SALTS

Salt is a compound formed when all or part of the ionisable hydrogen of an acid is replaced by metallic or ammonium ions. In other words, salt is that which is formed between a metallic or ammonium ion and non-hydroxide non-metallic (or negative radical).

For example: NaCl is a salt as it is formed from Na^+ (metallic ion) and Cl^- (negative ion). Other examples are KNO_3, $ZnSO_4$, etc.

Types of Salts

There are basically five main types of salts: normal salts, acid salts, basic salts, double salts and complex salts.

Normal Salts

Normal salts are formed when all the replaceable hydrogen ions in the acid have been completely replaced by metallic ions.

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

$$H_2SO_4\ (aq) + ZnO\ (s) \rightarrow ZnSO_4\ (aq) + H_2O\ (l)$$

Normal salts are neutral to litmus test. However, a few of them such as Na_2CO_3, Na_2SO_3, and $AlCl_3$ will undergo hydrolysis in water to give an acidic or alkaline medium.

Acid Salts

Acid salts are formed when the replaceable hydrogen ions in acids are only partially replaced by a metal. They are produced only by acids that have more than one replaceable hydrogen ion. Acids with two replaceable hydrogen ions can only form one acid salt, while acids with three replaceable hydrogen ions can form two different acid salts.

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

An acid salt still contains replaceable hydrogen ions and has acidic properties, e.g. it will turn blue litmus paper to red. In the presence of excess metallic ions the remaining replaceable hydrogen ions in the acid salt become replaced,

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

Basic Salts

Basic salts contain hydroxide ion, OH^-. They occur when there is insufficient supply of acids which is needed for the complete neutralization of the base. Basic salts have properties of a base and will react with excess acid to yield a normal salt and water.

$$Ca(OH)_{2\ (aq)} \rightarrow Ca(OH)Cl_{\ (aq)} + H_2O_{\ (l)}$$

$$Ca(OH)Cl_{\ (aq)} + HCl_{\ (aq)} \rightarrow CaCl_{2\ (aq)} + H_2O_{(l)}$$

Double Salts

When a solution containing a mixture of salts is cooled, the least soluble salt crystallizes out first. There are cases in which mixtures of two simple salts (ions) when cooled will crystallize together to give a compound of two salts. This compound is called double salt and the crystals have definite composition and definition crystal structure which is different from that of either of the constituent salts. A series of such salts is known which has the general formula $M^+M^{(3+)}(SO_4)_2 \cdot 12H_2O$ in which M^+

may be Na^+, K^+ or NH_4^+, and M^{3+} may be one or a large number of trivalent ions mainly transition metal ions. An example is $KAl(SO_4)_2 \cdot 12H_2O$.

Complex Salts

Complex salts are formed by mixing together two simple salts. These salts are characterized by the formation of a new ion called a complex ion which displays characteristic properties of its own both in the solid state and aqueous solution. An example of such salt is potassium hexacyanoferrate (II) [Fe(CN)6]4^-. This salt shows none of the properties of iron (II) ion or cyanide but displays new set of properties which are due to the complex ion formed.

$$K_4Fe(CN)_{6\ (aq)} \rightleftharpoons 4Fe^+_{(aq)} + [Fe(CN)_6]^{4-}_{\ (aq)}$$

Preparation of Soluble Salts

Salts that are soluble in water may be prepared by various methods. The salts formed are in aqueous solutions and so must be recovered from these

solutions and so must be recovered from these solutions by evaporation or crystallization.

A salt may be prepared by the *direct displacement* of the hydrogen ion in an acid by a metal that is more reactive than hydrogen, e.g. Ca, Mg, Zn, and Fe.

$$Zn_{(s)} + 2HCl_{(aq)} \rightarrow ZnCl_{2\ (aq)} + H_{2\ (g)}$$

$$Mg_{(s)} + H_2SO_{4\ (aq)} \rightarrow MgSO_{4\ (aq)} + H_{2\ (g)}$$

A salt may be prepared by *titrating* an alkali against an appropriate acid. A suitable indicator is used to determine when the neutralization reaction is complete.

$$KOH_{(aq)} + HNO_{3\ (aq)} \rightarrow KNO_{3\ (aq)} + H_2O_{(l)}$$

An acid will act on a trioxocarbonate (IV) to produce salt, water and carbon (IV) oxide. Where the trioxocarbonate (IV) is soluble, it is titrated against the acid using a suitable indicator. An insoluble trioxocarbonate (IV) is added in excess to the acid and the soluble salt formed is obtained by filtering of the excess trioxocarbonate (IV). This

method is not used if the trioxocarbonate (IV) and the salt are both insoluble.

Recovering Soluble Salts From Solution

Heating to dryness (evaporation) is a method that is used only when the soluble salt can withstand dry heating. Most chlorides, except Zn and Fe^{3+} chlorides, are recovered from solution by this method. The salt solution usually put into an evaporating dish and heated slowly to dryness to produce the salt in the solid crystalline form.

Crystallization is the method used when a salt can be destroyed or decomposed by dry heating. Trioxonitrate (V) and tetraoxosulphate (VI) salts are usually recovered by the crystallization method. The salt solution is first boiled to drive away some of the water. On cooling the concentrated solution, crystals of the salt will begin to appear in the solution. Sometimes, a speck of the salt is added to the solution as a seed to induce crystallization. Scratching the inside of the container with a glass

rod may also induce crystallization of the salt. The crystals of the salts obtained can be washed with distilled water and then dried between filter papers.

Preparation of Insoluble Salts

Double decomposition is one method that could be used to prepare insoluble salts. In this method, usually two soluble compounds, one containing the metallic radical and teh other the acidic radical of the required insoluble salt, are mixed together. During double decomposition, there is an exchange of ionic radicals resulting in the precipitation of the required salt, which is then obtained by filtration.

$$AgNO_{3\,(aq)} + NaCl_{\,(aq)} \rightarrow AgCl_{\,(s)} + NaNO_{3\,(aq)}$$

$$BaCl_{2\,(aq)} + K_2SO_{4\,(aq)} \rightarrow BaSO_{4\,(s)} + 2KCl_{\,(aq)}$$

Some metallic salts, such as chlorides and sulphides (SO_3^{2-}) may be prepared by the direct combination of the constituent elements. This

method of salt preparation is confined to salts made up of two elements only.

$$Fe_{(s)} + S_{(s)} \rightarrow FeS_{(s)}$$

$$2Fe_{(s)} + 3Cl_{2\,(s)} \rightarrow 2FeCl_{3\,(s)}$$

Uses of Salts

Name	Uses
Ammoniuim chloride	Used in washing powders and as electrolyte in dry cells
Calcium trioxocarbonate (IV)	Used as medicine to neutralize acidity in the stomach
Calcium chloride	Used as an antifreeze
Fused calcium chloride	Used as a drying agent
Calcium tetraoxosulphate (VI)	Used for making plaster of Paris
Cu^{2+} tetraoxosulphate (VI)	Used in dyeing and calico printing
Mg tetraoxosulphate (VI)	Used as a laxative
Potassium trioxonitrate (V)	Used for making gunpowder and matches and as soil fertilizers

Sodium chloride	Used for food preservation and in glazing pottery
Zinc chloride	Used in petroleum refining