Chapter 10

ACIDS, BASES, AND SALTS

Conceptual Linkage

Before reading this chapter, the student must know the:

- Types of matter.
- Difference between elements and compounds.
- Molecular formulae and chemical equations.

Time Allocation

Teaching periods	=16
Assessment periods	=03
Weightage	=07%

LEARNING OUTCOMES

Students will be able to:

- Define and give examples of Arrhenius acid and bases. (Understanding)
- Use of Bronsted-Lowry theory to classify substances as acids or bases, or as proton donors or proton acceptors. (Applying)
- Classify substances as Lewis acids or bases. (Analyzing)
- Write the equation for the self-ionization of water. (Remembering)
- Given the hydrogen ion or hydroxide ion concentration, classify a solution as neutral, acidic, or basic. (Applying)
- Complete and balance a neutralization reaction. (Applying)

Introduction

Acids, bases and salts are the three main categories of chemical compounds. They show very interesting characters. Acids, bases and salts are very common chemical compounds that we use frequently in many ways in our daily life. Most of the citrus as well as the fruit that is not ripen fully contain acids and their sour taste gives a peculiar taste to each fruit.

Not only the acids but bases also constitute some important fraction of our daily life usage. The soft drinks contain base sodium bicarbonate ($NaHCO_3$) which is used to reduce the acidity level of stomach. The salts which constitute another very important class of chemical compounds are formed when an acid reacts with some base. For example, the typical table salt NaCl results by the reaction of NaOH and HCl.

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

Other salts are also formed by such similar chemical reactions.

Other common examples include Epsom salts($MgSO_4$), used as purgative in medicines, ammonium nitrate (NH_4NO_3) used as fertilizer, sodium carbonate ($Na_2CO_3.10H_2O$) which is used in washing cloths and baking soda ($NaHCO_3$) used in cooking. Moreover KNO_3 which is seen as white precipitates on salty (callar) soils is also a salt. Remember that these are just few examples of common salts and there found thousands other salts and are used in many ways.

In this chapter we will study these three important and common classes of chemical compounds in detail.

10.1 Concepts of Acids and Bases

The acids and bases are although common chemical compounds, and unlike our general concept that they are very corrosive and dangerous when touched (especially the acids which are considered very corrosive) they are commonly used in our daily life as well as in our daily diet.

Many scientists tried to explain these compounds in different ways, which will be discussed in following section in detail.

The Acids

The word "acid" comes from the Latin "acidus" meaning "sour" and they have got this name due to their sour taste. The acids in general have the following characteristics.

- **Acids taste sour**

You taste many acids in your daily life, e.g. acetic acid is the acid ingredient

Interesting Information

The sour taste of citrus fruits is due to natural acids such as citric acid and ascorbic acid.

in vinegar. Citrus fruit such as lemons, grapefruit, orange, and limes have citric acid in their juices. Sour milk, sour cream, yogurt, and cottage cheese have lactic acid which is formed by the fermentation of the lactose sugar present in the milk.

- **Acids turn blue litmus red**

Litmus is one of a large number of organic compounds that change colour when a solution changes acidity. Litmus is the oldest known pH indicator. It is red in acid and blue in base. Litmus is often impregnated onto paper to make 'litmus paper.'

- **Acids corrode active metals**

Even gold, the least active metal, is attacked by an acid. A mixture of acids called 'aqua regia,' or 'royal liquid.' You may have seen the effect of corroded metal by leakage of build from battery of car. When an acid reacts with a metal, it produces a compound with the cation of the metal and the anion of the acid and hydrogen gas.

When acids are mixed in water they can pass electricity easily. This is because acids ionize water and due to presence of ions the electricity can pass easily.

Contrarily, the bases have the following important characteristics

- **Bases taste bitter**

Although the bases are bitter in taste but when we eat or drink, we use their dilute solutions mixed with flavouring agents that is why we do not feel their bitter taste.

- **Bases turn red litmus blue**

Contrary to acids, when litmus paper or solution is treated with a base it turns into blue colour from red.

- **They have slippery touch**

You can feel the slippery touch of bases when their dilute solutions are handled. (but remember the strong concentrated solutions of these are corrosive and must not be touched directly.) soap has slippery touch due to presence of base.

Considering these characters of acids and bases different scientists explained the acids in different ways, the important of these concepts are explained in following.

10.1.1 Concepts of Acids and Bases

Although the general properties for the acids and bases are described in the previous pages, but these do not define the terms acids and the bases in a satisfactory manner. To describe the nature of the acids and bases, different scientists proposed theories of acids and bases on different occasions. The three important theories are as follows.

The Arhenius concept of Acids and Bases

In 1884, a Swedish chemist Svante Arrhenius described that acid is a hydrogen containing compound which can gives hydrogen ion (H^+) in aqueous solution. For example, Hydrochloric acid (HCl) gives H^+ ion in its aqueous solution.

