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ACIDS, BASES AND SALTS

One hundred and fifteen different chemical elements are known to us at present. These elements combine to form a large number of compounds. **On the basis of their chemical properties, all the compounds can be classified into three groups :**

1. **Acids,**
2. **Bases,** and
3. **Salts**

In this Chapter, we will study all the three types of compounds, acids, bases and salts, in detail. Let us start with acids and bases. In order to know whether a substance is an acid or a base, we should first know the meaning of the term 'acid-base indicator'or just 'indicator'. This is discussed below.

Indicators for Testing Acids and Bases

An indicator is a 'dye' that changes colour when it is put into an acid or a base. An indicator gives *different* colours in acid and base. Thus, **an indicator tells us whether the substance we are testing is an acid or a base by change in its colour**. In other words, an indicator tells us whether the substance we are testing is *acidic* or *basic* by change in its colour. **The three most common indicators to test for acids and bases are : Litmus, Methyl orange and Phenolphthalein**.

The most common indicator used for testing acids and bases in the laboratory is litmus. Litmus can be used in the form of litmus solution or in the form of litmus paper. It is of two types : Blue litmus and Red litmus (see Figure 1).

(*a*) Blue litmus paper (*b*) Red litmus paper

Figure 1.

(*i*) An acid turns *blue* litmus to *red*.
(*ii*) A base (or alkali) turns *red* litmus to *blue*.

So, a convenient way to find out whether a solution is acidic or basic is to test it with litmus and observe the change in colour which takes place.

(*a*) If a drop of the given solution turns blue litmus to red, then the given solution will be acidic in nature (or it will be an acid). For example, orange juice turns blue litmus to red, so orange juice is acidic in nature. That is, orange juice contains an acid.

(*b*) If a drop of the given solution turns red litmus to blue, then the given solution will be basic in nature (or alkaline in nature). Or it will be a base (or alkali). For example, sodium hydroxide solution (caustic soda solution) turns red litmus to blue, so sodium hydroxide solution is basic in nature (or alkaline in nature). In other words, sodium hydroxide is a base (or an alkali). Please note that *a water soluble base is called an alkali.*

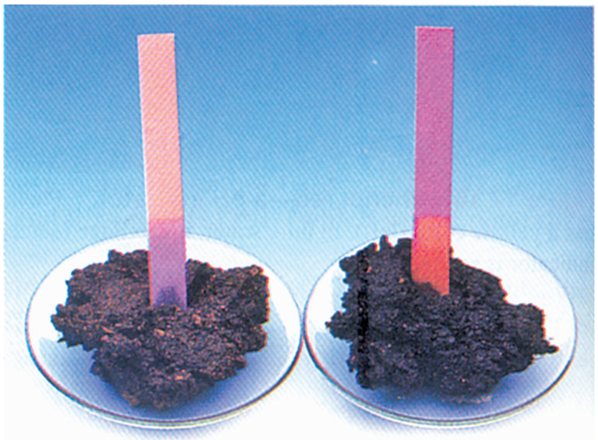


Figure 2. We often use litmus paper to find out whether a material is acidic or basic. In this picture, the soil sample on the left side turns red litmus paper blue, so it is basic. On the other hand, the soil sample on the right side turns blue litmus paper red, so this soil is acidic.

Litmus is a *natural* indicator (whose neutral colour is *purple*). It is made into blue litmus and red litmus for the sake of convenience in detecting colour change when an acid or base is added to it. But methyl orange and phenolphthalein are *synthetic* indicators. The neutral colour of methyl orange is '*orange*'. The colour changes which take place in methyl orange are as follows :

(*i*) Methyl orange indicator gives *red* colour in *acid* solution.

(*ii*) Methyl orange indicator gives *yellow* colour in *basic* solution.

The neutral colour of phenolphthalein is '*colourless*'. The colour changes which take place in phenolphthalein indicator are given below :

(*i*) Phenolphthalein indicator is *colourless* in *acid* solution.

(*ii*) Phenolphthalein indicator gives *pink* colour in *basic* solution.

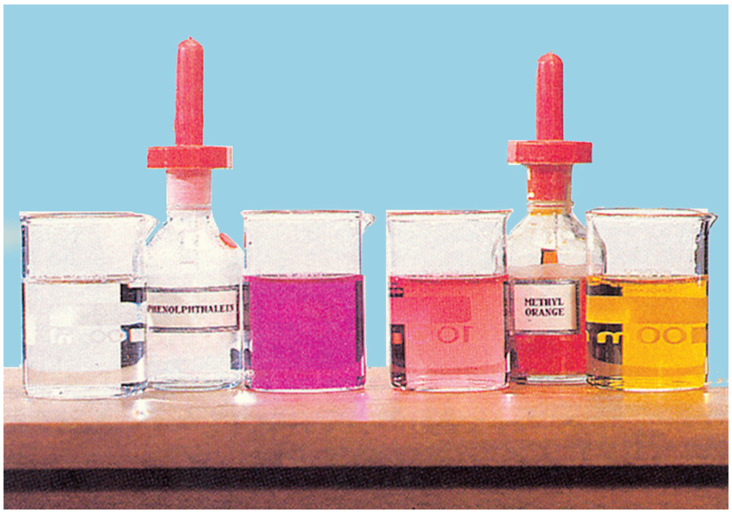


Figure 3. The bottle (with dropper) on the left side in this picture contains phenolphthalein indicator. Phenolphthalein indicator is colourless in acid solution but turns pink in basic solution. The bottle on the right side in the above picture contains methyl orange indicator. Methyl orange indicator is red in acid solution but yellow in basic solution.

A yet another acid-base indicator is the '**universal indicator**'. We will discuss it later on in this chapter. At the moment we will describe some of the natural indicators in a little more detail.

Litmus is a natural indicator. Litmus solution is a purple dye which is extracted from a type of plant called **'lichen'.** Lichen is a plant belonging to the division Thallophyta (see Figure 4). When litmus solution is neither acidic nor basic (it is neutral), then its colour is purple. It turns red in acidic solutions and blue in basic solutions. **Turmeric is also a natural indicator.** Turmeric (*haldi*) contains a yellow dye. It turns red in basic solutions. Many times we have noticed that a yellow stain of curry on a white cloth (which is due to the presence of turmeric in curry) turns reddish-brown when soap is scrubbed on it. This is due to the fact that soap solution is basic in nature which changes the colour of turmeric in the curry stain to red-brown. This stain turns to yellow again when the cloth is rinsed with plenty of water. This is because then the basic soap gets removed with water.

Figure 4. This is lichen. Litmus indicator is extracted from lichen.

The red cabbage extract (obtained from red cabbage leaves) is also a natural indicator. It is red in colour. The red cabbage extract remains red in acidic solutions but turns green on adding to basic solutions. The coloured petals of some flowers (such as *Hydrangea, Petunia* and *Geranium*) which change colour in the presence of acids or bases also act as indicators. For example, the flowers of *Hydrangea* plant are usually blue which turn pink in the presence of a base.

Olfactory Indicators

The term '*olfactory*' means '*relating to the sense of smell*'. **Those substances whose smell (or odour) changes in acidic or basic solutions are called olfactory indicators.** An olfactory indicator usually works on the principle that when an acid or base is added to it, then its 'characteristic smell' cannot be detected. **Onion and vanilla extract are olfactory indicators.**

(*i*) Onion has a characteristic smell. When a basic solution like sodium hydroxide solution is added to a cloth strip treated with onions (or onion extract), then the onion smell *cannot* be detected. An acidic solution like hydrochloric acid, however, does not destroy the smell of onions. This can be used as a test for acids and bases.

(*ii*) Vanilla extract has a characteristic pleasant smell. If a basic solution like sodium hydroxide solution is added to vanilla extract, then we *cannot* detect the characteristic smell of vanilla extract. An acidic solution like hydrochloric acid, however, does not destroy the smell of vanilla extract. This can be used as a test for acids and bases.

Let us solve one problem now.

Sample Problem. You have been provided with three test-tubes. One of them contains distilled water and the other two contain an acidic solution and a basic solution, respectively. If you are given only red litmus paper, how will you identify the contents of each test-tube ? **(NCERT Book Question)**

Solution. (*i*) Put the red litmus paper in all the test-tubes, turn by turn. The solution which turns *red* litmus to *blue* will be a *basic solution.* The blue litmus paper formed here can now be used to test the acidic solution.

(*ii*) Put the blue litmus paper (obtained above) in the remaining two test-tubes, one by one. The solution which turns the *blue* litmus paper to *red* will be the *acidic solution.*

(*iii*) The solution which has no effect on any litmus paper will be neutral and hence it will be distilled water.

ACIDS

If we cut a lemon (*neembu*) with a knife and taste it, the lemon appears to have a sour taste (*khatta swad*) (see Figure 5). The sour taste of lemon is due to the presence of an acid in it. The acid present in lemon which gives it a sour taste is citric acid. Thus : **Acids are those chemical substances which have a sour taste.** *Acids change the colour of blue litmus to red.* Some of the common fruits such as raw mango, raw grapes, lemon, orange, and tamarind (*imli*), etc., are sour in taste due to the presence of acids in them. Soured milk (or curd) also contains acid in it.

Figure 5. Lemon tastes sour due to the presence of an acid in it. The acid present in lemon is citric acid.

Figure 6. Oranges contain citric acid. They also contain ascorbic acid (vitamin C).

