Physical Properties of Acids and Bases

- Generally, acids are sour in taste but they can be bitter as well as sweet in taste.
- Bases taste bitter.
- Bases have a soapy texture, i.e. they are slippery to touch.
- Some acids and bases are highly corrosive in nature, i.e. they produce a burning sensation on the skin and damage it.
- Acids and bases dissociates into ions in their aqueous solution (dissolved in water) and hence, conducts electricity.

Classification of Acids Based on Source

(i) Organic acids: These are obtained from living sources, i.e. plants and animals.

Natural source	Acid	Natural source	Acid
Citrus fruits	Citric acid	Nettle sting	Formic acid / methanoic acid
Tamarind	Tartaric acid	Apple	Malic acid
Tomato	Oxalic acid	Ant sting / Honey bee sting	Formic acid / Methanoic acid
Vinegar (diluted form)	Acetic acid	Curd	Lactic acid

Lemon, Orange etc also, contains Vitamin C (Ascorbic acid)

Classification of Acids Based on Source

(ii) Inorganic acids/Mineral acids: These are obtained from non-living sources, i.e. rocks and minerals.

Examples: Hydrochloric acid (HCl), Sulphuric acid (H_2SO_4), Nitric acid (HNO_3) and more

Avoid Touching/Tasting To Identify an Acid/Base

'खतरा'

(i) Tasting/Touching an acid or a base can be disastrous as some acids and bases are highly corrosive, i.e. they produce a burning sensation on the skin and damage it.

(ii) Acids can taste bitter, sour as well as sweet. So, tasting is not a relied option.

To identify an acid/base we use indicators!

Indicators That Show a Change in Colour

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

Indicator	Neutral solution	Acidic solution	Basic solution
(a) Litmus solution	Pale Purple / Mauve	Red	Blue
(b) Turmeric paste	Yellow	Yellow	Brick Red
(c) Hydrangea flowers	Blue	Blue	Pink
(d) Phenolphthalein	Colourless	Colourless	Pink
(e) Methyl orange	Orange	Red / Pinkish red	Yellow

Natural Indicators

Synthetic indicators

Depending on nature of soil flowers change colour

Change in Colour

Indicators that show a change in odour – Olfactory Indicators

helpful for visually impaired people

	IN ACIDS	IN BASES
(A) Onion odoured cloth strips	smell remains same	smell vanishes
(B) Vanilla essence	—"—	—"—
(C) Clove oil	—"—	—"—

Chemical Properties of Acids

CHEMICAL PROPERTIES OF ACIDS

- **Reaction of Metal with Dilute Acids:**

Dilute acids react with metals to form metallic salts and hydrogen gas with effervescence.

↓

Evolution of gas from a solution in the form of bubbles along with fizzing and foaming.

- Type of Reaction: **Displacement Reaction**

EXAMPLES

(metal reactivity > hydrogen of acid)

Metal	+	Dilute acid	→	Salt	+	Hydrogen
Zn(s)	+	2dil.HCl(aq)	→	$ZnCl_2$(aq)	+	H_2(↑)

- H_2 gas burns with a squeaky pop sound (small explosion). It is combustible but not a supporter of combustion.

(Confirmatory Test)

Chemical Properties of Acids

CHEMICAL PROPERTIES OF ACIDS

- **Reaction of Metal Carbonate/Bicarbonate with Acids:**

Acids react with metal carbonates and metal hydrogen carbonates to produce corresponding salt, water and carbon dioxide gas with effervescence.