Arrhenius 1859-1927 (Swedish)

$$HCl_{(aq)} \xrightleftharpoons{H_2O} H^+_{(aq)} + Cl^-_{(aq)}$$

As water accepts H^+ ion, it forms H_3O^+, so this reaction can also be written in the following manner.

$$HCl_{(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$$

Similarly, the H_2SO_4 is an acid, because it also furnishes H^+ ion to water, as described in following reaction.

$$H_2SO_{4(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + HSO^-_{4\,(aq)}$$

And HNO_3 is also an acid because it gives hydrogen ions H^+ when dissolved in water.

$$HNO_{3(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + NO^-_{3(aq)}$$

Arrhenius defined, bases are the substances that produce OH^- ions when dissolved in water. e.g. NaOH is a base because it produces OH^- ions when it is dissolved in water.

$$NaOH_{(s)} \xrightleftharpoons{H_2O} Na^+_{(aq)} + OH^-_{(aq)}$$

The Arrhenius concept of acids and bases explains both these two common classes relatively in simple form. The theory explains many common acidic and basic compounds and also explain how acid and base react with each other yielding a neutral product called salt.

$$\underset{\text{Acid}}{HCl_{(aq)}} + \underset{\text{Base}}{NaOH_{(s)}} \longrightarrow \underset{\text{Salt}}{NaCl_{(aq)}} + H_2O_{(l)}$$

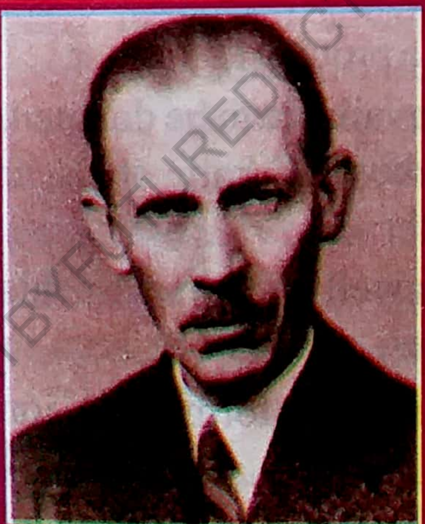
Although the Arrhenius theory helped to explain acids and bases in a simple way, there were still several drawbacks in this theory, like:

i) The theory can only classify these substances when dissolved in water.

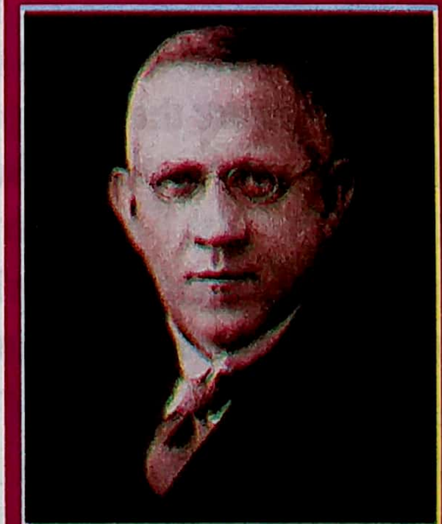
ii) Arrhenius theory fails to explain acids such as $AlCl_3$ and BF_3 which have no 'H' atom.

iii) The theory can only classify substances as bases if they contain the OH^- ion and cannot explain the bases having no OH^- ions such as Na_2CO_3.

10.1.2 The Bronsted-Lowry concept of Acids and Bases



Bronsted 1879-1947
(Denmark)



Lowry 1874-1936
(England)

The Arrhenius theory applies only when water is used as the solvent. It restricts the term acid to substances yielding hydronium ions and the term base to those yielding hydroxide ions. In 1923 J.N. Bronsted and T.M. Lowry independently proposed a much broader and more useful concept of acids and bases. According to their model, *acid is any substance capable of donating a hydrogen ion or proton (H^+) to another substance* e.g. HCl is an acid because it gives proton, e.g.

$$\underset{\text{Acid}}{HCl_{(aq)}} + \underset{\text{Base}}{H_2O_{(l)}} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$$

Similarly:

$$\underset{\text{Acid}}{H_2SO_{4(aq)}} + \underset{\text{Base}}{H_2O_{(l)}} \rightleftharpoons H_3O^+_{(aq)} + HSO^-_{4(aq)}$$

In the Brønsted-Lowry concept we usually refer to a hydrogen ion as a **proton**. That is because a proton is left when a **hydrogen atom** loses an electron to become an **ion**. According to this concept a base is any substance capable of accepting a proton or hydrogen ion (H^+) from another substance.

e.g.

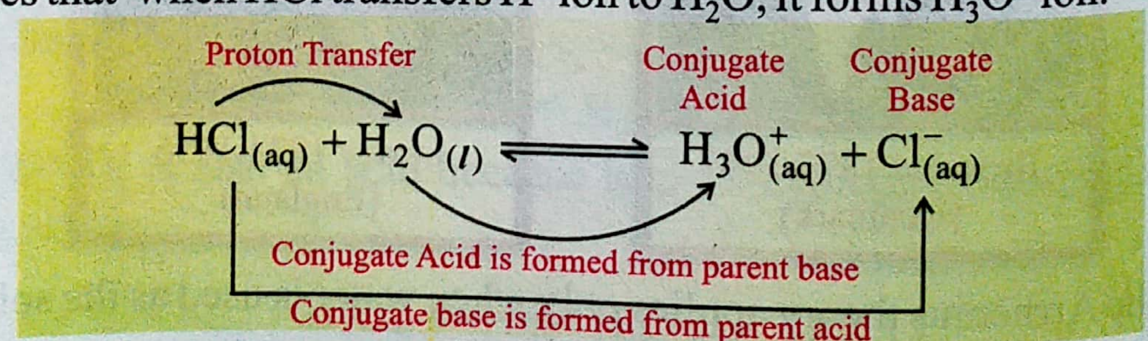
$$\underset{\text{Acid}}{HCl_{(aq)}} + \underset{\text{Base}}{H_2O_{(l)}} \rightleftharpoons H_3O^+_{(aq)} + Cl^-_{(aq)}$$

Here water (H_2O) is a base as it accept H^+ ions.

