EnviroAqua Consultants Inc.

Water Talk

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All About pH

pH is the measurement of the hydrogen concentration, $[H^+]$. Every aqueous solution can be measured to determine its pH value, which ranges from 0 to 14 pH. Values below 7 are acidic and everything above 7 is basic. At 7 pH, the ratio of $[H^+]$ to $[OH^-]$ is equal and the solution is therefore considered neutral. A change of one pH unit represents a 10-fold change in concentration of hydrogen ion. In a neutral solution, the $[H^+]=1x10^{-7}$ mol/L. This represents a pH of 7.

$$\begin{aligned} pH &= -\log(1 \times 10^{-7}) \\ &= -(\log 1 + \log 10^{-7}) \\ &= -(0.0+(-7)) \\ &= 7 \end{aligned}$$

Almost all process containing water have a need for pH measurement. The pH of wastewater leaving manufacturing plants and wastewater purification plants, as well as potable water from municipal drinking water plants, must be within a specific pH "window" as set forth by local, state or federal regulatory agencies, which is typically between 5 and 9 pH.

Other pH applications include:

- Neutralization of effluent in steel, pulp and paper, chemical, and pharmaceutical manufacturing
- Hexavalent chromium destruction
- Cyanide destruction
- Reverse osmosis
- Odor scrubbers
- Pharmaceutical manufacturing
- Chemical and petrochemical manufacturing
- Cooling tower control

Whether adjusting the pH for a proper reaction or making sure wastewater is at the proper pH value before sending it to the community sewer system, accurate pH measurement is required.

Aqueous solutions that have a hydrogen ion concentration greater than the hydroxide ion concentration are called acidic solutions. When the hydroxide ion concentration is greater than the hydrogen ion concentration, the solution is called basic or alkaline.

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Since the concentration of hydrogen ions and hydroxide ions are constant in a stable solution, either one can be quantified if the value of the other is known. Therefore, when determining the pH of a solution, the hydroxide ion concentration can be calculated:
$[H^+] [OH^-]=10^{-14}$

HOW IS pH MEASURED?

The measurement of pH in an aqueous solution can be made in a variety of ways, but the most common involves the use of a pH sensitive glass electrode, a reference electrode and a pH meter. Other ways of calculating pH are:

- **Indicators** are materials that are specifically designed to change color when exposed to different pH values. The color of a wetted sample paper is matched to a color on a color chart to infer a pH value. This method is usually used for preliminary and small volume measuring.

- **Calorimeters** have a filled vial with the appropriate volume of sample. A reagent is added in order to cause a color change so that the solution can be compared to a color wheel to determine the pH value.

- **pH meters** are recommended for precise and continuous measuring.

One common application of acid is for pH control in cooling towers. The purpose of a cooling tower is to cool down water which has been heated by ejecting heat from industrial processes and an HVAC system. Hot process water is cooled, then directed through the process, where it absorbs heat, and is then sent back to the tower to be re-cooled. Large amounts of water are required as evaporation occurs during the cooling cycle. Since water is an expensive commodity, primary concerns are efficiencies in the design of cooling towers and chemical treatment of the water being used.The heat transfer surfaces must be protected from corrosion and scale.

Proper control of a number of parameters will keep the tower operating efficiently and prevent damage to vital parts from scale, corrosion, and biological growth. As air flows through the tower, airborne contaminants would be carried through the system if they were not taken care of prior to distribution.

pH is one of many parameters that controls the water chemistry of the tower. Maintaining a pH level between 7.0 and 8.0 to increase water common is fairly common. This addresses the green initiatives of water recycling.

When water is used for evaporative cooling in a cooling tower, physical and chemical processes will change the composition. The carbon dioxide - bicarbonate buffer that determined the pH in the makeup will change to a bicarbonate - carbonate buffer in the cooling water. The natural pH of the cooling water will be in the range 8.3 to 9.2. Under the high temperature conditions of a steam boiler, bicarbonate ions will decompose into carbonate and hydroxide ion. The carbonate - hydroxide buffer in a boiler will determine a pH range of 10.5 to 12.0.

The pH will determine what occurs in solution or on the surfaces in contact with the water. In a strongly acidic pH range of 1 to 2, metals, like steel and copper, will be readily dissolved into the water. The process of dissolving metals by low pH water is called acidic corrosion. Mineral deposits like calcium carbonate and calcium phosphate, and corrosion products like rust will be dissolved by low pH water.

