2 ACIDS, BASES AND SALTS

2.1 INTRODUCTION

The term acids and bases have become so common in routine and involve such a variety of substances that have been accepted as such without questions. Several definitions of acids and bases have been proposed from time to time. Going back to the historical development of the subject acids were earlier characterised by their sour taste, ability to dissolve substances in water, action on vegetable dyes etc. Modern definitions of acids and bases started with Arrhenius approach between 1880-1890. **Latter on in 1923 Bronsted and Lowry independently defined acids and bases. But most advanced of defination of acids and bases was given by Lewis**.

Beside these the strength of any solution can be determined from the concentration of H^+ or OH^- ions in the solution, commonly described in terms of a parameter called pH. Further, salts are produced as a result of neutralization reaction between an acid and a base.

We will study all these one by one in this chapter.

2.2 BASICS OF ACIDS, BASES AND SALTS

Substance with sour taste are regarded as acids. Lemon juice, vinegar. grape fruit juice and spoilt milk etc. taste sour since they are acidic. Similarly, substances with bitter taste and soapy touch are regarded as bases. Familiar examples of the bases are caustic soda, caustic potash, slaked lime etc.

2.2.1 Acids

(i) The word acid was applied to the substances with 'sour taste'. Many substances can be identified as acids based on their taste. **But this cannot be the sole criteria for the acidic character.**
(ii) An acid may be defined as a substance which releases one or more H^+ ions in aqueous solution. Acids are mostly obtained from natural sources. Those obtained from rocks and minerals are called **mineral acids** while the acids present in animal and plant materials are known as **organic acids.**

\

2.2.2 Bases

(i) They can be identified by their bitter taste and soapy touch. However, this cannot be the sole criteria in order to identify bases. Since many of them like sodium hydroxide and potassium hydroxide have corrosive action on the skin and can even harm the body.

(ii) A base may be defined as a substance capable of releasing one or more OH^- ions in aqueous solution.

Some bases like sodium hydroxide and potassium hydroxide are water soluble. These known as alkalies.

Litmus solution is a purple dye, which is extracted from **lichen**, a plant belonging to the division **Thallophyta**, and is commonly used as an indicator. When the litmus solution is neither acidic nor basic, its colour is **purple**. There are many other natural materials like red cabbage leaves, turmeric, coloured petals of some flowers such as **Hydrangea**, **Petunia** and **Geranium**, which indicate the presence of acid or base in a solution. These are called **acid-base indicators** or sometimes simply indicators.

2.3 UNDERSTANDING THE CHEMICAL PROPERTIES OF ACIDS AND BASES

2.3.1 Acid and Bases in the Laboratory

Test of Distinguish Between Acids and Bases

There are many substances which show one characteristic property (colour, odour etc.) in the acidic medium and a different property in the basic medium. **Such substances are called as acid–base indicators**. Depending upon the property of the indicator, we have the following two types of acid-base indicators.

(a) Indicators showing different colours in acidic and basic medium.

(b) Indicators giving different odours in acidic and basic medium (called olfactory indicators).

Now, we shall discuss each of these one by one.

(a) Indicators show different colours in acidic and basic medium:

From the chemistry laboratory, collect the samples of a few acids like hydrochloric acid (HCl), nitric acid (HNO_3) and bases like sodium hydroxide (NaOH) and potassium hydroxide (KOH). Put a few drops of each of them on watch glass and then add one or two drops of the main acid base indicators on them. Note the observations i.e., change in colour if any in a tabular form.

Sample	Blue litmus solution	Red litmus solution	Phenolphthalein	Methyl orange
HCl	Changes to red	No colour change	Colourless	Changes to red
HNO_3	Changes to red	No colour change	Colourless	Changes to red
NaOH	No colour change	Changes to blue	Changes to pink	No change in colour
KOH	No colour change	Changes to blue	Changes to pink	No change in colour

(b) Indicators giving different odours in acidic and basic medium (Olfactory indicators):

There are some substance which give one type of odour in acidic and a different odour in the basic medium. Hence, they can be used to test whether the given substance is acidic or basic. Such indicators are called **olfactory indicators**. A few of these are briefly described below;

(i) Onion odoured cloth strips: Take some finely choped onions and a few strips of clean cloth in a plastic bag. Tie the open mouth of the bag tighty and then keep in the fridge overnight. The cloth strips now acquire the odour of the onion and can be used as **acid -base indicator**. To known the odour in the acidic medium and in the basic medium, take two cloth strips prepared above. Place them on a clean surface. Put a few drops of dilute HCl solution on one strip and a few drops of dilute NaOH solution on the other. Now rinse them with water and check their odour again.

(ii) Vanilla essence: Take 1 -2 mL dilute HCl solution in one test tube and 1-2 mL dilute NaOH solution in another test tube. Put a few drops of vanilla essence in each test tube and shake well. We observe that now a different odour is obtained from the two test tubes.

(iii) Clove oil : Check the odour of clove oil. Take 1-2 mL of dilute HCl solution in one test tube and 1-2 mL of dilute NaOH solution in another test tube. Add a few drops of clove oil in each of them. We shall again observe that now a different odour is obtained from the two test tubes.

Illustration 1

How acids have been classified?

Solution

Acids have been classified into two groups-

(i) Binary acids (ii) Oxy acids

Binary acids are those acids in which hydrogen atom combines with some other atom. These acids are also called hydroacids. Examples.

(i) Hydrochloric acid HCl

(ii) Hydrocyanic acid HCN

If an acid contains oxygen then it is called oxy acid.

Example :-

Example : (I) Nitric acid HNO_3

(II) Sulphuric Acid H_2SO_4

2.3.2 How do Acids and Bases React with metals?

(i) How metals react with acids: Dilute acids like dilute HCl and dilute H_2SO_4 react with certain active metals to evolve hydrogen gas

$$\text{Metal + Dilute acid} \rightarrow \text{Metal salt + Hydrogen}$$

$$2Na\ (s) + 2\ HCl\ (dilute) \rightarrow 2NaCl\ (aq) + H_2\ (g)$$

$$Mg\ (s) + H_2SO_4\ (dilute) \rightarrow MgSO_4\ (aq) + H_2\ (g)$$

Metals which can displace hydrogen from acids are known as acitve metals e.g. Na, K, Zn, Fe, Ca, Mg. etc.

In order to demonstrate the release of hydrogen when a metal reacts with dilute acid, take a few pieces of granulated zinc in a conical flask. Drop dilute sulphuric acid from a dropping funnel. Bubbles of hydrogen gas will evolve at a brisk speed. Now bring a burning candle near these bubbles. The gas will immediately catch fire and will burn more brightly accompanied by sound.

The active metals which lie above hydrogen in the acitivity series are electropositive in nature. Their atoms lose electrons to form positive ions and these are accepted by H^+ ions of the acid. As a result, H_2 (g) is evolved. For example

$$Zn\,(s) \rightarrow Zn^{2+}\,(aq) + 2e^-$$
$$2H^+(aq) + (aq) + 2e^- \rightarrow H_2(g) + (aq)$$
$$Zn(s) + 2H^+(aq) \rightarrow Zn^{2+}(aq) + H_2(g)$$

The strength of acids and bases depends on the number of H^+ ions and OH^- ions produced, respectivley. If we take hydrochloric acid and acetic acid of the same concentration, say one molar, then these produce different amounts of hydrogen ions. Acids that give rise to more H^+ ions are said to be strong acids, and acids that give less H^+ ions are said to be weak acids.

(ii) How metals react with base?

Metals like zinc, tin and aluminium react with strong alkalies like NaOH (caustic soda) and KOH (caustic potash) to evolve hydrogen gas.

$$Zn\,(s) + 2NaOH\,(aq) \rightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2\,(aq)} + H_2(g)\uparrow$$

$$Sn\,(s) + 2NaOH\,(aq) \rightarrow \underset{\text{Sodium stannite}}{Na_2SnO_2\,(aq)} + H_2\uparrow(g)$$

$$2Al + 2NaOH + 2H_2O \rightarrow \underset{\text{Sodium meta aluminate}}{2NaAlO_2\,(aq)} + 2H_2\uparrow(g)$$

In a test tube, take few granules of zinc. To this add a small amount of sodium hydroxide solution prepared in water. Warm the tube and hydrogen gas will evolve.It will catch fire when a burning candle is brought in its contact.

(iii) Action with Metal Oxides

Acids react with metal oxides to form salt and water. These reactions are mostly carried upon heating. For example,

$$\text{Metal oxide} + \text{Acid} \rightarrow \text{Salt} + \text{Water}$$
$$ZnO\,(s) + 2HCl \rightarrow ZnCl_2\,(aq) + H_2O\,(l)$$
$$MgO(s) + H_2SO_4(aq) \rightarrow MgSO_4\,(aq) + H_2O\,(l)$$

In a tube, take a small amount of copper (II) oxides also called cupric oxide. It is black in colour. To this add dilute HCl solution dropwise with slow stirring. The black colour changes to bluish green due to the formation of copper (II) chloride also called cupuric chloride.

$$\underset{\text{(Black)}}{CuO(s)} + 2HCl\,(dil). \rightarrow \underset{\text{(Bluish green)}}{CuCl_2\,(aq)} + H_2O\,(l)$$

Oxides of metals are generally basic in nature.

