CLASSROOM STUDY PACKAGE

CHEMISTRY

Acid and Bases

JEE EXPERT

ACID AND BASES

CONTENTS

KEY CONCEPTS

Acids and Bases : The sour taste of lemons and lime, and the tang of a tomato are all caused by acids. Citric acid, acetic acid, and tartaric acid are examples.

The slippery feel of soap and some household cleaning solutions, such as ammonia have the typical slippery feel of a base. Bases feel slippery because they react with oils on your skin to form soap-like substances.

Review Electrolytes in Aqueous solution :

Strong Electrolytes will largely dissociate into its ions in an aqueous solution and are written as separated ions in the ionic reactions.

Examples : Strong acids, Strong Bases, Soluble salts.

Strong Acids : HCl, HBr, HI,HNO_3, H_2SO_4, $HClO_4$, $HClO_3$

Strong Bases : soluble hydroxides from Group 1A (not including H) and Group II A, not including the top two) LiOH, NaOH, KOH, RbOH, $Ca(OH)_2$, $Sr(OH)_2$, $Ba(OH)_2$.

Soluble Salts : Ionic compounds that contain the cations from Group 1A, Li^+, Na^+, K^+, Bb^+, Cs^+, or ammonium ion, NH_4^+. A compound is probably soluble if it has the anion ; Cl^-, Br^-, I^- except with Ag^+, Hg_2^{2+}, or Pb^{2-}, and most compounds that include NO_3^- , ClO_4^-, $C_2H_3O_2^-$, Soluble with most SO_4^{2-} except Ba^{2+}, Hg_2^{2+} or Pb^{2+}.

Weak Electrolytes partially dissociate into its ions in an aqueous solution, but are written as compounds in an ionic equation. Weak electrolytes are weak acids and weak bases such as $HC_2H_3O_2$ or NH_3

ACIDS : Substances with sour taste are regarded as acids. Lemon juice, vinegar, grape fruit juice and spoilt milk etc. taste sour since they are acidic. Many substances can be identified as acids based on their taste but some fo the acids like sulphuric acid have very strong action on the skin which means that they are corrosive in nature. In such case it would be according to modern definition :

An acid may be defined as a substance which release one or more H^+ ions in aqueous solution.

Acids are mostly obtained from natural sources.

Hydrochloric Acid [HCl] : Hydrochloric acid is the main component of stomach acid. Hydrochloric acid is found in most chemistry laboratories. It is used in industry to clean metals, to propare and process foods, and to refine metal ores.

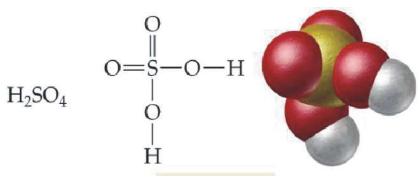
Hydrochloric acid helps break down foods, and to refine metal ores.

Hydrochloric acid helps break down food. It kills harmful bacteria that might enter the body through food. The sour taste associated with indigestion is caused by the stomach's hydrochloric acid.

Sulfuric Acid [H_2SO_4] :

* Sulfuric acid is used in the manufacture of fertilizers, explosives, dyes, and glue.

* Sulfuric acid is contained in most automobile batteries.

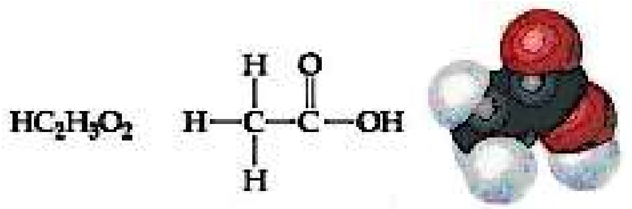


Sulfuric acid

Acetic Acid [CH_3COOH] :

* Acetic acid forms in improperly stored wines. The word vinegar originates from the French vin aigre, which means "sour wine."

* Acetic acid is an example of a carboxlic acid, an acid containing the COOH grouping of atoms, known as the carboxylic acid group.



Acetic acid

Classification of Acids :

(i) Classification of Acids on the basis of their Sources

On the basis of their sources, acids can be classified in two categories :

(A) Organic acids (B) Inorganic acids

The acids which are usually obtained from plants are known as organic acids. Oxalic acid [$(COOH)_2$], acetic acid (CH_3COOH) etc. are very common examples of organic acids. Some other organic acids with their natural sources are given in Table.

Some Organic Acids with Their Natural Sources

S.No.	Organic acid	Natural sources	S.No.	Organic acid	Natural sources
1	Acetic acid	Vinegar	7	Oleic acid	Olive Oil
2.	Citric acid	Citrus fruits (like orange and lemon)	8	Stearic acid	Fats
3.	Butyric acid	Rancid butter	9	Amino acid	Proteins
4.	Formic acid	String of bees and ants	10	Uric acid	Urine
5.	Lactic acid	Sour milk	11	Tartaric acid	Tamarind
6.	Malic acid	Apples	12	Oxalic acid	Tomatoes

→ All organic acids contain carbon as one of their constituting elements. These are weak acids and, therefore, do not ionise completely in their aqueous solutions. Since these acids do not ionise cmpletely in their aqueous solutions, therefore, their solutions contains both ions as well as undissociated molecules. For example, formic acid's aqueous solution contains H_3O^+, $HCOO^-$ as well as undissociated HCOOH molecules.

$$\underset{\text{Formic acid}}{HCOOH} + H_2O \rightleftharpoons \underset{\text{Hydronium ion}}{H_3O^+} + \underset{\text{Formate ion}}{HCOO^-}$$

(B) Inorganic Acids : The acids which are usually obtained from minerals are known as inorganic acids. Since the acids are obtained from minerals, therefore, these acids are also called mineral acids. Some common examples of inorganic acids are : Hydrochloric acid (HCl), Sulphuric acid (H_2SO_4), Nitric acid (HNO_3) etc.

→ Except carbonic acid (H_2CO_3), these acids do not contain carbon. Acids like HCl, H_2SO_4 and HNO_3 HNO_3 are strong acids which ionise completly in their aqueous solutions and therefore, their aqueous solutions do not contain any undissociated molecules.

(ii) Classification on the basis of their Basicity : The basicity of an acid is defined as the number of hydronium ions [H_3O^+ (aq.)] that can be produced by the complete ionisation of one molecule of that acid in aqueous solution.

For example, basisity of HCl, H_2SO_4, H_3PO_4 is 1, 2 and 3 respectively because one molecule of these acids, on ionisation, produces 1, 2 and 3 hydronium ions in aqueous solution respectively.

It may be pointed out here that the basicity of an acid is determined by number of hydronium ions produced per molecule of an acid on ionisation and not the number of hydrogen atoms present in one molecule of an acid. For example, basisity of acetic acid (CH_3COOH) is 1 because one molecule of acetic acid, on ionisation in aqueous solution, produces one hydronium ion although one molecule of acetic acid contains four hydrogen atoms.

$$\underset{\text{Acetic acid}}{CH_3COOH + H_2O} \rightleftharpoons \underset{\text{Hydronium ion}}{H_3O^+} + \underset{\text{Acetic ion}}{CH_3COO^-}$$

On the basis of basicity, the acids can be classified as under :

(A) Monobasic Acids : When one molecule of an acid on complete ionisation produces one hydronium ion (H_3O^+) in aqueous solution, the acid is said to be a monobasic acid.

Examples of Monobasic Acids :

Some examples of monobasic acids are :

(i) Hydrochloric acid (HCl)	(ii) Hydrobromic acid (HBr)
(iii) Hydrofluoric acid (HF)	(iv) Nitric acid (HNO_3)
(v) Acetic acid (CH_3COOH)	(vii) Formic acid (HCOOH)

Characteristics of Monobasic Acids :

Two important characteristics of monobasic acids are :

(i) A monobasic acid ionises in one step in aqueous solution. For example,

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

(Single step ionisation)

(ii) A monobasic acid forms only singles salt or a normal salt. For example,

$$HCl + NaOH \longrightarrow \underset{\substack{\text{Sodium chloride} \\ \text{(Normal salt)}}}{NaCl} + H_2O$$

(B) Dibasic Acids : When one molecule of an acid on complete ionisation produces two hydronium ions (H_3O^+) in aqueous solution, the acid is said to be a dibasic acid.

Examples of Dibasic Acids :

Some examples of dibasic acids are :

(i) Sulphuric acid (H_2SO_4)	(ii) Sulphurous acid (H_2SO_3)
(iii) Carbonic acid (H_2CO_3)	(iv) Oxalic acid [$(COOH)_2$]

Characteristics of Dibasic Acids :

Two important characteristics of dibasic acids are :

(i) A dibasic acid ionises in two steps in aqueous solution. For example, sulphuric acid which is a dibasic acid ionises to produce bisulphate ion (HSO_4^-) in the first step which further ionises to produce sulphate ion (SO_4^{2-}) in the second step.

$$\underset{\text{Sulphuric acid}}{H_2SO_4} + H_2O \rightleftharpoons H_3O^+ + \underset{\text{Bisulphate ion}}{HSO_4^-}$$

$$HSO_4^- + H_2O \rightleftharpoons H_3O^+ + \underset{\text{Sulphate ion}}{SO_4^{2-}}$$

(ii) Because of the presence of two replaceable hydrogen ions, a dibasic acid forms two series of salts i.e., an acid salt and a normal salt. For example, H_2SO_4 reacts with NaOH to form $NaHSO_4$ (an acid salt) and Na_2SO_4 (a normal salt)

$$NaOH + H_2SO_4 \longrightarrow \underset{\substack{\text{Sodium hydrogen} \\ \text{sulphate} \\ \text{(An acid salt)}}}{NaHSO_4} + H_2O$$

(C) Tribasic Acids : When one molecule of an acid on complete ionisation produces three hydronium ions (H_3O^+) in aqueous solution, the acid is said to be a triabsic acid.

An example of tribasic acids is Phosphoric acid (H_3PO_4).

(iii) Classification of acids on the basis of their strength : We know that acids ionise in the aqueous solution to produce hydronium ions. So, the strength of an acid depends upon the degree of ionisation, usually depends upon the degree of ionisation, usually depends upon the degree of ionisation, usually depends denoted by the letter alpha (α).

Degree of ionisation of an acid (α)

$$\frac{\text{Number of molecules of the acid undergoing ionisation}}{\text{Total number of acid molecules}} \times 100$$

More the degree of ionisation (α) of an acid, more stronger it will be.

On the basis of degree of ionisation, the acids can be classificed as under.

(A) Strong Acids : The acids which undergo almost complete ionisation in a dilute aqueous solution, there by producing a high concentration of hydronium ions (H_3O^+) are known as strong acids.

Examples of strong acids :

Some examples of strong acids are :

(i) Hydrochloric acid (HCl)

(ii) Sulphuric acid (H_2SO_4)

(iii) Nitric acid (HNO_3)

All these three mineral acids are considered to be strong acids because they ionise almost completely in their dilute aqueous solutions.

(B) Weak Acids : The acids which undergo partial or incomplete ionisation in a dilute aqueous solution, thereby producing a low concentration of hydronium ions (H_3O^+) are known as weak acids.

(i) Acetic acid (CH_3COOH)

(ii) Formic acid (HCOOH)

(iii) Oxalic acid [$(COOH)_2$]

(iv) Carbonic acid (H_2CO_3)

(v) Hydrogen sulphide (H_2S)

(vi) Hydrocyanic acid (HCN)

Clasification on the basis of Concentration of the Acid : By the term concentration, we mean the amount of water present in the given sample of acid solution in water.

(A) Concentrated Acid : The sample of an acid which contains very small or no amount of water is called a concentrated acid.

(B) Dilute Acid : The sample of an acid which contains far more amount of water than its own mass is known as a dilute acid.

It must be mentioned here that concentration of an acid simply tells the amount of water in the acid. It may not be confused with strength of an acid, which is a measure of concentration of hydronium ion it produces in aqueous solution.

A concentrated acid may not necessarily be a strong acid while a dilute acid may not necessarily be a weak acid. A strong acid will remain strong even if it is dilute because it produces a large concentration of hydronium ions in aqueous solution. On the other hand, a weak acid will remain weak even when concentrated because it will produce lesser concentration of hydronium ions in aqueous solution.

