

Chapter 2

Acids Bases and Salts

Generally Acid are sour in test. Acid contains H^+ ions in aqueous solution.

? Base are Bitter in test. Base contains OH^- ions in aqueous solution.

Indicators :-

Some chemical substances show a sharp change in their colour or colour in an acidic or basic medium. Such substances are called acid-base indicators.

- (i) Indicators that show a change in colour
- (ii) Indicators that show a change in odour [Olfactory Indicators]

In Litmus is a purple coloured dye [More or pale purple] obtained from lichens that belong to Thallophyta division of plant kingdom.

Types of litmus papers.

Red	Neutral	Blue
Acid $\rightarrow$ no change	Pale Purple / Mauve	Acid $\rightarrow$ Red
Neutral $\rightarrow$ no change	Acid $\rightarrow$ Red	Neutral $\rightarrow$ No change
Base $\rightarrow$ Blue	Base $\rightarrow$ Blue	Base $\rightarrow$ No change

Natural Indicators	Neutral Solution	Acidic Solution	Base Solution
1. Turmeric paste -	Yellow	Yellow	Red
2. Hydrangea flower - Petals	Blue Soil	Blue Soil	Pink Soil

Artificial Indicators or Man Made

3	Phenolphthalein	colourless	colourless	Pink
4	Methyl Orange	Orange	Red / Pink	Yellow
Natural	China rose solution	Light pink	Dark Pink (Magenta)	Green

Indicators show a change in colour [Olfactory Indicators]

- a) Onion coloured cloth strips ^{Base} Acid Smell remains same ^{Base} Smell vanishes
- b) Vanilla essence Smell remains same Smell vanishes
- c) Clove oil Smell remains same Smell vanishes

On the basis of source acids are classified into:

- only for
- (i) Organic
 - Source (ii) Plants & Animals
 - These are not corrosive
 - (ii) Inorganic
 - Rocks & minerals Earth
 - These are corrosive
- Special condition: (i) C and H are present. ~~For~~ These are corrosive
- (ii) At least one C is directly bonded to H

Examples:-

Natural source	Acid
Tea/animal	Tartaric
Tomato	Oxalic
Citrus fruit	Citric
Tomato	Oxalic
Vinegar	Acetic (CH_3COOH)

Examples:-

Hydrochloric acid (HCl)
Sulphuric acid H_2SO_4
Nitric acid (HNO_3)
Carbonic acid (H_2CO_3)

Physical properties of Acids

- (i) Some acids are found in solid state while others found in liquid state at room temperature 25°C
- Physical state:-

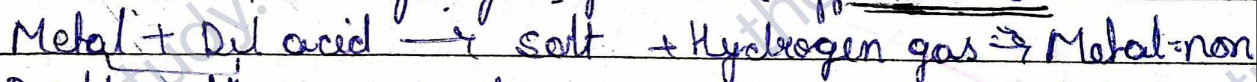
Examples:-

Acid	Physical state (At 25°C)
a) Boric acid (H_3BO_3)	Solid.
b) Tartaric acid ($C_4H_6O_6$)	
c) Oxalic acid ($(COOH)_2$)	
a) Hydrochloric acid (HCl)	Liquid.
b) Carbonic acid (H_2CO_3)	
c) Sulphuric acid (H_2SO_4)	
d) Nitric acid (HNO_3)	

(ii) Corrosive nature :- Generally all mineral acids are corrosive and can cause painful burns if fallen on the skin.

Chemical properties of Acids

(i) Reaction with Metals :- Dilute acids react with metal to form metallic salts and hydrogen gas with effervescence.



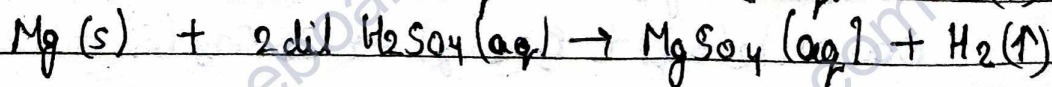
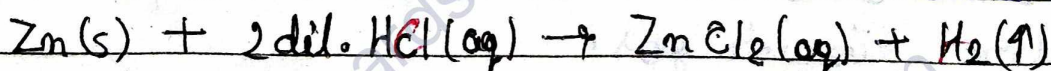
Displace Hydrogen of acid

When reactivity of metal > hydrogen

metal displacement reaction

~~Effervescence~~ $\rightarrow$ Evolution of gas from a solution in the form of bubbles along with fizzing and foaming.