(iv) Action with non - metallic oxides

Acids react with metal oxides but bases react with oxides of non - metals (e.g. CO_2 SO_2 SO_3 etc.) to form salt and water. For example,

$$2NaOH\,(aq) + CO_2\,(g) \rightarrow Na_2CO_3\,(aq) + H_2O\,(l)$$
$$Ca\,(OH)_2\,(s) + SO_2\,(g) \rightarrow CaSO_3\,(aq) + H_2O\,(l)$$

We have already discussed under acids that CO_2 (g) turns lime water containing traces of Ca $(OH)_2$ milky due to the formation of insoluble calcium carbonate

$$CO_2\,(g) + \underset{\text{(Lime Water)}}{Ca\,(OH)_2} \rightarrow \underset{\text{(White ppt) (Milky)}}{CaCO_3\,(s)} + H_2O\,(l)$$

(v) Action with Metal carbonates and Metal bicarbonates

Both metal carbonates and bicarbonates react with acids to evolve CO_2(g) and form salts. For example,

$$CaCO_3\,(s) + 2HCl\,(aq) \rightarrow CaCl_2\,(aq) + H_2O(aq) + CO_2\,(g)$$

Calcium carbonate

$$2NaHCO_3\,(s) + H_2SO_4\,(aq) \rightarrow Na_2SO_4\,(aq) + H_2O\,(aq) + CO_2\,(g)$$

(A bicarbonate is also called hydrogen carbonate)

Take small amount of calcium carbonate in a test tube. To this add a little of dilute HCl. Reaction will immediately start and will be accompained by brisk effervesence. This shows that a certain gas has been evolved. When the gas is bubbled through lime water, it immeditaely becomes milky. This shows that the gas evolved is CO_2 (g).

$$\underset{\text{(Lime water)}}{Ca(OH)_2} + CO_2\,(g) \rightarrow \underset{\text{(Milky)}}{CaCO_3} + H_2O$$

The milkiness disappers when the gas is bubbled in excess through the same solution.

$$\underset{\text{(Milkness)}}{CaCO_3\,(s)} + \underset{\text{(in excess)}}{CO_2\,(g)} + H_2O\,(l) \rightarrow \underset{\text{(Soluble)}}{Ca(HCO_3)_2\,(aq)}$$

$CaCO_3$ is insoluble in water while $Ca(HCO_3)_2$ is water soluble.

Limestone, chalk and marble are different forms of calcium carbonate. All metal carbonates and hydrogencarbonates react with acids to give a corresponding salt, carbon dioxide and water.

Thus, the reaction can be summarised as –

Metal carbonate / metal hydrogencarbonate + Acid → Salt + Carbon dioxide + Water.

Illustration 2

What will happen when magnesium carbonate react with nitric acid?

Solution

Magnisium nitrate and hydrogen gas will be formed and carbon dioxide gas will evoled, when magnesium will react with nitric acid.

$$MgCO_3 + 2HNO_3 \rightarrow Mg(NO_3)_2(aq) + H_2O\,(l) + CO_2\uparrow(g)$$

$$Mg + HNO_3 \rightarrow Mg(NO_3)_2 + H_2\uparrow$$

Illustration 3

What will happen when magnesium carbonate react with hydrochloric acid?

Solution

Magnesium chloride, water and carbon dioxide gas will be formed when magnesium carbonate will react with hydrochloric acid.

$$MgCO_3 + 2HCl \rightarrow MgCl_2(aq) + H_2O(l) + CO_2\uparrow(g)$$

2.3.3 Strong and Weak Acids

Acids which are almost completely ionised in water, are known as strong acids. For example, hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3) etc. are all strong acids.

$$HCl\,(l) \xrightarrow{\text{(Water)}} H^+\,(aq) + Cl^-\,(aq)$$

$$H_2SO_4\,(l) \xrightarrow{(Water)} 2H^+\,(aq) + SO_4^{2-}\,(aq)$$

Acids which are weakly ionised in water are known as weak acids. For example carbonic acid (H_2CO_3), phosphoric acid (H_3PO_4), formic acid (HCOOH), acetic acid (CH_3COOH) are weak acids.

$$CH_3COOH\,(l) \underset{}{\overset{(Water)}{\rightleftharpoons}} CH_3COO^- + H^+\,(aq)$$

In general, **mineral acids are strong acids while organic acids are weak acids**.

2.3.4 Basicity of the acids

Basicity of an acid may be defined as: **the number of replaceable hydrogen atoms present in an acid which it can release when dissolved in water or in aqueous solution.**

Acids have been classified as monobasic, dibasic, tribasic etc. depending upon the number of replaceable hydrogen atoms present. Please note the hydrogen atoms are replaced when acid is reacted with a base in aqueous solution. For example;

$$HCl\,(aq) + NaOH\,(aq) \longrightarrow NaCl\,(aq) + H_2O\,(l)$$
(Monobasic)

$$H_2SO_4\,(aq) + 2NaOH\,(aq) \longrightarrow Na_2SO_4\,(aq) + 2H_2O\,(l)$$
(Dibasic)

$$H_3PO_4\,(aq) + 3KOH\,(aq) \longrightarrow K_3PO_4\,(aq) + 3H_2O\,(l)$$
(Tribasic)

2.3.5 Strong and Weak Bases

We have learnt that a base contains in it one or more hydroxyl (OH) groups which releases in aqueous solution upon ionisation. Bases which are almost completely ionised in water, are known as strong bases. For example, sodium hydroxide (NaOH), potassium hydroxide (KOH), barium hydroxide $Ba(OH)_2$ are all strong bases.

$$NaOH\,(s) \xrightarrow{(water)} Na^+\,(aq) + OH^-\,(g)$$

$$KOH\,(s) \xrightarrow{(water)} K^+\,(aq) + OH^-\,(aq)$$

Bases which are ionised to small extent in water are known as weak bases. For example, magnesium hydroxide $Mg(OH)_2$, ammonium hydroxide NH_4OH, copper hydroxide $Cu(OH)_2$ are weak bases.

$$NH_4OH\,(l) \xrightarrow{(water)} NH_4^+\,(aq) + OH^-\,(aq)$$

$$Mg(OH)_2\,(g) \xrightarrow{(water)} Mg^{2+}\,(aq) + 2OH^-\,(aq)$$

Both NaOH and KOH are deliquescent in nature which means that they absorb moisture from air and get liquified.

Just like acids, relative strengths of bases can also be compared in terms of degree of ionisation also called degree of dissociation. It is denoted as α, Mathematically,

$$\alpha = \frac{\text{No. of molecules of base existing as ions}}{\text{Total no. of molecules of base}}$$

For strong bases, α is close to one while for weak bases, it has small value.

2.3.6 Acidity of Bases

Acidity of a base may be defined as: **The number of replaceable hydroxyl groups present in a base which it can release when dissolved in water or in aqueous solution as ions.**

Please note that the OH^- groups present in base can be released when reacted by an acid. Bases like NaOH and KOH are monoacid bases; $Ca(OH)_2$ is a diacid base while $Al(OH)_3$ behaves as a triacid base.

2.3.7 What do all acids and all bases have in common?

All acids and bases gives characteristic reactions. Both produce hydrogen gas when reacted with certain metals. **Do all acids and bases have something common between them?**

To know of it, let us perform the following example,

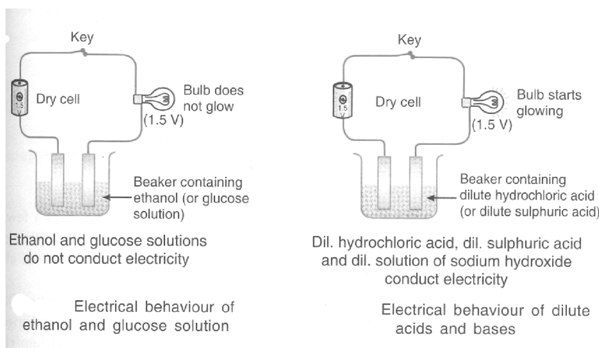
To find the characteristics common between acids and bases

Materials required: Dilute hydrochloric acid, Dilute sulphuric acid, Dilute solution of sodium hydroxide, Ethanol, Glucose solution

Apparatus required: Beaker (1), Carbon electrodes (2), Dry cells (2), Bulb 1.5 V (1) Key (1)

Precedure: Take a beaker and place two carbon electrodes into it. Connect the electrodes to a battery bulb through a key and a dry cell.