The acids present in plant materials and animals are called organic acids. Organic acids are naturally occurring acids. Some of the organic acids are : Acetic acid (or Ethanoic acid), Citric acid, Lactic acid, Tartaric acid, Oxalic acid and Formic acid (or Methanoic acid). Some of the natural sources of these organic acids are as follows : Acetic acid is found in vinegar (*sirka*), citric acid is present in citrus fruits such as lemons and oranges (see Figure 6), lactic acid is present in sour milk (or curd), tartaric acid is present in tamarind and unripe grapes, oxalic acid is present in tomatoes whereas formic acid (or methanoic acid) is present in ant sting and nettle leaf sting. Organic acids (or naturally occurring acids) are *weak acids.* **It is not harmful to eat or drink substances containing naturally occurring acids in them.**

The acids prepared from the minerals of the earth are called mineral acids. Mineral acids are *man-made* acids. The three most common mineral acids are : **Hydrochloric acid, Sulphuric acid and Nitric acid.** Concentrated mineral acids are very dangerous. They can burn our hands and clothes. These acids should be handled with care. In the laboratory, acids are generally mixed with water to dilute them. Such acids are called dilute acids. Dilute acids are less harmful to us. Please note that carbonic acid is also a mineral acid. But it is a weak acid.

Strong Acids and Weak Acids

All the acids can be divided into two groups : strong acids, and weak acids.

(*i*) Hydrochloric acid, sulphuric acid and nitric acid are strong acids.

(*ii*) Acetic acid (ethanoic acid), formic acid, citric acid, tartaric acid and carbonic acid are weak acids.

It is obvious that **all the mineral acids are strong acids.** Only one mineral acid, carbonic acid, is a weak acid. Strong acids are very dangerous to drink. Even the dilute solutions of strong acids are extremely harmful to drink. **The organic acids are**

Figure 7. Nitric acid, hydrochloric acid and sulphuric acid are strong acids.

Figure 8. Ethanoic acid (acetic acid) and citric acid are weak acids. Ethanoic acid (acetic acid) is present in vinegar and citric acid is present in lemon juice.

weak acids. The dilute solutions of weak acids are quite safe to drink. Being weak, the organic acids like acetic acid, citric acid and tartaric acid are used as food ingredients. For example, acetic acid (in the form of vinegar) is used in making pickles and tomato ketchup; tartaric acid is used in baking powder; whereas carbonic acid is used in fizzy soft drinks and soda water. The reasons for some acids being strong and others being weak will be explained later on in this chapter.

(*a*) Acetic acid is used in making pickles

(*b*) Acetic acid is also used in making tomato ketchup

(*c*) Carbonic acid is used in fizzy soft drinks

Figure 9.

Concentrated and Dilute Acids

A concentrated acid is one which contains the minimum possible amount of water in it. The concentration of an acid is decreased by adding more water to it. When water is added to a concentrated acid, then a dilute acid is formed. Thus, **a dilute acid is one which contains much more of water in it.**

Diluting Acids

A dilute acid is obtained by mixing the concentrated acid with water. The process of mixing the concentrated acid with water is *highly exothermic* (or heat producing). So, when a concentrated acid and water are mixed together, a large amount of heat is evolved. **The dilution of a concentrated acid should always be done by adding concentrated acid to water gradually with stirring and *not* by adding water to concentrated acid.** This is because :

(*i*) When a concentrated acid is added to water for preparing a dilute acid, then the heat is evolved gradually, and easily absorbed by the large amount of water (to which acid is being added).

(*ii*) If, however, water is added to concentrated acid to dilute it, then a large amount of heat is evolved at once. **This heat changes some of the water to steam explosively which can splash the acid on our face or clothes and cause acid burns** (see Figure 10). Even the glass container *may break* due to excessive heating.

Figure 10. This is what happens if water is added into a concentrated acid to dilute it. So, never pour water into a concentrated acid.

The fact that heat is evolved during the dilution of a concentrated acid can be shown as follows :

(*i*) Take about 10 mL of water in a beaker.

(*ii*) Add a few drops of concentrated sulphuric acid to water and swirl the beaker slowly.

(*iii*) Touch the bottom of the beaker.

(*iv*) The bottom of beaker appears to be hot showing that heat is evolved during the dilution of concentrated sulphuric acid. So, it is an *exothermic* process.

Properties of Acids

The important properties of acids are given below :

1. Acids have a sour taste

2. Acids turn blue litmus to red

3. Acid solutions conduct electricity (They are electrolytes)

When an acid is dissolved in water, we get the acid solution. The solutions of all the acids conduct electricity. That is, acid solutions allow electric current to pass through them. (The *reason* for the conduction of electricity by acid solutions will be explained later on).

4. Acids react with metals to form hydrogen gas

When an acid reacts with a metal, then a salt and hydrogen gas are formed. That is :

$$\textbf{Metal} + \textbf{Acid} \longrightarrow \textbf{Salt} + \textbf{Hydrogen gas}$$

For example, when dilute sulphuric acid reacts with zinc metal, then zinc sulphate and hydrogen gas are formed :

$$\underset{\substack{\text{Zinc} \\ \text{(A metal)}}}{Zn\,(s)} + \underset{\substack{\text{Sulphuric acid} \\ \text{(Dilute)}}}{H_2SO_4\,(aq)} \longrightarrow \underset{\substack{\text{Zinc sulphate} \\ \text{(A salt)}}}{ZnSO_4\,(aq)} + \underset{\text{Hydrogen}}{H_2\,(g)}$$

In this reaction, zinc metal displaces hydrogen from sulphuric acid. And this hydrogen is evolved as hydrogen gas. **Most of the acids react with metals to form salts and evolve hydrogen gas.** This shows that **hydrogen is common to all acids.**

The reaction of dilute sulphuric acid with zinc metal to show the formation of hydrogen gas can be carried out as follows :

(*i*) Take a few pieces of zinc granules in a boiling tube and add about 5 mL of dilute sulphuric acid to it (see Figure 11).

(*ii*) We will observe the formation of gas bubbles on the surface of zinc granules.

(*iii*) Pass the gas being formed through the soap solution taken in a trough (by means of a glass delivery tube). Gas filled bubbles are formed in the soap solution which rise into the air.

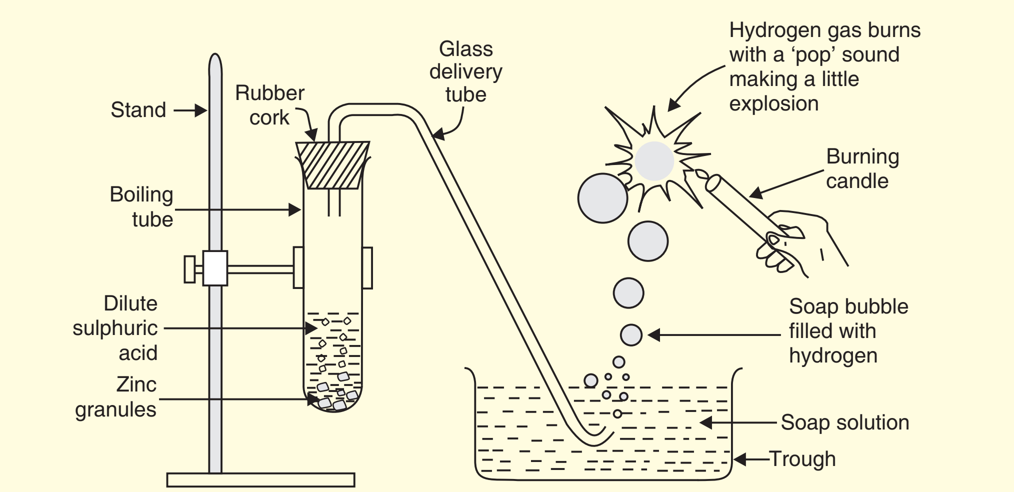


Figure 11. Experiment to show the reaction of dilute sulphuric acid with zinc metal. The hydrogen gas formed is being tested by the 'burning' test.

(*iv*) Bring a burning candle near a gas-filled soap bubble. The gas present in soap bubble burns with a 'pop' sound (making a little explosion) (see Figure 11).

(*v*) Only *hydrogen gas* burns making a 'pop' sound. This shows that hydrogen gas is evolved in the reaction of dilute sulphuric acid with zinc metal (taken in the form of zinc granules).

Please note that dilute hydrochloric acid reacts with metals to form metal chlorides and hydrogen gas. For example, dilute hydrochloric acid reacts with zinc to form zinc chloride and hydrogen gas. Write the equation for this reaction yourself.

Please note that **curd and other sour foodstuffs such as vinegar, lemon juice and orange juice, etc., should not be kept in metal vessels (like copper vessels or brass vessels)**. This is because curd and other sour foodstuffs contain acids which can react with the metal of the vessel to form poisonous metal compounds which can cause food poisoning and damage our health.

5. Acids react with metal carbonates (and metal hydrogencarbonates) to form carbon dioxide gas

When an acid reacts with a metal carbonate (or metal hydrogencarbonate), then a salt, carbon dioxide gas and water are formed :

Metal carbonate + Acid ⟶ Salt + Carbon dioxide + Water

Metal hydrogencarbonate + Acid ⟶ Salt + Carbon dioxide + Water

For example :

(*i*) When dilute hydrochloric acid reacts with sodium carbonate, then sodium chloride, carbon dioxide and water are formed :

Na_2CO_3 (s)	+	2HCl (aq)	⟶	2NaCl (aq)	+	CO_2 (g)	+	H_2O (l)
Sodium carbonate		Hydrochloric acid		Sodium chloride		Carbon dioxide		Water

The carbon dioxide gas is formed in the form of brisk effervescence (the rapid escape of small bubbles of gas from the liquid).