$\uparrow$ Sometimes.



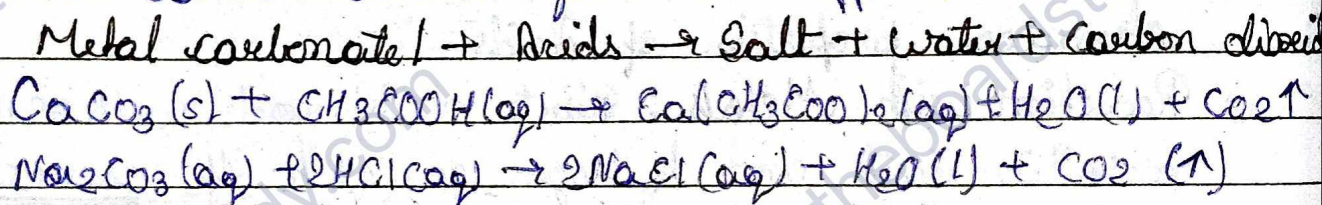
Experimental Verification of evolved Hydrogen:

On bringing a burning splinter near the mouth of the test tube or beaker in which the

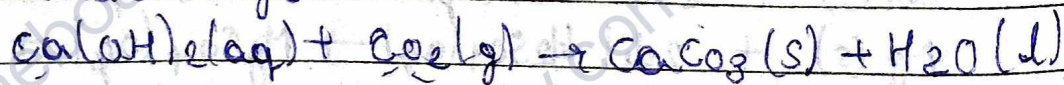
reaction take place a 'squeaky pop' sound is heard this confirms the presence of Hydrogen gas which is highly inflammable and explodes when ignited in the presence of air (or oxygen)

- 1) Hydrogen $\rightarrow$ Colourless & odourless gas.
 - 2) Hydrogen explodes in presence of oxygen (air) with a 'squeaky pop' sound.
- Hydrogen-Oxygen mixture is Detonating.

(ii) Reaction with metal carbonate/bicarbonates: Acids react with metal carbonates and metal hydrogen carbonate to produce corresponding salt, water and carbon dioxide gas with effervescence.

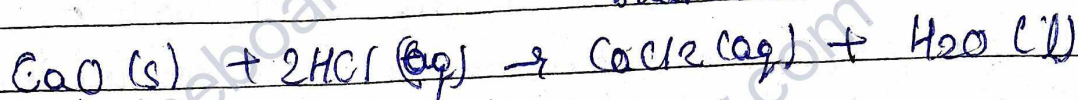
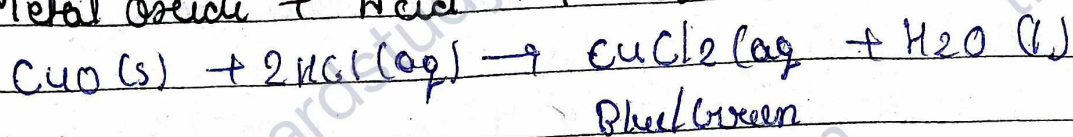


Experimental Verification of evolved Carbon dioxide:
When carbon dioxide is passed through lime water (saturated solution of $\text{Ca}(\text{OH})_2$), it turns the lime water milky or turbid due to the formation of insoluble calcium carbonate and confirms the presence of carbon dioxide gas.



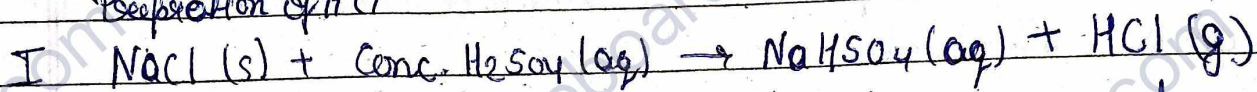
(iii) Reaction with metal oxides: Acids react with metal oxides to form a salt and water.

Metal oxide + Acid $\rightarrow$ Salt + water



Role of water in Dissociation of Acid

Preparation of HCl



II Dry litmus paper does not show any change in colour when brought near the mouth of the test tube

III Moist / wet blue litmus paper turns red when brought near the mouth of the test tube, indicating the presence of an acid, which in this case is HCl

* Acid (here HCl gas) shows its acidic character in presence of water.

