CHAPTER-2

Acids, Bases and salts

Acids

- An acid is a substance that produces hydrogen ions (H+) when placed in water
- When acids/ ionic compounds are dissolved in water, the ions split apart from each other (dissociation)
- Examples: Hydrochloric acid (HCl)
  Sulphuric acid (H_2SO_4)
  Nitric acid (HNO_3)

Properties of Acids

- The term acid has been derived from the Latin word acidus which means sour.
- Acids have sour taste.
- They turn blue litmus sulution red.
- They give H+ ions in queous solution.

Bases

- A base is a substance that produces **hydroxide ions** (OH^-) when placed in water
- When bases/ ionic compounds are dissolved in water, the ions split apart from each other (**dissociation**)
- Examples: Sodium hydroxide (NaOH)
  Potassium hydroxide (KOH)
  Calcium hydroxide ($Ca(OH)_2$)

Properties of Bases

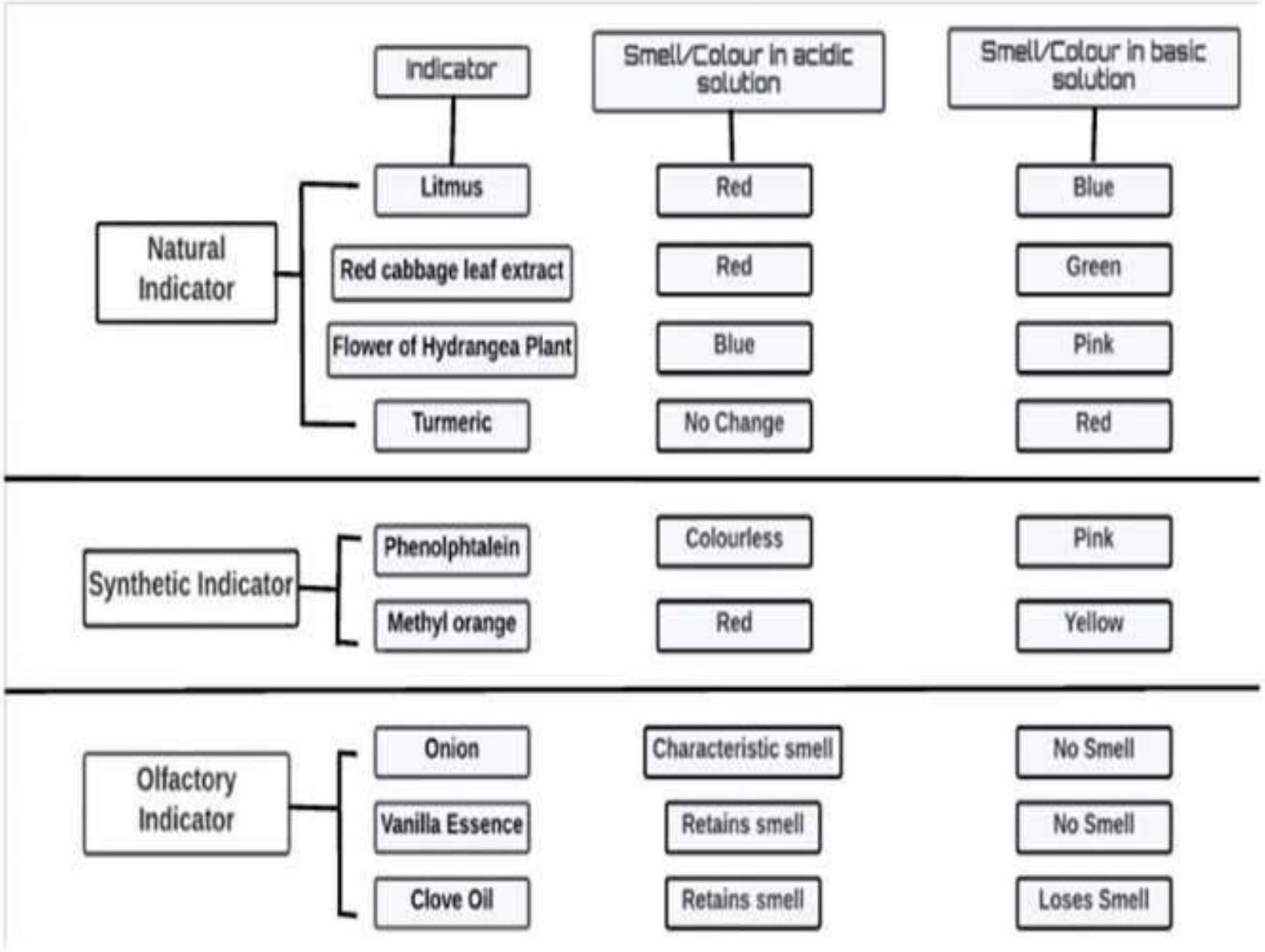
- These are the substances which are bitter in taste and soapy in touch.
- They turns ted litmus blue.
- They give OH- ions in aqueous solution.

Indicators

- Indicators are used to determine if a substance is an acid or a base
- An indicator changes a specific color when in the presence of an acid or a base

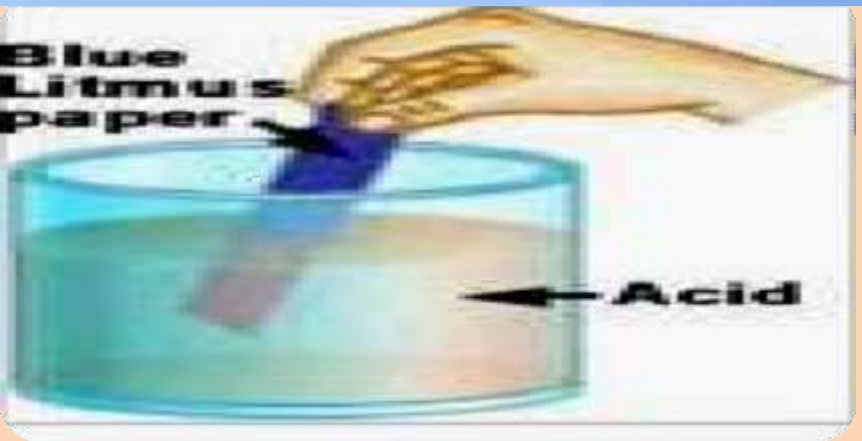
Types of Indicators

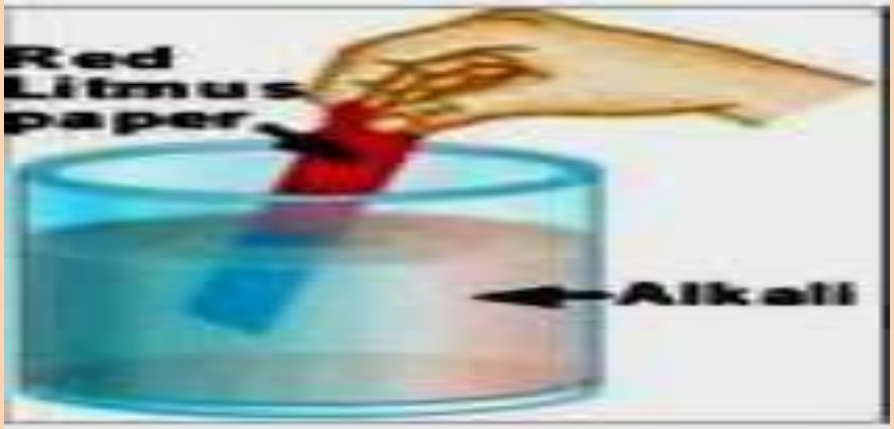
- Natural Indicators: Found in nature in plants. Examples:Litmus, Red cabbage leaves, Turmeric etc.
- Synthetic Indicators: Those are chemical substances. Examples : Methyl orange, Phenolphthalein etc.
- Olfactory indicators: Those substances have different odour in acids and bases. Examples:Clove, Vanila etc.


