Acids, Bases& Salts
Some important Commercial Salts

MORE ABOUT SALTS

Salts are the ionic compounds consisting of two parts, one part carrying a positive charge called positive ion or **cation** and the other part carrying a negative charge called a negative ion or **anion**.

¬ Family of Salts

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

Salts are generally formed by between an acid and base. Acid on the basis of kind of acid and base used they contain specific cation or anion. So we can divide salts in different families on the basis of cation or anion present.

The salts having the same positive radical (or cation) or negative radical (or anion) are said to belong to the same family. Or we can say, salts can be classified into different families based on the common ion present.

Activity:

Aim: Write the formulae of the salts and to identify their acids and bases and the families.

Method:

(i) Write down the formulae of the salts given below:

1. Potassium Sulphate
2. Sodium Sulphate
3. Calcium Sulphate
4. Magnesium Sulphate
5. Copper Sulphate
6. Sodium Chloride
7. Sodium Nitrate
8. Sodium Carbonate
9. Ammonium Chloride

(ii) Identify the acids and bases from which the above salts may be obtained.

(iii) Salts having the same positive or negative radicals are said to belong to a family.

For example, NaCl and Na_2SO_4 belong to the family of sodium salts. Similarly, NaCl and KCl belong to the family of chloride salts.
How many families can you identify among the salts given in this activity?

Observation and Conclusion:

S.No.	Salt	Formula	Acid	Base
1	Potassium Sulphate	K_2SO_4	H_2SO_4	KOH
2	Sodium Sulphate	Na_2SO_4	H_2SO_4	NaOH
3	Calcium Sulphate	$CaSO_4$	H_2SO_4	$Ca(OH)_2$
4	Magnesium Sulphate	$MgSO_4$	H_2SO_4	$Mg(OH)_2$
5	Copper Sulphate	$CuSO_4$	H_2SO_4	$Cu(OH)_2$
6	Sodium Chloride	NaCl	HCl	NaOH
7	Sodium Nitrate	$NaNO_3$	HNO_3	NaOH
8	Sodium Carbonate	Na_2CO_3	H_2CO_3	NaOH
9	Ammonium Chloride	NH_4Cl	HCl	NH_4OH

Families:

(i) On the basis of common salts

Sulphates = K_2SO_4, Na_2SO_4, $CaSO_4$, $MgSO_4$, $CuSO_4$

Chlorides = NaCl, NH_4Cl

Carbonates = Na_2CO_3

(ii) On the basis of common bases

Sodium Salts = Na_2SO_4, NaCl, $NaNO_3$, Na_2CO_3

Potassium Salts = K_2SO_4

Calcium Salts = $CaSO_4$

Magnesium Salts = $MgSO_4$

Copper Salts = $CuSO_4$

Ammonium Salts = NH_4Cl

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-}).

Formation of salts

Salts can be prepared by many reactions some of these are

(i) By neutralization of acids and bases.

E.g.

$$\underset{\text{(sodium hydroxide)}}{NaOH} + \underset{\text{(hydrochloric acid)}}{HCl} \longrightarrow \underset{\text{(sodium chloride)}}{NaCl} + \underset{\text{(water)}}{H_2O}$$

(ii) By action of metals on acids.

E.g.

$$\underset{\text{(zinc)}}{Zn} + \underset{\text{(sulphuric acid)}}{H_2SO_4} \longrightarrow \underset{\text{(zinc sulphate)}}{ZnSO_4} + \underset{\text{(hydrogen)}}{H_2}$$

(iii) By action of acids on metal carbonates and bicarbonates.

E.g.

$$\underset{\text{(calcium carbonate)}}{CaCO_3} + \underset{\text{(hydrochloric acid)}}{2HCl} \longrightarrow \underset{\text{(calcium chloride)}}{CaCl_2} + \underset{\text{(water)}}{H_2O} + \underset{\text{(carbon dioxide)}}{CO_2}$$

(iv) By action of metal on alkalis.