(*ii*) When dilute hydrochloric acid reacts with sodium hydrogencarbonate, then sodium chloride, carbon dioxide and water are formed :

$NaHCO_3$ (s)	+	HCl (aq)	⟶	NaCl (aq)	+	CO_2 (g)	+	H_2O (l)
Sodium hydrogen-carbonate		Hydrochloric acid		Sodium chloride		Carbon dioxide		Water

Thus, acids react with carbonates and hydrogencarbonates to evolve carbon dioxide gas. This **carbon dioxide gas reacts with lime water (calcium hydroxide solution) as follows :**

(*a*) When carbon dioxide gas is passed through lime water, the lime water *turns milky* due to the formation of a white precipitate of calcium carbonate :

$Ca(OH)_2$ (aq)	+	CO_2 (g)	⟶	$CaCO_3$ (s)	+	H_2O (l)
Calcium hydroxide (Lime water)		Carbon dioxide		Calcium carbonate (*White ppt*.) (Makes lime water milky)		Water

(*b*) If *excess* of carbon dioxide gas is passed through lime water, then the white precipitate formed first *dissolves* due to the formation of a soluble salt calcium hydrogencarbonate, and the solution becomes clear again :

$CaCO_3$ (s)	+	CO_2 (g)	+	H_2O (l)	⟶	$Ca(HCO_3)_2$ (aq)
Calcium carbonate (*White ppt*.) (Insoluble in water)		Carbon dioxide		Water		Calcium hydrogencarbonate (Soluble in water)

(*a*) Clear lime water. (*b*) When carbon dioxide is passed through lime water, it turns milky (*c*) If carbon dioxide is passed for a longer time, the milkiness disappears

Figure 12. Action of carbon dioxide gas on lime water.

The reaction between dilute hydrochloric acid and sodium carbonate can be performed as follows :

(*i*) Take a boiling tube and put about 0.5 g of sodium carbonate in it.

(*ii*) Add about 2 mL of dilute hydrochloric acid in the boiling tube (through a thistle funnel as shown in Figure 13).

(*iii*) We will observe that brisk effervescence of a gas is produced.

(*iv*) Pass the gas through lime water. The lime water turns milky (showing that it is carbon dioxide gas).

(*v*) Keep on passing carbon dioxide gas through milky lime water for some more time. The lime water becomes clear again. This shows that the white precipitate of calcium carbonate dissolves on passing excess of carbon dioxide gas.

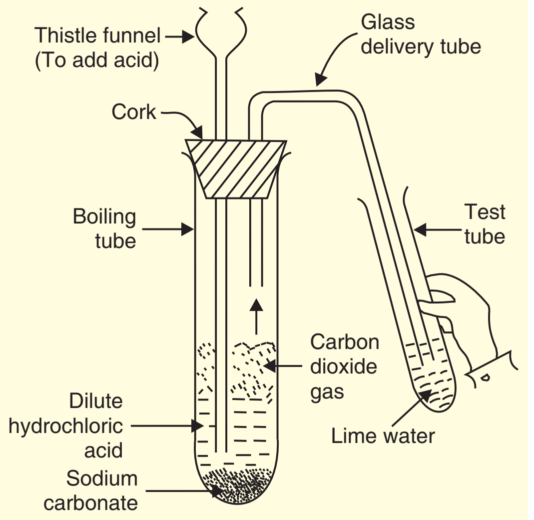


Figure 13. Carbon dioxide gas (formed by the action of dilute hydrochloric acid on sodium carbonate) being passed through lime water (calcium hydroxide solution).

We can repeat this experiment by using sodium hydrogencarbonate in place of sodium carbonate. Again we will get carbon dioxide gas which will turn lime water milky. On passing excess of carbon dioxide, the milky lime water will become clear again.

If someone is suffering from the problem of acidity after overeating, we can suggest taking baking soda solution as remedy. This is because baking soda is sodium hydrogencarbonate which reacts with excess hydrochloric acid in the stomach and *neutralises* it. This gives relief to the person suffering from acidity.

Please note that dilute sulphuric acid reacts with metal carbonates (and metal hydrogencarbonates) to form metal sulphates, carbon dioxide and water. Another point to be noted is that **limestone, marble and chalk are the different forms of the same chemical compound 'calcium carbonate'.** Even **the egg-shells are made of calcium carbonate.** Calcium carbonate reacts with dilute hydrochloric acid to form calcium chloride, carbon dioxide and water. Similarly, calcium carbonate reacts with dilute sulphuric acid to form calcium sulphate, carbon dioxide and water. A yet another point to be noted is that carbon dioxide gas does not support combustion. So, **carbon dioxide gas can extinguish a burning substance** (say, a burning candle).

Figure 14. Limestone is calcium carbonate. Carbon dioxide is formed when an acid is dropped onto the surface of limestone. This reaction is a convenient test for limestone.

6. Acids react with bases (or alkalis) to form salt and water

When an acid reacts with a base, then a salt and water are formed. That is :

$$\textbf{Acid} + \textbf{Base} \longrightarrow \textbf{Salt} + \textbf{Water}$$

Actually, when an acid is treated with a base, the base *neutralises* the acid and destroys its acidity. Since an acid and a base neutralise each other's effect, so **the reaction between an acid and a base to form salt and water is called a neutralisation reaction.** For example :

When hydrochloric acid reacts with sodium hydroxide solution, then a neutralisation reaction takes place to form sodium chloride and water :

$$\underset{\substack{\text{Sodium hydroxide} \\ \text{(Base)}}}{NaOH\,(aq)} + \underset{\substack{\text{Hydrochloric acid} \\ \text{(Acid)}}}{HCl\,(aq)} \longrightarrow \underset{\substack{\text{Sodium chloride} \\ \text{(Salt)}}}{NaCl\,(aq)} + \underset{\text{Water}}{H_2O\,(l)}$$

This is an example of a neutralisation reaction. In this reaction, sodium hydroxide base and hydrochloric acid neutralise (nullify) each other to form sodium chloride salt which is neither acidic nor basic, it is neutral.

We can carry out the neutralisation reaction between hydrochloric acid and sodium hydroxide solution in the laboratory. We will use phenolphthalein solution as indicator in this experiment. Please note that phenolphthalein solution is a *colourless* indicator which gives *pink colour in basic solution* (or alkaline solution). Phenolphthalein indicator remains colourless in acidic solution as well as in neutral solution. Let us carry out the neutralisation reaction now.

(*i*) Take about 5 mL of dilute sodium hydroxide solution in a test-tube (or a conical flask). Add 2 or 3 drops of phenolphthalein indicator. The solution will turn pink (showing that it is basic in nature).

(*ii*) Add dilute hydrochloric acid to the above sodium hydroxide solution dropwise (with the help of a dropper) and shake the test-tube after each addition.

(*iii*) After adding a certain volume of hydrochloric acid, we will find that the pink colour of solution in the test-tube just disappears. The solution becomes colourless.

(*iv*) At this stage, all the sodium hydroxide base taken in the test-tube has been completely neutralised by hydrochloric acid added from the dropper. The colour of phenolphthalein indicator changes from pink to colourless because no more sodium hydroxide base is left unreacted in the test-tube. The reaction mixture has become neutral.

(*v*) Now add a few drops of sodium hydroxide solution to the above colourless mixture. The mixture becomes pink in colour again. That is, the phenolphthalein indicator has changed its colour to pink. This has happened because after adding a few drops of sodium hydroxide solution, the reaction mixture has become basic again.

Figure 15. This student is carrying out the neutralisation reaction between sodium hydroxide solution and hydrochloric acid solution. She has taken sodium hydroxide solution (containing phenolphthalein indicator) in the conical flask and adding hydrochloric acid to it from the burette. The acid will be added to sodium hydroxide solution until the indicator just changes colour : from pink to colourless.

7. Acids react with metal oxides to form salt and water

Acids react with metal oxides to form salt and water :

Metal oxide + Acid ⟶ Salt + Water

Copper (II) oxide is a metal oxide. Dilute hydrochloric acid reacts with copper (II) oxide to form copper (II) chloride and water :

$$\underset{\substack{\text{Copper (II) oxide}\\\text{(Black)}}}{CuO\,(s)} + \underset{\text{Hydrochloric acid}}{2HCl\,(aq)} \longrightarrow \underset{\substack{\text{Copper (II) chloride}\\\text{(Blue-green)}}}{CuCl_2\,(aq)} + \underset{\text{Water}}{H_2O\,(l)}$$

We can carry out the reaction between copper (II) oxide and dilute hydrochloric acid as follows :

(*i*) Take a small amount of copper (II) oxide in a beaker. It is black in colour.

(*ii*) Add dilute hydrochloric acid slowly while stirring with a glass rod.

(*iii*) We will find that copper (II) oxide has dissolved in dilute hydrochloric acid to form a blue-green solution.

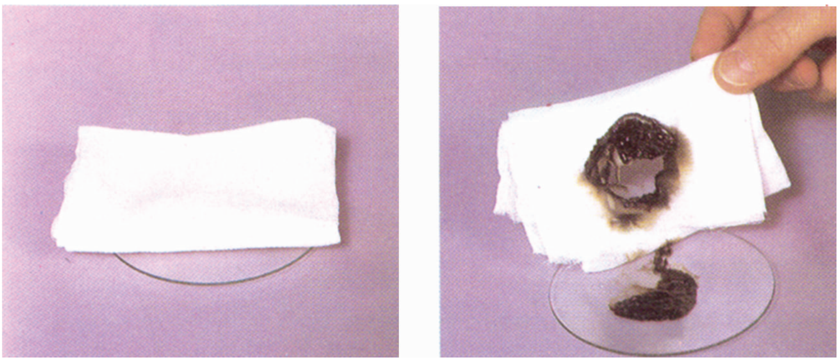
(*iv*) The blue-green colour of the solution is due to the formation of copper (II) chloride salt.

