Acid, Bases, and Salts of Medical Interests

Acid-Base Reaction Theories

Acids and bases are everywhere. Some foods contain acid, like the citric acid in lemons and the lactic acid in dairy. Cleaning products like bleach and ammonia are bases. Chemicals that are acidic or basic are an important part of chemistry.

Several different theories explain what composes an **acid** and a **base**. The first scientific definition of an acid was proposed by the French chemist Antoine Lavoisier in the eighteenth century , proposed that acids contained oxygen, although he did not know the dual composition of acids such as hydrochloric acid (HCl). Over the years, much more accurate definitions of acids and bases have been created

Arrhenius Theory

The Swedish chemist Svante Arrhenius published his theory of acids and bases in 1887. It can be simply explained by these two points:

Arrhenius Acids and Bases

1. An acid is a substance which dissociates in water to produce one or more hydrogen ions (H^+).
2. A base is a substance which dissociates in water to produce one or more hydroxide ions (OH^-).
3. Based on this definition, Arrhenius acids must be soluble in water. Arrhenius acid-base reactions can be summarized with three generic equations:

HA ------------> H^+ + A^-	An acid will dissociate in water producing hydrogen ions.
M OH ------------> M^+ + OH^-	A base (usually containing a metal) will dissociate in water to produce hydroxide ions.
HA(aq) + **M OH**(aq) **------>$H_2O_{(l)}$ +MA**(aq)	Acids and bases will neutralize each other when mixed. They produce water and an ionic salt, neither of which are acidic or basic.

The Arrhenius theory is simple and useful. It explains many properties and reactions of acids and bases. For instance, mixing hydrochloric acid (HCl) with sodium hydroxide (NaOH) results in a neutral solution containing table salt (NaCl).

However, the Arrhenius theory is not without flaws. There are many well known bases, such as ammonia (NH_3) that do not contain the hydroxide ion. Furthermore, acid-base reactions are observed in solutions that do not contain water. To resolve these problems, there is a more advanced acid-base theory.

Brønsted-Lowry Theory

The Brønsted-Lowry theory was proposed in 1923. It is more general than the Arrhenius theory—all Arrhenius acids/bases are also Brønsted-Lowry acids/bases .

Brønsted-Lowry Acids and Bases

1. An acid is a substance from which a proton (H^+ ion) can be removed. Essentially, an acid *donates* protons to bases.
2. A base is a substance to which a proton (H^+) can be added. Essentially, a base *accepts* protons from acids.

3. Acids that can donate only one proton are **monoprotic**, and acids that can donate more than one proton are **polyprotic**.
4. These reactions demonstrate the behavior of Brønsted-Lowry acids and bases:

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$	An acid (in this case, hydrochloric acid) will donate a proton to a base (in this case, water is the base). The acid loses its proton and the base gains it.
$HCl + NH_3 \rightarrow NH_4^+ + Cl^-$	Water is not necessary. In this case, hydrochloric acid is still the acid, but ammonia acts as the base.
$NH_4^+ + Cl^- \rightarrow HCl + NH_3$	The same reaction is happening, but now in reverse. What was once an acid is now a base ($HCl \rightarrow Cl^-$) and what was once a base is now an acid ($NH_3 \rightarrow NH_4^+$). This concept is called ***conjugates*.**
$HCl + NaOH \rightarrow NaCl + H_2O$ $H_3O^+ + OH^- \rightarrow 2H_2O$	Two examples of acids (HCl and H_3O^+) mixing with bases (NaOH and OH^-) to form neutral substances (NaCl and H_2O).
$NaOH + NH_3 \rightarrow H_2O + NH_2^- + Na^+$	A base (sodium hydroxide) will accept a proton from an acid (ammonia). A neutral substance is produced (water), which is not necessarily a part of every reaction. Compare this reaction to the second one. Ammonia was a base, and now it is an acid. This concept, called ***amphoterism***, is explained later.

Strong and Weak Acids/Bases

A **strong acid** is an acid which dissociates completely in water. That is, ***all*** the acid molecules break up into ions and solvate (attach) to water molecules. Therefore, the concentration of hydronium ions in a strong acid solution is equal to the concentration of the acid.