E.g.

$$\underset{\text{(sodium hydroxide)}}{2NaOH} + \underset{\text{(zinc)}}{Zn} \longrightarrow \underset{\text{(sodium zincate)}}{Na_2ZnO_2} + \underset{\text{(hydrogen)}}{H_2}$$

pH of salts

Depending upon the nature of acid and base which react to form the salt.

OR

The nature of acid and base produced when salt reacts with water, the salts can be classified into the following four types.

(i) Salts of strong acid and strong base. E.g. NaCl

$$\underset{\text{(sodium chloride)}}{NaCl} + \underset{\text{(water)}}{H_2O} \longrightarrow \underset{\substack{\text{(sodium hydroxide)}\\ \text{strong base}}}{NaOH} + \underset{\substack{\text{(hydrochloric acid)}\\ \text{strong acid}}}{HCl}$$

Hence, the acid and the base produced neutralise each other completely.

So, pH = 7.

(ii) Salt of strong acid and weak base. E.g. NH_4Cl

$$\underset{\text{(ammonium chloride)}}{NH_4Cl} + \underset{\text{(water)}}{H_2O} \longrightarrow \underset{\substack{\text{(ammonium hydroxide)}\\ \text{weak base}}}{NH_4OH} + \underset{\substack{\text{(hydrochloric acid)}\\ \text{strong acid}}}{HCl}$$

Here, pH < 7.

(iii) Salt of weak acid and strong base. E.g. Na_2CO_3

$$\underset{\text{(sodium carbonate)}}{Na_2CO_3} + \underset{\text{(water)}}{2H_2O} \longrightarrow \underset{\substack{\text{(sodium hydroxide)}\\ \text{strong base}}}{2NaOH} + \underset{\substack{\text{(carbonic acid)}\\ \text{weak acid}}}{H_2CO_3}$$

Here, pH > 7

(iv) Salt of weak acid and weak base. E.g. CH_3COONH_4

$$\underset{\text{(ammonium acetate)}}{CH_3COONH_4} + \underset{\text{(water)}}{H_2O} \longrightarrow \underset{\text{(acetic acid)}}{CH_3COOH} + \underset{\text{(ammonium hydroxide)}}{NH_4OH}$$

Here pH ≈ 7

¬ Common salt: A raw material for chemical

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

(i) Sodium Chloride (NaCl):

