The Arrhenius Concept

Acid	Base
Dissociates in aqueous solution to give H_3O^+ $HA_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + A^-_{(aq)}$ $HCl_{(aq)} + H_2O_{(l)} \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$	Dissociates in aqueous solution to give OH^- $BOH_{(aq)} \rightarrow B^+_{(aq)} + OH^-_{(aq)}$ $NaOH_{(aq)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$
On the basis of sources can be classified as **Organic** **HCOOH, CH_3COOH** **Inorganic** **HCl, H_2SO_4, HNO_3**	NA
On the basis of number of displaceable H^+ ions (basicity) per molecule, acids can be classified as **Monobasic,** **Dibasic or** **Tribasic**. **HCl** **H_2SO_4** **H_3PO_4**	On the basis of number of hydroxyl ion (OH^-) produced (acidity), can be of classified as **Monoacidic Base** **Diacidic Base** **Triacidic Base** **NaOH** **$Mg(OH)_2$** **$Al(OH)_3$**
On the basis of concentration, can be classified as concentrated and dilute acids.	On the basis of concentration,can be classified as concentrated or dilute bases.
On the basis of degree of ionisation, can be classified as strong or weak acid.	On the basis of degree of ionization, can be classified as strong base and weak base.

REMEMBER

All acids release H^+ ion in their aqueous solutions.
H^+ ion released combines with H_2O and form hydronium ion (H_3O^+).
The separation of H^+ ion from an acid molecule cannot occur in the absence of water.
Hence, acids show acidic character only in presence of water.
As acids and bases dissociate into ions they conduct electricity in their aqueous solution.
As dilution of acids or bases occur, concentration of ions (H_3O^+ / OH^-) per unit volume decreases.

Characters	Strong Acid / Base	Weak Acid / Base
Ionises	Completely in aqueous solution	Upto a certain extent
Equillibrium	Not achieved	Achieved

Strong Acid	Strong Base	Weak Acid	Weak Base
HCl	**NaOH**	**H_2CO_3**	**$Mg(OH)_2$**
H_2SO_4	**KOH**	**CH_3COOH**	**$Ca(OH)_2$**
HNO_3	**Ba $(OH)_2$**	**HCN**	**NH_4OH**

How to detct the presence of acids and bases...???

Touch

Acids (aqueous solutions) are watery.

Bases and their aqueous solutions are slimy.

Oxalic acid is crystalline solid. [$(COOH)_2 . 2H_2O$].

Taste

Acids (very dilute aqueous solutions) are sour.

Bases (aqueous solutions) are bitter.

Litmus test

Acids (aqueous solutions) turn blue litmus to red.

Bases (aqueous solutions) turn red litmus to blue.

Litmus

An acid base indicator.

A purple dye extracted from Lichens. (Member of Thallophyta)

For neutral medium the colour of litmus solution remains purple.

In Acidic medium the colour of litmus solution changes to red.

In Basic medium the colour of litmus solution changes to blue.

Other Natural Indicators

China rose is a flower which has pink petals.

The coloured solution extracted from it is light pink colour.

When used as an indicator, its colour changes to green in basic solution and dark pink colour (magenta) in acidic solutions.

In neutral solutions, there is no change in colour.

Turmeric, Red cabbage leaves, petals of Hydrangea, Pitunia and Geranium are other acid base indicators.

Olfactory indicators.

The substances whose odour change in acidic or basic media. **Eg** **Onion extract, Vanilla and Clove oil**

Synthetic Indicator

Organic dyes which are artificially synthesized. **Methyl orange** **Phenolphthalin**

Indicator	**Change in acidic medium**	**Change in basic medium**
Blue litmus paper	**Red**	**Blue**
Methyl orange	**Red**	**Yellow**
Phenolphthalein	**Colourless**	**Pink**
Turmeric paper	**Yellow**	**Red Brown**

Universal indicator

A mixture of several indicators.

The universal indicator shows different colours at different concentrations of hydrogen ions in a solution

THE pH SCALE **[Proposed by Sorensen ; pH = *Potenz* = Power]**

pH scale expresses H_3O^+ Concentration in a solution **[pH = - Log [H_3O^+]**

This scale measures between 0 (very acidic) to 14 (very alkaline).

pH should be thought of simply as a number which indicates the acidic or basic nature of a solution.

