ACID, BASE AND SALT

EDUMAX CLASSES

EDUCATION AT MAXIMUM

Introduction -

A wide variety of materials consists essentially of elements and compounds having different characteristics exist around us. Some of them are sour, some are bitter, while some are salty in taste.

For Example - Sour and bitter tastes of food are due to acids and bases, respectively, present in them.

Acids react with bases to produce salt whose properties are different from acid and base.

Acids -

The term "acid" is derived from the latin word "**acidus**" meaning sour to taste.

Example - Sour taste of lemon, unripened grapes, Vinegar, tomatoes etc.

According to Arrhenius theory :

"An acid is a substance which dissolved in water, it ionizes and releases hydrogen ions [H^+(aq.)] in solution".

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

Hydrochloric acid Hydrogen ion Chloride ion

or $HCl(g) + H_2O(l) \rightarrow H_3O^{Å}(aq.) + Cl^-(aq.)$

Note :- Hydrogen ion do not exist as H^+ ions in solution, they attach themselves to the polar water molecules to form hydronium ions or hydroxonium ions, ($H_3O^{Å}$ or H^+(aq.))

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

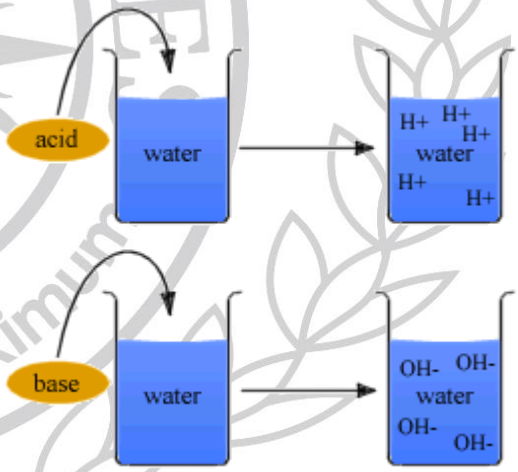
Hydrogen ion Water Hydronium ion

$H_2SO_4(aq.) \rightarrow 2H^+(aq.) + SO_4^{2-}(aq.)$

Sulphuric acid Hydrogen ion Sulphate ion

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

Nitric acid Hydrogen ion Nitrate ion



Classification of acids -

(I) On the basis of their source acids are of two type -

(i) Mineral acids ; (ii) Organic acids

(i) Mineral Acids (Inorganic acids) :-

The acids which are usually obtained from minerals are known as inorganic acids.

Name Chemical Formula Where found or used

- Hydrochloric acid HCl: In purification of common salt, in textile industry as bleaching agent, to make **aqua regia**.
- Sulphuric acid H_2SO_4: Commonly used in car batteries, in the manufacture of fertilizers (Ammonium phosphate, Super phosphate detergents etc, in paints, plastics, drugs) manufacture of artificial silk, in petroleum refining.

- Nitric acid HNO_3: Used in the manufacture of explosives (TNT, Nitroglycerine) and fertilizers (Ammonium nitrate, Calcium nitrate, Purification of Au, Ag.
- Carbonic acid H_2CO_3: In soft drinks and lends fizz, in stomach as gastric juice, used in tanning industry
- Phosphoric acid H_3PO_4: Used in antirust paints and in fertilizers

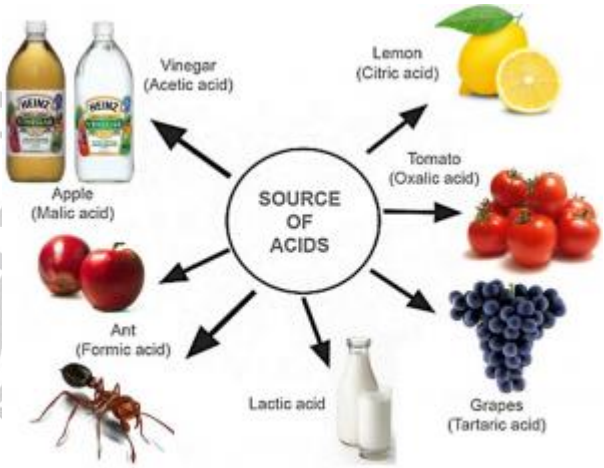
Note : Aqua regia is a mixture of (3 part HCl & 1 part HNO_3) which dissolves even noble metals like Au, Pt.

(ii) Organic Acids :-

The acids which are usually obtained from plants and animals are known as organic acids.

Name Where found or used

- Formic acid (HCOOH): Found in the stings of ants and bees, used in tanning leather, in medicines for treating gout.
- Acetic acid (CH_3COOH): Found in vinegar, used as solvent in the manufacture of dyes and perfumes.
- Lactic acid: Responsible for souring of milk in curd
- Benzoic acid: Used as a food preservative
- Citric acid: Present in lemon, orange and citrus fruits
- Tartaric acid: Present in tamarind.



Acids and their sources

(II) On the Basis of their Basicity :-

"The basicity of an acid is the number of replaceable hydrogen atoms present in a molecule that can be produced by the complete ionisation of one molecule of that acid in aqueous solution."

or

"Basicity of an acid is determined by number of hydronium ions (H_3O^+/H^+(aq)) produced per molecule of an acid on ionisation."

(i) Manobasic Acids :-

The acid on complete ionisation produce one hydronium ion in aqueous solution.

Example : Hydrochloric acid (HCl), Hydrobromic acid (HBr), Hydrofluoric acid (HF), Hydroiodic acid (HI), Nitric acid (HNO_3), Acetic acid (CH_3COOH), Formic acid (HCOOH)

$HCl + H_2O \rightarrow H_3O^+ + Cl$(Chloride ion)

Hydronium ion

$CH_3COOH + H_2O \rightarrow H_3O^+ + CH_3COO^-$

Hydronium ion Acetate ion

$HNO_3 + H_2O \rightarrow H_3O + NO_3^-$

Hydronium ion Nitrate ion

(ii) Dibasic Acid :-

The acid on complete ionisation produces two hydronium ions in aqueous solution.

Example : Sulphuric acid (H_2SO_4)

Carbonic acid (H_2CO_3)

Oxalic acid $(COOH)_2$

(iii) Tribasic Acid :-

The acid on complete ionisation produces three hydronium ions in aqueous solution.

Example :

$H_3PO_4 + 3H_2O \rightarrow 3H_3O^+ + PO_4^{-3}$

Hydronium ion Phosphate ion

(III) Classification on the basis of their strength :-

(i) Strong Acid :-

The acid which undergoes complete ionisation in aqueous solution are known as strong acids.

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

$H_2SO_4 + Water \rightarrow 2H^+(aq) + SO_4^{2-}(aq)$ Complete ionised

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

(ii) Weak Acid :-

The acid which undergoes partial or incomplete ionisation in aqueous solution are known as weak acids.

$CH_3COOH + Water \rightarrow CH_3COO^-(aq) + H^+(aq)$

Acetic acid Acetate ion

Example : Formic acid (HCOOH), Oxalic acid $(COOH)_2$

Carbonic acid (H_2CO_3), phosphoric acid (H_3PO_4)

(IV) Classification on the basis of concentration of the Acid :-

(i) Concentrated Acid :-

The acids which contains very small amount of water is called a concentrated acid.

(ii) Dilute Acid :-

The acids which contains more amount of water is called a dilute acid.

D "Strength of an acid is not depend upon the concentration of an acid"

Strength of an Acid µ Concentration of hydronium ion.

Bases

Substances with bitter taste and give a soapy touch are known as bases but many bases have corrosive nature. So bases are defined as "

According to Arrhenius :

those substances which give hydroxide or hydroxyl ion (OH^-) in their aqueous solution" are called bases.

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

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

Example - Sodium hydroxide (NaOH), Zinc oxide (ZnO), Copper oxide (CuO), Calcium hydroxide [$Ca(OH)_2$], Aluminium hydroxide [$Al(OH)_3$].

The compounds which are either metallic oxides or metallic hydroxides. Which combines with acids to form salts and water only.

$CuO + 2HCl \rightarrow CuCl_2 + H_2O$

Base Acid Salt Water

$NaOH + HCl \rightarrow NaCl + H_2O$

Base Acid Salt Water

$Mg(OH)_2 + H_2SO_4 \rightarrow MgSO_4 + 2H_2O$

Base Acid Salt Water

Alkalis -

Bases which completely dissolves in water are called alkalis.

Examples KOH, NaOH, $Ca(OH)_2$

All the alkalis are bases but all bases are not alkalis.

Examples [$Fe(OH)_3$] ferric hydroxide and cupric hydroxide [$Cu(OH)_2$] are base, but not an alkali.

Classification of Bases -

(I) Classification on the basis of their strength :-

(i) Strong alkalis or bases :-

The alkalis or bases which undergo almost complete ionisation in aqueous solution are known as strong alkalis or bases.

Examples -

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

Sodium hydroxide

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

Potassium hydroxide

$Ba(OH)_2(aq.) \rightarrow Ba^+(aq) + 2OH^-(aq)$

Barrium hydroxide

(ii) Weak alkalis or bases :-

The alkalis or bases which undergo only partial ionisation in aqueous solution are known as weak alkalis or Bases.

