SOME IMPORTANT CHEMICAL COMPOUNDS

Sodium sulphate	Na_2SO_4
Potassium sulphate	K_2SO_4
Zinc sulphate	$ZnSO_4$
Copper sulphate	$CuSO_4$
Magnesium sulphate	$MgSO_4$
Calcium sulphate	$CaSO_4$
Ferrous sulphate or Iron (II) sulphate	$FeSO_4$
Stannous sulphate	$SnSO_4$
Ferric sulphate or Fe (III) sulphate	$Fe_2(SO_4)_3$
Aluminium sulphate	$Al_2(SO_4)_3$
Chromium sulphate	$Cr_2(SO_4)_3$
Nickel sulphate	$NiSO_4$
Manganese sulphate	$MnSO_4$
Barium sulphate	$BaSO_4$
Cobalt sulphate	$CoSO_4$
Mercury (II) sulphate	$HgSO_4$
Lead sulphate	$PbSO_4$

CONTENTS

INTRODUCTION

◈ **Types of Salt :** When cation replaces H^+ of an acid, salt is formed. There are various types of salts.

(i) Sulphate : Those salts which are obtained by replacing hydrogen of sulphuric acid are called sulphates, e.g.,

(ii) Chlorides : When hydrogen of hydrochloric acid is replaced by cation, chloride salt are formed, e.g.,

Sodium Chloride	NaCl
Calcium Chloride	$CaCl_2$
Aluminium Chloride	$AlCl_3$
Copper chloride	$CuCl_2$
Nickel chloride	$NiCl_2$
Potassium chloride	KCl
Magnesium chloride	$MgCl_2$
Iron (III) chloride	$FeCl_3$
Arsenic chloride	$AsCl_3$
Antimony chloride	$SbCl_3$

(iii) Nitrates : Those salts which are obtained by replacing hydrogen of nitric acid by action are called nitrate salts, e.g.,

Sodium nitrate	$NaNO_3$
Potassium nitrate	KNO_3
Ammonium nitrate	NH_4NO_3
Lead nitrate	$Pb(NO_3)_2$
Calcium nitrate	$Ca(NO_3)_2$
Magnesium nitrate	$Mg(NO_3)_2$
Aluminium nitrate	$Al(NO_3)_3$
Copper nitrate	$Cu(NO_3)_2$

(iv) Carbonates : When hydrogen of carbonic acid is replaced by metal ion, carbonate salts are formed, e.g.,

Sodium carbonate	Na_2CO_3
Zinc carbonate	$ZnCO_3$
Iron (II) carbonate	$FeCO_3$
Potassium carbonate	K_2CO_3
Copper carbonate	$CuCO_3$
Lead carbonate	$PbCO_3$

2. **Salts.** Salts are also obtained by reaction of acid with base. Cation is derived from base anion is derived from acid. The salts derived from sodium hydroxide are called sodium salts. The salt derived from potassium hydroxide are called potassium salts. Calcium hydroxide gives calcium salts, magnesium hydroxide gives magnesium slats, copper hydroxide gives copper salts and so on.

3. **Diplacement Reactions.** Those reactions in which more reactive metal can displace less reactive metal from its salt solution.

4. **Hydrogen Carbonates.** Those salts which are obtained by replacement of one hydrogen of H_2CO_3 are called hydrogen carbonates or bicarbonates e.g.,

Sodium hydrogen carbonate	$NaHCO_3$
Potassium hydrogen carbonate	$KHCO_3$
Calcium hydrogen carbonate	$Ca(HCO_3)_2$
Magnesium hydrogen carbonate	$Mg(HCO_3)_2$

5. **Hydrogen Sulphates.** Those salts which formed by replacement of one atom of hydrogen of sulphuric acid by metal ion are called hydrogen suphates e.g.