Higher the hydronium ion concentration, lower is the pH value.

The pH of a neutral solution is 7.

Values less than 7 on the pH scale represent an acidic solution.

As the pH value increases from 7 to 14, it represents an increase in OH^- ion concentration in the solution,that is, increase in the strength of alkali.

REMEMBER

The strength of acids and bases depends on the number of H^+ ions and OH^- ions produced, respectively.
Acids that give rise to more H^+ ions are said to be strong acids, and acids that give less H^+ ions are said to be weak acids.
Hydrochloric acid and acetic acid of the same concentration, (1 molar or 1 mole per liter), produce different amounts of hydrogen Ions.

Solutions with pH = 0 →3 are strongly acidic, with pH = 3→5 are moderately acidic while with pH = 5 → 7 are weakly acidic.
Solution with pH = 7 → 9 are weakly basic, with pH = 9 → 12 are moderately basic while with pH = 12 →14 are strongly basic.

Decrease in single unit in pH scale = Ten times increase in acidic nature of solution or vice versa

pH Paper

A paper impregnated with the universal indicator.
The colour of the paper changes after it is treated with the aqueous solution, thereby is used for measuring pH.

0	1	2	3	4	5	6	7	8	9	10	11	12	13	14
RED	RED	RED	ORANGE	ORANGE	YELLOW	YELLOW	GREEN	INDIGO	INDIGO	BLUE	BLUE	NAVY BLUE	NAVY BLUE	VIOLET

MORE ABOUT pH

$$H_2O_{(l)} \rightleftharpoons H^+_{(aq)} + OH^-_{(aq)}$$

If water is pure

$[H^+][OH^-] = 1.0 \times 10^{-14}\ mol^2\ L^{-2}$

$[H^+]^2 = 1.0 \times 10^{-14}\ mol^2\ L^{-2}$ **As** $[H^+] = [OH^-]$

$[H^+] = 1.0 \times 10^{-7}\ mol\ L^{-1}$

Remember

$[H^+][OH^-] = 1.0 \times 10^{-14}\ mol^2\ L^{-2}$ is valid for pure water as well as for aqueous solution.
$[H^+][OH^-]$ is always equals to $1.0 \times 10^{-14}\ mol^2\ L^{-2}$

So If

$[H^+]$ increases $[OH^-]$ decreases or vice versa to maintain the value of **Ionic Product of Water** $1.0 \times 10^{-14}\ mol^2\ L^{-2}$

pH of certain familiar solutions

Solution	Approximate pH	Solution	Approximate pH
Gastric juice	1.0 - 3.0	Pure water	7
Lemon juice	2.2 - 2.4	Blood	7.36 - 7.42
Vinegar	3.0	Baking soda solution	8.4
Beer	4.0 - 5.0	Sea water	8.5
Tomato juice	4.1	Washing soda solution	9.0
Coffee	4.5 - 5.5	Lime water	10.5
Acid rain	5.6	Household ammonia	12.0
Milk	6.5	Sodium hydroxide	14.0
Saliva	6.5		

The pH sensitivity of organisms

pH variation during digestion of food

pH of saliva is 5.5 which indicates that the medium of digestion in mouth is acidic.

The pH of gastric HCl is 1 to 3 which makes the medium of digestion highly acidic in stomach.

The medium of digestion in small intestine (duodenum) is alkaline. This alkaline nature is brought about by bile juice and bile salts.

Excess of acid production in stomach may lead to hyperacidity and therefore is responsible for gastric irritation and pain.

Antacids **(Magnesium hydroxide or milk of magnesia)** are mild bases which neutralize the effect of excess of acid and relieves the pain.

Tooth decay due to pH change

The optimum pH of mouth is 6.5

When the sugar and other food particles (which remain stuck to teeth if are not brushed and rinsed thouroughly after meals) are decomposed by the bacteria present in buccal cavity, certain acids are produced.

In this way the pH of mouth cavity goes down and below 5.5 it causes decay of teeth enamel. **(Calcium phosphate)**

Tooth pastes **(basic in nature)** used during brushing of teeth neutralise the acid and brings the pH level up, thereby prevent tooth decay.

pH as a defensive mechanism

The low pH of gastric juice kills certain harmful bacteria and acts as a self defense mechanism.

