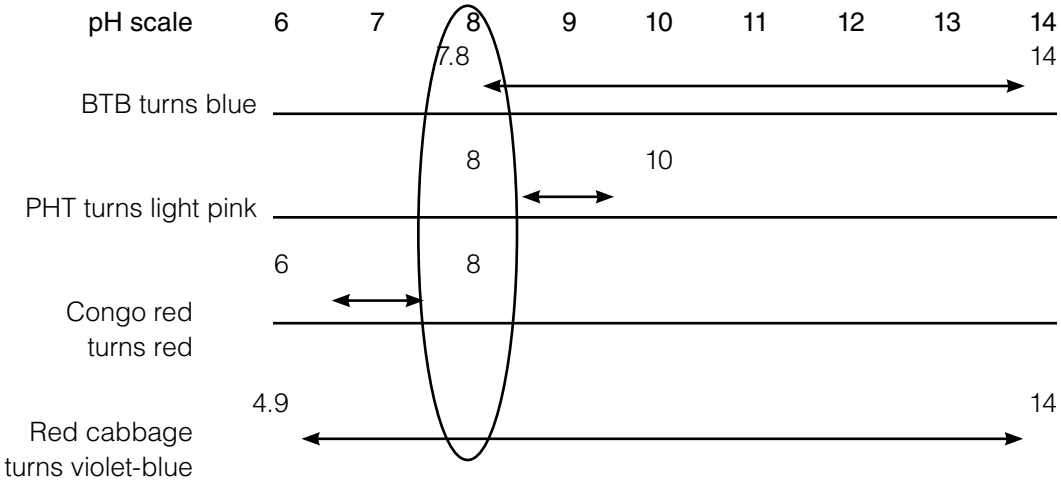
Handout 6-A
The Ion Balancing Act of pH

Red cabbage:

- red for a pH of 1 to 3
- purple for a pH of 4 to 5
- violet for a pH of 6 to 7
- blue for a pH of 8 to 9
- blue-green for a pH of 10 to 11
- greenish-yellow for a pH of 12 to 14

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Red			Purple		Violet		Blue		Blue/green			Greenish/yellow	

Since each pH indicator changes colors for different pH ranges, a solution can be tested with several indicators to narrow its possible pH range. For example in the diagram below, a hypothetical solution was tested with three pH indicators. By finding the pH overlap among them, the pH range becomes narrower.



The overlap of pH ranges is 7.8 – 8.

- Blue for a pH of 1 to 3
- Purple for a pH of 3 to 4.9
- Red for a pH of 4.9 to 14

Handout 6-A
The Ion Blancing Act of pH

Name _____ Date _____

What Did You Discover About the Ion Balancing Act of pH?

1. What are three ways pH is a part of our daily lives?

2. How can the pH of evidence be useful to a wildlife crime investigator?

3. What ions are formed in pure water and how do they affect the pH of a solution?

4. If the solution is neutral (pH 7), what color would the indicators turn?

   a. BTB _____
   b. PHT _____
   c. CR _____
   d. RC _____

STUDENTS: TAKE A CLOSER LOOK

- Does pure water have a higher concentration of H^+ or OH^-? Justify your answer.
- Why are both strong acids and strong bases dangerous?
- All pH indicators test the same pH levels. Agree or disagree, and justify your answer.
- pH levels change as H^+ amounts change. Agree or disagree, and justify your answer.

Handout 6-B

Testing pH With pH Indicators: Student Lab Investigation

Name _____ Date _____

- CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS -

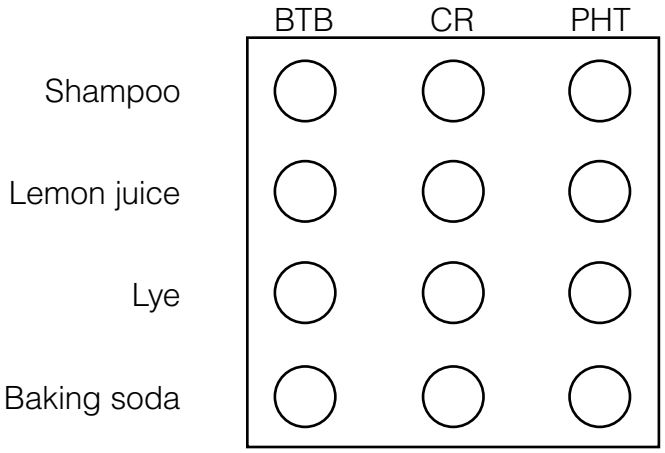
Your Job

Use a combination of pH indicators to determine the pH of household solutions.

