

2

Acids, Bases and Salts



"Sour fruits contain various amounts of citric acid."



Do You Remember ?

- ★ We have studied matter on the basis of composition, state, solubility, types of mixture, types of compound.
- ★ Now in this chapter we will categorise some compounds on the basis of their nature as acids, bases and salts.

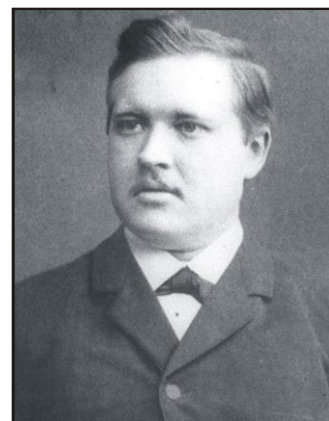
1. Introduction

The chemicals which we come across are usually categorised as acids, bases and salts.

Earlier this classification was based on different taste of chemicals.

Acids were first recognized as substances that taste sour. Vinegar tastes sour because it is a dilute solution of acetic acid. Citric acid is responsible for the sour taste of a lemon.

Bases, sometimes called alkalis, are characterised by their bitter taste and they are soapy to feel. Most hand soaps and commercial preparation for unclogging drains are highly basic. Substances having taste similar to that of common salt are called **salts**. However, some substances have very unpleasant taste and even may be poisonous. Usually salts are prepared by chemical reaction between acids and bases.



Svante Arrhenius
(1859 – 1927)

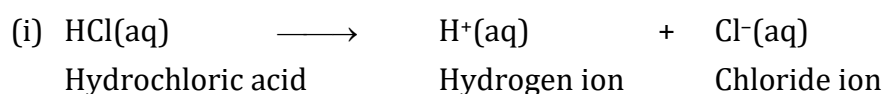
Now, the question arises – how to test that the given substance is an acid or a base without tasting it? In this chapter, we shall discuss the common characteristics of acids and bases and their chemical nature. We shall also discuss how salts are produced and important applications of some of these salts.

2. Acids

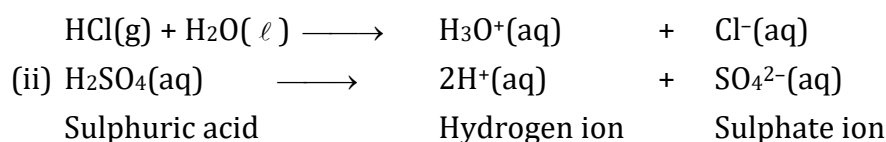
The term "acid" is derived from the latin word "**acidus**" meaning sour in taste.

According to Arrhenius theory, "An acid is a substance which when dissolved in water, ionizes and releases hydrogen ions $[H^+(aq)]$ in solution".

Example,



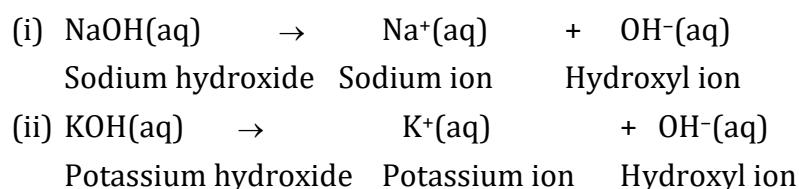
OR



3. Bases

According to Arrhenius theory "Those substances which give hydroxide or hydroxyl ion (OH^-) in their aqueous solution are called bases".

For example,



Bases which completely dissolve in water are called alkalis, example NaOH, KOH, etc. "All alkalis are bases but all bases are not alkalis".

SPOT LIGHT



Do You

Remember ?

- ★ In earlier classes, we have studied about some common indicators like – litmus paper.
- ★ As we know, acid turn blue litmus paper red and base turns red litmus paper blue.

4. Chemical properties of acids and bases

1. Action of indicators

Indicators: It is a chemical which indicates the nature of solution by changing its colour/odour.

Natural indicators: Some plants are natural indicators. For example, onion extract. Litmus is obtained from a plant called lichens.

Litmus paper is made by soaking paper in litmus solution. It turns red in acid and blue in alkali.

Turmeric (haldi) is commonly used as a spice in kitchen. It is yellow in colour and stains a white cloth yellow. If the yellow stain is rubbed with soap solution, the colour of the stain changes to brownish red. Why does this happen?

The soap solution always contains a small amount of chemical called sodium hydroxide. It is the sodium hydroxide which changes the colour of turmeric stain from yellow to brownish red. Now, if we rub stain with lemon, it again changes to yellow colour. The lemon contains another substance called citric acid, which neutralises the effect of sodium hydroxide.

Olfactory indicators: Indicators giving different odour in acidic and basic medium are called olfactory indicators.

Examples: Onion extract, vanilla and clove oil.



What causes indicators to show different colours in acids and bases?

Explanation

Indicators undergo some structural changes in the presence of acids or bases which causes them to show different colours.

Note: Litmus is the most commonly used indicator in the lab.



Aim

To test acids and bases in the laboratory using acid-base indicators that changes colour.

Materials required

Watch glass, test tube, hydrochloric acid, sulphuric acid, nitric acid, acetic acid, sodium hydroxide, calcium hydroxide, potassium hydroxide, magnesium hydroxide, ammonium hydroxide, red and blue litmus solution, phenolphthalein solution, methyl orange solution.

Method

- (i) Collect the following samples from the science laboratory-hydrochloric acid (HCl), sulphuric acid (H_2SO_4), nitric acid (HNO_3), acetic acid (CH_3COOH), sodium hydroxide (NaOH), calcium hydroxide [$\text{Ca}(\text{OH})_2$], potassium hydroxide (KOH), magnesium hydroxide [$\text{Mg}(\text{OH})_2$], and ammonium hydroxide (NH_4OH).
- (ii) Put a drop of each of the above solutions on a watch-glass and test with a drop of the following indicators.
Red litmus solution, Blue litmus solution, Phenolphthalein solution, Methyl orange solution.

Observation

The changes observed are as follows:

Sample solution	Red litmus solution	Blue litmus solution	Phenolphthalein solution	Methyl orange solution
Hydrochloric acid (HCl)	No effect	Red	Colourless	Red
Sulphuric acid (H ₂ SO ₄)	No effect	Red	Colourless	Red
Nitric acid (HNO ₃)	No effect	Red	Colourless	Red
Acetic acid (CH ₃ COOH)	No effect	Red	Colourless	Red
Sodium hydroxide (NaOH)	Blue	No effect	Pink	Yellow
Calcium hydroxide (Ca(OH) ₂)	Blue	No effect	Pink	Yellow
Potassium hydroxide (KOH)	Blue	No effect	Pink	Yellow
Magnesium hydroxide (Mg(OH) ₂)	Blue	No effect	Pink	Yellow
Ammonium hydroxide (NH ₄ OH)	Blue	No effect	Pink	Yellow

Conclusion

Acids turn blue litmus red but have no effect on red litmus.

Bases turn red litmus blue but have no effect on blue litmus.

Phenolphthalein is colourless in acidic medium and turns pink in basic medium.

Methyl orange is yellow in basic medium and red in acidic medium.

**Quick Tips**

- ★ Colour of indicator in acidic/basic medium.

Indicator	Neutral medium (pH = 7)	Acidic medium (pH < 7)	Basic medium (pH > 7)
Red litmus paper (Red)	No change	No change	Red to Blue
Blue litmus paper (Blue)	No change	Blue to red	No change
Phenolphthalein (Colourless)	No change	No change	Pink
Turmeric paper (Yellow)	No change	No change	Reddish brown
Methyl orange (Orange)	No change	Red	Yellow
China rose (Light pink colour)	No change	Dark pink (Magenta)	Green

**Aim**

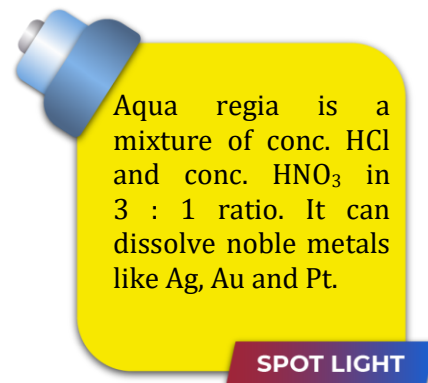
To test acids and bases using olfactory indicators.

Materials required

Plastic bag, chopped onion, strips of clean cloth, dilute HCl solution, dilute NaOH solution, test tube, vanilla essence, clove oil.

