Acids, Bases, and salts

Acids :

An acid is a substance that forms hydrogen (H^+) ions as the only positive ion when dissolved in water.

There are two types of acids: Mineral acid (or inorganic acid) and organic acid.

1- Mineral acids : Are acids that are derived from one or more mineral elements or inorganic matter and can normally be prepared in a laboratory . Phosphoric acid (H_3PO_4), Sulfuric acid (H_2SO_4), hydrochloric acid (HCI), carbonic acid (H_2CO_3) and nitric acid (HNO_3) are examples of mineral acids.

2- Organic acids : Are obtained from plants and animals and are mainly naturally occurring organic compounds with acidic properties. They include malic acid ($C_4H_6O_5$) which is found in apple, ethanoic acid ($C_2H_4O_2$) that can be found in vinegar and citric acid ($C_6H_8O_7$) that is present in citrus fruits like lemon.

The strength of an acid refers to the extent to which an acid molecule dissociated or ionizes in an aqueous solution to form ions.

Classification of acids :

1- Strong acid : Are acids that are completely dissociated in water to produce a high concentration of hydrogen ions. Hence, strong acid ionizes completely. The strong acid has a PH in the region of about 1. Sulfuric acid, nitric acid, and hydrochloric acid are an example of a strong acid.

$$HCI_{(aq)} \rightarrow H^+_{(aq)} + CI^-_{(aq)}$$

(dilute hydrochloric acid contains only hydrogen and chloride ions) .

$$H_3PO_{4(aq)} \rightarrow 3H^+_{(aq)} + PO_4^{-3}{}_{(aq)}$$

2- Weak acids : Are acids that ionized only slightly when dissolved in water to produce a low concentration of hydrogen ions. Carbonic acid and ethanoic acid where only a few of its molecules. Carbonic acid and ethanoic acid where only a few of its

molecules ionizes. A weak acid has a PH in the region at about 2.5. Other examples include citric acid and malic acid.

$$CH_3COOH_{(aq)} \leftrightharpoons H^+_{(aq)} + CH_3COO^-_{(aq)}$$

(dilute ethanoic acid contains mainly acid molecules that remain unchanged in the water; very few molecules dissociated to produce hydrogen ions).

$$C_6H_8O_{7\,(aq)} \leftrightharpoons 3H^+_{(aq)} + C_6H_5O_7^{-3}{}_{(aq)} \quad \text{(Citric Acid)}$$

Properties of Acids :

1- The hydrogen atoms of an acidic molecule that are released to form hydrogen ions in water are called acidic hydrogen in acids such as HCI, H_2SO_4, and HNO_3, all the hydrogens in the compound are acidic. In acetic acid only one of the hydrogen is acidic.

2- Not all the acids are liquids, there are many solids also like boric acid (H_3BO_3) and citric acid.

3- The acids taste of the acids is due to the hydrogen ions produced when these acids are dissolved in water. So citric acid is responsible for the acidic taste of lemon and grapefruit juices. Acetic acid is responsible for the acidity of the vinegar. Lactic acid is responsible for the acidity of yogurt.

4- When acids react with certain compounds, these compounds change in the color. Substances that change in color in the presence of acids are called indicator.

One of the most common indicators for acids is litmus. Blue litmus turns red in the presence of an acid. Another common indicator phenolphthalein turns from red to colorless in the presence of an acid.

Chemical Reaction of Acids :

1- Acids react with metal oxide and metal hydroxide to formed water and salt.

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$$

$$2HCI + MgO \rightarrow MgCI_2 + H_2O$$

$$H_2SO_4 + 2NaOH \rightarrow 2H_2O + Na_2SO_4$$

The reaction of an acid with certain metal hydroxide (called bases) is termed neutralization. That is acids neutralize bases to form water and a salt.

2- Acid react with Na, Ca, Mg, Zn, Fe, Sn and Pb to produce hydrogen gas and a salt.