Name	Type	Chemical Formula	Where found or used
Carbonic acid	Mineral acid	H_2CO_3	In soft drinks and lends fizz,
Nitric acid	Mineral Acid	HNO_3	Used in the manufacture of explosives. (TNT, Nitroglycerine) and fertilizers (Ammonium nitrate, Calcium nitrate, Purification of Au, Ag.)
Hydrochloric acid	Mineral Acid	HCl	In purification of common salt, in textile industry as bealching agent, to make aqua regia, In stomach as gastric juice, used in tanning industry
Sulhuric acid	Mineral Acid	H_2SO_4	Commonly used in car batteries, in the manufacture of fertilizers (Ammonium sulphate), detergents etc, in paints, plastics, drugs, in manufacture of artificial silk, in petroleum refining.
Phosphoric acid	Mineral Acid	H_3PO_4	Used in antirust paints and in fertilizers.
Formic acid	Organic Acid	$HCOOH(CH_2O_2)$	Found in the stings of ants and bees, used in tanning leather, in medicines for treating gout disease of jointly.
Acetic acid	Organic Acid	$CH_3COOH(C_2H_4O_2)$	Found in vinegar, used a solvent in the manufacture of dyes and perfumes.
Lactic acid	Organic Acid	$CH_3CH(OH)COOH(C_3H_6O_3)$	Responsible for souring of milk in curd.
Benzoic acid	Organic Acid	C_6H_5COOH	Used as a food preservation.
Critic acid	Organic Acid	C_6H_8O	Present in lemons, oranges and citrus fruits.

Chemical Properties of Acids :

1. Action with metals: Dilute acids like dilute HCl and dilute H_2SO_4 react with certain active metals to evolve hydrogen gas.

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

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

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

$$Zn(s) + H_2SO_4\ (dilute) \longrightarrow ZnSO_4(aq) + H_2(g)$$

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

For e.g.

$$Zn(s) \longrightarrow Zn^{2+}\ (aq) + 2e^-$$

$$Zn^{+2}(aq) + SO_4^{2-}(aq) + 2e^- \longrightarrow H_2(g) + SO_4^{2-}\ (aq)$$

$$Zn(s) + 2H^+\ (aq) \longrightarrow Zn^{2+}(aq) + H_2(g)$$

2. **Action with metal oxides :** Acids react with metal oxides to form salt and water. These reactions are mostly carried out upon heating.
For e.g.

$$ZnO(s) + 2HCl(aq) \longrightarrow ZNCl_2(aq) + H_2O$$

$$MgO(s) + H_2SO_4(aq) \longrightarrow MgSO_4(aq) + H_2O$$

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

3. **Action with metal carbonates and metal bicarbonates :** Both metal carbonates and bicarbonates react with acids to evolve CO_2 gas and form salts.
For e.g.

$$\underset{\text{Calcium carbonate}}{CaCO_3(s)} + 2HCl(aq) \longrightarrow \underset{\text{Calcium chloride}}{CaCl_2(aq)} + H_2O + CO_2(g)$$

$$\underset{\text{Sodium bicarbonate}}{2NaHCO_3(s)} + H_2SO_4(aq) \longrightarrow \underset{\text{Sodium sulpahte}}{Na_2SO_4(aq)} + H_2O(aq) + CO_2(g)$$

4. **Action with bases :** Acids react with bases to give salts and water. (Neutralisation)

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

Bases : Substances with bitter taste and soapy touch are regarded as bases. Since many bases like sodium hydroxide and potassium hydroxide have corrosive action on the skin and can even harm the body, so according to the modern definition.
A base many be defined as a substance capable of releasing one or more OH^- ions in aqueous solution.

(a) Characteristics of a Base :
(i) A base changes red litmus to blue.
(ii) A base reacts with an acid so that a salt and water are formed.

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

(iii) A base cmbines with carbon dioxide so that a carbonate is formed.
(iv) A base is slippery like soap. It tastes unpleasent and bitter.

Distinction Between an Alkali and a Base : It may be kept in mind that a base which is soluble in water is called an alkali. This means that all alkalis are bases but all bases are not alkalis. For example. Ferric hydroxide [$Fe(OH)_3$] and cupric hydroxide [$Cu(OH)_2$] are bases but not termed as akalis because they are insoluble in water.

(b) Classification of bases or Alkalis :
Classification of bases or alkalis can be done in different ways as given below :
(i) Classification on the basis of their strength
(ii) Classification on the basis of their concentration.
(iii) Classification on the basis of their acidity.

(i) Classification of the Bases or Alkalis on the Basis of their Strength : We know that alkalis (soluble bases) ionise in aqueous solution to produce hydroxyl (OH^-) ions. So the strength of an alkali (solubel base) depends upon its degree of ionisation, usually denoted by the letter alpha(α).
Degree of ionisation of an alkali (α)

$$= \frac{\text{Number of molecules of the alkali undergoing ionisation}}{\text{Total number of alkali molecules}} \times 100$$

More the degree of ionisation (α) of an alkali (or a soluble base), more stronger it will be. On the basis of degree of ionisation, the alkalis (or soluble bases) can be classified as under.

(A) Strong alkalis or bases : The alkalis or bases which undergo almost complete ionisation in aqueous solution to produce high concentration of hydroxyl (OH^-) ions are known as strong alkalis or strong bases.

Example of strong alkalis or bases : Some example of strong alkalis or bases are : Sodium hydroxide (NaOH), Potassium hydroxide (KOH) and Barium hydroxide [$Ba(OH)_2$] etc.

$$\left.\begin{array}{l} NaOH(aq.) \longrightarrow Na^+ (aq) + OH^- (aq.) \\ Ba(OH)_2(aq.) \longrightarrow Ba^{2+} (aq) + 2OH^- (aq.) \end{array}\right\} \text{(Almost completely ionised)}$$

(B) Weak alkalis or bases : The alkalis or bases which undergo only partial ionisation in aqueous solution to produce a relatively low concentration of hydroxyl (OH^-) ions are known as weak alkalis or weak base.
Some examples of weak alkalis or bases are : Ammonium hydroxde (NH_4OH). Calcium hydroxide [$Ca(OH)_2$],Magnesium hydroxide [$Mg(OH)_2$] etc.

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

Since these alkalis are not ionising completely, therefore, there is a dynamic equilibrium between the undissolved alkali and the ions produced by it.

(ii) Classification of Bases or Alkalis on the Basis of their Concentration : By the term concentration, we mean the amount of water present in the given sample of alkali solution in water. On the basis of concentration, the alkalis can be classified as under :

(A) Concentrated alkali : A solution of alkali having a relatively high percentage of alkali in its aqueous solution is known as concentrated alkali.

(B) Dilute alkali : A solution of alkali having a relatively low percentage of alkali in its aqueous solution is known as a dilute alkali.
If the concentration of alkali in the solution is less than 1 mole per litre, then it is considred to be a dilute alkali.

(iii) Classification of Bases or Alkalis on the Basis of their Acidity : The number of hydroxyl (OH^-) ions produced by one molecule of an alkali on complete dissociation in water or the number or hydrogen ions (of an acid) with which a molecule of that alkali reacts to produce salt and water only is known as acidity of an alkali.
For water insoluble hydroxides, acidity of the base is equal to the number of OH^- ions present in one molecule of that base.
On the basis of acidity, the bases can be classified as under.

(A) Monoacidic Bases (or alkalis) : When one molecule of the base on complete ionisation produces one hydroxyl (OH^-) ion in aqueous solution, the base or alkali is said to be monoacidic

OR

A monoacidic base (or alkali) may be defined as one whose one molecule reacts with one hydrgen (H^+) ion completely to form salt and water as the only products.

Examples of Monoacidic Base (or alkalis) : Sodium hydroxide (NaOH), Potassium hydroxide (KOH), Ammonium hydroxide (NH_4OH). All these substances produce only one hydroxyl ion on complete ionisation in aqueous solution.

$$NaOH(aq) \longrightarrow Na^+ (aq) + OH^- (aq)$$
$$KOH(aq) \longrightarrow K^+ (aq) + OH^- (aq)$$

The dissociation of monoacidic bases or alkalis takes place in a single step.

(B) Diacidic Bases (or alkalis) : When one molecule of a base or alkali on complete ionisation produces two hydroxyl (OH^-) ions in aqueous solution, the base or alkali is said to be diacidic.

OR

A diacidic base (or alkali) may be defined as one whose one molecule reacts with two hydrogen (H^+) ions completely to form salt and water as the only products.

Examples of Diacidic Bases (or alkalis).

Calcium hydroxide [$Ca(OH)_2$] and magnesium hydroxide [$Mg(OH)_2$].

$$Ca(OH)_2(aq) \longrightarrow Ca^{2+} (aq) + 2OH^-(aq)$$
$$Mg(OH)_2(aq) \longrightarrow Mg^{2+} (aq) + 2OH^- (aq)$$

One molecule of both the alkalis are producing $2OH^-$ ions in aqueous solution, therefore, these are termed as diacidic alkalis.

Diacidic Bases :

Ferrous hydroxide [$Fe(OH)_2$] and copper hydroxide [$Cu(OH)_2$]

$$Cu^{2+}(OH)_2^- + 2H^+Cl^-(aq) \longrightarrow CuCl_2 + 2H_2O$$

Since one molecule of $Cu(OH)_2$ is reacting with two hydrogen (H^+) ions, therefore, this is termed as a diacidic base.

(C) Triacidic Bases : When one molecule of a base or alkali on complete ionisation produces three hydroxyl (OH^-) ions in aqueous solution, the base or alkali is said to be triacidic base.

Examples of Triacidic Bases :

Aluminium hydroxide [$Al(OH)_3$], Ferric hydroxide [$Fe(OH)_3$].

$$Al(OH)_3(aq) \longrightarrow Al^{3+}(aq) + 3OH^-(aq)$$

$$Al(OH)_3 + 3HCl\,(aq) \longrightarrow AlCl_3 + 3H_2O$$

In the above equations, one molecule of $Al(OH)_3$ is producing three OH^- ions and one molecule of $Al(OH)_3$ is reacting with three hydrogen (H^+) ions to form salt and water only, therefore, it is termed as a triacidic base.

Name	**Commercial Name**	**Chemical Formula**	**Uses**
Sodium hydroxide	Caustic Soda	$NaOH$	In manufacture of soap, paper, pulp, refining of petroleum etc.
Potassium hydroxide	Caustic potash	KOH	In alkaline storage batteries, manufacture of soap, absorbing CO_2 gas etc.
Calcium hydroxide	Slaked lime	$Ca(OH)_2$	In manufacture of bleaching powder softening of hard water etc.
Magnesium hydroxide	Milk of magnesia	$Mg(OH)_2$	As an antacid to remove acidity from stomach
Aluminium hydroxide	-	$Al(OH)_3$	As foaming agent in fire extinguishers.

Chemical Properties :

1. **Action with metals :** Metals like zinc, tin and aluminum react with strong alkalies like NaOH (caustic soda), KOH (caustic potash) to evolve hydrogen gas.

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

$$2Al(s) + 2NaOH + 2H_2O \longrightarrow \underset{\text{Sodium meta aluminate}}{2NaAlO_2(aq)} + 3H_2(g)$$

2. **Action with non-metallic oxides :** Acids react with metal oxides, but bases react with oxides of non-metals to form salt and water.

For e.g.

$$2NaOH(aq) + CO_2(g) \longrightarrow Na_2CO_3(aq) + H_2O\,(\ell)$$

$$Ca(OH)_2(s) + CO_2(g) \longrightarrow CaCO_3(s) + H_2O\,(\ell)$$

Some common bases :

* Sodium hydroxide (NaOH) and potassium hydroxide (KOH), are found in most chemistry laboratories. They are used in processing petroleum and cotton, and in soap and plastic manufacturing.

* Sodium bicarbonate ($NaHCO_3$) can be found in most homes as baking soda and is an active ingredient in many antacids. When taken as an antacid, sodium bicarbonate neutralizes stomach acid, relieving heartburn and sour stomach.
* Bases are less common in foods than acids because of their bitter taste. Our aversion to the taste of bases is probably an adaptation to protect us against alkaloids, organic bases found in plants, which are often poisonous.
  The bitter taste warns us against eating them.
* Coffee is **acidic** overall, but bases present in coffee such as caffeine - impart a bitter flavor.