Method

- (i) Take some finely chopped onion in a plastic bag along with some strip of clean cloth. Tie up the bag tightly and leave overnight in the fridge. The cloth strips can now be used to test for acids and bases.
- (ii) Take two of these cloth strips and check their odour.
- (iii) Keep them on a clean surface and put a few drops of dilute HCl solution on one strip and a few drops of dilute NaOH solution on the other.
- (iv) Rinse both cloth strips with water and again check their odour.
- (v) Note your observations.
- (vi) Now take some dilute vanilla essence and clove oil and check their odour.
- (vii) Take some dilute HCl solution in one test tube and dilute NaOH solution in another. Add a few drops of dilute vanilla essence to both test tubes and shake well. Check the odour once again and record change in odour, if any.
- (viii) Similarly, test the change in the odour of clove oil with dilute HCl and dilute NaOH solutions and record your observation.

**Observation**

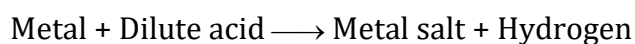
Onion, vanilla essence and clove oil loses their smell in bases but does not change their smell in acids.

Conclusion

A substance whose smell varies when it is mixed with an acidic or basic solution, can be used as an acid base indicator (called olfactory indicator).

(2) Reaction of metals with acids and bases

- (i) Dilute acids like dilute HCl and dilute H₂SO₄ react with certain active metals to evolve hydrogen gas.



Lets discuss the following activity to understand the reaction between acid and metal.

**Aim**

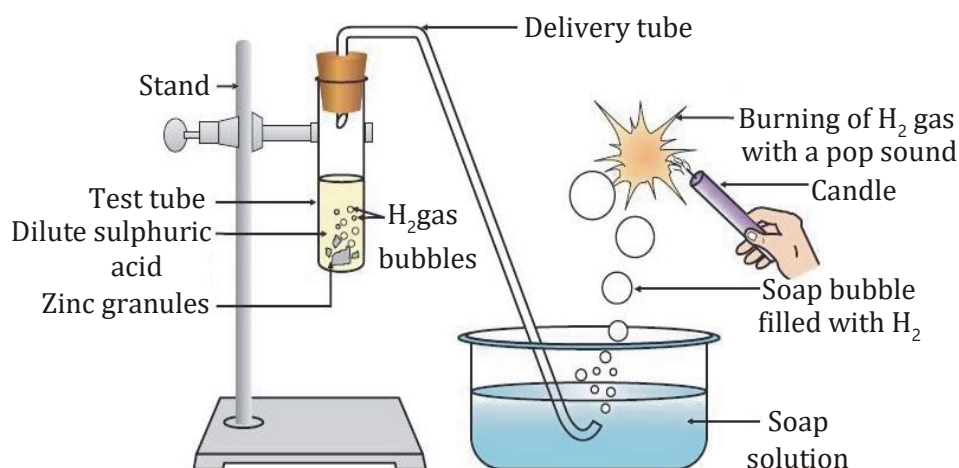
To study the reaction of acids with metals.

Materials required

Test tube, dilute H_2SO_4 , zinc granules, soap solution, test tube stand, cork, delivery tube, candle.

Method

- Take about 5 mL of dil. H_2SO_4 in a test tube and add a few pieces of zinc granules to it.
- What do you observe on the surface of zinc granules?
- Pass the gas being evolved through the soap solution.



Reaction of zinc granules with dilute sulphuric acid and testing H_2 gas by burning.

Now answer

- Why are bubbles formed in the soap solution?
- Take a burning candle near a gas filled bubble. What do you observe when burning candle is brought near the gas bubbles?

Observation and discussion

- Bubbles are formed in the soap solution indicating that some gas is evolved during the reaction between the metal and the acid.
- The gas burns with a popping sound showing that the gas evolved is hydrogen.



Conclusion

The active metal like zinc displaces hydrogen from dilute acids and the remaining part of the acid combines with the metal to form the corresponding salts.

More examples, (i) $2\text{Na(s)} + 2\text{HCl(dil)} \rightarrow 2\text{NaCl(aq)} + \text{H}_2\text{(g)}$

(ii) $\text{Fe(s)} + \text{H}_2\text{SO}_4\text{(dil)} \rightarrow \text{FeSO}_4\text{(aq)} + \text{H}_2\text{(g)}$

(ii) Metals like zinc, tin and aluminium react with strong alkalies like NaOH (caustic soda) and KOH (caustic potash) to evolve hydrogen gas.

Consider the following activity.

**Aim**

To study the reaction of a base with metal.

Materials required

Test tube, granulated zinc, NaOH solution, burner.

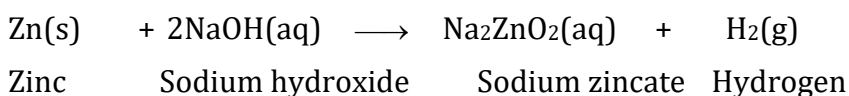
Method

- (i) Place a few pieces of granulated zinc metal in a test tube.
- (ii) Add 2 mL of NaOH (sodium hydroxide) solution and warm the contents of the test tube.
- (iii) Repeat the rest of the steps as in previous activity and record your observation.

Observation

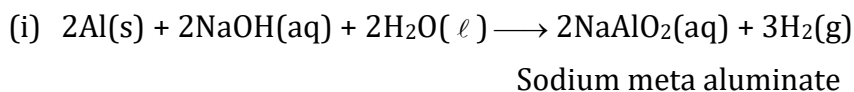
It is observed that metals like zinc react with strong base like NaOH, KOH, etc. to liberate hydrogen gas and form the corresponding salt.

For example,

**Conclusion**

Some metals react with bases to liberate hydrogen gas.

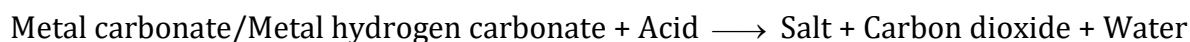
Some more examples,



Note: Non-metals do not react with dilute acids as they do not displace hydrogen from acids.

(3) Reaction of acid with metal carbonates and metal hydrogen carbonates

All metal carbonates and hydrogen carbonates react with acids to give a corresponding salt, carbon dioxide and water.



Let's discuss the following activity

**Aim**

To study reaction of metal carbonates and metal hydrogen carbonates with acids.

Materials required

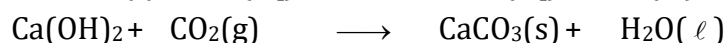
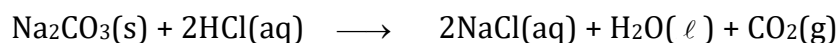
Test tubes, sodium carbonate, sodium hydrogen carbonate, dilute HCl solution, lime water.

Method

- (i) Take two test tubes. Label them as A and B.
- (ii) Take about 0.5 g of sodium carbonate (Na_2CO_3) in test tube A and about 0.5 g of sodium hydrogen carbonate (NaHCO_3) in test tube B.
- (iii) Add about 2 mL dilute HCl to both the test tubes.
- (iv) Pass the gas produced in each case through lime water (calcium hydroxide solution)

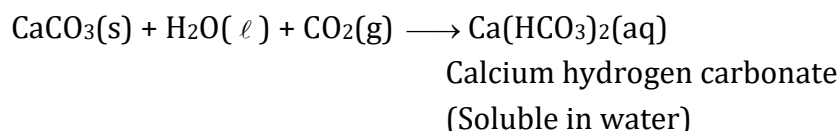
Observation

It is observed that carbon dioxide gas is evolved in each case which turns lime water milky.



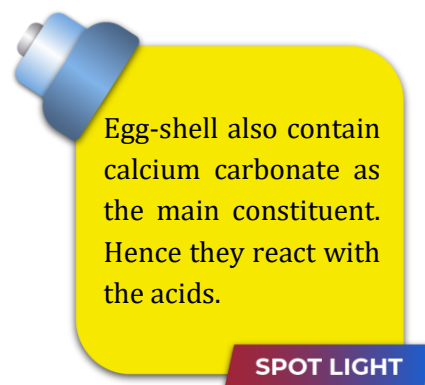
Lime	Carbon	Calcium carbonate
water	dioxide	(White ppt.)

On passing excess CO_2 , the solution becomes clear due to conversion of insoluble CaCO_3 into soluble calcium hydrogen carbonate.

**Conclusion**

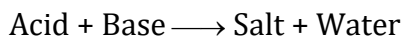
All metal carbonates and hydrogen carbonates react with acids to give a corresponding salt, carbon dioxide and water.