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

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

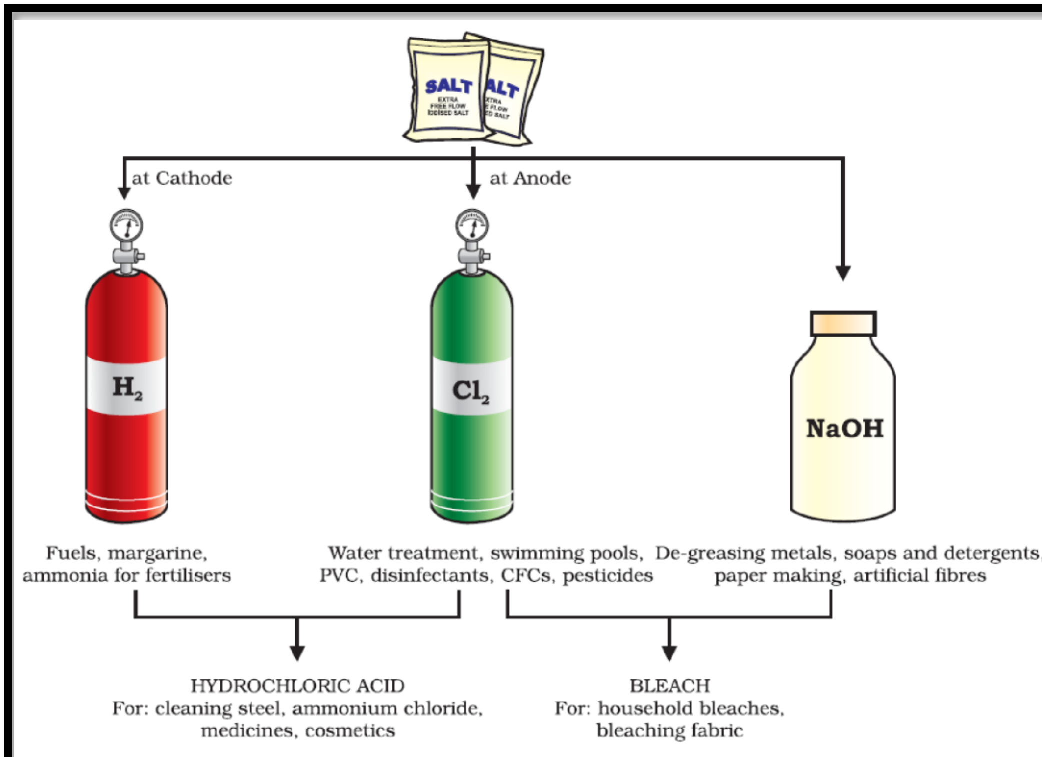
$$NaOH + HCl \quad NaCl + H_2O$$

(ii) Sodium Hydroxide (NaOH):

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

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

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



Important products from the chlor-alkali process

(iii) Bleaching Powder ($CaOCl_2$)

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

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

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

Properties

1. Bleaching powder is a yellowish white powder which gives strong smell of chlorine.
2. It is soluble in water leaving behind a small residue of lime.
3. When exposed to air, bleaching powder deteriorates giving off chlorine. Decomposition of bleaching powder in air takes place due to its reaction with carbon dioxide gas.

$$CaOCl_2 + CO_2 \quad CaCO_3 + Cl_2 \uparrow$$

4. When bleaching powder is treated with excess dilute acid, chlorine gas is produced.

$$CaOCl_2 + H_2SO_4 \quad CaSO_4 + H_2O + Cl_2 \uparrow$$

$$CaOCl_2 + 2HCl \quad CaCl_2 + H_2O + Cl_2 \uparrow$$

Chlorine gas produced in this way is known as 'available chlorine'. It is this available chlorine which is responsible for the bleaching action of the bleaching powder.

Uses of Bleaching Powder.

1. Bleaching powder is chiefly used for bleaching cotton and linen textiles, wood and paper pulp. Delicate articles like silk, wool, straw etc are not bleached by it, as these are likely to be damaged.
2. It is strong disinfectant and is therefore, used for sterilization of water.
3. It is employed for making wool unshrinkable.
4. It is also used as an oxidizing agent in the manufacture of many chemicals.

Bleaching of Cloth by bleaching powder

The cloth to be bleached is initially treated with a very dilute solution of sodium hydroxide which removes any greasy matter. It is then dipped in bleaching powder solution followed by dilute hydrochloric solution taken in a separate tank. The acid also reacts with bleaching powder to evolve chlorine which bleaches the cloth. In order to remove the unreacted chlorine, it is then dipped in a dilute solution of sodium thiosulphate called **antichlor**.

$$\underset{\text{(sodium thiosulphate)}}{Na_2S_2O_3} + Cl_2 + H_2O \longrightarrow Na_2SO_4 + 2HCl + S$$

An antichlor is a substance which removes the unreacted chlorine. The cloth is thoroughly washed with water and is then dried.

(iv) Baking Soda ($NaHCO_3$)

The soda commonly used in the kitchen for making tasty crispy pakoras is baking soda. Sometimes it is added for faster cooking. The chemical name of the compound is sodium hydrogen carbonate ($NaHCO_3$). **It is produced using sodium chloride as one of the raw materials.**

$$NaCl + H_2O + CO_2 + NH_3 \longrightarrow \underset{\text{(ammonium chloride)}}{NH_4Cl} + \underset{\text{(sodium hydrogen carbonate)}}{NaHCO_3}$$

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

Sodium hydrogen carbonate has got various uses in the household.