$C_8H_{10}N_4O_2$

Caffeine

	Acids		Bases
1.	Sour in taste.	**1.**	Bitterness in taste.
2.	Change colours of indicators Ex. Litmus turns from blue to red, phenolphthalein remains colourless.	**2.**	Change colours of indicators eg, litmus turns from red to blue, phenolphthalein turns from colourless to pink.
3.	Shows electrolytic conductivity in aqueous solution.	**3.**	Shows electrolytic conductivity in aqueous solutions.
4.	Acidic properties disappear when reacts with bases (Neutralisation).	**4.**	Basic properties disappear when reacts with acids (Neutralisation).
5.	Acids decompose carbonate salts.	**5.**	No decomposition of carbonate salts by bases.

ROLE OF WATER IN THE IONISATION OF ACIDS AND BASES : Substances can act as acids and bases only in the presence of water in aqueous solution. In dry state which is also called anhydrous state, these characters cannot be shown Actually, water helps in the ionisation of acids or base by separating the ions. This is also known as dissociation and is explained on the basis of a theory called Arrhenius theory of acids and bases.

In the dry state, hydrochloric acid is known as hydrogen chloride gas i.e. HCl(g). It is not in the position to give any H^+ ions. Therefore, the acidic character is not shown. Now, let us pass the gas through water taken in a beaker with the help of glass pipe. H_2O molecules are of polar nature which means that they have partial negative charge on oxygen atom and partial positive charge on hydrogen atoms. They will try to form a sort of envelope around the hydrogen atoms as well as chlorine atoms present in the acid and thus help in their separation as ions. These ions are said to be hydrated ions.

$$HCl(g) + Water \longrightarrow \underset{\text{(Hydrated ions)}}{H^+(aq) + Cl^-(aq)}$$

DILUTION OF ACIDS AND BASES : Acids and bases are mostly water soluble and can be diluted by adding the required amount of water. With the addition of water the amount of acid or base per unit volume decrease and dilution occurs. The process is generally exothermic in nature. A concentrated acid like sulphuric acid or nitric acid is to be diluted with water. Acid should be added dropwise to water taken in the container with constant stirring.

NOMENCLATURE OF ACIDS,BASES & SALTS :

(a) **Acid :** Acid have two groups

(i) **Hydra acids :** Those acids in which hydrogen atom combines with some other atom. Those acid are also called hydracids.

(ii) **Oxy acids :** Acids with oxygen is called oxy acids.

Nomenclature of Binary acids :

Hydracids generally begin with 'hydro' and end in 'ic'.

e.g. Hydrochloric acid - HCl
Hydrobromic acids - HBr
Hydrocyanic acids - HCN

Nomenclature of Oxy acids : Oxy acids are named according to their oxygen content. In case of element forming more than one oxy acid, the one containing less oxygen has a suffix ; 'ous' and the other 'ic'.
e.g. Nitrous acid - HNO_2 Nitric acid - HNO_3

(b) Bases :

(i) The prefix after the name of the element and the suffix is always hydroxide.

(ii) The suffix 'ous' is given to base if the oxidation number of the element is lower and 'ic' for a higher oxidation number.

Examples of bases are

$Sn(OH)_2 \longrightarrow$ Stannous hydroxide : $Sn(OH)_4 \longrightarrow$ Stanic hydroxide

Nomenclature of Salts :

1. In case of hydra acids the salts end with 'ide' e.g. Potassium chloride.

2. In case of oxyacids, if the suffix of acids is 'ous' the salt ends with 'ite' and if the acid ends in 'ic' the salt ends with 'ate'

Acid	**Potassium salt**
Chlorous acids	Potassium Chlorite
Chloric acid	Potassium Chlorate

INDICATORS :

Indicator indicated the nature of particular solution whether acidic, basic or neutral. Apart from this, indicator also represents the change in nature of the solution from acidic to basic and vice versa. Indicators are basically coloured organic substances extracted from different plants. A few common acid base indicators are

(a) **Litmus :** Litmus is a purple dye which is extracted from 'lichen' a plant belonging to variety Thallophytic. It can also be applied on paper in the form of strips and is available as blue and red strips. A blue litmus strip, when dipped in an acid solution acquires red colour. Similarly a red strip when dipped in a base solution becomes blue.

(b) **Phenolphthalein :** It is also an organic dye and acidic in nature. In neutral or acidic solution, it remains colourless while in the basic solution, the colour of indicator changes to pink.

(c) **Methyl Orange :** Methyl orange is an orange coloured dye (yellow) and basis in nature. In the acidic medium the colour of indicator becomes red and in the basic or natural medium, it colour remains unchanged.

(d) **Red Cabbage Juice :** It is purple in colour in natural medium and turns red or pink in the acidic medium. In the basic or alkaline medium, its colour changes to green.

(e) **Turmeric Juice :** It is yellow in colour and remains as such in the neutral and acidic medium. In the basic medium its colour becomes reddish or deep brown.

Sample	**Blue litmus solution**	**Red litmus solution**	**Phenolphthalein**	**Methyl orange**
HCl	Changes to red	No colour change	Remains colourless	Changes to red
HNO_3	Changes to red	No colour change	Remains colourless	Changes to red
NaOH	No colour change	Changes to blue	Changes to light pink	No changes in colour
KOH	No colour change	Changes to blue	Changes to light pink	No changes in colour

NEUTRALISATION : It is defined as a reaction between acid and base present in aqueous solution to form salt and water.

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

Basically neutralision is the combination between H^+ ions of the acid with OH^- ions of the base to form H_2O.

For e.g.

$$H^+(aq) + Cl^-(aq) + Na^+ (aq) + OH^-(aq) \longrightarrow Na^+(aq) + Cl^-(aq) + H_2O$$

$$H^+(aq) + OH^-(aq) \longrightarrow H_2O$$

Neutralisation reaction involving an acid and base is of exothermic nature. Heat is evolved in all naturalisation reactions. If both acid and base are strong, the value of heat energy evolved remains same irrespective of their nature.

For e.g.

$$\underset{\text{(Strong acid)}}{HCl\ (aq)} + \underset{\text{(Strong base)}}{NaOH\ (aq)} \longrightarrow NaCl\ (aq) + H_2O(\ell) + 57.1\ KJ$$

$$\underset{\text{(Strong acid)}}{HNO_3(aq)} + \underset{\text{(Strong base)}}{KOH(aq)} \longrightarrow KNO_3(aq) + H_3O(\ell) + 57.1\ J$$

Strong acids and strong bases are completely ionised of their own in the solution. No energy is needed for their ionisation. Since the cation of base and anion of acid on both sides of the equation cancels out completely, the heat evolved is given by the following reaction -

$$H^+(aq) + OH^-(aq) \longrightarrow H_2O + 57.1\ KJ$$

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 sting 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.

ACID-BASE THEORIES

Arrhenius Definition (1884) : Most limited, requires water.

Acid : Substance which furnish H^+ ion in their aqueous solution.

H^+ (acid or proton) = $H(H_2O)_n^+ = H_3O^+$ (hydronium ion)

Base : Substance which furnish OH^- ion in their aqueous solution.

Bronsted Lowry Definitions : In 1923, Johannes Brønsted, working in Denmark, and Thomas Lowry, working in England, developed the concept of proton transfer in acid–base behavior independently and simultaneously. This is a broader definition, more possibilities.

Acid : Donates one H^+ ion. (HA), NH_4^+

(Proton = H^+)

Base : Accepts one H^+ ion. (A^-), NH_3

The Brønsted–Lowry definition works well with bases such as NH_3 that do not inherently contain OH^- ions but still produce OH^- ions in solution.

Conjugate Acid/Base Pairs : Any two substances related to each other by the transfer of a proton can be considered a conjugate acid–base pair.

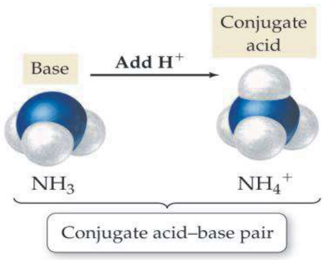
Bronsted Lowry acid/base conjugates are different by only a single H^+.

The acid has one more H^+ compared to the base in a conjugate pair

NH_4^+ is the conjugate acid for NH_3 the conjugate base HF is the conjugate acid for F^- the conjugate base.

For the reaction…

$NH_3(aq) + H_2O(\ell) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$



NH_3 is a Brønsted–Lowry base because it accepts a proton

H_2O is a Brønsted–Lowry acid because it donates a proton

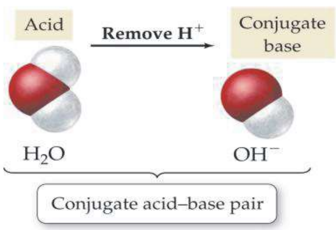
NH_4^+ is the conjugate acid of the NH_3 base

OH^- is the conjugate base of the H_2O acid

Amphoteric substances can act as an acid as well as a base.

Water acting as both an acid and a base

$$\underset{\substack{\text{Acid}\\ \text{(Proton donor)}}}{H_2O(l)} + \underset{\substack{\text{Base}\\ \text{(Proton acceptor)}}}{H_2O(l)} \rightleftharpoons H_3O^+(aq) + OH^-(aq)$$



Example 1 :

(a) Write the formulas for the conjugate bases of given acids:

NH_4^+, HF, HNO_2, H_2SO_3, HSO_3^-, H_2O

(b) Write the formulas for the conjugate acids of given bases:

$C_2H_3O_2^-$, OH^-, ClO^- , SO_3^{-2} , HSO_3^-, H_2O

(c) Which of the species above are amphoteric ?

Relative strengths :

A stronger acid will have a weaker conjugate base. Stronger bases have weaker conjugate acids. Reactions always favor making more of the weaker acid or base in the reaction.

Example 2 :

(a) Which acid - HI (strong acid) or HF (weaker acid) - will have the weaker conjugate base?

(b) Which base - $C_2H_3O_2^-$ or OH^-(stronger base) will have the stronger conjugate acid ?

Acid Base Titrations :

* Titration is a common lab procedure that applies solution stoichiometry. In titration, a substance in a solution of known concentration is reacted with another substance in a solution of unknown concentration. The end point is a visible change, such as color change of an indicator (phenolphthalein) that occurs near the stoichiometric equivalence point where neither reactant is present in excess, and both are limiting.

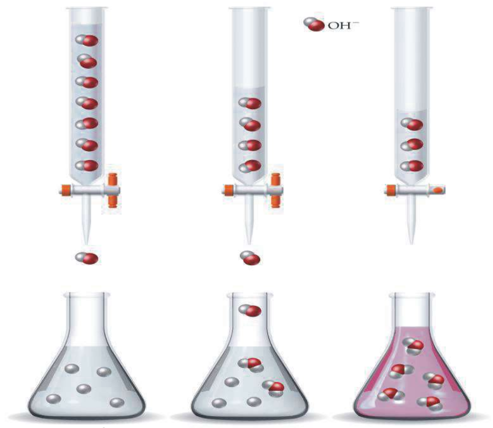
* After adding a few drops of indicator to the flask, slowly measure and add a solution of known concentration from a buret to the solution of unknown concentration in the flask.

* When you reach stoichiometric proportions (1 mol of OH. for every 1 mol of H+), the indicator (phenolphthalein) changes to pink, signaling the equivalence point of the titration.

* Indicators are intense colored organic dyes that change color at different pH values. Phenolphthalein is a common indicator that is

(i) Colorless in acidic solution and

(ii) Pink in basic solution.



Beginning of titration Equivalence point

Water :

Pure water ionizes just slightly. It is generally considered a nonelectrolyte since the amount it ionizes is tiny. Water is also considered amphoteric since it can act as an acid and gives up H^+ and as a base and accepts an H^+.

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

The hydronium ion (H_3O^+) is often written as a proton in water, H^+ (aq), even though the H^+ is really chemically bonded to one or more water molecules in an aqueous solution connected by hydrogen bonding. $H(H_2O)_n^+$.