One more example,

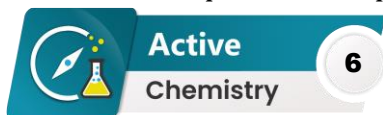


(4) Reaction of acid and base with each other

Whenever a solution of acid is treated with a solution of base, salt and water are formed as the products. This reaction is known as neutralisation reaction. In general, a neutralisation reaction can be written as :



The reaction is called neutralisation because the salt which is formed is generally neutral towards litmus. Thus, neutralisation may be defined as: "The reaction between acid and base present in aqueous solution to form salt and water."

**Aim**

To study the reaction between acids and bases, i.e. neutralisation reaction.

Materials required

Test tube, dilute NaOH solution, phenolphthalein solution, dilute HCl solution.

Method

- (i) Take about 2 mL of dilute NaOH solution in a test tube and add two drops of phenolphthalein solution.
- (ii) Note the colour of the solution.
- (iii) Add dilute HCl solution to the above solution drop by drop.
- (iv) Note the change in colour of the reaction mixture.
- (v) Now add a few drops of NaOH solution to the above mixture.

Now answer

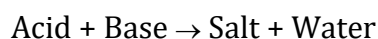
- (i) What is the colour of the NaOH solution on adding phenolphthalein?
- (ii) What change in colour takes place on adding dilute HCl?
- (iii) Does the pink colour of phenolphthalein reappear on adding NaOH?
- (iv) Why do you think this has happened?

Observation and discussion

On adding phenolphthalein to NaOH solution, the colour becomes pink. On adding dilute HCl solution dropwise, finally the pink colour disappears and the solution again become colourless. On adding NaOH, pink colour reappears because the medium becomes basic again.

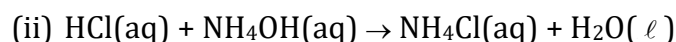
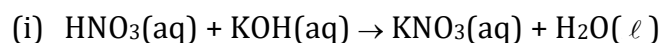
Conclusion

Acid and base react together to form salt and water.



The reaction is called neutralization reaction.

Some more examples,



(5) Reaction of metallic oxides with acids

A metal oxide reacts with dilute acids to form salt and water.



This can be explained with the help of following activity.



Aim

To study the reaction of metal oxides with acids.

Materials required

Beaker, copper oxide, dilute hydrochloric acid.

Method

- (i) Take a small amount of copper oxide in a beaker and add dilute hydrochloric acid slowly while stirring.
- (ii) Note the colour of the solution.

Now answer

What has happened to the copper oxide?

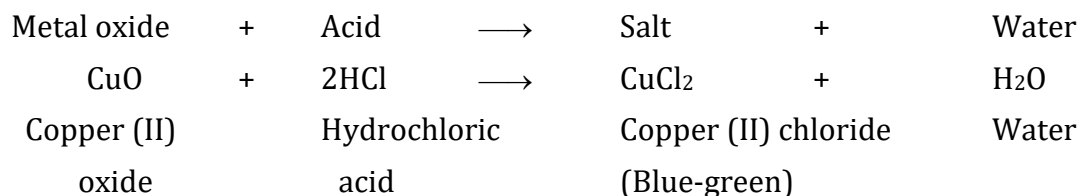
Observation and discussion

It is observed that the colour of the solution become blue-green and the copper oxide dissolves.

The blue green colour of the solution is due to formation of copper (II) chloride in the solution.

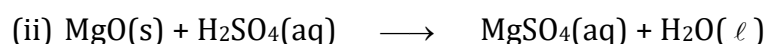
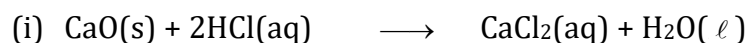
Conclusion

Metal oxides react with the acids to form salt and water.



This shows that metal oxides are basic in nature.

Some more examples:

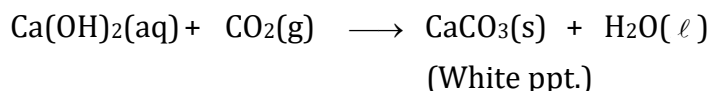


(6) Reaction of a Non-Metallic oxide with a base

Acids react with metal oxides but base react with non-metallic oxide to form their respective salts and water.

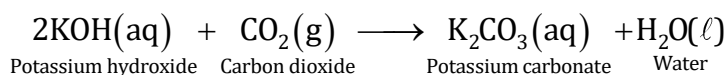
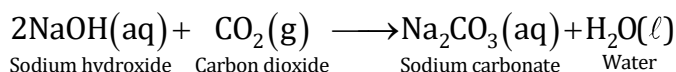
Base + Non-metallic oxide $\longrightarrow$ Salt + Water

We have already discussed under acids that metal carbonates and metal hydrogen carbonates react with acids to form carbon dioxide. On passing the CO_2 gas evolved through lime water $[\text{Ca}(\text{OH})_2]$, lime water turns milky.



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

Some more examples,



Comparison between properties of acids and bases

Acids		Bases	
(i)	Sour in taste.	(i)	Bitter in taste.
(ii)	The properties are due to the presence of hydrogen ion (H^+) in aqueous solution of an acid.	(ii)	The properties are due to the presence of hydroxide ion (OH^-) in aqueous solution of a base.
(iii)	Turns blue litmus to red.	(iii)	Turns red litmus to blue.
(iv)	Aqueous solution conducts electricity.	(iv)	Aqueous solution conducts electricity.
(v)	Reacts with active metals like Na, K, Ca and Zn to give hydrogen gas.	(v)	Does not react with metals except with Zn, Al and Sn.
(vi)	Acidic properties disappear when react with bases (Neutralization).	(vi)	Basic properties disappear when react with acids (Neutralization).
(vii)	Reacts with carbonates to give carbon dioxide.	(vii)	Absorbs carbon dioxide to form carbonate.
(viii)	Corrosive to skin.	(viii)	Corrosive to skin and slippery in nature.
(ix)	The pH value is less than 7 at 25°C (room temp.).	(ix)	The pH value is greater than 7 at 25°C (room temp.).


**Quick
Tips**

★ Nature of oxides

Oxides	Nature	Examples
Metal oxide	Basic in nature	CaO, MgO, CuO etc.
Non-metal oxide	Acidic in nature	CO ₂ , SO ₂ , SO ₃ etc.
Amphoteric oxide	Acidic and basic	ZnO, Al ₂ O ₃ , SnO and PbO
Neutral oxide	Neutral	H ₂ O, CO, N ₂ O and NO

5. What do all acids and all bases have in common?

In general, all acids have similar chemical properties. We have seen that all acids generate hydrogen gas on reacting with metals, so hydrogen seems to be common in all acids.

All acids produce hydrogen ions [H⁺(aq)] when dissolved in water.

For example, HCl, H₂SO₄, HNO₃, CH₃COOH, etc.

Similarly all bases produce hydroxide ions (OH⁻) when dissolved in water. For example, NaOH, Mg(OH)₂, Ca(OH)₂, NH₄OH, etc.

Since the ions are the carriers of charge, therefore tendency to conduct electric current is the common characteristic of all acids and bases when dissolved in water.


**Check your
Concepts**
1

- How will you test for a gas which is liberated when HCl reacts with an active metal?
- Name the gas evolved when dilute HCl reacts with Sodium hydrogen carbonate.
- Define olfactory indicators.


**Active
Chemistry**
8
Aim

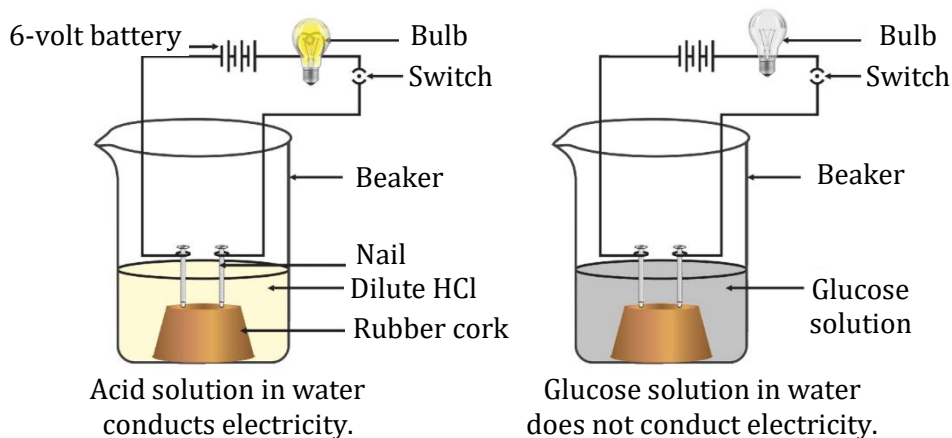
To study the conduction of electricity by aqueous solutions of acids and bases.