Pour dilute hydrochloric acid into the beaker and press the key. Did the bulb glow? Perform similar experiment with all the given solutions, and record your observations.



Observations:

Solution	Bulb glows	Bulb does not glow	Nature of the solution
Dil. Hydrochloric acid	✔	✘	Conducting
Dil. Sulphuric acid	✔	✘	Conducting
Dil. Sodium hydroxide solution	✔	✘	Conducting
Ethanol	✘	✔	Nonconducting
Glucose solution	✘	✔	Nonconducting

Conclusion: The solutions of acids and bases are good conductors of electricity. The solution of glucose and ethanol are nonconductors of electricity.

Explanation: Solutions conduct electricity due to the presence of ions in them. Therefore, acids and base/alkalis furnish ions in their solutions. Acids produce H^+(aq) ions and bases/alkalis produce free OH^- (aq) ions in their solutions in water.

Ethanol and the solution of glucose do not conduct electricity. Therefore, these compounds do not produce ions in their solutions.

Thus, the tendency to produce ions in their solutions in water is a common property of acids and bases/alkalis.

2.3.8 What happens to an acid or a base in a Water Solution?

Experiment suggests that hydrogen ions in HCl are produced in the presence of water. The separation of H^+ ion from HCl molecules cannot occur in the absence of water.

$$HCl + H_2O \rightarrow H_3O^+ + Cl^-$$

Hydrogen ions cannot exist alone, but they exist after combining with water molecules. Thus hydrogen ions must always be shown as H^+ (aq) or hydronium ion (H_3O^+).

$$H^+ + H_2O \rightarrow H_3O^+$$

We have seen that acids give H_3O^+ or H^+ (aq) ion in water. Let us see what happens when a base is dissolved in water.

$$NaOH\ (s) \xrightarrow{H_2O} Na^+\ (aq) + OH^-\ (aq)$$

$$KOH\ (s) \xrightarrow{H_2O} K^+\ (aq) + OH^-\ (aq)$$

$$Mg(OH)_2\ (s) \xrightarrow{H_2O} Mg^{2+}\ (aq) + 2OH^-\ (aq)$$

Bases generate hydroxide (OH^-) ions in water. Bases which are soluble in water are called alkalies.

Now as we have identified that all acids generate H^+ (aq) and all bases generate OH^- (aq), we can view the neutralisation reaction as follows –

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

$$H\ \boxed{X + M}\ OH \rightarrow MX + HOH$$

$$H^+\ (aq) + OH^-\ (aq) \rightarrow H_2O\ (l)$$

The reaction is called neutralisation because the salt (NaCl) which is formed in this case is neutral towards litmus. It means that the colour of the litmus paper (blue or red) if dipped in the salt solution does not change. Thus, neutralisation may be defined as:

the reaction between acid and base present in aqueous solution to form salt and water.

Explanation: According to Arrhenius theory, an acid when dissolved in water gives H^+ ions. Similarly a base when dissolved in water gives OH^- ions. Neutralisation is the combination between H^+ ions of the acid with OH^- ions of the base to form H_2O. For example,

$$\underbrace{H^+(aq) + Cl^-(aq)}_{HCl(aq)} + \underbrace{Na^+(aq) + OH^-(aq)}_{NaOH(aq)} \rightarrow \underbrace{Na^+(aq) + Cl^-(aq)}_{NaCl(aq)} + H_2O$$

Practical Applications of Neutralisation

(i) People particularly of old age suffer from acidity problems in the stomach which is caused mainly due to release of excessive gastric juices containing HCl. The acidity is neutralised by **antacid** tablets which contain sodium hydrogen carbonate (baking soda), magnesium hydroxide etc.

(ii) The stings of **bees** and **ants** contain formic acid. Its corrosive and poisonous effect can be neutralised by rubbing soap which contains NaOH (an alkali).

(iii) The stings of wasps contain an alkali and its poisonous effect can be neutralised by an acid like acetic acid (present in vinegar).

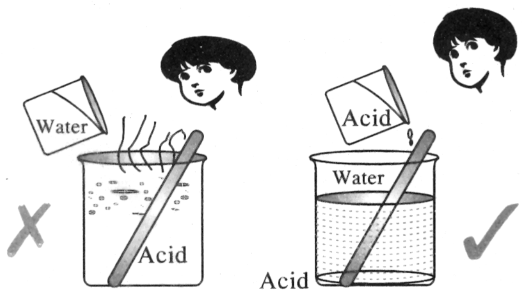
(iv) Farmers generally neutralise the effect of acidity in the soil caused by acid rain by adding slaked lime (calcium hydroxide) to the soil.

2.3.9 What happens in the dilution of Acid and Base with water?

Acids and bases are mostly water soluble and can be diluted by adding the required amount of water. In fact, with the addition of water, the amount of acid or base per unit volume decreases and dilution occurs. The process is generally exothermic in nature. In some cases, so much heat is evolved that the acid or base immediately changes into vapour state. This will lead to the formation of dense fog which is likely to pollute the atmosphere.

Precaution needed for dilution

Whenever a concentrated acid like sulphuric acid or nitric acid is to be diluted with water, care must be taken that acid should be added dropwise to water taken in the container with constant stirring. Heat evolved in this case will be quite slow. If water is added to the acid, it will have affinity for the entire quantity of the acid present . So much heat will be evolved that the glass container in which dilution is carried will crack. Moreover, the vapours released in the atmosphere as fog will cause pollution problem.



Diluting concentrated H_2SO_4 acid with water

How strong are Acid and Base solution

We have studied that acids and bases may be either strong or weak and have compared their relative strengths on the basis of the Arrhenius theory. According to the theory, more the number of H^+ ions released by acid in water, stronger is the acid. Similarly, more the number of OH^- ions released by a base in water, stronger is the base.

Illustration 4

Define alkalies, give examples also.

Solution

Base which are highly soluble in water are called alkalies. It means that an alkali is a water soluble bases.

- **All alkalies are bases but all bases are not alkalies.**

Examples of alkalies are as:

NaOH: Sodium hydroxide or Caustic Soda

$Ca(OH)_2$: Calcium hydroxide or Slaked lime.

Illustration 5

What are the characteristics of acids?
Solution

1. Acids have sour taste.
2. Acids change the colour of litmus from blue to red.
3. Acids react with certain metals liberating hydrogen gas.
4. Acids decompose carbonates and hydrogen carbonates giving out carbon dioxide gas.
5. Acids neutralise bases to give salt and water.

Illustration 6

What are the characteristics of bases ?

Solution

1. Bases have bitter taste.
2. Bases are slippery to touch.
3. Bases change the colour of litmus from red to blue.
4. Bases neutralise acids to form salt and water.

*2.4 THEORIES OF ACIDS AND BASES

2.4.1 Arrhenius concept of acids and Bases

The swedish chemist **Svante Arrhenius** in 1887 explained the ionisation of the strong and weak electrolytes (**i.e. acids and bases**) in water.

(i) According to Arrhehius an acid is defined as a substance containing hydrogen. [HA], which gives free hydrogen ions when dissolved in water.

$HA\ (aq) \rightleftharpoons H^+\ (aq) + A^-\ (aq)$

Strong acids like HCl, HNO_3. H_2SO_4 are almost completely ionised in water as shown below:

$HCl\ (aq) \rightarrow H^+\ (aq) + Cl^-\ (aq)$

$HNO_3\ (aq) \rightarrow H^+\ (aq) + NO_3^-\ (aq)$

Weak acids like CH_3COOH and H_3PO_4 are ionised to small extent. Therefore, there is a state of equilibrium between the unionised acid and ions formed in solution.

$CH_3COOH\ (aq) \rightleftharpoons CH_3COO^-\ (aq) + H^+\ (aq)$

$H_3PO_4\ (aq) \rightleftharpoons 3H^+\ (aq) + PO_4^{3-}\ (aq)$

Hence the common characteristics of acids are attributed to the presence of H^+ ions in aqueous solution.

(ii) According to Arrhenius a base is a hydroxyl group containing compound (BOH), which gives free hydroxyl ions when dissolved in water.

$BOH\ (aq) \rightarrow B^+\ (aq) + OH^-\ (aq)$

strong bases like NaOH, KOH are completely ionised.

$NaOH\ (aq) \rightarrow Na^+(aq) + OH^-\ (aq)$

$KOH\ (aq) \rightarrow K^+\ (aq) + OH^-\ (aq)$

Whereas weak bases like NH_4OH, are ionised to a smaller extent.

$$NH_4OH \rightleftharpoons NH_4^+ (aq) + OH^- (aq)$$

Thus, hydroxyl ion is responsible for the basic properties exhibited by the bases in water.

According to this concept, neutralisation is the combination of H^+ ion of the acid with OH^- ion of the base to form molecules of H_2O, which are neutral.

$$H^+ (aq) + OH^- (aq) \xrightarrow{neutralisation} H_2O (l)$$

Illustration 7

Classify the following acids into strong and weak acids.