Sodium hydrogen sulphate	$NaHSO_4$
Calcium hydrogen sulphate	$Ca(HSO_4)_2$
Potassium hydrogen sulphate	$KHSO_4$
Magnesium hydrogen sulphate	$Mg(HSO_4)_2$

6. **Monoprotic Acids.** Those acids which give one H^+ ion in aqueous solution are called monoprotic acids, e.g., HCl, HBr, HI, HNO_3, HNO_2 (nitrous acid), CH_3COOH (acetic acid), HCOOH (formic acid). They form only one type of salts.

7. **Diprotic Acids.** Those acids which give two H^+ ions in aqueous solution are called diprotic acids, e.g., H_2SO_4, H_2CO_3 (carbonic acid), H_2SO_3 (sulphuric acid), $(COOH)_2$ (oxalic acid). They form two series of salts, one by replacing one hydrogen and another by replacing both the hydrogen atoms.

Sodium hydrogen phosphate	NaH_2PO_4
Sodium phosphate	Na_3PO_4
Disodium hydrogen phosphate	Na_2HPO_4

8. **Triprotic Acids.** Those acids which give three protons i.e. three H^+ ions in aqueous solution are called triprotic acid, e.g., H_3PO_4 (phosphoric acid). They form three series of salts.

9. **Chemical in Common Salt.** The main chemical present in common salt is sodium chloride. It is obtained by neutralization reaction of sodium hydroxide with HCl (Hydrochloric acid).

   It is obtained on a large scale from sea water. It is found in large deposits called rock salt.

10. **Uses of Common Salt.**

    (i) It is used in daily food.

    (ii) It is used as preservative

    (iii) It is used for manufacture of Na metal and Cl_2 (g) by electrolysis in molten state.

    (iv) It is used for manufacture of caustic soda.

    (v) It is used for manufacture of baking soda and washing soda by Solvay process.

11. **Manufacture of Sodium Hydroxide.**

    Sodium hydroxide is the most important alkali and is made commercially by electrolysis of saturated brine solution (sodium chloride). Three kinds of cells are used :

Castner-Kellner Cell. In this cell, mercury flows along the bottom of the cell and is made cathode in outer compartments as shown in figure. The anode consists of number of graphite blocks.

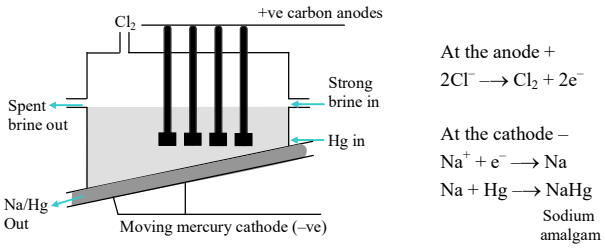

Fig. THE CASTNER-KELLNER CELL

Thee electrolysis of brine solution takes place. Since hydrogen has a over voltage (i.e.more energy is required to discharge H^+ ion) at mercury cathode, sodium is preferentially discharged at cathode forming amalgam with mercury. Sodium amalgam flows out and is reacted with H_2O to give NaOH.

$$2NaHg + 2H_2O \longrightarrow 2NaOH + 2Hg + H_2$$

The mercury is recirculated in the cell. H_2 and Cl_2 are two important by-products.

12. Properties of Sodium Hydroxide.

(i) It is deliquescent solid and absorbs moisture and CO_2 finally forming solid hydrated carbonate.

(ii) It can precipitate cations like Zn^{2+}, Al^{3+}, Pb^{2+}, Sn^{2+} but these precipitates get dissolved in excess of NaOH.

$Zn(OH)_2 + 2OH^- \longrightarrow [Zn(OH)_4]^{2-}$ (Zincate ion)

$Al(OH)_3 + 3OH^- \longrightarrow [Al(OH)_6]^{3-}$ (Aluminate ion)

$Sn(OH)_2 + 4OH^- \longrightarrow [Sn(OH)_6]^{3-}$ (Stannate ion)

$Pb(OH)_2 + 2OH^- \longrightarrow [Pb(OH)_4]^{2-}$ (Plumbate ion)

13. Uses of Sodium Hydroxide.

(i) It is used in soap industry.