Materials required

Beaker, solution of glucose, alcohol, hydrochloric acid, sulphuric acid, nails, cork, battery, bulb, switch.

Method

- Take solution of glucose, alcohol, hydrochloric acid, sulphuric acid, etc.
- Fix two nails on a cork and place the cork in a 100 mL beaker.
- Connect the nails to the two terminals of a 6-volt battery through a bulb and a switch.
- Now pour some dilute HCl in the beaker and switch on the current.
- Repeat with dilute sulphuric acid.
- Repeat the experiment separately with glucose and alcohol solutions.



Now answer

- What do you observe on passing electric current?
- What do you observe in case of glucose and alcohol solution?
- Does the bulb glow in all cases?

Observation and discussion

The bulb is found to glow in case of acids but not in case of glucose and alcohol solutions.

Conclusion

As electric current is carried through the solution by ions, this shows that acids dissociate in the solution to produce H^+ (aq) ions but substances like glucose and alcohol do not dissociate to give H^+ ions and hence are not acidic. Thus, H^+ ions are responsible for the acidic properties.

If we repeat the same activity using alkalis such as sodium hydroxide, calcium hydroxide etc, similar results will be observed. As bases also produce ions in water i.e. OH^- (aq) ions, they are also electrically conducting in nature.

What happens to an acid or a base in a water solution?

The acidic behaviour of acids is due to the presence of hydrogen ions [H^+ (aq)], in them. The acids produce hydrogen ions only in the presence of water. So, in the absence of water, a substance will not form hydrogen ions and hence will not show its acidic behaviour.

This can be well illustrated with the following activity.

Note: H^+ (aq) = H_3O^+

OR

Aq. hydrogen ion = Hydronium ion

**Aim**

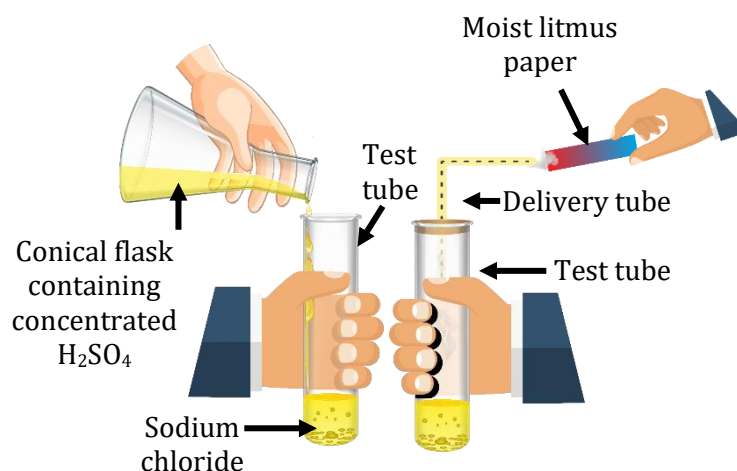
To test that dry HCl gas is not acidic but its aqueous solution is acidic.

Materials required

Test tube, NaCl, concentrated sulphuric acid, moist blue litmus paper.

Method

- (i) Take about 1 g solid NaCl in a clean and dry test tube and set up the apparatus.
- (ii) Add some concentrated sulphuric acid to the test tube.
- (iii) Test the gas evolved successively with dry and wet blue litmus paper.



Preparation of HCl gas.

Now answer

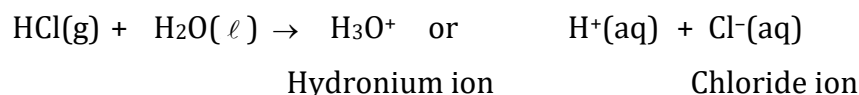
- (i) In which case does the litmus paper change colour?
- (ii) On the basis of the above activity, what do you infer about the acidic character of (a) dry HCl gas (b) HCl solution?

Observation and discussion

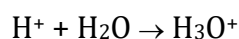
Dry blue litmus paper does not change colour but wet blue litmus paper changes its colour to red.

Conclusion

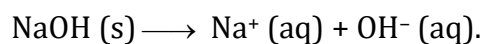
Dry HCl gas is not acidic but HCl solution is acidic. This is because in the presence of water, HCl dissociates to give H^+ ions.



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

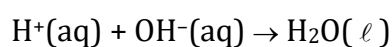
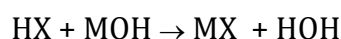


Similarly, when a base is dissolved in water, it forms $\text{OH}^-(\text{aq})$ ion.



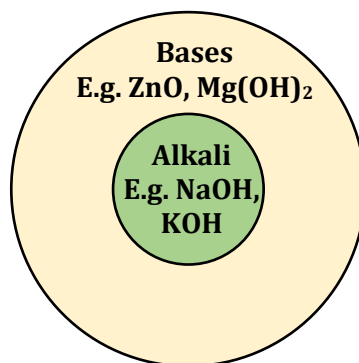
As we have seen that all acids generate $\text{H}^+(\text{aq})$ ions and all bases generate $\text{OH}^-(\text{aq})$ ions, this explains the formation of $\text{H}_2\text{O}(\ell)$ during neutralisation reaction.

Acid + Base $\rightarrow$ Salt + water



Quick Tips

- ★ Bases which are soluble in water are called **alkalis**. All bases do not dissolve in water.

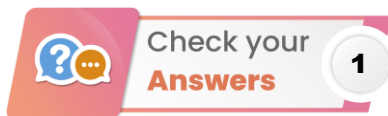


Be Alert !

- ★ Mixing of acid or base in water is called **dilution** and the acid or the base is said to be diluted. During dilution, concentration of ions ($\text{H}_3\text{O}^+/\text{OH}^-$) per unit volume decreases. This process is generally exothermic in nature, which produces heat. Heat produced may be harmful because it may cause the mixture to splash out and cause burns. Moreover, the glass container may also break due to excessive local heating. So, precautions are recommended during dilution of an acid or bases.



Warning sign displayed on containers containing concentrated acids and bases.



1. The gas burns with pop sound when a burning candle is brought near the gas bubbles.
2. Carbon dioxide gas.
3. There are some substances whose odour changes in acidic and basic medium. These are called olfactory indicators.



How can we say all alkalis are bases but all bases are not alkalis?

Explanation

Only those bases which are soluble in water are called **alkalis**. All bases do not dissolve in water. So, we can say all alkalis are bases but all bases are not alkalis.

E.g. KOH and NaOH are alkalis, while $\text{Mg}(\text{OH})_2$ is a base.



Aim

To test that dilution of a strong acid like H_2SO_4 and strong base like NaOH is exothermic.

Materials required

Beaker, water, concentrated H_2SO_4 , NaOH pellets.

Method

- (i) Take 10 mL water in a beaker.
- (ii) Add a few drops of concentrated H_2SO_4 to it and swirl the beaker slowly.
- (iii) Touch the base of the beaker.
- (iv) Repeat the above activity with NaOH pellets.

Caution

Add sulphuric acid into water for dilution and not water into sulphuric acid as otherwise the solution may splash out and cause burns.

Now answer

- (i) Is there a change in temperature in the two cases?
- (ii) Is this an exothermic or endothermic process?

Observation and discussion

In both cases, the temperature is found to rise.

Conclusion

Dilution of concentrated H_2SO_4 with water as well as dissolution of NaOH in water is exothermic.

Precaution needed for dilution

During dilution small quantity of acid or base should be added in water with stirring. Heat evolved in this case will be quite slow.

If water will be added to the container containing acid or base, large amount of heat will be produced immediately, which may be harmful.

6. How strong are acid or base solution?

Acids and bases may be either strong or weak. We can compare their relative strengths on the basis of the Arrhenius theory. According to this theory, more the number of H^+ ions released by acid in water, stronger is the acid. Similarly, more the number of OH^- ions released by base in water, stronger is the base.