H_2SO_4, H_2CO_3, H_3PO_4, HCl, HCOOH, HNO_3, CH_3COOH

Solution

Strong acids : H_2SO_4, HNO_3, HCl;

Weak acids : H_2CO_3, H_3PO_4, HCOOH, CH_3COOH

*2.4.2 Bronsted Lowry concept of Acids and Bases

In 1923, **J.N. Bronsted** and **J.M. Lowry** proposed more general definitions for acids and bases, simultaneously and independently. According to them, an acid is any substance which can donate a proton to any other substance. A base on the other hand, is any subtance that can accept a proton.

In short, an acid is a proton donor, and a base is a proton acceptor

Conjugate acid and base pairs: In the ionisation of hydrogen chloride

$$HCl (aq) + H_2O (l) \rightarrow H_3O^+ (aq) + Cl^- (aq)$$

Acid base

Hydrogen chloride donates a proton to water and hence is acid. Water on the other hand is accepting a proton from HCl and hence is acting as a base. Consider the reverse reaction. The hydronium ion, H_3O^+ donates a proton to chloride ion, hence it is an acid, chloride ion, is accepting a proton from hydronium ion, it is a base.

- It is significant that according to Bronsted Lowry concept, not only neutral compounds, but ionic species can also act as acids or bases.

The acid hydrogen chloride, by Losing a proton, froms the base, Chloride ion, which in turn, by gaining a proton, can form acid hydrogen chloride thus:

$$\underset{Acid}{HCl} \underset{+H^+}{\overset{-H^+}{\rightleftharpoons}} \underset{Base}{Cl^-}$$

Such an acid –base pair, the members of which can be formed from each other mutually by the gain loss of proton is called a conjugate acid - base pair.

Similarly, the base water, accepts a proton to form the acid, hydronium ion, which in turn, forms water by loss of a proton.

$$\underset{Base}{H_2O} \underset{-H^+}{\overset{+H^+}{\rightleftharpoons}} \underset{Acid}{H_3O^+}$$

In general, we can represent any Bronsted - Lowry acid - base reaction as :

Conjugate acid pair (Loses proton)

$$\text{acid I} + \text{base II} \rightleftharpoons \text{acid II} + \text{base I}$$

Conjugate base pair (Adds proton)

Where acid I and base I represent one conjugate pair, whereas acid II and base II the other.
Some more examples :

$HNO_3 + H_2O \rightleftharpoons H_3O^+ + NO_3^-$; $HCN + H_2O \rightleftharpoons H_3O^+ + CN^-$

$H_2SO_4 + H_2O \rightleftharpoons H_3O^+ + HSO_4^-$

$NH_4^+ + H_2O \rightleftharpoons H_3O^+(aq) + NH_3(aq)$
Acid base

$H_2O(l) + NH_3(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$
Acid Base

$H_2O(l) + CO_3^{2-}(aq) \rightleftharpoons HCO_3^-(aq) + OH^-(aq)$
Acid Base

*2.4.3 Lewis concept of Acids and Bases

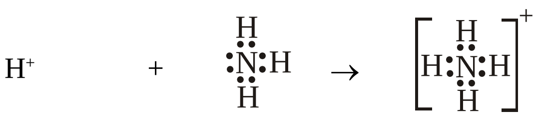
G. N. Lewis put forward a more general concept which does not require hydrogen to be an essential constituent of all acids. According to Lewis, an acid is a substance which can accept a pair of electrons, while a base is a substance which can donate a pair of electron to form a coordinate or dative bond.
Hence, acid is an electron pair acceptor having empty orbitals to accomodate lone pair and base is an electron pair donar. This concept is also known as electronic–concept and is most fundamental of acids–bases concepts.

In general :

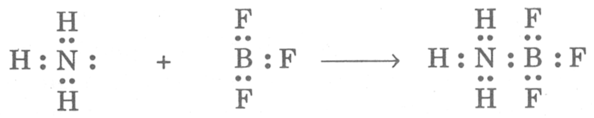
$A^+ + \ddot{B} \rightarrow B: \rightarrow A$

Species with empty orbital — Species with Lone pair of electron

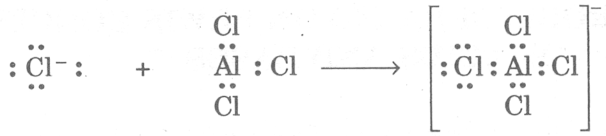
For Examples,



Lewis Acid Lewis Base



LEWIS BASE LEWIS ACID



LEWIS BASE LEWIS ACID

Types of Lewis Acids: The Lewis acids are of following types :

(i) Molecules having the central atom with incomplete octate. e.g. anhydrous BF_3, anhydrous $AlCl_3$. anhydrous $FeCl_3$.

(ii) Simple Cation : all cations can be considered as Lewis acids, as they are deficient in electrons. e.g. Na^+, K^+, H^+, Ag^+.

(iii) Molecules in which the central atom has available vacant orbitals and may acquire more than 8 electrons i.e. molecules which can expand their octet. For example SiF_4, $SnCl_4$ etc.

(iv) Molecules in which atoms of different electronegativities are linked by multiple bonds. For example CO_2.

Types of Lewis Bases: Lewis bases are of following types :

(i) Neutral molecules with atleast one lone pair of electrons which can be donated easily. For example, $\ddot{N}H_3$ is a Lewis base.

(ii) Anions having negative charge acts as Lewis base. For example, F^-, Cl^-, Br^-, OH^-, etc.

(iii) Molecules having –C = C– and –C ≡ C– also acts as Lewis bases.

Illustration 8

Out of the following pairs, point out the stronger Lewis acid and assign reason.

(a) BF_3 or BH_3 ***(b) Sn^{2+} or Sn^{4+}***

Solution

(a) BF_3 is stronger Lewis acid because B atom in BF_3 is more electron deficient than BH_3.

(b) Sn^{4+} is a stronger Lewis acid because it has greater number of vacant orbitals as compared to Sn^{2+} ion.

Illustration 9

What are amphoteric or amphiprotic species?

Solution

According to Bronsted Lowry concept, such species which can function both as acids as well as bases depending on the conditions are called amphoteric or amphiprotic species.

e.g. H_2O and NH_3 are amphoteric.

2.5 IONIC PRODUCT OF WATER

Pure water is a very weak conductor of electricity i.e. it is a very weak electrolyte. Hence, it undergoes self ionisation to a very small extent. So that the following equillibrium is set up between water and its ions

$$H_2O(\ell) + H_2O(\ell) \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$

Applying law of mass action, the dissociation constant K is written as :

$$K = \frac{[H_3O^+(aq)][OH^-(aq)]}{[H_2O(l)]^2}$$

Since, water is ionised to a very small extent and its degree of ionisation is low, its ionisation does not appreciably change the concentration of water molecule. Therefore, $[H_2O(l)]$ may be supposed to remain constant, thus -

$K\,[H_2O(\ell)]^2 = [H_3O^++(aq)][OH^-(aq)]$

or $K \times K^1 = [H_3O^++(aq)][OH^-(aq)]$

Where $K^1 = [H_2O(\ell)]^2$

Or $Kw = k \times K^1 = [H_3O^++(aq)]\,[OH^-(aq)]$

Here, Kw is a constant, known as ionic product of water.

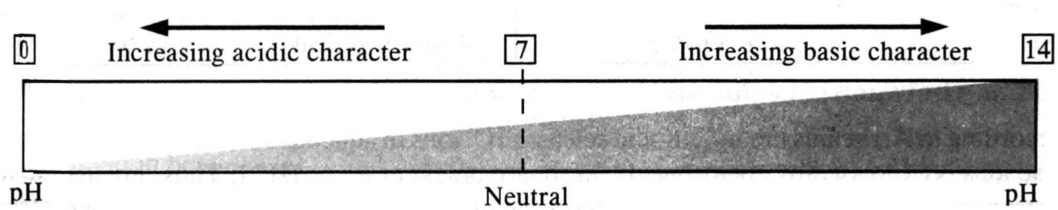
At room temperatures. (25ºC or 298 K), the value of Kw of water is 1.0×10^{-14}.

2.6 THE pH SCALE

An easier way to measure the strength of an acid or base solution was worked out by the Danish bio-chemist S. Sorensen. He was interested in checking the acidity of beer and introduced a scale known as **pH scale** (In German 'p' stands for 'potenz' meaning power). The scale runs from 0 to 14 and the characteristics of the scale are:

* Acids have pH less than 7
* The more acidic is a solution, lesser will be its pH
* Neutral solutions (e.g., water) have pH of 7
* Alkalies have pH more than 7
* The more alkaline is a solution, higher will be its pH.

The pH scale may be shown as follows:



pH scale for expressing concentration of solutions

Universal indicator papers for pH values

We have seen the role of indicators like litmus, phenolphthalein and methyl orange in predicting the acidic and basic characters of the solutions. However, universal indicator papers have been developed to predict the pH of different solution. Such papers represent specific colours for different concentrations in terms of pH values.

