'Applications of Acids' And 'pH Scale'

Learning Outcomes:

Students will be able to:

1. describe the applications of acids.
2. explain the process of etching in art and industry.
3. define and explain pH.
4. classify a solution as neutral, acidic or basic from given hydrogen ion or hydroxide ion concentrations.

Introduction

Acids play a very important role in the human body. The hydrochloric acid present in our stomach aids in digestion, by breaking down large and complex food molecules. Amino acids are required for synthesis of proteins, growth and repair of our body tissues. Along with amino acids, fatty acids are also required for growth and repair of body tissues. Nucleic acids are important for the manufacturing of DNA, RNA and transmission of characters to offspring through genes. Carbonic acid is important for maintenance of pH equilibrium in the body.

General Applications of Acids:

There are countless applications of acids. Some of the important applications of acids are:

1. Pickling:

- Acids are often used to remove rust and other corrosion from metals in a process known as *pickling*

2. Electrolytes:

Acids may be often used as an electrolyte in a lead storage battery. Sulphuric acid, for example, can be used as an electrolyte in a car battery to generate current.

3. Fertilizers:

Acids can be used in the manufacturing of fertilizers. For example, nitric acid reacts with ammonia in neutralization reaction to produce ammonium nitrate which is used as a fertilizer. Sulphuric acid is used in manufacturing fertilizers such as super phosphate, ammonium sulphate etc.

4. Esters:

Carboxylic acids react with alcohols to produce sweet smelling compounds called esters.

5. Preservatives:

Acids can be used as additives to drinks and foods, as they change their taste and serve as preservatives.

For example:

(i) ***Acetic acid*** *is used in day to day life as vinegar.*

(ii) ***Carbonic acid*** is an important constituent of soft drinks.

(iii) ***Citric acid*** is used in effervescent salts and as a preservative in sauces and pickles.

(iv) Tartaric acid *is an important component of some commonly used foods like unripened mangoes and tamarind.*

(v) Phosphoric acid *is a component of cola drinks.*

(vi) Tannic acid *is used in the manufacture of ink and leather.*

(vii) Hydrochloric acid *is used to make aqua regia, which is used to dissolve noble metals such as gold and platinum.*

Home Applications:

- Boric acid is a weak acid used as antiseptic and cleanser.
- Sodium hypochlorite makes white clothes whiter and is better known as bleach.
- Acids and bases help make soaps and unclog pipes.
- The most used home acids are acetic acid and citric acid. We know these better as vinegar and lemon juice.

Industrial Applications:

Acids and bases help in many different forms of industry.

- Nitric acid helps make TNT (tri-nitro toluene) explosive.
- Acids can also be used to clean metal and tiles.

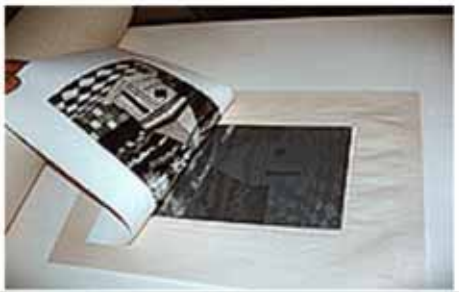
Bases have many uses as well.

- Sodium Bicarbonate (baking soda) is used as a buffer to either bring the pH of water up or to protect its pH in the environmental field.
- Strontium hydroxide is used to refine sugar by bonding to it to make strontium saccharate so that impurities can be washed out.

Etching:

(The process to make designs on metals, glass or any other surface by eating out the lines with an acid.)

The artist draws with a needle on to a copper, zinc or steel plate that has been covered with an acid resistant wax. When the plate is immersed in acid, the bare metal, exposed by the lines of the drawing, is eroded. The depth of the `etch' is controlled by the amount of time the acid is allowed to `bite' the metal. The longer in acid, the deeper the line and the darker it will print.