Indicator
Smell/Colour in acidic solution
Smell/Colour in basic solution
Natural Indicator
Litmus
Red
Blue
Red cabbage leaf extract
Red
Green
Flower of Hydrangea Plant
Blue
Pink
Turmeric
No Change
Red
Synthetic Indicator
Phenolphtalein
Colourless
Pink
Methyl orange
Red
Yellow
Olfactory Indicator
Onion
Characteristic smell
No Smell
Vanilla Essence
Retains smell
No Smell
Clove Oil
Retains smell
Loses Smell


75
50
25


75
50
25


Blue
Litmus
paper
Acid


Red
Litmus
paper
Alkali

Reactions of acids and bases

a) Reaction of acids and bases with metals

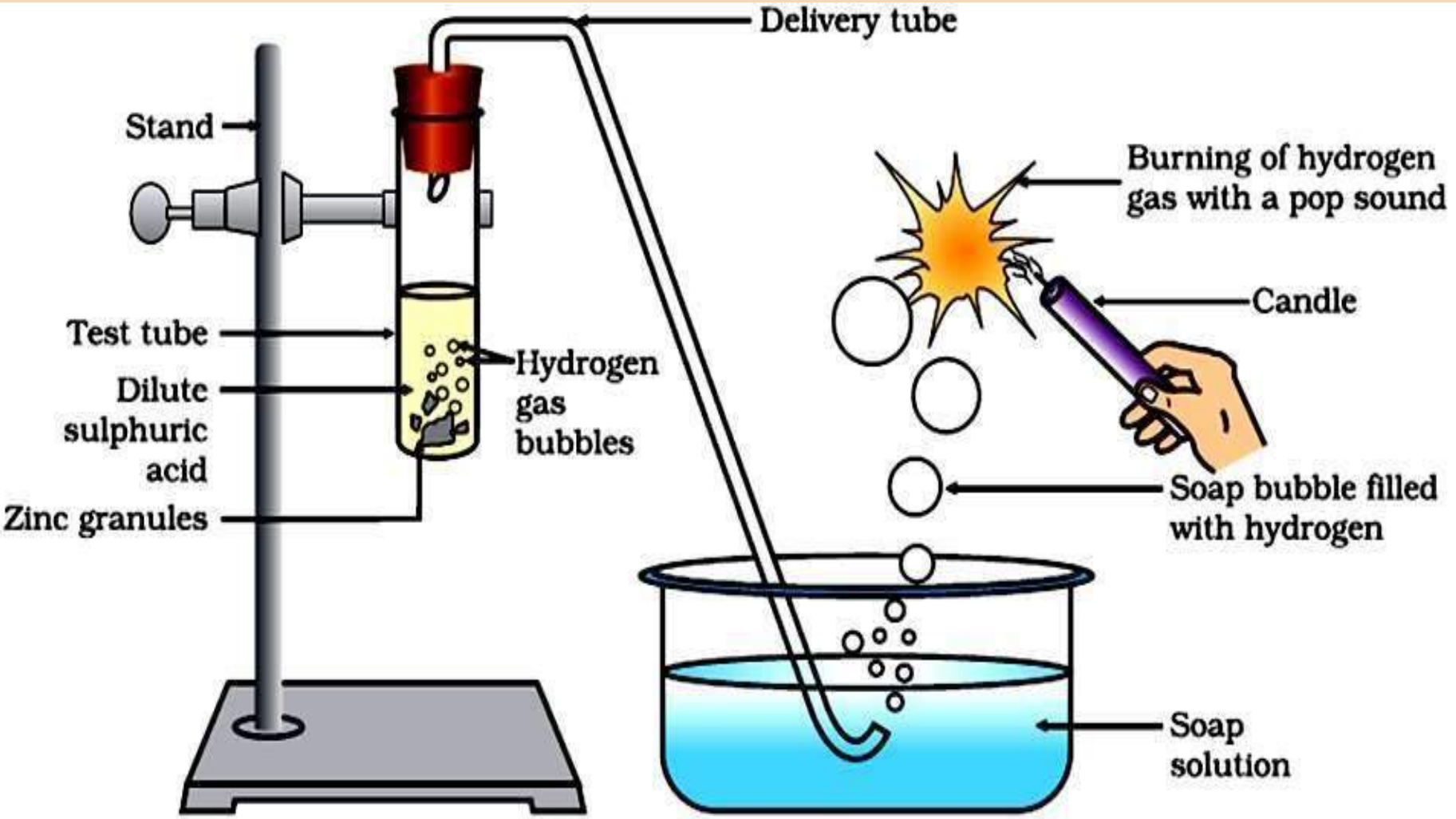
Acid + active metal → salt + hydrogen + heat

$2HCl+Mg \rightarrow MgCl_2+H_2 (\uparrow)$

Base + metal → salt + hydrogen + heat

$2NaOH+Zn \rightarrow Na_2ZnO_2+H_2 (\uparrow)$

On burning H_2 gas produced POP sound



Reaction of zinc granules with dilute sulphuric acid and testing hydrogen gas by burning

