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pH Scale, Salts and some uses of salts

Lec(2)

First stage

By

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hyperacidity

Sometimes stomach produces too much acid. It causes stomach acidity also called hyperacidity. Symptoms of this disease are feeling burning sensation throughout the gastro intestinal track. These feelings sometimes extend towards the chest, that is called heart burning.

The best prevention from hyperacidity is:

- *i) Avoiding over-eating and staying away from fatty acids and spicy foods.*
- *ii) Simple and regular eating, remaining in an upright position for about 45 minutes after taking a meal.*
- *iii) Keeping the head elevated while sleeping.*

pH SCALE

Concentration of hydrogen ion [H+] in pure water is the basis for the pH scale. Water is a weak electrolyte because it ionizes very slightly into ions in a process called autoionization or self-ionization;

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

The equilibrium expression of this reaction may be written as

$$K_c = \frac{[H^+][OH^-]}{[H_2O]}$$

As concentration of water (H2O) is almost constant. The above equation may be written as

$$K_c [H_2O] = [H^+][OH^-]$$

A new equilibrium constant known as ionic product constant of water 'Kw' is used instead of product of equilibrium constant and [H2O]. Therefore,

$$K_w = [H^+][OH^-] = 1.0 \times 10^{-14} \text{ at } 25°C$$

As we know, one molecule of water produces one H+ ion and one OH- ion on dissociation so

$$[H^+] = [OH^-] \quad \text{Or} \quad [H^+]^2 = 1.0 \times 10^{-14}$$

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

$$[H^+] = 1.0 \times 10^{-7}\ M \quad \text{at} \quad 25°C$$

As it is difficult to deal with such small figures having negative exponents, so it is convenient to convert these figures into a positive figure using a numerical system. It is taking the common (base-10) logarithm of the figure and multiplying it with -1. ‘p’ before a symbol means’ negative logarithm of the symbol. So ‘p’ before H means negative logarithm of [H+].

Therefore, pH is the negative logarithm of molar concentration of the hydrogen ions. That is,

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

with reference to this equation, a scale develops according to the molar concentration of H+ ions that is called pH scale. It ranges from 0 to 14. According to this scale, pH of water is calculated as:

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

$$pH = -\log (1.0 \times 10^{-7}) = 7$$

Similarly

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

$$pOH = -\log (1.0 \times 10^{-7}) = 7$$

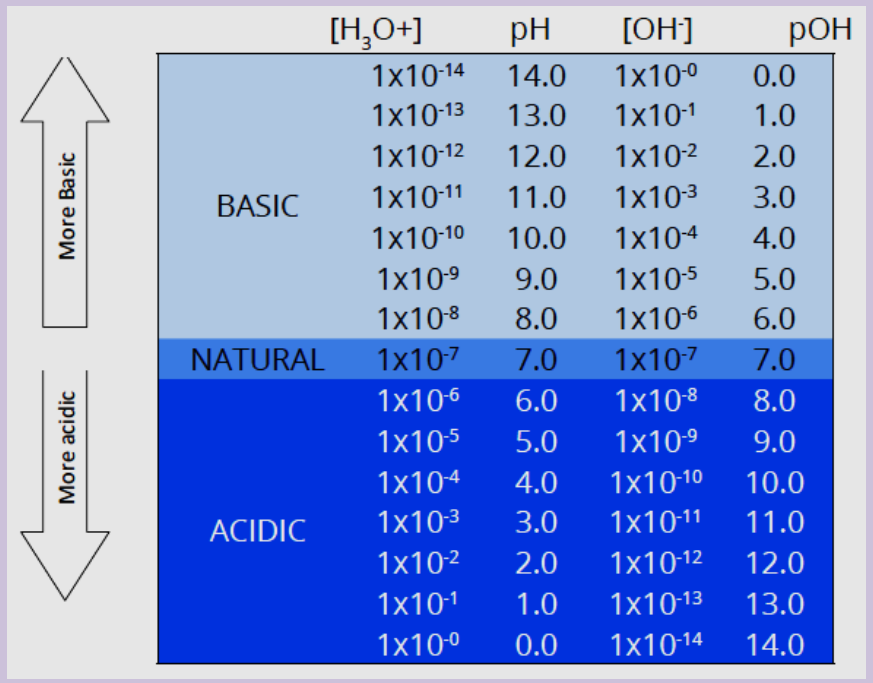
pH value normally varies from 0 to 14. Therefore:

pH + pOH = 14

So, the sum of the pH and pOH of the solution is always 14 at 25 °C. Such as;

	Highly acidic			Slightly acidic			neutral		Slightly basic				Highly basic	
pH	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
pOH	14	13	12	11	10	9	8	7	6	5	4	3	2	1	0

A solution of a compound of pH 7 or pOH 7 is considered a neutral solution. Solutions of pH less than 7 are acidic and more than 7 are basic.