Ion product constant for water (K_w) :

$H_2O\ (l) + H_2O\ (l) \longrightarrow H_3O^+\ (aq) + OH^-(aq)$

$K_w = [H^+][OH^-]$; the numerical value of $K_w = 1.0 \times 10^{-14}$ at 25ºC

[M], square parenthesis represents the substances concentration is measured in units of **Molarity.**

As the temperature changes, so will K_w, only at 25ºC is to be remembered.

0ºC $K_w = 1.1 \times 10^{-15}$

25ºC $K_w = 1.0 \times 10^{-14}$

37ºC $K_w = 2.5 \times 10^{-14}$

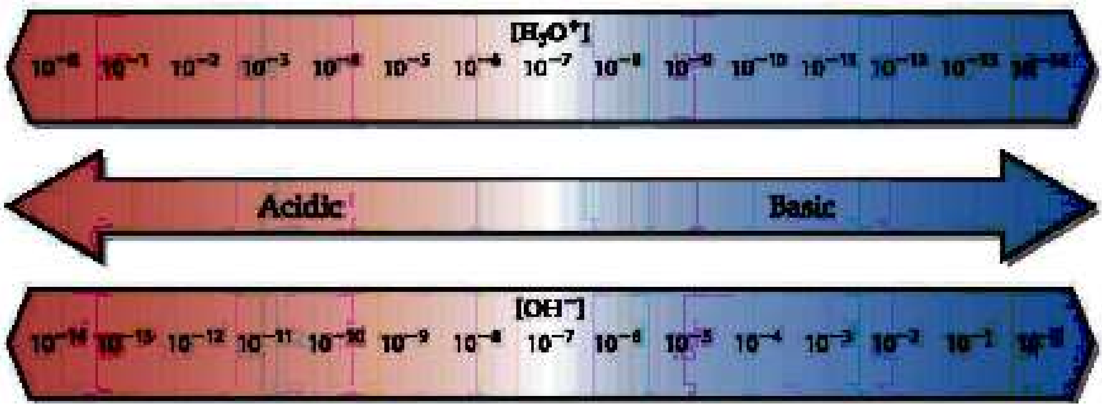
Example 4 :

use $K_w = [H^+][OH^-]$ 1.0×10^{-14} at 25ºC

(a) Solve for the Molarity of $[H^+]$ and $[OH^-]$ in neutral water

(b) Solve for the Molarity of $[H^+]$ if $[OH^-] = 5.0 \times 10^{-4}$M

(c) Solve for the Molarity of $[OH^-]$ if $[H^+] = 4.0 \times 10^{-3}$M



pH Definition :

pH is a value that helps in determining the acidity of a solution.

pH can be determined using pH meter, pH paper, or indicators

Formulas :

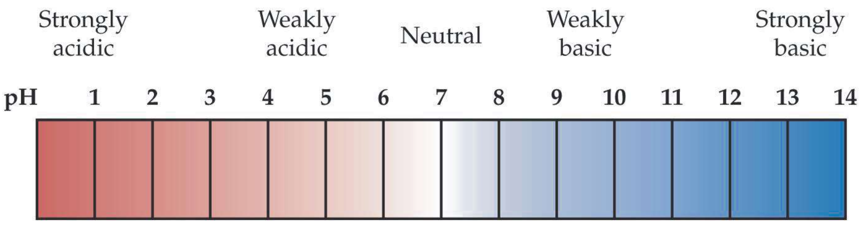
$K_w = 1.0 \times 10^{-14} = [H^+][OH^-]$, at 25°C

$pH = -\log[H^+]$	$[H^+] = 10^{-pH}$
$pOH = -\log[OH^-]$	$[OH^-] = 10^{-pOH}$
$pK_w = -\log[K_w]$	$pK_w = pH + pOH = 14$

Acid has a pH < 7

Neutral has pH = 7

Base has a pH > 7



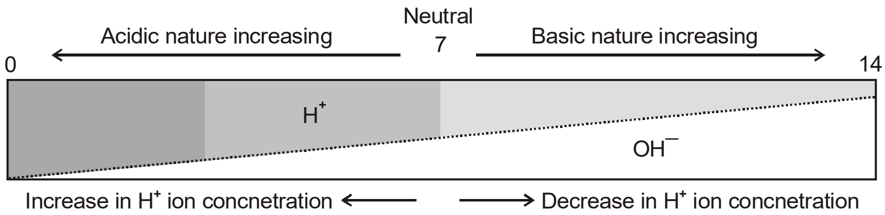
Example 5 :

Given that the pH of a solution is 4.88, Decide if the solution is neutral, acidic, or basic and solve for the $[H^+]$, $[OH^-]$, and pOH.

pH SCALE : A scale for measuring hydrogen ion concentration in a solution called pH scale, has been developed by S.P.L. sorrensen. The p in pH stands for potenz' in German meaning power. On the pH scale we can measure pH from 0 (very acidic) to 14 (very alkaline). pH should be thought of simply as a number which indicates the acidic or basic nature of solution. Higher the hydrogen ion concentration, Lower is the pH scale.

Characteristic of pH scale are :

(i) For acidic solution, pH < 7 (ii) For alkaline solution, pH > 7 (iii) For neutral solution, pH = 7



(a) Universal Indicator Papers for pH Values : Indicators like litmus, phenolphthalein and methyl orange are used in predicting the acidic and basic characters of the solutions. However universal indicator papers have been developed to predict the pH of different solutions. Such papers represent specified colours for different concentrations in terms of pH values.

The exact pH of the solution can be measured with the help of pH meter which gives instant reading and it can be relied upon.

pH values of a few common solutions are given below :

Solution	Approximate pH	Solution	Approximate pH
Gastric juices	1.0 – 3.0	Pure water	7.0
Lemon juices	2.2 – 2.4	Blood	7.36 – 7.42
Vinegar	3.0	Baking soda solution	8.4
Bear	4.0 – 5.0	Sea water	9.0
Tomato juice	4.1	Washing soda solution	10.5
Coffee	4.5 – 5.5	Lime water	12.0
Acid rain	5.6	House hold ammonia	11.9
Milk	6.5	Sodium hydroxide	14.0
Saliva	6.5 - 7.5		

(b) Significance of pH in daily life :

(i) pH in our digestive system : Dilute hydrochloric acid produced in our stomach helps in the digestion of food. However, excess of acid causes indigestion and leads to pain as well as irritation. The pH of the digestive system in the stomach will decrease. The excessive acid can be neutralised with the help of antacid which are recommended by the doctors. Actually, these are group of compounds (basic in nature) and have hardly any side effects. A very popular antacid is 'Milk of Magnesia' which is insoluble magnesium hydroxide. Aluminum hydroxide and sodium hydrogen carbonate can also be used for the same purpose. These antacids will bring the pH of the system back to its normal value. The pH of human blood varies between 7.36 to 7.42. it is maintained by the soluble bicarbonates and carbonic acid present in the blood.

(ii) pH change leads to tooth decay : The white enamel coating on our teeth is of insoluble calcium phosphate which is quite hard. It is not affected by water. However, when the pH in the mouth falls below 5.5 the enamel gets corroded. Water will have a direct access to the roots and decay of teeth will occur. The bacteria present in the mouth break down the sugar that we eat in one form or the other to acids, Lactic acid is one these. The formation of these acids causes decrease in pH. It is therefore advisable to avoid eating sugery foods and also to keep the mouth clean so that sugar and food particles may not be present. The tooth pastes contain in them some basic ingredients and they help in neutralising the effect of the acids and also increasing the pH in the mouth.

(iii) Role of pH in curing stings by insects : The stings of bees and ants contain methanoic acid (or formic acid). When stung, they cause lot of pain and irritation. The cure is in rubbing the affected area with soap. Sodium hydroxide present in the soap neutralises acid injected in the body and thus brings the pH back to its original level bringing relief to the person who has been stung. Similarly, the effect of stings by wasps containing alkali is neutralised by the application of vinegar which is ethanoic acid (or acetic acid)

(iv) Soil pH and plant growth : The growth of plants in a particular soil is also related to its pH. Actually, different plants prefer different pH range for their growth. it is therefore, quite important to provide the soil with proper pH for their healthy growth. Soils with high iron minerals or with vegetation tend to become acidic. This soil pH can reach as lows as 4. The acidic effect can be neutralised by 'liming the soil' which is carried by adding calcium hydroxide. These are all basic in nature and have neutralising effect. Similarly, the soil with excess of lime stone or chalk is usually alkaline. Sometimes, its pH reaches as high as 8.3 and is quite harmful for the plant growth. In order to reduce the alkaline effect, it is better to add some decaying organic matter (compost or manure). The soil pH is also affected by the acid rain and the use of fertilizers. Therefore soil treatment is quite essential.

SALTS : Such ionic compounds which when dissolved in water dissociate to yield positive ions other than hydrogen ions (H^+) and negative ions other than hydroxyl ions (OH^-) are called salts.

KCl, NH_4Cl, $ZnCl_2$, $NaCl$, K_2SO_4, Na_2SO_4 are common examples of salts.

A salt is a compound formed by partial or complete replacement of ionisable H atoms of an acid by a metallic ion or an ammonium ion. For example :

$$H_2SO_4 + NaOH \longrightarrow NaHSO_4 + H_2O$$

(Partial replacement : Only one hydrogen atom is replaced)

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

In this case, both sodium hydrogensulphate and sodium sulphate are known as salts

Let us now take up hydrochloric acid and add ammonium hydroxide to it.

$$HCl + NH_4OH \longrightarrow NH_4Cl + H_2O$$

In this case, hydrogen atom of hydrochloric acid has been replaced by ammonium ion and not the metallic ion, therefore, ammonium chloride is also known as a salt.

CLASSIFICATION OF SALTS (BASED ON THEIR MODE OF FORMATION) : Salts can be classified into different categories such as normal salts, acidic salts, basic salts double salts and mixed salts, etc.

1. **NORMAL SALTS :** The salts which are obtained by complete replacement of the ionisable hydrogen atoms of an acid by a metallic or an ammonium ion, are known as normal salt. For example, normal salts such as sodium chloride and sodium sulphate are formed by the complete replacement of ionisable hydrogen atoms of hydrochloric acid and sulphuric acid respectively.

$$HCl + NaOH \longrightarrow NaCl + H_2O$$

2. **ACIDIC SALTS :** The salts which are obtained by the partial replacement of ionisable hydrogen atoms of a polybasic acid by a metal or an ammonium ion are known as acidic salts.
   These are usually formed when insufficient amount of the base is taken for the neutralization of the acid. For example, when insufficient amount of sodium hydroxide is taken to neutralize sulphuric acid, we get an acidic salt (Sodium hydrogensulphate).

$$H_2SO_4 + NaOH \longrightarrow NaHSO_4 + H_2O$$

3. **BASIC SALTS :** The salts which are formed by partial replacement of hydroxyl (–OH) groups of a di-or a triacidic base by an acid radical are known as basic salts.
   These are usually formed when insufficient amount of acid is taken for the neutralization of the base. For example, when insufficient amount of hydrochloric acid is added to lead hydroxide, basic lead chloride. [Pb(OH)Cl] is formed.

$$Pb(OH)_2 + HCl \longrightarrow Pb(OH)Cl + H_2O$$

4. **DOUBLE SALTS :** The salts which are obtained by the crystallization of two simple salts, from a mixture of their saturated solutions are known as double salts.
   For example , a double salt, potash alum, [$K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$] is prepared by mixing saturated solutions of two simple salts, potassium sulphate and aluminium sulphate and crystallisation of the mixture.

$$K_2SO_4 + Al_2(SO_4)_3 + 24H_2O \xrightarrow{\text{Crystallisation}} K_2SO_4 . Al_2(SO_4)_3 . 24H_2O$$

   Some other examples of double salts are
   (i) Mohr's salt, $FeSO_4 . (NH_4)_2SO_4 . 6H_2O$ (ii) Dolomite, $CaCO_3 . MgCO_3$
   (iii) Carnallite $KCl . MgCl_2 . 6H_2O$)

5. **MIXED SALTS :** The salts which contain two or more or acidic or basic radicals are called mixed salts. E.g $NaKCO_3$, $NaKSO_4$

pH OF SALT SOLUTIONS : We have already discussed that an acid and a base react to form salt and water. The reaction is called 'neutralization reaction.' The reverse reaction can also occur, i.e. a salt reacts with water to give back the acid and the base. This reaction is called "salt hydrolysis".

