Chapter

4

Acids, Bases and Salts

In class VII you learnt about acids, bases and salts.

You know that acids are sour to taste and turn blue litmus to red, bases are soapy to touch and turn red litmus to blue.

If someone in the family is suffering from a problem of acidity, which of the following would you suggest as a remedy?
lemon juice, vinegar or baking soda solution.

- Which property do you think of while suggesting the remedy?

There are many natural materials like litmus, extract of red cabbage, turmeric solution and extracts of coloured petals of some flowers contain dye molecules which are weak acids or bases. These can be used as acid-base indicators to detect the nature of the solution for acidity or basicity. In adition to the above natural acid-base indicators, there are some synthetic indicators such as methyl orange and phenolphthalein that can be used to test for acids and bases.

In this chapter you study the reactions of acids and bases. How do acids neutralize bases? Many more interesting activities that we use and see in our day-to-day life are also studied.

Do you know?

Litmus solution is a dye extracted from lichen, a plant belonging to the division of Thallophyta and is used as indicator. In neutral solution litmus colour is purple. Coloured petals of some flowers such as Hydrangea, Petunia and Geranium are also used as indicators.

Chemical properties of Acids and Bases

Response of various laboratory substances with indicators.

Activity 1

Collect the following samples from the science laboratory; hydrochloric acid (HC*l*), sulphuric acid (H_2SO_4), nitric acid (HNO_3), acetic acid (CH_3COOH), sodium hydroxide (NaOH), calcium hydroxide [$Ca(OH)_2$], magnesium hydroxide [$Mg(OH)_2$],ammonium hydroxide (NH_4OH) and potassium hydroxide (KOH), prepare dilute solutions of the respective substances.

Take four watch glasses and put one drop of the first solution in each one of them and test the solution as follows.

i. dip the blue litmus paper in the first watch glass.

ii. dip the red litmus paper in the second watch glass.

iii. add a drop of methyle organge to the third watch glass, and

iv. add a drop of phenolphthalein to the fourth watch glass.

Observe the respective colour changes and note down in the chart below.

Table-1

S.No.	Sample solution	Red litmus paper	Blue litmus paper	Phenolphthalein solution	Methyl orange solution
1	HC*l*				
2	H_2SO_4				
3	HNO_3				
4	CH_3COOH				
5	NaOH				
6	KOH				
7	$Mg(OH)_2$				
8	NH_4OH				
9	$Ca(OH)_2$				

- What do you conclude from the observations noted in table-1?
- Identify the sample as acidic or basic solution.

There are some substances whose odour changes in acidic or basic media. These are called olfactory indicators.

Let us work with some of such indicators.

Activity 2

- Put some finely chopped onions in a plastic bag along with some clean cloth. Tie up the bag tightly and keep it overnight in the fridge. The cloth strips can now be used to test for acid or base.
- Check the odour of the cloth strips.
- Keep two strips on a clean surface and put a few drops of dilute HCl on one strip and a few drops of dilute $NaOH$ on the other.
- Rinse both the strips separately with distilled water and again check their odour and note the observation.
- Take some clove oil and vanilla essence.
- Take some dilute HCl in one test tube and dilute $NaOH$ in another test tube. Add a drop of dilute vanilla essence to both test tubes and shake well. Check the odour and record your observations.
- Test the change of odour with clove oil using dilute HCl and dilute $NaOH$ and record your observations.

Suggest which of these- onion, vanilla essence and clove oil, can be used as olfactory indicators on the basis of your observations.

- What do you conclude from above activity?
- Can you give example for use of olfactory indicators in daily life? Discuss with your teacher.

Why pickles and sour substances are not stored in brass and copper vessels?

Reaction of Acids and bases with Metals

Lab Activity

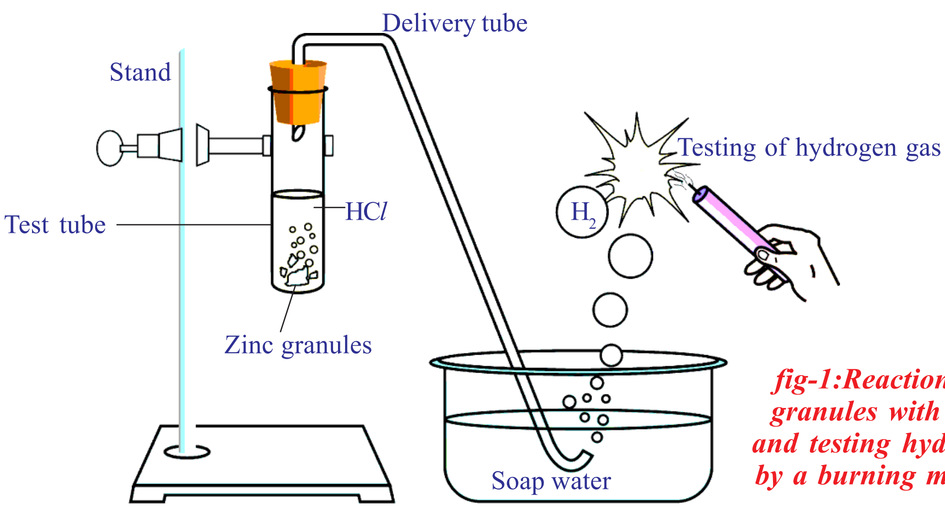

fig-1:Reaction of zinc granules with dil. HCl and testing hydrogen gas by a burning match stick

Materials required: test tube, delivery tube, glass trough, candle, soap water, dil. HC*l*, and zinc granules.

Procedure: Set the apparatus as shown in fig. 1.

- Take about 10ml of dilute HC*l* in a test tube and add a few zinc granules to it.
- What do you observe on the surface of the zinc granules?
- Pass the gas being evolved through the soap water.
- Why are bubbles formed in the soap solution?
- Bring a burning candle near the gas filled bubble.
- What do you observe?