2.6.1 Relation between pH value and hydrogen ion concentration

According to Arrhenius theory, an acid releases H^+ ions in aqueous solution. The concentration of these ions is expressed by enclosing H^+ separately in square bracket i.e., as $[H^+]$. Thus, greater the $[H^+]$ ions, stronger will be the acid. However, according pH scale, lesser the pH value, stronger will be the acid. From the above discussion, we can conclude that:

pH value and H^+ ion concentration $[H^+]$ are inversely proportional to each other.

The relation between them can also be expressed:

$$pH = -\log [H^+] = \log \left[\frac{1}{H^+}\right]$$

For example, let the $[H^+]$ of an acid solution be 10^{-3} M. Its pH can be calculated as:

$$pH = -\log [H^+] = -\log [10^{-3}] = (-)(-3) \log 10 = 3$$

(Please remember that log 10 = 1)

For neutral solution : $pH = 7$, and $[H^+] = 10^{-7}$

For acidic solution : $pH < 7$ and $[H^+] > 10^{-7}$

For basic solution : $pH > 7$ and $[H^+] < 10^{-7}$

Note : Just as the $[H^+]$ of a solution can be expresed in term of pH value, the $[OH^-]$ can be expressed as pOH.

Mathematically, $$pOH = -\log [OH^-] = \log \frac{1}{[OH^-]}$$

Moreover, $pH + pOH = 14$

Thus, if pH value of solution is known, its pOH value can be calculated.

Illustration 10

Calculate the pH of (i) 0.0001 M HCl (ii) 0.001 M NaOH solutions.

Solution

(i) pH value of 0.0001 M HCl solution.As HCl is a strong acid, it is competely dissociated and $[H^+]$ is the same as that of acid i.e., 0.0001 M.

$$[H^+] = 0.0001\ M = 10^{-4}\ M$$

$$pH = -\log [H^+] = -\log [10^{-4}] = (-)(-4) \log 10 = 4$$

(ii) pH value of 0.001 M NaOH solution

As NaOH is a strong base, it is completely dissociated and $[OH^-]$ is the same as that of base i.e., 0.001 M.

$$[OH^-] = 0.001\ M$$

$$pOH = -\log [OH^-] = -\log [10^{-3}] = (-)(-3) \log 10 = 3$$

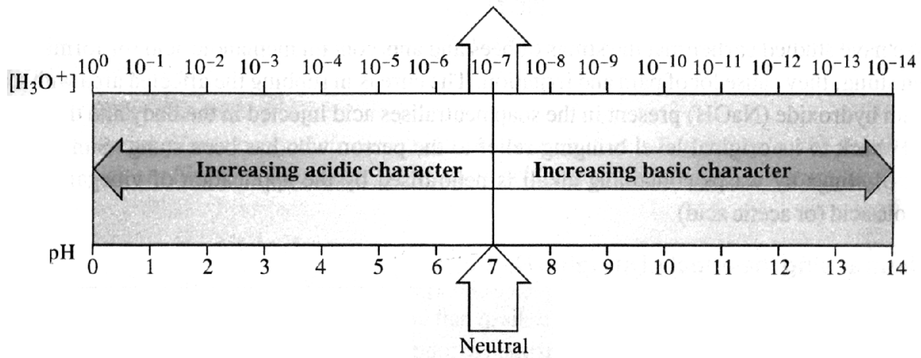
$$pH = 14 - pOH = 14 - 3 = 11$$

Illustration 11

An aqueous solution has hydrogen ion concentration $[H^+] = 1.0 \times 10^{-7}$ mol L^{-1}. Calculate its pH value.
Solution

$$[H^+] = 10^{-7} \text{ mol } L^{-1} = 10^{-7} \text{ M}$$
$$pH = -\log [H^+] = -\log [10^{-7}] = (-)(-7) \log 10 = 7$$

The relation between $[H^+]$ and pH scale of expressing the nature of a solution is shown in the Figure:



Relation between pH scale and $[H^+]$ or $[H_3O]^+$ at room temperature (298 K)

2.6.2 Importance of pH in everyday life

Are plants and animals pH sensitive?

Our body works within the pH range of 7.0 to 7.8. Living organisms can survive only in a narrow rang of pH change. When pH of rain water is less than 5.6, it is called acid rain. When acid rain flow into the rivers it lowers the pH of the riverwater. The survival of aquatic life in such river becomes difficult.

Acids in other planets

The atmosphere of venous is made up of thick white and yellowish clouds of sulphuric acid. Do you think life can exist on this planet?

(i) pH of the soil

Plants require a specific pH range for their healthy growth. To find out the pH required for the healthy growth of a plant, we should collect the soil from various places and check the pH. Also, we should note down which plants are growing in the region from which you have collected the soil.

(ii) pH in our digestive system

Our stomach produces hydrochloric acid. It helps in the digestion of food without harming the stomach. During indigestion the stomach produces too much acid and this causes pain and irritation. To get rid of this pain, people use bases called antacids. These antacids neutralise the excess acid. Magnesium hydroxide (milk of magnesia), a mild base, is often used for this purpose.

(iii) pH change as the cause of tooth decay

Tooth decay starts when the pH of the mouth is lower than 5.5. Tooth enamel, made up of calcium phosphate is the hardest substance in the body. It does not dissolve in water, but is corroded when the pH in the mouth is below 5.5. Bacteria present in the mouth produce acids by degradation of sugar and food particles remaining in the mouth after eating. The best way to prevent this is to clean the mouth after eating food. Using toothpastes, which are generally basic, for cleaning the teeth, can neutralise the excess acid and prevent tooth decay.

(iv) Self defence by animals and plants through chemical warfare

Bee-sting leaves an acid which causes pain and irritation. Use of a mild base like baking soda on the stung area gives relief. Stinging hair of nettle leaves inject methanoic acid causing burning pain.

(v) Nature provides neutralisation options

Nettle leaves have stinging hall which cause painful stings when touched accidentally. This is due to the methanoic acid secreted by them. A traditional remedy is rubbing the area with the leaf of the dock plant, which often grows beside the nettle in the wild.

Illustration 12

What is the pH of 0.1 M solution of HCl?

Solution

HCl is a strong acid. It is completely ionised in aqueous solution.

HCl ® $H^+(aq) + Cl^-(aq)$

$[H^+]$ = [HCl] = 0.1 M or 0.1 mol L^{-1}

pH = – log $[H^+]$ = – log (0.1) = – log (10^{-1}) = 1

= 1

Illustration 13

Calculate the pH of the solution when hydrogen ion concentration is 1.0×10^{-9} ***M.***

Solution

$[H_3O^+]$ or $[H^+]$ = 1.0×10^{-9} mol L^{-1}

– pH = – log $[H^+]$

= – log (1.0×10^{-9}) = 9.0

2.7 MORE ABOUT SALTS

In the previous sections we have seen the formation of salts during various reactions. Let us understand more about their preprations properties and uses.

2.7.1 Family of Salts

Salts of a strong acid and a strong base are neutral with pH value of 7. On the other hand, salts of a strong acid and weak base are acidic with pH value less than 7 and those of a strong base and weak acid are basic in nature, with pH value more than 7.

Sodium Chloride (NaCl): By now we have learnt that the salt formed by the combination of hydrochloric acid and sodium hydroxide solution is called **sodium chloride**. This is the salt that we use in food it is a neutral salt.

Seawater contains many salts dissolved in it. Sodium chloride is separated from these salts. These large crystals are often brown due to impurities. This is called rock salt. Beds of **rock salt** were formed when seas of bygone ages dried up. Rock salt is mined like coal.

$NaOH + HCl \rightarrow NaCl + H_2O$

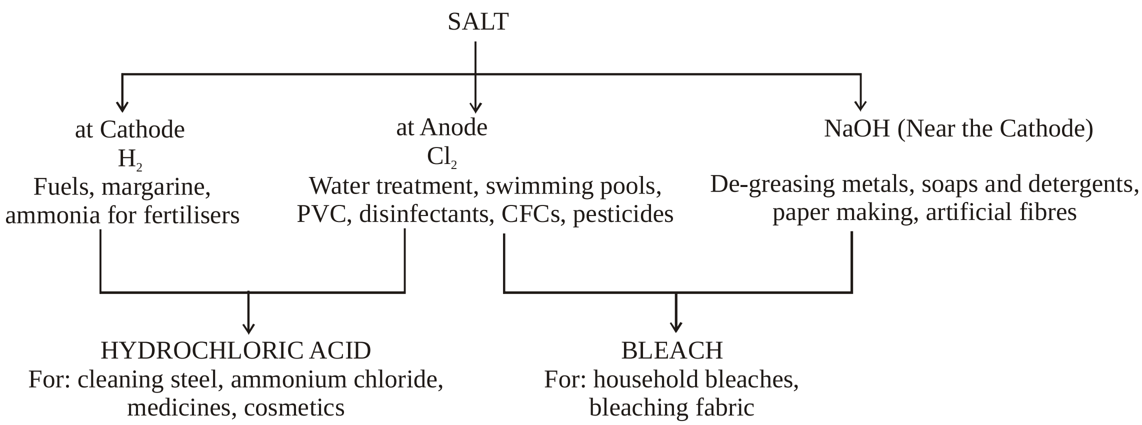
2.7.2 Common salt: A raw material for chemical

The common salt thus obtained is an important raw material for materials of daily use, such as sodium hydroxide, baking soda, washing soda, bleaching powder and many more.