Reactions of acids and bases

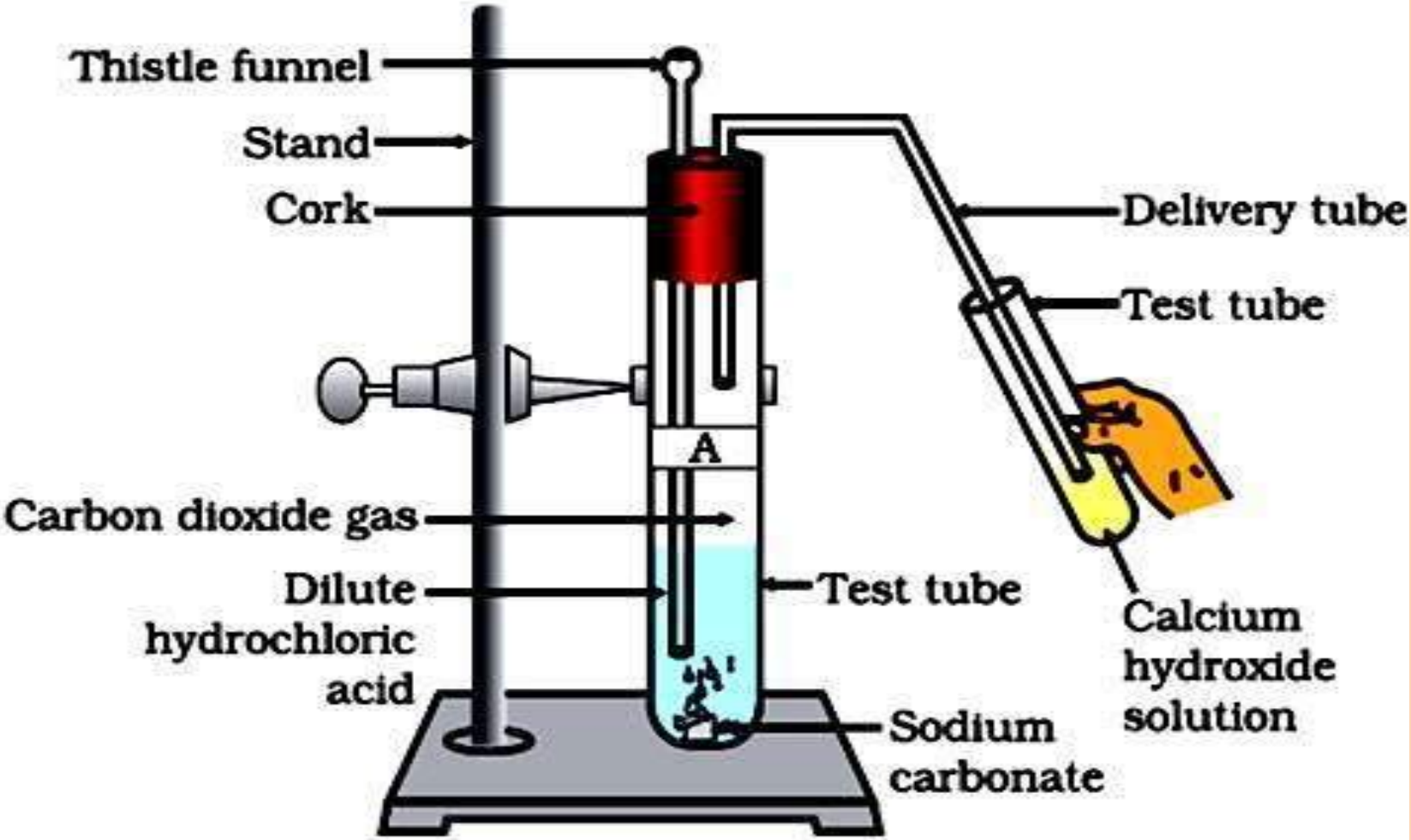
b) Reaction of acids with metal carbonates and bicarbonates

Acid + metal carbonate or bicarbonate → salt + water + carbon dioxide.

$2HCl+CaCO_3 \rightarrow CaCl_2+H_2O+CO_2$

$H_2SO_4+Mg(HCO_3)_2 \rightarrow MgSO_4+2H_2O+2CO_2$

Effervescence indicates liberation of CO_2 gas.



Passing carbon dioxide gas through calcium hydroxide solution

Effect of Carbon di oxide on lime water

On passing the carbon dioxide gas evolved through lime water,

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

(Lime water) (White precipitate)

On passing excess carbon dioxide the following reaction takes place:

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

(Soluble in water)

How do acids and bases react with each other?

we have observed that the effect of a base is nullified by an acid and vice-versa. The reaction taking place is written as –

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

The reaction between an acid and a base to give a salt and water is known as a *neutralisation reaction*. In general, a neutralisation reaction

$$Base + Acid \rightarrow Salt + Water$$

Reaction of Metallic Oxides with Acids

The general reaction between a metal oxide and an acid can be written as –

Since metallic oxides react with acids to give salts and water, similar to the reaction of a base with an acid, metallic oxides are said to be basic oxides.

Reaction of Non Metallic Oxides with Bases

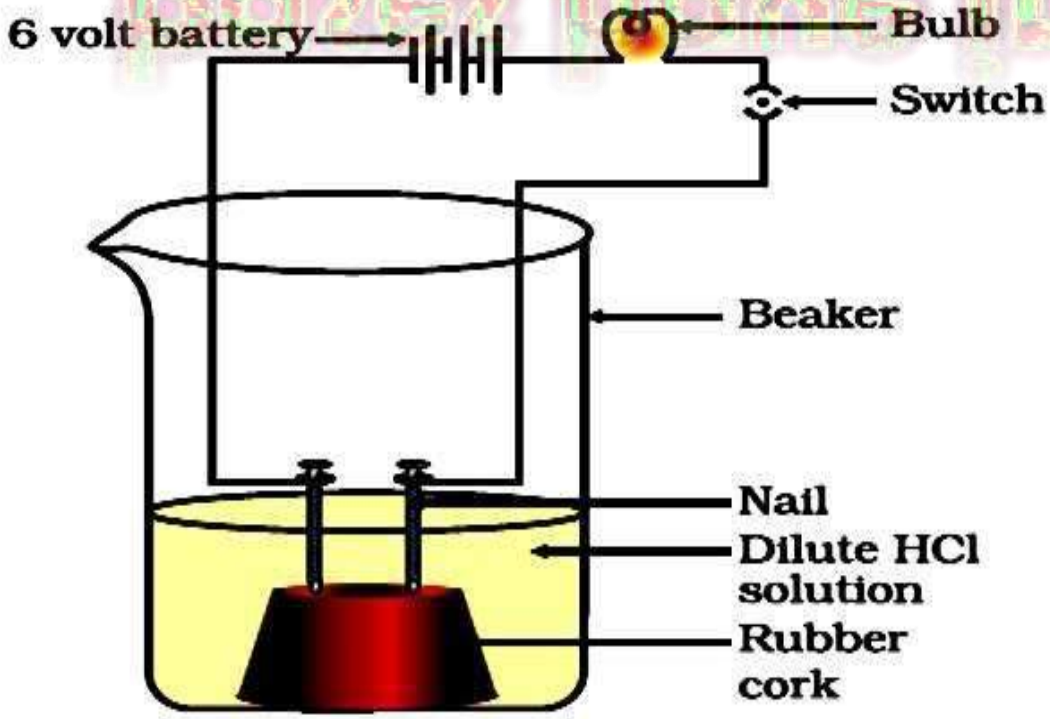
The general reaction between a Non-metal oxide and a base can be written as –

Since this is similar to the reaction between a base and an acid, we can conclude that non -metallic oxides are acidic in nature.