Metal + Acid → Salt + Hydrogen

$$Zn_{(s)} + H_2SO_4 \rightarrow ZnSO_4 + H_2 \uparrow$$

$$Mg + 2HCI \rightarrow MgCI_2 + H_2 \uparrow$$

So acids cannot be stored in containers made of these metals. Iron can react with acids, therefore, acids should not be allowed to come in contact with the surgical or dental instrument.

3- Acids react with carbonate (CO_3^{-2}) and bicarbonate (HCO_3^-) to product Carbone dioxide gas (CO_2), water and salt.

Acids + Carbonate → Salt + Carbon dioxide + Water

$$2HCI + CaCO_3 \rightarrow CaCI_2 + CO_2 + H_2O$$

Acids + Hydrogen Carbonate → Salt + Carbon dioxide + Water

$$H_2SO_4 + 2NaHCO_3 \rightarrow Na_2SO_4 + CO_2 + H_2O$$

Uses of Acids :

1- hydrochloric acid, HCI: In industry, an aqueous solution of hydrochloric acid is called muriatic acid. It is used to clean swimming pools. Hydrochloric acid normally found in the gastric juices, is necessary for the proper digestion of protein in the stomach. Patients who have a lower than normal amount of hydrochloric acid in the stomach, a condition called hypoacidity, are given dilute hydrochloric acid orally before a meal to overcome this deficiency.

2- Nitric acid, HNO_3: Is used to test for the presence of albumin in urine because it will coagulate protein. Nitric acid has been used to remove warts, but trichloroacetic acid is now commonly used for this purpose.

3- Sulfuric acid, H_2SO_4 (dilute): Previously dilute sulfuric acid was used as an antidote against the poisoning with lead (Pb) because it formed insoluble lead sulfate.

4- Hypochlorous acid, HCLO: Is used as a disinfectant for floors and walls in the hospital.

5- Boric acid, H_3BO_4: It is used as a germicide and as a solution, it is used to clean the eyes, this use has been stopped due to the side effects caused by the acid molecules itself.

6- Acetylsalicylic acid (aspirin): Is widely used as an analgesic and as an antipyretic. Aspirin is frequently taken by people with a cold to relieve a headache, muscle pain, and fever.

7- Ascorbic acid (vitamin C): Is found in orange and used mainly in the treatment of scurvy.

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Bases :

Definition :

A base is any compound that increases the hydroxide ion concentration in water. Bases are also called alkaline substances. Sodium hydroxide **(NaOH)** is a common example of a base. It is an ionic compound that exists as sodium ions **(Na^+)** and hydroxide ions **(OH^-)** in the solid state. When dissolved in water, hydrated sodium ions and hydroxide ions are formed.

Strength of an alkali refers to the extent to which an alkali molecule dissociates or ionize in an aqueous solution to form ions.

Classification of alkalis :

1- Strong alkali : Are alkalis that are completely dissociated in water to produce a high of hydroxide ions. Hence, strong alkalis ionize completely. Strong alkali has a PH in the region of about 13. Sodium hydroxide **(NaOH)**, potassium hydroxide **(KOH)** and calcium hydroxide **$Ca(OH)_2$** are example strong alkali.

$$NaOH_{(aq)} \rightarrow OH^-_{(aq)} + Na^+_{(aq)}$$

(dilute sodium hydroxide contains only sodium and hydroxide ions, the ionic lattice structure of the hydroxide break down to allow free ions to form.

$$KOH_{(aq)} \rightarrow OH^-_{(aq)} + K^+_{(aq)}$$

$$Ca(OH)_{2(aq)} \rightarrow 2OH^-_{(aq)} + Ca^{+2}_{(aq)}$$

2- Weak alkali : Are alkali that is partially dissociated in water to produce a low concentration of hydroxide ions. Weak alkali has a PH in the region of about 11. Aqueous ammonia is the example of a weak alkali.

$$NH_{3(q)} + H_2O \rightarrow OH^-_{(aq)} + NH_4^+{}_{(aq)}$$

(aqueous ammonia has most of it is molecules remaining unchanged in water; only a small fraction of ammonia molecules dissociate to produce hydroxide ions.