Example

$Ca(OH)_2(aq.) \rightarrow Ca^{2+}(aq) + 2OH^-(aq.)$

Calcium hydroxide Partial Ionisation

$Mg(OH)_2(aq.) \rightarrow Mg^{2+}(aq) + 2OH^-(aq.)$

Magnesium hydroxide

(II) Classification on the basis of their concentration

(i) Concentrated Base or Alkali

The bases or alkalis which contain very small amount of water is called a concentrated bases or alkalis.

(ii) Dilute Acid -

The bases or alkali which contain more amount of water is called a dilute bases or alkalis.

(III) Classification on the basis of their acidity -

Acidity of a base is determined by the number of hydroxyl (OH^-) ions produced by per molecule of a Base or Alkali on complete dissociation in water "or"

The "number of hydrogen ions of an acid with which a molecule of that alkali or base react to produce salt and water is known as acidity of an alkali or Base".

(i) Mono acidic Bases or Alkali -

The base or alkali on complete ionisation produce one hydroxyl (OH^-) ion in aqueous solution.

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

Hydroxyl ion

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

Hydroxyl ion

(ii) Diacidic Bases (or alkalis) -

The base or alkali on complete ionisation produce two hydroxyl ion (OH^-) in aqueous solution

Example -

(A) Diacidic Bases of -

$Ca(OH)_2(aq.) \rightarrow Ca^{2+}(aq.) + 2OH^-(aq.)$

$Mg(OH)_2(aq.) \rightarrow Mg^{2+}(aq.) + 2OH^-(aq.)$

(B) Diacidic Bases -

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

$Fe(OH)_2(aq.) \rightarrow Fe^{2+} + 2OH^-(aq.)$

$Fe^{+2}(OH)_{2-} + 2H^+Cl^-(aq.) \rightarrow FeCl_2 + 2H_2O$

(iii) Tri Acidic Bases -

The base or alkali on complete ionisation produce three hydroxyl ion $(OH)^-$ in aqueous solution.

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

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

$Al^{3+}(OH)_{3-} + 3HCl(aq.) \rightarrow AlCl_3 + 3H_2O$

==========

Properties of Acid and Bases -

(1) Physical properties of Acid -

(I) Taste - Acids have sour test.

(II) Physical state Some acid are solids while other are liquid at room temperature.

Example Solid Oxalic acid $(COOH)_2$, Boric acid (H_3BO_3)

Liquid Acetic acid (CH_3COOH), Formic acid ($HCOOH$),

Sulphuric acid (H_2SO_4)

Volatile liquid Carbonic acid (H_2CO_3), Hydrochloric acid (HCl)

Nitric acid (HNO_3)

(III) Effect of Indicator

They affect the indicators as given below

Indicator Change in acidic medium

- Blue litmus paper Blue to Red
- Methyl orange Orange to pink
- Phenolphthalein Remains colourless
- Turmeric paper Remains colourless
- Carbonic acid (H_2CO_3) turns blue litmus to pink. Because this is weak mineral acid.

Litmus: A water soluble purple dye, extracted from certain lichens, a plant belonging to the division thallophyta and is commonly used as an indicator. The pH range for litmus is 4.5-8.3 at room temperature.

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

Activity : Take small amount of finely chopped onions along with some strips of clean cloth in a plastic bag. Tie up the bag tigthtly and leave it as such in a refrigerator for a night. In the morning, take two of these strips and check their odour. Now put a few drops of dilute HCl solution on one strip and a few drops of dilute NaOH solution on the other. Rinse both the cloth strips with water and again check their odour and note down in your note book. You will see that onion will give different odour in HCl and NaOH.

You can repeat the activity by taking dilute vanilla essence. Smell dilute vanilla essence. Now take some dilute HCl solution in one test tube and dilute NaOH solution in another test tube add a few drops of dilute vanilla essence to both the test tubes and shake well. Check the odour once again. You will feel different smells in both the test tubes.

Lastly, you can repeat the activity by taking clove oil in place of vanilla essence.

From this activity, we conclude that vanilla, onion or clove oil can also be used as olfactory indicators since these change their odour in acidic and basic media.

(IV) Effect on Skin All strong mineral acids have a corrosive action on skin and cause painful burns.

Example Concentrated sulphuric acid stains the skin black.

Concentrated nitric acid & hydrochloric acid stains the skin yellow.

(V) Electrical Conductivity All mineral acids are good conductors of electricity and conduct electricity in their aqueous solution. On electrolysis, they decompose liberating hydrogen at cathode.

(2) Chemical Properties of Acids

(I) Reaction with metals

Dilute acids like hydrochloric acid (HCl), sulphuric acid (H_2SO_4) react with certain active metals to evolve hydrogen gas and form their metallic salt

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

dilute

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

dilute

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

dilute

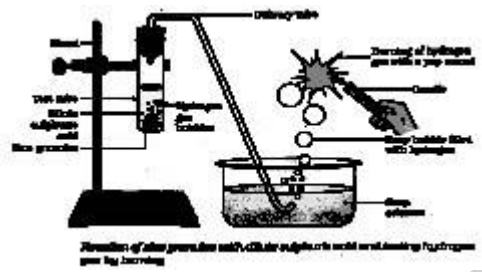
$Fe(s) + H_2SO_4 \rightarrow FeSO_4 (aq) + H_2 (g)$

dilute

Activity : To study the reaction of acids, with metals.

·**Materials required :** Granulated zinc, Dilute sulphuric acid, Boiling tube, Matchbox

·**Procedure :** Take about 5 ml of dilute sulphuric acid in a boiling tube. Add a few piece of zinc metal into it and place an inverted boiling tube over its mouth . Your can see the bubbles of hydrogen gas coming out of the mixture in the lower tube. After a few minutes, remove the upper boiling tube (Keeping its mouth downwards) near to its mouth. What do you see ? The gas in the upper boiling tube burns with a blue flame producing popping sound. Repeat similar experiment with different acids and a few other metals. Write down your observations.



·**Observation :** Colourless, odourless gas is evolved. It burns explosively with a 'pop' sound.

$Zn(s) + H_2SO_4$ (dil) ® $ZnSO_4$ (aq) + $H_2(g)$

·**Conclusion :** Reactive metals react with dilute acid to liberate hydrogen gas.

Metals which can displace hydrogen from dilute acid are known as active metals.

e.g. Na, K, Zn, Fe, Ca, Mg etc.

(II) Reaction with metal carbonates and metal Hydrogen Carbonates

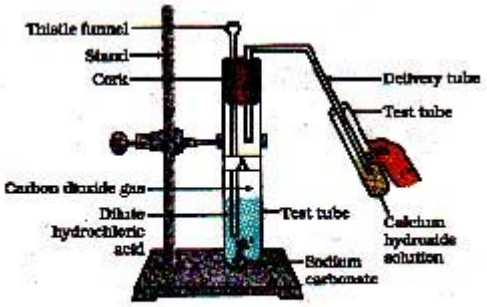
Both metal carbonates and hydrogen carbonates (bicarbonates) react with dilute acids to evolve CO_2 gas and form salt.

Activity : To study the reaction of sodium carbonate and sodium hydrogen carbonate with dilute acids.

·**Materials required :** Sodium carbonate (Na_2CO_3), Sodium hydrogencarbonate, Hydrochloric acid (dil.), Limewater, Boiling tubes, Delivery tube.

·**Procedure :** Take about 0.5g of sodium carbonate in a boiling tube, and 2-3 mL of freshly prepared limewater in another test tube. Set a delivery tube as shown in fig. given alongside. Add about 2mL of dilute hydrochloric acid into the boiling tube containing sodium carbonate. A brisk effervescence is seen in the reaction mixture. Pass the gas evolved through limewater with the help of a delivery tube. What do your observe ? The limewater turns milky. When excess of carbon dioxide is passed, the milkyness disappears. Repeat similar experiemnt with sodium hydrogencarbonate ($NaHCO_3$), and if desired with other acids also.

·**Conclusion :** All acids decompose carbonates and hydrogencarbonates with the liberation of carbon dioxide gas.



Reaction of hydrochloric acid with sodium carbonate (washing soda) and testing the gas evolved

$CaCO_3$ (s) + 2HCl → $CaCl_2$(aq) + H_2O (l) + CO_2(g)

Calcium carbonate Dilute Calcium chloride

$Ca(HCO_3)_2$ (s) + 2HCl → $CaCl_2$(aq) + $2H_2O$ (l) + $2CO_2$(g)

Calcium hydrogen Dilute

Carbonate

K_2CO_3 (s) + 2HCl → 2KCl(aq) + H_2O (l) + CO_2(g)

Potassium carbonate Dilute Potassium chloride

$KHCO_3$ (s) + HCl → KCl(aq) + H_2O (l) + CO_2(g)

Potassium hydrogen Dilute Carbonate

Na_2CO_3 (s) + 2HCl → 2NaCl(aq) + H_2O (l) + CO_2(g)

Sodium carbonate Sodium chloride

$NaHCO_3$ (s) + HCl → NaCl(aq) + H_2O (l) + CO_2(g)

Sodium hydrogen carbonate

(III) Reaction with metallic oxide

Metal oxides react with dilute acids to form salt and water.

Activity : To study the reaction of dilute acid with metal oxides (or basic oxides.)