Type of Reaction: **Double Displacement Reaction (Gas Forming Reaction)**

EXAMPLES

H_2CO_3

Metal carbonate/ hydrogen carbonate + Acid → Salt + Water + Carbon dioxide

$$CaCO_3(s) + CH_3COOH(aq) \rightarrow Ca(CH_3COO)_2(aq) + H_2O(l) + CO_2(\uparrow)$$

C A A C

Turns limewater milky

'Limewater' ← Colourless soltn

$$Ca(OH)_2(aq) + CO_2(g) \rightarrow CaCO_3(s) + H_2O(l)$$

↳ milky / turbid due to this

Excess of carbon dioxide gas passed through limewater

Colourless soltn

$$CaCO_3(s) + H_2O(l) + CO_2(g) \rightarrow Ca(HCO_3)_2(aq)$$

Chemical Properties of Acids

CHEMICAL PROPERTIES OF ACIDS	EXAMPLES
• **Reaction of Metal oxide with acid:** Some metal oxides/hydroxides are basic in nature which reacts with acids to form salt and water.	Base Metal oxide + Acid → Salt + Water $CuO(s) + 2HCl(aq) \rightarrow CuCl_2(aq) + H_2O(l)$ BLACK — Colourless Soln — BLUE-GREEN SOLUTION
• Type of Reaction: **Double Displacement Reaction (Neutralisation Reaction)**	

Chemical Properties of Bases

CHEMICAL PROPERTIES OF BASES

- **Reaction of Amphoteric Metal with Alkali:**

Amphoteric metals like Al, Zn etc. reacts with water-soluble bases (alkalis) to form salt and hydrogen gas.

- **Reaction of Non-metallic Oxides with Base:**

Some non-metallic oxides are acidic in nature like CO_2, SO_2, NO_2 etc. which reacts with bases to form salt and water.

EXAMPLES

Salt

$$2NaOH(aq) + Zn(s) \rightarrow Na_2ZnO_2(s) + H_2(g)$$

(Sodium zincate)

Water-soluble base (alkali)

Amphoteric metal

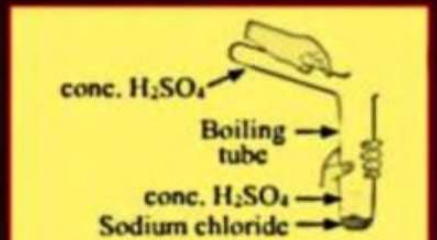
Neutralisation Rxn (Double displacement rxn)

Acid

Non-metal oxide	+	Base	→	Salt	+	Water
$CO_2(g)$	+	$Ca(OH)_2(aq)$	→	$CaCO_3(s)$	+	$H_2O(l)$
$SO_3(g)$	+	$2NaOH(aq)$	→	$Na_2SO_4(aq)$	+	$H_2O(l)$

Role of Water in Dissociation of Acids

Acids show their acidic character due to the hydronium ions $H^+(aq)$ or H_3O^+ ions that are produced in the aqueous solutions.



(a) Preparation of HCl gas

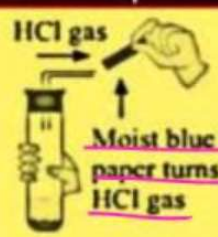
$$HCl + H_2O \longrightarrow H_3O^+ + Cl^-$$

H_3O^+ OR $H^+(aq)$

[T < 200°C] ✓ ✓

$$NaCl(s) + \text{conc. } H_2SO_4(aq) \rightarrow NaHSO_4(aq) + HCl(g)$$

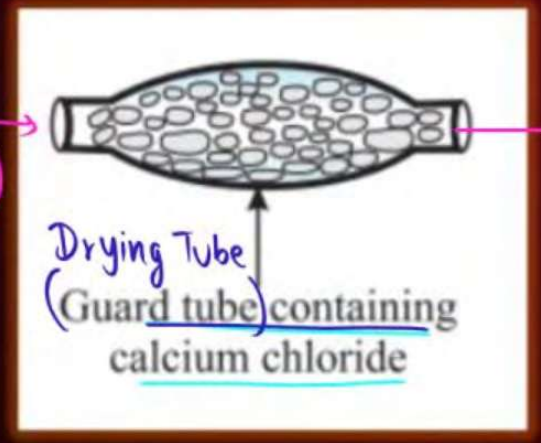
(b) Testing HCl gas with dry litmus paper



(c) Testing HCl gas with moist (wet) paper

Important Condition

During the humid climate, hydrogen chloride gas is first passed through a guard tube containing anhydrous calcium chloride which absorbs the moisture and makes the gas dry.