The majority of acids exist as **weak acids**, an acid which dissociates only partially. On average, only about 1% of a weak acid solution dissociates in water in a 0.1 mol/L solution. Therefore, the concentration of hydronium ions in a weak acid solution is always less than the concentration of the dissolved acid.

Strong bases and **weak bases** do not require additional explanation; the concept is the same.

*The conjugate of a strong acid/base is very weak. The conjugate of a weak acid/base is not necessarily strong.

This explains why, in all of the above example reactions, the reverse chemical reaction does not occur. The stronger acid/base will prevail, and the weaker one will not contribute to the overall acidity/basicity. For example, hydrochloric acid is strong, and upon dissociation chloride ions are formed. Chloride ions are a weak base, but the solution is not basic because the acidity of HCl is over stronger than basicity of Cl^-. Most acids and bases are weak.

Formula	**Strong Acid**
$HClO_4$	Perchloric acid
HNO_3	Nitric acid
H_2SO_4	Sulfuric acid
HCl, HBr, HI	Hydrohalic acids

Although the other halogens make strong acids, **hydrofluoric acid** (HF) is a weak acid. Despite being weak, it is incredibly corrosive—hydrofluoric acid dissolves glass and metal .

Within a series of ***oxyacids***, the ions with the greatest number of oxygen molecules are the strongest. For example, nitric acid (HNO_3) is strong, but nitrous acid (HNO_2) is weak. Perchloric acid ($HClO_4$) is stronger than chloric acid ($HClO_3$), which is stronger than the weak chlorous acid ($HClO_2$). Hypochlorous acid ($HClO$) is the weakest of the four.

Common strong bases are the hydroxides of Group 1 and most Group 2 metals. For example, potassium hydroxide and calcium hydroxide are some of the strongest bases. Can be assume that any other bases (including ammonia and ammonium hydroxide) are weak.

Formula	**Strong Base**
LiOH	Lithium hydroxide
NaOH	Sodium hydroxide
KOH	Potassium hydroxide
RbOH	Rubidium hydroxide
CsOH	Cesium hydroxide
$Ca(OH)_2$	Calcium hydroxide
$Sr(OH)_2$	Strontium hydroxide
$Ba(OH)_2$	Barium hydroxide

Acids and bases that are strong are not necessarily concentrated, and weak acids/bases are not necessarily dilute. Concentration has nothing to do with the ability of a substance to dissociate. Furthermore, ***polyprotic* acids** are not necessarily stronger than ***monoprotic* acids**.

Ionization Constants of Acids and Bases

Strong acids are more completely ionized in solution than are weak acids .The degree of ionization of any acid is given by its **ionization constant, Ka** .Ionization constant can be expressed on a logarithmic scale .These values are called **pKa** , and they defined as follows:

pKa = - log Ka

For bases ,the same thing : **K_b and pK_b , pK_b = -log K_b**

Properties of Acids and Bases

Acids and bases have very different properties, allowing them to be distinguished by observation.

Indicators

Bromothymol blue is an indicator that turns blue in a base, or yellow in acid. Made with special chemical compounds that react slightly with an acid or base, **indicators** will change color in the presence of an acid or base. A common indicator is **litmus paper**. Litmus paper turns red in acidic conditions and blue in basic conditions. **Phenolphthalein purple** is colorless in acidic and neutral solutions, but it turns purple once the solution becomes basic. It is useful when attempting to neutralize an acidic solution; once the indicator turns purple, enough base has been added.

Physical properties

The following is for informative purposes only. **Do not sniff, touch, or taste any acids or bases** as they may result in injury or death.

The physical properties of acids and bases are opposites.

Acids	Bases

Taste	sour	bitter
Feel	stinging	slippery
Odor	sharp	odorless

These properties are very general; they may not be true for every single acid or base. Another warning: if an acid or base is spilled, it must be cleaned up immediately and properly (according to the procedures of the lab you are working in). If, for example, sodium hydroxide is spilled, the water will begin to evaporate. Sodium hydroxide does not evaporate, so the concentration of the base steadily increases until it becomes damaging to its surrounding surfaces.