(1) Salts of strong acid and strong base :

For example,

$$NaCl + H_2O \longrightarrow \underset{\text{(Strong base)}}{NaOH} + \underset{\text{(Strong acid)}}{HCl}$$

Hence, the acid and the base produced neutralize each other completely. As a result, the solution is neutral with pH = 7.

(2) Salts of strong acid and weak base :

For example,

$$NH_4Cl + H_2O \longrightarrow \underset{\text{(weak base)}}{NH_4OH} + \underset{\text{(strong acid)}}{HCl}$$

The strong acid produced is not completely neutralized by the weak base. Hence, the solution is acidic with pH < 7.

(3) Salts of weak acid and strong base.. For example,

$$Na_2CO_3 + 2H_2O \longrightarrow \underset{\text{(strong base)}}{2NaOH} + \underset{\text{(weak acid)}}{H_2CO_3}$$

The strong base produced is not completely neutralized by the weak acid. Hence, the solution is basic with pH > 7.

(4) Salts of weak acid and weak base. For example,

CH_3COONH_4 (Ammonium acetate)

When this salt is dissolved in water, it produces weak acid and weak base. Hence, the solution is almost neutral with pH nearly 7.

SOME IMPORTANT CHEMICAL COMPOUNDS :

SODIUM CHLORIDE - COMMON SALT (TABLE SALT) : Sodium chloride (NaCl) also called common salt or table salt is the most essential part of our diet. Chemically it is formed by the reaction between solutions of sodium hydroxide and hydrochloric acid. Sea water is the major source of sodium chloride where it is present in dissolved form along with other soluble salts such as chlorides and sulphates of calcium and magnesium. it is separated by some suitable methods. Deposits of the salts are found in different part of the world and is known as rock salt. When pure, it is a white crystalline solid, However, it is often brown due to the presence of impurities.

(a) Uses :

(i) Essential for life : Sodium chloride is quite essential for life. Biologically, it has a number of function to perform such as in muscle contraction, in conduction of nerve impulse in the nervous system and is also converted in hydrochloric acid which helps in the digestion of food in the stomach. When we sweat, there is loss of sodium chloride along with water. It leads to muscle cramps. Its loss has to be compensated suitably by giving certain salt preparations to the patient. Electrol powder is an important substitute of common salt.

(ii) Raw Material for Chemical : Sodium chloride is also a very useful raw material for different chemical. A few out of these are hydrochloric acid (HCl), washing soda ($Na_2CO_3.10H_2O$), baking soda ($NaHCO_3$) etc. Upon electrolysis of a strong solution of the salt (brine), sodium hydroxide, chlorine and hydrogen are obtained. Apart from these, it is used in leather industry for the leather tanning. In severe cold, rock salt is spread on icy roads to melt ice. it is also used as fertilizer for sugar beet.

(b) Electrolysis of aqueous Solution of NaCl :

$$2NaCl\,(s) + 2H_2O(\ell) \xrightarrow{\text{Electrolysis}} 2NaOH(aq) + Cl_2(g) + H_2(g)$$

reaction takes place in two steps

(i) $2Cl^- \longrightarrow Cl_2(g) + 2e^-$ (anode reaction) **(ii)** $2H_2O + 2e^- \longrightarrow H_2 + OH^-$ (cathode reaction)

WASHING SODA :

Chemical Name :

Sodium carbonate decahydrate

Chemical formula : $Na_2CO_3 . 10H_2O$

(a) Recrystallization of Sodium Carbonate : Sodium carbonate is recrystallized by dissolving in water to get washing soda it is a basic salt.

$$\underset{\text{Sodium carbonate}}{Na_2CO_3} + 10H_2O \longrightarrow \underset{\text{Washing soda}}{Na_2CO_3 . 10H_2O}$$

(b) Uses :

(i) It is used as cleansing agent for domestic purposes.

(ii) It is used in softening hard water and controlling the pH of water.

(iii) It is used in manufacture of glass.

(iv) Due to its detergent properties, it is used as a constituent of several dry soap powders.

(v) It also finds use in photography, textile and paper industries etc.

(vi) It is used in the manufacture of borax ($Na_2B_4O_7 . 10H_2O$)

BAKING SODA : Baking soda is sodium hydrogen carbonate or sodium bicarbonate ($NaHCO_3$).

(a) Preparation : It is obtained as an intermediate product in the preparation of sodium carbonate by Solvay process. In this process, a saturated solution of sodium chloride in water is saturated with ammonia and then carbon dioxide gas is passed into the liquid. Sodium chloride is converted into sodium bicarbonate which, being less soluble, separates out from the solution.

$$2NH_3\,(g) + H_2O\,(\ell) + CO_2\,(g) \longrightarrow (NH_4)_2\,CO_3(aq)$$

$$(NH_4)_2CO_3(aq) + 2NaCl(aq) \longrightarrow Na_2CO_3(aq) + 2NH_4Cl(aq)$$

$$Na_2CO_3(aq) + H_2O + CO_2(g) \longrightarrow 2NaHCO_3(s)$$

(b) Properties :

(i) It is a white, crystalline substance that forms an alkaline solution with water. The aqueous solution of sodium bicarbonate is neutral to methyl orange but gives pink colour with phenolphthalein orange. (Phenolphthalein and methyl orange are dyes used as acid-base indicators.)

(ii) When heated above 543 K, it is converted into sodium carbonate.

$$2NaHCO_3(s) \longrightarrow Na_2CO_3\,(s) + CO_2(g) + H_2O$$

(c) Uses :

(i) It is used in the manufacture of baking powder. Baking powder is a mixture or potassium hydrogen tartar ate and sodium bicarbonate. During the preparation of bread the evolution of carbon dioxide causes bread to rise (swell).

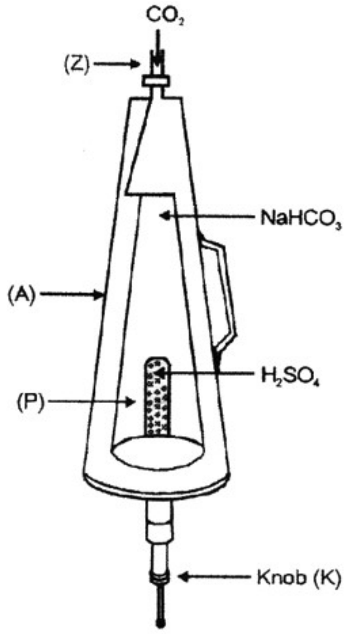
$$\begin{array}{l} CH(OH)COOK \\ | \\ CH(OH)COOH \end{array} + NaHCO_3 \longrightarrow \begin{array}{l} CH(OH)COOK \\ | \\ CH(OH)COONa \end{array} + CO_2 + H_2O$$

(ii) It is largely used in the treatment of acid spillage and in medicine as soda bicarb, which acts as an antacid.

(iii) It is an important chemical in the textile, tanning, paper and ceramic industries.

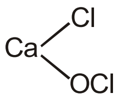
(iv) It is also used in a particular type of fire extinguishers.

The following diagram shows a fire extinguisher that uses $NaHCO_3$ and H_2SO_4 to produce CO_2 gas. The extinguisher consists of a conical metallic container (A) with a nozzle (Z) at one end. A strong solution of $NaHCO_3$ is kept in the container. A glass ampoule (P) containing H_2SO_4 is attached to a knob (K) and placed inside the $NaHCO_3$ solution. The ampoule can be broken by hitting the knob. As soon as the acid comes in contact with the $NaHCO_3$ solution, CO_2 gas is formed. When enough pressure in built up inside the container, CO_2 gas rushes out through the nozzle (A). Since CO_2 does not support combustion, a small fire can be put out by pointing the nozzle towards the fire. The gas is produced according to the following reaction.



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

BLEACHING POWDER : Bleaching powder is commercially called 'chloride of lime or' chlorinated lime'. It is principally calcium oxychloride having the following formula :



Bleaching powder is prepared by passing chlorine over slaked lime at 313 K.

$$\underset{\text{Slaked lime}}{2Ca(OH)_2(aq) + 2Cl_2(g)} \xrightarrow{313K} \underset{\text{Bleaching powder}}{Ca(OCl)_2(s)} + CaCl_2 + 2H_2O(g)$$

Actually beaching powder is not a compound but a mixture of compounds :

$$Ca(OCl)_2 + CaCl_2.Ca(OH)_2.H_2O + H_2O$$

(a) Uses :

(i) It is commonly used as a bleaching agent in paper and textile industries.

(ii) It is also used for disinfecting water to make water free from germs.

(iii) It is used to prepare chloroform.

(iv) It is also used to make wool shrink-proof.

PLASTER OF PARIS : ($CaSO_4$.1/2 H_2O)

(a) Preparation :

It is prepared by heating gypsum ($CaSO_4$. $2H_2O$) at about 373 k in large seel pots with mechanical stirrer , or in a revolving furnace.

$$\underset{\text{Gypsum}}{2(CaSO_4{,}2H_2O)} \xrightarrow{373K} \underset{\text{Plaster of Paris}}{(CaSO_4)_2{,}\ H_2O} + 3H_2O$$

or $$CaSO_4{,}\ 2H_2O \longrightarrow CaSO_4{,}\ \frac{1}{2}H_2O + \frac{3}{2}H_2O$$

The temperature is carefully controlled, as at higher temperature gypsum is fully dehydrated . The properties of dehydrated gypsum are completely different from those of plaster of Paris.

(b) Properties :

(i) Action with water : When it is dissolved in water , it gets crystallized and forms gypsum

$$CaSO_4.\frac{1}{2}H_2O + H_2O \longrightarrow CaSO_4.2H_2O$$

(c) Uses : When finely powered Plaster of Parries is mixed with water and made into a paste, it quickly sets into a hard mass. In the process, its volume also increases slightly. These properties find a number of uses. Addition of water turns Plaster of Parries back into gypsum.

(i) It is used in the laboratories for sealing gaps where airtight arrangement is required.

(ii) It is also used for making toys, cosmetic and casts of statues.

(iii) It is used as a cast for setting broken bones.

(iv) It also find use in making moulds in pottery.

(iv) It is also used for making surfaces smooth and for making designs on walls and ceilings.

HYDRATED SATLS - SALTS CONTAINING WATER OF CRYSTALLISATION : Certain salts contain definite amount of some H_2O molecules loosely attached to their own molecules. These are known as hydrated salts and are of crystalline nature. The molecules of H_2O present are known as 'water of crystallisation'.

In colourd crystalline and hydrated salts, the molecules of water of crystallisation also account for their characteristic colours. Thus, upon heating of hydrated salt, its colour changes since molecules of water of crystallisation are removed and the salt becomes anhydrous, For example, take a few crystals of blue vitriol i.e. hydrated copper sulphate in a dry test tube or boiling tube. Heat the tube from below. The salt will change to a white anhydrous powder and water droplet will appear on the walls of the tube. Cool the tube and add a few droops of water again. The white anhydrous powder will again acquire blue colour.

$$CuSO_4.5H_2O \xrightarrow{\Delta} CuSO_4 + 5H_2O$$

Copper sulphate Copper sulphate

(Hydrated) (Anhydrous)

SOME SOLVED ILLUSTRATIONS

ILLUSTRATION-1.

You have been provided with three test tubes. One of them contains distilled water and the other two an acidic solution and a basic solution respectively. If you are given only red litmus paper, how will you identify the contents of each test tube ?

SOLUTION.

Dip red litmus paper in all the three test tubes. The tube in which it turns blue contains a basic solution, the two tubes in which there is no change in colour contain either water or an acidic solution. Now, put the same red litmus paper which had already turned blue in basic solution in the rest of two test tubes containing water and an acidic solution. The tube in which there is no change in colour contains water but the tube in which the blue colour again changes to red contains an acid.

ILLUSTRATION-2.

Why does dry HCl gas not change the colour of the dry litmus paper?

SOLUTION.

Dry HCl gas does not change the colour of dry litmus paper because in the absence of water, it can not ionize to give H^+(aq) ions and therefore, the colour of dry litmus paper does not change.

ILLUSTRATION-3.