(i) Sodium Hydroxide (NaOH): When electricity is passed through an aqueous solution of sodium chloride (called brine), it decomposes to form sodium hydroxide process is called the chlor-alkali process because of the products chlor for chlorine and alkali for sodium hydroxide.

$$2NaCl\ (aq) + 2H_2O\ (l) \rightarrow 2NaOH\ (aq) + Cl_2 \uparrow (g) + H_2 \uparrow (g)$$

Chlorine gas is given off at the anode, and hydrogen gas at the cathode Sodium hydroxide solution is formed near the cathode. The products produced in this process are all useful.



Important products from the chlor-alkali process

(ii) Bleaching Powder ($CaOCl_2$)

It is a calcium salt of hypochlorous acid. It may be represented by $CaOCl_2$ or $CaO.CaCl_2$ (Calcium Chlorohypochlorite, Chloride of lime).

Actually it is a mixture of $CaOCl_2.4H_2O$ and basic calcium chloride, $CaCl_2.Ca(OH)_2.H_2O$ chlorine is produced during electrolysis of aqueous sodium chloride (brine). This chlorine gas is use for the manufacture of bleaching powder. Bleaching powder is produce by the action of chlorine on dry slaked lime [$Ca(OH)_2$]. Bleaching power is represented as $CaOCl_2$, though the actual composition is complex.

$$Ca(OH)_2, + Cl_2 \rightarrow CaOCl_2 + H_2O$$

Bleaching reaction

$$2CaOCl_2 + H_2SO_4 \rightarrow CaCl_2 + CaSO_4 + HClO$$

$$HClO \rightarrow HCl + [O]$$

$$[O] + \text{coloured material} \rightarrow \text{decolourise}$$

Bleaching powder is used

(a) for bleaching cotton and linen in the textile industry, for bleaching wood pulp in paper factories and for bleaching washed clothes in laundry;

(b) as an oxidising agent in many chemical industries; and

(c) for disinfecting drinking water to make it free of germs.

(d) as an oxidising agent in chemical industries.

(iii) Baking Soda ($NaHCO_3$)

The soda commonly used in the kitchen for making tasty crispy pakoras is baking soda. Sometimes it is added for faster cooking. The chemical name of the compound is sodium hydrogencarbonate ($NaHCO_3$).

It is produced using sodium chloride as one of the raw materials.

$$NaCl + H_2O + CO_2 + NH_3 \rightarrow \underset{\text{Ammonium chloride}}{NH_4Cl} + \underset{\text{Sodium hydrogen carbonate}}{NaHCO_3}$$

It can be used to neutralise an acid It is a mild non-corrosive base. The following reaction takes place when it is heated.

Sodium hydrogen carbonate has got various uses in the household.

$$\underset{\text{Sodium hydrogen carbonate}}{NaHCO_3} \xrightarrow{\text{Heat}} \underset{\text{Sodium carbonate}}{Na_2CO_3} + H_2O + CO_2 \uparrow$$

Uses:

(i) For making baking powder, which is a mixture of baking soda (sodium hydrogencarbonate) and a mild edible acid such as tartaric acid. When baking powder is heated or mixed in water, the following reaction takes place -

$$NaHCO_3 + \underset{\text{(From any acid)}}{H^+} \rightarrow CO_2 + H_2O + \text{Sodium salt of acid}$$

Carbon dioxide produced during the reaction causes bread or cake to rise making them soft and spongy.

(ii) Sodium hydrogencarbonate is also an ingredient in antacids. Being alkaline, it neutralises excess acid in the stomach and provides relief.

(iii) It is also used in soda-acid fire extinguishers

Illustration 14

A baker found that the cake prepared by him is hard and small in size. Which ingredient has he forgotten to add that would have made the cake fluffy? Give reason.

Solution

The baker has forgotten to add baking powder. Baking powder is a mixture containing sodium bicarbonate ($NaHCO_3$) and an acidic compound such as potassium hydrogentartaiate or citric acid, during the preparation of cake/ bread, sodium bicarbonate reacts with the acidic compound to liberate carbon dioxide. The CO_2 so released make the cake/ bread porous and fluffy (light in weight and soft).

(iv) Washing Soda ($NaCO_3.10H_2O$)

The chemical formula of washing soda is $Na_2CO_3.10H_2O$. Anhydrous sodium carbonate is generally called soda ash. (Na_2CO_3). Sodium Carbonate is obtained on commercial scale by **Solvay's process**.

Raw materials used are

Sodium chloride (NaCl) in the form of its concentrated solution called brine.

(i) Ammonia (NH_3).

(ii) Lime Stone ($CaCO_3$)

The reactions taking place in this process are as follow :

Step I: $NaCl\ (aq) + NH_3\ (g) + H_2O + CO_2\ (g) \rightarrow NaHCO_3\ (s) + NH_4Cl\ (aq)$

Step II: $2\ NaHCO_3 \xrightarrow{\Delta} Na_2CO_3 + H_2O(g) + CO_2\ (g)$

Step (III): $Na_2CO_3\ (s) + H_2O\ (l) \rightarrow Na_2CO_3\ (aq) \xrightarrow{Crystallisation} Na_2CO_3.10H_2O$

Uses :

(i) Used for washing clothes.

(ii) Used for softening hard water.

(iii) Sodium carbonate is used for the manufacture of detergents.

(iv) Soldium Carbonate is used in paper and paint industry.

2.8 ARE THE CRYSTALS OF SALTS REALLY DRY?

Copper sulphate crystals which seem to be dry contain water of crystallisation. When we heat the crystals, this water is removed and the salt turns white.

If we moisten the crystals again with water, we will find that blue colour of the crystals reappears.

Water of crystallisation is the fixed number of water molecules present in one formula unit of a salt. Five water molecules are present in one formula unit of copper sulphate. Chemical formula for hydrated copper sulphate is $Cu\ SO_4.\ 5H_2O$. Now we would be able to answer the question whether the molecule of $Na_2CO_3.10H_2O$ is wet or not.

One other salt, which possesses water of crystallisation is gypsum. It has two water molecules as water of cyrstallisation. It has the formula $CaSO_4.2H_2O$.

(i) Plaster of Paris

On heating gypsum at 373 K, it loses water molecules and becomes calcium sulphate hemihydrate ($CaSO_4 . \frac{1}{2} H_2O$). This is called Plaster of Paris, the substance which doctors use as plaster for supporting fractured bones in the right position. Plaster of Paris is a white powder, on mixing with water, it changes to gypsum once again giving a solid mass.

$$\underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + 1\frac{1}{2}H_2O \rightarrow \underset{\text{Gypsum}}{CaSO_4.2H_2O}$$

Note that only half a water molecule is shown to be attached as water crystallisation. It is written in his form because two formula units of $CaSO_4$ share one molecule of water. Plaster of Paris is used for making toys, materials for decoration and for making surfaces smooth. Calcium sulphate hemihydrate called ‘Plaster of Paris’.