(ii) It is used in paper industry

(iii) It is used in textile industry

(iv) It is used for preparation of pure fats and oils.

(v) It is used in preparation of artificial silk (rayon).

(vi) It is used in petroleum industry.

(vii) It is used in absorbing poisonous gases.

(viii) It is used as reagent in laboratory.

14. Washing Soda. Its chemical formula is $Na_2CO_3.10H_2O$, i.e. sodium carbonate decahydrate, i.e. one mole of Na_2CO_3 contains 10 moles of water of crystallization.

Anhydrous sodium carbonate is called soda ash.

15. Solvay Process. It is used for manufacture of washing soda. It is also called Ammonia Soda process.

Raw materials. Sodium chloride (NaCl), ammonia (NH_3) and limestone ($CaCO_3$).

Process.

(i) In this process a cold and concentrated solution of sodium chloride (called brine) is saturated with ammonia.

(ii) The ammonical brine is fed from the top of the carbonating tower packed with perforated plates.

(iii) Carbon dioxide (CO_2) is introduced from the base of the tower which reacts with NH_3 and H_2O to form ammonium bicarbonate (ammonium hydrogen carbonate).

$$NH_3 + H_2O + CO_2 \longrightarrow (NH_4)HCO_3 \quad \text{.....(i)}$$

(iv) Ammonia hydrogen carbonate reacts with sodium chloride (NaCl) to form sodium hydrogen carbonate and ammonia chloride.

$$\underset{\text{Ammonium Hydrogen carbonate}}{(NH_4)HCO_3} + \underset{\text{Sodium chloride}}{NaCl} \longrightarrow \underset{\text{Sodium Hydrogen carbonate}}{NaHCO_3} + \underset{\text{Ammonium chloride}}{NH_4Cl} \quad \text{.....(ii)}$$

(v) CO_2 used in first reaction is produced by heating limestone in lime kiln (furnace).

$$\underset{\text{Limestone}}{CaCO_3} \xrightarrow{\text{heat}} \underset{\text{Quicklime}}{CaO} + \underset{\text{Carbon dioxide}}{CO_2}$$

(vi) Quiklime reacts with H_2O to form slaked lime.

$$\underset{\text{Calcium oxide}}{CaO} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2}$$

(vii) Slaked lime reacts with ammonium chloride produced in reaction (ii) to generate ammonia which can be used again in reaction (i).

$$\underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Ammonium chloride}}{2NH_4Cl} \longrightarrow \underset{\text{Calcium chloride}}{CaCl_2} + \underset{\text{Ammonia}}{2NH_3} + \underset{\text{Water}}{2H_2O}$$

Thus, most of ammonia can be recovered and reused, therefore, this process is economical. Secondly, calcium chloride is obtained as a by-product.

(viii) Sodium hydrogen carbonate, formed in reaction (ii) is sparingly (partially) soluble in water and can be separated by filtration.

(ix) Sodium hydrogen carbonate is heated to form sodium carbonate.

$$\underset{\text{Sodium hydrogen carbonate}}{2NaHCO_3} \xrightarrow{\text{heat}} \underset{\text{Sodium carbonate}}{Na_2CO_3} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2}$$

CO_2 formed is recirculated., i.e. used again in reaction

(i).

(x) Sodium carbonate is recrystallized by dissolving in water to get washing soda.

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

16. Properties of Washing Soda

(i) It is a transparent crystalline solid.

(ii) It contains ten molecules of water of crystallization.