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pH-A Measure of Acidity:

Because the concentration of H^+ and OH^- ions are frequently very small numbers and therefore inconvenient to work with, the Danish biochemist Soren Sorensen in 1909 proposed a more practical measure called pH. The pH of a solution is defined as *"the negative logarithm of hydrogen ion concentration" (in moles per liter):*

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

Since pH is simply a way to express hydrogen ion concentration, acidic and basic solution at 25^0C can be identified by their pH values, as follows:

Acidic solution: $[H^+] > 1.0 \times 10^{-7}\ M$, pH < 7.00
Basic solution: $[H^+] < 1.0 \times 10^{-7}\ M$, pH > 7.00
Neutral solution: $[H^+] = 1.0 \times 10^{-7}\ M$, pH = 7.00

A pOH scale similar to the pH scale can be devised using the negative logarithm of the hydroxide ion concentration. Thus we define pOH as

$$pOH = -\log [OH^-]$$

Now consider the ion-product costant for water:

$H_2O \rightleftharpoons H^+ + OH^-$

$$[H^+][OH^-] = K_w = 1.0 \times 10^{-14}$$

$\log(a \times b) = \log a + \log b$

$\log(a \div b) = \log a - \log b$

$\log 10^5$ $\log a^b$

$b \log a$

Taking the negative logarithm on both sides, we obtain

$$-\log\{[H^+][OH^-]\} = -\log(1.0 \times 10^{-14})$$
$$-\log[H^+] + (-\log[OH^-]) = -\log 1.0 - \log 10^{-14}$$
$$pH + pOH = 0 - (-14 \log 10)$$
$$pH + pOH = 14 \times 1$$

$$pH + pOH = 14$$

pH Meter

Numerical:

Find the pH and pOH of a 0.00001 M solution of hydrochloric acid.

Solution: $HCl \xrightarrow[H_2O]{\text{ionization}} H^+_{(aq)} + Cl^-_{(aq)}$.

$[H^+] = 0.00001 = 1 \times 10^{-5} M$.

formula:

