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Berkeley Engineers and Mentors

Lesson Name: Acid Chemistry Elementary
Lesson Type: Exploration and Project
Author: Seema
Last Updated: 3/13/11

Materials:
Group size: 20-30 students [1 classroom]

Part 1: Testing the pH of different household liquids
Part 2: Experimenting with acids and bases
- Red cabbage juice collected from 1 red cabbage
- Approximately 60 clear cups (10 cups per group; total 6 groups)
- Approximately 4 ounces of the following liquids:
  - Vinegar
  - Household detergent
  - Baking soda
  - Lime juice or lemon sprite
  - Water

Part 3 (optional): Dissolving penny and acid reactivity
- 20-30 dull pennies (6 groups * 5 pennies)
- 1.5 cups white vinegar (6 groups * ¼ cup white vinegar per bowl)
- 6 teaspoons salt (6 groups * 1 teaspoon salt per bowl)
- 6 clear plastic bowls (6 groups * 1 bowl)

Agenda:
- Introduction to pH and chemical reactions (10 minutes)
- Testing the pH of different liquids (15 minutes)
- Experimenting with acids and bases (20 minutes)
- Concluding thoughts (5 minutes)

Introduction
- What does a lemon taste like?
- Why is it sour?
- What is an acid? What is a base? Where do we see examples of acids?
- What is the pH scale?
- Why are acids unique? (Explain how acids are reactive.)

Activities
Part 1: Testing the pH of different household liquids
1. Pour about 1 ounce red cabbage juice into 5 clear cups.

2. Add about a tablespoon of each individual liquid () into the cups filled with red cabbage juice.
3. Use the worksheet to aid in understanding the color changes. (Acids turn the solution red, bases turn the solution green, and neutral solutions keep the solution purple.)

Part 2: Experimenting with acids and bases

1. Mix different household liquids in new cups filled with cabbage indicator to see how bases and acids can be neutralized.
2. See if a gradient of colored cups can be created by making solutions of weak acids and bases.

Part 3 (optional): Dissolving penny and acid reactivity

1. Pour 1 teaspoon salt and ¼ cup vinegar into plastic bowl.
2. Stir until salt dissolves into the vinegar.
3. Dip penny halfway into liquid. Hold for 30 seconds. Half the penny should be visibly shinier.
4. Put the rest of the pennies into the solution.
5. Wait for 5 minutes. Cleaning action should be visible.
6. Remove pennies. They should be shiny now.

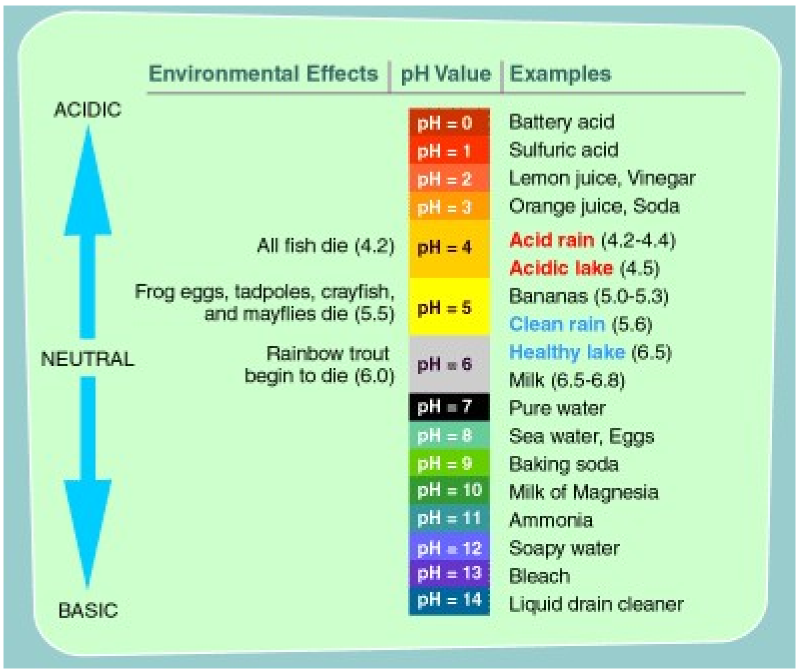
Discussion:

How is chemistry related to engineering? Answers are flexible. Mentors can give their own experience.

Background:

pH is a measure of the acidity or basicity of a solution. Solutions with a pH less than 7 are acidic, while solutions with a pH greater than 7 are basic. Pure water at room temperature (25° C) is neutral with a pH of 7. pH is equal to the negative logarithm of [H3O+] or the molar concentration of free hydronium ions. Thus, a high concentration of hydronium ions indicates a low pH and an acidic solution, and a low concentration of hydronium ions indicates a high pH and a basic solution.

Acids play an expansive role- from toilet cleaners to essential biological molecules. Acids are often used to remove rust and other corrosion from metals. They are used extensively in mineral processing and fertilizer production. Acids are often additives of food, for example phosphoric acid in Coke, or are natural ingredient of fruits, for the example the citric acid in lemons and oranges. In our body, amino acids are the basic building blocks of our proteins, nucleic acids are the building blocks of our hereditary material (DNA), and fatty acids are



integral factors to growth and tissue repair. Lastly, acids play a role in our environment, notably the problem of acid rain.