Chemical Reactions

Neutralization

Acids will react with bases to form a **salt** and **water**. This is a **neutralization** reaction. The products of a neutralization reaction are much less acidic or basic than the reactants were. For example, sodium hydroxide (a base) is added to hydrochloric acid.

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

hydrochloric acid + sodium hydroxide → sodium chloride + water

This is **a double replacement** reaction.

Acids

$2HCl_{(aq)} + Zn_{(s)} \rightarrow ZnCl_{2(aq)} + H_{2(g)}$	Acids react with metal to produce a metal salt and hydrogen gas bubbles.
$H_2SO_{4(l)} + CaCO_{3(s)} \rightarrow CaSO_{3(s)} + H_2O_{(l)} + CO_{2(g)}$	Acids react with metal carbonates to produce water, CO_2 gas bubbles, and a salt.
$2HNO_{3(aq)} + Na_2O \rightarrow 2NaNO_{3(aq)} + H_2O$	Acids react with metal oxides to produce water and a salt.

Uses of Acids

Acids can be found everywhere in the world around us. **Lactic acid** occurs in sour milk, **citric acid** in citrus fruits, **oxalic acid** in rhubarb, **malic acid** in apples, and tartaric acid in wine. Acids uses in an industry purposes ; laboratory works in large amts; and in medical purposes. **HCl** (Hydrochloric Acid - commercially known as muriatic acid, used in industry and lab works in large amts);

HCl : found in gastric juices for proper digestion of proteins in the stomach .

HNO3 (Nitric Acid): Protein coagulator used to test for the presence of albumin in urine; it has been used to remove warts but now dichloracetic acid, trichloracetic acids are more commonly used for that.

HCL_{10} (hypochlorous acid) : Used for desinfectant for floors and walls in hospitals

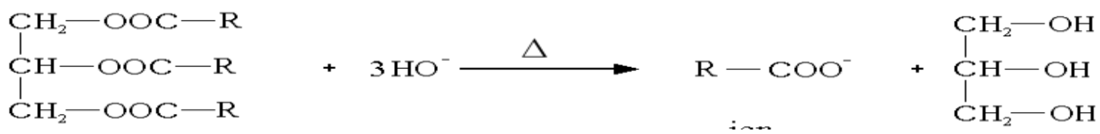
H_3BO_3 (boric acid) : Used for germicide , no longer used for eyewashes (should be labeled poisonous for it's been practically obsolete.

Acetylsalicylic Acid (ASPIRIN): Analgesic + antipyretic

Ascorbic Acid (Vitamin C) : Prevention + Treatment of scurvy.

Bases

Bases are typically less reactive and violent than acids. They do still undergo many chemical reactions, especially with organic compounds. A common reactions is ***saponificiation*****:** the reaction of a base with fat or oil to create soap.



Saponification converts an "ester" into an "alcohol" and salt.

Uses of bases

Calicium hydroxide solution ;Ca(OH)2: Commonly known **as** lime water ,is used to overcome excess acidity in the stomach .It is also used to medically as an antidote for oxalic acid poisoning because it reacts with the oxalic acid to form an insoluble compound ,calcium oxalate .

Magnesium hydroxide;Mg(OH)2: Is commonly known as milk of magnesia .In dilute solutions it is used as antacid for the stomach.In the form of a suspension of magnesium hydroxide in wter ,it used as a laxative .

Ammonium hydroxide ; NH4OH : Is also called spirit of ammonia ,it is used as a heart and respiratory stimulant .

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

Salts

Salts are ionic compounds composed of cations and anions held together by ionc 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 ;as follow :

Iron salts : Are necessary for the formation of hemoglobin .

I**odine salts** : Are necessary for the proper functioning of the thyroid gland .

Calcium and phosphorus salts : Are necessary for the formation of bones and teeth .

Sodium and potassium salts :regulate the acid – base balance of the body .

Salts regulate the irritability of nerve and muscle cells ,regulate the beating of the heart , 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.