QUESTIONS

1. Why should curd and sour substances not be kept in brass and copper vessels?
2. Which gas is usually liberated when an acid reacts with a metal? Illustrate with an example. How will you test for the presence of this gas?
3. Metal compound A reacts with dilute hydrochloric acid to produce effervescence. The gas evolved extinguishes a burning candle. Write a balanced chemical equation for the reaction if one of the compounds formed is calcium chloride.

❖What do all acids and bases have in common?



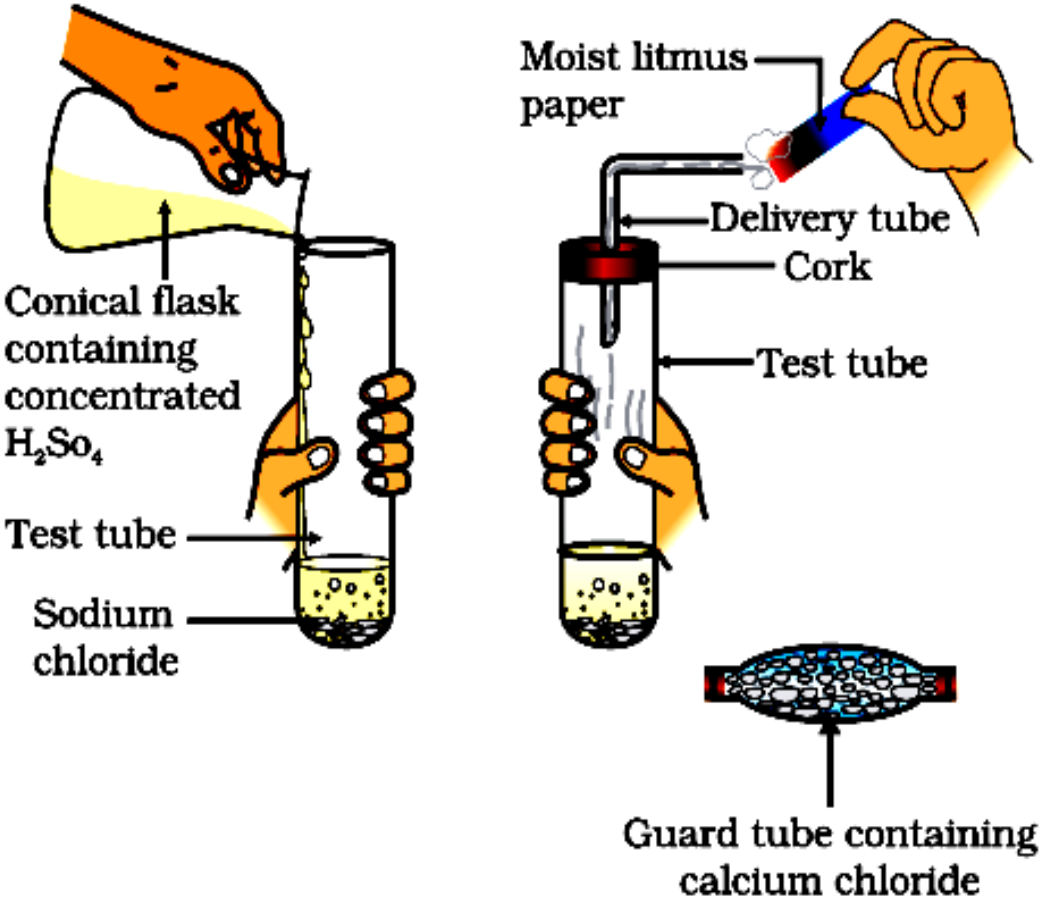
Acid solution in water conducts electricity

Glowing of the bulb indicates that there is a flow of electric current through the solution. The electric current is carried through the solution by ions.

Since the cation present in acids is H^+, this suggests that acids produce hydrogen ions, $H^+(aq)$, in solution, which are responsible for their acidic properties.

Similarly base contain OH-(aq) in solution, which are responsible for their basic properties.

What Happens to an Acid or a Base in a Water Solution?



Preparation of HCl *gas*

This experiment suggests that hydrogen ions in HCl are produced in the presence of water. The separation of H^+ ion from HCl molecules cannot occur in the absence of water.

Hydrogen ions cannot exist alone, but they exist after combining with water molecules. Thus hydrogen ions must always be shown as $H^+(aq)$ or hydronium ion (H_3O^+).

$H^+ + H_2O \rightarrow H_3O^+$

We have seen that acids give H_3O^+ or H^+ (aq) ion in water. Let us see what happens when a base is dissolved in water..

$$NaOH(s) \xrightarrow{H_2O} Na^+(aq) + OH^-(aq)$$

$$KOH(s) \xrightarrow{H_2O} K^+(aq) + OH^-(aq)$$

$$Mg(OH)_2(s) \xrightarrow{H_2O} Mg^{2+}(aq) + 2OH\ (aq)$$

Bases generate hydroxide (OH^-) ions in water.
Bases which are soluble in water are called **alkalis.**

Do You Know?

All bases do not dissolve in water. An alkali is a base that dissolves in water. They are soapy to touch, bitter and corrosive. Never taste or touch them as they may cause harm. Which of the bases in the Table 2.1 are alkalis?

Now as we have identified that all acids generate $H^+(aq)$ and all bases generate $OH^-(aq)$, we can view the neutralisation reaction as follows –

$$\text{Acid} + \text{Base} \rightarrow \text{Salt} + \text{Water}$$

$$H\boxed{X + M}OH \rightarrow MX + HOH$$

$$H^+(aq) + OH^-(aq) \rightarrow H_2O(l)$$

The process of dissolving an acid or a base in water is a highly exothermic one. Care must be taken while mixing concentrated nitric acid or sulphuric acid with water. The acid must always be added slowly to water with constant stirring. If water is added to a concentrated acid, the heat generated may cause the mixture to splash out and cause burns. The glass container may also break due to excessive local heating. Look out for the warning sign on the can of concentrated sulphuric acid and on the bottle of sodium hydroxide pellets.

Mixing an acid or base with water results in decrease in the concentration of ions (H_3O^+/OH^-) per unit volume. Such a process is called **dilution** and the acid or the base is said to be diluted.

❖QUESTIONS:-

Q1. Why do HCl, HNO_3, etc., show acidic characters in aqueous solutions while solutions of compounds like alcohol and glucose do not show acidic character ?

ANS-The dissociation of HCl or HNO_3 to form hydrogen ions always occurs in the presence of water. Hydrogen ions (H^+) combine with H_2O to form hydronium ions (H_3O^+).

$$HCl_{(aq)} \longrightarrow H^+ + Cl^-$$

$$H^+ + H_2O \longrightarrow H_3O^+$$

Although aqueous solutions of glucose and alcohol contain hydrogen, these cannot dissociate in water to form hydrogen ions. Hence, they do not show

Q2. Why does an aqueous solution of an acid conduct electricity?

ANS- Acids dissociate in aqueous solutions to form ions. These ions are responsible for electricity.