EXERCISE-I

1. How will you show that acetic acid is monobasic acid? **[1]**
2. Why alkalies like sodium hydroxide and potassium hydroxide should not be left exposed to air? **[1]**
3. What is the relation between hydrogen ion concentration of an aqueous solution and pH? **[1]**
4. The pH of an aqueous solution decreases from 3 to 2. What will happen to the nature of the solution? **[1]**
5. What happens to the crystal of washing soda when exposed to air? **[1]**
6. Name two industries based on the uses of washing soda. **[1]**
7. State whether aqueous solution of washing soda is acidic or alkaline. **[1]**
8. A solution of acetic acid in water is highly concentrated. Will you call it a strong acid? **[1]**
9. Why it is not proper to call HCl (g) as hydrochloric acid? **[1]**
10. Give the names and formulae of two (i) strong monobasic acids (ii) two weak dibasic acids? **[2]**
11. Name the substance which upon treating with chlorine gives bleaching powder. Write the chemical equation for the reaction. **[2]**
12. A metal compound 'A' reacts with dilute hydrochloric acid to produce effervescence. The gas evolved extinguishes candle. Write a balanced chemical equation for the reaction if one of the compounds formed is calcium chloride. **[2]**
13. Aqueous solution of HCl. HNO_3 and H_2SO_4 etc. show acidic character while those of the compounds like ethyl alcohol (C_2H_5OH) and glucose ($C_6H_{12}O_6$) fail to do so. Explain. **[2]**
14. Why does not acid show any acidic behaviour in the absence of water? **[2]**
15. Dry ammonia has no action on litmus paper but a solution of ammonia in water turns red litmus paper blue. Why is it so? **[2]**
16. What effect does concentration of H^+(aq) have on the acidic nature of the solution? **[2]**
17. What happens when crystals of washing soda are exposed to air? **[2]**
18. State the chemical property in each case on which the following uses of baking soda are based:
    (i) as an antacid
    (ii) as a constituent of baking powder. **[2]**
19. How is Plaster of Paris obtained? What reactions are involved in the setting of plaster of Paris? **[2]**
20. What is efflorescence ? Give an example. **[2]**
21. Out of calcium compounds calcium carbonate, quick lime and slaked lime, which one can be used for removing moisture from ammonia gas and why? **[2]**
22. Do basic solutions also have H^+ (aq) ions? If yes, then why are these basic? **[2]**
23. Discuss the role of water in the ionisation of acids and bases. **[2]**
24. Explain giving reasons;
    (i) Tartaric acid is a component of baking powder used in making cakes.
    (ii) Gypsum, $CaSO_4.2H_2O$ is used in the manufacture of cement. **[2]**

25. How is chloride of lime chemically different from calcium chloride? Why does chloride of lime gradually lose its chlorine when kept exposed to air? **[3]**

26. Five solutions A, B, C, D and E when tested with universal indicator show pH as 4, 2, 12, 7 and 9 respectively.Which solution is

    (a) neutral (b) strongly alkaline (c) strongly acidic (d) weakly alkaline, (e) weakly acidic, (f) Arrange the pH in increasing order of H^+ ion concentration. **[3]**

27. Which gas is usually liberated when an acid reacts with metal? Illustrate with an example. How will you test presence of the gas? **[3]**

28. A compound which is prepared from Gypsum has a property of hardening when mixed with proper quantity of water. Identify the compound. Write chemical equation to prepare the compound. Mention one important use of the compound. **[3]**

29. Give chemical names of the following compounds.Also state one use in each case.

    (i) Washing soda (ii) Baking soda
    (iii) Bleaching powder **[3]**

30. A chemical compound having smell of chlorine is used to remove yellowness of white clothes in laundries. Name the compound and write the chemical equation involved in its preparation. **[3]**

31. How is Plaster of Paris chemically different from gypsum? How may these be inter converted? Write one use of Plaster of Paris. **[3]**

32. Write chemical name and formula of washing soda. What are the raw materials used for its manufacture by Solvay process? What happens when crystals of washing soda are exposed to air? **[3]**

33. (a) An aqueous solution has a pH value of 7.0. Is this solution acidic, basic or neutral?

    (b) If H^+ concentration of a solution is 1×10^{-2} mol L^{-1}, what is its pH value?

    (c) Which has a higher pH value ; 1 M HCl or 1 M NaOH solution? **[3]**

34. What will you observe when:

    (i) Red litmus paper is introduced into a solution of sodium sulphate.

    (ii) Methyl orange is added to dilute hydrochloric acid

    (iii) A drop of phenolphthalein is added to solution of lime water.

    (iv) Blue litmus is introduced into a solution of ferric chloride. **[5]**

35. Explain why:

    (i) Common salt becomes sticky during the rainy season

    (ii) Blue vitriol changes to white upon heating

    (iii) Anhydrous calcium chloride is used in desiccators

    (iv) If bottle full of concentrated sulphuric acid is left open in the atmosphere by accident, the acid starts flowing out of the bottle of its own. **[5]**

36. Write the word equation and the balanced equation for the reactions when:

    (i) dilute sulphuric acid reacts with zinc granules.

    (ii) dilute hydrochloric acid reacts with magnesium ribbon.

    (iii) dilute sulphuric acid reacts with aluminium powder.

    (iv) dilute hydrochloric acid reacts with iron filings. **[5]**

Try yourself:

1. Which acid is present in Guava?
2. Sting of bees, red ant and wasps contain which acid?
3. What is the formula of Nitrous acid?

Try yourself

4. Write down the products of the reaction between magnesium oxide and sulphuric acid.
5.. What will be the product when zinc react with suphuric acid.

Try yourself

8. Classify the following bases into the categories of strong and weak bases.
   $Ca(OH)_2$, NaOH, KOH, NH_4OH

Try yourself

9. A solution turns red litmus blue, its pH is likely to be :
   (A) 1 (B) 4 (C) 5 (D) 10
10. Calculate the pH of a solution which is $1x10^{-4}$ mol/L in HCl.
11. Fresh milk has pH of 6. How do you think the pH will change as it turns into curd?

Try yourself

12. Which one of the following type of medicine is used, for treating indigestion?
   (A) Antibiotic (B) Analgesic (C) Antacid (D) Antiseptic.
13. A solution reacts with crushed egg-shells to give a gas that turns limewater milky. The solution contains.
   (A) NaCl (B) HCl (C) LiCl (D) KCl

EXERCISE-II

1. Why does an aqueous solution of an acid conduct electricity? **[1]**
2. How is the concentration of hydroxide ions (OH^-) affected when excess base is dissolved in a solution hydroxide? **[1]**
3. Under what soil condition do you think a farmer would treat the soil of his fields with quick lime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate)? **[1]**
4. What is the common name of the compound $CaOCl_2$? **[1]**
5. Name the sodium compound which is used for softening hard water? **[1]**
6. Write an equation to show the reaction between Plaster of Paris and water? **[1]**
7. Why should curd and sour substances not be kept in brass and copper vessels? **[2]**
8. Metal compound A reacts with dilute hydrochloric acid to produce effervescence. The gas evolved extinguishes a burning candle. Write a balanced chemical equation for the reaction if one of the compounds formed is calcium chloride. **[2]**
9. While diluting an acid, why is it recommended that the acid should be added to water and not water to the acid? **[2]**
10. You have two solutions A and B, the pH of solution A is 6 and pH of solution B is 8. Which solution has more hydrogen ion concentration?Which of this is acidic and which one is basic? **[2]**

11. What will happen if a solution of sodium hydrocarbonate is heated? Give the equation of the reaction involved. **[2]**
12. Why does distilled water not conduct electricity, where as rain water does? **[2]**
13. Fresh milk has a pH of 6. How do you think the pH will change as it turns into curd?
    Explain your answer. **[2]**
14. A milkman adds a very small amount of baking soda to fresh milk.
    (a) Why does he shift the pH of the fresh milk from 6 to slightly alkaline?
    (b) Why does this milk take a long time to set as curd? **[2]**
15. Plaster of Paris should be stored in a moisture - proof container. Explain why? **[2]**
16. What is a neutralisation reaction? Give two examples. **[2]**
17. Equal lengths of magnesium ribbons are taken in test tubes A and B. Hydrochloric acid (HCl) is added to test tube. A, while acetic acid (CH_3COOH) is added to test tube B. In which test tube will the fizzing occur more vigorously and why? **[3]**

EXERCISE-III

SECTION-A

- **Fill in the blanks**

1. Colour, odour, taste, state are all .... properties.
2. Tamarind taste sour due to presence of ....
3. Litmus solution is extracted from ....
4. Nitric acid is an example of .... acid.
5. .... acid is a weak acid.
6. Grapes contain .... acid.
7. Honey-bee sting has .... acid.
8. .... gas is evolued when metals react with ....
9. Acids obtained from plants and animals are called .... acid.
10. Anhydrous sodium carbonate is commonly known as ....