Drying Agent

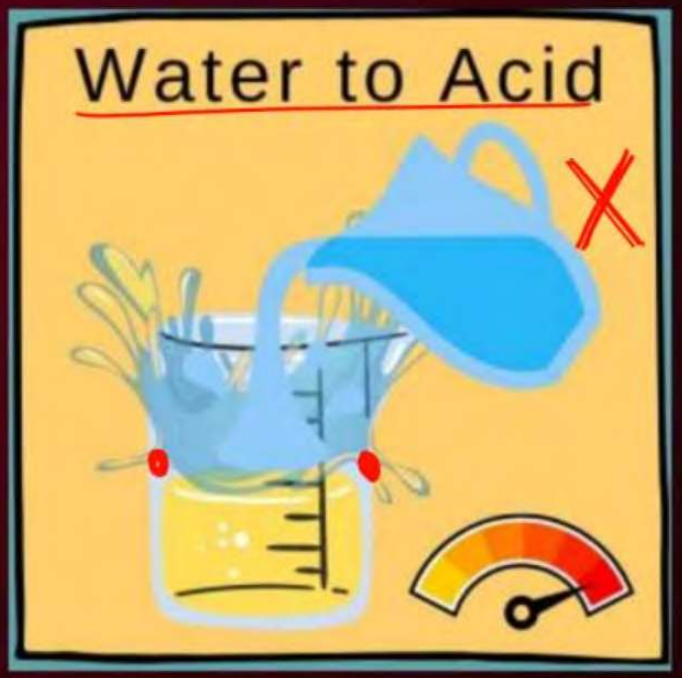
Dessicant

Dilution of Acid – Water Should Not Be Added to Acid

Generally,

(i) Density of water < acid. Also, reaction of acid with water is exothermic, i.e. a large amount of heat is generated. So, if water is added to acid, some water converts to water-vapour on the interface and a mixture of acid and water-vapour splash-out and cause burns.

(ii) The beaker in which the dilution is carried out may also break due to excessive local heating.



Dilution of Acid – How to Do It?

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.

pH, Acidity and Alkanity in Terms of pH

C-I

pH stands for "*power of hydrogen*" where "p" represents the German word for power, *potenz* and H is the element symbol of hydrogen.

C-II

ACIDITY AND ALKANITY IN TERMS OF pH

At 25 °C, the solutions may have pH from 0 to 14. For different solutions the pH values will be:

Neutral solutions: pH = 7, (Concentration of $H^+(aq)$ = $OH^-(aq)$ ions)

Acidic solutions: pH < 7, (Concentration of $H^+(aq) > OH^-(aq)$ ions)

Basic solutions: pH > 7, (Concentration of $H^+(aq) < OH^-(aq)$ ions)