3. Why does dry HCl gas not change the colour of the dry litmus paper?

ANS- Color of the litmus paper is changed by the hydrogen ions. Dry HCl gas does not contain H^+ ions. It is only in the aqueous solution that an acid dissociates to give ions. since in this case, neither HCl is in the aqueous form nor the litmus paper is wet, therefore, the color of the litmus paper does not change.

Q4. While diluting an acid, why is it recommended that the acid should be added to water and not water to the acid?

ANS-Since the process of dissolving an acid in w
Is exothermic, it is always recommended that ac
Should be added to water. If is done in the oth
Then it is possible that because of the large am
Heat generated, the mixture splashes out and c
burns.

q5. How is the concentration of hydronium ions (H_3O^+) affected when a solution of an acid is diluted ?

ANS-When an acid is diluted, the concentration of hydronium ions (H_3O^+) per unit volume decreases. This means that the strength of the

6. How is the concentration of hydroxide ions (OH^-) affected when excess base is dissolved in a solution of sodiumhydroxide?

ANS-The concentration of hydroxide ions(OH^-) would increases when excess base is dissolved in a solution of sodium hydroxide.

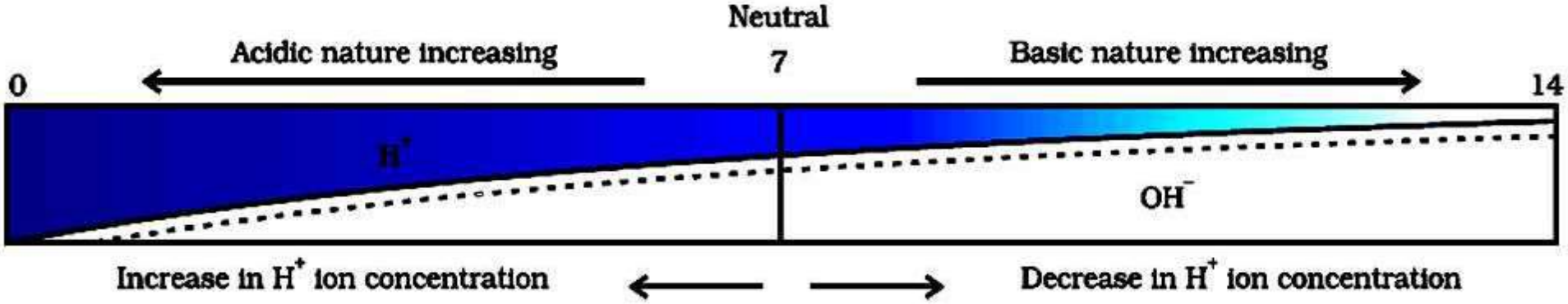
❖HOW STRONG ARE ACID OR BASE SOLUTIONS?

We Can quantitatively find the amount of H^+ or OH^- ions present in a solution, We Can also judge how strong a given acid or base. By making use of a universal indicator, which is a mixture of several indicators. The universal indicator shows different colours at different concentrations of hydrogen ions in a solution.

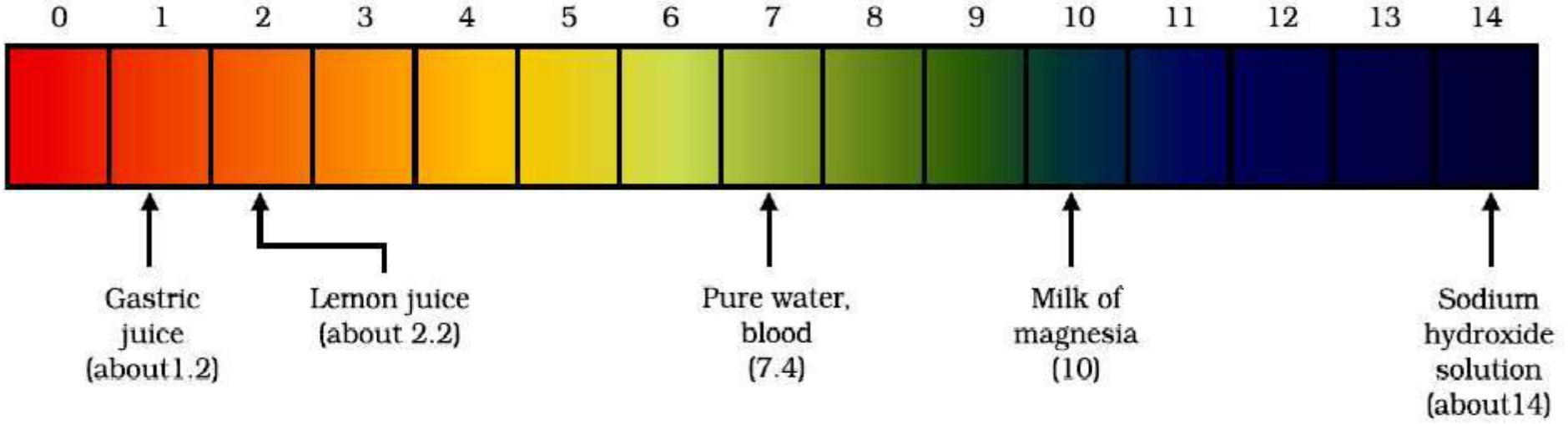
Ascale for measuring hydrogen ion concentration in a solution, called pH scale has been developed. The p in pH stands for 'potenz' in German, meaning power. On the pH scale we can measure pH from 0 (very acidic) to 14 (very alkaline). pH should be thought of simply as a number which indicates the acidic 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.