In other words, acids are proton (H^+) donors, and bases are proton (H^+) acceptors. According to this concept, any reaction involving the transfer of a proton or H^+ from one substance to another is an acid-base reaction where a base is a proton (H^+) acceptor and an acid is a proton (H^+) donor.

There may be more than one proton available to be donated, such acids that can donate more protons are said to be polyprotic acids, for example H_2SO_4, H_3PO_4.

Another interesting feature which is well explained by this concept is the formation of conjugate acids and bases, as it can be seen in the above examples that when HCl transfers H^+ ion to H_2O, it forms H_3O^+ ion.



This H_3O^+ ion has a great tendency of donating H^+ ion and is thus a very strong acid, such formed acid is called conjugate acid.

Proton is being transfered from acid to base

Conjugate Acid   Conjugate Base

$$H_2SO_{4(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + HSO^-_{4(aq)}$$

Conjugate acid is being formed from parent base

Conjugate base is being formed from parent acid

The HSO_4^- and Cl^- ions are the conjugate bases in above cases which have strong ability to accept H^+.

Activity 10.1

Identify the species in the given reactions as acids, bases, conjugate acids and conjugate bases reactions.

$$NH_{3(g)} + H_2O_{(l)} \rightleftharpoons NH^+_{4(aq)} + OH^-_{(aq)}$$

$$HNO_{3(aq)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + NO^-_{3(aq)}$$

$$CH_3COOH_{(aq)} + H_2O_{(l)} \rightleftharpoons CH_3COO^-_{(aq)} + H_3O^+_{(aq)}$$

Another important advantage of this theory is the explanation of relative strength of acids and bases, for example it is common observation that HCl is very strong acid which citric acid which is found in lemon is relatively weaker and can be used easily in food. According to this theory the acid that have the strong tendency of donating proton (H^+) are more stronger acids than those who have less tendency, similarly the bases which have strong tendency of accepting proton (H^+) are more basic in nature than those who have less tendency.

The Bronsted-Lowry theory does not explain the nature of acidic character of non-metal oxides like SO_2, NO_2 etc. and the compounds like Aluminum chloride ($AlCl_3$), and Boron trifluoride (BF_3). In the similar way this theory is also unable to explain the basic character of metallic oxides like CaO, MgO etc.

10.1.3 The Lewis concept

Gilbert Newton Lewis
(1875 –1946)

In 1923, G. N. Lewis introduced a theory of acids and bases that is more efficient than the previous theories.

Lewis noted that the Brønsted theory was limited because it focused exclusively on the transfer of a proton (H^+). He argued that a more general definition of acid-base reactions could be obtained by looking at what happens when an H^+ ion combines with an OH^- ion to form water.

$$H^+ + :\underset{\cdot\cdot}{\ddot{O}}—H^- \longrightarrow H—\underset{\cdot\cdot}{\ddot{O}}—H$$

Lewis argued that the H^+ ion picks up (or accepts) a pair of electrons from the OH^- ion to form a new covalent bond. As a result, any substance that can act as an electron-pair acceptor is a **Lewis acid.** Therefore, Lewis acid an electron-pair acceptor, such as the H^+ ion.

The pair of electrons that went into the new covalent bond were donated by the OH^- ion. Lewis therefore argued that any substance that can act as an electron-pair donor is a **Lewis base**. Therefore, Lewis base is an electron-pair donor, such as the OH^- ion.

The Lewis acid-base theory doesn't affect the category of compounds we have called "bases" because any Bronsted base must have a pair of nonbonding electrons in order to accept a proton. This theory, however, vastly expanded the family of compounds that can be called "acids." Anything that has one or more empty valence-shell orbitals can now act as Lewis acid.

This theory explains why BF_3 reacts instantaneously with NH_3. The nonbonding electrons on the nitrogen in ammonia are donated into an empty orbital on the boron to form a new type of covalent bond called co-ordinate covalent bond, as shown in the equation in figure-10.1.

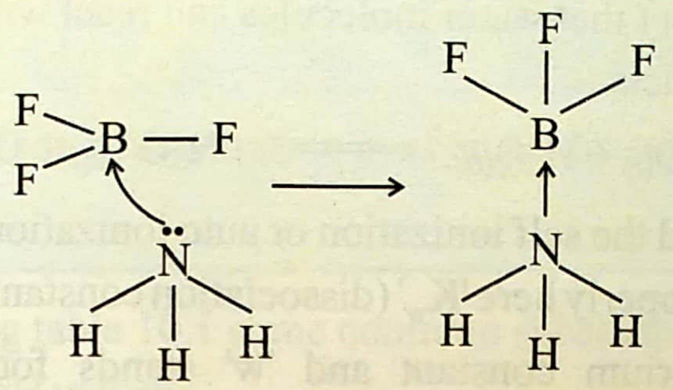


Figure-10.1: Reaction involving electron pair transfer between BF_3 and NH_3

The vacant orbital of BF_3 are shown in figure-10.2, where transfer of lone electron pair of NH_3 takes place is also elaborated.