acidic character

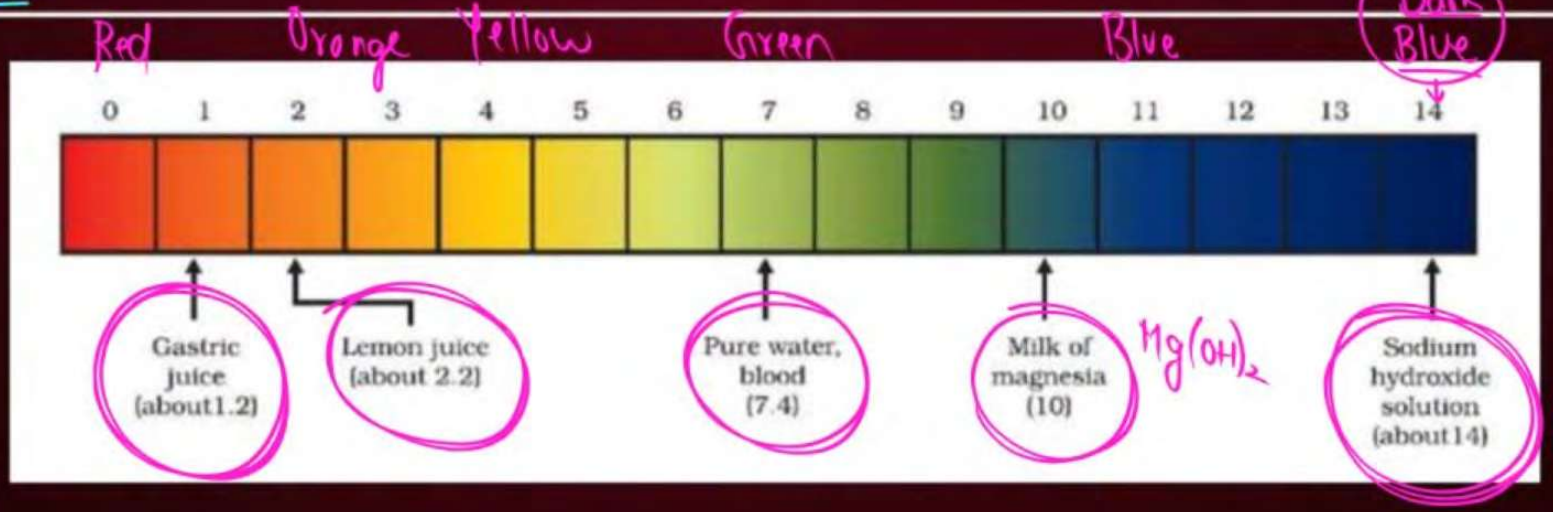
basic character

hydroxyl or hydroxide ions

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 $H(aq)^+$ ions concentration in the solution.



Importance of pH in Everyday Life

Problem I: When we are stung by a bee or an ant, we feel pain and irritation. This is because ant and bee- sting inject formic acid.

Solution I: To nullify its effect and to provide relief, a solution of mild base like baking soda should be applied.

Problem II: Leaves of nettle plants have stinging hair that injects formic acid when touched accidentally.

Solution II: A traditional remedy is rubbing the area with the leaf of the dock plant that grows in the vicinity of the nettle plant.

Importance of pH in Everyday Life

Problem III: Our tooth enamel is made of calcium hydroxyapatite (a crystalline form of calcium phosphate), which is the hardest substance in the human body. It is insoluble in water but it gets corroded when the pH of the mouth falls below 5.5, i.e. moderately acidic.

Solution III: The best way to prevent tooth decay is to clean the teeth with a basic substance like toothpaste that neutralises the effect of acid produced in the mouth.

Importance of pH in Everyday Life

Problem IV: Due to overeating, eating too much spicy food or drinking too many caffeinated drinks, the stomach produces more amount of hydrochloric acid than required which starts to move upwards in oesophagus. This results in the pain and irritation in the lower chest area. This condition is called acidity./acid reflux

Solution IV: It can be cured by taking antacids like Milk of Magnesia, $Mg(OH)_2$ which neutralises the excess acid.

Cold milk can also be taken!
↓
'antacid'

Strong Acid/Base and Weak Acid/Base

STRONG ACID/STRONG BASE

- A strong acid or a base is a one that completely dissociates into ions.

WEAK ACID/WEAK BASE

- A weak acid or a base is a one that partially dissociates into ions.

$HCl(aq) \longrightarrow H^+(aq) + Cl^-(aq)$

$NH_4OH(aq) \rightleftharpoons NH_4^+(aq) + OH^-(aq)$

WEAK BASES

(i) NH_4OH – Ammonium hydroxide
(ii) $Cu(OH)_2$ – Copper hydroxide

STRONG BASES

(i) NaOH - Sodium hydroxide
(ii) KOH - Potassium hydroxide
(iii) $Ca(OH)_2$ - Calcium hydroxide
(iv) $Mg(OH)_2$ - Magnesium hydroxide

STRONG ACIDS

other than these are weak

(i) H_2SO_4 - Sulphuric acid
(ii) HNO_3- Nitric acid
(iii) HCl - Hydrochloric acid
(iv) HBr - Hydrobromic acid
(v) HI - Hydroiodic acid
(vi) $HClO_4$ - Perchloric acid
(vii) $HClO_3$ - Chloric acid