The reaction between magnesium carbonate and hydrochloric acid can be written as follows :

$$MgCO_3 + 2HCl \longrightarrow MgCl_2 + H_2O + CO_2$$

Identify the salts involved in the reaction.

SOLUTION.

Salts involved in the reaction are : $MgCO_3$ and $MgCl_2$.

ILLUSTRATION-4.

A gas is highly soluble in water and the solution so obtained turns red litmus blue. Name the gas and explain the results obtained.

SOLUTION.

The gas in question must be ammonia gas. Ammonia gas is highly soluble and dissolve in water to give ammonium hydroxide which is basic in nature and turns red litmus blue.

$$NH_3(g) + H_2O \longrightarrow NH_4OH(aq) \xrightarrow[\text{Litmus}]{\text{Red}} \text{Blue Colour}$$

ILLUSTRATION-5.

Under what soil condition do you think a farmer would treat the soil of his field with quick lime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate) ?

SOLUTION.

All compounds mentioned in the question are basic in nature. Therefore, the farmer should treat the soil with these compounds only, if the soil is acidic in nature.

ILLUSTRATION-6

Out of the following , which can be termed as 'salts':

Na_2SO_4, oxalic acid, $NaHCO_3$, $NaHSO_4$ and CH_3COONa, NaOH

SOLUTION.

Out of the above, Na_2SO_4, $NaHCO_3$, $NaHSO_4$ and CH_3COONa are 'salts'.

ILLUSTRATION-7

Write down positive and negative ions of the following compounds:

$NaNO_3$, KCl, K_2SO_4, $Ca(OH)_2$, Cu_2O, CaO, $MgSO_4$, $MgCO_3$

SOLUTION. $NaNO_3 – Na^+, NO_3^-$; $KCl – K^+, Cl^-$; $K_2SO_4 – 2K^+, SO_4^{2-}$;

$Ca(OH)_2 – Ca^{2+}, OH^-$; $Cu_2O – 2Cu^+, O^{2-}$; $CaO – Ca^{2+}, O^{2-}$;

$MgSO_4 – Mg^{2+}, SO_4^{2-}$; $CaCO_3 – Ca^{2+}, CO_3^{2-}$; $MgCO_3 – Mg^{2+}, CO_3^{2-}$;

ILLUSTRATION-8.

Tap water conducts electricity whereas distilled water does not. Why?

SOLUTION.

Tap water contains certain soluble salts, so it can conduct electricity. On the other hand, distilled water does not contain any salt, so it cannot conduct electricity.

ILLUSTRATION-9.

Why do acids not show acidic behaviour in the absence of water?

SOLUTION.

Acids do not ionize in the absence of water to produce H^+ (aq) or H_3O^+(aq) ions, therefore, acids do not show acidic behaviour in the absence of water.

ILLUSTRATION-10.

Why should curd and sour substances not be kept in brass and copper vessel?

SOLUTION.

Curd and other sour substances contain acids which react with the metal surface of brass and copper vessels to produce toxic compounds which are unfit for consumption.

ILLUSTRATION -11.

Compounds such as alcohols and glucose also contain hydrogen but are not categorized as acids, describe an activity to prove it.

SOLUTION.

Fix two nails on a cork and place it in a 100 ml. beaker. Connect these nails to a 6 volt battery through a bulb and a switch as shown below. Pour some aqueous solution of alcohol or aqueous solution of glucose in the beaker so that nails dip in it. Switch on the circuit. The bulb does not glow indicating that alcohol and glucose don't dissociate in aqueous solution and hence does not produce H^+ (aq) ions although they contain hydrogen.

ILLUSTRATION-12.

How will you compare the strengths of acids?

SOLUTION.

The strength of an acid depends upon the number of H+ ions produced by it on dissociation in aqueous solution, i.e. upon the degree of dissociation of an acid. The more the degree of dissociation of an acid, the stronger the acid will be. For example, the acids like HCl, H_2SO_4, HNO_3, etc, are stronger acid because they have high degree of dissociation whereas the acids like CH_3COOH, oxalic acid, etc. are weak acids because they have low degree of dissociation.

ILLUSTRATION-13.

Give one example in each case :

(i) A basic oxide which is soluble in water
(ii) A hydroxide which is highly soluble in water
(iii) A basic oxide which is insoluble in water.
(iv) A hydroxide which is insoluble in water
(v) A weak mineral acid
(vi) A base which is not an alkali.
(vii) An oxide which is a base.
(viii) A hydrogen containing compound which is not an acid.

SOLUTION.
(i) Sodium oxide, Na_2O
(ii) Potassium hydroxide, KOH
(iii) Copper (II) oxide, CuO
(iv) Ferric hydroxide, $Fe(OH)_3$
(v) Carbonic acid, H_2CO_3
(vi) Copper (II) hydroxide, $Cu(OH)_2$
(vii) Copper (II) Oxide, CuO
(viii) Methane, CH_4

ILLUSTRATION-14.

10 ml of a solution of Na OH is found to be completely neutralized by 8mL of a given solution of HCl. If we take 20mL of the same solution of Na OH, the amount of HCl solution (the same solution as before) required to neutralize it will be

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

SOLUTION.

If we take double the amount of the same NaOH solution the amount of the same HCl solution required to neutralize it is also double. Hence the correct option is (d).

ILLUSTRATION-15.

Choose strong and weak acids as well as strong and weak bases from the following

H_2CO_3,HNO_3,CH_3 COOH, NaOH, NH_4 OH, KOH, $Zn(OH)_2$, HCl.

SOLUTION. Strong acids : HNO_3 HCl

Weak acids : H_2CO_3, CH_3COOH

Strong bases : NaOH, KOH

Weak bases : NH_4OH, $Zn(OH)_2$

ILLUSTRATION-16.

A small amount of hydrochloric acid is always produced in the stomach. Is it useful or harmful and in what way? If excess of acid is produced in the stomach, what do we do ?

SOLUTION.

A small amount of hydrochloric acid is always produced in the stomach useful as it can kill the harmful bacteria that may enter into the stomach along with the food. However, if excess of acid is produced, there is a burning sensation in the stomach. We take milk of magnesia ($Mg(OH)_2$) as antacid medicine to neutralize the excess acid.

ILLUSTRATION-17.

A solution contains 0.02 mole HCl in 2.0 litres of the solution. Calculate the molarity (or molar concentration).

SOLUTION.

Molarity of a solution is the number of moles of the solute present in one litre of solution. Here 2 litres of solution contain HCl = 0.02 mole

1 litre of the solution will contain HCl = 0.02 /2= 0.01 mole

$\therefore$ Hence moarity of solution = 0.01 mol L^{-1} = 0.01 M

ILLUSTRATION-18.

Why alkalis like sodium hydroxide and potassium hydroxide should not be left exposed to air ?

SOLUTION.

Because, they are hygroscopic in nature and absorb moisture from atmosphere in which they ultimately dissolve.

ILLUSTRATION-19

A solution of acetic acid in water is highly concentrated. Will you call it a strong acid ?

SOLUTION:

No acetic acid will remain a weak acid even if it is highly concentrated because its degree of dissociation (α) is much less than one. This means that in water, only a small amount of the acid exists as ions whatever may be its concentration or amount dissolved in a given volume of water.

ILLUSTRATION-20.

An acidic solution always contain some OH^- ions in it. Comment.

SOLUTION.

The statement is correct .Actually, acids are always dissolved in water to form the solution. Now water (H_2O)will also ionise to small extent as it is a weak electrolyte. The OH^- ion released by water will remain in solution. Therefore, an acidic solution will always contain some OH-ions.

ILLUSTRATION-21.

Do basic solution also have $H^+(aq)$ ion ? If yes then why are these basic ?

SOLUTION.

Yes basic solution have also $H^+(aq)$ ions present in them. Actually, these solutions are prepared in water. Being a weak electrolyte, it dissociates to give H^+ and OH^- ions However, the number of H^+ ions is very small as compared to the number of OH^- ions which are released by the base also. Therefore, the solution as a whole are of basic nature.

ILLUSTRATION-22.

What is the pH of 0.1 solution of HCl

SOLUTION. HCl is a strong acid. It is completely ionized in aqueous solution.

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

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

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

ILLUSTRATION-23.

The pH of a solution is 3. What is the concentration of OH- ions in the solution ?

SOLUTION. $pH = -\log [H^+]$

$\log [H^+] = -pH = -3$

$[H^+] = 10^{-3}$ mol L^{-1}

$[OH^-] = \{1 \times 10^{-14} / 10^{-3}\}$

$= 1 \times 10^{-11}$ mol L^{-1}

ILLUSTRATION-24.

With the help of a chemical reaction explain how a soda-acid fire. Extinguisher helps in putting out a fire.

SOLUTION.

In a extinguisher, dilute sulphuric acid reacts with sodium hydrogencarbonate Liberating carbon dioxide.

$$2NaHCO_3(aq) + H_2SO_4(aq) \longrightarrow Na_2SO_4(aq) + 2CO_2(g) + 2H_2O(l)$$

The liberated carbon dioxide helps in extinguishing the fire.

ILLUSTRATION-25.

"Bleaching powder is not a compound." Comment on this statement.

SOLUTION.

Bleaching powder is the commercial formulation containing slaked lime and calcium oxychloride.

ILLUSTRATION-26.

Name the acid present in ant sting and give its chemical formula. Also give the common method to get relief from the discomfort caused by the ant sting.

SOLUTION.

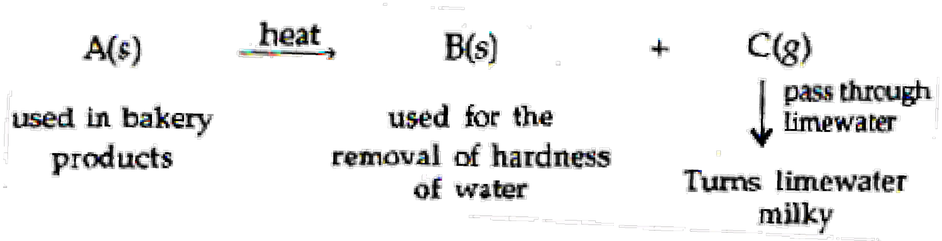
The acid present in ant sting : Methanoic acid (Formic acid)

Chemical formula of the above acid: HCOOH

To get relief one should apply baking soda ($NaHCO_3$) on the sting.

ILLUSTRATION-27.

Salt A commonly used in bakery products on heating gets converted into another salt B which itself is used for removal of hardness of water and a gas C is evolved. The gas C when passed through limewater, turns it milky. Identify A, B and C.



From the given information, one can conclude

* The salt A is sodium hydrogencarbonate $NaHCO_3$
* The salt B is sodium carbonate Na_2CO_3
* The gas C is carbon dioxide CO_2

ILLUSTRATION-28.

A white crystalline substance taken in a test tube when reacted with dilute sulphuric acid gives off a colourless gas. This gas turns limewater milky and extinguishes a burning metal stick.

(a) Name the substance and the gas evolved.

(b) Write chemical equation for the reaction between the substance and sulphuric acid.

SOLUTION.

(a) Sodium carbonate, Carbon dioxide (CO_2)

(b) $Na_2CO_3(s) + H_2SO_4 \longrightarrow Na_2SO_4(aq) + H_2O(l) + CO_2(g)$

ILLUSTRATION-29.

A small amount of black powdery substance is taken in a test tube. When reacted with dilute hydrochloric acid, it gives a blue solution.

(a) Name the black powdery substance, and the compound which gives blue solution.

(b) Write chemical equation for the reaction between black powder and dilute hydrochloric acid.

SOLUTION.

Blue colour of the solution indicates the substance to be a copper salt. So, black Powdery substance is also a compound of copper.

(a) Black powdery substance is copper(II) oxide.

The compound that gives blue colour in the solution is copper(II) chloride.

(b) $CuO(s) + 2HCl(aq) \longrightarrow CuCl_2(aq) + H_2O$

ILLUSTRATION-30.

A gas formed when sodium chloride is reacted with conc. sulphuric acid turns moist blue litmus red. Answer the following questions.

(a) What is the nature of the gas ?

(b) What is the name and formula of the gas?

(c) What will happen when a dry blue litmus paper is exposed to dry gas?

SOLUTION.

(a) The gas is acidic.