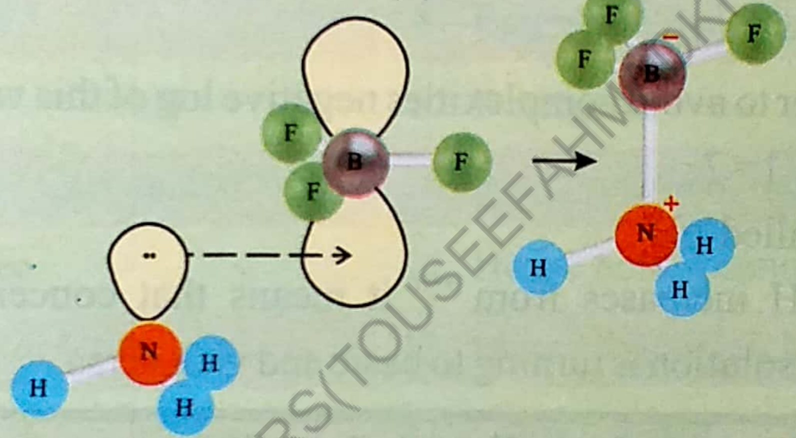


Figure-10.2: Transfer of lone pair of electrons from 'N' to vacant orbitals of Boron

The Lewis concept of acids and bases has a marked edge over previous theories as it explains not only the hydrogen containing acids but covers also other species that lack this hydrogen ion (H^+). This also explains bases as well in comprehensive manner.

10.2 The pH scale (Hydrogen ion concentration)

So far we have discussed the acidic and basic properties of chemical compounds, now we will discuss the relative strengths of acids / bases.

In order to understand and compare the relative strength of different acids and bases, scientists have developed a scale which easily describe the required information in figures 10.3, this makes it very easy to understand and compare the relative strength of different acids or bases. This scale has been created from the fact that water molecules can react with each other to form the following products.

$$H_2O_{(l)} + H_2O_{(l)} \rightleftharpoons H_3O^+_{(aq)} + OH^-_{(aq)}$$

This is called the self ionization or auto ionization of water molecules. The 'K_c' or more properly here 'K_w' (dissociation constant for water), where 'K' represents equilibrium constant and 'w' stands for water. The K_w is calculated experimentally.

$K_w = 1 \times 10^{-14}$

Where $[H^+][OH^-] = 1 \times 10^{-14}$

And $[H^+] = 1 \times 10^{-7}$

And $[OH^-] = 1 \times 10^{-7}$

In order to avoid complexities negative log of this value is taken.

i.e. $-\log[H^+] = 7$

This is called 'pH'.

If the pH increases from '7' it means that concentration of H^+ is decreasing and solution is turning to basic and vice versa.

Example-10.1: Calculating pH from molarity

Calculate pH of a solution where concentration of hydrogen ions is 0.0001 moles/lit.

Solution:

As $pH = -\log[H^+]$ put the value from question

$pH = -\log 1 \times 10^{-4}$ where $\log m \times n = \log$ of $m + \log$ of n

$pH = -(\log 1 + \log 10^{-4})$ where $\log 1 = 0$

$pH = -(0 + \log 10^{-4})$ but $\log m^n = n \log^m$

$pH = -(-4 \times \log 10)$

$pH = +4 \log 10$ where $\log 10 = 1$

So,

$pH = 4 \times 1$

$pH = 4$

This '4' is the pH of the given solution.

Activity 10.2

Calculate hydrogen ion concentration in of an acidic solution whose pH is '3'.

In the following table 10.1 some common substances of our daily life are written with their pH values.

pH	Substance	pH	Substance
1	Hydrochloric Acid / Battery Acid	7.4	Blood
2	Gastric Fluid	8	Egg white, baking soda
3	Lemon Juice, Vinegar	9	Detergents
4	Soda Water / Carbonated Water	10	Soapy solutions, milk of magnesia
5	Black Coffee	11	House hold Ammonia
6	Tomato Juice, Urine	12	House hold Bleach
6.7	Milk	13	Drain Cleaner
7	Pure Water	14	Caustic Soda

Table 10.1: Some household species with their pH values

10.2.1 Indicators

Scientists use different chemicals to identify the different ranges of pH, e.g. the Phenolphthalein shows pink or purple colour in basic media and is colourless in acidic media, similarly the litmus shows blue colour in base and red colour in acids, methyl orange shows yellow colour in basic media and red colour in acidic media.

The universal indicator (which is obtained by mixing various indicators provides a good tool for identification of pH, the figure-10.3 shows various colours in different pH ranges by the universal indicator.

The pH scale is very helpful in understanding and calculating the relative strength of acids and bases, e.g. in the table 10.1 acid/basic character of some of the commonly used substances of our life. You can see that how easy it is to compare the relative acidic and basic strengths of each substance in a comprehensive manner.