SECTION-B

- **Multiple choice question with one correct answers**

1. A solutions turns red litmus blue. Its pH is likely to be:
   (A) 2 (B) 4 (C) 7 (D) 10
2. A solution reacts with crushed egg - shells to give a gas that turns lime water mikly. The solutions contains.
   (A) NaCl (B) HCl (C) LiCl (D) KCl
3. 10 mL of a solution of NaOH is found to be completely neutralised by 8 mL of a given solutions of HCl. If we take 20 mL of the same solution of NaOH, the amount of HCl solution (the same solution as before) required to neutralise will be

(A) 4 mL (B) 8 mL (C) 12 mL (D) 16 mL

4. Which of the following types of medicines is used for treating indigestion?
(A) Antibiotic (B) Analgesic (C) Antacid (D) Antiseptic

5. A salt derived from strong acid and weak base will dissolve in water to give a solution which is
(A) acidic (B) basic (C) neutral (D) none of these

6. Which of the following metals can displace hydrogen from the aqueous solution of sodium hydroxide?
(A) Mg (B) Cu (C) Al (D) Ag

7. An aqueous solution with pH = zero is
(A) Acidic (B) Alkaline (C) Neutral (D) Amphoteric

8. The pH of a solution of hydrochloric acid is 4. The molarity of solution is
(A) 4.0 (B) 0.4 (C) 0.0001 (D) 0.04

9. When water is added to quick lime, the reaction is :
(A) explosive (B) endothermic (C) Exothermic (D) photochemical

10. Carbonic acid (H_2CO_3) is
(A) strong acid (B) weak acid (C) strong base (D) weak base

11. If pH of solution is 13, it means that it is :
(A) weakly acidic (B) weakly basic (C) strongly acidic (D) strongly basic

12. Which is a base and not an alkali?
(A) NaOH (B) KOH (C) $Fe(OH)_3$ (D) None is true

13. The H^+ ion concentration of a solution 1.0×10^{-5} M. The solution is
(A) acidic (B) alkaline (C) neutral (D) amphoteric

14. Which of the following salts on dissolving in water, will give a solution with pH less than 7 at 298 K?
(A) KCN (B) CH_3COONa (C) NaBr (D) NH_4Cl

15. Which of the following gives carbon dioxide on heating?
(A) Slaked lime (B) Lime stone (C) Quick lime (D) Soda ash

SECTION-C

- **Assertion & Reason**

Instructions: In the following questions as Assertion (A) is given followed by a Reason (R). Mark your responses from the following options.

(A) Both Assertion and Reason are true and Reason is the correct explanation of ‘Assertion’
(B) Both Assertion and Reason are true and Reason is not the correct explanation of ‘Assertion’
(C) Assertion is true but Reason is false
(D) Assertion is false but Reason is true

1. **Assertion:** The bleaching powder is yellowish with powder and smells like chlorine.
Reason: It loose its chlorine on exposure to air.

2. **Assertion:** All Bronsted-Lowry bases are also Lewis bases.
Reason: All Bronsted acids are Lewis acids..

SECTION-D

- **Match the following (one to one)**

  Column-I and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. Only One entries of column-I may have the matching with the same entries of column-II and one entry of column-II Only one matching with entries of column-I

1.

Column I (Substances)	Column II (ph range)
(A) Human blood	(P) 2.0 - 4.0
(B) Soft drinks	(Q) 4.8 - 8.4
(C) Vinegar	(R) 7.36 - 7.42
(D) Human Urine	(S) 2.4 - 3.4

EXERCISE-IV

SECTION-A

- **Multiple choice question with one correct answers**

1. Bleaching powder gives smell of chlorine because it
   (A) is unstable (B) gives chlorine on exposure to atmosphere
   (C) is a mixture of chlorine and salked lime (D) contains excess of chlorine
2. Baking powder contains baking soda and
   (A) tartaric acid (B) calcium bicarbonate (C) sodium carbonate (D) vinegar
3. Plaster of Paris is made from:
   (A) lime stone (B) slaked lime (C) quick lime (D) gypsum
4. Which of the following is formed when Na_2CO_3 is heated?
   (A) CO_2 gas (B) CO gas (C) O_2 gas (D) NO gas
5. Setting of plaster of Paris takes place due to
   (A) oxidation (B) reduction (C) dehydration (D) hydration
6. Chemical formula of baking soda is
   (A) $MgSO_4$ (B) Na_2CO_3 (C) $NaHCO_3$ (D) $MgCO_3$
7. A white chemical becomes hard on mixing with water and is used in surgery. It is
   (A) baking soda (B) baking powder (C) washing soda (D) plaster of Paris
8. The chemical name of marble is
   (A) Calcium carbonate (B) Magnesium carbonate
   (C) Calcium chloride (D) Calcium sulphate
9. Washing soda has the formula
   (A) $Na_2CO_3 . 7H_2O$ (B) $Na_2CO_3 . 10H_2O$ (C) $Na_2CO_3 . H_2O$ (D) Na_2CO_3

10. The raw materials required for the manufacture of Na_2CO_3 by solvay process are

(A) $CaCl_2$,$(NH_4)_2CO_2$, NH_3 (B) NH_4Cl, NaCl, $Ca(OH)_2$

(C) NaCl, $(HN_4)_2CO_2$, NH_3 (D) NaCl, NH_3, $CaCO_3$

11. Plaster of Paris hardens by

(A) Giving off CO_2 (B) Changing into a $CaCO_3$

(C) Combining with water (D) Giving out water

12. The difference of water molecules in gypsum and plaster of Paris is

(A) 5/2 (B) 2 (C) 1/2 (D) 3/2

SECTION - B

- **Multiple choice question with one or more than one correct answers**

1. Which of the following contain citric acid.

(A) Oranges (B) Lemon (C) Amla (D) Apple

2. Cl^- is not a conjugate base of which acid?.

(A) HCl (B) HOCl (C) $HClO_3$ (D) H_3O^+

3. Which of the following are complex salt.

(A) $K_2(SO_4)$. $Al_2(SO_4)_3.24H_2O$ (B) $K_4Fe(CN)_6$

(C) $NaAg(CN)_2$ (D) NaCl

4. Which of the following are basic in nature?

(A) Milk of Magnesia (B) Vinegar (C) Ammonia (D) Lemon Juice

5. Which one/are Lewis acid among the following:

(A) $AlCl_3$ (B) BF_3 (C) $BeCl_2$ (D) $FeCl_3$

SECTION-C

- **Comprehension**

Salt is the product of a neutralisation reaction between an acid and a base. For examples, Sodium chloride is formed by the reaction between sodium hydroxide and hydrochloric acid.

In this reaction hydrogen ion of an acid is replaced by metal ion or ammonium ion, thus, a salt may also be defined as the compound when the hydrogen ion of an acid is replaced by a metal ion or an ammonium ion. Salts are formed by the reaction between an acid and a base.

$$HA + MOH \rightarrow M^+A^- + H_2O$$

acid base/alkali Salt Water

1. Zinc sulphate ($ZnSO_4$) is :

(A) Acidic salt (B) Basic salt (C) Neutral salt (D) Double Salt

2. 20% common salt solution is called

(A) Wine (B) Shine (C) Brine (D) none of these

3. Formula of Soda ash is :

(A) NaOH (B) Na_2CO_3 (C) $Na_2CO_3.10H_2O$ (D) $NaHCO_3$

4. Salt formed by combination of actic acid (CH_3COOH) and sodium hydroxide (NaOH) is-

(A) $(CH_3COO)_2Na$ (B) CH_3COONa (C) CH_3CONa (D) None of these

SECTION-D

- **Match the following (one to many)**

Column-I and **column-II** contains **four** entries each. Entries of column-I are to be matched with some entries of column-II. One or more than one entries of column-I may have the matching with the some entries of column-II and one entry of column-II may have one or more than one matching with entries of column-I

1.

	Column A		**Column B**
(A)	Hydrochloric acid	(P)	Good conductor of electricity
(B)	Sulphuric Acid	(Q)	Mono Basic
(C)	Nitric Acid	(R)	Oxy Acid
(D)	Acetic Acid	(S)	Weak Acid

Answers

TRY YOURSELF

1. Oxalic acid. $\begin{array}{l} COOH \\ | \\ COOH \end{array}$
2. Formic acid HCOOH, which causes pain.
3. HNO_2
4. Magnesium sulphate and water.
5. Products will be zinc sulphate and hydrogen.
8. When a solution of an acid is diluted, the concentration of H_3O^+ decreases.
9. (D) 10. 4
11. Curd contains free lactic acid. So, pH of the curd will be less than that of the fresh milk.
12. (C) 13. (B)

EXERCISE-III

SECTION-A

1. Physical	**2.** Acid	**3.** Lichen
4. Oxy	**5.** Acetic	**6.** Tartaric
7. Formic	**8.** Carbondioxides, Carbonates	**9.** Organic
10. Soda ash		

SECTION-B

1.	(D)	**2.**	(B)	**3.**	(D)	**4.**	(C)	**5.**	(A)	**6.**	(C)
7.	(A)	**8.**	(C)	**9.**	(C)	**10.**	(B)	**11.**	(D)	**12.**	(C)
13.	(A)	**14.**	(D)	**15.**	(B)						

SECTION-C

1. (A) **2.** (B)

SECTION-D

1. (A)-(R), (B)-(P), (C)-(S), (D)-(Q)

EXERCISE-IV

SECTION-A

1.	(B)	**2.**	(A)	**3.**	(D)	**4.**	(A)	**5.**	(D)	**6.**	(C)
7.	(D)	**8.**	(A)	**9.**	(B)	**10.**	(D)	**11.**	(D)	**12.**	(D)

SECTION-B

1. (A,B,C) **2.** (A,C) **3.** (B,C) **4.** (A,C) **5.** (A,B,D)

SECTION-C

1. (A) **2.** (C) **3.** (B) **4.** (B)

SECTION-D

1. (A)-(P,Q), (B)-(P,R), (C)-(P,Q,R), (D)-(P,Q,R,S)

*****