Your Steps

1. Work in pairs.

2. Set the spot plate on a paper towel and label the rows and columns as shown below. Leave your spot plate on the paper towel during the lab.



3. Fill out columns 1 and 2 (Solution and Indicators) of your data table, "My Findings" (p. 131).

4. Put 2–3 drops of the solutions into the labeled cups.

5. Add 1 drop of the pH indicator to the labeled cups.

6. Complete the data table:

   a. Record the indicator and color change, if any, for each sample.

   b. Write the solution's pH range that the color indicates. Refer to page 126 for the pH ranges for each indicator.

Handout 6-B
Testing pH With pH Indicators: Student Lab Investigation

c. Compare the pH ranges shown by the three indicators. Where do the ranges overlap? For example, if Indicator 1 pH range is 2–7 and Indicator 2 pH range is 6–8, then the overlap range is 6–7. Record this range in the data table.

d. Record the pH category for this range: acid, base, or neutral. In the previous example, the solution is neutral or a very weak acid.

What Did You Discover About pH Indicators?

1. a. Which is a base indicator? (*Hint:* Acids and neutrals were the same color.)
   b. Which is an acid indicator? (*Hint:* Neutrals and bases were the same color.)
   c. Which indicator identified the full pH scale (acids, neutral solutions, and bases)?

2. Why was each solution tested with three indicators instead of just one?

3. What should you do if two indicators show the solution is a strong base, and another indicator shows the same solution is neutral?

4. Read your comments about pH and pH indicators in your Investigator Notebook *(What do I <u>know</u> about pH and pH indicators? What do I <u>want to know</u> about pH and pH indicators?).* Then respond to the following question: *What have I <u>learned</u> about pH and pH indicators?*

Handout 6-B

Testing pH With pH Indicators: Student Lab Investigation

- CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS -

My Findings (Data Table)

Instructions:
Record the results of your three pH indicator tests for each of the four solutions. Then find the pH range indicated by each color change. Finally, compare the pH ranges for all three indicators for each solution to determine the overlapping range. Use the pH scale to match that range with the category of acid, neutral, or base. Record the solution's pH category.

Solution	Indicator	Color change from indicator	Color's pH range (1–14)	pH Range Acid, Base, Neutral

Handout 6-C
More Practice With pH Indicators

Name _____ Date _____

- CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS - CRIME SCENE - DO NOT CROSS -

Instructions: Use your notes on pH and pH indicator ranges to answer the following questions.

1. Solution A turns blue when bromthymol blue (BTB) is added. What range of pH can you say the solution is?

2. Solution A turns light pink when phenolphthalein (PHT) is added. What range of pH can you say the solution is, based on this test?

3. Congo red (CR) is added to Solution B. It turns purple. What range does this indicate?

4. If PHT is added to Solution B, what color would you predict it to turn? Why?

5. The following results were reported for Solution C.

Results	What pH range does this result indicate?
BTB—Solution turns green	_____
CR—Solution turns red	_____
PHT—Solution turns hot pink	_____

Which test does not support the results of the other two tests? Why?

6. a. If you want to find out if an unknown solution has a pH greater than 10, which indicator would you use?
   b. What color would indicate this pH?

7. a. If you want to find out if an unknown solution has a pH of less than 3, which indicator would you use?
   b. What color would indicate this pH?

8. a. If you want to find out if an unknown solution has a pH of 8, what TWO indicators would you need to use?
   b. What color would each indicator need to become?
   Indicator 1: _____
   Indicator 2: _____