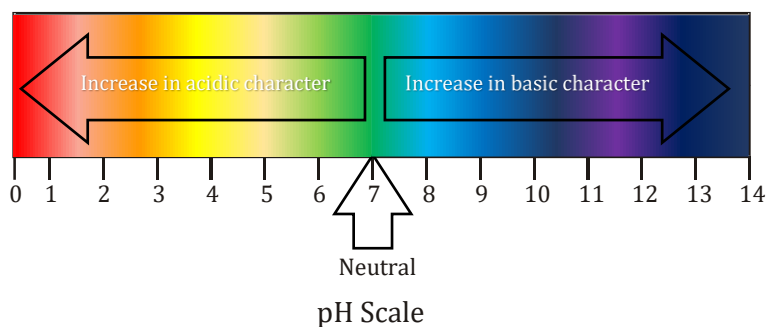
The concentration of $\text{H}^+(\text{aq})$ or $\text{OH}^-(\text{aq})$ ions in the acidic and basic solution respectively decreases on dilution with water.

If we find quantitatively, the amount of $\text{H}^+(\text{aq})/\text{OH}^-(\text{aq})$ ions present in a solution, we can judge how strong an acid or a base is?

We can do this with the help of a **universal indicator**, which is a mixture of several indicators. The universal indicator shows different colours at different concentration of hydrogen ions or pH values in solution.

pH Scale

S.P.L. Sorenson, a Danish chemist in 1909 introduced the concept of measuring the concentration of hydrogen ions $[\text{H}^+(\text{aq})]$ in a particular solution. 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).

- (i) Solutions with pH = 0-3 are strongly acidic, with pH = 3-5 are moderately acidic while with pH = 5-7 are weakly acidic.
- (ii) Solution with pH = 7-9 are weakly basic, with pH = 9-12 are moderately basic while with pH = 12-14 are strongly basic.
- (iii) If pH = 7, then the solution is neutral.

**Aim**

To test the pH values of some solutions.

Materials required

pH paper, given solutions in table.

Method

- (i) Test the pH value of solutions given in following table.
- (ii) Record your observations.

Now answer

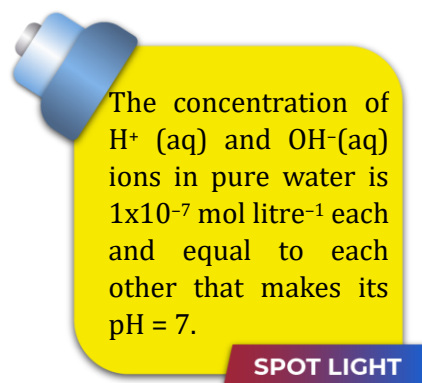
- (i) What is the nature of each substance on the basis of your observations?

Observations

S.No.	Solution	Colour of pH paper	Approximate pH value	Nature of substance
1	Saliva (before meal)	Light green	7.4	Basic
2	Saliva (after meal)	Yellow	5.8	Acidic
3	Lemon juice	Red	2.3	Acidic
4	Colourless aerated drink	Red-orange	3	Acidic
5	Carrot juice	Yellow	6	Acidic
6	Coffee	Yellowish orange	5	Acidic
7	Tomato juice	Orange	4.1	Acidic
8	Tap water	Light green	7.4	Basic
9	1M NaOH	Dark violet	14	Basic
10	1M HCl	Dark red	0	Acidic

Conclusion

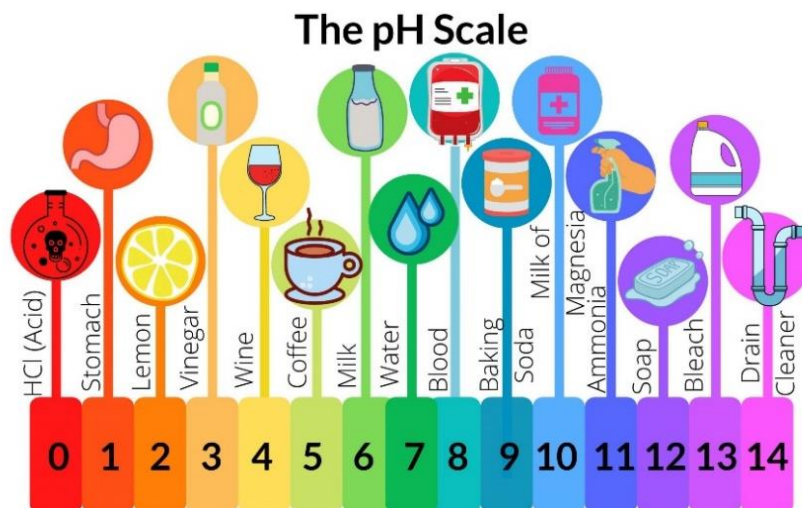
Solutions with pH < 7 but close to 7 are weakly acidic, solutions with pH << 7 are strongly acidic, solution with pH > 7 but close to 7 are weakly basic, solutions with pH >> 7 are strongly basic.



SPOT LIGHT

**Quick
Tips**

- ★ Some important pH of common substances.

**Important note**

The pH of human blood varies between 7.36 to 7.42. It is maintained by the soluble hydrogen carbonates and carbonic acid present in blood.

7. Importance of pH in everyday life**(1) Plants and animals are pH sensitive**

The pH plays an important role in the survival of animals, including human beings. Our body works well within a narrow pH range of 7.0 to 7.8. The aquatic animals, like fish can survive in river water within a narrow range of pH change.

For example, when the pH of rain water is less than 5.6, it is called acid rain. Acid rain can lower the pH of river water to such an extent and make it so acidic that the survival of aquatic animals becomes difficult or may even kill the aquatic animals.



Red blood cells can exist only over a narrow range of pH

(2) Soil pH and plants

The growth of plants in a particular soil is related to its pH. Actually, different plants prefer different pH range for their growth. It is therefore, quite important to provide the soil with proper pH for their healthy growth. Plants require a specific pH for their growth. If the soil is too acidic or too basic the plants grow badly or do not grow at all.

**Aim**

To test the pH of the soil in the backyard of our home.

Materials required

Test tube, water, soil, pH paper.

Method

- (i) Put about 2 g soil in a test tube and add 5 mL water to it.
- (ii) Shake the contents of the test tube.
- (iii) Filter the contents and collect the filtrate in the test tube.
- (iv) Check the pH of this filtrate with the help of universal indicator paper.

Now answer

What can you conclude about the ideal soil pH for the growth of plants in your region?

Observation and conclusion

The ideal soil pH should be close to 7, i.e., neither very acidic nor very alkaline.

Treatment of acidic or basic Soil

The pH of acidic soil can reach as low as 4 and that of the basic soil can go up to 8.3. Chemicals can be added to soil to adjust its pH and make it suitable for growing plants.

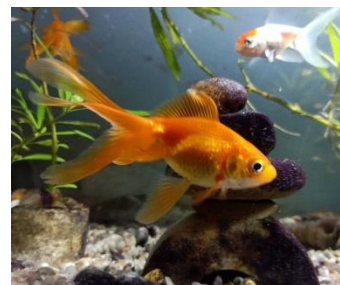
If the soil is too acidic, then it is treated with materials like quicklime (calcium oxide) or slaked lime (calcium hydroxide) or chalk (calcium carbonate). All these materials are bases and hence react with the excess acid present in soil and reduce its acidity. If the soil is too basic (or too alkaline) then its alkalinity can be reduced by adding decaying organic matter (manure or compost), which contains acidic materials.

Soils with high peat content or iron mineral or with rotting vegetation tend to become acidic.

(3) Importance of pH in our digestive system

As we know our stomach produces gastric juice which contains large amount of hydrochloric acid (pH about 1.4). The acid so produced does not harm the stomach walls, but kills germs and bacteria which enter in our digestive system along with food, thus in a way it protects us from diseases and helps in digestion. Sometimes excess of acid is produced in the stomach due to overeating or eating spicy foods. This stage is called acidity. To get relief from this pain, we take tablets known as antacids. These are weak bases which neutralise the excess of acids.

For example, Magnesium hydroxide (milk of magnesia)
 $\text{Mg}(\text{OH})_2$



For Goldfish to survive, the pH of water must be carefully controlled



“Milk of Magnesia” commonly used as antacid.

(4) pH changes as the cause of tooth decay

Generally, the pH in the mouth is more than 7, as the saliva produced in the mouth is basic in nature. However, when we take food, some food particles remain in the mouth after eating and bacteria present in the mouth produce acids by degradation of food particles.

This acid lowers the pH in the mouth, tooth decay starts when the pH of acid formed in the mouth falls below 5.5 and the enamel get corroded.

The bacteria present in the mouth break down the sugar that we eat into acids. Lactic acid is one of these. The formation of these acids causes decrease in pH. The acids react with calcium phosphate and the enamel coating slowly breaks.

