Chemistry in the Library: Acid-Base Chemistry

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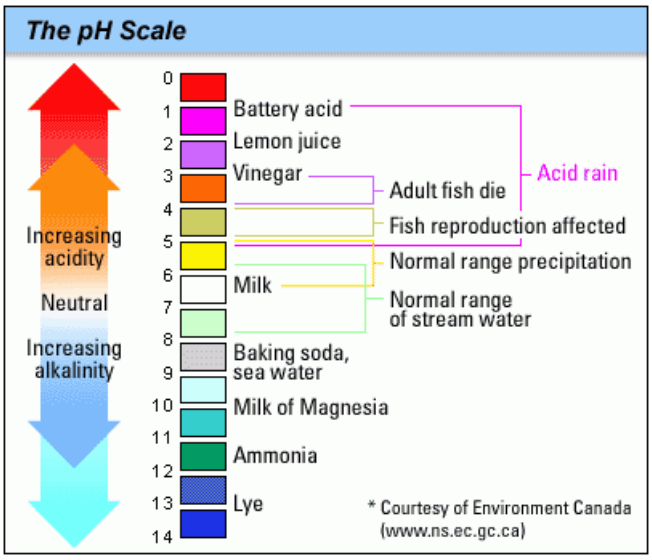
Introduction to pH

What is pH paper?

Also known as litmus paper, this is a special type of paper containing a chemical that will tell you the pH of a substance by the color it turns when it is dipped into the substance. pH paper color codes can be different depending on the manufacturer – check your pH paper container for the color code.

What does pH mean?

This is a measure of how acidic or alkaline a substance is. The initials pH stand for "Potential of Hydrogen." Acids have pH values under 7, and alkalis have pH values over 7. If a substance has a pH value of 7, it is neutral-neither acidic or alkaline.



pH scale.

Because the pH scale is logarithmic, a difference of one pH unit represents a tenfold, or ten times change. For example, the acidity of a sample with a pH of 5 is ten times greater than that of a sample with a pH of 6. A difference of 2 units, from 6 to 4, would mean that the acidity is one hundred times greater, and so on.

How is the pH of a substance measured?

A pH can be measured by dipping a pH paper into solutions such as water or other liquid substances.

Safety Rules

- **Wear safety goggles.** This means from when you're told to put them on until you're told they can come off.
- **Detect odors safely.** Use you hand to wave fumes to your nose. Never stick your nose directly into anything.
- **Wash spills immediately.**
- **No running, pushing, or shoving.**

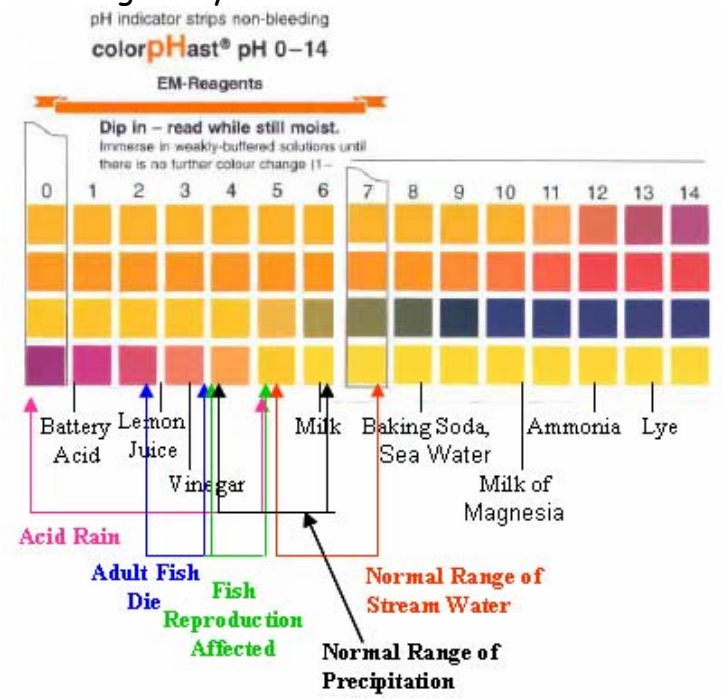
- **Clean up your mess!**
- **Get help.** If you have any questions, please ask before proceeding.
- **No eating or drinking.**
- **No unauthorized experiments.** Only do the things the leader tells you to.

Experiment #1: Introduction to pH

Materials:

5 vials with different liquids in them	5 pieces of pH paper	pencil

This table shows the color code for the pH paper we are using today:



pH is a chemical property of liquids that tells whether the liquid is an acid or a base. Distilled water is neutral with a pH of 7. As this diagram shows, pH ranges from 0 to 14, with 7 being neutral. pHs less than 7 (pH of 1-6) are acidic - acids have free hydrogen ions. pHs greater than 7 (pH of 8-14) are alkaline (basic) - bases have free hydroxyl ions. From this table, you can see that acid rain can be very acidic, and it can affect the environment in a negative way. Not only does the pH of a stream affect organisms living in the water, a changing pH in a stream can be an indicator of increasing pollution or some other environmental factor.