(iii) It is efflorescent substance (i.e. loses water of crystallization) when exposed to air. It loses nine molecules of water and forms monohydrate.

$$\underset{\text{Sodium carbonate (decahydrate)}}{Na_2CO_3.10H_2O} \longrightarrow \underset{\text{(Sodium carbonate) monohydrate}}{Na_2CO_3.H_2O} + 9H_2O$$

(iv) Washing soda loses all the water of crystallisation on heating and becomes anhydrous (which does not contain water of cyrstallisation). It does not decompose on heating.

$$\underset{\text{Sodium carbonate (decahydrate)}}{Na_2CO_3.10H_2O} \xrightarrow{\Delta} \underset{\text{Soda ash (Anhydrous sodium carbonate)}}{Na_2CO_3.} + 10H_2O$$

(v) Washing soda dissolves in water to form an alkaline solution which turns red litmus blue. It shows that its aqueous solution is alkaline in nature.

$$Na_2CO_3 + 2H_2O \rightleftharpoons 2NaOH + H_2CO_3 \quad \ldots\ldots(iv)$$

(vi) When treated with HCl or H_2SO_4, it liberates CO_2 gas.

$$Na_2CO_3 + 2HCl \longrightarrow 2NaCl + H_2O + CO_2 \ldots(v)$$

$$Na_2CO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + H_2O + CO_2 \quad \ldots(vi)$$

(vii) When CO_2 gas is passed through aqueous solution of sodium carbonate, sodium hydrogen carbonate gets precipitated.

$$Na_2CO_3 + CO_2 + H_2O \longrightarrow 2NaHCO_3 \quad (vii)$$

17. Uses of Sodium Carbonate.

(i) It is used in manufacture of glass, soap, paper and other sodium compounds like borax, caustic soda, etc.

(ii) It is used in softening of hard water.

(iii) It is used as washing soda in laundries.

(iv) It is used as cleaning agent for domestic purposes.

(v) It is used as laboratory reagent.

(vi) It is used in textile and petroleum refining.

(vii) It is used for preparation of carbonate of metals.

(viii) It is used in fusion mixture ($Na_2CO_3 + K_2CO_3$) which helps in qualitative analysis i.e., in preparation of soda extract in case of insoluble salts.

18. Baking Soda ($NaHCO_3$). Baking soda, chemically is sodium hydrogen carbonate. It is obtained as a first product in Solvay process as shown in reaction (ii). It can also be obtained by passing CO_2 gas through aqueous solution of sodium carbonate as shown in reaction (vii).

19. Properties of Sodium Hydrogen Carbonate.

(i) It is white crystalline solid.

(ii) It is sparingly soluble in water.

(iii) Its aqueous solution is alkaline in nature due to hydrolysis. The solution is weakly basic.

$$NaHCO_3 + H_2O \rightleftharpoons NaOH + H_2CO_3 \quad \ldots\ldots(vii)$$

This solution gives yellow colour with methyl orange (indicator) but no colour with phenolphthalein.

(iv) On heating, it loses carbon dioxide and water forming sodium carbonate.

$$\underset{\text{(Sodium hydrogen carbonate)}}{2NaHCO_3} \xrightarrow{heat} Na_2CO_3 + CO_2 + H_2O$$

(v) When it comes in contact with H_2SO_4. It gives CO_2 which is used in fire extinguishers.

$$2NaHCO_3 + H_2SO_4 \longrightarrow Na_2SO_4 + 2H_2O + 2CO_2$$

20. Uses of Sodium Hydrogen Carbonate .

(i) It is used as antacid (medicine) under the name soda bicarbonate to neutralize excess of acidity (hyper-acidity) in the stomach.

(ii) It is an ingredient of baking powder which contains $NaHCO_3$ and tartaric acid. When baking powder is heated, sodium hydrogen carbonate decomposes to give CO_2 and sodium carbonate. CO_2 causes bread and cake to rise. Tartaric acid helps to remove bitter taste due to formation of Na_2CO_3.

(iii) It is used as additive in foods.

(iv) It is used in making aerated soft drinks.