·**Materials required :** Copper (II) oxide, Dilute hydrochloric acid , Test tube

·**Procedure :** Take about 0.5g of copper (II) oxide (black in colour) in a test tube. Add dilute hydrochloric acid dropwise with occasional shaking till copper (II) oxide dissolve. Note the colour of the solution. I not it bluish-green ? It is the solution of copper (II) chloride.

·**Conclusion :** Acids react with metal oxides to give the corresponding salt & water.

Na_2O (s) + $2HNO_3$ → $2NaNO_3$(aq) + H_2O (l)

Sodium oxide Dilute Sodium Nitrate

CuO (s) + 2HCl → $CuCl_2$(aq) + H_2O (l)

Copper (II) oxide Dilute Copper (II) chloride

$PbO\ (s) + 2HNO_3 \rightarrow Pb(NO_3)_2(aq) + H_2O\ (l)$

Lead (II) oxide Dilute Lead (II) Nitrate

FeO (s) + 2HCl ¾¾® $FeCl_2(aq) + H_2O\ (l)$

Iron (II) oxide Dilute Iron (II) chloride

(IV) Reaction with metallic sulphites and hydrogen sulphites

Metallic sulphites and hydrogen sulphites react with dilute acids to liberate sulphur dioxide.

$CaSO_3\ (s) + H_2SO_4 \rightarrow CaSO_4(aq) + H_2O\ (l) + SO_2\ (g)$

Calcium sulphite Dilute

$NaHSO_3\ (s) + HCl \rightarrow NaCl(aq) + H_2O\ (l) + SO_2\ (g)$

Sodium hydrogen Dilute sulphite

(V) Reaction with metallic sulphides and hydrogen sulphides

Metallic sulphides and hydrogen sulphides react with dilute acid to liberate hydrogen sulphide gas.

$FeS + H_2SO_4 \rightarrow FeSO_4\ (aq) + H_2S\ (g)$

Iron (II) sulphide Dilute Iron sulphate

$KHS + HCl \rightarrow KCl\ (aq) + H_2S\ (g)$

Potassium Dilute Potassium chloride

hydrogen sulphide

$ZnS + H_2SO_4 \rightarrow ZnSO_4\ (aq) + H_2S\ (g)$

Zinc sulphide Dilute Zinc sulphate

(VI) Reaction with metal chlorides

Metal chlorides react with concentrated acids to produce hydrogen chloride gas. Which give white dense fumes with ammonia.

$2NaCl\ (s) + \text{conc. } H_2SO_4 \xrightarrow{\Delta} Na_2SO_4(aq) + 2HCl(g)$

Sodium chloride Sodium sulphate

$2KCl\ (s) + \text{conc. } H_2SO_4 \xrightarrow{\Delta} K_2SO_4\ (aq) + 2HCl(g)$

Potassium chloride Potassium sulphate

(VII) Reaction with metal nitrates

Metal nitrate react with concentrated acids to produce more volatile nitric acid.

$2NaNO_3$ + conc. $H_2SO_4 \xrightarrow{\Delta} Na_2SO_4$ (aq) + $2HNO_3$

Sodium nitrate Sodium sulphate

(VIII) Reaction of Acid and Base with each other

All metallic hydroxides (Bases) react with acids to form their metallic salt and water. This reaction is also known as acid-base neutralisation reaction.

Activity : To study a reaction of an acid say, hydrochloric acid with an alkali or base.

·**Materials required :** Hydrochloric acid solution, sodium hydroxide solution, phenolphthalein indicator, Boiling tube, dropper, trough.

·**Procedure :** Take about 5 mL of dilute solution of sodium hydroxide (NaOH) in a test tube. Add 2 drops of phenolphthalein indicator in it. The solution in the test tube turns pink. Now, add dilute solution of hydrochloric acid (HCl) when the pink colour of the solution just disappears.

Now, add a drop of sodium hydroxide solution and shake the test tube to mix the solution. What do you see? The solution turns pink. Add a drop of HCl solution to the solution in the test tube. The pink colour disappears. Keep repeating the addition of sodium hydroxide and hydrochloric acid solution one after the other and watch the appearance and disappearance of pink colour.

·**Conclusion :** This experiment show that the addition of HCl solution destroys the alkaline nature of NaOH. On the other hand , the addition of NaOH solution destroys the acidic nature of HCl. That is, both NaOH and HCl appear to cancel the effect of each other. Such a reaction between an acid and alkali is called neutralisation.

Q. What is a neutralisation reaction ? Give two examples. **[ncert]**

KOH (aq) + HCl → KCl (aq) + H_2O (l)

Potassium hydroxide Dilute Potassium chloride

NaOH (aq) + HCl → NaCl (aq) + H_2O (l)

Sodium hydroxide Dilute Sodium chloride

$Ca(OH)_2$ (aq) + $2HNO_3$ → $Ca(NO_3)_2$ (aq) + $2H_2O$ (l)

Calcium hydroxide Dilute Calcium nitrate

$Mg(OH)_2$ (s) + H_2SO_4 → $MgSO_4$ (aq) + $2H_2O$ (l)

Magnesium hydroxide Dilute Magnesium sulphate

$Cu(OH)_2$ (s) + $2HNO_3$ → $Cu(NO_3)_2$ (aq) + $2H_2O$ (l)

Copper(II) hydroxide Dilute Copper(II) nitrate

==========

Physical Properties of Bases

(I) Taste They are sharp bitter in taste.

(II) Effect on skin They give a feeling of soapy touch and all alkali have a mild corrosive action on skin.

(III) Effect on Indicator They effect the indicators as given below

Indicator Change in acidic medium

Red Litmus Red to Blue

Methyl orange Orange to yellow

Phenolphthalein Colourless to pink

Turmeric paper Yellow to red brown

(4) Chemical Properties of Bases

(I) Reaction with Metals

Bases react with some metals to liberate hydrogen gas.

$Zn (s) + 2NaOH \rightarrow Na_2ZnO_2 (aq) + H_2 (g)$

Zinc Dilute Sodium zincate Hydrogen gas

$2Al (s) + 2NaOH+2H_2O (l) \rightarrow 2NaAlO_2 + 3H_2 (g)$

Dilute Sodium aluminate

(II) Reaction of Bases with Non-metallic oxide

Base react with non-metallic oxide to form their respective carbonates and water.

$2NaOH (aq) + CO_2(g) \rightarrow Na_2CO_3 (aq) + H_2O (l)$

Sodium hydroxide Carbon dioxide Sodium carbonate water

$2KOH (aq) + CO_2(g) \rightarrow K_2CO_3 (aq) + H_2O (l)$

Potassium hydroxide Potassium carbonate

Some of the alkalis like sodium hydroxide (NaOH) are called **deliquescenc** because they absorbs carbon dioxide from the air and its strength decreases with time.

(III) Reaction of Bases with Acids

They neutralise the acids to form salt and water.

Acid + Base → Salt + Water

(IV) Reaction of Bases with ammonium salt

Bases react with ammonium salt to evolve ammonia gas.

$NaOH (aq) + NH_4Cl(g) \rightarrow NaCl (aq) + H_2O (l) + NH_3 (g)$

Sodium hydroxide Sodium chloride

$Ca(OH)_2$ (aq) + $2NH_4Cl$(g) → $CaCl_2$ (aq) + $2H_2O$ (l) + NH_3 (g)

Calcium hydroxide Calcium chloride

(V) Reaction of Bases with Salt

Bases react with salt solution to form another base and another salt.

3NaOH (aq) + $FeCl_3$(aq) → $Fe(OH)_3$ (aq) + 3NaCl(aq)

Sodium hydroxide Iron (III) chloride Iron (III) hydroxide

Base-1 Salt_1 Base_2 (Brown ppt.) Salt_2

2NaOH (aq) + $ZnSO_4$(aq) → $Zn(OH)_2$ (s) + Na_2SO_4(aq)

Sodium hydroxide Zinc sulphate Zinc hydroxide Sodium sulphate

(White ppt.)

Uses of Bases or Comparis Between Properties of ACIDS & BASES

Acids Bases

(i) Sour in taste (i) Bitter in taste

(ii) The properties are due to the presence of (ii) The properties are due to the presence of

hydrogen ion (H^+) in water solution of an acid hydroxide ion (OH^-) in water solution of a base.

(iii) Turns blue litmus to red (iii) Turns red litmus to blue

(iv) Aqueous solution conducts electricity (iv) Aqueous solution conducts electricity

(v) Reacts with active metals like Na, K, Ca and (v) Does not react with metals except with Zn to give hydrogen gas. Zn, Al and Sn.

(vi) Acidic properties disappear when react with (vi) Basic properties disappears when react bases (Neutralization) with acids (Neutralization)

(vii) Reacts with carbonates to give carbon dioxide (vii) Absorbs carbon dioxide to form carbonate.

(viii) Frequently corrosive to skin (viii) Frequently corrosive to skin and slippery in nature.

(ix) The pH value is less than 7 at 25°C (ix)

What do All Acids and Bases have in Common ?

A common thing for all the acids is that they produce hydrogen ions [H^+ (aq.)] when dissolved in water.