In this lesson plan, acetic acid (vinegar) is used to remove the corroded layer of dull copper pennies. Pennies become dull over time as the copper layer reacts with oxygen in the air to form the solid copper oxide. When the pennies are immersed in the acid, the acid dissolves the copper oxide leaving only the copper layer of the penny behind. The penny then appears shiny and relatively new.

pH scale compares various liquids and shows the environmental impact of acid rain

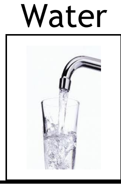
<u>Worksheet</u>:
See below
***Alternative to worksheet: Write the chart on the board and fill out as a class.*

Websites:
http://chemistry.about.com/cs/demonstrations/a/aa022204a.htm
http://www.saskschools.ca/curr_content/science9/chemistry/lesson11t.html

Acids and Bases

Color Key:

Acids = red **Bases = green** **Neutral = purple**

Household Liquid	pH	Color	Acid or Base?
Vinegar 			
Household detergent 			
Baking soda 			
Lime Juice or lemon sprite 			
Water 			

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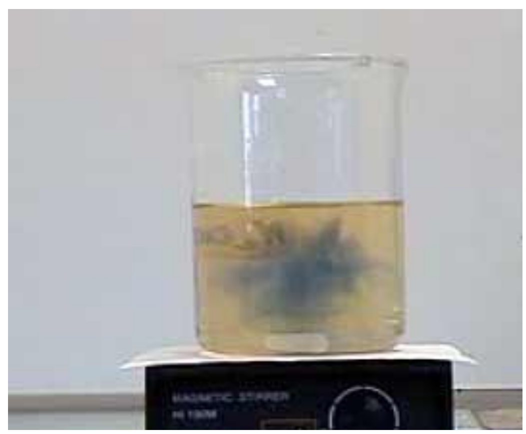
Lesson Name: Clock Reaction
Lesson Type: Demonstration
Author: Phillip Tu
Last Updated: 11/11/11

<u>Background:</u>
A chemical clock, or oscillating reaction, is a mixture of reacting chemical compounds in which the concentration of one or more components exhibit periodic changes. Specifically, changes in color of both intensity and hue.

Examples of clock reactions are the Belousov-Zhabotinsky reaction, the Briggs-Rauscher reaction, the Bray-Liebhafsky reaction and the iodine clock reaction.

This lesson involves the Briggs-Rauscher reaction. It has a very striking color change from a colorless solution to an amber color to a deep blue. This slowly fades and the process repeats itself.



The demonstration primarily involves mixing three solutions

1. Solution 1: Potassium iodate (KIO_3) dissolved in distilled water with sulfuric acid (H_2SO_4)
2. Solution 2: Malonic acid ($HOOCCH_2COOH$) and manganese sulfate monohydrate ($MnSO_4$. H_2O) in distilled water
3. Solution 3: 30% hydrogen peroxide (H_2O_2)

*Concentrations and volume of solutions will vary; the kit will take care of those details

The Briggs-Rauscher reaction mechanism is very complicated, but it can be broken down into two key processes.
Process A: slow consumption of free iodine by the malonic acid substrate in the presence of iodate. This process produces the iodide ion.
Process B: A fast autocatalytic process involving manganese and free radical intermediates, which converts hydrogen peroxide and iodate to free iodine and oxygen. This process also can consume iodide up to a limiting rate, which means B can only occur when iodide concentrations are low.

Initially iodide concentration is low which causes process B to go forward. This increases free iodine concentration. Since free iodine is a reactant of A this drives A forward, and will generate iodide. The iodide concentration increases, but remember this *limits* B, so B will slow down. This in turn will also slow A down because B generates the free iodine reactant for A. This is when the entire reaction essentially resets and goes back to the beginning of low iodide concentration. *If you need to convince yourself further draw a flowchart!

The overall reaction is

$$IO_3^- + 2H_2O_2 + CH_2(CO_2H)_2 + H^+ \longrightarrow ICH(CO_2H)_2 + 2O_2 + 3H_2O$$

The color changes are as such, the free iodine produces the amber color, and the iodide ion gives the blue color. When it resets it will go back to being colorless, and the cycle will start over again.

<u>What to Discuss:</u>
Since the clock reaction is merely a demonstration and the mechanism is very complex the concept should be simplified for elementary school kids, and a more in depth discussion can be included for high school students. An idea that can be gotten across is that chemistry can be considered the science of change. Particularly for this lesson try to stress the concept of

A —> B or Reactants —> Products

This is fundamental idea that chemical reactions depend on specific chemical species. For this case it would be more like A goes to B goes to C goes back to A. More topics to discuss can be competition of chemical species, and time factors which would be the realm of chemical kinetics.

<u>Procedure:</u>

- Start by adding equal parts solution 1 and 2, and mix well
- Afterwards quickly add another equal part of solution 3, and continue mixing
- Reaction should take place in a matter of seconds.
- Ideally a stirring bar and a stirring plate would be used to create optimum mixing, but that would only speed up the rate of color change
- *For commercial kits follow included directions, the idea should be the same though

<u>Materials:</u>
One Briggs-Rauscher Oscillating Reaction kit
Can be bought from-
http://www.teachersource.com/Chemistry/ChemistryKits/FascinatingOscillatingReactionKit.aspx
or
http://sargentwelch.com/oscillating-reaction-kit/p/IG0040207/

<u>References:</u>
http://chemistry.about.com/cs/demonstrations/a/aa050204a.htm
http://en.wikipedia.org/wiki/Briggs%E2%80%93Rauscher_reaction
http://wohba.com/2008/01/briggs-rauscher-reaction.html