

Lesson Three

pH

Acidity

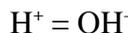
Acidity is determined by how many hydrogen ions are in a solution. The more hydrogen ions (H^+) found, the more acidic the solution. A base is formed by hydroxide ions (OH^-). The more hydroxide ions found, the more base the solution. Pure water has equal amounts of H^+ and OH^- in it. That is why when a base and an acid are put together they are neutralized and water (H_2O) is one of the byproducts.



When measured in solution, the concentration of H^+ is used to define pH.

$$pH = -\log [H^+]$$

When neutral, the ions are in equal concentrations.



The pH of the neutral water is 7 (this is the negative log of the hydrogen ion concentration of 10^{-7}).

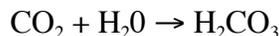
The pH scale ranges from 1 to 14.

Ion	Strong Acid	Weak Acid	NEUTRAL	Weak Base	Strong Base
H^+	large number of Hydrogens	>	equal number of Hydrogen and Hydroxide ions	>	small number of Hydrogens
OH^-	small number of Hydroxides	<		<	large number of Hydroxides
pH	1		7		14

pH Table

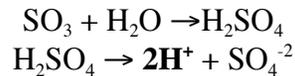
(Created by Teresa Thornton, 2006)

Carbon dioxide (CO_2) is soluble in water. CO_2 in the air is mixed with water through wind. Once it equilibrates it can change the pH of water. The actual chemical change is:



HCO_3^{2-} is called the bicarbonate ion. In the absence of other ions it dominates so the number of hydrogen ions increase and the water becomes more acidic.

Rainwater falling on the ground is saturated with atmospheric CO₂. It usually has a pH measurement around 5.5. This acidic water hits the ground and strips positively charged ions from soils and bedrock. This is called *cation exchange* because the positively charged acid (proton or H⁺) is exchanged on surface sites with other positively charged ions that are natural to the make-up of soils and rocks. In Maine, cations like Ca⁺², K⁺, Mg⁺², and Na⁺ are stripped from the surface and go into the soil water. They are called base cations. Sulfates (and nitrates) from air pollution increase the acidity further and make the rainwater an even stronger cation exchange catalyst.



Plants that need these base cations in the soils are starved. The ions are then flushed into runoff and groundwaters.

When groundwaters and runoff feed the surface water, the plants in the surface waters are fed. The plants in the surface water then grow until they take over and eutrophication of the habitat ensues.

Alkalintiy

Alkalintiy measures the waters ability to temper the acidity of the ions in solution. This does not include hydrogen. Through cation exchange, the hydrogens can get bound up in the soils (adsorption) and Ca⁺², Mg⁺², Na⁺, and HCO³⁻ can be released.

VOCABULARY

Acid- A substance capable of yielding hydrogen ions in solution

Base (alkaline)- Having a relatively low concentration of hydrogen ions (yields OH⁻ in solution).

Neutralize- to counteract the activity or effect of: make ineffective

Ion- An atom or a group of atoms that has acquired a net electric charge by gaining or losing one or more electrons.

Cation- An ion or group of ions having a positive charge

Anion- A negatively charged ion

Catalyst- A substance, usually used in small amounts relative to the reactants, that modifies and increases the rate of a reaction without being consumed in the process.

Eutrophication- Having waters rich in mineral and organic nutrients that promote a proliferation of plant life, especially algae, which reduces the dissolved oxygen content and often causes the extinction of other organisms. Used of a lake or pond.

Hardness- large amounts of undissolved cations found in water; particularly Ca⁺² (calcium) and Mg⁺² (magnesium)

Soft water- water that has low concentrations of cations (Ca⁺² & Mg⁺²)

Hard water can be softened by exchanging:

Ca⁺² & Mg⁺² for Na⁺ (sodium) & K⁺ (potassium).

Base cations-common cations found in water

ACTIVITY

250 mL to 500 mL sized Beaker for each group of students

250 mL to 500 mL graduated cylinder

straws (one for each sample)

pH test strips (one for each sample)

Several different types of water: Water fountain Tap water
 Bottled water Any kind!

1. Measure out 250mL of each type of water you wish to sample into a beaker. Use a pH strip to measure the acidity of each water sample. Using a straw, exhale into the beaker for 30 seconds. Measure the change in the pH.
2. Use several different household products and test pH.

HOMEWORK

Short Essay Questions

Answer these questions in complete thoughts and sentences.

1. Do you have soft or hard water in your home?
2. How can you tell?
3. How does this affect the amount of soap used in laundry and dish cleaning?
4. Is there a water filtration system in your home?
5. What kind? (i.e., Does the filtration system filter the house, a sink, or a drinking jug?)
6. Why is bottled water and tap water filtration popular?
7. What industry, machines, or heating systems in your neighborhood would contribute to the acidity of your groundwater, surface water, and drinking water?
8. Describe the smell, color and taste of your tap water at home.