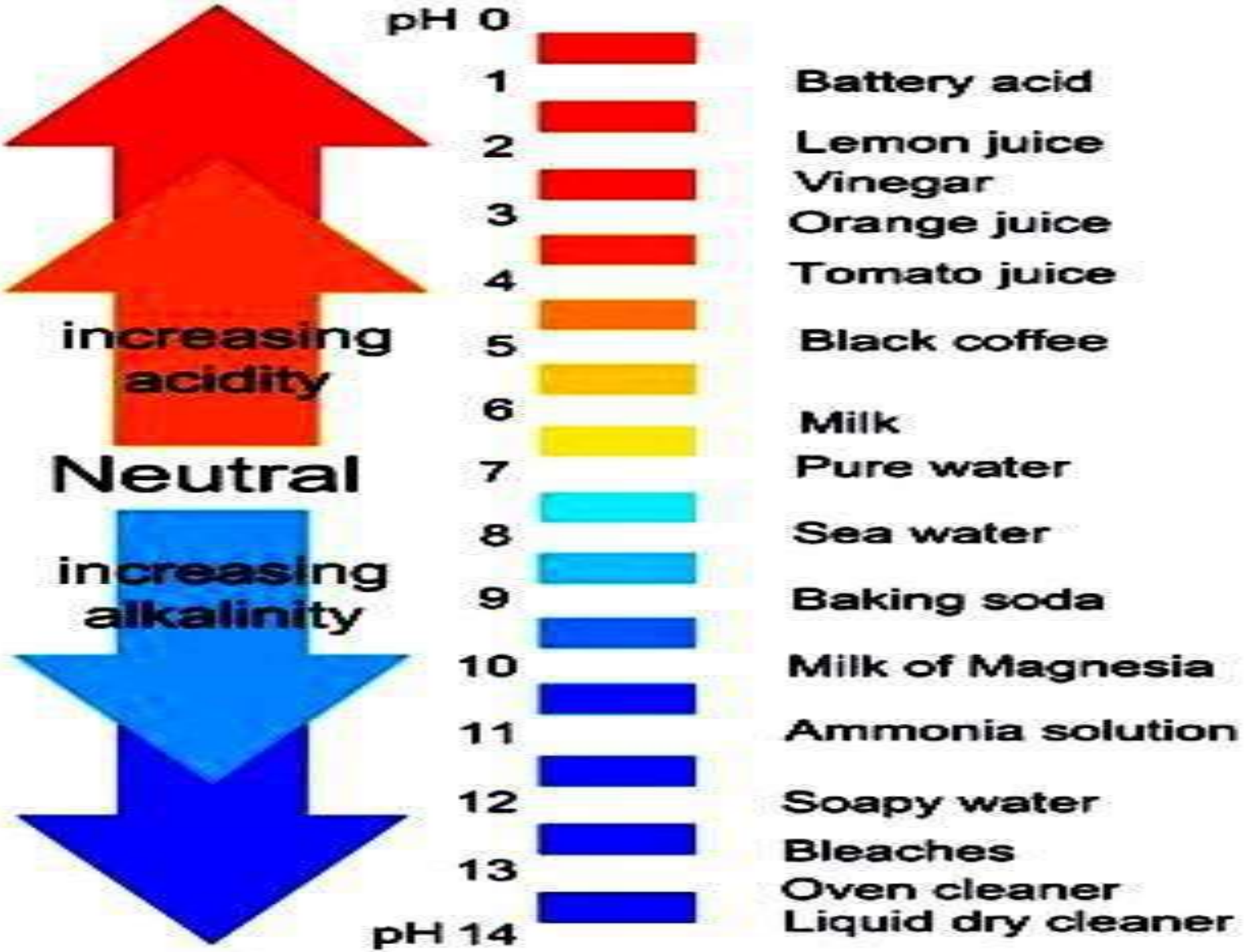
Generally paper impregnated with the universal indicator is used for measuring pH. One such paper is shown below



Variation of pH *with the change in concentration of* $H^+(aq)$ *and* $OH^-(aq)$ *ions*



pH *of some common substances shown on a* pH *paper*


pH 0
1
2
3
4
5
6
7
8
9
10
11
12
13
pH 14
Battery acid
Lemon juice
Vinegar
Orange juice
Tomato juice
Black coffee
Milk
Pure water
Sea water
Baking soda
Milk of Magnesia
Ammonia solution
Soapy water
Bleaches
Oven cleaner
Liquid dry cleaner
increasing acidity
Neutral
increasing alkalinity

pH Range for a Few Common Substances

Substance	pH Range
Gastric contents (human)	1.6–3.0
Soft drinks	2.0–4.0
Lemons	2.2–2.4
Vinegar	2.4–3.4
Tomatoes	4.0–4.4
Beer	4.0–5.0
Urine (human)	4.8–8.4
Milk (cow's)	6.3–6.6
Saliva (human)	6.5–7.5
Blood plasma (human)	7.3–7.5
Egg white	7.6–8.0
Milk of magnesia	10.5
Household ammonia	11–12

More acidic

More basic

The strength of acids and bases depends on the number of H^+ ions and OH^- ions produced, respectively. If we take hydrochloric acid and acetic acid of the same concentration, say one molar, then these produce different amounts of hydrogen ions. 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.

A strong acid is an acid that is completely ionised in water. This means that all the acid molecules become ions in the water. Examples : sulphuric acid, hydrochloric acid.

A weak acid is an acid that is only *partially ionised in water*. This means that only a few molecules of the acid become ions in water. Examples : ethanoic acid, citric acid.

Importance of pH in Everyday Life

✓Are plants and animals pH sensitive?

Our body works within the pH range of 7.0 to 7.8. Living organisms can survive only in a narrow range of pH change. 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.

Do You Know?

Acids in other planets

The atmosphere of venus is made up of thick white and yellowish clouds of sulphuric acid. Do you think life can exist on this planet?

√What is the pH of the soil in your backyard?

Plants require a specific pH range for their healthy growth. To find out the pH required for the healthy growth of a plant, you can collect the soil from various places and check the pH, Also, you can note down which plants are

✓pH in our digestive system

It is very interesting to note that our stomach produces hydrochloric acid. It helps in the digestion of food without harming the stomach.

During indigestion the stomach produces too much acid and this causes pain and irritation. To get rid of this pain, people use bases called antacids. One such remedy must have been suggested by you at the beginning of this Chapter. These antacids neutralise the excess acid.

✓ pH change as the cause of tooth decay

Tooth decay starts when the pH of the mouth is lower than 5.5. Tooth enamel, made up of calcium phosphate is the hardest substance in the body. It does not dissolve in water, but is corroded when the pH in the mouth is below 5.5. Bacteria present in the mouth produce acids by degradation of sugar and food particles remaining in the mouth after eating. The best way to prevent this is to clean the mouth after eating food. Using toothpastes, which are

✓Self defence by animals and plants through chemical warfare

Have you ever been stung by a honey-bee? Bee-sting leaves an acid which causes pain and irritation. Use of a mild base like baking soda on the stung area gives relief. Stinging hair of nettle leaves inject methanoic

Do You Know?

Nature provides neutralisation options

Nettle is a herbaceous plant which grows in the wild. Its leaves have stinging hair, which cause painful stings when touched accidentally. This is due to the methanoic acid secreted by them. A traditional remedy is rubbing the area with the leaf of the dock plant, which often grows beside the nettle in the wild. Can you guess the nature of the dock plant? So next time you know what to look out for if you accidentally touch a nettle plant while trekking. Are you aware of any other effective traditional remedies for such stings?

Some naturally occurring acids

Natural source	Acid	Natural source	Acid
Vinegar	Acetic acid	Sour milk (Curd)	Lactic acid
Orange	Citric acid	Lemon	Citric acid
Tamarind	Tartaric acid	Ant sting	Methanoic acid
Tomato	Oxalic acid	Nettle sting	Methanoic acid

Q1. You have two solutions, A and B. The pH of solution A is 6 and pH of solution B is 8. Which solution has more hydrogen ion concentration ? Which of this is acidic and which one is basic?

ANS-A pH value of less than 7 indicates an acidic solution, while greater than 7 indicates a basic solution. Therefore, the solution with pH = 6 is acidic and has more hydrogen ion concentration than the solution of pH = 8 which is basic.

Q2. What effect does the concentration of $H^+(aq)$ ions have on the nature of the solution ?