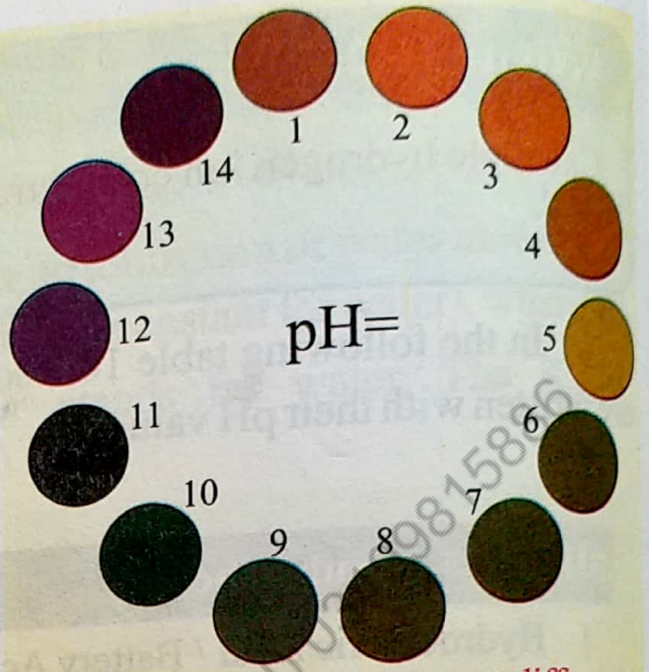


Fig. 10.3: Colour changes at different pH of Universal indicator solution

Interesting Information

Many fruits and vegetables contain pigments that change colour in response to pH, making them natural and edible pH indicators. Most of these pigments are anthocyanins (found in beet root and red cabbage), which commonly range in colour from red to purple to blue in plants, depending on their pH. Plants containing anthocyanins include acai, currant, chokeberry, eggplant, orange, blackberry, raspberry, blueberry, cherry, grapes and coloured corn. Any of these fruits can be used as pH indicators.

Activity 10.3

One of the natural indicator Flavin which belongs to Anthocyanin family is found in red cabbage, which is a water soluble compound. In order to extract this, boil some well pieced leaves of red cabbage and then take the water solution, this is the required indicator solution from red cabbage. Try this indicator solution with the items specified in the table and record your results.

10.3 The Salts

Salts are the neutralization products when an acid reacts with a base.

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

Here the NaCl is a salt which is used in our food frequently. You can see that in this reaction a water molecule is also produced.

Fig. 10.4: Crystal lattice of table salt (NaCl)

Similarly sulphuric acid when reacts with potassium hydroxide which is a base it also gives a salt.

$$H_2SO_{4(aq)} + 2KOH_{(aq)} \rightarrow K_2SO_{4(aq)} + 2H_2O_{(l)}$$

There are thousands of other salts and the majority of inorganic compounds are included in this class of chemical compounds. They are used in a variety of ways and not only they are used in food but even they could have deadly effects for livings.

The salts are the ionic compounds, and have high melting and boiling points. e.g the common table salt, the NaCl has the melting point 801 °C.

The salts have the following important characters.

In the given table 10.2 some common salts are listed alongwith their usage in daily life.

Some common salts

Name	Formula	Usage
Sodium Chloride	$NaCl$	Used in food
Potassium Sulphate	K_2SO_4	Found in salinity effected areas, also used in making explosives
Ammonium Chloride	NH_4Cl	Used in cough medicines
Ammonium Phosphate	$(NH_4)_3PO_4$	Used as fertilizer
Sodium Nitrate	$NaNO_3$	Used as flavoring agent and as fertilizer
Silver Nitrate	$AgNO_3$	Used in photography

Name	Formula	Usage
Silver Bromide	$AgBr$	Used in photography
Copper Sulphate	$CuSO_4$	A poisonous salt, used in medicines in very little quantity
Washing Soda	$Na_2CO_3.10H_2O$	Used in laundry
Baking Soda	$NaHCO_3$	Used in bakery, cooking

Table 10.2: Names and uses of some common salts

Colour

Mostly salts appear to be clear and transparent (sodium chloride), opaque, and even metallic and lustrous (iron disulfide). While poly-crystalline aggregates look like white powders. Many salts exist in different colours, e.g. yellow (sodium chromate), orange (potassium dichromate), red (mercury sulfide), mauve (cobalt chloride hexahydrate), blue (copper sulfate pentahydrate, ferric hexacyanoferrate), colourless (magnesium sulfate), white, and most minerals and inorganic pigments as well as many synthetic organic dyes are salts.

Taste

Different salts can bring all five basic tastes, e.g. salty (sodium chloride), sweet (lead diacetate Warning: lead diacetate is extremely toxic and therefore should not be ingested), sour (potassium bitartrate), bitter (magnesium sulfate), and umami or savory (monosodium glutamate).

Odour

Salts of strong acids and strong bases ("strong salts") are non-volatile and odourless, while salts of either weak acids or weak bases ("weak salts") may smell after the conjugate acid (e.g. acetates like acetic acid (vinegar) and cyanides like hydrogen cyanide (almonds) or the conjugate base (e.g. ammonium salts like ammonia) of the component ions.

Activity 10.3

Write down the balanced chemical reaction among following acids and bases.

