ACID, BASE AND SALTS

by Uloma L.K

THE CONCEPT OF ACID

The term acid was first used in the seventeenth century; it comes from the Latin root ac-, meaning “sharp", as in acetum, vinegar. Acids have long been recognized as a distinctive class of compounds whose aqueous solutions exhibit the following properties:

1. A characteristic sour taste

2. Ability to change the color of litmus from blue to red

3. React with certain metals to produce gaseous H2

4. React with bases to form a salt and water

The first chemical definition of an acid turned out to be wrong. In 1787, Antoine Lavoisier, as part of his masterful classification of substances, identified the known acids as a separate group of the “complex substances" (compounds). Their special nature, he postulated, derived from the presence of some common element that embodies the “acidity" principle, which he named oxygen, derived from the Greek word for “acid former".

In 1811, Humphrey Davy showed that muriatic (hydrochloric) acid (which Lavoisier had regarded as an element) does not contain oxygen, but this merely convinced some that chlorine was not an element but an oxygen-containing compound. Although a dozen oxygen-free acids had been discovered by 1830, it was not until about 1840 that the hydrogen theory of acids became generally accepted. By this time, the misnomer oxygen was too well established a name to be changed (Lower Stephen, 1787).

PHYSICAL PROPERTIES OF ACIDS

Acids possess the following physical properties;

1. It has a sour taste.

2. It turns blue litmus to red.

3. Acids turn methyl-orange to red.

4. Acids are electrolytes when in aqueous medium.

5. Strong acids are very corrosive. It can cause skin burns and destruction of textiles and fabrics.

CHEMICAL PROPERTIES OF ACIDS

Acids react with bases to produce salt and water in the neutralization process.

Example $HNO_3 + NaOH$ $NaCl + H_2O$ (2.1)

Acids react with carbonates to produce salt, water, and carbon dioxides

Example $MgCO_3 + 2HCl$ $MgCl_2 + CO_2 + H_2O$ (2.2)

3. Acids react with bicarbonates to produce salt, water and carbon dioxide

Example $NaHCO_3 + HCl$ $NaCl + CO_2 + H_2O$ (2.3)

4. Acids have pH values lower than 7. The stronger an acid is, the lower its pH value.

ACIDS AND THE HYDROGEN ION

The key to understanding acids (as well as bases and salts) had to await Michael Faraday's mid-nineteenth century discovery that solutions of salts (known as electrolytes) conduct electricity. This implies the existence of charged particles that can migrate under the influence of an electric field. Faraday named these particles ions (“wanderers"). Later studies on electrolytic solutions suggested that the properties we associate with acids are due to the presence of an excess of hydrogen ions in the solution. An operational definition of an acid is the following:

An acid is a substance that yields an excess of hydrogen ions when dissolved in water (Arrhenius 1961)

There are three important points to understand about hydrogen in acids:

1. Although all Arrhenius acids contain hydrogen, not all hydrogen atoms in a substance are capable of dissociating; thus the CH_3 hydrogens of acetic acid are “non-acidic".

2. Those hydrogen that do dissociate can do so to different degrees. The strong acids such as HCl and HNO_3 are effectively 100% dissociated in solution. Most organic acids, such as acetic acid, are weak; only a small fraction of the acid is dissociated in most solutions. HF and HCN are examples of weak inorganic acids.

3. Acids that possess more than one dissociable hydrogen atom are known as polyprotic acids; H_2SO_4 and H_3PO_4 are well-known examples. Intermediate forms such as HPO_4^{2-} , being capable of both accepting and losing protons, are called ampholytes.

CLASSIFICATION OF ACIDS

Acids are classified into strong and weak acids based on their extent of ionization in water (Adam 1987).

STRONG ACIDS

A strong acid is an acid that ionizes almost completely in water. Examples of strong acids are: hydrochloric acid, HCl; nitric acid, HNO_3; sulphuric acid, H_2SO_4. Other strong acids are HBr, HI, HF, $HClO_3$ and $HClO_4$. Properties of strong acids include:

1. A strong acid is a good proton (H+) donor.

2. Strong acids are good electrolytes because the molecular form completely dissociates into ions.

3. Strong acids are completely dissociated containing a large concentration of ions in solution and are therefore good conductors.

4. Strong acids have a lower pH (pH=1) compared than a weak acid (pH=3) of the same concentration because they produce more hydrogen ions in solution.

2.1.4.2 WEAK ACIDS

Weak acids are those that only slightly/partially ionizes in water. Examples include: ethanoic acid, CH_3COOH; carbonic acid, H_2CO_3 ; citric acid ; NH_4^- ion ; aqueous carbon dioxide, CO_2. Properties of strong acids include:

1. Weak acids are poor proton (H+) donors.

2. Dissociation in a weak acid is not complete or partial. The position of equilibrium favors the reverse reaction or the reactants.

3. They are weak or poor electrolytes because they produce fewer ions in solution than strong acids. A substantial amount of the molecular form remains.

4. Because weak acids are not completely dissociated into ions they are poor conductors of electricity because they contain a low concentration of ions in solution.

5. Have a higher pH (pH=3) compared than a strong acid (pH=1) of the same concentration because as the hydrogen ion concentration decreases the pH increases.

WEAK ACID

Nitric acid (HNO3) also known as aqua fortis (strong water) and spirit of nitre, is a highly corrosive and toxic strong acid, is colorless when pure but is yellowish when it is contaminated. Nitric acid is mostly used as strong oxidizing agent. It is highly corrosive and toxic. Strong acid causes severe burn when in direct contact with the skin so it is important to handle it with great care especially protecting the eyes. It is present in nature in the form of nitrate salts.

Pure nitric acid is an inorganic compound used primarily to make synthetic commercial fertilizer. Other uses include the production of explosives, the etching and dissolution of metals and in organic oxidation in adipic acid manufacture. Nitric acid can react explosively with compounds such as cyanides, carbides and metallic powders. In addition, nitric acid also reacts with most metals and is used in the extraction and purification of gold (Renner et al., 1995). It is used to determine the difference between heroin and morphine in a colorimetric test. Aqueous blends of nitric acid and phosphoric acid are commonly used for cleaning food and dairy equipment in order to remove precipitated calcium and magnesium compounds.

In fertilizer production, about 80% of the nitric acid produced is consumed as an intermediate in the manufacture of ammonium nitrate (NH4NO3) which in turn is used in fertilizers. The majority of nitric acid plants in the USA are located in agricultural regions such as the Midwest, South Central and Gulf States because of the high demand for fertilizer in these areas (Peer et al., 1995). Another 5 to 10% is used in the manufacture of adipic acid (C6H10O4) a white crystalline solid that is used primarily as the main constituent of nylon, representing about half of the nylon molecule. Adipic acid is also used in the manufacture of some low temperature synthetic lubricants, synthetic fibers, coatings, plastics, polyurethane resins, and plasticizers, and to give some imitation food products a tangy flavor.