ANS-Concentration of $H^+(aq)$ can have a varied effect on the nature of the solution. With an increase in H^+ ion concentration, the solution becomes more acidic, while a decrease of H^+ ion causes an increase in the basicity of the solution.

q3. Do basic solutions also have $H^+(aq)$ ions? If yes, then why are these basic ?

ANS-Yes, basic solution also has $H^+(aq)$ ions. However, their concentration is less as compared to the concentration of OH^- ions that makes the solution basic.

q4. Under what soil condition do you think a farmer would treat the soil of his fields with quick lime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate)?

ANS-If the soil is acidic and improper for cultivation, then to increase the basicity of soil, the farmer would treat the soil with

Salts

A salt is formed when an acid is neutralised by a base.
A salt contains two parts:
Metal part : *cation* (comes from the base)
Non-metal part : *anion* (comes from the acid)

Examples of Salts

Table 1

Base (alkali)	Acid	Salt formed
Sodium hydroxide	Hydrochloric acid	Sodium chloride
Potassium hydroxide	Hydrochloric acid	Potassium chloride
Sodium hydroxide	Sulphuric acid	Sodium sulphate
Potassium hydroxide	Sulphuric acid	Potassium sulphate
Calcium hydroxide	Nitric acid	Calcium nitrate
Ammonia solution	Nitric acid	Ammonium nitrate

Hydrate crystals (left to right): cobalt nitrate, calcium nitrate and nickel sulphate (top) and manganese sulphate, copper sulphate and chromium potassium sulphate (bottom).

USES OF SALTS

S.No.	SALT	USE
1	Ammonium Chloride	In torch batteries
2	Ammonium Nitrate	In fertilizers
3	Calcium Chloride	As drying agent
4	Iron Sulphate	In Iron tablets
5	Magnesium Sulphate	In medicine
6	Potassium Nitrate	In gunpowder etc.
7	Silver Bromide	In photography
8	Sodium Chloride	Making NaOH
9	Sodium Stearate	In making soap.

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.

➢pH 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.

Chemical from common salts-

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. 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.

Common salt – A raw material for chemicals

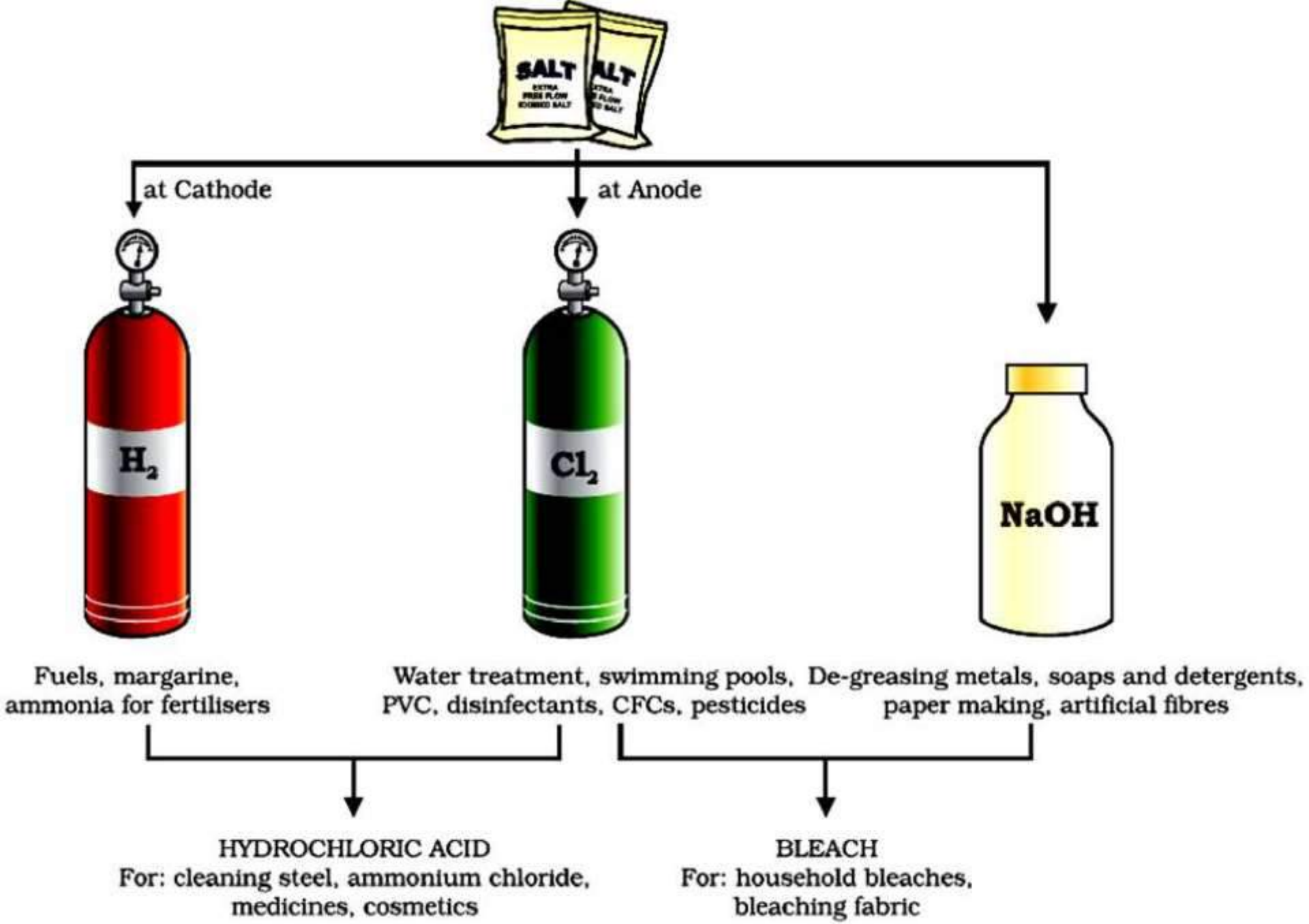
The common salt thus obtained is an important raw material for various materials of daily use, such as sodium hydroxide baking , soda washing soda, bleaching powder and many more.

✓Sodium hydroxide:

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

$$2NaCl(aq) + 2H_2O(l) \rightarrow 2NaOH(aq) + Cl_2(g) + H_2(g)$$

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



Important products from the chlor-alkali process

✓Bleaching powder:

You have already come to know that chlorine is produced during the electrolysis of aqueous sodium chloride (brine). This chlorine gas is used for the manufacture of bleaching powder. Bleaching powder is produced by the action of chlorine on dry slaked lime [$Ca(OH)_2$]. Bleaching powder is represented as $CaOCl_2$, though the actual composition is quite complex.

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

Bleaching powder is used –
(i)for bleaching cotton and linen in the textile industry, for bleaching wood pulp in paper factories and for bleaching washed clothes in laundry;
(ii)as an oxidising agent in many chemical industries; and
(iii)for disinfecting drinking water to make it free of germs.
Chemical name of bleaching powder is calcium oxy chloride.