You will notice the gas evolved burns with a pop sound indicating H_2 .

The chemical reaction of the above activity is:

$$\text{Acid} + \text{Metal} \rightarrow \text{Salt} + \text{Hydrogen}$$

$$2\,HCl_{(aq)} + Zn_{(s)} \rightarrow ZnCl_{2\,(aq)} + H_{2\,(g)}$$

Repeat the above experiment with some other acids like H_2SO_4 and HNO_3.

- What do you observe in all these cases?

From the above activities you can conclude that when acid reacts with metal H_2 gas is evolved.

Caution: This activity needs the teacher's assistance.

Activity 3

Place a few granules of zinc metal in one of the test tubes and add 10 ml of sodium hydroxide (NaOH) solution and warm the contents of the test tube.

Repeat the rest of the steps as in activity-2 and record your observations.

In this activity also you will notice that evolved gas is hydrogen (H_2) and salt formed is sodium zincate.

The reaction is written as follows.

$$2\,NaOH + Zn \rightarrow \underset{\text{(Sodium zincate)}}{Na_2ZnO_2} + H_2$$

However, such reactions are not possible with all metals.

Reaction of carbonates and metal hydrogen carbonates with Acids

Activity 4

- Take two test tubes; label them as A and B. Take about 0.5 gm of sodium carbonate (Na_2CO_3) in test tube A and about 0.5 gm of sodium hydrogen carbonate ($NaHCO_3$) in test tube B.
- Add about 2 ml of dilute HC*l* to both the test tubes.
- What do you observe?
- Pass the gas produced in each case through lime water (calcium hydroxide solution) as shown in Fig 2 and record your observations.

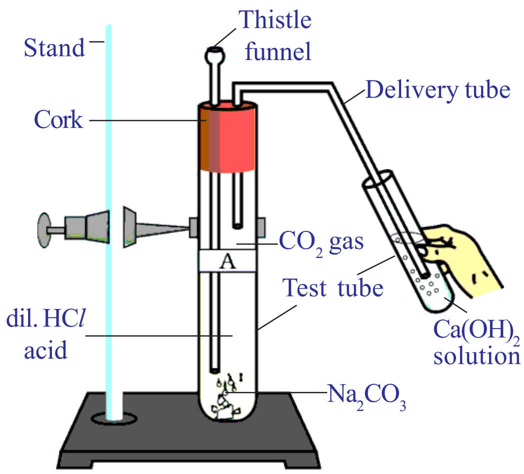

fig-2: Passing CO_2 gas through $Ca(OH)_2$ solution

The reactions occurring in the above activities are as follows:

$$Na_2CO_{3\,(S)} + 2\,HCl_{\,(aq)} \rightarrow 2\,NaCl_{\,(aq)} + H_2O_{\,(l)} + CO_{2\,(g)}$$

$$NaHCO_{3\,(S)} + HCl_{\,(aq)} \rightarrow NaCl_{\,(aq)} + H_2O_{\,(l)} + CO_{2\,(g)}$$

Pass the gas evolved through lime water.

$$Ca(OH)_{2\,(aq)} + CO_{2\,(g)} \rightarrow CaCO_3\downarrow + H_2O_{\,(l)}$$

(White precipitate)

On passing excess carbon dioxide the following reaction takes places:

$$CaCO_{3\,(S)} + H_2O_{\,(l)} + CO_{2\,(g)} \rightarrow Ca(HCO_3)_{2\,(aq)}$$

(Soluble in water)

Thus from above activities you can conclude that the reaction of metal carbonates and hydrogen carbonates with acids give a corresponding salt, carbon dioxide and water. We can write generalized form of these chemical reactions as shown below:

metal carbonate + acid $\rightarrow$ salt + carbon dioxide + water

metal hydrogen carbonate + acid $\rightarrow$ salt + carbon dioxide + water

Neutralization reaction

Activity 5

Acid – base (Neutralization) reaction

Take about 2 ml of dilute NaOH solution in a test tube and add one drop of phenolphthalein indicator. Observe the colour of the solution.

- Add dilute HC*l* solution to the above solution drop by drop. Is there any change of colour of the solution?

• Why did the colour of the solution change after adding the HC*l* solution?

- Now add one or two drops of NaOH to the above mixture.

• Does the Pink colour reappear?

• Do you guess the reason for reappearance of pink colour?

In the above activity you observe that the pink colour disappears on adding HC*l* because NaOH is completely reacted with HC*l*. The effect of base is nullified by an acid. Pink colour reappears on adding a drop of NaOH because the solution becomes basic once again. The reaction occuring between acid and base in the above activity can be written as:

$$NaOH_{(aq)} + HCl_{(aq)} \rightarrow NaCl_{(aq)} + H_2O_{(l)}$$

The reaction of an acid with a base to give a salt and water is known as a neutralization reaction. In general, a neutralization reaction can be written as:

Base + Acid → Salt + Water

Think and discuss

• Is the substance present in antacid tablet acidic or basic?

• What type of reaction takes place in stomach when an antacid tablet is consumed?

Reaction of metal oxides with acids

Acivity 6

• Take a small amount of copper oxide in a beaker and slowly add dilute hydrochloric acid while stirring. Observe the changes in the solution.

• Note the colour of the solution.

- What do you observe in the above reaction?

You will notice that the copper oxide present in the beaker dissolves in dilute HC*l* and the colour of the solution becomes blueish-green. The reason for this change is the formation of copper (II) chloride in the reaction. The general reaction between a metal oxide and an acid can be written as:

Metal oxide + Acid → Salt + Water

Write the chemical equation for the reaction between copper oxide and HC*l* and balance it.