	$[H_3O^+]$	pH	$[OH^-]$	pOH
BASIC	$1x10^{-14}$	14.0	$1x10^{-0}$	0.0
	$1x10^{-13}$	13.0	$1x10^{-1}$	1.0
	$1x10^{-12}$	12.0	$1x10^{-2}$	2.0
	$1x10^{-11}$	11.0	$1x10^{-3}$	3.0
	$1x10^{-10}$	10.0	$1x10^{-4}$	4.0
	$1x10^{-9}$	9.0	$1x10^{-5}$	5.0
	$1x10^{-8}$	8.0	$1x10^{-6}$	6.0
NATURAL	$1x10^{-7}$	7.0	$1x10^{-7}$	7.0
ACIDIC	$1x10^{-6}$	6.0	$1x10^{-8}$	8.0
	$1x10^{-5}$	5.0	$1x10^{-9}$	9.0
	$1x10^{-4}$	4.0	$1x10^{-10}$	10.0
	$1x10^{-3}$	3.0	$1x10^{-11}$	11.0
	$1x10^{-2}$	2.0	$1x10^{-12}$	12.0
	$1x10^{-1}$	1.0	$1x10^{-13}$	13.0
	$1x10^{-0}$	0.0	$1x10^{-14}$	14.0

Since the pH scale is logarithmic, a solution of pH 1 has 10 times higher concentration of [H+] than that of a solution of pH 2; 100 times than that of a solution of pH 3 and so on. Hence, low pH value means strong acid while high pH value means a strong base and vice versa.

Conclusion

(i) pH of a neutral solution is always 7.

(ii) Acidic solutions have pH less than 7.

(iii) Basic solutions have pH value greater than 7.

(iv) pH and pOH values range from 0 to 14.

- **Uses of pH**

(i) It is used to determine acidic or basic nature of a solution.

(ii) It is used to produce medicines, culture at a microbiological particular concentration of H+ ion.

(iii) It is used to prepare solutions of required concentrations necessary for certain biological reactions.

SALTS

Salts *are ionic compounds generally formed by the neutralization of an acid with a base*.

Salts are made up of positive ions (cations) and negative ions (anions). A cation is metallic ion derived from a base, therefore, it is called basic radical. While anion is derived from an acid, therefore, it is called acidic radical.

A salt gets its name from the names of the metal and the acid

Metal	Acid	Salt name
Sodium (Na)	Hydrochloric acid (HCl)	Sodium chloride (NaCl)
Potassium (K)	Nitric acid (HNO_3)	Potassium nitrate (KNO_3)
Zinic (Zn)	Sulphuric acid (H_2SO_4)	Zinc sulphate ($ZnSO_4$)
Calcium (Ca)	Phosphoric acid (H_3PO_4)	Calcium phosphate $Ca_3 (PO_4)_2$
Silver (Ag)	Acetic acid (CH_3COOH)	Silver acetate (CH_3COOAg)

Characteristic properties of salts

(i) Salts are ionic compounds found in crystalline form.

(ii) They have high melting and boiling points.

(iii) Most of the salts contain water of crystallization which is responsible for the shape of the crystals. Number of molecules of water are specific for each salt and they are written with the chemical formula of a salt.

For example, Copper sulphate $CuSO_4.5H_2O$; Calcium sulphate $CaSO_4.2H_2O$

(iv) Salts are neutral compounds. Although, they do not have equal number of positive and negative ions, but have equal number of positive and negative charges.

Preparation of salts

(a) By the reaction of an acid and a metal: (Direct Displacement method)

This is direct displacement method in which hydrogen ion of acid is replaced by a reactive metal. Such as calcium, magnesium, zinc and iron, e.g.