✓Baking soda:

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 hydrogencarbonate ($NaHCO_3$). It is produced using sodium chloride as one of the raw materials.

$$NaCl + H_2O + CO_2 + NH_3 \rightarrow \underset{\text{(Ammonium chloride)}}{NH_4Cl} + \underset{\text{(Sodium hydrogencarbonate)}}{NaHCO_3}$$

It is a mild non-corrosive base. The following reaction takes place when it is heated during cooking -

$$\underset{\text{(Sodium hydrogencarbonate)}}{2NaHCO_3} \xrightarrow{\text{Heat}} \underset{\text{(Sodium carbonate)}}{Na_2CO_3} + H_2O + CO_2$$

Uses of sodium hydrogencarbonate ($NaHCO_3$)

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

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

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

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

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

✓Whasing soda:

Another chemical that can be obtained from sodium chloride is $Na_2CO_3.10H_2O$ (washing soda). You have seen above that sodium carbonate can be obtained by heating baking soda; recrystallisation of sodium carbonate gives washing soda. It is also a basic salt.

$$Na_2CO_3 + 10H_2O \rightarrow Na_2CO_3.10H_2O$$

(Sodium carbonate)

Uses of washing soda

(i)Sodium carbonate (washing soda) is used in glass, soap and paper industries.

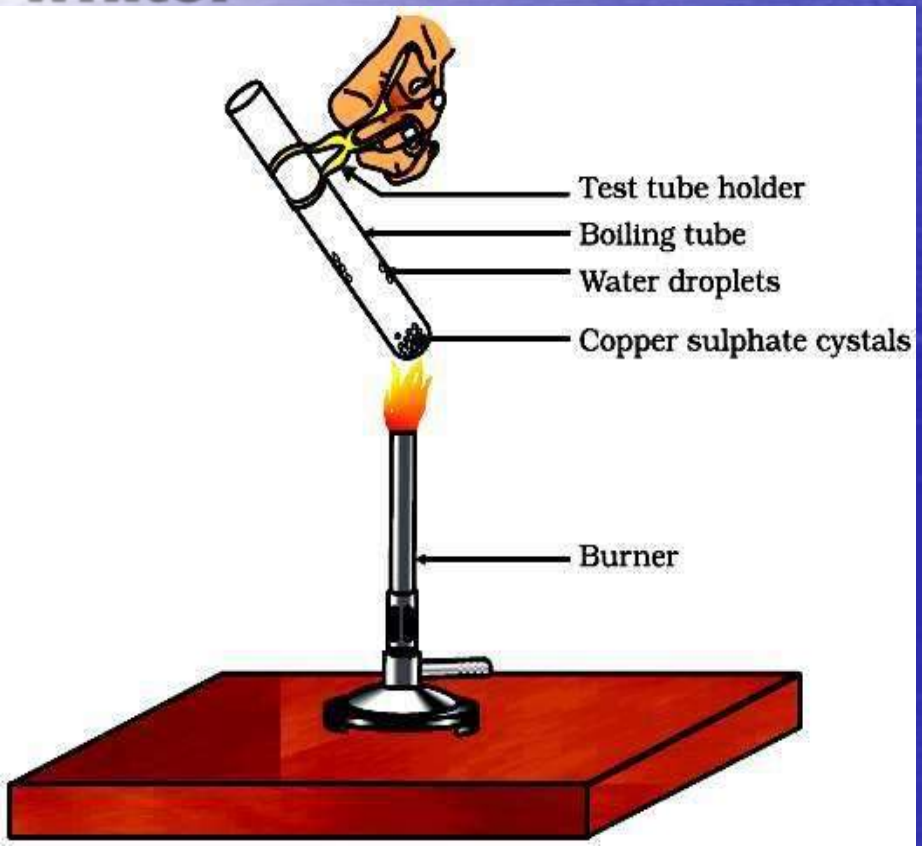
(ii)It is used in the manufacture of sodium compounds such as borax.

(iii)Sodium carbonate can be used as a cleaning agent for domestic purposes.

(iv)It is used for removing permanent hardness of water.

➢Are the crystals of salts really dry?–

Copper sulphate crystals which seem to be dry contain water of crystallisation. When we heat the crystals, this water is removed and the salt turns white.



If you moisten the crystals again with water, you will find that blue colour of the crystals reappears.

Water of crystallisation is the fixed number of water molecules present in one formula unit of a salt. Five water molecules are present in one formula unit of copper sulphate. Chemical formula for hydrated copper sulphate is Cu SO_4. $5H_2O$. Now you would be able to answer the question whether the molecule of $Na_2CO_3.10H_2O$ is wet.

One other salt, which possesses water of crystallisation is gypsum. It has two water molecules as water of crystallisation. It has the formula $CaSO_4.2H_2O$.

✓Plaster of Paris:-

On heating gypsum at 373 K, it loses water molecules and becomes calcium sulphate hemihydrate . This is called Plaster of Paris, the substance which doctors use as plaster for supporting fractured bones in the right position. Plaster of Paris is a white powder and on mixing with water, it changes to gypsum once again giving a hard solid mass.

$$\underset{\text{(Plaster of Paris)}}{CaSO_4 . \frac{1}{2} H_2O} + 1\frac{1}{2} H_2O \rightarrow \underset{\text{(Gypsum)}}{CaSO_4 . 2H_2O}$$

It is written in this form because two formula units of CaSO4 share one molecule of water. Plaster of Paris is used for making toys, materials for decoration and for making surfaces smooth.

❖QUESTIONS:-

Q1. What is the common name of the compound $CaOCl_2$?

ANS-The common name of the compound $CaOCl_2$ is bleaching powder.

Q2.Name the substance which on treatmen with chlorine yields bleaching powder.

ANS-Calcium hydroxide [$Ca(OH)_2$], on treatment with chlorine, yields bleaching powder.

Q3. Name the sodium compound which is used for softening hard water.

ANS-Washing soda ($Na_2CO_3.10H_2O$) is used for softening hard water.

Q4. What will happen if a solution of sodium hydrocarbonate is heated? Give the equation of the reaction involved.

ANS-When a solution of sodium hydrocarbonate (sodium hydrogencarbonate) is heated, sodium carbonate and water are formed with the evolution of carbon dioxide gas.

$$\underset{\text{Sodium hydrogencarbonate}}{2NaHCO_3} \xrightarrow{\Delta} \underset{\text{Sodium carbonate}}{Na_2CO_3} + \underset{\text{Water}}{H_2O} + \underset{\text{Carbon dioxide}}{CO_2\uparrow}$$

Q5. Write an equation to show the reaction between Plaster of Paris and water.

ANS-The chemical equation for the reaction of Plaster of Paris and water can be represented as

$$\underset{\text{Plaster of Paris}}{CaSO_4 \cdot \frac{1}{2}H_2O} + \underset{\text{Water}}{1\frac{1}{2}H_2O} \longrightarrow \underset{\text{Gypsum}}{CaSO_4.2H_2O}$$

THE END