The reaction between acids and metal oxides to form salt and water is similar to the neutralisation reaction between an acid and a base to form salt and water. Thus, the reaction between acids and metal oxides is a kind of neutralisation reaction. It shows the basic nature of metal oxides.

Just like metal oxides, the metal hydroxides are also basic in nature. **The acids also react with metal hydroxides to form salt and water.** The reaction between an acid and a metal hydroxide is also a kind of neutralisation reaction. The antacid called 'Milk of Magnesia' which is used to remove indigestion (caused by too much hydrochloric acid in the stomach) is a metal hydroxide called 'magnesium hydroxide'. Magnesium hydroxide is basic in nature. It reacts with the excess hydrochloric acid present in the stomach and neutralises it.

8. Acids have corrosive nature

The mineral acids cause severe burns on the skin and attack and eat up materials like cloth, wood, metal structures and stonework, so they are said to be corrosive. For example, if concentrated sulphuric acid falls accidently on skin, clothes or wood, it causes severe burns on the skin, it cuts holes in the clothes, and burns the wood producing black spots on its surface (see Figure 16). All the three common mineral acids, sulphuric acid, hydrochloric acid and nitric acid, are very corrosive in their concentrated form. We should be very careful while using these acids in the laboratory. **Acids are never stored in metal containers because they gradually corrode and eat up the metal container.** Acids are stored in containers made of *glass* and *ceramics* because they are not attacked by acids.



(*a*) This is a cotton cloth (*b*) Concentrated sulphuric acid has burnt a hole in the cotton cloth

Figure 16. Acids have corrosive nature.

In addition to concentrated mineral acids, **the strong bases (or alkalis) such as sodium hydroxide are also very corrosive, and attack and destroy our skin** (see Figure 17). In order to warn people about the dangerous corrosive nature of mineral acids and strong bases, a hazard warning sign is usually printed on their containers. Such a hazard warning sign is shown in Figure 18. We can see such hazard warning signs on the cans of concentrated sulphuric acid and bottles of sodium hydroxide pellets, etc. The hazard warning sign shows that these chemicals attack living tissue like skin (shown by cut in hand), and wood, etc. The hazard warning sign tells the people to be careful and protect themselves from these dangerous chemicals. Let us solve some problems now.

Figure 17. The strong bases (or strong alkalis) are just as dangerous as strong acids. These burns were caused by sodium hydroxide.

Figure 18. This is a hazard warning sign for the corrosive nature of concentrated mineral acids and strong bases (or alkalis) which is displayed on their containers.

Sample Problem 1. Metal compound A reacts with dilute hydrochloric acid to produce effervescence. The gas evolved extinguishes a burning candle. Write a balanced chemical equation for the reaction if one of the compounds formed is calcium chloride. **(NCERT Book Question)**

Solution. The gas that extinguishes a burning candle is carbon dioxide which is formed by the action of dilute hydrochloric acid on a metal carbonate (or metal hydrogencarbonate) and produces effervescence. Now, since one of the compounds formed is calcium chloride, it shows that the metal compound is calcium carbonate (It cannot be calcium hydrogencarbonate because calcium hydrogencarbonate is found only in solution, it is too unstable to exist as a solid). Thus, the metal compound A is calcium carbonate ($CaCO_3$). Calcium carbonate reacts with dilute hydrochloric acid to form calcium chloride, carbon dioxide and water.

This can be written as :

$$\underset{\substack{\text{Calcium carbonate}\\\text{(Metal compound A)}}}{CaCO_3\ (s)} + \underset{\text{Hydrochloric acid}}{2HCl\ (aq)} \longrightarrow \underset{\text{Calcium chloride}}{CaCl_2\ (aq)} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2\ (g)} + \underset{\text{Water}}{H_2O\ (l)}$$

Sample Problem 2. 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 **(NCERT Book Question)**

Solution. The egg shells are made of calcium carbonate and the gas which turns lime water milky is carbon dioxide. Carbon dioxide gas can be formed by the action of an acid solution on calcium carbonate (or egg shells). So, the solution contains HCl (which is hydrochloric acid).

WHAT DO ALL ACIDS HAVE IN COMMON

All the acids contain hydrogen. The hydrogen present in acids is such that when acid is dissolved in water, it separates out as positively charged hydrogen ions (H^+) and enters the solution as H^+(aq) ions. We can now define an acid on the basis of hydrogen ions as follows : **An acid is a substance which dissociates (or ionises) on dissolving in water to produce hydrogen ions [H^+(aq) ions].** For example, an aqueous solution of hydrochloric acid dissociates (or ionises) to form hydrogen ions (alongwith chloride ions) :

$$\underset{\text{Hydrochloric acid}}{HCl\ (aq)} \longrightarrow \underset{\text{Hydrogen ions}}{H^+\ (aq)} + \underset{\text{Chloride ions}}{Cl^-\ (aq)}$$

It is the presence of hydrogen ions [H^+(aq) ions] in hydrochloric acid solution which makes it behave like an acid.

Please note that hydrogen ions do not exist as H^+ ions in solution, they attach themselves to the polar water molecules to form hydronium ions, H_3O^+. That is,

$$\underset{\text{Hydrogen ion}}{H^+} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+}$$

So, hydrogen ions must always be written as either H^+(aq) or as hydronium ions, H_3O^+. Please note that H^+(aq) and H_3O^+ are just the same because : $H^+(aq) = H^+ + H_2O$. In this class we will be representing hydrogen ions as H^+(aq) for the sake of convenience in writing.

A common thing in all the acids is that they produce hydrogen ions [H^+(aq) ions] when dissolved in water. Thus, the acidic behaviour of an acid solution is due to the presence of hydrogen ions in it. In other words, *it is the presence of hydrogen ions which gives an acid solution its acidic properties.* For example :

(*i*) Hydrochloric acid (HCl) shows acidic character because it ionises in aqueous solution to form hydrogen ions, H^+(aq) (alongwith chloride ions) :

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

(*ii*) Sulphuric acid (H_2SO_4) shows acidic behaviour because it ionises in aqueous solution to give hydrogen ions, H^+(aq) (alongwith sulphate ions) :

$$H_2SO_4\ (aq) \longrightarrow 2H^+\ (aq) + SO_4^{2-}\ (aq)$$

(*iii*) Nitric acid (HNO_3) shows acidic properties because it ionises in aqueous solution to release hydrogen ions, H^+(aq) (alongwith nitrate ions) :

$$HNO_3\ (aq) \longrightarrow H^+\ (aq) + NO_3^-\ (aq)$$

(*iv*) Acetic acid (CH_3COOH) shows acidic behaviour because it ionises in aqueous solution to produce hydrogen ions, H^+(aq) (alongwith acetate ions) :

$$CH_3COOH\ (aq) \longrightarrow CH_3COO^-\ (aq) + H^+\ (aq)$$

Thus, the acids like HCl, H_2SO_4, HNO_3 and CH_3COOH, etc., show acidic character because they dissociate (or ionise) in aqueous solutions to produce hydrogen ions, H^+ (aq) ions. The compounds such as glucose ($C_6H_{12}O_6$) and alcohol (C_2H_5OH) also contain hydrogen but they do not show acidic character. **The aqueous**

solutions of glucose and alcohol do not show acidic character because their hydrogen does not separate out as hydrogen ions [H^+(aq) ions] on dissolving in water. In other words, the hydrogen containing compounds such as glucose and alcohol do not behave as acids because they do not dissociate (or ionise) in water to produce hydrogen ions. From this we conclude that ***though all the acids contain hydrogen, but all the hydrogen containing compounds are not acids.***

To Show That All the Compounds Containing Hydrogen are Not Acids

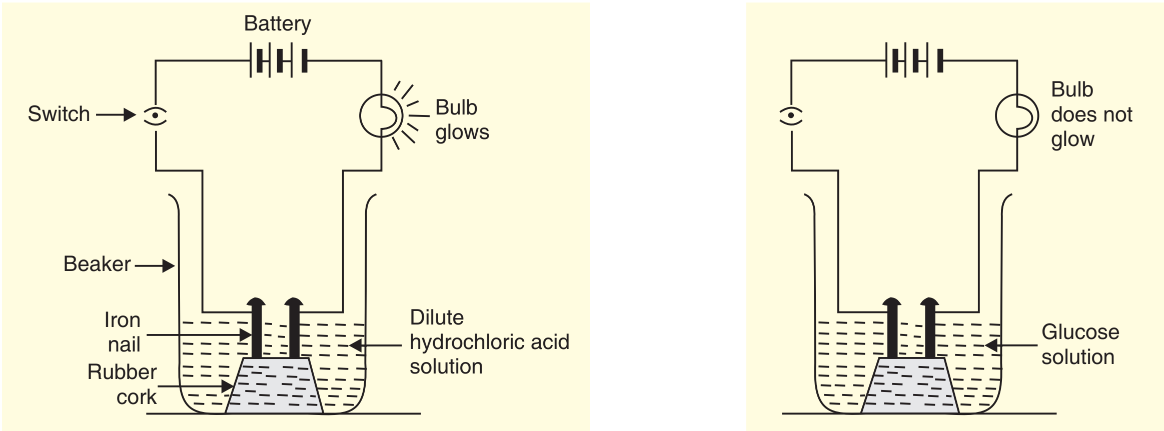
The fact that all the hydrogen containing compounds are not acids can be shown by the following experiment (or activity).