Salt and Its Types (On Basis of pH)

- Salts are ionic compounds that contain a positively charged ion (cation) and negatively charged ion (anion).
- Salts are electrically neutral as the total positive charge is equal to the total negative charge.
- Salts of weak acid and weak base or strong acid and strong base: **NEUTRAL (pH =7)**
- Salts of strong acid and weak base: **ACIDIC (pH < 7)**
- Salts of strong base and weak acid: **BASIC (pH > 7)**

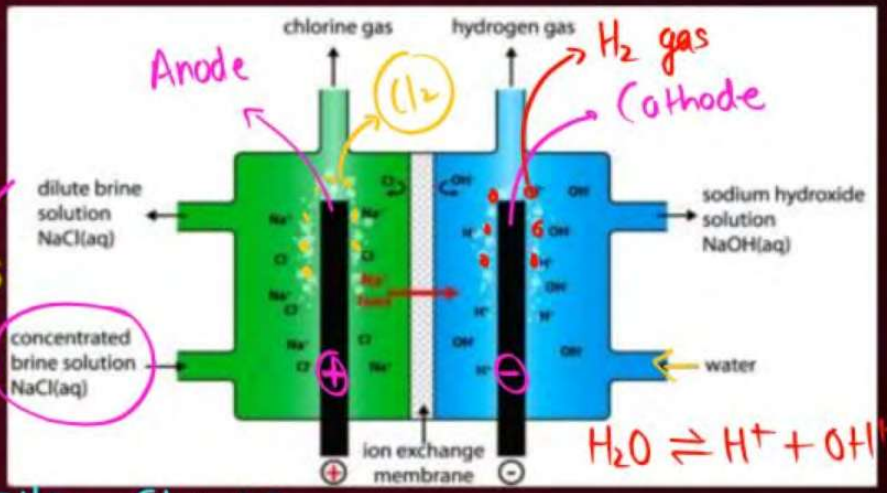
Common Salt / Table Salt

- Chemical name: **Sodium chloride**
- Chemical formula: **NaCl**
- Occurrence and extraction: (a) Seawater through evaporation (b) Rock salt (solid deposits which are brown due to earthly impurities)
- Uses: (a) It is an essential constituent of our diet (transportation of nutrients and maintains blood pressure) . (b) Important raw material for the production of other materials of daily use such as sodium hydroxide, bleaching powder etc.

Caustic Soda / Lye

- Chemical name: **Sodium hydroxide**
- Chemical formula: **NaOH**
- Name of process: **Chlor-alkali process**
- Reaction at cathode and anode:

At cathode:	$2H^+ + 2e^- \rightarrow H_2$
At anode:	$2Cl^- \rightarrow Cl_2 + 2e^-$



$Cl^- \rightarrow Cl + e^-$

$Cl^- \rightarrow Cl + e^-$

$2Cl^- \rightarrow Cl_2 + 2e^-$

- Overall reaction:

$$2NaCl(aq) + 2H_2O(l) \xrightarrow{\text{Electricity}} 2NaOH(aq) + H_2(g) + Cl_2(g)$$

Uses of Products of Chlor-alkali Process

Main Product

Uses of Caustic Soda (Near the cathode)

(a) It is used to manufacture soaps and detergents.
(b) It is used for degreasing metals. (to remove oil & grease)
(c) It is used as a drain cleaner to open clogged drains.

By-product

Uses of Hydrogen Gas (Liberated at cathode)

(a) Liquid hydrogen is used as a rocket fuel.
(b) It is used to manufacture ammonia for fertilisers.
(c) It is used to produce margarine (bread spread).

Uses of Products of Chlor-alkali Process

By-product

Uses of Chlorine Gas (Liberated at anode)

(a) It is used to manufacture pesticides and PVC.

(b) It is used to manufacture CFCs' for refrigerators.

(c) It is used as a disinfectant in the swimming pools.