Acid $\rightarrow$ comes in contact with water $\rightarrow$ Dissociate (Breaks) into ions $\rightarrow$ Then it shows its acidic character.

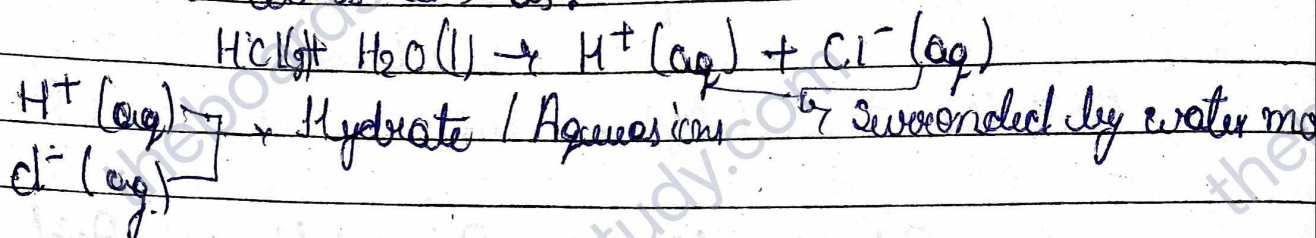
Important condition

During the chemical climate hydrogen & chloride gas is first passed through a gas jar tube containing anhydrous calcium chloride which absorb the moisture and makes the gas dry. $\rightarrow$ Drying Agent.

Conclusion

Acid show their acidic character only in the presence of water. In the discussed case HCl gas dissolves in water and

dissociates into ions e.g. hydrogen ions (H^+) and chloride ions (Cl^-) as:



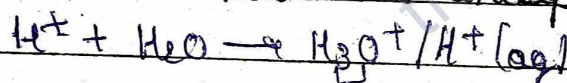
Arrhenius concept - Any substance that releases H^+ ions in water.

Are H^+ and $H^+(aq)$ are same?

No H^+ and $H^+(aq)$ are not same.

Does H^+ ions have an independent existence?

No



Hydronium Ion

Hydrogen

1 electron

1 Proton

1 electron lost

unstable H^+ $\rightarrow$ 1 Proton only

What happens when water is added to acids?

- (i) The reaction between acid and water is exothermic i.e. it will release a large amount of heat. So if the water is added to the acid some water converts to water vapour on the interface and a mixture of acid and water vapour is splash out and cause burns.
- (ii) The beaker in which the dilution is carried out may also break due to excessive local heating.

Why we should add acid to water?

To slow down the exothermic reaction, dilution of concentrated acid is always done by slowly adding concentrated acid into a sufficient amount of water with gentle stirring.

Types of Acids

① Hydroacids

Hydrogen + Non Metal

① Hydrochloric Acid

Hydrogen + Chlorine

(HCl), HBr, HI, HF

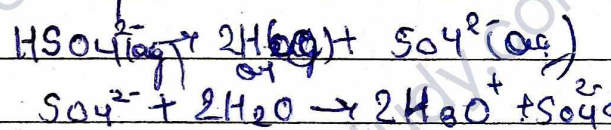
② Oxyacids

Hydrogen + Polyatomic anion

Containing Oxygen

SO_4^{2-} , NO_3^- , CO_3^{2-} etc

Sulphuric acid



What are Bases?

Metal oxides [CaO, MgO, Na₂O, K₂O etc]

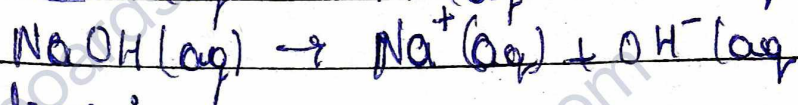
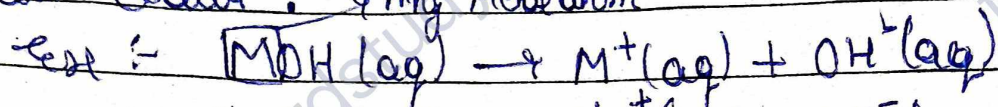
Metal hydroxides [Ca(OH)₂, Mg(OH)₂, NaOH, KOH etc]

~~Ammonium hydroxide (Non Metal)~~
(NH₄OH)