Therefore, to prevent tooth decay, it is advised to clean the mouth and use toothpastes which are generally basic, for cleaning the teeth. It neutralise the excess acid and prevent tooth decay.

(5) Self-defence by animals and plants through chemical warfare

The sting of the honey bee contains formic acid, this acid causes a lot of irritation and pain. The pain can be reduced by applying baking soda paste on the affected region as the acid gets neutralised.

In plant kingdom, **nettle** (Bichu Booti) is a herbaceous plant which grows in wild. The nettle leaves have stinging hair.

When a person happens to touch the leaves of a nettle plant accidentally, the stinging hair of nettle leaves inject methanoic acid

(HCOOH) into the skin of the person causing burning pain. The nettle sting, being acidic can be neutralised by rubbing baking soda on the skin. Nature provides remedy for the nettle sting in the form of a 'dock' plant, which often grows besides the nettle plants. The leaves of dock plant contain some basic chemicals which neutralises methanoic acid. Some flowering plants carry their own 'built in pH indicators'. For example, the flowers of a hydrangea bush are blue in colour when grown in an acidic soil. If it is alkaline in nature, the flowers become pink.



Nettle plant

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



1. How is the concentration of H^+ ions of an acid influenced when it is diluted?
2. Arrange these in increasing order of their pH values- NaOH, blood, lemon juice.
3. Rainwater conducts electricity but distilled water does not. Why?
4. Why do acids not show acidic behaviour in the absence of water?

8. 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**.

Families of salts

Salts are generally formed by reaction between an acid and base. 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.



Aim

Write the formulae of the salts and to identify their acids and bases and their 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 belong to the same 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.



A Digital pH meter

Now answer

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 ₂ SO ₄	H ₂ SO ₄	KOH
2	Sodium sulphate	Na ₂ SO ₄	H ₂ SO ₄	NaOH
3	Calcium sulphate	CaSO ₄	H ₂ SO ₄	Ca(OH) ₂
4	Magnesium sulphate	MgSO ₄	H ₂ SO ₄	Mg(OH) ₂
5	Copper sulphate	CuSO ₄	H ₂ SO ₄	Cu(OH) ₂
6	Sodium chloride	NaCl	HCl	NaOH
7	Sodium nitrate	NaNO ₃	HNO ₃	NaOH
8	Sodium carbonate	Na ₂ CO ₃	H ₂ CO ₃	NaOH
9	Ammonium chloride	NH ₄ Cl	HCl	NH ₄ OH

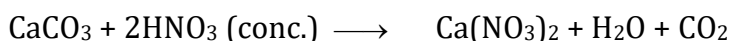
Families observed :- sulphate family, chloride family, sodium family.



What will happen when egg shell is placed in conc. HNO₃?

Explanation

Egg shell contains calcium carbonate as its main constituent. When dipped in concentrated HNO₃, calcium carbonate reacts to evolve CO₂. As a result, eggshell slowly dissolves.



pH of salts

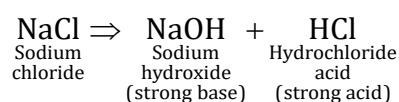
Depending upon the nature of acid and base which react to form the salt.

OR

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

- (1) Salts of strong acid and strong base. (Neutral salts)

For example, NaCl



Hence, the acid and the base produced neutralize each other completely, so pH = 7.

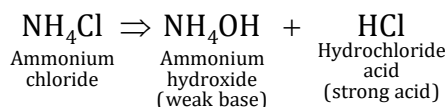
- (2) Salt of strong acid and weak base. (Acidic salt)



Metal sulphides are formed by the complete displacement of ionisable hydrogen ions of H₂S. For example,
 $\text{Ca}(\text{OH})_2 + \text{H}_2\text{S} \longrightarrow \text{CaS} + 2\text{H}_2\text{O}$
 Thus, metal sulphides are salts.

SPOT LIGHT

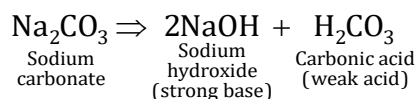
For example, NH_4Cl



Here, $\text{pH} < 7$.

(3) Salt of weak acid and strong base (Basic salt)

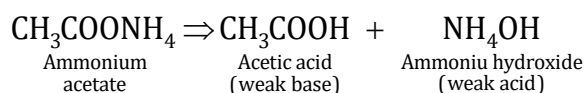
For example, Na_2CO_3



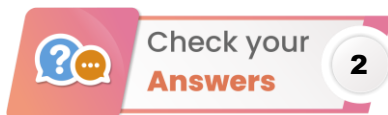
Here, $\text{pH} > 7$.

(4) Salt of weak acid and weak base (Neutral salts)

For example, $\text{CH}_3\text{COONH}_4$



Here $\text{pH} \approx 7$.



1. On dilution with water, the concentration of H^+ ions of an acid decreases.
2. Lemon juice < Blood < NaOH
3. As electric current is carried through the solution by ions, distilled water does not contain ions but rain water contains ions that's why rain water conducts electricity.
4. In the absence of water, a substance does not produce hydrogen ions and hence does not show its acidic behaviour.



Aim

To find the pH of the given salt solutions.

Method

(i) Collect the following salt samples:

- | | |
|------------------------|-------------------------------|
| (a) Sodium chloride | (b) Potassium nitrate |
| (c) Aluminium chloride | (d) Zinc sulphate |
| (e) Copper sulphate | (f) Sodium acetate |
| (g) Sodium carbonate | (h) Sodium hydrogen carbonate |

(ii) Check their solubility in water (use distilled water only).

(iii) Check the action of these solutions on litmus and find the pH using a pH paper.

(iv) Report your observations in a tabular form.

Now answer

(i) Which of the salts are acidic, basic or neutral?

(ii) Identify the acid or base used to form the salt.

Salt	Formula	Solubility in water	Action on litmus	pH	Acid used	Base used
Sodium chloride	NaCl	Soluble	No action	7	HCl	NaOH
Potassium nitrate	KNO ₃	Soluble	No action	7	HNO ₃	KOH
Aluminium chloride	AlCl ₃	Soluble	Turns red	<7	HCl	Al(OH) ₃
Zinc sulphate	ZnSO ₄	Soluble	Turns red	<7	H ₂ SO ₄	Zn(OH) ₂ or ZnO
Copper sulphate	CuSO ₄	Soluble	Turns red	<7	H ₂ SO ₄	Cu(OH) ₂ or CuO
Sodium acetate	CH ₃ COONa	Soluble	Turns blue	>7	CH ₃ COOH	NaOH
Sodium carbonate	Na ₂ CO ₃	Soluble	Turns blue	>7	H ₂ CO ₃	NaOH
Sodium hydrogen carbonate	NaHCO ₃	Soluble	Turns blue	>7	H ₂ CO ₃	NaOH

9. Chemicals from common salt

Sodium chloride (Common salt / table salt)

We know that hydrochloric acid and sodium hydroxide combine with each other to form sodium chloride (NaCl) which in common language is also known as common salt. This is the salt which you sprinkle on your salads and use in your kitchens. Common salt is an ionic compound of sodium and chlorine (Na⁺Cl⁻)_n.

The main source of common salt (sodium chloride) is the sea water. Sea water contains about 3.5% of soluble salts, the most common of which is sodium chloride (2.7 to 2.9%). Saline water of inland lakes, such as Sambhar lake in Rajasthan is also a good source of common salt. Sodium chloride is also found as rock salt. Beds of rock salt were formed when lakes/seas dried up in past. Common salt act as raw material for making various materials of daily use. Let us discuss some of them.



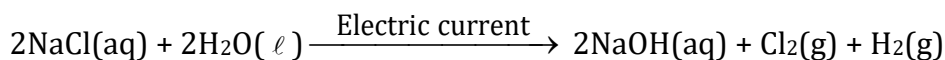
Sodium chloride is an important symbol in our struggle for freedom. Remember Mahatma Gandhi's Dandi March !