Honey bee sting and red ants leaves methanoic acid (formic acid), which causes pain and irritation.

Stinging hair of nettle leaves also contain methanoic acid (formic acid) which produces same effect.

This irritation and pain can be neutralised by mild base like sodium hydrogen carbonate solution.

A traditional remedy is rubbing the area with the leaf of the dock plant, which often grows beside the nettle in the wild.

Acid Rains

When pH of rain water is less than 5.6, it is called acid rain.

When acid rain flows into the rivers, it lowers the pH of the river water.

The survival of aquatic life in such rivers becomes difficult.

Note The atmosphere of venus is made up of thick white and yellowish clouds of sulphuric acid.

Optimum pH for human body is 7. to 7.8.

Plants growing in acidic soil - Garlic, Cactus, Oaks

Plants growing in basic soil - Olive, Mulbery

Plants growing in neutral soil - Urd, Cow-Pea

Common acid containing food stuffs

Netural source	Acid	Netural source	Acid
Vinegar	Acetic acid	Curd	Lactic acid
Orange	Citric acid	Lemon	Citric acid
Tamarind	Tartaric acid	Ant sting	Methanoic acid
Tomato	Oxalic acid	Nettle sting	Methanoic acid

Chemical behaviour of Acids & Bases

Reaction with metal

Acids **Metal + Acid → Salt + Hydrogen** $Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_{2(g)}$

Bases **Metal + Base → Salt + Hydrogen** $Zn_{(s)} + NaOH_{(aq)} \rightarrow NaZnO_{2(aq)} + H_{2(g)}$
Sodium Zincate

Only those metals which are positioned above hydrogen in the reactivity series, show this reaction.
Evolved H_2 gas is tested with a burning splinter, It burns with a pop sound.
Al, Sn, Pb, Zn form $NaAlO_2$, Na_2SnO_2, Na_2PbO_2 and Na_2ZnO_2, respectively with NaOH (alkali).

Reaction with metallic oxides

Acids **Metal oxide + Acid → Salt + Water** $Zn_{(s)} + H_2SO_{4(aq)} \rightarrow ZnSO_{4(aq)} + H_2O_{(l)}$

Bases **Metal oxides + base → Salt + Water** $Zn_{(s)} + NaOH_{(aq)} \rightarrow NaZnO_{2(aq)} + H_2O_{(l)}$

This is the reason why metallic oxides are basic in nature.
Metallic oxide which can react with both acids and bases are considered as amphoterric.
Non metallic oxides react with base to form carbonates. (CO_2 with lime water), hence non-metallic oxides are acidic in nature.

Reaction with metal carbonates

Acids **Metal Carbonate + acid → Salt + Water + Carbon dioxide**
$CaCO_{3\,(s)} + H_2SO_{4(aq)} \rightarrow CaSO_{4(aq)} + H_2O_{(l)} + CO_{2(g)}$

Bases **Metal Carbonate + Base → No Reaction**
Metal carbonates do not react with base, however CO_2 when treated with lime water [$Ca(OH)_2$] forms carbonates
On passing excess CO_2, the solution becomes clear due to conversion of insoluble $CaCO_3$ into soluble calcium hydrogen carbonate.

$Ca(OH)_{2\,(aq)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + H_2O_{(l)}$
Lime water **Less** **Insoluble Carbonate (Milkyness)**

$CaCO_{3\,(aq)} + CO_{2(g)} \rightarrow Ca(HCO)_{3(aq)} + H_2O_{(l)}$
Carbonate **Excess** **Soluble Hydrogencarbonate (Milkyness disappear)**

Reaction with each other

Acids **Acid + Base → Salt + Water** $HCl_{(aq)} + NaOH_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$
Base
This reaction is termed as nutralisation reaction All reactions take place in aqueous solutions.
These reactions are generally exothermic.

Hydration

Acids $HCl_{(g)} + H_2O \rightarrow H_3O^+_{(aq)} + Cl^-_{(aq)}$

Bases $NaOH_{(s)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)}$

The bases which completely dissolve in water are called alkalis. (All alkalis are bases but all bases are not alkali.)
Dissolution of acid / base in water (i.e. dilution) is highly exothermic.
The quick generation of heat may crack glass containers or spurting of acids.