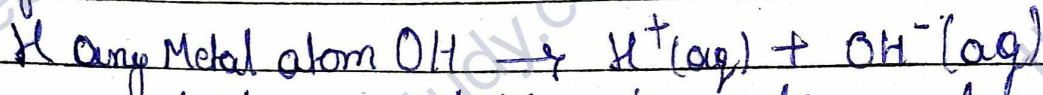
Physical Properties of Bases

- (i) Taste and texture: They taste bitter and they are slippery.
- (ii) Corrosive nature: Some bases, like Sodium Hydroxide (NaOH caustic soda) and potassium hydroxide (KOH) etc produce a burning sensation on the skin. So it is advisable to not touch or taste any basic substance. All Bases are not corrosive.
- (iii) Electricity conduction: Like acids, bases also conduct electricity in their aqueous solution (bases dissolved).

in water. Any Metal atom



General form:



The bases which are soluble in water and furnish hydroxyl ions (OH^-) in aqueous solution are known as alkalis.

Alkali $\rightarrow \text{Na}_2\text{O}, \text{K}_2\text{O}, \text{MgO}, \text{CaO}, \text{KOH}$

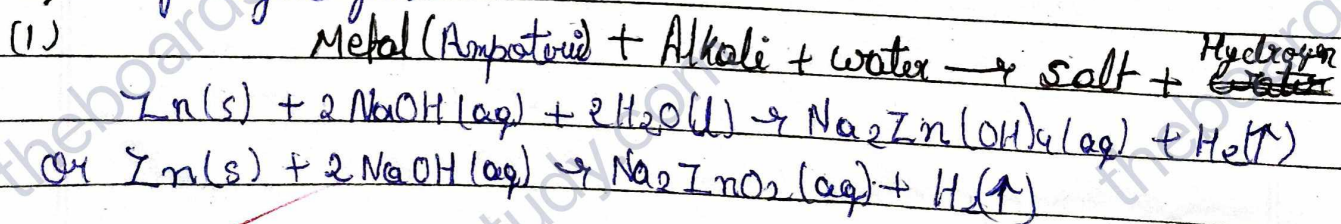
Base $\rightarrow \text{Na}_2\text{O}, \text{CuO}, \text{Fe}_2\text{O}_3, \text{CaO}, \text{KOH}$

cation

Cation move to Cathode, anion move to Anode

Chemical Properties of Bases

Not all metals react with bases to form salt and hydrogen gas. Only amphoteric metals (S, A, B, P, Z, Sn, Aluminium (Al), Beryllium (Be), Lead (Pb), Zinc (Zn)) reacts with both acid & Base to form salt and hydrogen gas.



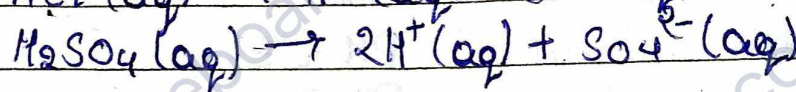
(ii) Reaction with non Metal oxides: Bases react with non metal oxides to form a salt and water.

Non-metal oxide (Acids/Neutral) + Base (Alkali) $\rightarrow$ Salt + water

The above reaction is a type of Neutralisation reaction.

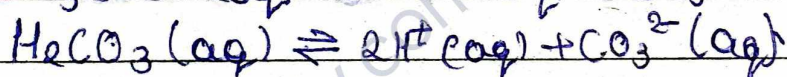
* Non metallic oxides are neutral and acidic in nature

(i) Strong Acids: The acids that dissociate completely into ions when dissolved in water and produce large amounts of $H^+(aq)$ in the solution are known as strong acids.



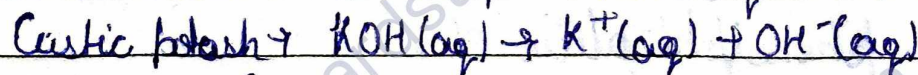
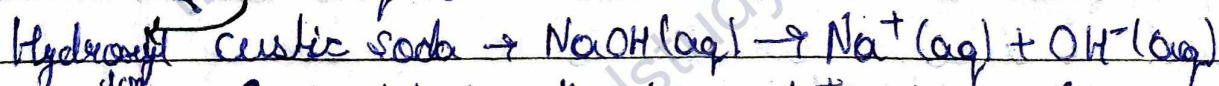
* All mineral / inorganic acids are strong acids with exception including carbonic / ^{weak} acid (H_2CO_3) and more.