(*i*) Take solutions of hydrochloric acid, sulphuric acid, glucose and alcohol. All these are hydrogen containing compounds.

(*ii*) Fix two iron nails on a rubber cork and place the cork in a beaker [as shown in Figure 19(*a*).]

(*iii*) Connect the nails to the two terminals of a 6 volt battery through a switch and a bulb.

(*iv*) Pour some dilute hydrochloric acid solution (HCl solution) in the beaker and switch on the current. The bulb starts glowing [see Figure 19(*a*)]. This shows that **hydrochloric acid solution taken in the beaker conducts electricity.** If we repeat this experiment by taking sulphuric acid solution in the beaker, the bulb glows again. This shows that **sulphuric acid solution also conducts electricity.** In fact, all the acid solutions conduct electricity.



(*a*) Hydrochloric acid solution in water conducts electricity

(*b*) Glucose solution in water does not conduct electricity

Figure 19.

(*v*) Let us now take glucose solution ($C_6H_{12}O_6$ solution) in the beaker and switch on the current. The bulb does not glow in this case [see Figure 19(*b*)]. This shows that **glucose solution does not conduct electricity.** If we repeat this experiment by taking alcohol solution in the beaker, the bulb does not glow again. This shows that **alcohol solution also does not conduct electricity.**

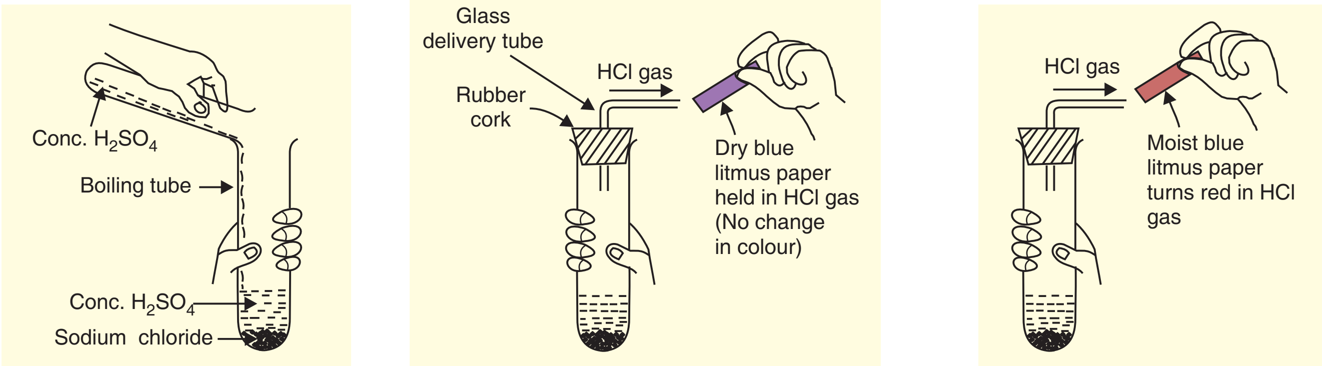
The aqueous solution of an acid conducts electricity due to the presence of charged particles called ions in it. For example, when hydrochloric acid (HCl) is dissolved in water, then its solution contains hydrogen ions, H^+(aq) and chloride ions, Cl^-(aq). These ions can carry electric current. So, due to the presence of H^+(aq) ions and Cl^-(aq) ions, a solution of hydrochloric acid conducts electricity. And this makes the bulb glow (in the above experiment). On the other hand, the hydrogen containing compounds like glucose and alcohol do not produce hydrogen ions or some other ions in solution. So, **due to the absence of ions, glucose solution and alcohol solution do not conduct electricity** (and bulb does not glow in the above experiment). From this experiment we conclude that *the hydrogen containing compounds such as glucose and alcohol are not categorised as acids because they do not dissociate (or ionise) in water to produce hydrogen ions [H^+(aq) ions].*

Distilled water does not conduct electricity because it does not contain any ionic compound (like acids, bases or salts) dissolved in it. On the other hand, rain water conducts electricity. This can be explained as follows : Rain water, while falling to the earth through the atmosphere, dissolves an acidic gas carbon dioxide from the air and forms carbonic acid (H_2CO_3). Carbonic acid provides hydrogen ions, H^+(aq), and carbonate ions, CO_3^{2-} (aq), to rain water. So, **due to the presence of carbonic acid (which provides ions to rain water), the rain water conducts electricity.** Please note that rain water may also dissolve other acidic gases such as SO_2, NO_2, etc., present in air to form acids which help it further in conducting electricity.

Acids Do Not Show Acidic Behaviour in the Absence of Water

The acidic behaviour of acids is due to the presence of hydrogen ions, H^+(aq) ions, 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.** We will now describe an experiment to show that acids do not show acidic behaviour *without* water. We will take the example of hydrogen chloride gas for this purpose. Dry hydrogen chloride gas (dry HCl gas) does not show acidic behaviour but when some water is present, then its acidic behaviour can be observed. Let us describe the experiment now.

(*i*) Take about 1 gram solid sodium chloride (NaCl) in a clean and dry boiling tube and add some concentrated sulphuric acid to it *very carefully* [see Figure 20(*a*)]. Fit a rubber cork with a small glass delivery tube in the mouth of the boiling tube as shown in Figure 20(*b*). Concentrated sulphuric acid reacts with sodium chloride to form hydrogen chloride gas. The hydrogen chloride gas starts coming out of the open end of the glass tube.



(*a*) Preparation of HCl gas (*b*) Testing HCl gas with dry litmus paper (*c*) Testing HCl gas with moist (wet) litmus paper

Figure 20.

(*ii*) Hold a 'dry' blue litmus paper in hydrogen chloride gas [see Figure 20(*b*)]. There is no change in the colour of 'dry' blue litmus paper. This shows that hydrogen chloride gas (HCl gas) does not behave as an acid in the absence of water (there is no water in 'dry' litmus paper).

(*iii*) We now hold a 'moist' (or wet) blue litmus paper in hydrogen chloride gas [see Figure 20(*c*)]. We will see that the 'moist' blue litmus paper turns red. This shows that hydrogen chloride gas (HCl gas) shows acidic behaviour in the presence of water (which is present in 'moist' or 'wet' litmus paper).

The above experiment shows that HCl gas does not show acidic behaviour in the *absence* of water but it shows acidic behaviour in the *presence* of water. This can be explained as follows :

Dry HCl gas does not contain any hydrogen ions in it, so it does not show acidic behaviour. In fact, **dry HCl gas does not change the colour of dry blue litmus paper because it has no hydrogen ions [H^+(aq) ions] in it.** However, when HCl gas dissolves in water, it forms hydrogen ions and hence shows acidic behaviour :

$$HCl\ (g) \xrightarrow{\text{Dissolve in water}} H^+\ (aq) + Cl^-\ (aq)$$

Actually, hydrogen chloride gas, HCl (g), first dissolves in water to form hydrochloric acid solution, HCl (aq), which then produces H^+(aq) and Cl^-(aq) ions. The separation of H^+ ions from HCl molecules cannot occur in the absence of water. The separation of H^+ ions from HCl molecules can occur only in the presence of water. That is why HCl gas shows acidic behaviour only in the presence of water. **The HCl gas turns 'wet' blue litmus paper red because it dissolves in the water present in wet litmus paper to form hydrogen ions, $H^+(aq)$ ions, which can turn blue litmus paper to red.** Please note that the above reaction of dissolving HCl gas in water can also be written in another way as follows in which hydrogen ions are written in the form of hydronium ions :

$$HCl + H_2O \longrightarrow \underset{\text{Hydronium ion}}{H_3O^+} + Cl^-$$

Strong Acids

An acid which is completely ionised in water and thus produces a large amount of hydrogen ions is called a strong acid. For example, **hydrochloric acid** is completely ionised in water, so it is a **strong acid :**

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

The *single arrow* pointing towards right in the above equation indicates that hydrochloric acid is completely ionised to form ions. **Sulphuric acid (H_2SO_4) and nitric acid (HNO_3) are also strong acids** because they are fully ionised in water to produce a large amount of hydrogen ions. *Please note that the word 'strong' here refers to the 'degree of ionisation' and not to the 'concentration' of the acid.* Due to large amount of hydrogen ions in their solution, **strong acids react very rapidly with other substances (such as metals, metal carbonates and metal hydrogencarbonates, etc.).** Strong acids also have a high electrical conductivity because of the high concentration of hydrogen ions in their solution (see Figure 21). Thus, all the strong acids are strong electrolytes.

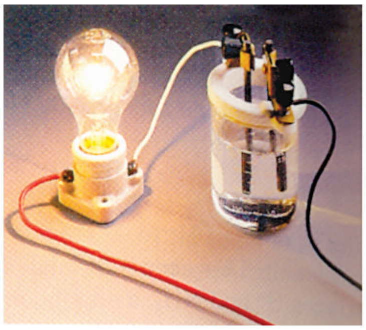


Figure 21. A strong acid (say, hydrochloric acid) has a high electrical conductivity, so the bulb glows brightly.