For Example _ Acids like HCl, H_2SO_4, HNO_3, CH_3COOH etc. show acidic character because they dissociate in aqueous solution to produce hydrogen ions.

But all the compounds containing hydrogen are not acids such as glucose ($C_6H_{12}O_6$) and alcohol (C_2H_5OH) also contain hydrogen but they do not show acidic character.

Activity : 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 & Beaker, Carbon electrodes , Dry cells, bulb 1.5 V, Key.

·**Procedure :** 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 observation

·**Observation :**

Solution Bulb glows Bulb does not glow Nature of solution

Dil. Hydrochloric acid P × Conducting

Dil Sulphuric acid P × Conducting

Dil. Sodium hydroxide P × Conducting

Ethanol × P Non- Conducting

Glucose solution × P Non- Conducting

·**Conclusion :** The solutions of acids and bases are good conductors of electricity. The solution of glucose and ehtanol are nonconductor of electricity.

A common thing for all the bases (or) is that they all produce hydroxide ions (OH^-) when dissolved in water.

For Example - $NaOH$, $Mg(OH)_2$, $Ca(OH)_2$ and NH_4OH are all bases because they dissolve in water to produce hydroxide ion (OH^-)

Acids or Bases (Alkali) in Water Solution -

The acidic behaviour of acids due to the presence of hydrogen ions. H^+ (aq) ions, in them. The acids produce hydrogen ions only in the presence of water. So, in the absence of water, a substance will not form hydrogen ions and hence will not show its acidic behaviour.

Activity : To show that acids furnish H^+ (aq) ions only in the presence of water.

·**Materials required :** Common salt, Conc. sulphuric acid, anhydrous calcium chloride, blue litmus paper, boiling tube, delivery tube packed with anhydrous calcium chloride.

·**Procedure :** Take 0.5g of dry common salt in a dry boiling tube. Add a few drops of concentrated sulphuric acid over common salt in the boiling tube. What do you see ? A colourless, irritating gas is evolved. Fit a cork carrying a calcium chloride packed delivery tube into the mouth of the boiling tube.

Bring a dry blue litmus paper near the opening of the calcium

chloride tube. Observe, if there is any change in colour. Colour of the litmus paper remains unchanged. Now, bring a moistened blue litmus paper near the mouth of the calcium chloride tube. Do you observe any change in the colour of litmus paper ? Yes, blue litmus has changed to red.

From the above activity, following conclusion can be drawn :-

·**Conclusion :** Dry HCl gas on coming in contact with dry blue litmus paper does not produce H^+ ions, and hence the colour of litmus paper does not change. so, we can say that separation of H^+ ions form acid takes place only in the presence of water.

Important Point - Why should water be never added to dilution of an Acid ?

Ans. Mixing of water in acid is an exothermic process and more heat is produced that splashing of water. In order to avoid this. We must add acid into water and not water into acid.

Morever, acid must also be added to water in small lots and not in one instalment.

How Strong are Acid or Base Solution -

Acids and bases on dilution with water, decreases the concentration of H^+(aq) or OH^-(aq) ions in the acidic and basic solutions respectively.

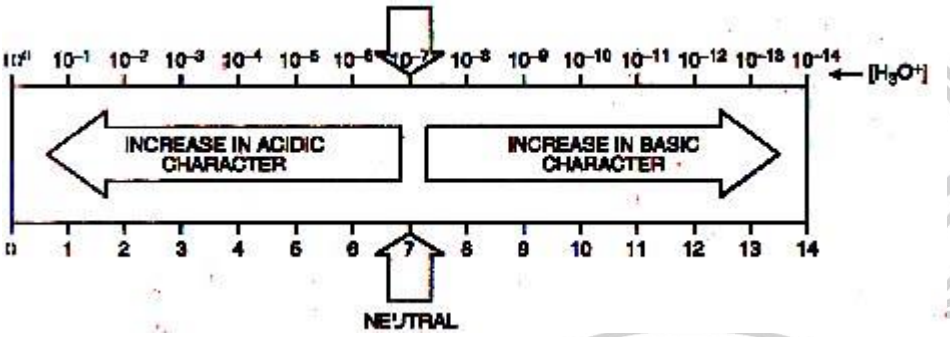
If we find quantitatively, the amount of H^+(aq) / OH^-(aq) ions present in a solution, we can judge how sttrong an acid or a base is ?

We can do this by the help of a universal indicator, which is a mixture of several indicators. The universal indicator shows different colours at different concentration of hydrogen ions or pH values in solution.

==========

pH SCALE -

S.P.L. sorenson, a Danish Chemist in 1909 introduced the concept of measuring the concentration of hydrogen ions (H^+ (aq)] in a particular solution., 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).



Variation of pH with the change in concentration of H^+(aq) and OH (aq) ions

The concentration of H^+ (aq) and OH^- (aq) ions in pure water is 1×10^{-7} mol litre^{-1}. This means that all aqueous solutions contain both H^+(aq) and OH^- (aq) ions. The product of concentration of H^+(aq) and OH^-(aq) in water is constant (equal to 1×10^{-14} mol^2 litre^{-2} at 25°C) and is known as ionic product of water (K_W).

- If [H^+(aq)] = [OH^-(aq)] = 1×10^{-7} mol litre^{-1}, then the solution is neutral.
- if H^+(aq) > OH^- (aq)

(H^+ (aq) > 1×10^{-7} mol litre^{-1}), then the solution should be acidic

- if H^+(aq) < OH^-(aq) or
  H^+(aq) < 1×10^{-7} mol litre^{-1}, then the solution should be basic or alkaline.

Table _ pH Value of Some Common Substances

Solution pH Value Solution pH Value

Conc. Hydrochloric acid 0 Dil. Hydrochloric acid 1.0

Conc. Sodium hydroxide 14.0 Dil. Sodium hydroxide 13.0

Gastric Juice 1.4 Lemon juice 2.5

Vinegar 4.0 Tomato juice 4.1

Saliva (before meals) 7.4 Saliva (after meals) 5.8

Coffee 5.0 Soft drinks 6.0

Blood 7.4 Eggs 7.8

Toothpaste 8.0 Baking Soda Solution 8.5

Washing Soda Solution 9.0 Pure Water 7.0

Importance of pH in everyday life -

(1) Plants and Animals are pH Sensitive -

The pH plays an important role in the survival of animals, including human being. Our body works well with in a narrow pH range of 7.0 to 7.8. The aquatic animals (Fish) can survive in river water with in a narrow range of pH change.

Example - When the pH of rain water is about 5.6, it is called acid rain. Too much acid rain can lower the pH of river water to such an extent and make it so acidic that the survival of aquatic animals becomes difficult or kill the aquatic animals.

Soil pH and Plants -

Most of the plants grow best when the pH of soil is close to 7. If the soil is too acidic or too basic (too alkaline), the plants grow badly or do not grow at all.

Treatment of Acidic or Basic Soil -

The pH of acidic soil can reach as low as 4 and that of the basic soil can go up to 8.3. Chemicals can be added to soil to adjust its pH and make it suitable for growing plants. If the soil is too acidic, then it is treated with materials like quicklime (calcium oxide) or slaked lime (Calcium hydroxide) or chalk (Calcium carbonate). All these materials are bases and hence react with the excess acid present in soil and reduce its acidity. If the soil is too basic (or too alkaline) then its alkalinity can be reduced by adding decaying organic matter (manure or compost). Which contains acidic materials.

(2) Importance of pH in our digestive system -

As we know our stomach produces gastric juice which contains large amount of hydrochloric acid (pH about 1.4). The acid so produced does not harm the stomach walls, but kills germs and bacteria which enter in our digestive system along with food, thus in a way it protects us from diseases and helps in digestion. Sometimes excess of acid is produced in the stomach due to overeating or eating spicy foods. This stage is called acidity. To get relief from this pain, we take tablets known as **antacids**. These contain bases to neutralise the excess acids.

Example _ Magnesium hydroxide (milk of magnesia).$Mg(OH)_2$

(3) pH change as the cause of tooth decay _

Generally, the pH in the mouth is more than 7, as the saliva produced in the mouth is basic in nature. However, when we take food, some food particales remain in the mouth after eating and bacteria present in the mouth produce acids by degradation of food particles. This acid lowers the pH in the mouth, tooth decay starts when the pH of acid formed in the mouth falls below 5.5. Therefore to prevent tooth decay, it is advised to clean the mouth and use toothpastes which are generally basic, for cleaning the teeth. It neutralise the excess acid and prevent tooth decay.

(4) Self defence by animals and plants through chemical Warfare _

The sting of the honey bee contains formic acid, this acid causes a lot of irritation and pain. The pain can be reduced by applying baking soda paste on the affected region as the acid gets neutralised.

In plant kingdom **nettle** (Bichu Booti) is a herbaceous plant which grows in wild. The nettle leaves have stinging hair. When a person happens to touch the leaves of a nettle plant accidently, the stining hair of nettle leaves inject methanoic acid (HCOOH) into the skin of the person causing burning pain. The nettle sting, being acidic can be neutralised by rubbing baking soda on the skin. Nature provides remedy for the nettle sting in the form of a 'dock' plant, which often grows besides the nettle plants. The leaves of dock plant contain some basic chemicals which neutralises methanoic acid.