(i) Sodium hydroxide

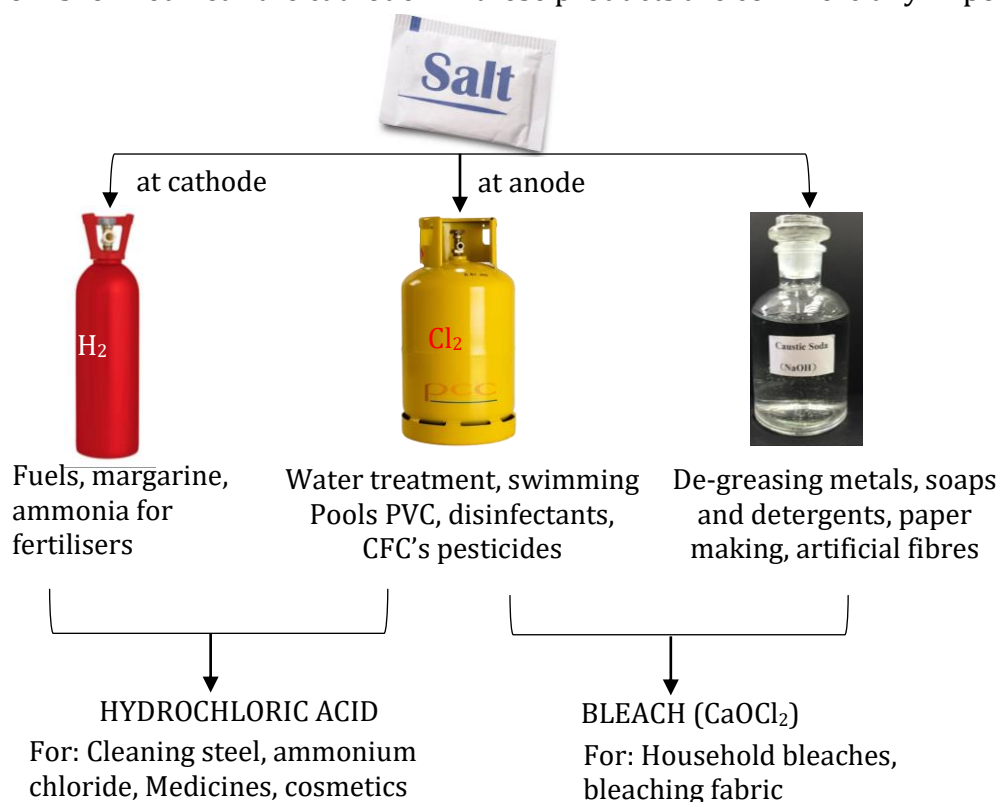
Commercially, sodium hydroxide is also called **caustic soda** because of its corrosive action on animal and vegetable tissues.

Chlor-alkali process for obtaining sodium hydroxide

When we pass electricity through a solution of sodium chloride, commonly called **brine**, it decomposes to form sodium hydroxide according to the following equation:



On electrolysis, chlorine gas is formed at anode and hydrogen at cathode, sodium hydroxide solution is formed near the cathode. All these products are commercially important.

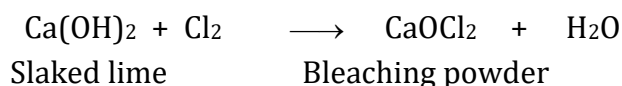


Products of chlor-alkali process.

(ii) Bleaching powder

Chemically, bleaching powder is generally represented by the formula, CaOCl_2 (called, calcium oxychloride).

We 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 $[\text{Ca}(\text{OH})_2]$. Bleaching powder is represented as CaOCl_2 , though the actual composition is quite complex.



The process of production of sodium hydroxide from sodium chloride is known as chlor-alkali process because of products formed – chlor for chlorine and alkali for sodium hydroxide.

SPOT LIGHT

Uses of bleaching powder

- (a) For bleaching cotton and linen in the textile industry, for bleaching wood pulp in paper factories and for bleaching washed clothes in laundry.
- (b) As an oxidising agent in many chemical industries.
- (c) For disinfecting drinking water to make it free of germs.

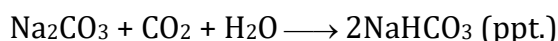
Note: Bleaching powder is also known as chloride of lime.

(iii) Baking soda

The chemical name of baking soda is sodium hydrogen carbonate or sodium bicarbonate. Baking soda (or sodium bicarbonate) is represented by the formula NaHCO_3 . The soda commonly used in the kitchen for making tasty crispy pakoras is baking soda. Sometime it is added for faster cooking. It is produced using sodium chloride as one of the raw materials.

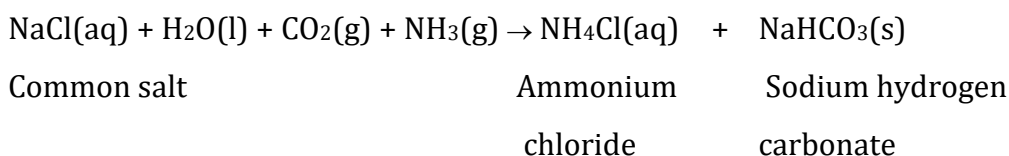
Note: Anhydrous sodium carbonate (Na_2CO_3) is generally called soda ash.

In laboratory, baking soda can be prepared by passing excess of CO_2 gas through the saturated solution of sodium carbonate. As a result, sodium hydrogen carbonate is formed. It gets precipitated due to supersaturation. The precipitate is separated, washed and dried without heating.



On commercial scale, NaHCO_3 is formed as an intermediate product, when washing soda is prepared by

Solvay process or **ammonia-soda** process. In this method, a solution of sodium chloride (called "brine") saturated with ammonia is allowed to react with CO_2 , sodium hydrogen carbonate & ammonium chloride are formed.



It can be used to neutralise an acid because it is mild, non-corrosive base due to the presence of HCO_3^- ion.

The following reaction takes place when it is heated during cooking.



Baking soda can be used to neutralise formic acid present in red ant's sting.

Uses of washing soda

- (a) Washing soda (or sodium carbonate) is used for washing clothes (laundry purposes).
- (b) Washing soda is used for softening hard water.
- (c) Sodium carbonate (soda ash) is used for the manufacture of detergents.
- (d) Sodium carbonate is used for the manufacture of many important compounds, such as borax ($\text{Na}_2\text{B}_4\text{O}_7$), hypo ($\text{Na}_2\text{S}_2\text{O}_3 \cdot 5\text{H}_2\text{O}$), etc.
- (e) Sodium carbonate is also used in paper, glass, soap and paint industries.

Note: Since one of the source of washing soda is ashes of plants, it is sometimes called soda ash.



1. What do you mean by neutralization reaction? Give two examples.
2. What happens when baking soda is heated?
3. Name the compound used for softening hard water.
4. What is the common name of CaOCl_2 ?

10. Are the crystals of salts really dry?

Crystals of some salts contain certain amount of associated water.

The water associated with the crystal (or molecule) of any salt is called water of crystallisation.

The salt containing water of crystallisation are called hydrated salts.



Raw gypsum, an important constituent of cement

**Aim**

To test the presence of water of crystallisation in copper sulphate crystals.

Materials required

Boiling tube, copper sulphate crystals, burner, water, test tube holder.

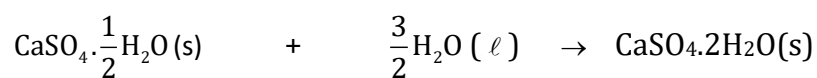
Method

- (i) Heat a few crystals of copper sulphate in a dry boiling tube.
- (ii) Note the colour of copper sulphate after heating.
- (iii) Observe the water droplets in the boiling tube.
- (iv) Add 2-3 drops of water on the sample of copper sulphate obtained after heating.

Now answer

- (i) What do you observe on heating blue copper sulphate crystals?
- (ii) Is the blue colour of copper sulphate restored on adding water?

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



Plaster of Paris

Water

Gypsum (Hard mass)

Uses of plaster of Paris

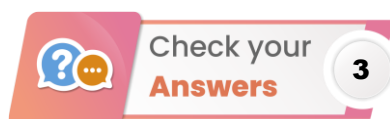
- (1) Plaster of Paris is used in making casts and patterns for moulds and statues.
- (2) Plaster of Paris is used as cement in ornamental casting and for making decorative materials.



Ornamental castings made from POP

- (3) Plaster of Paris is used as a fire proofing material and for making chalks.
- (4) Plaster of Paris is used in hospitals for immobilising the affected part in case of bone fracture or strain.
- (5) Plaster of Paris (POP) is used to fill small gaps on walls and roofs.

Note: Gypsum on heating gives Plaster of Paris, on the other hand Plaster of Paris on hydration gives gypsum.