Weak Acids

An acid which is partially ionised in water and thus produces a small amount of hydrogen ions is called a weak acid. For example, **acetic acid** is partially ionised in water to produce only a small amount of hydrogen ions, so it is a **weak acid** :

$$\underset{\text{Acetic acid}}{CH_3COOH\,(aq)} \rightleftharpoons \underset{\text{Acetate ions}}{CH_3COO^-\,(aq)} + \underset{\text{Hydrogen ions}}{H^+\,(aq)}$$

The *double arrow* pointing towards right as well as left in the above equation tells us that acetic acid does not ionise fully to form hydrogen ions. **Carbonic acid (H_2CO_3) and sulphurous acid (H_2SO_3) are also weak acids** because they ionise only partially in water to form a small amount of hydrogen ions. Due to a small amount of hydrogen ions present in their solutions, **weak acids react quite slowly with other substances (such as metals, metal carbonates and metal hydrogencarbonates, etc.).** Weak acids have low electrical conductivity because of the low concentration of hydrogen ions in them (see Figure 22). Thus, all the weak acids are weak electrolytes. Please note that **when the concentrated solution of an acid is diluted by mixing water, then the concentration of hydrogen ions $H^+(aq)$ [or hydronium ions, H_3O^+] per unit volume decreases.** We will now give some of the important uses of mineral acids.

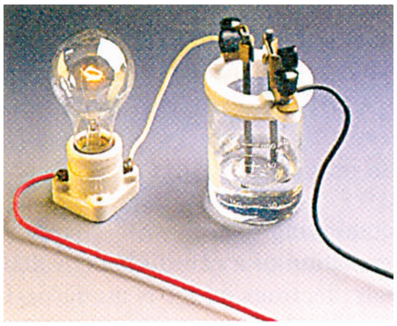


Figure 22. A weak acid (say, acetic acid) has a low electrical conductivity, so the bulb glows dimly.

Uses of Mineral Acids in Industry

1. Sulphuric acid is used in the manufacture of fertilisers (like ammonium sulphate), paints, dyes, chemicals, plastics, synthetic fibres, detergents, explosives and car batteries.

(*a*) Fertilisers (*b*) Plastics (*c*) Synthetic fibres (*d*) Detergents (*e*) Car batteries

Figure 23. Some of the products made by using sulphuric acid.

2. Nitric acid is used for making fertilisers (like ammonium nitrate), explosives (like TNT : Tri-Nitro Toluene), dyes and plastics.
3. Hydrochloric acid is used for removing oxide film from steel objects (before they are galvanised) and for removing 'scale' deposits from inside the boilers. It is also used in dye-stuffs, textile, food and leather industries.

Let us solve one problem now.

Sample Problem. Equal lengths of magnesium ribbons are taken in test-tubes A and B. Hydrochloric acid (HCl) is added to test-tube A while acetic acid (CH_3COOH) is added to test-tube B. In which test-tube will the fizzing occur more vigorously and why ? **(NCERT Book Question)**

Solution. Hydrochloric acid (HCl) is a strong acid whereas acetic acid (CH_3COOH) is a weak acid. Being a strong acid, the hydrochloric acid solution contains a much greater amount of hydrogen ions in it due to which the fizzing will occur more vigorously in test-tube A (containing hydrochloric acid). The fizzing is due to the evolution of hydrogen gas which is formed by the action of acid on the magnesium metal (of magnesium ribbon).

Before we go further and discuss bases in detail, **please answer the following questions :**

Very Short Answer Type Questions

1. What colour do the following indicators turn when added to a base or alkali (such as sodium hydroxide) ?
   (*a*) methyl orange (*b*) litmus (*c*) red cabbage extract
2. What colours do the following indicators turn when added to an acid (such as hydrochloric acid) ?
   (*a*) litmus (*b*) methyl orange
3. Name an indicator which is red in acid solution but turns blue in basic solution.
4. Name an indicator which is pink in alkaline solution but turns colourless in acidic solution.
5. When a solution is added to a cloth strip treated with onion extract, then the smell of onion cannot be detected. State whether the given solution contains an acid or a base.
6. When a solution is added to vanilla extract, then the characteristic smell of vanilla cannot be detected. State whether the given solution is an acid or a base.
7. How will you test for the gas which is liberated when hydrochloric acid reacts with an active metal ?
8. Name the gas evolved when dilute HCl reacts with sodium hydrogencarbonate. How is it recognised ?
9. Give the names and formulae of two strong acids and two weak acids.
10. Name one natural source of each of the following acids :
    (*a*) Citric acid (*b*) Oxalic acid (*c*) Lactic acid (*d*) Tartaric acid
11. Name one animal and one plant whose stings contain formic acid (or methanoic acid).
12. How is the concentration of hydronium ions (H_3O^+) affected when the solution of an acid is diluted ?
13. Write word equations and then balanced equations for the reactions taking place when :
    (*a*) dilute sulphuric acid reacts with zinc granules.
    (*b*) dilute hydrochloric acid reacts with magnesium ribbon.

(*c*) dilute sulphuric acid reacts with aluminium powder.
(*d*) dilute hydrochloric acid reacts with iron filings.

14. Complete and balance the following chemical equations :
(*a*) Zn (s) + HCl (aq) $\longrightarrow$
(*b*) Na_2CO_3 (s) + HCl (aq) $\longrightarrow$
(*c*) $NaHCO_3$ (s) + HCl (aq) $\longrightarrow$
(*d*) NaOH (aq) + HCl (aq) $\longrightarrow$
(*e*) CuO (s) + HCl (aq) $\longrightarrow$

15. Fill in the blanks in the following sentences :
(*a*) Acids have a ....taste and they turn..................litmus to.......................
(*b*) Substances do not show their acidic properties without................... .
(*c*) Acids produce.....................ions on dissolving in water.
(*d*) Those substances whose smell (or odour) changes in acidic or basic solutions are called................indicators.
(*e*) Onion and vanilla extract are.................indicators.

Short Answer Type Questions

16. (*a*) What is an indicator ? Name three common indicators.
(*b*) Name the acid-base indicator extracted from lichen.
(*c*) What colour does the turmeric paper turn when put in an alkaline solution ?

17. What is an olfactory indicator ? Name two olfactory indicators. What is the effect of adding sodium hydroxide solution to these olfactory indicators ?

18. (*a*) What happens when an acid reacts with a metal ? Give chemical equation of the reaction involved.
(*b*) Which gas is usually liberated when an acid reacts with a metal ? How will you test for the presence of this gas ?

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

20. What happens when an acid reacts with a metal hydrogencarbonate ? Write equation of the reaction which takes place.

21. (*a*) What happens when dilute hydrochloric acid is added to sodium carbonate ? Write a balanced chemical equation of the reaction involved.
(*b*) Which gas is liberated when dilute hydrochloric acid reacts with sodium carbonate ? How will you test for the presence of this gas ?

22. What happens when an acid reacts with a base ? Explain by taking the example of hydrochloric acid and sodium hydroxide. Give equation of the chemical reaction which takes place. What is the special name of such a reaction ?

23. What happens when an acid reacts with a metal oxide ? Explain with the help of an example. Write a balanced equation for the reaction involved.

24. (*a*) What are organic acids and mineral acids ?
(*b*) Give two examples each of organic acids and mineral acids.
(*c*) State some of the uses of mineral acids in industry.

25. What is meant by strong acids and weak acids ? Classify the following into strong acids and weak acids :
HCl, CH_3COOH, H_2SO_4, HNO_3, H_2CO_3, H_2SO_3

26. Why do HCl, H_2SO_4, HNO_3, etc., show acidic character in aqueous solutions while solutions of compounds like $C_6H_{12}O_6$ (glucose) and C_2H_5OH (alcohol) do not show acidic character ?

27. What is a neutralisation reaction ? Explain with an example. Give the chemical equation of the reaction which takes place.

28. Why should curd and other sour foodstuffs (like lemon juice, etc.) not be kept in metal containers (such as copper and brass vessels) ?

29. (*a*) What is produced if an acid is added to a base ?
(*b*) Why does dry HCl gas not change the colour of dry litmus paper ?
(*c*) What colour does phenolphthalein indicator turn when added to an alkali (such as sodium hydroxide) ?

30. (*a*) Why do acids not show acidic behaviour in the absence of water ?
(*b*) Why does an aqueous solution of an acid conduct electricity ?
(c) Why does distilled water not conduct electricity whereas rain water does ?

Long Answer Type Questions

31. (*a*) What happens when an acid reacts with a metal carbonate ? Explain with the help of an example. Write chemical equation of the reaction involved.

(*b*) What happens when carbon dioxide gas is passed through lime water :

(*i*) for a short time ?

(*ii*) for a considerable time ?

Write equations of the reactions involved.

32. With the help of labelled diagrams, describe an activity to show that acids produce ions only in aqueous solutions.

33. (*a*) Which element is common to all acids ?

(*b*) Compounds such as alcohol and glucose also contain hydrogen but are not categorised as acids. Describe an activity to prove it.