Salts
The product of the reaction of acid and base

Acidic Salts

Product of reaction of strong acid and weak base.
Eg. : NH_4Cl (Product of NH_4OH and HCl)
$(NH_4)_2SO_4$ (Product of NH_4OH and H_2SO_4)
Produce acidic solutions when dissolved in water thereby turns blue litmus red.

Basic salts

Product of the reaction of weak acid and strong base.
Eg. : Na_2CO_3 (Product of NaOH and H_2CO_3)
CH_3COONa (Product of NaOH and CH_3COOH)
Produce alkaline solution when dissolved in water hence, turn red litmus to blue.

Neutral salts

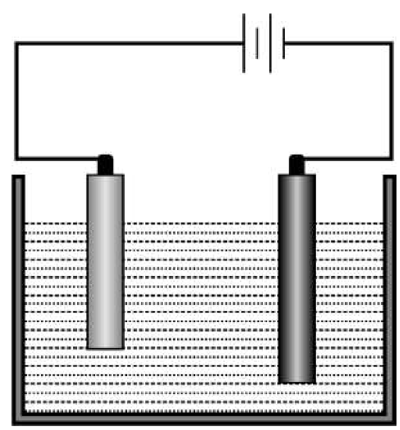
Product of the reaction of strong acid and strong base.
Eg. : NaCl (Product of NaOH and HCl)
K_2SO_4 (Product of KOH and H_2SO_4)
Produce neutral solution when dissolved in water, hence the litmus remains purple.

SOME USEFUL SALTS

Sodium hydroxide [NaOH] or Caustic Soda

Preparation

By Chlor-alkali process — Electrolysis of brine solution (aqueous NaCl)



Requirement

Aqueous solution of NaCl — Graphite rods (electrodes) — Electric current

Reactions

$NaCl_{(s)} \rightarrow Na^+_{(aq)} + Cl^-_{(aq)}$

$H_2O_{(l)} \rightarrow H^+_{(aq)} + OH^-_{(aq)}$

Cathode $H^+_{(aq)} + e^- \rightarrow H_{2(g)}$

Anode $Cl^-_{(aq)} \rightarrow Cl_{2(g)} + e^-$

Overall Reaction $NaCl_{(s)} + H_2O_{(l)} \rightarrow Na^+_{(aq)} + OH^-_{(aq)} + H_{2(g)} + Cl_{2(g)}$

Uses of H_2

Fuels, manufacturing of NH_3, HCl etc.

Uses of Cl_2

Sterelization of drinking water, swimming pool water.
Polymers like PVC, pesticides, distinfectant manufacturing.

Use of NaOH

Manufacturing of soaps and detergents, paper artificial fibres etc.
De-greasing of metals.

Baking Soda or Sodium Hydrogen Carbonate ($NaHCO_3$)

Preparation

By Solvay's process or Solvay Ammonia Process or Ammonia - Soda Process

Carbonation of Ammoniated Brine

Step 1: $NaCl_{(s)} + H_2O_{(l)} + NH_{3(g)} + CO_{2(g)} \rightarrow NaHCO_{3(s)} + NH_4Cl_{(aq)}$

Cold solution of Ammoniated brine → **Baking Soda**

Properties

White, Crystalline, Solid   Soluble in water   Forms weak base when dissolved in water

Uses

For making baking powder

[Baking soda + Tartaric acid (a mild eadible acid) ⟶ Baking powder]
1 : 1

When baking powder is heated or mixed in water, the following reaction takes place

$NaHCO_{3(s)} + H^+_{(aq)} \rightarrow \text{Acid Salt}_{(s)} + H_2O_{(l)} + CO_{2(g)}$

Baking soda + **(From any acid)**

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

Sodium hydrogencarbonate is also an ingredient in antacids because it is mild non-corrosive base due to the presence of HCO_3^- ion.

Being alkaline, it neutralises excess acid in the stomach and provides relief.

It is also used in soda-acid fire extinguishers.