In above reaction metal oxide reacts with acid to give salt and water. This reaction is similar to the reaction of a base with an acid that we have observed in activity - 5.

- What do you conclude from the Activity-5 and 6?

In both the reactions salt and water are the products. Both metallic oxides and metal hydrides give salt and water when they react with an acid. Thus we can conclude that metal oxides are basic in nature like the metal hydroxides.

Reaction of a non-metal oxide with a base

You saw the reaction between carbon dioxide and calcium hydroxide (lime water) in activity-4. Calcium hydroxide, which is a base, reacts with carbon dioxide to produce a salt and water. This reaction is similar to the reaction between a base and an acid. Thus we can conclude that carbon dioxide which is a non metal oxide is acidic in nature. In general all non-metal oxides are acidic in nature.

Think and discuss

- You are provided with three test tubes containing distilled water, an acid and a base solution respectively. If you are given only blue litmus paper, how do you identify the contents of each test tube?
- Which gas is usually liberated when an acid reacts with a metal? How will you test for the presence of this gas?
- A compound of a calcium reacts with dilute hydrochloric acid to produce effervescence. The gas evolved extinguishes a burning candle; turns lime water milky. Write a balanced chemical equation for the reaction if one of the compounds formed is calcium chloride.

What do acids have in common?

In previous sections you have seen that acids have similar chemical properties. In lab activity you have observed that acids generate hydrogen gas on reacting with metals, so hydrogen seems to be common element to all acids. Let us perform an activity to investigate whether all compounds containing hydrogen are acids or not.

Activity 7

Prepare solutions of glucose, alcohol, hydrochloric acid and sulphuric acid etc.,

Connect two different coloured electrical wires to graphite rods separately in a 100 ml beaker as shown in figure.

Connect free ends of the wire to 230 volts AC plug and complete the circuit as shown in the fig-3 by connecting a bulb to one of the wires.

Now pour some dilute HC*l* in the beaker and switch on the current.

- What do you notice?

Repeat activity with dilute sulphuric acid and glucose and alcohol solutions separately.

- What do you observe?
- Does the bulb glow in all cases?

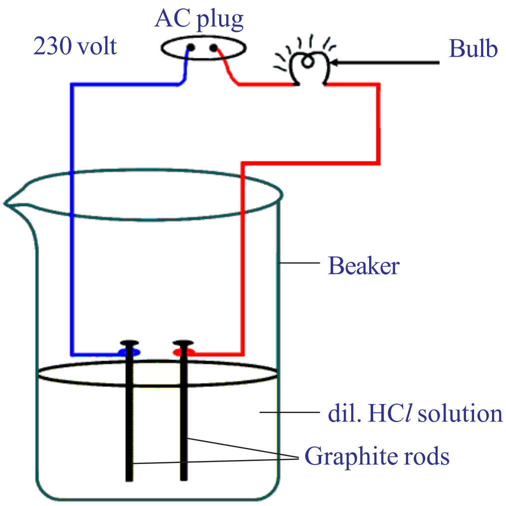

fig-3: Acid solution in water conducts electricity

You will notice that the bulb glows only in acid solutions but not in glucose and alcohol solutions. Glowing of bulb indicates that there is flow of electric current through the solution. Acid solutions have ions and the moment of these ions in solution helps for flow of electric current through the solution.

The positive ion (cation) present in HC*l* solution is H^+. This suggests that acids produce hydrogen ions H^+ in solution, which are responsible for their acidic properties. In glucose and alcohol solution the bulb did not glow indicating the absence of H^+ ions in these solutions. The acidity of acids is attributed to the H^+ ions produced by them in solutions.

Properties of Bases

What do Bases have in common?

Repeat the Activity-7 using alkalis such as sodium hydroxide, calcium hydroxide solutions etc., instead of acid solutions.

- Does the bulb glow?
- What do you conclude from the results of this activity?

Do acids produce ions only in aqueous solution? Let us test this.

Activity 8

- Take about 1.0g of solid Na*Cl* in a clean and dry test tube.
- Add some concentrated sulphuric acid to the test tube.

- What do you observe? Is there a gas coming out of the delivery tube?

Let us write chemical equation for the above reaction.

$$2NaCl_{(s)} + H_2SO_{4(l)} \rightarrow 2HCl_{(g)} \uparrow + Na_2SO_{4(s)}$$

Test the gas evolved successively with dry and wet blue litmus paper. In which case does the litmus paper change colour?

- What do you infer from the above observation?

You can conclude that dry H*Cl* gas (Hydrogen chloride) is not an acid because you have noticed that there is no change in colour of dry litmus paper but H*Cl* aqueous solution is an acid because wet blue litmus paper turned into red.

Note to teachers: If the climate is very humid, pass the gas produced through a guard tube (drying tube) containing calcium chloride to dry the gas.

- Can you write the chemical equation for the reaction taking place at the mouth of delivery tube?