1. The reaction between acid and base present in aqueous solution to form salt and water is called a neutralisation reaction.

$$\text{NaOH} + \text{HCl} \longrightarrow \text{NaCl} + \text{H}_2\text{O}$$

$$\text{KOH} + \text{HCl} \longrightarrow \text{KCl} + \text{H}_2\text{O}$$
2. $2\text{NaHCO}_3 \longrightarrow \text{Na}_2\text{CO}_3 + \text{CO}_2 + \text{H}_2\text{O}$
3. Washing soda ($\text{Na}_2\text{CO}_3 \cdot 10\text{H}_2\text{O}$)
4. Bleaching powder


**Quick
Tips**

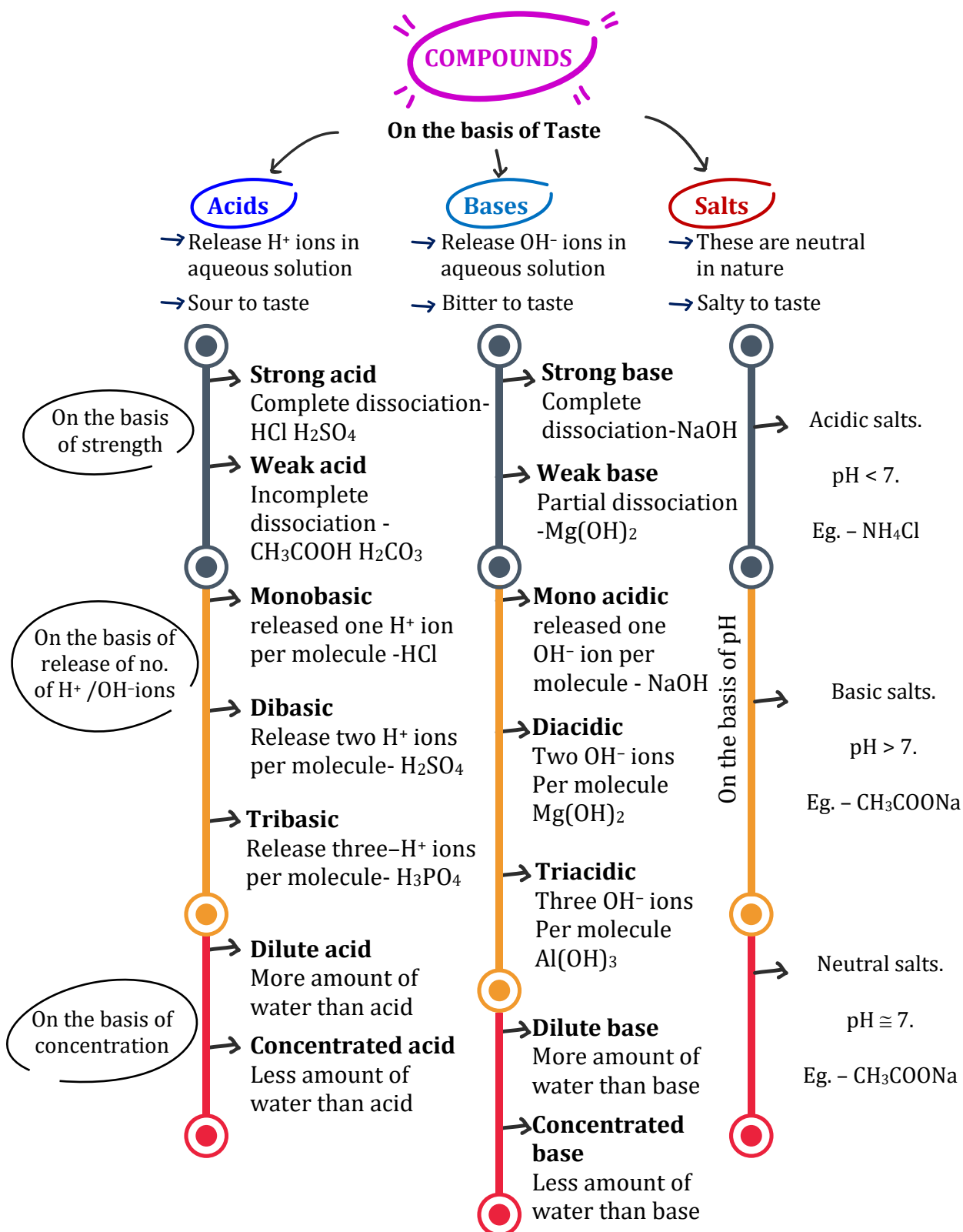
- ★ List of some important chemical compounds with their Common Names & Formulas.

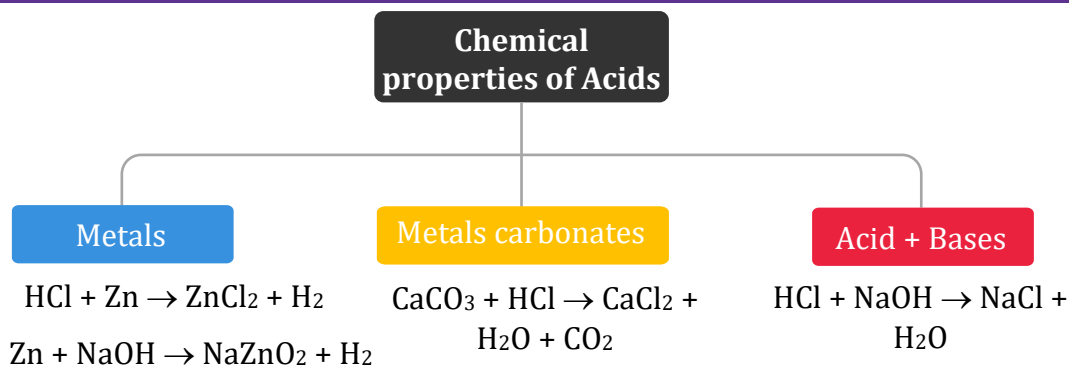
Common Names	Chemical Name of Compound	Chemical Formula
Baking Soda	Sodium Bicarbonate or Sodium Hydrogen Carbonate	NaHCO_3
Washing Soda	Sodium Carbonate Decahydrate	$\text{NaCO}_3 \cdot 10\text{H}_2\text{O}$
Caustic Soda	Sodium Hydroxide	NaOH
Bleaching Powder	Calcium Oxychloride	CaOCl_2
Bleach	Sodium Hypochlorite	NaOCl
Caustic Potash	Potassium Hydroxide	KOH
Quick Lime	Calcium Oxide	CaO
Slaked Lime	Calcium Hydroxide	Ca(OH)_2
Limestone	Calcium Carbonate	CaCO_3
Milk of Magnesia	Magnesium Hydroxide	Mg(OH)_2
Plaster of Paris	Calcium Sulphate Hemihydrate	$\text{CaSO}_4 \cdot 1/2\text{H}_2\text{O}$
Gypsum		$\text{CaSO}_4 \cdot 2\text{H}_2\text{O}$
Laughing Gas	Dinitrogen Monoxide/ Nitrous Oxide	N_2O
Brine		$\text{NaCl} + \text{H}_2\text{O}$
Acetic acid		CH_3COOH
White Vitriol	Zinc Sulphate	$\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$
Blue vitriol	Copper sulphate	$\text{CuSO}_4 \cdot 5\text{H}_2\text{O}$
Green vitriol	Iron sulphate	$\text{FeSO}_4 \cdot 7\text{H}_2\text{O}$

Basic terminology

- Olfactory** - Related with sense of smell
- Odour** - Smell
- Brine** - Saturated salt solution
- Crystals** - Definite shaped salt
- Mild** - Neither strong nor weak
- Edible** - Can be eaten
- Popping** - To make a short, quick explosive sound.
- Unclogging** - To remove accumulated matter.
- Stain** - To leave a coloured mark that is difficult to remove.
- Cation** - Positively charged ion.
- Anion** - Negatively charged ion.
- Pellet** - Small particles created by compressing an original material.
- Swirl** - To cause something to make fast circular movements.
- Splash** - A small amount of liquid that falls onto something.
- Casting** - Is the process of pouring liquid metal into a mold where it cools and solidifies.
- Ornamental** - Made somewhere in order to look attractive.
- Disinfectant** - A substance that destroys bacteria and is used for cleaning.

Memory Map



**pH Scale**

→ A measure of the acidity or alkalinity of a solution is called pH, short form of power of hydrogen. $\text{pH} < 7$ (Acidic), $\text{pH} > 7$ (Basic), $\text{pH} \cong 7$ (Neutral)

Indicators

→ It is a chemical which indicates by the means of a sharp change in colour, according to the nature of the solutions.

- Chemicals from common salt (NaCl)**