$HCl_{(aq)}$ and $KOH_{(aq)}$

$CH_3COOH_{(aq)}$ and $NaOH_{(aq)}$

$HNO_{3(aq)}$ and $Ca(OH)_{2(aq)}$

10.3.1 Preparation of Salts

The salt found in nature in a variety of sources naturally, from where they can be isolated using proper chemical techniques, and if required they can also be prepared by a number of methods, largely dependent upon the type of the salt which is to be prepared.

From natural source mostly the salts are obtained through mining process e.g. calcium carbonate ($CaCO_3$) which is commonly known as lime and marble, table salt or Halite (NaCl), Gypsum ($CaSO_4.2H_2O$), Sodium Carbonate ($Na_2CO_3.10H_2O$), Sodium bicarbonate ($NaHCO_3$) etc. are obtained mostly by this mining process. In Pakistan the world's second largest mine of Halite is situated near Jhelum at Khewra.

Some salts are obtained by evaporating the sea water, e.g. the table salt (NaCl) is obtained by the evaporating the sea water, which leaves behind the salty deposits of sea water in large ponds. By this method a great quantity of table salt is obtained and the packed table salt pouches we use commonly comes through this source.

Moreover this table salt is also obtained by mining process.

Chemically, A number of methods are available for preparing the salts artificially, and these methods depend largely upon the type of salts.

There are two main categories of the salts according to their solubility, one of these is the water soluble and the other one is the water insoluble salts.

Various methods are available for the preparation of the water soluble salts, these include.

i) **By the action of an acid and a base:** Salt are prepared by famous acid-base neutralization reactions. e.g

$$HCl_{(aq)} + NaOH_{(aq)} \longrightarrow \underset{\text{Sodium Chloride Salt}}{\underline{NaCl_{(aq)}}} + H_2O_{(l)}$$

And

$$HNO_{3(aq)} + NaOH_{(aq)} \longrightarrow \underset{\text{Sodium Nitrate Salt}}{\underline{NaNO_{3(aq)}}} + H_2O_{(l)}$$

ii) **By the action of an acid upon a metal:** When a reactive metal (generally the metals of Groups 1 and 2) are reacted with an acid, a salt is produced, along with the evolution of hydrogen gas e.g.

$$H_2SO_{4(aq)} + 2Na_{(s)} \longrightarrow \underset{\text{Sodium Sulphate Salt}}{\underline{Na_2SO_{4(aq)}}} + H_{2(g)}$$

And

$$2HCl_{(aq)} + Ca_{(s)} \longrightarrow \underset{\text{Calcium Chloride Salt}}{\underline{CaCl_{2(aq)}}} + H_{2(g)}$$

iii) **By the action of an acid with a metallic oxide:** When a metal oxide is reacted with a dilute acid, the salts are produced, e.g.

$$2HCl_{(aq)} + CuO_{(aq)} \longrightarrow \underset{\text{Copper-II Chloride Salt}}{\underline{CuCl_{2(aq)}}} + H_2O_{(l)}$$

And

$$H_2SO_{4(aq)} + MgO_{(aq)} \longrightarrow \underset{\text{Magnesium Sulphate Salt}}{\underline{MgSO_{4(aq)}}} + H_2O_{(l)}$$

iv) **When a dilute acid is reacted with a metal carbonate, a salt is produced along** with the evolution of CO_2, e.g.

$$H_2SO_{4(aq)} + Na_2CO_{3(aq)} \longrightarrow \underset{\text{Sodium Sulphate Salt}}{\underline{Na_2SO_{4(aq)}}} + H_2O_{(l)} + CO_{2(g)}$$

The water insoluble salts are relatively more easy to be prepared by simple precipitation reactions (precipitate is a solid compound which is formed during the aqueous reaction of some species). This is because the separation of the prepared salt is quite easy by the use of simple filtration, moreover the raw materials used are normally not corrosive and thus are easy to handle.

The general methods employed for this purpose involve the mixing of solutions of two suitable water soluble salts proceeded by the filteration of the reaction mixture, some examples of such preparations are stated in the following equations.

$$CaCl_{2(aq)} + K_2SO_{4(aq)} \longrightarrow 2KCl_{(aq)} + CaSO_{4(s)}$$

$$MgSO_{4(aq)} + Na_2CO_{3(aq)} \longrightarrow Na_2SO_{4(aq)} + MgCO_{3(s)}$$

$$PbCl_{2(aq)} + CuSO_{4(aq)} \longrightarrow CuCl_{2(aq)} + PbSO_{4(s)}$$

It is to be noted that there are two types of the salts formed by such displacement reactions, one of the salt is soluble (or in aqueous form, denoted as "aq"), and the other is the insoluble, which is denoted as (s) in the above reaction equations, this insoluble solid salt is precipitated and can be separated through the simple filtration process, while the soluble salt can be separated by evaporating the solvent from filtrate.

Interesting Information

The salts are not only the inorganic compounds but many organic substances do also have salts, and many organic daily usage substances and drugs are converted into their salts because of the fact that the organic compounds are generally insoluble in water but their salts are soluble in water and thus are easy to use. Many fruit salts (used to treat acidity of stomach), Monosodium glutamate (Chinese salt), Tartarates, Oxalates include in this organic salt category.