See the table below – you will be measuring the pH of water and other liquid samples.

	Sample	pH	Acid or Base?
1	Water from the sink		
2	Coca-Cola®		
3	Vinegar		
4	Hand Soap Solution		
5	Glass Cleaner		

Questions:

1. How do the pHs' of the different liquids compare to each other? (Which ones are acids & which ones are bases?)
2. Which liquid has a pH most like pure water? (pH of 7)
3. What is a common taste of acidic foods? Salty? Sweet? Tart?
4. What do a lot of food companies do to cut this taste of acidic foods?
5. Did you know? Strong Acids are used as cleaning agents (soda)

Experiment #2: Mixing Acids & Bases

Materials:

1 vial with vinegar	1 vial with glass cleaner	1 piece of pH paper

Procedure:

1. Fill in the pH of each liquid from your previous experiment in the following table.

LIQUID	pH	Acid? or Base?
Distilled Water		
Vinegar		
Glass Cleaner		
New Mixture : Vinegar + Glass Cleaner		

2. Which one is the acid? _____ the base? _____
3. What do you think might happen to the pH if an acid and a base are mixed together?
4. Test your hypothesis by pouring one into the other. Swirl the vial gently to mix the two.
5. Test the mixture with a clean piece of pH test paper and record the results in the table.

Questions:

1. What was the approximate pH of the mixture?
2. Based on the pH, what did mixing the acid & base together do?

Experiment #3: Digestion Experiment

Materials:

1 vial with vinegar in it	1 vial with antacid powder in it	1 piece of pH paper	1 cup

Procedure:

1. Now let's model your stomach. Take your vial that is $\frac{1}{2}$ full of vinegar and pour it into the cup. (The cup will simulate your stomach and the vinegar will simulate the hydrochloric acid in your stomach.)
2. Sometimes people get stomach aches and take an antacid tablet to help. Let's experiment why. (I have already done this: Wrap an antacid tablet in a piece of paper and carefully stomp on it until it is crushed.)
3. Pour some of the antacid into the cup, swirl the cup around to mix things up.
4. Test the pH: _____

Questions:

1. What happened to the pH in the "stomach"?
2. I gave you a crushed up antacid tablet. What part of the digestive process would you have simulated by stomping on the antacid?

Experiment #4: Acid Rain

What is Acid Rain?

We all know what rain is. It is water that falls from the sky. But what is acid rain? Acid rain comes from air pollution. It looks just like regular rain. Although it has very little effect on us, it makes a big difference for plants and also eats away slowly at stone, metal, and buildings.

Acid rain is not new. It was first noticed in England about 200 years ago. Most of the cities in England are quite old and have many buildings with marble carvings and statues. Marble is a beautiful stone that stands up well over time. Many of the statues carved by the ancient Greeks and Romans still stand. But marble dissolves in acid rain (see "Disappearing Statues", to the right). During the late 1800s, people began to notice that marble statues and carvings were slowly starting to dissolve. Fine details were gone, and larger features on the statues, such as noses and ears, were disappearing. Scientists turned to chemistry for the answer. By testing rainwater, they were able to figure out that it contained an acid and that the acid was reacting with the statues.

At that time, most people used coal to cook their food and stay warm through the winter. The coal that they used had a lot of sulfur in it that burned to form sulfur dioxide. The sulfur dioxide floated up into the air with the smoke from the fire and mixed with water vapor in the clouds. When sulfur dioxide and water mix in air, they react to make sulfuric acid. The sulfuric acid stays mixed in the water vapor and falls to the ground as "acid rain". Acid rain can also come from other sources, such as exhaust fumes from cars and other gas-powered engines.

Acid rain also affects plants and animals. Along the east coast of the United States, where acid rain is a problem, some trees have begun to loose their leaves or needles. New trees have also been slow to grow, and few seeds are able to sprout. Ponds and streams have also been contaminated, which causes problems for fish.

In the United States, most of the pollution that causes acid rain comes from electric power plants that burn coal to make energy. Recently, chemists working for the power plants have begun to install "scrubbers" on the coal furnaces. The scrubbers wash the exhaust fumes with water to remove the sulfur dioxide. Some other pollutants remain, but the amount of pollution produced has been greatly reduced.

Acid rain-producing pollution from cars has also been reduced in recent years. All new cars sold in the United States must have a "catalytic converter" installed. It is a device that gets rid of the pollutants that make acid rain. Chemists at gasoline companies have also been working hard to invent detergents and other additives that keep car motors clean on the inside. Cleaner engines work better, use less fuel, and produce less pollution.

We can help to prevent acid rain in many different ways. For example, we can switch from gas-powered lawn mowers and leaf blowers to tools powered by electricity. Last year, lawn mowers produced about one-tenth of the air pollution in the United States. We can also cut down on air pollution by walking, carpooling, or taking public transportation. Finally, we can look for cleaner-burning fuels. Chemists and engineers are developing new technologies, such as hydrogen-fueled cars, gas/electric hybrids, and more efficient electric motors.