Washing soda or Sodium Carbonate Decahydrate ($Na_2CO_3.10H_2O$)

Preparation

By Solvay's process or Solvay Ammonia Process or Ammonia - Soda Process

By thermal decomposition of baking soda

Step I: $NaHCO_{3(s)} \xrightarrow{Heat} Na_2CO_{3(s)} + H_2O_{(l)} + CO_{2(g)}$

Baking soda → **Anhydrous sodium carbonate (soda ash)**

Step II: $Na_2CO_{3(s)} + 10\,H_2O_{(l)} \rightarrow Na_2CO_3.10\,H_2O_{(s)}$

Anhydrous Sodium carbonate → **Sodium carbonate deca hydrate (Washing Soda)**

Properties

White, Crystalline, Transperent solid

Efflorescent   Loses water of crystallisation when exposed to air.

$Na_2CO_3.10\,H_2O_{(s)} \xrightarrow{\text{Exposed to Air}} Na_2CO_{3(s)} + 9H_2O_{(l)}$

Transparent crystals → **White powder**

Uses of washing soda

It is used for washing clothes (laundry purposes).

It is used for softening hard water can remove permanent hardness of water.

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

It is used for the manufacture of many important compounds, such as borax ($Na_2B_4O_7$), hypo ($Na_2S_2O_3.5H_2O$), etc.

Sodium carbonate is also used in paper, glass, soap and paint industries.

REMEMBER

Seawater contains many salts dissolved in it. Sodium chloride is separated from these salts. Deposits of solid salt are also found in several parts of the world. 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.

Bleaching powder or Calcium Oxychloride ($CaOCl_2$)

Preparation

By chlorination of $Ca(OH)_2$ in Hasenclever plant or in Bachmann plant

$$Ca(OH)_{2(s)} + Cl_{2(g)} \rightarrow CaOCl_{2(s)} + H_2O_{(l)}$$

Slaked lime → **Bleaching powder**

Properties

Yellowish, white powder

Gives strong smell of chlorine because it loses Cl_2 when exposed to air

$$CaOCl_{2(s)} + CO_{2(g)} \rightarrow CaCO_{3(s)} + Cl_{2(g)}$$

Bleaching powder

Uses

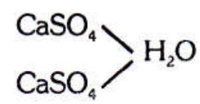
For bleaching cotton and linen in the textile industry, for bleaching of wood pulp in paper factories and for bleaching washed clothes in laundry;

It is used as an oxidising agent in many chemical industries

It is used for disinfecting and sterelization of drinking water to make it free of germs.

It is used to manufacture chloroform

Plaster of Paris

Calcium Sulphate Hemihydrate ($CaSO_4 . {}^1/_2 H_2O$) Or ($CaSO_4)_2 . H_2O$ Or 

Preparation

By heating Gypsum

$$CaSO_4.2H_2O_{(s)} \xrightarrow{120^o C} CaSO_4.1/2H_2O_{(s)} + 3/2\ H_2O_{(l)}$$

Gypsum → **Plaster of Paris**

Gypsum requires controlled heating at 373 K to avoid complete loss of water resulting into $CaSO_4$ (anhydrous calcium sulphate or dead burnt plaster) which does not set into a hard mass when water is mixed.

$$CaSO_4.2H_2O_{(s)} \xrightarrow{>120^o C} CaSO_{4(s)} + 2\ H_2O_{(l)}$$

Gypsum → **Anhydrous calcium sulphate**
dead burnt plaster

Properties

Plaster of Paris is a white, odourless powder.

At 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), it forms a plastic mass, evolves heat and quickly sets to a hard porous mass within minutes. This is called the **setting process.**

$$CaSO_4.1/2H_2O_{(s)} + 3/2\ H_2O_{(l)} \rightarrow CaSO_4.2H_2O_{(s)}$$

Plaster of Paris → **Gypsum**

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

Uses

It is used in making casts and patterns for moulds for pottery, Ceramics etc.
Commonly used as cement in ornamental casting and for making decorative materials like Statues, Models etc..
It is used as a fire proofing material and for making chalks.
Plaster of Paris is used in hospitals for immobilising the affected part in case of bone fracture or strain.
Plaster of Paris (POP) is used to fill small gaps on walls & roofs.