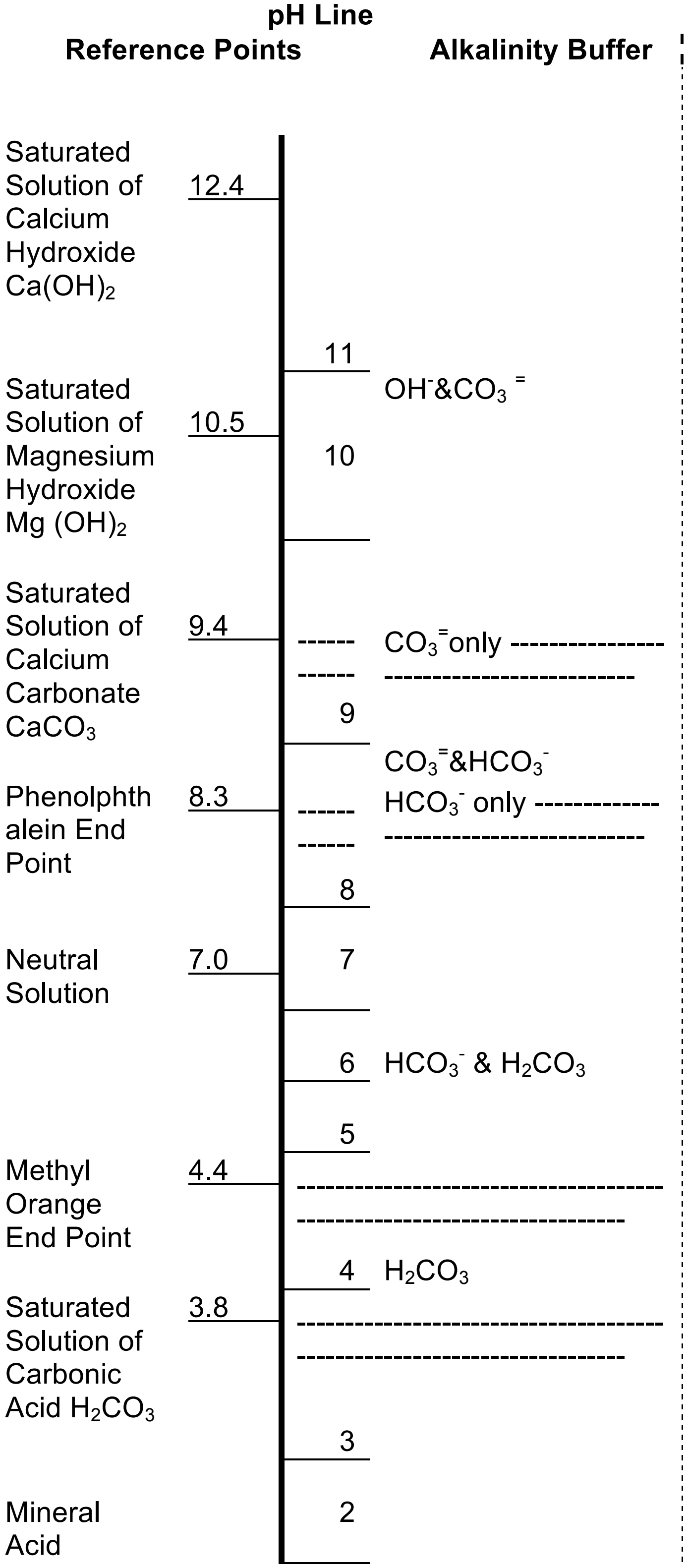
In water having a pH above 7.0, the corrosion process on steel or copper is significantly reduced. Further, the type of corrosion occurring in the pH 7 to 9 range is oxygen pitting and differential oxygen cell (AKA underdeposit corrosion). In water having a pH above 7, iron (ferric) hydroxide and other salts with limited solubility can precipitate from solution. At 8.3, calcium carbonate will begin to precipitate, and above pH 10.5, magnesium hydroxide will drop out. Also, metals like aluminum and zinc will dissolve or corrode in water above pH 9.

pH can be determined in the laboratory or field by two methods. The traditional method utilizes chemical reagents, which have a color response to the specific pH value. The contemporary methods utilize an electronic device called a pH meter.

pH is influenced by the temperature of the water. As the temperature increases, the pH will decrease. pH measurements are usually standardized to a temperature of 77°F (25°C).

Temperature		4.01 Buffer	7.01 Buffer	10.01 Buffer
C	F	pH	pH	pH
0	32	4.01	7.13	10.32
5	41	4.00	7.10	10.24
10	50	4.00	7.07	10.18
15	59	4.00	7.04	10.12
20	68	4.00	7.03	10.06
25	77	4.01	7.01	10.01
30	86	4.02	7.00	9.96
35	95	4.03	6.99	9.92
40	104	4.04	6.98	9.88
45	113	4.05	6.98	9.85
50	122	4.06	6.98	9.82
55	131	4.07	6.98	9.79
60	140	4.09	6.98	9.77

DIAGRAM OF pH AND ALKALINITY RELATIONSHIP



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