Acid + Metal ⟶ Salt + Hydrogen gas

$2HCl_{(aq)} + Mg_{(s)} \longrightarrow MgCl_{2(aq)} + H_{2(g)}$

(b) By the reaction of an acid and a base: (Neutralization method)

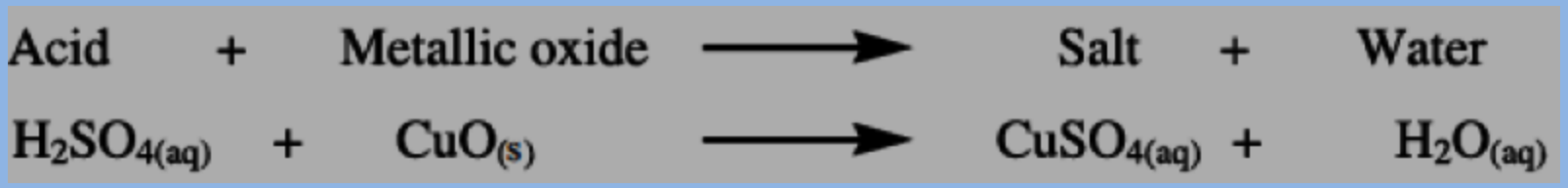
It is a neutralization reaction in which acid and base react to produce a salt and water.

Acid + Base ⟶ Salt + Water

$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow NaCl_{(aq)} + H_2O_{(l)}$

(c) By the reaction of an acid and metallic oxide:

Mostly the insoluble metallic oxides react with dilute acids to form salt and water.



(d) By the reaction of an acid and a carbonate:

Dilute acids react with metallic carbonates to produce salts, water and carbon dioxide gas.

Uses of Salts

Salts have vast applications in industries and in our daily life. Some common salts and their uses are given in Table:

Name of salts	Common and Industrial Uses
Sodium chloride (NaCl)	It is commonly used as a table salt and for cooking purposes, it is also used for de-icing roads in winter and for the manufacture of sodium metal, caustic soda, washing soda.
Sodium carbonate Na_2CO_2) Soda ash	It is used for the manufacture of glass, detergents, pulp and paper and other chemicals.
Sodium carbonate Na_2CO_3, $10H_2O$) Washing soda	It is used as cleaning agent for domestic and commercial purposes, for softening of water, in manufacture of chemicals like caustic soda (NaOH), borax, glass, soap and paper.
Sodium sulphate (Na_2SO_4)	It is used for the manufacture of glass, paper and detergents.
Sodium silicate (Na_2SiO_3)	It is used for the manufacture of detergents, cleaning agents and adhesives.
sodium chlorate ($NaClO_3$)	It is used for manufacture of explosives, plastics and other chemicals.

Questions

(1) What are conjugate bases of each of the following?

HS^-, H_3O^+, $H_2PO_4^-$, HSO_4^-, HF, CH_3COOH

(2) Give the conjugate acids of the following:

OH^-, HCO_3^- , HPO_4^{2-}, CH_3NH_2 , CO_3^{2-}, CH_3COOH

(3) Which of the following behave both as Bronsted acids and Bronsted bases?

H_2O, HCO_3^-, H_2SO_4 , H_3PO_4 , HS^-

(4) What is the difference between Arrhenius base and Bronsted-Lowry base?

(5) What is mean by neutralization reaction according to Arrhenius acid-base concept?

(5) Prove that water is an amphoteric specie.

(6) How can you justify that NH_3 is Bronsted-Lowry base but not Arrhenius base?

(7) State and explain the neutralization reaction according to Lewis concept.

(8) Define and give the characteristics of a Lewis acid.

(9) Why BF_3 behaves as a Lewis acid?

(10) Water is an amphoteric specie according to Bronsted- Lowry concept. What is its nature according to Lewis concept?

(11) When acids react with carbonates and bicarbonates, which gas evolves ?

(12) Which types of salts produce SO2 gas on reacting with acids?

(13) Give the uses of sulphuric acid.

(14) Name the gas liberated when alkalies react with ammonium salts.

(15) Write down the colours of the precipitates formed by reaction of aqueous

(16) caustic soda with solutions of: copper, zinc and ferric salts.

(17) Name an alkali used in alkaline batteries.