(ii) Weak Acids: The acids that partially dissociate into ions when dissolved in water and produce small amounts of $H^+(aq)$ in the solution are known as weak acids.



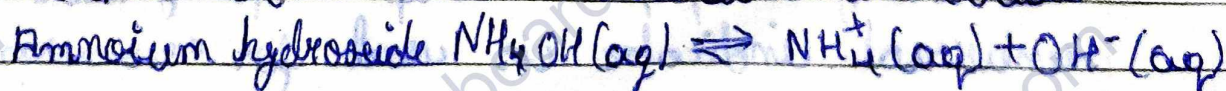
Organic acids are weak acids

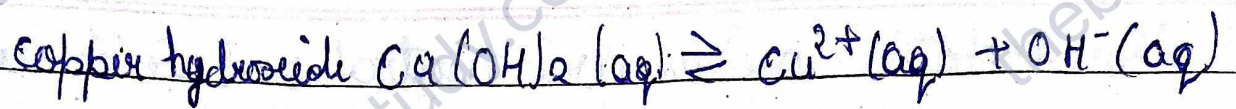
(iii) Strong Bases: The bases that dissociate completely into ions when dissolved in water and produce large amounts of $OH^-(aq)$ in the solution are known as strong bases.



ex: $NaOH$, $Ca(OH)_2$, $Mg(OH)_2$, KOH

(iv) Weak Bases: The bases that partially dissociate into ions when dissolved in water and produce small amounts of $OH^-(aq)$ in the solution are known as weak bases.





Introduction to PH

A room temp. 25°C the solution may have PH from 0 to 14 for different solutions

the PH values will be:

Neutral solution: $\text{PH} = 7$

Acidic solution: $\text{PH} < 7$

Basic solution: $\text{PH} > 7$

PH scale

If the PH value decrease than 7, the H^{+} ions concentration increases and hence the acidic character increase.

If the PH value increase than 7 the H^{+} ions concentration decrease or OH^{-} ions concentration increases and hence the basic character increase.

Universal Indicator

The PH of a solution can be measured using a universal indicator which is a mixture of thymol blue, phenolphthalein etc.

It shows different colours at different H^{+} ions concentration in the solution.

Generally a paper strip impregnated in the universal indicator is used for measuring the

PH of the solution. This paper strip is known as PH Paper

Salt :- Salts are ionic compounds that contain a positively charged ion (cation) usually a metal ion except NH_4^+ and negatively charged (anion) is a non-metal ion

ex:	Salt	Formula	Positive ion	Negative ion
	Sodium chloride	NaCl	Na^+	Cl^-
	Magnesium chloride	MgCl_2	Mg^{2+}	2Cl^-
	Potassium nitrate	KNO_3	K^+	NO_3^-
	Sodium carbonate	Na_2CO_3	2Na^+	CO_3^{2-}
	Ammonium chloride	NH_4Cl	NH_4^+	Cl^-

cations comes from Base, Anion comes from Acid.

Acid + Base $\rightarrow$ Salt + water

$\text{HCl} + \text{NH}_4\text{OH} \rightarrow \text{NH}_4\text{Cl} + \text{H}_2\text{O}$ PH < 7 when dissolve in water
strong $\rightarrow$ weak $\rightarrow$ Acidic $\rightarrow$ water
Acid Base Salt

What is iodised salt? why it is used?

Sodium iodide / Potassium iodide is added in common salt To fulfill demand of iodine in body

$\rightarrow$ Deficiency of iodine in body by lack of iodine.

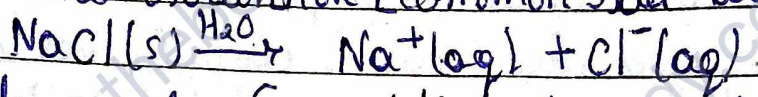
$\rightarrow$ Goiter. Lack of iodine during pregnancy $\rightarrow$ mentally retarded child

Sodium hydroxide - Manufacturing and uses.
Common name - caustic soda ; chemical formula: NaOH

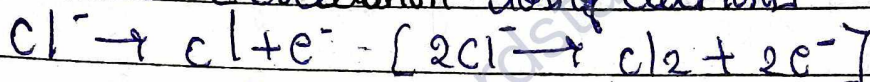
Manufactured by: chlor Alkali Process
Chlor [chlorine by product] NaOH [Main product]