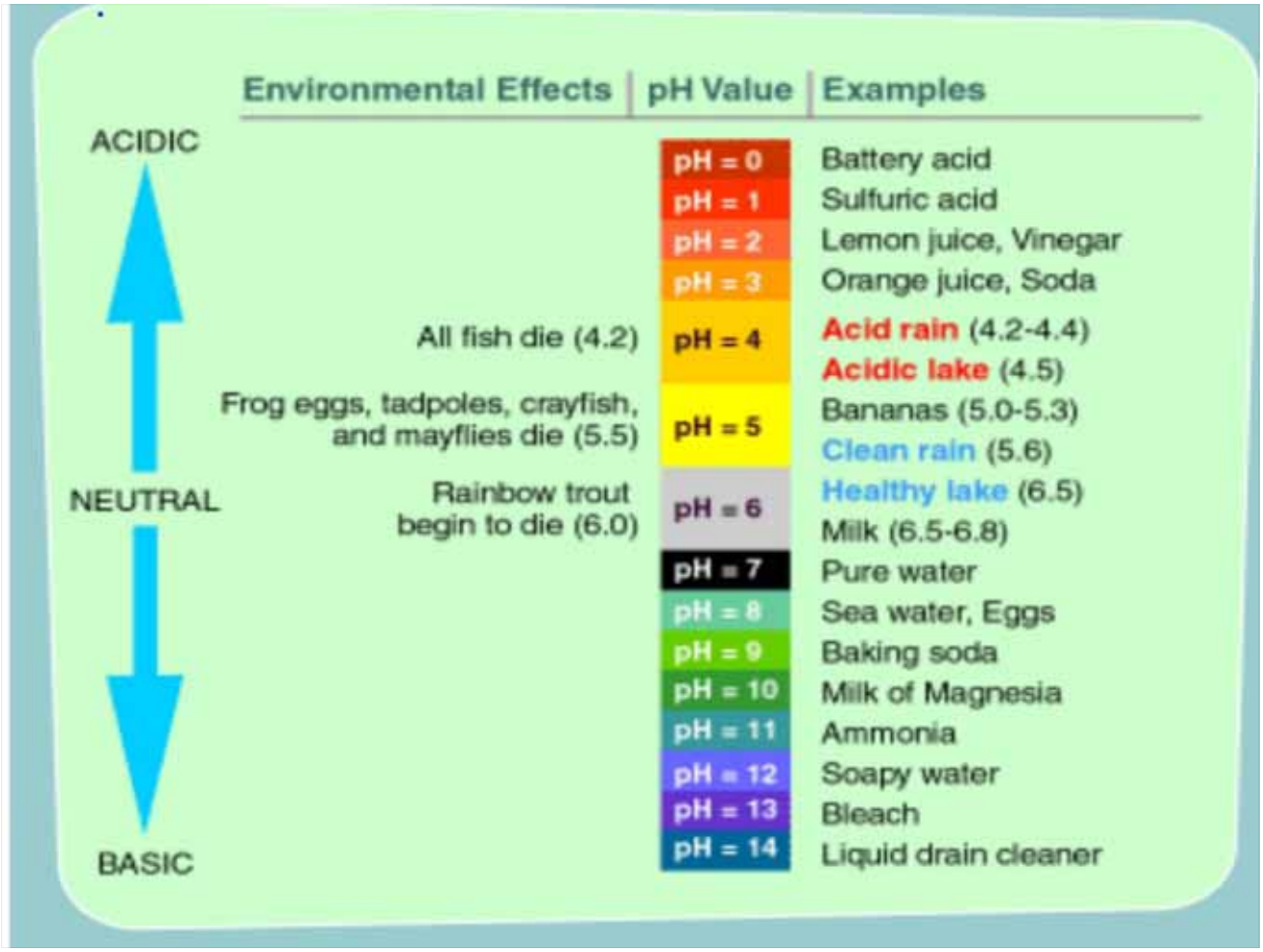
$pH = -\log[H^+]$

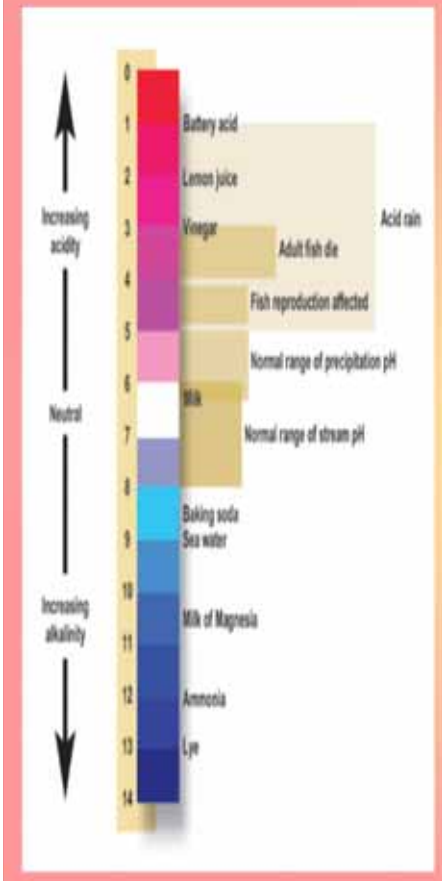
$= -\log[1 \times 10^{-5}]$

$pH = +5 \Rightarrow pH = 5$

Classification of some of the common substances as acids snd bases with respect to their pH values:

Sample	pH value
Gastric juice in the stomach	1.0-2.0
Lemon juice	2.4
Vinegar	3.0
Grapefruit juice	3.2
Orange juice	3.5
Water exposed to air	5.5
Saliva	6.4-6.9
Milk	6.5
Pure water	7.0
Blood	7.35-7.45
Tears	7.4
Milk of magnesia	0.6
Household ammonia	11.5


Environmental Effects
pH Value
Examples
ACIDIC
NEUTRAL
BASIC
All fish die (4.2)
Frog eggs, tadpoles, crayfish, and mayflies die (5.5)
Rainbow trout begin to die (6.0)
pH = 0
pH = 1
pH = 2
pH = 3
pH = 4
pH = 5
pH = 6
pH = 7
pH = 8
pH = 9
pH = 10
pH = 11
pH = 12
pH = 13
pH = 14
Battery acid
Sulfuric acid
Lemon juice, Vinegar
Orange juice, Soda
Acid rain (4.2-4.4)
Acidic lake (4.5)
Bananas (5.0-5.3)
Clean rain (5.6)
Healthy lake (6.5)
Milk (6.5-6.8)
Pure water
Sea water, Eggs
Baking soda
Milk of Magnesia
Ammonia
Soapy water
Bleach
Liquid drain cleaner



Multiple Choice Questions

1. Which of the following is most suitable substance used for pickling process?

A. Carbonic acid
B. Folic acid
C. Sulphuric acid
D. Vinegar

2. If a solution contain 0.0001 M H^+ ion concentration, its pH will be:

A. 6.0
B. 4.0
C. 1.5
D. 0.3

3. Which of the following technique can be applied to make designs on different metal surfaces?

A. Pickling
B. Etching
C. Titration
D. Carbonation