Multiple Choice Questions (MCQs)

34. 10 mL of a solution of NaOH is found to be completely neutralised by 8 mL of a given solution of HCl. If we take 20 mL of the same solution of NaOH, the amount of HCl solution (the same solution as before) required to neutralise it will be :

(*a*) 4 mL (*b*) 8 mL (*c*) 12 mL (*d*) 16 mL

35. Which of the following types of medicine is used for treating indigestion caused by over-eating ?

(*a*) antibiotic (*b*) analgesic (*c*) antacid (*d*) antiseptic

36. A solution reacts with marble chips to produce a gas which turns lime water milky. The solution contains :

(*a*) Na_2SO_4 (*b*) $CaSO_4$ (*c*) H_2SO_4 (*d*) K_2SO_4

37. One of the following is not an organic acid. This is :

(*a*) ethanoic acid (*b*) formic acid (*c*) citric acid (*d*) carbonic acid

38. The property which is not shown by acids is :

(*a*) they have sour taste (*b*) they feel soapy

(*c*) they turn litmus red (*d*) their pH is less than seven

39. The indicators which turn red in acid solution are :

(*a*) turmeric and litmus (*b*) phenolphthalein and methyl orange

(*c*) litmus and methyl orange (*d*) phenolphthalein and litmus

40. The discomfort caused by indigestion due to overeating can be cured by taking :

(*a*) vinegar (*b*) lemon juice (*c*) baking soda (*d*) caustic soda

41. The property which is common between vinegar and curd is that they :

(*a*) have sweet taste (*b*) have bitter taste (*c*) are tasteless (*d*) have sour taste

42. The indicator which produces a pink colour in an alkaline solution is :

(*a*) methyl orange (*b*) turmeric paper (*c*) phenolphthalein (*d*) litmus paper

43. A solution reacts with zinc granules to give a gas which burns with a 'pop' sound. The solution contains :

(*a*) $Mg(OH)_2$ (*b*) Na_2CO_3 (*c*) NaCl (*d*) HCl

Questions Based on High Order Thinking Skills (HOTS)

44. When a piece of limestone reacts with dilute HCl, a gas X is produced. When gas X is passed through lime water then a white precipitate Y is formed. On passing excess of gas X, the white precipitate dissolves forming a soluble compound Z.

(*a*) What are X, Y and Z ?

(*b*) Write equations for the reactions which take place :

(*i*) when limestone reacts with dilute HCl

(*ii*) when gas X reacts with lime water to form white precipitate Y

(*iii*) when excess of gas X dissolves white precipitate Y to form a soluble compound Z

45. If someone is suffering from the problem of acidity after overeating, which of the following would you suggest as remedy ?

Lemon juice, Vinegar, Baking soda solution

Give reason for your choice.

46. On adding dilute hydrochloric acid to copper oxide powder, the solution formed is blue-green.
(*a*) Predict the new compound formed which imparts a blue-green colour to solution.
(*b*) Write a balanced chemical equation of the reaction which takes place.
(*c*) On the basis of the above reaction, what can you say about the nature of copper oxide ?

47. A white shirt has a yellow stain of curry. When soap is rubbed on this shirt during washing, the yellow stain turns reddish-brown. On rinsing the shirt with plenty of water, the reddish-brown stain turns yellow again.
(*a*) Name the natural indicator present in curry stain.
(*b*) Explain the changes in colour of this indicator which take place during washing and rinsing the shirt.
(*c*) What is the nature of soap (acidic/basic) as shown by the indicator present in curry stain ?

48. You have been provided with three test-tubes. One of these test-tubes contains distilled water and the other two contain an acidic and a basic solution respectively. If you are given only blue litmus paper, how will you identify the contents of each test-tube ?

49. A substance X which is used as an antacid reacts with dilute hydrochloric acid to produce a gas Y which is used in one type of fire-extinguisher. Name the substance X and gas Y. Write a balanced equation for the chemical reaction which takes place.

50. How is the neutralisation of a carbonate with an acid different from the neutralisation of an oxide or a hydroxide ?

51. What happens to (*a*) the H^+ ions, and (*b*) temperature of the solution, when an acid is neutralised ?

ANSWERS

3. Litmus **4.** Phenolphthalein **5.** Base **6.** Base **15.** (*a*) sour ; blue ; red (*b*) water (*c*) hydrogen (*d*) olfactory (*e*) olfactory **34.** (*d*) **35.** (*c*) **36.** (*c*) **37.** (*d*) **38.** (*b*) **39.** (*c*) **40.** (*c*) **41.** (*d*) **42.** (*c*) **43.** (*d*) **44.** (*a*) X is carbon dioxide ; Y is calcium carbonate ; Z is calcium hydrogencarbonate **45.** Baking soda solution; Being basic, it neutralises excess acid in the stomach **46.** (*a*) Copper (II) chloride, $CuCl_2$ (*c*) Copper oxide is basic in nature **47.** (*a*) Turmeric (*c*) Basic **48.** Acidic solution will turn blue litmus red ; This red litmus will turn blue in basic solution ; Distilled water will have no effect on any type of litmus paper **49.** Substance X is sodium hydrogencarbonate ; Gas Y is carbon dioxide **50.** Neutralisation of a carbonate with an acid produces carbon dioxide gas but not with an oxide or hydroxide **51.** (*a*) H^+ ions of acid combine with OH^- ions of alkali to form water, H_2O (*b*) Temperature of the solution rises

BASES

The solutions of substances like caustic soda, lime (*choona)* and washing soda are bitter in taste (*kadwa swad*), and soapy to touch (slippery to touch). They are called bases. Thus : **Bases are those chemical substances which have a bitter taste.** All the bases change the colour of red litmus to blue.

Bases are the chemical opposites of acids. When bases are added to acids, they neutralise (or cancel) the effect of acids. So, we can also define a base as follows : **A base is a chemical substance which can neutralise an acid.** All the *metal oxides* and *metal hydroxides* are bases. For example, sodium oxide (Na_2O) is a metal oxide, so it is a base; and sodium hydroxide (NaOH) is a metal hydroxide, so it is also a base. Similarly, calcium oxide (or lime) (CaO) and calcium hydroxide (or slaked lime) [$Ca(OH)_2$] are bases. Ammonium hydroxide (NH_4OH) is also a base though it is not a metal hydroxide. Please note that metal carbonates and metal hydrogencarbonates are also considered to be bases because they neutralise the acids. Thus, sodium carbonate (Na_2CO_3), calcium carbonate ($CaCO_3$) and sodium hydrogencarbonate ($NaHCO_3$) are also bases.

Water Soluble Bases : Alkalis

Most of the bases *do not* dissolve in water but some bases dissolve in water. Those bases which dissolve in water without any chemical reaction have a special name. They are called alkalis. Thus, **a base which is soluble in water is called an alkali.** Some of the common water soluble bases (or alkalis) are : Sodium hydroxide (NaOH), Potassium hydroxide (KOH), Calcium hydroxide [$Ca(OH)_2$], Ammonium hydroxide (NH_4OH), and Magnesium hydroxide [$Mg(OH)_2$]. The soluble bases (or alkalis) are much more useful than insoluble bases because most of the chemical reactions take place only in aqueous solutions (or water solutions). In this class, we will study only the water soluble bases. So, **when we talk of a base in these discussions, it will actually mean a water soluble base or alkali.** So, **whether we call it a base or an alkali, it will mean the same thing.**

What Do All the Bases Have in Common

When a base is dissolved in water, it always produces hydroxide ions (OH^- ions). Thus : **A base is a substance which dissolves in water to produce hydroxide ions (OH^- ions) in solution.** For example, sodium hydroxide is a base because it dissolves in water to produce hydroxide ions (alongwith sodium ions) :

$$\underset{\substack{\text{Sodium hydroxide} \\ \text{(Base or Alkali)}}}{NaOH\ (s)} \xrightarrow{\text{Water}} \underset{\text{Sodium ions}}{Na^+\ (aq)} + \underset{\text{Hydroxide ions}}{OH^-\ (aq)}$$

A sodium hydroxide solution shows basic behaviour due to the presence of hydroxide ions (OH^- ions) in it.

Similarly, potassium hydroxide is a base which dissolves in water to give hydroxide ions (alongwith potassium ions) :

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

It is the presence of hydroxide ions (OH^- ions) in potassium hydroxide solution which imparts it basic properties (or alkaline properties).

Magnesium hydroxide is also a base which dissolves in water to some extent to produce hydroxide ions (alongwith magnesium ions) :

$$Mg(OH)_2\ (s) \xrightarrow{\text{Water}} Mg^{2+}\ (aq) + 2OH^-\ (aq)$$

Magnesium hydroxide solution shows basic character due to the presence of hydroxide ions (OH^- ions) in it.

From the above discussion we conclude that **a common property of all the bases (or alkalis) is that they all produce hydroxide ions (OH^- ions) when dissolved in water.** NaOH, KOH, $Mg(OH)_2$, $Ca(OH)_2$ and NH_4OH are all bases (or alkalis) because they dissolve in water to produce hydroxide ions (OH^- ions). Please note that when the solution of a base is diluted by mixing more water in it, then the concentration of hydroxide ions (OH^- ions) per unit volume decreases. This gives us a dilute solution of the base (or alkali). **Bases are of two types : strong bases and weak bases.** These are discussed below.

Strong Bases

A base which completely ionises in water and thus produces a large amount of hydroxide ions (OH^- ions) is called a strong base (or a strong alkali). Sodium hydroxide (NaOH) and potassium hydroxide (KOH) are strong bases (or strong alkalis). This is because they completely ionise on dissolving in water to produce a large amount of hydroxide ions (OH^- ions).

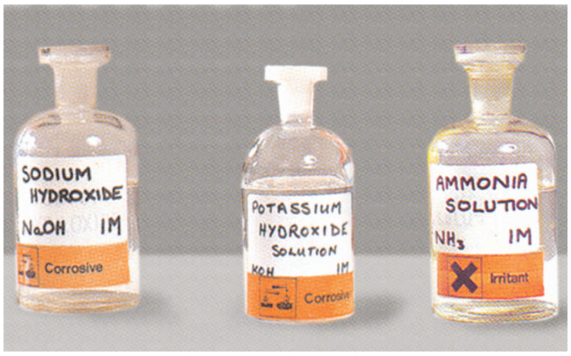


Figure 24. Sodium hydroxide and potassium hydroxide are strong bases whereas ammonium hydroxide (also called ammonia solution) is a weak base.