If we all do our part, we can make the planet a better place to live, and we can ensure that future generations will have clean air, water, and soil.

Disappearing Statues

Acids are substances that have a sour taste and strong smell. Lemon juice and vinegar are common acids. Acid rain is formed when pollution in the air mixes with the rain and falls to the ground. In this activity, vinegar will represent acid rain, and an antacid tablet will represent a marble statue in a city park. Both the antacid tablet and marble are made of the same chemical: calcium carbonate.

Materials

- Pencil
- 2 antacid tablets *(Look at the ingredients label on the back of the bottle. The active ingredient should be calcium carbonate.)*
- Small disposable paper plate
- 2 disposable paper or plastic cups (3 oz.)
- Masking tape
- Marking pen
- 2 droppers or pipettes
- Measuring spoon (tablespoon)
- Water
- Vinegar

NOTE: It is best to use antacid tablets without any acids among the ingredients. Look on the back of the bottle to see if the word "acid" appears in the list of inert ingredients. Less expensive generic or store brands usually work best for this activity.

ADAPTATION *To prevent spills, a cupcake pan may be used in place of cups. A magnifying glass may be helpful to see the reactions. In addition, a rubber stamp and inkpad may be used to make a design on the antacid tablets–but be sure to use waterproof ink.*

SAFETY! *Be sure to follow Milli's Safety Tips and do this activity only with adult supervision! Do not drink any of the liquid samples in this activity. Keep your face away from the cups. Eye protection must be worn by everyone doing this activity.*

Procedure

1. Using the pencil, draw a face or picture on the smooth side of each antacid tablet.
2. Place the two antacid tablets on a paper plate with your drawings facing up. One of the tablets should be on the right side of the paper plate, and the other should be on the left.
3. Using the masking tape and marking pen, label one cup "water" and the other "vinegar".
4. Ask your adult partner to help you pour 1 tablespoon of water into the cup labeled "water" and 1 tablespoon of vinegar into the cup labeled "vinegar".
5. Use the marking pen to label one of the droppers with a "W" for water and the other dropper with a "V" for vinegar.
6. Using the dropper labeled "W", carefully place three drops of water onto one of the antacid tablets. Watch what happens to the tablet, and write your observations in the "What Did You Observe?" section.
7. Using the dropper labeled "V", carefully place three drops of vinegar onto one of the antacid tablets. Watch what happens to the tablet, and write your observations in the "What Did You Observe?" section.
8. Thoroughly clean the work area. Pour the liquids down the drain, and rinse the containers. Throw away any other trash, including undissolved tablets. Be sure to wash your hands.

What Did You Observe?

What happened to the antacid tablet when you dropped water onto it? Is the picture that you drew on the tablet still there, or did it disappear?

Draw a picture of the antacid tablet with water on top.

What happened to the antacid tablet when you dropped vinegar onto it? Is the picture that you drew on the tablet still there, or did it disappear?

Draw a picture of the antacid tablet with vinegar on top.

Where's the Chemistry?

The tablet treated with vinegar is eaten away in much the same way that acid rain eats away at a marble statue, only faster. The vinegar is reacting chemically with the calcium carbonate in the antacid tablet. The calcium carbonate is used up, and a gas called carbon dioxide is formed. Acid rain is more acidic than normal rain and is caused by pollution in the air.

Experiments To Do at Home with a friend and/or a parent:

- When working at Home: ALWAYS remember the safety rules!!
- When working at Home: ALWAYS ask a parent before you start any experiment!!
- When working at Home: ALWAYS remember to work on a surface that is easily cleaned – never work directly on a table. Working on a wax paper or plastic surface will minimize any problems with cleaning up afterwards!

Experiment #1 (To Do at Home!): What else do we eat that is acidic?

In experiment #1 in the Library, we learned that acidic foods taste tart or sour. What are some other foods that we eat that are likely to be acidic? See if you can list 4-5 different foods (solid or liquid):

1. _____
2. _____
3. _____
4. _____
5. _____

Using the pH paper that we gave you, test a couple of these foods if the food is readily available. Were you correct that each liquid was acidic?

Experiment #2 (To Do at Home!): Cleaning Pennies

Many of the cleaners that we use are either highly acidic or basic. Some of our foods are highly acidic. Two of the highly acidic foods that come to mind are tomato sauce and orange juice.

Materials:

3 dirty pennies	Soap & water	Tomato sauce
Orange juice	Paper towel	

Procedure:

- Taking 1 of your dirty pennies - try to clean it with soap & water.
- Taking another 1 of your dirty pennies - try to clean it with the tomato sauce.
- Taking the last 1 of your dirty pennies - try to clean it with orange juice.

Questions to ask yourself:

1. What 'cleaner' was the <u>most</u> successful at cleaning the penny?
2. What 'cleaner' was the <u>least</u> successful at cleaning the penny?
3. Test the pH of the different liquids. What has the strongest pH (most acidic)? Was this the liquid that worked the best?