(v) It is used in fire extinguishers because it forms CO_2 , when reacted with H_2SO_4.CO_2 surrounds the combustible substance which helps in extinguishing fire.

(vi) It is used for production of carbon dioxide.

21. Bleaching Powder ($CaOCl_2$). Chemically, it is called calcium oxychloride. It is also called as chloride of lime.

Manufacture. It is manufactured by Hasenclever's plant or in Bachmann's plant by the reaction of dry slaked lime with chlorine gas.

$$\underset{\text{Slaked lime}}{Ca(OH)_2} + \underset{\text{Chlorine}}{Cl_2} \longrightarrow \underset{\text{Bleaching powder}}{CaOCl_2} + \underset{\text{Water}}{H_2O}$$

22. Properties of Bleaching Powder (Calcium oxychloride).

(i) It is a pale yellow powder. It has a strong smell of chlorine.

(ii) It is soluble in water but a clear solution is never formed due to presence of impurities.

(iii) It loses chlorine by the action of carbon dioxide.

$$CaOCl_2 + CO_2 \longrightarrow CaCO_3 + Cl_2$$

23. Uses of Bleaching Powder.

(i) It is used for bleaching cotton, linen in textile industries, for bleaching washed clothes in laundry.

(ii) It is used as oxidizing agent in many chemical industries.

(iii) It is used for disinfecting drinking water to make water free from micro-organisms.

(iv) it is used for manufacture of chloroform.

(v) It makes wool unshrinkable.

24. Plaster of Paris ($CaSO_4.\frac{1}{2}H_2O$).

Chemically, Plaster of Paris is calcium sulphate hemihydrate. It is called Plaster of Paris because it is obtained from gypsum which is mainly found in Paris.

Preparation. Plaster of Paris is obtained by heating gypsum ($CaSO_4.2H_2O$) at 373 K in a kiln. Heating should be done carefully.

$$\underset{\text{Gypsum}}{CaSO_4.2H_2O} \xrightarrow{373K} \underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + \frac{3}{2}H_2O$$

25. Properties of Plaster of Paris.

(i) It is white powder.

(ii) When it is mixed with water, crystals of gypsum are produced and set into hard mass.

$$\underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + \frac{3}{2}H_2O \longrightarrow \underset{\text{Gypsum}}{CaSO_4.} + 2H_2O$$

The setting process is exothermic, i.e., heat is evolved. The setting process may be catalysed by sodium chloride while it can be retarded by borax or alum.

(iii) When Plaster of Pairs is heated at 473 K, if forms anhydrous calcium sulphate which is known as

dead burnt plaster of paris. It has no setting property as it takes up water very slowly.

$$CaSO_4.\ \frac{1}{2}H_2O \xrightarrow{473\ K} CaSO_4 + \frac{1}{2}H_2O$$

26. Uses of Plaster of Paris.

(i) It is used for plastering fractured bones and dislocated bones so as to set them in proper place.

(ii) It is used in making toys, decorative materials.

(iii) It is used in making casts for statues, toys, surgical instruments, etc.

(iv) It is used in making blackboard chalks.

(v) It is used in dentistry.

(vi) It is used for making smooth surface and ornate designs on walls and ceilings.

(vii) It is used in laboratories for sealing air gaps in apparatus so as to make it airtight.

27. Uses of Mild Bases.

(i) Washing soda is used as cleaning agent.

(ii) $NaHCO_3$ acts a antacid.

(iii) Sodium carbonate is used in removing permanent as well as temporary hardness of water.

28. Water of Crystallization. It is fixed number of water molecules present in crystalline salt, e.g,

Blue vitriol	$CuSO_4.5H_2O$
Glauber's salt	$Na_2SO_4.10H_2O$
Gypsum	$CaSO_4.2H_2O$
Green vitriol	$FeSO_4.7H_2O$
White vitriol	$ZnSO_4.7H_2O$
Epsom salt	$MgSO_4.7H_2O$