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

Anhydrous sodium carbonate is generally called soda ash.

Uses:

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

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

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

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

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

(iv) It is used in medicines. It acts as mild antiseptic for infections. It is also present as an ingredient in ant-acids. Being alkaline it neutralises excess acid in the stomach.

- **Baking Soda as Antacid**

The acidity in the stomach is caused due to the formation of excess of hydrochloric acid (HCl). Sodium hydrogen carbonate (baking soda) reacts with the acid because of its alkaline nature and neutralises this effect.

$$NaHCO_3 + HCl \quad NaCl + H_2O + CO_2$$

It therefore, acts as an antacid and is the major constituent of antacid medicines.

- **Baking soda in fire extinguishers**

Sodium hydrogen carbonate or baking soda is used in soda acid fire extinguishers. It is in the form of a conical metallic vessel. A strong solution of

$NaHCO_3$ is taken in a container. A glass ampoule containing H_2SO_4 and provided with a knob is placed inside the container. When required, the ampoule can be broken by hitting the knob. As a result, the acid will come in contact with sodium hydrogen carbonate. The two will react to evolve CO_2 gas. When enough pressure gets generated inside the container, the gas pushes the water solution which escapes out of the nozzle with force and extinguishes fire.

Properties

1. Sodium hydrogen carbonate is a white crystalline solid. It is sparingly soluble in water at room temperature.
2. Aqueous solution of sodium hydrogen carbonate is weakly alkaline in nature due to hydrolysis.

$$NaHCO_3 + H_2O \;\; H_2CO_3 + NaOH$$

3. **Thermal decomposition:** On heating, sodium hydrogen carbonate decomposes to give carbon dioxide.

$$2NaHCO_3 \;\; Na_2CO_3 + CO_2 + H_2O$$

4. **Reaction with acids:** It reacts with acids to liberate carbon dioxide gas with brisk effervescence.

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

$$NaHCO_3 + HCl \;\; NaCl + CO_2\uparrow + H_2O$$

(v) Washing Soda ($Na_2CO_3.10H_2O$)

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

Raw materials used are

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

(i) Ammonia (NH_3).

(ii) Lime Stone ($CaCO_3$)

The reactions taking place in this process are as follow :

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

Step II: $2\ NaHCO_3\ Na_2CO_3 + H_2O(l) + CO_2\ (g)$

Step III: $Na_2CO_3\ (s) + H_2O\ (l) \;\; Na_2CO_3\ (aq) \;\; Na_2CO_3 \cdot H_2O + 9H_2O$

$Na_2CO_3 \cdot 10H_2O$ is obtained by recrystallisation from a saturated solution of soda ash exposed to air. The loss of H_2O by crystalline solid to the atmosphere on exposure to air is called efflorescence.

Uses :

(i) Used for washing clothes.

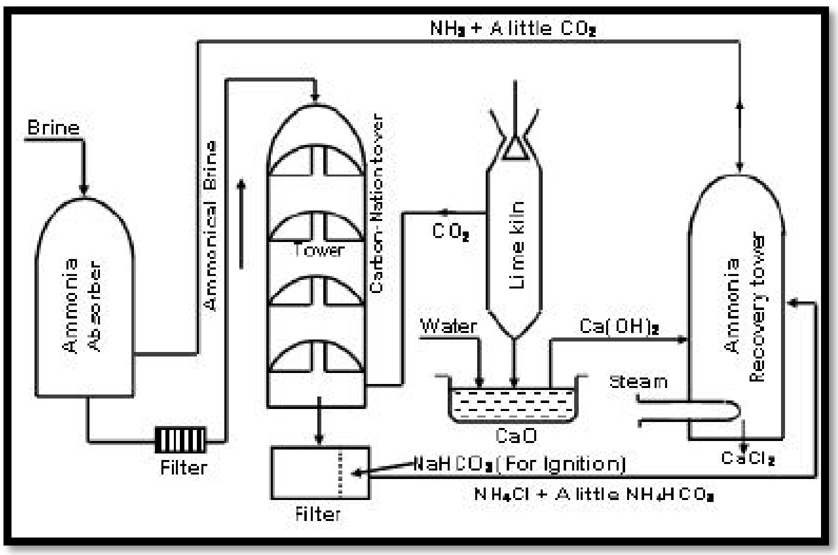
(ii) Used for softening hard water.