Properties and chemical reaction of Bases :

1- Bases are produced when the metallic oxide is dissolved in water.

$$CaO + H_2O \rightarrow Ca(OH)_2$$

Calcium oxide **Calcium hydroxide**

2- Bases react with the indicator. Bases, turn litmus from red to blue, turn methyl orange from red to yellow, and turn phenolphthalein from colorless to red.

3- Bases neutralize acid to form water and salt.

$$Ca(OH)_2 + H_2SO_4 \rightarrow CaSO_4 + 2H_2O$$

4- Strong bases react with certain metals to produce hydrogen gas.

$$2AI + 6NaOH + 6H_2O \rightarrow 3H_2\uparrow + 2Na_3AI(OH)_6$$

sodium aluminate

Thus a strong base such as (NaOH) can not store in an aluminum container because it will react with it and dissolve the container.

5- Strong bases have a corrosive effect on tissues due to their ability to react with protein and fats. If the strong base is spilled on the skin a serious burn may result. The procedure, in this case, is to apply copious of water followed by treatment with a weak acid such as acetic acid to neutralize any base that might be left.

6- Strong base can dissolve lipids and proteins.

Uses of Bases :

1- Calcium hydroxide solution, $Ca(OH)_2$: Commonly known as limewater, is used to overcome excess acidity in the stomach. It is also used medicinally as an antidote for oxalic acid poisoning because a reacts with the oxalic acid to form an insoluble compound, calcium oxalate.

2- Magnesium hydroxide, $Mg(OH)_2$: Is commonly known as milk of magnesia. In dilute solutions, it is used as an antacid for the stomach.

3- Ammonium hydroxide, NH_4OH: Is also called the ammonia, it is used as a heart and respiratory stimulate.

4- Sodium hydroxide, NaOH: It is used for removing and dissolving fats and other lipids in the closed waste pipes.

Ionization constants of Acid and Base :

Strong acids are more completely ionized in solution than are weak acids. The degree of ionization of an acid is given by it is ionization constant, Ka.

The equilibrium constant for the ionization of an acid in water is defined as it is ionization constant. For acetic acid:

$$C_2H_3O_2H + H_2O \leftrightharpoons H_3O^+ + C_2H_3O_2^-$$

Acetic acid Acetate

The equilibrium constant (K) will be :

$$K = \frac{[H_3O^+][C_2H_3O_2^-]}{[H_2O][C_2H_3O_2\ H]}$$

Since the concentration of water is constant, therefore :

$$K[H_2O] = K_a = \frac{[H^+][C_2H_3O_2^-]}{[C_2H_3O_2\ H]}$$

Ionization constant can be express on a logarithmic scale.

These values are called PKa and they are defined as follows :

PKa = - log Ka

Strong acids have large values of Ka and small values of PKa. Weak acids have small values of Ka and large values of PKa .

It is important to distinguish between the hydrogen ion concentration in an aqueous solution of an acid and the total acid present, which includes both hydrogen ions and un-ionized molecules.

For bases, we have the same thing :

K_b and PK_b

PK_b = -log K_b

Salts

Salts are ionic compounds composed of cations, and anions held together by ionic bonds, they are solid at room temperature .

Salts are formed by the reaction of an acid and a base. Some salts are quite soluble in water. Others are classified as slightly soluble or insoluble.

Uses of Salts

Salts are necessary for the proper growth and metabolism of the body. Iron salts are necessary for the formation of hemoglobin, iodine salts for the proper functioning of the thyroid gland , calcium and phosphorus salts for the formation of bones and teeth, sodium and potassium salts help regulate the acid-base balance of the-body

Salts regulate the irritability of nerve and muscle cells. Salts regulate the beating on the heart, salts help maintain the proper osmotic pressure of the cells .
Many salts have specific uses. Barium sulfate, BaSO4, is used for x-ray work. Even though barium compounds are poisonous, barium sulfate is insoluble in body fluids and so has no effect on the body. Barium sulfate is opaque to x-rays and, when swallowed, it can be used to outline the gastrointestinal (GI) system for x-ray photographs .