(b) The gas formed : Hydrogen chloride, HCl

(c) When a dry blue litmus paper is exposed to dry gas, there will be no change in its colour

ILLUSTRATION-31.

What will be the pH of HCl solution when 0.005 moles of it is added to 5 litres of water ?

Sol. Concentration of H^+ ions = $\dfrac{\text{Moles of } H^+}{\text{Volume of solution}}$

$[H]^+ = \dfrac{0.005 \text{ moles}}{5L}$

$= 0.001$

$[H^+] = 10^{-3}$

$pH = -\log [H^+]$

$= -\log 10^{-3}$

$pH = 3$

EXERCISE - I

1. Name any two natural indicators.

2. Which colour will be obtained when a drop of phenolphthalein is added to sodium hydroxide solution?

3. Name the Latin word from which the word acid has been derived.

4. Name the acids present in (i) vinegar (ii) lemon (iii) orange

5. Define basicity of an acid.

6. Which type of acid forms only the normal salts ?

7. Can a concentrated acid always be a strong acid ? Say yes or no.

8. Which type of acids are obtained by dissolving acidic oxides in water ?

9. Is PbO_2 a base or not ? Comment.

10. How alkalis differ from bases? Explain.

11. A weak base dissolves in water and dissociates into ions. Will there be any undissolved base left or not? Comment.

12. $Cu(OH)_2$ is a diacidic base and not diacidic alkali. Why ?

13. Name the gas used to convert a metal into its basic oxide.

14. On heating calcium carbonate, a colourless gas is evolved. Name the gas.

STATE TRUE OR FALSE :

1. Litmus solution is a purple dye, extracted from a plant called lichen.

2. Acids are always harmful for us.

3. Baking soda turns red litmus blue.

4. Washing soda has a chemical formula $Na_2CO_3 . 10\ H_2O$

5. One molecule of tribasic acid on complete ionization produces only one hydronium ion.

6. Chemical formula of sulphurous acid is H_2SO_4.

7. Oxalic acid is an organic acid.

8. The chemical formula of slaked lime is $[Ca(OH)_2]$

9. The pH of pure milk is 11.

10. Sodium hydrogensulphate can be obtained by heating sodium nitrate with concentrated sulphuric acid.

11. Formation of coordinate covalent bond between NH_3 and BF_3 is an example of neutralization reaction, according to Bronsted theory.

12. A diacidic base has one replaceable hydroxide ion.

13. For a dibasic acid, normality is twice the molarity for a given solution.

14. S^{-2} is the conjugate base of HS^-

15. Methyl orange exhibits yellow colour in basic medium.

16. Curd is sour in taste due to the presence of acidic substance.

17. $K_2SO_4 . Al_2(SO_4)_3\ 24H_2O$ gives reactions of both K^+ and Al^{+3} ions respectively.

MATCH THE COLUMN :

Each question contains statements given in two columns which have to be matched. Statements (A,B,C,D) in column I have to be matched with statements (p,q,r,s) in column-II.

(a) Column-II gives natural sources for acid mention in column I match them correctly :

	COLUMN-I		**COLUMN-II**
(A)	Acetic acid	(p)	Tomato
(B)	Citric acid	(q)	Tamarind
(C)	Tartaric acid	(r)	Orange
(D)	Oxalic acid	(s)	Vinegar

(b) Column-II gives nature of acids and bases mention in column-I, match them correctly-

	COLUMN-I		COLUMN-II
(A)	HCl	(p)	strong acid
(B)	HCN	(q)	weak acid
(C)	NaOH	(r)	weak base
(D)	NH_4OH	(s)	strong base

(c) Match the entries given in column A with appropriate ones from column B.

	COLUMN-I		COLUMN-II
(A)	Sodium chloride	(a)	Baking powder
(B)	Tartaric acid	(b)	Freezing mixture in ice creams
(C)	Potassium nitrate	(c)	Antacid in medicine
(D)	Sodium bicarbonate	(d)	Gun powder
(E)	Citric acid	(e)	Bleaching powder
(F)	Calcium hydroxide	(f)	Flavouring agent

FILL IN THE BLANKS :

(a) An acid is a compound that produces the …………………ion in solution, which is also written as the hydronium ion (……………………) A base is a compound that produces an ion with the formula……………and the name……………..ion. Strong acids are essentially………………% ionized in aqueous……….solution, whereas weak acids are ……………..ionised. Sodium hydroxide is a strong base, but ammonia is a …………..The reaction between an acid and a base is known as a ……………………… reaction. The net ionic…………..equation of this reaction always has ……………….. ….as a product. The spectator ions of the reaction form a ……………………The partial neutralization of polyprotic acids produces an……….and water.

(b) Pure water contains a small but important concentration of …………………….and ………ions. The product of the concentrations of these two ions is known as the ………………………..of water, is symbolized by ………., and has a value of …………….at 25°C. The pH of a solution is defined as ……………. An acidic solution is one that has a $[H_3O^+]$ greater than …………and a pH……………than 7. A basic solution is one that has a $[OH^-]$ greater than ………………..and a pH……….than 7.

(c) M is an element in the form of powder. 'M' burns in oxygen and the product is soluble in water. The solution is tested with litmus. Write down only the word which will correctly complete each of the following sentences:

(i) If M is a metal, then the litmus will turn …………………………

(ii) If M is a non-metal, then the litmus will turn………………………

(iii) If M is a reactive metal, then ……………..will be evolved when M reacts with dilute sulphuric acid.

(iv) If M is a metal, it will form ……………oxide, which will form ……………solution with water.

(v) If M is a non-metal, it will not conduct electricity in the form of ……………

(d) (1) Phenolphthalein is a/an ________ indicator.

(2) The salt obtained by partial neutralization of sodium hydroxide and sulphuric acid is ____ in nature.

(3) Metallic oxides are either ________ or _______ in nature.

(4) $[H^+]$ of nitric acid having a pH value of 6 is _______

(5) The pH of aqueous solution of salt obtained by the reaction between NaOH and CH_3COOH is ________ at 25ºC.

(6) A salt, X is prepared by the complete neutralization of $Cu(OH)_2$ with H_2SO_4. The nature of X is _________

(7) The units of Kw are _______ .

EXERCISE - II

1. Ammonium hydroxide is a weak base because :
(A) it has low vapour pressure (B) It is only slightly ionized
(C) it is not a hydroxide by any metal (D) it has low density

2. The pH is less than 7, of the solution of :
(A) $FeCl_3$ (B) NaCN (C) NaOH (D) NaCl

3. The correct order of acid strength is :
(A) $HClO < HClO_2 < HClO_3 < HClO_4$ (B) $HClO_4 > HClO < HClO_2 < HClO_3$
(C) $HClO_2 > HClO_3 < HClO_4 < HClO$ (D) $HClO_4 > HClO_3 < HClO_2 < HClO$
(**Hint :** On increasing oxidation number acidic strength increases.)

4. Which of the following is the weakest base :
(A) NaOH (B) $Ca(OH)_2$ (C) NH_4OH (D) KOH

5. In a solution of pH = 5, more acid is added in order to reduce the pH = 2. The increase in hydrogen ion concentration is-
(A) 100 times (B) 1000 times (C) 3 times (D) 5 times

6. If 4.0 gm NaOH is present in 1 litre solution, then its pH will be :
(A) 6 (B) 13 (C) 18 (D) 24

7. Which salt can be classified as an acid salt
(A) Na_2SO_4 (B) NaCl (C) Pb(OH)Cl (D) Na_2HPO_4

8. The acid used in making of vinegar is-
(A) formic acid (B) acetic acid (C) sulphuric acid (D) nitric acid

9. $CuO + (x) \longrightarrow CuSO_4 + H_2O$. Here (X) is :
(A) $CuSO_4$ (B) HCl (C) H_2SO_4 (D) HNO_3

10. Which is correct order of increasing strength of given acids-
(A) HI < HBr < HCl < HF (B) HI < HF < HCl < HBr
(C) HF < HCl < HBr < HI (D) HBr < HF < HCl < HI

11. Reaction of an acid with a base is known as :
(A) decomposition (B) combination (C) redox reaction (D) neutralization

12. Arhenius acid gives-
(A) H^+ in water (B) OH^- in water (C) Both (A) and (B) (D) None of these

13. A solution turns red litmus blue. Its pH is likely to be :
(A) 2 (B) 4 (C) 7 (D) 10

14. Methyl orange is :
(A) an acidic indicator (B) a basic indicator (C) a neutral indicator (D) None of these

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

16. What will be the pH of 10^{-3} M NaOH
(A) 3 (B) 11 (C) 7 (D) 10

17. A salt derived from strong acid and weak base will be soluble in water to give a solution which is :
(A) acidic (B) basic (C) neutral (D) None of these

18. A solution reacts with crushed egg-shells to give a gas that turns lime-water milky. The solution contains-
(A) NaCl (B) HCl (C) LiCl (D) KCl

19. Which of the following acids present in sour milk?
(A) glycolic acid (B) lactic acid (C) Citrus acid (D) Tartaric acid

20. Which of the following is strongest acid-
(A) Nitric acid (B) Citrus acid (C) Formic acid (D) Lactic acid

21. The sharp pain caused by the sting on an ant is due to :
(A) Malic acid (B) Nitric acid (C) Formic acid (D) Lactic acid

22. Which of the following acids is used in car batteries :
(A) Nitric acid (B) Hydrochloric acid (C) Sulphuric acid (D) perchloric acid

23. Soaps are sodium salts of :
(A) Mineral acids (B) Fatty acids (C) Bases (D) Carbonic acid

24. Acidity of aluminium hydroxide is-
(A) 1 (B) 2 (C) 4 (D) 3

25. Which of the following is not a property of acid-
(A) all acids have a sour taste (B) Acids turn blue litmus red
(C) Acids turn red litmus blue (D) All acids form H^+ ions in water

26. The acidity and alkalinity of a compound is represented on a scale known as :
(A) pH scale (B) Mohr scale (C) Kelvin scale (D) None of these

27. Which of the following acid is present in vinegar-
(A) Lactic acid (B) Malic acid (C) Acetic acid (D) Tartaric acid

28. Soda water has a pH value :
(A) > 7 (B) < 7 (C) 7 (D) > 14

29. Basic salts are formed by neutralization of-
(A) strong acid and strong base (B) strong acid and weak base
(C) weak acid and weak base (D) strong base and weak acid

30. The pH of three solutions A, B, C is 6, 4, 8 respectively which of the following is the correct option :
(A) A > B > C decreasing acidic strength (B) C > B > A increasing acidic strength
(C) B > A > C is decreasing acidic strength (D) C > B > A decreasing acidic strength

31. 'Alum' is an example of
(A) single salt (B) double salt (C) acids (D) None of these

32. A solution of pH = 2 is more acidic than one with pH = 6 by a factor of :
(A) 4000 (B) 2 (C) 10000 (D) 8000

33. The acid having a highest H^+ ions concentration is one with-
(A) pH = 7.0 (B) pH = 1.2 (C) pH = 2.3 (D) pH = 8.2

34. Which of these choices is considered a Bronsted-Lowery base :
(A) Proton Donor (B) Proton Acceptor (C) Electron acceptor (D) None of these

35. The conjugate acid of OH^- in the following would be :
(A) H_2O (B) H_2SO_4 (C) H_3O^+ (D) HCl

36. In the reaction, $HNO_3(aq) + H_2O(l) \rightleftharpoons H_3O^+ + NO_3^-$ the water is a
(A) Bronsted acid (B) Bronsted base (C) Conjugate acid (D) Conjugate base

37. In the reaction, $NH_3(aq) + H_2O(l) = NH_4^+ + OH^-$ the water is a :
(A) Bronsted acid (B) Bronsted base (C) Conjugate acid (D) Conjugate base

38. What is the approx. $[OH^-]$ in a solution with pH = 9
(A) 1×10^{-9}M (B) 5 (C) 1×10^{-5} M (D) 1×10^{-7}M

39. Which one of the following is a weak acid ?
(A) HCl (B) H_2CO_3 (C) H_2SO_4 (D) HNO_3

40. Which one of the following is a strong base ?
(A) NH_4OH (B) $Ca(OH)_2$ (C) $Mg(OH)_2$ (D) KOH

41. Which of the following does not from an acid salt ?
(A) Phosphoric acid (B) Hydrochloric acid (C) Carbonic acid (D) Sulphuric acid.