10.3.2 Types of Salts

The salt comprise vast class of chemical compounds. Generally they are inorganic compounds, but even they may contain organic part too. They can be classified by several ways, e.g on the basis of their organic or inorganic nature. On the basis of their composition or properties, and the most famous and accepted classification is based on the basis of their solubility, according to which they are of two types,

(i) Soluble in water (ii) Insoluble in water

Activity 10.4

- On the basis of their solubility, list at least 10 salts into various classes.
- On the basis of their organic and inorganic nature, list at least 10 salts into two of described classes.

On the basis of their composition and properties they can be classified into several types, important of which are described here:

(i) Normal or neutral salts (ii) Acidic salts
(iii) Basic salts (iv) Double salts

i) Normal or neutral salt: A normal or neutral salt which is neutral in properties and they contain the ions that neutralize the effect of each other. Upon dissolving in water they do not produce H^+ or HO^- ions. The examples of such salts include NaCl, KCl, $NaNO_3$, K_2SO_4 etc

ii) Acidic salts: These salts when dissolved in water dissociate partially to produce either H^+ ions or tend to accept lone pair of electrons during chemical reactions. Examples of such salts are $KHSO_4$, $AlCl_3$, NH_4Cl etc

iii) Basic salts: This is the class of salts which show basic character due to the fact that during solvation they produce HO^- ions or tend to accept the H^+ ion, the examples of such salts include carbonates (e.g Na_2CO_3)$10H_2O$. bicarbonates (e.g. $NaHCO_3$) and sodium acetate (CH_3COONa).

iv) Double salts: These are the salts that contain the ions of more than two types, e.g Mohr's salt, $FeSO_4.(NH_4)_2SO_4.6H_2O$, potash alum, $K_2SO_4.Al_2(SO_4)_3.24H_2O$ etc. They are actually made up of two salts.

10.3.3 Uses of Salts

The salts are used in many field of life, e.g. they are important constitute of our daily food intake and not only provide taste to our food but are also essential for normal body processes, e.g the NaCl, monosodium glutamate, sodium citrate, sodium tartarate, sodium bicarbonate.

Many salts are used as colour pigments, some examples of such salts include Potassium dichromate ($K_2Cr_2O_7$) which is orange in colour, nickel chloride ($NiCl_2$) which is green in colour, cadmium sulphide (CdS) which is yellow in colour, tetraamine copper sulphate which is intense blue in colour. Lead chromate ($PbCrO_4$) which is yellow in colour.

Salts are also used in preserving the food items, e.g. Sodium metabisulphite $Na_2S_2O_5$, table salt (NaCl), sodium acetate (CH_3COONa), etc.

The salts are also used in many medicinal preparations, e.g $MgSO_4.7H_2O$ epsom salt in purgative preparations, sodium and potassium salts in blood pressure regulating, fluoride salts are used in tooth decay problems, calcium salts are good source of calcium which is necessary for animal bones growth,etc

Besides these different salts are used in other fields, e.g $CaSO_4.2H_2O$ gypsum Salt, KNO_3 nitre, ammonium phosphate, $(NH_4)_3PO_4$ are used in fertilizers, sodium silicate (Na_2SiO_3) is used in glass making, bleaching powder, Ca(OCl)Cl is used for bleaching purposes, Calcium sulphate as plaster of paris

Interesting Information

Although salts do a lot for us, but at the same time they also cause some problems for us too, e.g. oxalate salts produce kidney stone, the salt in sea water makes it unusable for drinking and cultivating lands. There are various methods available for desalinating sea water which contains about 35,000ppm of salt as compared to fresh water which has almost below 1000ppm of salts. The desalination commercially is brought about by reverse osmosis technique in which a semipermeable membrane is used to filter off the salts, nonotubes are also used for the same function. Besides these particulate material like fine sand has also been used for desalinating sea water.

Summary of the Chapter

- Acids and bases constitute two important classes of chemical compounds which are common in our daily life.
- Acids are sour in taste and they turn litmus red from blue.
- The bases are bitter in taste and they turn litmus blue from red.
- In order to explain the behaviour of acids and bases, many scientists proposed various theories, among these theories the Arhenius theory, the Bronsted-Lowry theory and the Lewis theory are important.
- Arrhenius defined Acids as the substance which donates H^+ ions when dissolved in water, and he defined bases as the substances which donates HO^- ions in water.
- Two scientists Bronsted and Lowry described the acids as the species which donate or tend to donate H^+ ions in water and the bases as the substances that accept or tend to accept H^+ ions when dissolved in water.
- According to Lewis concept the bases are the substances that donate electron pair during chemical reactions and the acids are the substances that accept electron pair in chemical reactions.
- Salts are the neutralized products of chemical reactions between acids and the bases.
- The salts are prepared by a number of methods, for example by reacting acids and bases together, by the action of acids on metals or metallic oxides or metallic carbonates.
- The salts are of different types; there classification is based upon different criteria, e.g. on the basis of their solubility in water, on the basis of their composition and properties etc.
- On the basis of solubility salts fall in two categories, i.e. water soluble and water insoluble salts.
- On the basis of their composition and properties they can be divided

into, normal, neutral, acidic, basic and double salts.