Manufacturing of NaOH

I Brine solution [common salt dissolve in water]



II At anode [Oxidation - loss of electrons]



III At cathode [Reduction Gain of e^-]



Na^+ & OH^- ions are left near cathode

self ionisation of water $\text{H}_2\text{O} \rightleftharpoons \text{H}^+ + \text{OH}^-$

IV $2\text{NaCl}(\text{aq}) + 2\text{H}_2\text{O}(\text{l}) \xrightarrow{\text{Electricity}} 2\text{NaOH}(\text{aq}) + \text{H}_2(\text{g}) + \text{Cl}_2(\text{g})$
Complete reaction this process -

Materials obtained and uses



- * HCl use for cleaning steel, medicines, cosmetics
- * H_2 use for fuels, margarine, ammonia for fertilisers
- * Cl_2 use for water treatment, swimming pools, PVC, disinfectants, CFCs, pesticides.

* Uses of NaOH formed near cathode - De greasing metals, soaps and detergents, paper making, artificial fibres

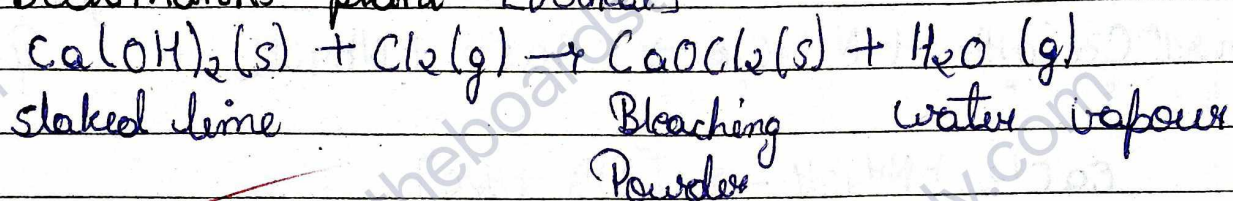
Calcium oxychloride - Manufacturing and uses.
Calcium oxychloride $[\text{CaOCl}_2]$

common name Bleaching Powder [yellowish white]

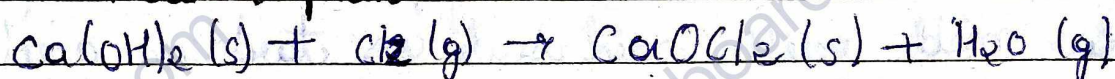
Manufacture by: Hoeselver plant and Beckmann plant.

Principle of manufacture :- The chlorine gas obtained as a by-product from the chlor alkali process when reacts with dry slaked lime $[\text{Ca}(\text{OH})_2]$ produces bleaching powder.

Beckmann's plant [vertical]



Harsenclaver plant



Uses of Bleaching powder (CaOCl_2)

- It is used in the textile industry for bleaching cotton and linen (Natural fiber obtained from flax plant).
- It is used as an oxidising agent in chemical industries.
- It is used for disinfecting drinking water by killing germs.
 because of chlorine gas.

Baking Soda - Manufacturing and uses.

Baking Soda [Common name]

Chemical formula $\rightarrow \text{NaHCO}_3$

Chemical Name $\rightarrow$ Sodium hydrogen carbonate / bicarbonate

Manufactured by $\rightarrow$ Ammonia Soda process / Solvay process

Ammonia - Soda process / Solvay process - Flow chart

Brine Solution $[NaCl + H_2O] \rightarrow$ Ammonia Tower $[NH_3]$

lime kiln

Ammoniated Brine $[NaCl + H_2O + NH_3]$

*

$CaCO_3(s) \xrightarrow{\text{Heat}} CaO(s) + CO_2(g) \rightarrow$ Carbonating Tower

*

$CaO(s) \xrightarrow{H_2O} Ca(OH)_2$

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

$CH_4Cl(aq) + NaHCO_3$

* When $Ca(OH)_2 + NH_4Cl \rightarrow CaCl_2 + NH_4OH$

Filter out
Main prod

$CaCl_2 + NH_4OH \rightarrow [NH_3 + H_2O]$

uses of Baking Soda

- It is used to make baking powder (mixture of baking soda & edible acid such as tartaric acid and cream of tartar) [absorb moisture to avoid wetting of baking soda & tartaric acid].
- It is used in soda-acid fire extinguishers.
- It is used as an ingredient of antacid medicines.