Salts -

A substance formed by the partial or complete replacement of H^+(aq) ions of an acid by a metal or electropositive ion, is called a salt.

For Example -

$H_2SO_4 + NaOH \rightarrow NaHSO_4 + H_2O$

Sodium hydrogen sulphate

(Partial replacement : only one hydrogen atom is replaced)

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

Sodium sulphate

(Complete replacement : Both the hydrogen atom are replaced)

A substance formed by neutralization of an acid with a base is called a salt.

Example - HCl (aq) + NaOH (aq) → NaCl (aq) + H_2O

Acid Base Salt Water

A salt is a ionic compound which dissolved in water dissociate to positive ions other than hydrogen ions (H^+) and negative ions other than hydroxyl ions (OH^-) are called salts.

Example _ $NaCl + Water \rightarrow Na^{+}(aq) + Cl^{-}(aq)$

$CuSO_4 + Water \rightarrow Ca^{2+}(aq) + SO_4^{2-}(aq)$

Naming of Salts-

(A) Salt obtained from "Sulphuric acid" are called "Sulphates". **e.g.** Na_2SO_4, $CuSO_4$

(B) Salt obtained from "nitric acid" are called "Nitrates" **e.g.** KNO_3, $NaNO_3$

(C) Salt obtained from "hydrochoric acid" are called "Chlorides" **e.g.** NaCl, $CaCl_2$, KCl

(D) Salt obtained from "phosphoric acid" are called "Phosphates" **e.g.** $Ca_3(PO_4)_2$, Na_3PO_4, $Mg_3(PO_4)_2$

(E) Salt obtained from "carbonic acid" are called "Carbonates" **e.g.** Na_2CO_3, K_2CO_3, $CaCO_3$.

(F) Salt obtained from acetic acid are called "Acetates" **e.g.** CH_3COONa, $(CH_3COO)_2Ca$, $CH_3(COO)_2Pb$.

Classification of Salts -

The salts may be classified in the following ways -

(1) Normal Salts -

The salts which are obtained by complete replacement of the ionisable hydrogen atoms or hydroxyl ion by a metallic or an ammonium ion are called normal salts

"OR"

A salt that does not contain any replaceable hydrogen atoms or hydroxyl groups is called a normal salt.

Examples _ $HCl + NaOH \rightarrow NaCl + H_2O$

(Normal salt) Sodium chloride

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

(Normal salt) Sodium sulphate

$Pb(OH)Cl + HCl \rightarrow PbCl_2 + H_2O$

(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 called Acid Salts.

$H_2SO_4 + NaOH \rightarrow NaHSO_4 + H_2O$

Insufficient amount Sodium hydrogen

sulphate (acid salt)

$NaHSO_4 \rightarrow Na^{+} + H^{+} + SO_4^{2-}$

(3) Basic Salt -

The salt which are formed by partial replacement of hydroxyl (-OH) groups of a polyacidic base by an acid radial are called basic salts.

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

Lead hydroxide Lead oxychloride

(Basic salt)

(4) Double salt -

The salt which are obtained by the crystallisation of two simple salts, from a mixture of their saturated salt solutions are known as double salts.

For Example -

(A) Potash alum -

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

Potassium sulphate Aluminium sulphate Potash alum (Double salt)

(B) Mohr's Salt _ $FeSO_4(NH_4)_2SO_4.6H_2O$

(C) Dolomite _ $CaCO_3.MgCO_3$

(D) Carnallite _ $KCl.MgCl_2.6H_2O$

(E) Ferric alum _ $Fe_2(SO_4)_3.24H_2O$

(5) Mixed Salt -

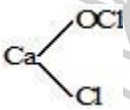
The salts containing more than one cations or anions other than H^+ or OH^- ions are called mixed salts.

For Example -

Sodium Potassium Carbonate - $NaKCO_3$ (contains two cations)

Bleaching powder - $CaOCl_2$ (contains two anions Cl^- and OCl^-)

or



Disodium potassium phosphate - (Na_2KPO_4)

Microcosmic salt - $NaNH_4HPO_4$

General methods of preparation of soluble salts -

(I) By direct combination of elements - By heating two elements together

$2Na + Cl_2 \xrightarrow{\Delta} 2NaCl$

Molten Sodium Chlorine Sodium chloride

(Metal) (non-metal)

$Zn + Cl_2 \rightarrow ZnCl_2$

(metal) (non-metal) Zinc chloride

(II) By the action of dilute mineral acids on active metals _

$Zn + dil.\ H_2SO_4 \rightarrow ZnSO_4 + H_2(g)$

$2Al + dil\ 6HCl \rightarrow 2AlCl_3 + 3H_2\ (g)$

$2Na + dil.\ 2HCl \rightarrow 2NaCl + H_2\ (g)$

(III) By Decomposition -

(a) By Decomposition of metal hydrogen carbonates -

$NaHCO_3(s) + HCl\ (dil) \rightarrow NaCl + H_2O + CO_2(g)$

(b) By Decomposition of metal carbonates-

$CuCO_3(s) + 2HCl\ (dil) \rightarrow CuCl_2 + H_2O + CO_2(g)$

Copper carbonate

(c) By decomposition of metal chloride _

$2NaCl + H_2SO_4\ (conc.) \xrightarrow[200°C]{\Delta} Na_2SO_4 + 2HCl\ (g)$

Sodium sulphate

(IV) By the process of neutralization -

Acid + Base (alkali) → Salt + water

$HNO_3 + NaOH \rightarrow NaNO_3 + H_2O$

Nitric acid Sodium hydroxide Sodium nitrate

(V) By the action of alkalis on metals -

$Zn + 2NaOH \rightarrow Na_2ZnO_2 + H_2(g)$

Sodium zincate

General methods of preparation of insoluble salts -

(VI) By direct combination of elements -

When metal powder is heated with sulphur, we get corresponding metal sulphides which are insoluble salts.

$Pb + S \rightarrow PbS$

Lead Sulphur Lead sulphide

(2) By double decomposition of two soluble salt _

Soluble salt + Soluble salt → Insoluble salt + Soluble salt

(I) (II) (Precipitate)

$NaCl + AgNO_3 \rightarrow AgCl\ (\bar{\ }) + NaNO_3$

(Sodium chloride) (Silver nitrate) (Silver chloride) (Sodium nitrate)

$BaCl_2 + Na_2SO_4 \rightarrow BaSO_4$ (¯) + 2NaCl

(Barium chloride) (Sodium sulphate) (Barium sulphate) (Sodium chloride)

$Pb(NO_3)_2 + Na_2SO_4 \rightarrow PbSO_4$ (¯) + $2NaNO_3$

(Lead nitrate) (Sodium sulphate) (Lead sulphate) (Sodium nitrate)

Family of Salt -

The salts having the same positive radical (or cation) or negative radical (or anion) are said to belong to the same family. For example,

·NaCl (sodium chloride) and Na_2SO_4 (sodium sulphate) belong to the family of sodium salts because both contain the same radical (or cation), that is Na^+. These may be called sodium salts.

·Copper sulphate ($CuSO_4$) and sodium sulphate (Na_2SO_4) belong to the family of sulphates because both contain the same acid radical (or anion), that is sulphate (SO_4^{2-}).

The salts belong to certain families are listed belong :

Sulphate family Sodium family Chloride family

Potassium sulphate (K_2SO_4) Sodium sulphate (Na_2SO_4) Sodium chloride (NaCl)

Sodium sulphate (Na_2SO_4) Sodium bromide (NaBr) Ammonium chloride (NH_4Cl)

Magnesium sulphate ($MgSO_4$) Sodium nitrate ($NaNO_3$) Calcium chloride ($CaCl_2$)

Calcium sulphate ($CaSO_4$) Sodium carbonate (Na_2CO_3) Potassium chloride (KCl)

Copper sulphate ($CuSO_4$)

pH of Salt :

Activity :

·Collect the following salt samples - sodium chloride, potassium nitrate , aluminium chloride, zinc sulphate, copper sulphate, sodium acetate, sodium carbonate and sodium hydrogencarbonate.

·Check their solubility in water.

·Check the action of these solutions on litmus and find the pH using a pH paper.

·Which of the salts are acidic, basic or neutral ?

·Identify the acid or base used to form the salt.

The pH value is greater than 7 at 25°C.

Sodium chloride (Common salt/ Table salt) -

We know that hydrochloric acid and sodium hydroxide combine with each other to form sodium chloride (NaCl) which in common language is also known as common salt. This is the salt which you sprinkle on your salads and use in your kitchens. Common salt is an ionic compound of sodium and chlorine $\mathbf{(Na^+Cl^-)_n}$.

The main source of common salt (sodium chloride) is the sea water. Sea water contains about 3.5% of soluble salts, the most common of which is sodium chloride (2.7 to 2.9%). Saline water of inland lakes, such as Sambhar lake in Rajasthan is also a good source of common salt (sodium chloride) is also found as rock salt. Beds of rock salt were formed when lakes/Seas dried up in past.