42. 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

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

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

45. Plaster of Pairs is made from:
(A) lime stone (B) slaked lime (B) quick lime (D) gypsum.

46. Which of the following is formed when Na_2CO_3 is heated
(A) CO_2 gas (B) CO gas (C) O_2 (D) NO gas

47. Which of the following is not a base according to any of the theories?
(A) $Mg(OH)_2$ (B) NH_3 (C) $H_2PO_4^-$ (D) BF_3

48. At a certain temperature, Kw was found to be 1×10^{-10} mole^2 l^{-2}. At this temperature, a solution is taken and red litmus is added to this solution. The solution turned to blue. pH range of the solution could be
(A) between 5 and 7 (B) between 7 and 10
(C) less than 5 (D) Both 1 and 2

49. The indicator which shows colour changes in the entire pH range is
(A) phenolphthalein (B) methyl orange (C) universal indicator (D) thymol blue

50. Which of the following has the highest value of pH?
(A) HCl (B) NaOH (C) $Ca(OH)_2$ (D) CH_3COOH

51. Heat of neautralization is less than 13.7 Kcal/mole for the reaction
(A) $HCl + NaOH \longrightarrow NaCl + H_2O$ (B) $H_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O$
(C) $HNO_3 + NaOH \longrightarrow NaNO_3 + H_2O$ (D) $CH_3COOH + NaOH \longrightarrow CH_3COONa + H_2O$

52. Common name of H_2SO_4 is :
(A) Oil of vitriol (B) Muriatic acid (C) Blue vitriol (D) Green vitriol

53. Caustic soda is the common name for :
(A) $Mg(OH)_2$ (B) KOH (C) $Ca(OH)_2$ (D) NaOH

54. Antacids contain -
(A) Weak base (B) Weak acid (C) Strong base (D) Strong acid

55. Calcium hydroxide (slaked lime) is used in :
(A) Plastics and dyes (B) Fertilizers (C) Antacids (D) White washing

56. If pH of any solution is equal to zero then solution will be :
(A) acidic (B) basic (C) neutral (D) none of these

57. Methyl orange is :
(A) an acidic indicator (B) a basic indicator (C) a neutral indicator (D) none of these

58. pH of Blood is :
(A) 6.4 (B) 7.4 (C) 4.7 (D) 6.4

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

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

61. Energy released in neutralisation reaction which occurs between strong acid and strong base is-
(A)57.8 kJ (B) 57.1 kJ (C) 57.9 kJ (D) 56.1 kJ

62. A solution has pH 9. On dilution the pH value
(A) decreases (B) increases (C) remain same (D) none of these

63. 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

64. Materials used in the manufacture of bleaching powder are :
(A) lime stone and chlorine (B) quick lime and chlorine
(C) slaked lime and HCl (D) slaked lime and chlorine

65. Bleaching powder gives smell of chlorine because it :
(A) is unstable (C) gives chlorine on exposure to atmosphere
(C) is mixture of chlorine and slaked lime (D) contains excess of chlorine

66. Baking powder contains, baking soda and :
(A) potassium hydrogen tartarate (B) calcium bicarbonate
(C) sodium carbonate (D) vinegar

67. Setting of plaster of Paris takes place due to :
(A) oxidation (B) reduction (C) dehydration (D) hydration

68. Chemical formula of baking soda is-
(A) $MgSO_4$ (B) Na_2CO_3 (C) $NaHCO_3$ (D) $MgCO_3$

69. The chemical name of marble is -
(A) calcium carbonate (B) Magnesium carbonate
(C) calcium chloride (D) calcium sulphate

70. 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

71. The raw materials required for the manufacture of $NaHCO_3$ by Solvay process are -
(A) $CaCl_2$, $(NH_4)_2\ CO_3$, NH_3 (B) NH_4Cl,NaCl, $Ca(OH)_2$
(C) $NaCl_2$,$(NH_4)_2CO_3$,NH_3 (D) Na_2CO_3, $(NH_4)_2CO_3$, H_2O

72. Plaster of Paries hardens by :
(A) giving off CO_2. (B) changing into $CaCO_3$.
(C) combining with water (D) giving out water.

73. The difference in number of water molecules in gypsum and plaster of paris is-
(A) 5/2 (B) 2 (C) ½ (D) 3/2

74. Which is correct set of acid properties, as :

(A) Sour taste, corrosive, change red litmus to blue

(B) Sour taste, corrosive, change blue litmus to red

(C) Sweet, slippery, change blue litmus to red

(D) Bitter taste, change blue litmus to red

75. Which of the following is an indicator, use to distinguish between acids and bases ?

(A) Phenolphthalein (B) Litmus paper (C) Methyl orange (D) All of these

76. Which of the following statements is true concerning acids and bases ?

(A) Acids and bases don't react with each other (B) Acids mixed with bases neutralize each other

(C) Acid mixes with bases make stronger (D) Acids mixed with bases make weaker acids

77. On diluting a solution of pH of 4, its pH will

(A) Remain same (B) Increase (C) Decrease (D) No change

78. The equation between and acid and a base is

$$XOH + HY \rightarrow XY + H_2O$$

Which of the following is the cation part of salt ?

(A) X (B) OH (C) H (D) HY

EXERCISE-III

1. Esha performed a simple experiment to distinguish strong from weak acid. For this she performed qualitative experiments with universal indicator, using tamarind and the acid present in gastric juice and she recorded her observations. Which of the following findings did she observe ?

	Acid present in gastric juice		**Acid present in tamarind**	
	Strength	**Colour of universal indicator**	**Strength**	**Colour of universal indicator**
(A)	Weak	Red	Strong	Red
(B)	Weak	Yellow	Weak	Green
(C)	Strong	Light red	Weak	Yellow
(D)	Strong	Green	Strong	Blue

2. Oxides are acidic, basic or amphoteric based on their metallic or non-metallic character. Which one of the following oxides reacts with both HCl and NaOH.

(A) CaO (B) ZnO (C) SO_2 (D) CO_2

3. The compounds Na_2O, Al_2O_3 and SO_2 respectively are

(A) Acidic, amphoteric and basic (B) Amphoteric, basic and acidic.

(C) Basic, acidic and amphoteric. (D) Basic, amphoteric and acidic.

4. The pH of solution **X** is 1 and that of **Y** is 2. Which statement is correct about the hydrogen ion concentrations in the two solutions ?

(A) $[H^+]$ in **X** is half that in **Y**. (B) $[H^+]$ in **X** is twice that in **Y**.

(C) $[H^+]$ in **X** is one tenth of that in **Y**. (D) $[H^+]$ in **X** is ten times that in **Y**.

5. Which of the following oxides is an acid anhydride ?

(A) Al_2O_3 (B) CO_2 (C) CO (D) Red lead

6. The compound whose 0.1 M solution is basic is

(A) Ammonium acetate (B) Ammonium chloride (C) Sodium acetate (D) Sodium sulphate

7. Upon mixing equal volumes of aqueous solutions of 0.1 M HCl and 0.2 M H_2SO_4, the concentration of H^+ in the resulting solution is :

(A) 0.30 mol/L (B) 0.25 mol/L (C) 0.15 mol/L (D) 0.10 mol/L

8. The pH of a 0.025 M solution of KOH is

(A) 1.60 (B) 3.69 (C) 10.31 (D) 12.40

9. When the pH of the environment of a protein is changed, it is said to be denatured. This is due to

(A) breakage of peptide bonds (B) Breakage of disulfide links
(C) Loss of tertairy structure (D) Breakdown of R groups

10. A student adds 5.85 gm of NaCl to 1 litre of water (the pH of which was measured to be 7.0) in a flask (X) to make a 0.1 M solution. He transfers 500 ml into another flask (Y). He covers the flask (Y) with tissue paper and the original flask (X) with a watch glass and goes to watch a movie. When he returns to the lab the next morning, he checks the pH of both the solutions using a perfectly calibrated pH meter. Which of the following is correct ?

(A) X has pH = 7 and Y has pH > 7. (B) X has pH < 7 and Y has pH = 7.
(C) X has pH = 7 and Y has pH < 7. (D) Both X and Y have pH = 7.

11. Which of the following solutions will have pH close to 1.0 ?

(A) 100 mL 0.1 M HCl + 100 mL 0.1 M NaOH (B) 55 mL 0.1 M HCl + 45 mL 0.1 M NaOH
(C) 10 mL 0.1 M HCl + 90 mL 0.1 M NaOH (D) 75 mL 0.2M HCl + 25 mL 0.2 M NaOH

12. The degree of dissociation of acetic acid (0.1 mol L^{-1}) in water (K_a of acetic acid is 10^{-5}) is

(A) 0.01 (B) 0.5 (C) 0.1 (D) 1.0

13. The compound used to remove carbon dioxide from air is

(A) Sodium carbonate (B) Sodium hydroxide (C) Sodium nitrate (D) Sodium Chloride

14. The pH of blood is maintained with in the range 7.36 – 7.42 by

(A) CH_3COONH_4 (B) CH_3COONa/CH_3COOH
(C) HCO_3 / CO_3 (D) CH_3COOH

15. The pH of 0.1 M aqueous solutions of NaCl, CH_3COONa and NH_4 Cl will follow the order

(A) NaCl < CH_3COONa < NH_4Cl (B) NH_4Cl < NaCl < CH_3COONa

(C) NH_4Cl < CH_3COONa < NaCl (D) NaCl < NH_4Cl < CH_3COONa

ANSWER KEY

EXERCISE - I

3. Acidus **5.** ((i) Acetic acid (ii) Citric acid (iii) Citric acid)

6. Monobasic acids form only the normal salts. **7.** No **8.** Oxyacids.

11. Undissociated base will be left after dissolution.

15. (i)(True) (ii) (False) (iii) (True) (iv) (True) (v) (False) (vi) (False)
(vii) (True) (viii) (True) (ix) (False) (x) (True) (xi) (False) (xii) (False)
(xiii) (True) (xiv) (True) (xv) (True) (xvi) (True) (xvii) (True)

16. (a)A-s , B-r ,C-q ,D-p (b) A-p , B-q , C-s , D-r (c) A-b , B-a , C-d , D-c , E-f , F-e

17. (a) H^+ , H_3O^+,OH^- , hydroxide , 100 , partially , wea k base , neutralization , water , salt , acid , salt (b) H_3O^+, OH^- , ion product , K_w, 1×10^{-14}, $-\log [H_3O^+]$, 10^{-7}, less , 10^{-7}, greater
(c) (i) Blue (ii) Red (iii) Hydrogen (iv) Basic, alkaline (v) solid
(d) (1) acidic (2) acidic (3) basic, amphoteric (4) 0.000001 mole ion / ℓ
(5) greater than 7 (6) Normal salt (7) mol.ion^2 / lit^2

EXERCISE - II

1.	B	**2.**	A	**3.**	A	**4.**	C	**5.**	B	**6.**	B	**7.**	D
8.	B	**9.**	C	**10.**	C	**11.**	D	**12.**	A	**13.**	B	**14.**	B
15.	C	**16.**	B	**17.**	A	**18.**	B	**19.**	B	**20.**	A	**21.**	C
22.	C	**23.**	B	**24.**	D	**25.**	C	**26.**	A	**27.**	C	**28.**	B
29.	D	**30.**	C	**31.**	B	**32.**	C	**33.**	B	**34.**	B	**35.**	C
36.	B	**37.**	A	**38.**	C	**39.**	B	**40.**	D	**41.**	B	**42.**	C
43.	A	**44.**	D	**45.**	D	**46.**	D	**47.**	D	**48.**	D	**49.**	C
50.	B	**51.**	A	**52.**	A	**53.**	D	**54.**	A	**55.**	D	**56.**	A
57.	B	**58.**	B	**59.**	D	**60.**	C	**61.**	B	**62.**	A	**63.**	A
64.	D	**65.**	B	**66.**	A	**67.**	D	**68.**	C	**69.**	A	**70.**	B
71.	D	**72.**	C	**73.**	D	**74.**	B	**75.**	D	**76.**	B	**77.**	B
78.	A												

EXERCISE - III

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