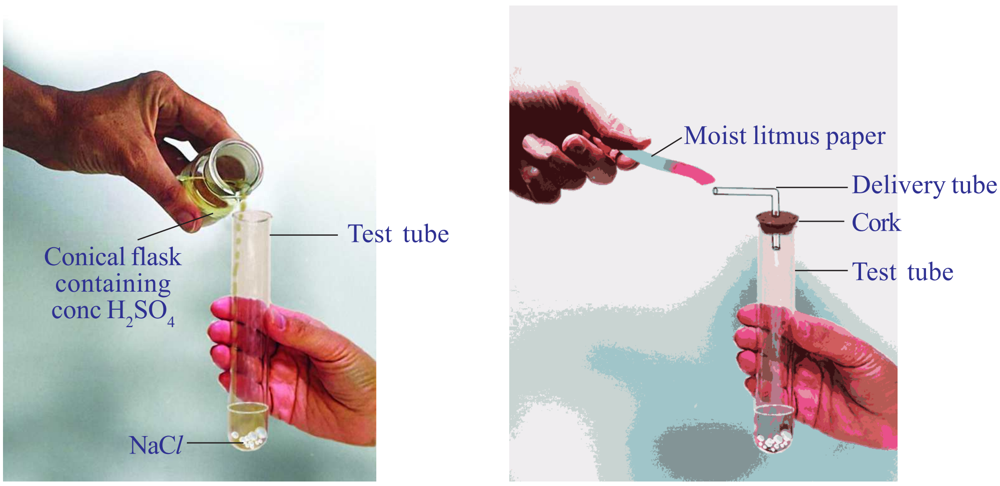

fig-4: Preparation of HCl gas

The H*Cl* gas evolved at delivery tube dissociates in presence of water to produce hydrogen ions. In the absence of water dissociation of H*Cl* molecules do not occur.

The dissociation of HC*l* in water is shown below.

$HCl + H_2O \rightarrow H_3O^+ + Cl^-_{(aq)}$

Hydrogen ions cannot exist as bare ions. They associate with water molecules and exist as as hydrated ions with each H^+ attached by 4 to 6 water molecules. For this we represent H^+ as hydronium ion, H_3O^+.

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

You have learnt that acids give H_3O^+ or $H^+_{(aq)}$ ion in water.
Let us see what happens when a base is dissolved in water.

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

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

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

On dissolving bases in water produces hydroxide (OH^-) ions. Bases which are soluble in water are called alkalis. All bases donot dissolve in water. $Be(OH)_2$ is slightly soluble in water.

What do you observe when water is mixed with acid or base?

Activity 9

- Take 10 ml water in a test tube.
- Add a few drops of concentrated H_2SO_4 to it and swirl the test tube slowly.
- Touch the bottom of the test tube.

- What do you feel?
- Is it an exothermic or endothermic process?

fig-5: Warning sign displayed on containers containing concentrated Acids and Bases

Carry out the above activity with sodium hydroxide pellets instead of H_2SO_4 and record your observation.

The process of dissolving an acid or a base in water is an exothermic process. 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 (shown in

Fig.5) on the can of concentrated sulphuric acid and on the bottle of sodium hydroxide pellets.

Mixing an acid or base with water result 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.

Think and discuss

- Why do HC*l*, HNO_3 etc., show acidic characters in aqueous solutions while solutions of compounds like alcohol and glucose do not show acidic character?
- While diluting an acid, why is it recommended that the acid should be added to water and not water to the acid?

Can you decide the strength of an acid or base solutions?

Let us find.

Strength of acid or base:

Activity 10

A test to know whether the Acid is strong or weak.

- Take two beakers A and B.
- Fill the beaker A with dil. CH_3 COOH (acetic acid) and beaker B with dil. HC*l* (Hydrochloric Acid)
- Arrange the apparatus as used in activity-7, and pass electric current through the solutions in separate beakers.

- What do you observe?
- Can you guess the reason for the changes you observed?

You notice that the bulb glows brightly in HC*l* solution while the intensity of the bulb is low in acetic acid solution. This indicates that there are more ions in HC*l* solution and fewer ions are present in acetic acid solution. More ions in HC*l* solution mean more H_3O^+ions.Therfore it is a strong acid. Whereas acetic acid has fewer H_3O^+ions and hence it is weak acid.

Carry out the above experiment by taking bases like dil. NaOH (sodium hydroxide) and dil. NH_4OH (ammonium hydroxide) instead of acids.

- What do you observe? Explain your observations.

The universal indicator can also be used to know the strength of acid or base. Universal indicator is a mixture of several indicators. The universal indicator shows different colours at different concentrations of hydrogen ions in a solution.

pH scale

A scale for measuring hydrogen ion concentration in a solution is called pH scale. (The 'p' in pH stands for 'Potenz' German 'Potenz' is power). pH value of a solution is simply a number which indicates the acidic or basic nature of a solution.

The pH of neutral solutions 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 a decrease in H_3O^+ ion concentration or an increase in OH^- ion concentration in the solution. pH value of a solution above '7' represents a basic solution.

Observe the following figure.