(kill the germs on non-living surfaces)

Bleaching Powder

- Chemical name: **Calcium oxychloride**
- Chemical formula: **$CaOCl_2$ (Actual formula is quite complex)**
- Principle of Manufacture: The chlorine gas obtained as a by-product from the chlor-alkali process when reacts with dry slaked lime [$Ca(OH)_2$] produces bleaching powder.
- Reaction:

$$Ca(OH)_2(s) + Cl_2(g) \rightarrow CaOCl_2(s) + H_2O(g)$$

Uses of Bleaching Powder

(a) It is used in the textile industry for bleaching cotton and linen.
(b) It is used as an oxidising agent in chemical industries.
(c) It is used for disinfecting drinking water by killing germs.

decolourise

because of Cl_2 gas

Baking Soda

- Chemical name: **Sodium hydrogen carbonate**
- Chemical formula: **$NaHCO_3$**
- Manufactured By: **Ammonia-Soda Process/Solvay's Process (Intermediate Product of This Process)**
- Reaction:

$$NaCl(aq) + H_2O(l) + CO_2(g) + NH_3(g) \rightarrow NaHCO_3(s) + NH_4Cl(aq)$$

Uses of Baking Soda

(a) It is used to make baking powder (*mixture of baking soda, mild edible acid such as tartaric acid and cornstarch*).

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

dry acid

(c) It is used as an ingredient of antacid medicines.

Washing Soda

- Chemical name: **Sodium carbonate decahydrate**
- Chemical formula: **$Na_2CO_3.10H_2O$**
- Manufactured By: **Ammonia-Soda Process/Solvay's Process (Main or Primary Product of This Process is Na_2CO_3)** → SODA ASH
- Reaction: (i) Thermal decomposition of baking soda

$$2NaHCO_3(s) \xrightarrow{heat} Na_2CO_3(s) + H_2O(g) + CO_2(g)$$

(ii) Recrystallisation of soda ash

$$Na_2CO_3(s) + 10H_2O(l) \rightarrow Na_2CO_3.10H_2O(s)$$

These fixed number of water molecules that attach on 1 formula unit and give it a fixed geometrical shape along with colour in some cases is called water of crystallisation.

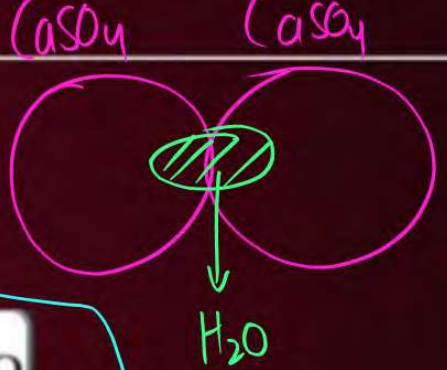
Uses of Washing Soda

(a) It is used in glass, soap and paper industries.
(b) It is used to remove permanent hardness of water.
(b) It is used to manufacture sodium compounds such as borax, i.e. sodium tetraborate decahydrate ($Na_2B_4O_7.10H_2O$).
(c) It is used as a cleaning agent to remove stubborn stains from clothes.

$CaSO_4$, $MgSO_4$, $CaCl_2$ & $MgCl_2$

Plaster of Paris

POP is stored in moisture-proof container!



- Chemical name: **Calcium sulphate hemihydrate**
- Chemical formula: **$CaSO_4.1/2H_2O$ or $(CaSO_4)_2.H_2O$**
- Principle of Manufacture (Reaction):

$$\underset{\text{Gypsum}}{CaSO_4 \cdot 2H_2O} \xrightarrow[\text{OR } T=100\,^\circ C]{373\ K} \underset{\text{Plaster of Paris}}{CaSO_4 \cdot \frac{1}{2}H_2O} + \frac{3}{2}H_2O$$

25.1 | 75.1

- Setting of Plaster of Paris (Reaction):

$$CaSO_4.\frac{1}{2}H_2O(s) + 1\frac{1}{2}H_2O\ (l) \rightarrow CaSO_4.2H_2O(s)$$

Hard mass [Gypsum]

To avoid this ⇒ from moisture from air

Uses of Plaster of Paris

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