Chemicals from common salt -

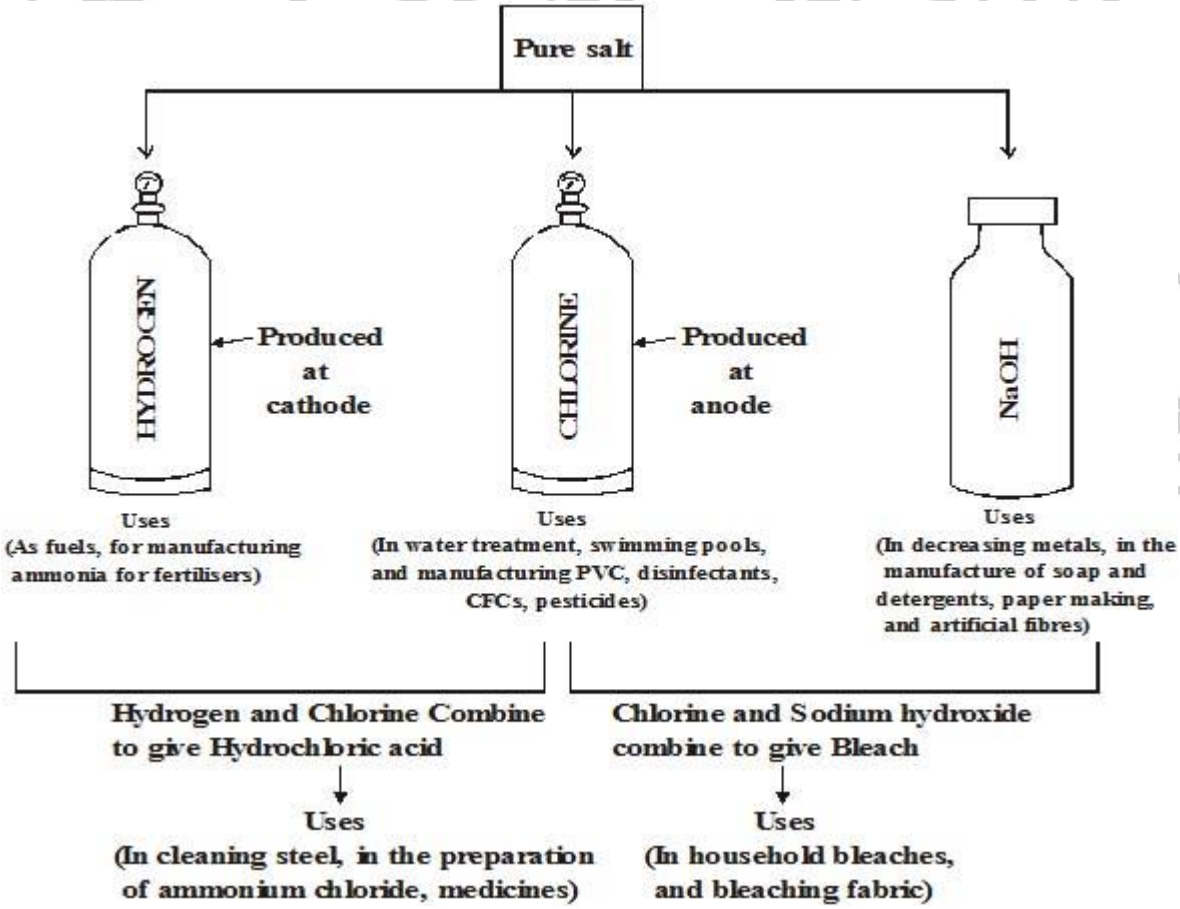
Common salt is a raw material for chemicals and play an important role for making various materials of daily use. Such as sodium hydroxide. baking soda, washing soda, bleaching power and many more.

(i) Sodium hydroxide :- Commercially , sodium hydroxide is also called **caustic soda** because of its corrosive action on animal and vegetable tissues.

Chlor-alkali process for obtaining sodium hydroxide _ When we pass electricity through a solution of sodium chloride, commonly called **brine**. It decomposes to form sodium hydroxide according to the following equation:

$$2NaCl(aq) + 2H_2O(l) \xrightarrow[\text{Current}]{\text{Electric}} 2NaOH(aq) + Cl_2(g) + H_2(g)$$

On electrolysis, chlorine gas is formed at anode and hydrogen at cathode sodium hydroxide solution is formed near the cathode. All these products are commercially important. The process of production of sodium hydroxide from sodium chloride is known as chlor-alkali process because of products formed _ chlor for chlorine and alkali for sodium hydroxide.



(ii) Bleaching powder :-

We know that chlorine is produced during the electrolysis of aqueous sodium choride **(brine)**. This chlorine gas is used for the manufacture of bleaching powder. Bleaching powdr is produced by the action of chlorine on dry slaked lime [$Ca(OH)_2$]. Bleaching powder is represented as $CaOCl_2$, though the actual composition is quite complex.

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

Slaked lime Bleaching powder

Uses of bleaching powder

(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.

(iii) Baking soda :-

The chemical name of baking soda is sodium hydrogencarbonate or sodium bicarbonate. Baking soda (or sodium bicarbonate) is represented by the formula $NaHCO_3$. The soda commonly used in the kitchen for making tasty crispy pakoras is baking soda. Sometime it is added for faster cooking. It is produced using sodium chloride as one of the raw materials.

$NaCl(aq) + H_2O(l) + CO_2(g) + NH_3(g) \rightarrow NH_4Cl(aq) + NaHCO_3(s)$

common salt ammonium Sodium chloride hydrogencarbonate

It can be used to neutralise an acid because it is mild non-corrosive base due to the hydrolysis of HCO_3^- ion.

The following reaction takes place when it is heated during cooking.

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

Uses of sodium hydrogencarbonate ($NaHCO_3$)

(a) For making baking powder which is a mixture of baking soda (sodium hydrogencarbonate) and a mild edible acid like tartaric acid. When baking powder is mixed with water, the following reaction takes place.

$NaHCO_3 + H^+ \rightarrow CO_2 + H_2O$ + Sodium salt of the acid

From acid

Carbon dioxide so produced during the reaciton is responsible for making the bread and cake to rise making them soft and spongy.

(b) As an ingredient in antacids. Being alkaline, it neutralises excess acid in the stomach and provides relief.

(c) It is used in soda-acid fire extinguisher.

(iv) Washing soda (Sodium carbonate) :-

The chemical formula of washing sode is $Na_2CO_3 \cdot 10H_2O$, (sodium carbonate decahydrate). Anhydrous sodium carbonate (Na_2CO_3) is generally called soda ash. Washing soda is manufactured by **Solvay process**. This process is also known as **Ammonia soda process**. The raw material needed for the process are sodium chloride, lime stone ($CaCO_3$) and ammonia (NH_3). The reactions involved are.

Step-I $NaCl(aq) + H_2O(l) + CO_2(g) + NH_3(g)$ ¾® $NH_4Cl(aq) + NaHCO_3(s)$

common salt ammonium Sodium

chloride hydrogencarbonate

The CO_2 required in this reaction is obtained by heating limestone.

$CaCO_3 \xrightarrow{Heat} CaO + CO_2(g)$

limestone quicklime

Step-II Dry sodium hydrogencarbonate is heated strongly to produce sodium carbonate.

$NaHCO_3(s) \xrightarrow{Heat} Na_2CO_3\ (s) + H_2O(l) + CO_2(g)$

sodium carbonate

soda ash

Step-III Washing soda ($Na_2CO_3 \cdot 10H_2O$) is obtained by crystallisation from a saturated solution of soda ash (Na_2CO_3)

$Na_2CO_3(s) + H_2O(l)$ ¾® $Na_2CO_3\ (aq) \xrightarrow{crystallisation} Na_2CO_3 \cdot 10H_2O$

sodium carbonate water washing soda

Uses of washing soda :-

(a) Washing soda (or sodium carbonate) is used for washing clothes (laundry purposes).

(b) Washing soda is used for softening hard water.

(c) Sodium carbonate (soda ash) is used for the manufacture of detergents.

(d) Sodium carbonate is used for the manufacture of many important compounds, such as borax ($Na_2B_4O_7$), Hypo ($Na_2S_2O_3 \cdot 5H_2O$), etc.

(e) Sodium carbonate is also used in paper and paint industries.

Are the crystals of salts really dry ?

Crystals of some salts contain certain amount of associated water. The water associated the crystal (or molecule) of any salt is called water of **crystallisation**.

The salt containing water of crystallisation are called **hydrated salts**.

Activity :_ To show that water of crystallisation can be removed by heating.

·**Materials required :** _ $CuSO_4 \cdot 5H_2O$ (Blue vitriol), boiling tube, burner,

cork, delivery tube, test tube, clamp stand.

·**Procedure :** _ Take 2 g of $CuSO_4 \cdot 5H_2O$ in a boiling tube

fitted in a clamp stand.

Observe its colour. Fit it with cork and delivery tube bent at two right angles which dips into a test tube.

Heat crystals in boiling tube.

Observe vapours being condensed in test tube.

Cool the crystals and add few drops of water into it

·**Observation :** Water vapours get condensed in a test tube and colour of blue crystals changes into white. On adding water to anhydrous copper sulphate it changes into blue again.

$CuSO_4 \cdot 5H_2O$ $CuSO_4 + 5H_2O$

Blue vitriol White

·**Conclusion :** Crystalline substances have water of crystallization which is lost on heating.