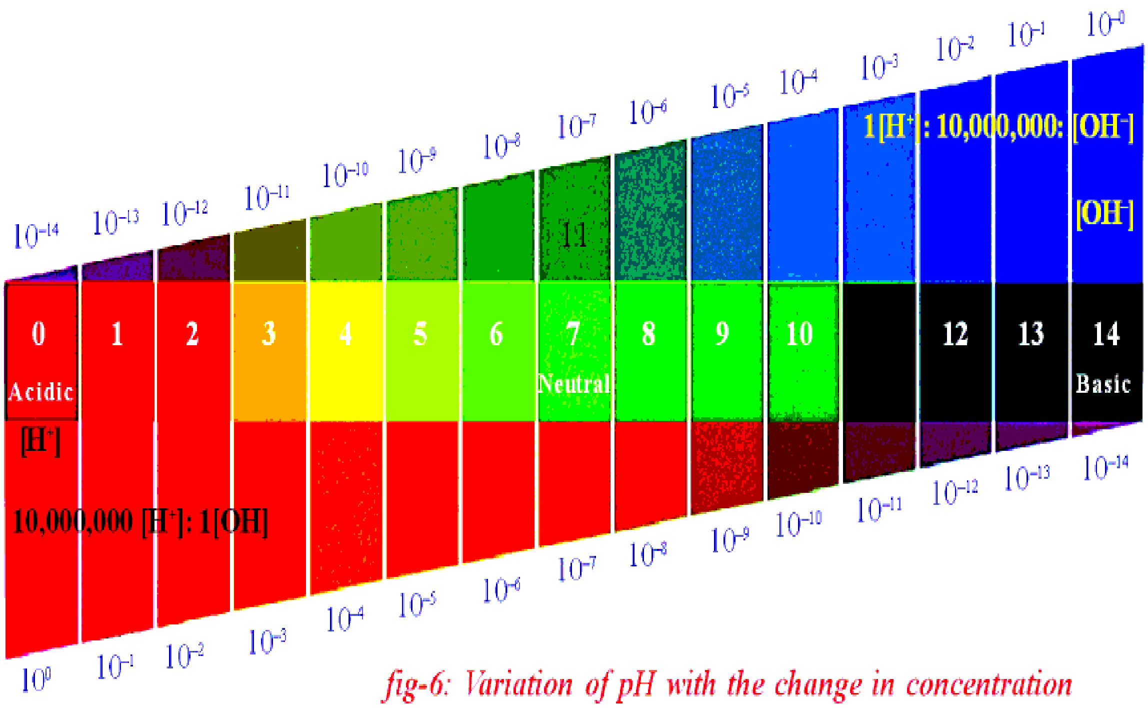

fig-6: Variation of pH with the change in concentration of $H^+_{(aq)}$ ions and $OH^-_{(aq)}$ ions.

Activity 11

- Test the pH value of solutions given in table using pH paper.
- Record your observations in column three of Table – 2.
- Write approximate pH values in column 4 using Universal Indicator solution.

• What is the nature of each substance on the basis of your observations?

Table-2

S.No.	Solution	Colour pH paper	Approximate pH value	Nature of substances
1	HCl			
2	CH_3COOH			
3	NH_4Cl			
4	CH_3COONa			
5	NaHCO3			
6	Na_2CO_3			
7	NaOH			
8	Distilled water			
9	Lemon juice			
10	Carrot juice			
11	Coffee			
12	Tomato juice			
13	Tap water			
14	Banana juice			
15	Colourless aerated drink			
16	Saliva (before meal)			
17	Saliva (after meal)			

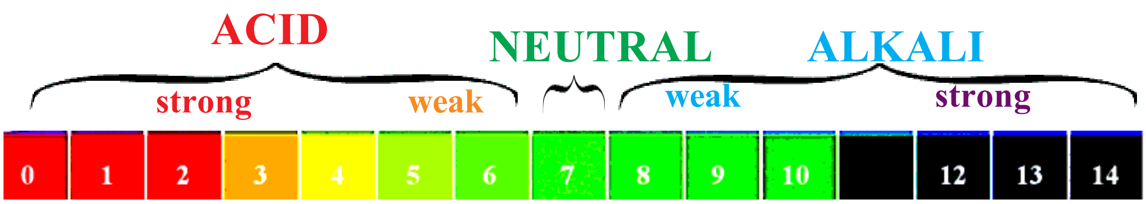

fig -7: pH value as shown by different colour in universal indicator

The strength of acid or base depends on the concentraction of H_3O^+ ions or OH^- produced in solution. If we take hydrochloric acid and acetic acid of the same concentration then they produce different concentration of hydrogen ions. Acids that give more H_3O^+ ions are said to be strong acids that give fewer H_3O^+ ions are said to be weak acid. Can you now predict what weak and strong bases are?

Do you know?

To avoid the negative powers of H^+ concentration in dilute acid and base solutions Sorensen introduced the concept of pH. Due to this pH concept may be restricted for solutions of $[H^+]$ less than 1 molar.

The pH scale is from 0-14. The pH is an indication of concentration of H^+. For example, at a pH of zero the hydronium ion concentration is one molar. Typically the concentrations of H^+ in water in most solutions fall between a range of 1 M (pH=0) and 10^{-14} M (pH=14). Figure 8 depicts the pH scale with common solutions.

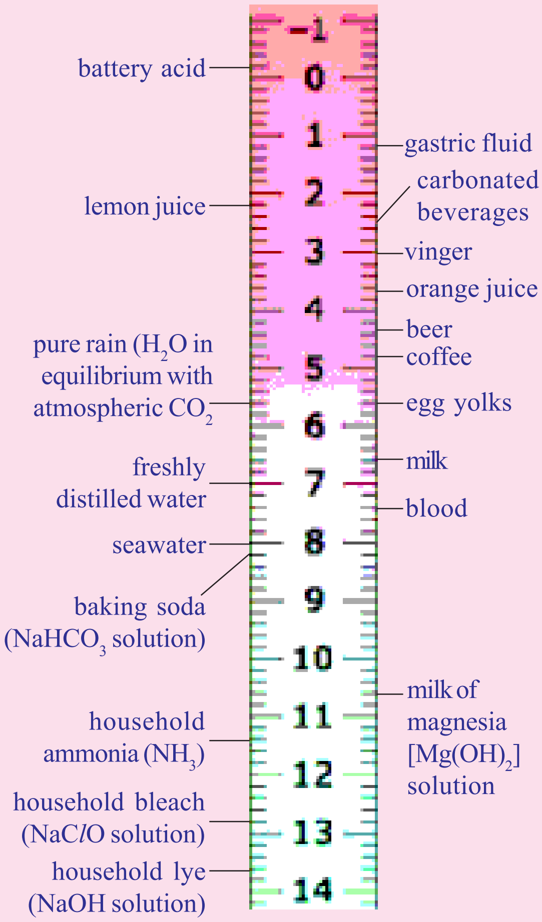

fig -8: Solutions and the placement of them on pH scale

Importance of pH in everyday life

1. Are plants and animals pH sensitive?

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 in to the rivers, it lowers the pH of the river water, the survival of aquatic life in such rivers becomes difficult.

Think and discuss

- What will happen if the pH value in our body increases?
- Why do living organism have narrow pH range?