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

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

Manufacturing of Washing Soda

Washing soda is manufactured by Solvay Process, also called Ammonia-soda process. In addition to this, Le Blanc process and Electrolytic process are also available but are less popular.

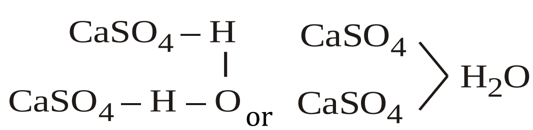


Solvay ammonia process for the manufacture of Na_2CO_3.

(vi) Plaster of Paris

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

In Plaster of Paris one molecule of water is shared by two formula units of $CaSO_4$ as,



Preparation of Plaster of Paris

Plaster of Paris is obtained by heating gypsum ($CaSO_4 \cdot 2H_2O$) in a kiln at 373 K (or 100°C).

$$2\left[\underset{\text{(gypsum)}}{CaSO_4 \cdot 2H_2O}\right](s) \xrightarrow[\text{heat}]{373\text{ K }(100^\circ\text{C})} \underset{\text{(Plaster of Paris)}}{(CaSO_4)_2 \cdot H_2O(s)} + 3H_2O\,(g)$$

$$\underset{\text{(gypsum)}}{CaSO_4 \cdot 2H_2O\,(s)} \xrightarrow[\text{heat}]{373\text{ K }(100^\circ\text{C})} \underset{\text{(Plaster of Paris)}}{CaSO_4 \cdot \frac{1}{2}H_2O\,(s)} + \frac{3}{2}H_2O\,(g)$$

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.

$$CaSO_4 \cdot 2H_2O \xrightarrow[\text{373 K}]{\text{more than}} \underset{\text{(dead burnt plaster)}}{CaSO_4}$$

Properties of Plaster of Paris

1. Plaster of Paris is a white, odourless powder.
2. At ordinary room temperature, Plaster of Paris absorbs water and a large amount of heat is liberated.
3. When mixed with a limited amount of water (50% by mass), it forms a plastic mass, evolves heat and quickly sets to a hard porous mass within 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

$$\underset{\text{(Plaster of paris)}}{CaSO_4 \cdot \frac{1}{2}H_2O\,(s)} + \underset{\text{(water)}}{\frac{3}{2}H_2O\,(l)} \longrightarrow \underset{\text{(gypsum hard mass)}}{CaSO_4 \cdot 2H_2O\,(s)}$$

Uses of Plaster of Paris

1. It is used for producing moulds for industries such as pottery, ceramics. On mixing with water it changes into plastic mass and solidifies due to rehydration. This is called **setting of Plaster of Paris**.

$$\underset{\text{(Plaster of paris)}}{CaSO_4 \cdot \frac{1}{2}H_2O} + \underset{\text{(water)}}{\frac{1}{2}H_2O} \longrightarrow \underset{\text{(gypsum hard mass)}}{CaSO_4 \cdot 2H_2O}$$

During the process of setting, it undergoes slight expansion (about 1%).

Consequently, it produces a very sharp impression of the mould into which it is put.

2. It is used for setting fractured bones in right position in the body.

or

It is used in hospitals for immobilising the affected part in case of bone fracture or strain.

3. It is used for making statues, models and other decorative material.
4. It is used as a fire proofing material and for making chalks.
5. It is used in laboratories for sealing the air gaps in apparatus to make it airtight.

   It is also used to fill small gaps on walks & roofs.

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