·**Water of crystallization :** _ It is fixed number of water molecules present in crystalline salt, eg.,

Blue vitriol $CuSO_4 + 5H_2O$ Green vitriol $FeSO_4 + 7H_2O$

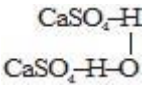
Glauber's salt $Na_2SO_4 + 10H_2O$ White vitriol $ZnSO_4 + 7H_2O$

Gypsum $CaSO_4 + 2H_2O$ Epsom salt $MgSO_4 + 7H_2O$

Plaster of Peris : ($caSo_4$ ½ h_2o)

·Plaster of peris is hemihydrate (hemi means half and hydrate means water) of calcium sulphate. Its molecular formula is $CaSO_4.½\ H_2O$ or $(CaSO_4)_2.H_2O$

·In plaster of paris one molecule of water is shared by two $CaSO_4$ as



Preparation of Plaster of Paris :

Plaster of paris is obtained by heating gypsum ($CaSO_4.2H_2O$) at 373K (or 100°C).

$$2[CaSO_4.2H_2O](s) \xrightarrow[\text{heat}]{373K,(100°C)} (CaSO_4)_2 \cdot H_2O(s) + 3H_2O(g)$$

gypsum Plaster of paris

$$\text{or } CaSO_4.2H_2O(s) \xrightarrow[\text{heat}]{373K,(100°C)} CaSO_4.\frac{1}{2}H_2O(s) + \frac{3}{2}H_2O(g)$$

gypsum Plaster of paris

During the preparation of plaster of paris, temperature should be controlled carefully. Otherwise, anhydrous calcium sulphate ($CaSO_4$) will be formed. Anhydrous calcium sulphate does not set into hard mass when mixed with water. So, if temperature is not controlled carefully, the plaster of paris obtained will have poor setting property.

Property of Plaster Paris :

·Plaster of paris is a white, odourless powder.

·At ordinary room temperature, plaster of paris absorbs water and a large amount of heat is liberated.

·When mixed with a limited amount of water (50% by mass), if forms a plastic mass, evolves heat and quickly sets to a hard porous mass with in minutes. This is called the **setting process**.

During setting, a slight expansion in volume occurs. It is due to this that it fills the mould completely and gives sharp impression. The reaction during process is

$CaSO_4 .0.5H_2O(s) + 1.5\ H_2O(l)$ ® $CaSO_4 . 2H_2O(s)$

Plaster of paris Water Gypsum (Hard mass)

Uses of Plaster of Paris :

·Plaster of paris is used in making casts and patterns for moulds and statue.

·Plaster of paris is used as cement in ornamental casting and for making decorative materials.

·Plaster of paris is used as a fire proofing material and for making chalks.

·Plaster of pairs is used in hospitals for immobilising the affected part in case of bone fracture of strain.

·Plaster of paris (POP) is used to fill small gaps on walls & roofs.

- **Efflorescence**
- Certain hydrated crystalline salts when exposed to atmosphere lose their water of crystallisation spontaneously and change into amorphous powder.
- **The spontaneous loss of water of crystallisation, wholly or partly, when crystals with water of crystallisation are exposed to air is called efforescence and the substances exhibiting effocrecence are called efforescent substance.**
- For Example : Washing soda ($Na_2CO_3.10\ H_2O$), Glauber's salt ($Na_2SO_4.10\ H_2O$), blue vitriol
- ($CuSO_4.5H_2O$)
- **Deliguescence**
- Certain crystalline substance when exposed to atmosphere absorb moisture and change into solution.
- **The absorption of moisture from air by crystals to form a solution is called deliquescence.**
- Sodium hydroxide, potassium hydroxide, calcium chloride etc. are deliquescent substances.
- **Hygroscopic substances**
- Certain substance absorb water from the atmosphere without undergoing change in physical state. Such substances are known as **hygroscopic substance.**

- Anhydroux sodium carbonate, anhydrous copper sulphate, concentrated sulphuric acid are examples of hygroscopic substances.

==========

Solved questions

1. What are acids ?

Ans. A substance is an acid if it dissolves in water to provide hydrogen ions.

2. What is a base ? Give one example.

Ans. Base is a substance which gives OH ions when dissolved in water. An example of base is NaOH.

3. Write the equation for dissociation of hydrochloric acid (HCl) in water.

Ans. $HCl + H_2 \rightarrow H_3O^+ + Cl$

or it can also be written as

$HCl \xrightarrow{H_2O} H^+(aq) + Cl(aq)$

4. Which one of these has a higher concentration of H^+ ions ?

1M HCl or 1M CH_2COOH

Ans. 1M HCl will have higher concentration of H^+ ions.

5. While diluting an acid why is it recommended that the acid should be added to water and not water to the acid ?

Or

Why should water be never added dropwise to concentrated sulphuric acid ?

Ans. While diluting an acid, water should not be added to a concentrated acid because the heat generated may cause the mixture to splash out.

6. How is the concentration of H_3O^+ ions affected when a solution of an acid is diluted ?

Ans. The concentration of H_2O^+ ions is reduced when a solution of an acid is diluted.

7. How is the concentration of hydroxide ions (OH) affected when excess base is dissolved in a solution of sodium hydroxide ?

Ans. The concentration of hydroxide ions (OH) is increased when excess base is dissolved in a solution of sodium hydroxide.

8. What effect does the concentration of H^+ (aq) has on the acidic nature of the solution ?

Ans. A solution is more acidic if it has high concentration of H^+ (aq) ions.

9. Do basic solutions also have H^+ (aq) ions ? If yes, then why are these basic ?

Ans. Basic solutions also have H^+ (aq) ions. A solution of an acid or a base always contains both H^+ (aq) ions as well as OH (aq) ions. It shows basic character if it has more OH (aq) ions and acidic character if it has more H^+ (aq) ions.

10. Choose strong acid and strong base from the following : CH_3COOH, NH_4OH, KOH, HCl

Ans. Strong acid is HCl and strong base is KOH.

11. What is meant by pH of a solution ?

Ans. pH value of a solution tells about its acidic or basic nature. Values less than 7 represents an acidic solution and above 7 indicates a basic solution.

12. Which is more acidic a solution with pH = 6.0 or a solution with pH = 2.0 ?

Ans. A solution with pH = 2.0 is more acidic.

13. Which is more basic, a solution with pH = 9.0 or a solution with pH = 13.0 ?

Ans. A solution with pH = 13.0 is more basic.

14. What effect does an increase in concentration of H^+ (aq) in a solution have on the pH of solution ?

Ans. pH of solution decreases when the concentration of H^+ increases.

15. How would you show that lemon and tomato contain acids ?

Ans. Both, lemon juice and tomato juice turn blue litmus red. It shows that both of them contain acids.

16. What is the action of the solution of sodium carbonate towards litmus ?

Ans. Solution of sodium carbonate will turn the colour of red litmus into blue indicating that it is alkaline in nature.

17. Dry ammonia gas has no action on litmus paper but a solution of ammonia in water turns red litmus paper blue. Why is it so ?

Ans. Ammonia in water forms ammonium hydroxide. These hydroxide ions turn red litmus blue.

18. What is the action on litmus of :

(a) Dry ammonia gas ? (b) Solution of ammonia gas in water ?

Ans. (a) Dry ammonia gas has no action on litmus. (b) Solution of ammonia gas in water turns red litmus blue.

19. Why should curd and sour substances not be kept in brass and copper vessels ?

Ans. Curd and sour substance contain acids which react with brass and copper.

20. Why do HCl, HNO_3, etc. show acidic character in aqueous solutions while solutions of compounds like. C_2H_5OH and glucose do not show acidic character.

Ans. A substance will show acidic character if it gives H^+ ions when dissolved in water. Among these substances HCl and HNO_3 provide H^+ ions whereas C_2H_5OH and glucose do not give H^+ ions so they do not show acidic character.

21. Why does an aqueous solution of an acid conduct electricity ?

Ans. Aqueous solution of an acid conducts electricity because it dissociates to provide ions.

22. Given two unlabelled bottles, one containing dilute acid and the other water. How would you decide to label them ?

Ans. Acid and water can be identified by testing with litmus. Water will not change the colour of red or blue litmus whereas acid will change blue litmus into red.

23. Why does distilled water not conduct electricity, whereas rain water does ?

Ans. The electric current is carried by ions in solutions. Distilled water has no ions whereas rain water is slightly acidic and contains ions so rain water conducts electricity.

24. 10 mL of a solution of NaOH is found to be completely neutralised by 8 mL of a given solution 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 it, will be :

Ans. 16 mL. Since the quantity of NaOH solution is doubled, it will require the double quantity of HCl solutions also.

25. What happens when carbon dioxide gas is passed through sodium hydroxide solution ?

Ans. When carbon dioxide gas is passed through sodium hydroxide solution, sodium carbonate is formed.
$2NaOH + CO_2 \rightarrow Na_2CO_3 + H_2O$

26. Name the sodium compound which is used, for softening hard water.

Ans. The sodium compound used for softening hard water is sodium carbonate ($Na_2CO_3 . 10H_2O$).

27. What is the chemical name and formula of baking soda ?

Ans. Chemical name of baking soda is sodium hydrogen carbonate and its formula is $NaHCO_3$.