2. Is pH change cause of tooth decay?

Tooth decay starts when the pH of the mouth is lower than 5.5. Tooth enamel, made 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. The best way to prevent this is to clean the mouth after eating food. Using tooth pastes, which are generally basic neutralize the excess acid and prevent tooth decay.

3. 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. These antacids neutralize the excess acid in the stomach. Magnesium hydroxide (milk of magnesia), a mild base, is often used for this purpose.

Activity 12

- Take dil. HCl in a beaker and add two to three drops methyl orange indicator. Note the colour of the solution
- Mix antacid tablet powder to the above solution in the beaker. Now observe the change in colour of solution.

- What is the reason for the change in colour of solution?
- Can you write the chemical equation for this reaction?

4. pH of the soil

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 samples from various places and check the pH in the manner described below in the following activity. Also you can note down what type of plants are growing in the region from which you have collected the soil.

Activity 13

Put about 2g soil in a test tube and add 5ml water to it. Shake the contents of the test tube. Filter the contents and collect the filtrate in a test tube.

Check the pH of this filtrate with the help of universal indicator paper.

- What can you conclude about the ideal soil pH for the growth of plants in your region?
- Under what soil conditions a farmer would treat the soil of his fields with quicklime (calcium hydroxide) or calcium carbonate?

Self defense by animals and plants through chemical war fare?

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 leaves of nettle plant, inject methanoic acid causing burning pain.

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

More about salts

In the previous sections you have studied the formation of salts by the neutralization reaction of base with an acid. Let us understand more about the preparation, properties and uses of salts.

Family of salts

Activity 14

- Write the formulae of the following salts.
- Potassium sulphate, sodium sulphate, calcium sulphate, magnesium sulphate, copper sulphate, sodium chloride, sodium nitrate, sodium corbonate and ammonium chloride.
- Identify the acids and bases from which the above salts are obtained.
- Salts having the same positive or negative radicals 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.

- How many families can you identify among the salts given above?

pH of Salts

Activity 15

- Collect the salt samples like, sodium chloride, aluminum chloride, copper sulphate, sodium acetate, ammonium chloride, sodium hydrogen carbonate and sodium carbonate.
- Dissolve them in distilled water.
- Check the action of these solutions with litmus papers.
- Find the pH using pH paper (universal indicator).
- Classify them into acidic, basic or neutral salts?
- Identify the acid and base used to form the above salts.
- Record your observations in Table - given below.

Salt	pH	Acidic	Basic	Neutral

Salt of a strong acid and a strong base are neutral and the pH value is 7. The salts of a strong acid and weak base are acidic and the pH value is less than 7. The salts of a strong base and weak acid are basic in nature and the pH value is more than 7.

- What do you say about salts of both weak acid and weak base?

In such cases the pH depends on the relative strengths of acid and base.

Chemicals from common salt

Salts are the ionic compounds which are produced by the neutralization of acid with base. Salts are electrically neutral. There are number of salts but sodium chloride is the most common among them. Sodium chloride is also known as table salt or common salt. Sodium chloride is used to enhance the taste of food.

Sea water contains many salts dissolved in it. Sodium chloride is the predominant component and it is separated from these salts. Deposits of solid salt are also found in several parts of the world. These deposits of 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 is an important raw material for various materials of daily use, such as sodium hydroxide, baking soda, washing soda, bleaching powder and many more. Let us see how one substance is used for making all these different substances.

Sodium hydroxide from common salt

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.

Do you know?

Salt – a symbol of freedom struggle: You know common salt as a substance which enhances the taste of food; it also has played a remarkable role in motivating the people towards freedom struggle. The tax levied by the British government on common food substance (salt), for both the poor and the rich, made them to become unite in the freedom struggle.

You must have heard about Mahatma Gandhi's Dandi March and about 'salt satyagraha' in the struggle for freedom of India.

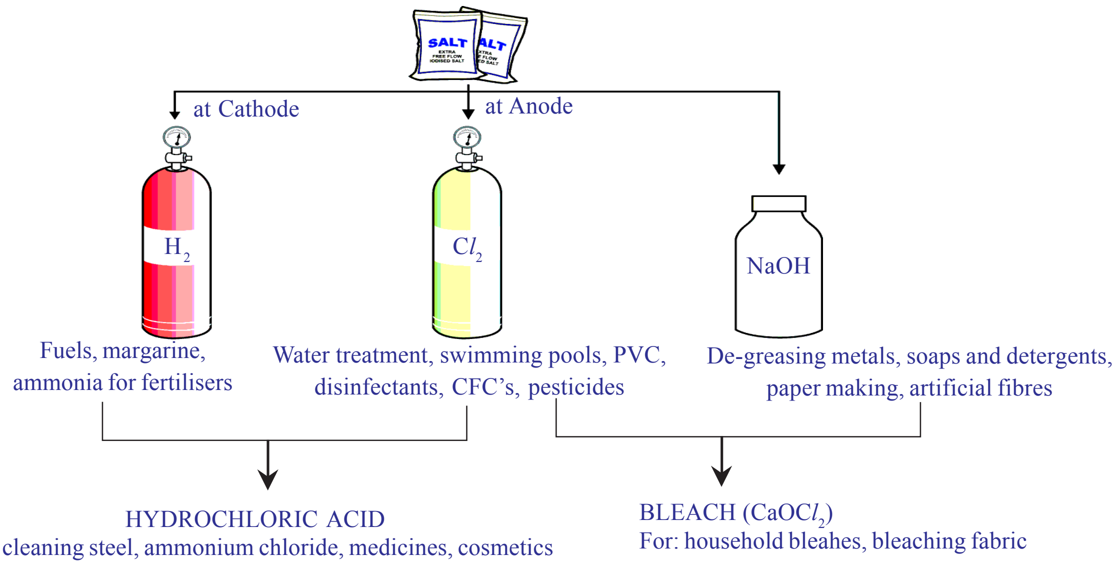

fig-9: Important product from chlor-alkali process

$$2\,NaCl_{(aq)} + 2H_2O_{(l)} \rightarrow 2\,NaOH_{(aq)} + Cl_{2\,(g)} + H_{2\,(g)}$$

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 Fig. shows the different uses of these products.