- A concept of pH is used to describe the relative strength acids and bases in much easier way.
- pH is defined as the $-\log[H^+]$, (negative log of hydrogen ion concentration).
- According to this system the substance having pH from 1-6.9 are acidic, from 7.1 to 14.0 pH the substances are basic in nature, and the substance that have pH 7.0 are neutral in this sense.
- As the pH increases from 1-6.9, the acidic character of the given substance decreases, i.e. the substance having low pH is more acidic than the substance having high pH, for example compound having pH = 2 is more acidic than the compound having pH = 3.
- The pH increase from 7.1 to 14.0 increases the strength of a base, i.e. a substance having pH = 8 is less basic than the substance having pH=10.

Exercise

Q1: Fill in the blanks.

i) Acids have.............. taste.

ii) Bases turn red litmus ....

iii) Stomach has .... acid which helps in digesting the food.

iv) Salts are produced by the reaction of .... with a base.

v) The basic character of ammonia is well explained by .... concept.

vi) Arhenius described acids as .... donor.

vii) According to Lewis concept the .... tend to donate electron pair.

viii) The aluminium chloride falls under the type of .... salts.

ix) The citrus fruits contain .... acid.

x) The $-\log$ of $[H^+]$ is called the..............

Q2: Tick the correct answer from the given list.

i) A solution having pH of 7.5 mean that it is

(a) Acidic (b) Basic

(c) Neutral (d) Amphoteric

ii) A liquid has a pH of 7, what does this tell about the liquid?

(a) It is acid solution (b) It is neutral

(c) It is basic solution (d) It is a solution of a NaOH

iii) Which of the statements below is correct?

(a) All bases dissolve in water

(b) All acids are soluble in water

(c) Sodium chloride is a basic salt

(d) Alkalis are bases.

iv) Name the salt that forms when HCl is reacted with $Ca(OH)_2$

(a) Calcium carbonate (b) Calcium hydrate

(c) Calcium chloride (d) Calcium oxide

v) Which pair of substances will react together to form $CuSO_4$.
   (a) Copper and Sulphuric acid.
   (b) Copper oxide and Sulphuric acid
   (c) Copper oxide and hydrochloric acid
   (d) Copper and Sodium sulphate.

vi) The colour of potassium dichromate salt is:
   (a) Yellow (b) Green
   (c) Orange (d) Blue

vii) For a system where $[H^+]=10^5$, the $[HO^-]$=?
   (a) 10^5 (b) 10^6
   (c) 10^9 (d) 10^{10}

viii) Phenolphthalein indicator shows purple colour in basic media, while its colour in acidic media is:
   (a) Red (b) Blue
   (c) Yellow (d) Colourless

ix) Salts are produced when a base reacts with
   (a) An Acid (b) Another base
   (c) Another salt (d) Oxides

x) $CaCO_3$ is a salt which is:
   (a) Soluble in water (b) Insoluble in water
   (c) Sparingly soluble in water (d) Soluble in benzene

Q3: Answer the following questions briefly.

i) Write down the general properties of acids.
ii) What are the general characters of bases?
iii) Describe the general composition of a salt.
iv) What is a precipitate?
v) What is meant by neutralization reaction?
vi) What are the polyprotic acids?
vii) How you will explain the basic character of NH_3?
viii) What is an indicator?

ix) Write some uses of NaCl.

x) Name some salts that are important to medicinal use?

Q4: Answer the following questions with reasoning.

i) The Stomach contents of animals have very high acidic pH (about 1-2), explain why it does not damages the walls of stomach?

ii) Why the acidic character of a solution increases with the decrease in pH?

iii) Name 5 acids that are found in our food?

iv) How salts affect our health?

v) How molarity is related with the pH of a solution?

Q5: Write a note on strength of acids and bases?

Q6: Name a household consumer product that contains.

a) A strong acid b) A weak acid

c) A strong base d) A weak base

Q7: Describe the theory of Arhenius to explain the acids and bases.

Q8: How Bronsted-Lowry theory helps us to understand the Acids and Bases?

Q9: Comment that the Lewis theory can be best in order to understand the nature of acids and bases.

Q10: What do you understand by the chemical term "Indicator"? Name some of the natural substances that contain indicators?

Q11: Write down the colours of following indicators in both the acidic and basic medias?

Phenolphthalein, Litmus, methyl orange

Q12: Can you suggest two methods by which the sea water can be desalinated to make it drinkable?

Q13: What is a Salt? Describe the general characters of the Salts.

Q14: How Salts are prepared and purified?

Q15: What types of Salts are found in nature? Explain with examples.

Q 16: Arrange the following chemical species into Acids, Bases and Salts.

$NaHCO_3$,	$Na_2CO_3.10H_2O$,	$Al(OH)_3$,
$Ca(OH)_2$,	CH_3COOH,	CH_3COONa,
$HCOOH$,	NH_3,	NH_4OH,
HNO_3,	$NaOH$,	$Ca(OCl)Cl$,
Na_2SO_3,	H_2CO_3, H_2SO_3.	

Q17: Calculate the pH of a solution which contains 0.01 moles of HCl?

Q18: Calculate the molarity of H^+ for aqueous solutions for which the pH is:

a) 3.0 b) 10.0

Q19 : Calculate the pH of a solution that has the H^+ molarity,

a) 1×10^{-6} b) 1×10^{-11}