28. A compound 'X' is an important ingredient of an antacid. It is also used in fire extinguishers. Identify 'X'.

Ans. Compound 'X' is sodium hydrogen carbonate ($NaHCO_3$).

29. Fresh milk has a pH of 6. How do you think the pH will change as it turns into curd ? Explain your answer.

Or

Fresh milk has a pH of 6. When it changes into curd (yogurt) will its pH value increase or decrease ? Why?

Ans. The pH will decrease from 6 because it becomes more acidic when milk is converted into curd and more acidic solutions has lower pH value.

30. What is the neutralisation reaction ? Give two examples.

Ans. When an acid racts with a base to form salt and water, it is called neutralisation reaction. Two examples are (i) the reaction between hydrochloric acid and sodium hydroxide and (ii) the reaction between sodium carbonate and sulphuric acid.

$HCl + NaOH \rightarrow NaCl + H_2O$

$Na_2CO_3 + H_2SO_4 \rightarrow Na_2SO_4 + H_2O + CO_2$

31. What happens when cdrystats of washing soda are left open in dry air ? What is this change named as ? Name two industries based on use of washing soda.

Ans. When crystals of washing soda are left open in dry air, they lose nine molecules of water of crystallisation and become white powder.

$Na_2CO_3 . 10\ H_2O\ Na_2CO_3 . H_2O + 9\ H_2O$

Washing soda White powder

This change is called efflorescence.

Two industries based on the use of washing soda are :

(i) manufacture of glass

(ii) paper and textile industries.

32. What will happen if the solution of sodium hydrogencarbonate is heated ? Give the equation of the reaction involved.

Or

(i) Name the products formed when sodium hydrogen carbonate is heated.

(ii) Write the chemical equation for the reaction involved in the above.

33. When the solution of sodium hydrogencarbonate is heated, it decomposes to form sodium carbonate with the evolution of carbon dioxide gas.

$2NaHCO_3$ $Na_2CO_3 + CO_2 + H_2O$

34. How is Plaster of Paris chemically different from gypsum ? How may they be interconverted ? Write one use of Plaster or Paris.

Or

How is Plaster of Paris obtained ? What reaction is involved in the setting of a paste of Plaster of Paris?

Or

State the chemical difference between Plaster of Paris and gypsum. Describe their either way inter conversions.

Ans. Plaster of Paris is chemically different from gypsum in terms of water of crystallisation. Gypsum has 2 moles of water per mole of $CaSO_4$, $\left(CaSO_4.\frac{1}{2}H_2O\right)$. It can also be written as if one mole of water of crystallisation is present for two moles of $CaSO_4$, ($2CaSO_4 . H_2O$). Gypsum on heating at 373 K gets converted into Plaster of Paris.

$$CaSO_4 . 2H_2O \xrightarrow[373\ K]{Heat} CaSO_4 + \frac{1}{2} H_2O + 1\ H_2O.$$

Gypsum Plaster or Paris

When Plaster of Paris is mixed with water, it gets converted into gypsum.

$$CaSO_4 + H_2O + 1\ H_2O \xrightarrow[373\ K]{Heat} CaSO_4 . 2H_2O$$

Plaster of Paris Gypsum

Plaster of Paris is used for making statues and for setting of fractured bones.

35. Name three compounds of calcium which are used in day-to-day life and write one important use of each of them.

Ans. The three compounds of calcium and their uses are :

(i) Slaked lime [Calcium hydroxide, $Ca(OH)_2$] used for the manufacture of bleaching power.

(ii) Bleaching powder [Calcium oxychloride, $CaOCl_2$] used as bleaching agent in laundry.

(iii) Plaster of Paris [Calcium sulphate hemihydrate, $CaSO_4 . H_2O$] used to plaster the fractured bones.

Previous Years' Board Questions

36. 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. **[CBSE Delhi 2001 Supp.]**

Ans. The compound is bleaching power ($CaOCl_2$). It removes yellowness from clothes due to its bleaching action. For details, consult text part.

37. Explain giving reasons :

(i) Tartaric acid is a component of baking powder used in making cakes. **[CBSE Sample paper 2003]**

(ii) Gypsum, $CaSO_4.2H_2O$ is used in the manufacture of cement. **[CBSE Sample paper 2003]**

Ans. (i) Role of tartaric acid in baking powder (mixture of tartaric acid and sodium hydrogen carbonate) is to neutralise sodium carbonate formed upon heating sodium hydrogen carbonate.

$$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + H_2O + CO_2$$

Sod. hydrogen carbonate Sod. carbonate

(ii) The role of gypsum ($CaSO_4.2H_2O$) in the manufacture of cement is to slow down the process of setting of cement.

38. What happens when crystals of washing soda are exposed to air? **[CB.S.E. Delhi 2003 ; CB.S.E. All India 2005]**

Ans. Washing soda undergoes efflorescence and as a result loses nine molecules of water to form white powder.

$$Na_2CO_3 .10H_2O \xrightarrow{\text{(Air)}} Na_2CO_3 . H_2O + 9H_2O$$

Washing soda Washing powder

(white crystals) (white powder)

39. How is chloride of lime chemically different from calcium chloride ? Why does chloride of lime gradually lose its chlorine when kept exposed to air ? **[C.B.S.E. All India 2004]**

Ans. Chloride of lime is calcium oxy chloride [(Ca(OCl)Cl] also known as bleaching powder. Calcium chloride is CaC12. Bleaching powder loses its chlorine on exposure to air because CO_2 present in air reacts with it to evolve chlorine as follows :

$$CaOC1_2 + CO_2 \longrightarrow CaCO_3 + C1_2$$

Chloride of lime (Air) (Bleaching powder

40. What is the chemical name of washing soda. ? Name three raw materials used in making washing soda by Solvay process. **[C.B.S.E. Delhi 2004]**

Ans. Chemical name : Sodium carbonate decahydrate ($Na_2CO_3.10\ H_2O$).

Raw materials : Brine, lime stone, ammonia.

41. 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. **[C.B.S.E. Delhi 2004]**

Ans. (i) It is weakly alkaline in nature and neutralizes acid (HCl) formed in the stomach.$NaHCO_3$ + HCl $\longrightarrow$ NaCl + H_2O + CO_2(ii) It evolves CO_2 in the form of bubbles when cake is made by baking. As a result, the cake becomes porous as well as fluffy.

$2\ NaHCO_3 \xrightarrow{heat} Na_2CO_3 + H_2O + CO_2$.

42. How is Plaster of Paris obtained ? What reactions are involved in the setting of Plaster of Paris ? **[C.B.S.E delhi 2004]**

Ans. For answer, consult text part.**43.** How is Plaster of Paris chemically different from gypsum ? How may these be inter converted ? Write one use of Plaster of Paris.

Ans. For details, consult text-part.

44. Name two industries based on the uses of washing soda. **[C.B.S.E All India 2004]**

Ans. The two industries are : glass industry and paper industry.

45. 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 ?**[C.B.S.E. Delhi.2005 Comptt.]**

Ans. For answer, consult text part.

46. (a) Name the two chief chemicals used for making a soda acid fire extinguisher.

(b) How does the soda-acid fire extinguisher help to extinguish the fire ? **[CB.S.E. All India 2006]**

Ans. (a) The two chief chemicals are ; sodium hydrogen carbonate ($NaHCO_3$) and sulphuric acid (H_2SO_4)

(b) For the details of the operation, consult text part.

47. What is efflorescence ? Give an example. **[C.B.S.E. Delhi 2006]**

Ans. For details, consult text part.

48. (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 will be its pH value ?

(c) Which has a higher pH value : I—M HCl or I—M NaOH solution ? **[C.B.S.E. Delhi 2006]**

Ans. (a) The solution with pH value of 7.0 is neutral in nature

(b) Given : $[H^+] = 1 \times 10^2$ mol $L^1 = 10^2$ M.

pH = log= log$[H^+]$ = log$[10^2]$ = (2) log 10 = 2

(c) 1 M NaOH solution (basic) has higher pH value than 1 M HCI solution (acidic).

49. Out of calcium compounds calcium carbonate, quick lime and slaked lime, which one can be used for removing moisture from ammonia gas and why ? **[C.B.S.E. Foreign 2006]**

Ans. Quick lime (CaO) can be used to remove moisture from ammonia gas because of its hygroscopic nature. Therefore, it can act as the best dehydrating agent for ammonia.

50. (a) Name the raw materials used in the manufacture of sodium carbonate by Solvay process.

(b) How is sodium hydrogen carbonate formed during Solvay process separated from a mixture of NH_4Cl and $NaHCO_3$?

(c) How is sodium carbonate obtained from sodium hydrogen carbonate ? **[C.B.S.E. All India 2006]**

Ans. (a) The raw materials used are : NaCl, lime stone or $CaCO_3$ and NH_3.

(b) Sodium hydrogen carbonate ($NaHCO_3$) is sparingly soluble or less soluble in water and gets separated as a preciptate while NH_4Cl remains in solution. The precipitate is removed by filtration.

(c) Sodium hydrogen carbonate is converted to sodium carbonate upon heating.

$$2NaHCO_3 \xrightarrow{heat} Na_2CO_3 + H_2O + CO_2$$