Bleaching Powder

You 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 power is produced by the action of chlorine on dry slaked lime [$Ca(OH)_2$]. Bleaching powder is represented by formula $CaOCl_2$, though the actual composition is quite complex.

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

Uses of Bleaching Powder:

1. It is used for bleaching cotton and linen in the textile industry for bleaching wood pulp in paper industry and for bleaching washed clothes in laundry.
2. Used as an oxidizing agent in many chemical industries.
3. Used for disinfecting drinking water to make it free of germs.
4. Used as a reagent in the preparation of chloroform.

Baking soda

Baking soda is sometimes added for faster cooking. The chemical name of the compound is sodium hydrogen carbonate ($NaHCO_3$). It is prepared as follows:

$$NaCl + H_2O + CO_2 + NH_3 \rightarrow NH_4Cl + NaHCO_3$$

Can you find the pH of sodium hydrogen carbonate as you have done in activity-14? Can you predict the reason for using $NaHCO_3$ to neutralize an acid?

Baking soda is a mild non-corrosive base.

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

$$2NaHCO_3 \xrightarrow{\text{Heat}} Na_2CO_3 + H_2O + CO_2$$

Uses of sodium hydrogen carbonate

i) Baking powder is a mixture of baking soda and a mild edible acid such as tartaric acid. When baking powder is heated or mixed in water, the following reaction takes place.

$$NaHCO_3 + H^+ \rightarrow CO_2 + H_2O + \text{sodium salt of acid.}$$

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

ii) Sodium hydrogen carbonate is also an ingredient in antacids. Being alkaline, it neutralizes excess acid in the stomach and provides relief.

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

iv) It acts as mild antiseptic.

Washing soda (sodium carbonate)

Another chemical that can be obtained from sodium chloride is Na_2CO_3. 10 H_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.

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

Sodium carbonate and sodium hydrogen carbonate are useful chemicals for many industrial processes.

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.

- What does 10 H_2O signify?
- Does it make Na_2CO_3 wet?
- Are the crystals of salts really dry?

Let us find

Removing water of crystallisation

Activity 16

- Take a few crystals of copper sulphate in a dry test tube and heat the test tube.

- What change did you notice in the colour of the copper sulphate after heating?

- Did you notice water droplets on sides of the test tube? Where did they come from?

Add 2-3 drops of water on the sample of copper sulphate obtained after heating.

- What do you observe? Is the blue colour of copper sulphate restored?

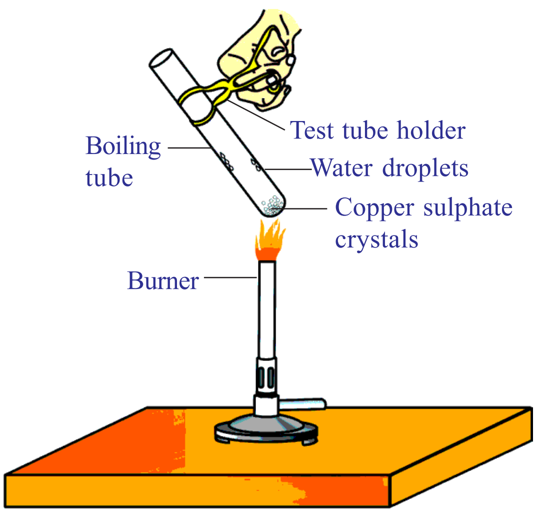

fig-10: Removing water of crystallisation

In the above activity copper sulphate crystals which seem to be dry contain the water of crystallization, when these crystals are heated, water present in crystals is evaporated and the salt turns white.

When the crystals are moistened with water, the blue colour reappears.

Water of crystallization 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 $CuSO_4.5\ H_2O$.

Now you would be able to answer the question whether the molecule of $Na_2\ CO_3.\ 10\ H_2O$ is wet or not.

Another salt which possesses water of crystallisation is gypsum. It has two water molecules in its crystals and the formula is $CaSO_4.\ 2H_2O$.

Let us see the use of this salt.

Plaster of paris ($CaSO_4$ ½ H_2O)

On careful heating of gypsum ($CaSO_4\ 2\ H_2O$) at 373 K it loses water molecules partially to become calcium sulphate hemihydrate ($CaSO_4.½\ H_2O$). 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 sets into hard solid mass due to the formation of gypsum.

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

Note: You might have noticed that only half a water molecule is shown to be attached as water of crystalisation.

- How can you get half a water molecule?

It is written in this form because two formula units of $CaSO_4$ share one molecule of water.

Plaster of paris is used for making toys, materials for decoration and for making surfaces smooth.

- Try to collect the information for calling calcium sulphate hemihydrates as Plaster of Paris.

Key words

Indicator, Acid, Base, Red litmus, Blue litmus, Phenolphthalein, Methyl orange, Salts, Neutralization, Guard tube, Hydronium ion, Alkali, Strong acid, Strong base, Universal indicator, pH scale, Potenz, Antacids, tooth decay, Family of Salts, Common salt, Bleaching powder, Baking soda, Washing soda,Hydrated salt, Water of crystallization, Plaster of Paris.