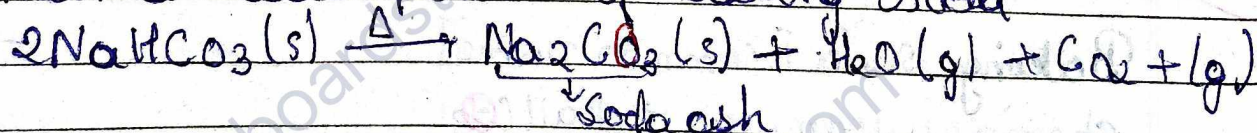
Manufacture of Soda Ash

Soda Ash $[Na_2CO_3]$

Chemical Name: Sodium carbonate

Manufactured By: Solvay / Ammonia Soda process

Thermal decomposition of Baking Soda

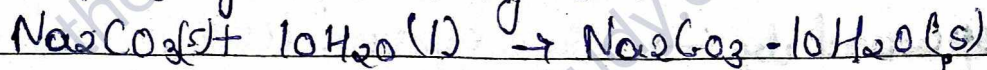


Washing Soda: preparation and uses

Washing Soda [common name] formed of Sodium carbonate. Chemical formula $\rightarrow Na_2CO_3 \cdot 10H_2O$

Chemical Name: Sodium carbonate decahydrate

Prepared by:- we have observed that on heating, sodium hydrogen carbonate (NaHCO_3) decomposes to give sodium carbonate (Na_2CO_3); crystallisation of Na_2CO_3 gives washing soda. It is also basic salt.



[Hydrated Salts]

Water of Crystallisation

The fixed number of water molecules that are attached to one formula unit salt and makes the salt crystalline is called water of crystallisation.

* Water that provides a salt $\rightarrow$ crystal like structure $\rightarrow$ definite geometrical shape because of regular arrangements of atoms.

Uses of washing soda.

- 1 It is used to remove permanent hardness of water
- 2 It is used to manufacture sodium compounds such as borax (sodium tetraborate decahydrate, $\text{Na}_2\text{B}_4\text{O}_7 \cdot 10\text{H}_2\text{O}$).
- 3 It is used as a cleaning agent to remove stubborn stain from clothes.

Water

① Hard water
dissolved salt

est $\rightarrow$ $\rightarrow$

② Soft water

No dissolved salt
or distilled water

Easily removed by boiling $\leftarrow$ Temporary Because of bicarbonates of Ca & Mg

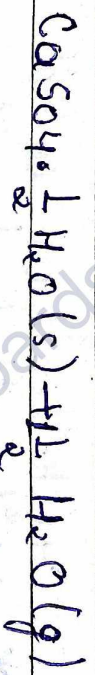
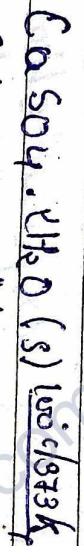
Permanent Because of chlorides & sulphate of Ca & Mg

* Plaster of Paris: Preparation and uses.

Plaster of Paris [Common name]

Chemical formula $\rightarrow \text{CaSO}_4 \cdot \frac{1}{2} \text{H}_2\text{O}$ or $(\text{CaSO}_4)_2 \cdot \text{H}_2\text{O}$
Chemical name $\rightarrow$ Calcium sulphate hemihydrate

~~Prepared~~ by $\rightarrow$ when gypsum ($\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$) is heated in a kiln (stf) at 120°C or 373K , it loses three-fourth of its water of crystallisation forming the plaster of Paris.



Calcium sulphate dihydrate

Best Bount plaster $\rightarrow \text{CaSO}_4 \cdot 2\text{H}_2\text{O (s)} \xrightarrow{120^\circ\text{C}} \text{CaSO}_4\text{(s)} + 2\text{H}_2\text{O(g)}$

Hydrated calcium sulphate

Setting of pop $\rightarrow$ when plaster of Paris is mixed with water and left for half an hour to one hour, it hydrates to form a hard mass, i.e. gypsum.



uses of plaster Paris

- It is used for setting fractured bones in the right position.
- It is used for making toys, decorative items, statues and more.
- It is used to make the surface of walls and ceilings smooth.

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