What we have learnt

- Acid – base indicators are dyes or mixtures of dyes which are used to indicate the presence of acids and bases.
- Acidic nature of a substance is due to the formation of H^+ (aq) ions in solution. Formation of OH^- (aq) ions in solution is responsible for the basic nature of a substance.
- When a base reacts with a metal with the evolution of hydrogen gas, a salt is formed.
- When an acid reacts with a metal carbonate or metal hydrogen carbonate gives the corresponding salt, carbon dioxide gas and water.
- Acidic and basic solutions in water conduct electricity because they produce hydrogen ions and hydroxide ions respectively.
- The strength of an acid or an alkali can be tested by using a scale called the pH scale (0-14) which gives the measure of hydrogen ion concentration in a solution.
- A neutral solution has a pH of 7, while an acidic solution has a pH less than 7 and a basic solution has a pH more than 7.
- Living beings carry out their metabolic activities within an optimal pH range.
- Mixing concentrated acids or bases with water is a highly exothermic process.
- Acids and bases neutralize each other to form corresponding salts and water.
- Water of crystallization is the fixed number of water molecules chemically attached to each formula unit of a salt in its crystalline form.
- Salts have various uses in everyday life and in industries.

Improve your learning

1. Five solutions A, B, C, D and E when tested with universal indicator showed pH as 4, 1, 11, 7 and 9, respectively, which solution is (AS1)

   (a) neutral (b) strongly alkaline (c) strongly acidic (d) weakly acidic (e) weakly alkaline

   Arrange the pH in increasing order of hydrogen ion concentration.

2. What is a neutralization reaction? Give two examples. (AS1)
3. What happens when an acid or base is mixed with water? (AS1)
4. Why does tooth decay start when the pH of mouth is lower than 5.5? (AS1)
5. Why does not distilled water conduct electricity? (AS2)
6. Dry hydrogen chloride gas does not turn blue litmus to red whereas hydrochloric acid does. Why? (AS1)
7. Why pure acetic acid does not turn blue litmus to red? (AS2)
8. A milkman adds a very small amount of baking soda to fresh milk. (AS2)
   a) Why does he shift the pH of the fresh milk from 6 to slightly alkaline?
   b) Why does this milk take a long time to set as curd?
9. Plaster of Paris should be stored in moisture – proof container. Explain why? (AS2)
10. Fresh milk has a pH of 6. Explain why the pH changes as it turns into curd? (AS3)
11. Compounds such as alcohols and glucose contain hydrogen but are not categorized as acids. Describe an activity to prove it. (AS3)
12. What is meant by "water of crystallization" of a substance? Describe an activity to show the water of crystallisation. (AS3)
13. Equal lengths of magnesium ribbons are taken in test tubes A and B. Hydrochloric acid is added to test tube A, while acetic acid is added to test tube B. Amount and concentration of both the acids is same. In which test tube will the fizzing occur more vigorously and why? (AS4)
14. Draw a neat diagram showing acid solution in water conducts electricity. (AS5)
15. How do you prepare your own indicator using beetroot? Explain. (AS5)
16. How does the flow of acid rain into a river make the survival of aquatic life in a river difficult? (AS7)
17. What is baking powder? How does it make the cake soft and spongy? (AS7)
18. Give two important uses of washing soda and baking soda. (AS7)

Fill in the blanks

1. i. ____________ taste is a characteristic property of all acids in aqueous solution.
   ii. Acids react with some metals to produce ____________ gas.
   iii. Because aqueous acid solutions conduct electricity, they are identified as ________
   iv. Acids react with bases to produce a ________ and water.
   v. Acids turn ____________ different colours.
2. i. Bases tend to taste ____________ and feel ____________
   ii. Like acids, aqueous basic solutions conduct _____, and are identified as______.
   iii. Bases react with ______________ to produce a salt and ______________.
   iv. Bases turn ________________ different colours.

3. Match the following:

a) Plaster of Paris	( )	1) CaO Cl_2
b) Gypsum	( )	2) $NaHCO_3$
c) Bleaching powder	( )	3) Na_2 CO_3
d) Baking soda	( )	4) $CaSO_4$. ½ H_2O
e) Washing soda	( )	5) $CaSO_4$. 2 H_2O

Multiple choice questions

1. The colour of methyl orange indicator in acidic medium is .... [ ]
   a) yellow b) green c) orange d) red
2. The colour of phenolphthalein indicator in basic solution is .... [ ]
   a) yellow b) green c) pink d) orange
3. Colour of methyl orange in alkali conditions? [ ]
   a) orange b) yellow c) red d) blue
4. A solution turns red litmus blue, its pH is likely to be .... [ ]
   a) 1 b) 4 c) 5 d) 10
5. A solution reacts with crushed egg-shells to give a gas that turns lime-water milky the solution contains .... [ ]
   a) NaCl b) HCl c) LiCl d) KCl
7. If a base dissolves in water by what name is it better known? [ ]
   a) neutralization b) basic c) acid d) alkali
8. Which of the following substances when mixed together will produce table salt? [ ]
   a) Sodium thiosulphate and sulphur dioxide
   b) Hydrochloric acid and sodium hydroxide
   c) Chlorine and oxygen
   d) Nitric acid and sodium hydrogen carbonate
9. What colour would hydrochloric acid (pH=1) turn universal indicator? [ ]
   a) orange b) purple c) yellow d) red
10. Which one of the following types of medicines is used for treating indigestion? [ ]
    a) antibiotic b) analgesic c) antacid d) antiseptic
11. What gas is produced when magnesium is made to react with hydrochloric acid? [ ]
    a) hydrogen b) oxygen c) carbon dioxide d) no gas is produced
12. Which of the following is the most accurate way of showing neutralization? [ ]
    a) Acid + base $\longrightarrow$ acid-base solution
    b) Acid + base $\longrightarrow$ salt + water
    c) Acid + base $\longrightarrow$ sodium chloride + hydrogen
    d) Acid + base $\longrightarrow$ neutral solution