Weak Bases

A base which is partially ionised in water and thus produces a small amount of hydroxide ions (OH^- ions) is called a weak base (or weak alkali). Ammonium hydroxide (NH_4OH), calcium hydroxide [$Ca(OH)_2$] and magnesium hydroxide [$Mg(OH)_2$] are weak bases (or weak alkalis). This is because they ionise only partially on dissolving in water and produce a small amount of hydroxide ions (OH^- ions).

Properties of Bases

The important properties of water soluble bases (or alkalis) are given below :

1. Bases have bitter taste

2. Bases feel soapy to touch

For example, if we rub a drop of sodium hydroxide solution between the tips of our fingers, they will soon begin to feel soapy (or slippery) as if we have applied soap to them.

3. Bases turn red litmus to blue

4. Bases conduct electricity in solution (They are electrolytes)

When a base is dissolved in water, it splits up into ions. Due to the presence of ions, the solutions of bases conduct electricity.

5. Bases react with some metals to form hydrogen gas

When a base reacts with a metal, then a metal salt and hydrogen gas are formed. For example, when sodium hydroxide solution is heated with zinc, then sodium zincate and hydrogen gas are formed :

$$\underset{\substack{\text{Sodium hydroxide}\\\text{(Base)}}}{2NaOH\ (aq)} + \underset{\text{Zinc}}{Zn\ (s)} \xrightarrow{\text{Heat}} \underset{\substack{\text{Sodium zincate}\\\text{(Salt)}}}{Na_2ZnO_2\ (aq)} + \underset{\text{Hydrogen}}{H_2\ (g)}$$

Please note that in the salt formed by the reaction between a base and a metal, the metal is present as a part of the negative ion (or anion). For example, in the sodium zincate salt (Na_2ZnO_2) formed by the reaction between sodium hydroxide and zinc metal, the zinc metal is present as a part of the negative ion, zincate ion (ZnO_2^{2-}). It is very important to note that **all the metals do not react with bases to form salts and hydrogen gas.**

We can show the formation of hydrogen gas in the reaction of sodium hydroxide with zinc metal by using the experimental set-up shown in Figure 11 (on page 57).

(*i*) Take a few pieces of zinc granules in a boiling tube, add 5 mL of sodium hydroxide solution, and heat the boiling tube on a burner.

(*ii*) Repeat all the remaining steps as described in the experiment given on page 57.

(*iii*) We will find that the gas present in soap bubbles burns with a 'pop' sound showing that it is hydrogen gas.

6. Bases react with acids to form salt and water

When a *base* reacts with an *acid*, then a *salt* and *water* are formed. For example, when sodium hydroxide reacts with sulphuric acid, then sodium sulphate and water are formed :

$$\underset{\substack{\text{Sodium hydroxide}\\\text{(Base)}}}{2NaOH\ (aq)} + \underset{\substack{\text{Sulphuric acid}\\\text{(Acid)}}}{H_2SO_4\ (aq)} \longrightarrow \underset{\substack{\text{Sodium sulphate}\\\text{(Salt)}}}{Na_2SO_4\ (aq)} + \underset{\text{Water}}{2H_2O\ (l)}$$

This is an example of neutralisation reaction. We have already discussed the neutralisation reactions of acids and bases in detail in the topic on acids (see page 59).

We now know that all the acids produce hydrogen ions (H^+ ions) in solution whereas all bases produce hydroxide ions (OH^- ions) in solution. So, **when an acid and a base combine then the real neutralisation reaction occurs due to the combination of hydrogen ions present in acid and hydroxide ions present in base to form water.** So, we can write the neutralisation reaction between an acid and a base in terms of hydrogen ions and hydroxide ions as follows :

$$\underset{\substack{\text{Hydrogen ions}\\\text{(From acid)}}}{H^+\ (aq)} + \underset{\substack{\text{Hydroxide ions}\\\text{(From base)}}}{OH^-\ (aq)} \xrightarrow[\text{reaction}]{\text{Neutralisation}} \underset{\text{Water}}{H_2O\ (l)}$$

7. Bases react with non-metal oxides to form salt and water

Bases react with non-metal oxides to form salt and water :

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

Now, calcium hydroxide is a base and carbon dioxide is a non-metal oxide. So, calcium hydroxide solution reacts with carbon dioxide to produce calcium carbonate and water :

$$\underset{\substack{\text{Calcium hydroxide}\\\text{(Base)}}}{Ca(OH)_2\ (aq)} + \underset{\substack{\text{Carbon dioxide}\\\text{(Non-metal oxide)}}}{CO_2\,(g)} \longrightarrow \underset{\substack{\text{Calcium carbonate}\\\text{(Salt)}}}{CaCO_3\,(s)} + \underset{\text{Water}}{H_2O\ (l)}$$

The reactions of non-metal oxides with bases to form salt and water show that *non-metal oxides are acidic in nature.*

Uses of Bases

Some of the important uses of bases are given below :

1. Sodium hydroxide is used in the manufacture of soap, paper and a synthetic fibre called 'rayon'.
2. Calcium hydroxide (called slaked lime) is used in the manufacture of bleaching powder.
3. Magnesium hydroxide is used as an 'antacid' to neutralise excess acid in the stomach and cure indigestion.
4. Sodium carbonate is used as washing soda and for softening hard water.
5. Sodium hydrogencarbonate is used as baking soda in cooking food, for making baking powders, as an antacid to cure indigestion and in soda-acid fire extinguishers.

Figure 25. Ammonia solution is a base. Ammonia solution can be used to clean toilets and sinks.

STRENGTH OF ACID AND BASE SOLUTIONS : pH SCALE

Water (H_2O) is slightly ionised into hydrogen ions (H^+) and hydroxide ions (OH^-). ***In pure water, the concentrations of hydrogen ions and hydroxide ions are equal.*** Due to this, pure water is neither acidic nor basic, it is neutral. Now :

(*i*) Acids produce hydrogen ions in water. So, when an acid is added to water, then the concentration of hydrogen ions in water increases. The solution of acid thus formed will have more of hydrogen ions (and less of hydroxide ions), and it will be acidic in nature. In other words, ***acidic solutions have excess of hydrogen ions.*** Please note that *even the acidic solutions contain hydroxide ions* which come from the ionisation of water but the concentration of hydroxide ions in acidic solutions is much less than that of hydrogen ions.

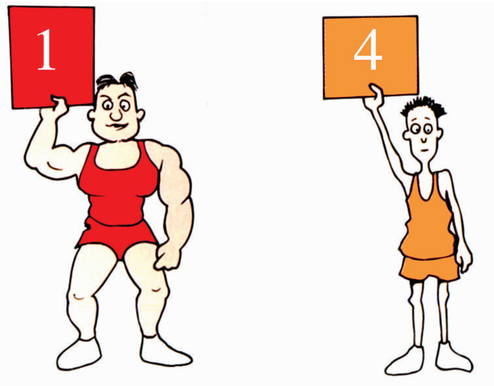
(*ii*) Bases produce hydroxide ions in water. So, when a base is added to water, then the concentration of hydroxide ions in it increases. The solution formed by dissolving a base in water will have more of hydroxide ions (and less of hydrogen ions), and it will be basic in nature. In other words, ***the basic solutions have excess of hydroxide ions***. Please note that *even the basic solutions have hydrogen ions in them* which come from the ionisation of water but the concentration of hydrogen ions in basic solutions is much less than that of hydroxide ions.

From the above discussion we conclude that *both acidic solutions as well as basic solutions contain hydrogen ions.* **In 1909 Sorenson devised a scale (known as pH scale) on which the strength of acid solutions as well as basic solutions could be represented by making use of the hydrogen ion concentrations in them.** Sorenson linked the hydrogen ion concentrations of acid and base solutions to the simple numbers 0 to 14 on his pH scale. **The pH of a solution is inversely proportional to the concentration of hydrogen ions in it.** That is, a solution having a *high* concentration of hydrogen ions has a *low* pH value. On the other hand, a solution having *low* concentration of hydrogen ions has a *high* pH value. In the term pH, letter 'p' stands for a German word 'potenz' which means 'power' and letter H stands for hydrogen ion concentration [H^+].

The strength of an acid or base is measured on a scale of numbers called the pH scale. The pH scale has values from 0 to 14. Please note that pH is a pure number, it has *no units.* According to the rules of pH scale :

1. Neutral substances have a pH of exactly 7. Pure water is a neutral substance (it is neither acidic nor basic). So, **the pH of pure water is 7.** A sugar solution and sodium chloride solution are also neutral, each having a pH of 7. So, whenever the pH of a solution is 7, it will be a neutral substance. *A substance having pH 7 will have no effect on litmus or any other common indicator such as methyl orange or phenolphthalein, etc.*

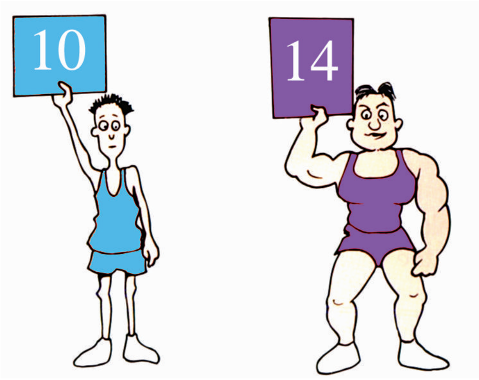
2. Acids (or acidic solutions) have a pH of less than 7. Whenever a solution has a pH of less than 7, it will be an *acidic* solution. For example, a solution having a pH of 4 will be acidic in nature (or it will be an acid). Please note that **more acidic a solution is, the lower will be its pH.** For example, a solution of pH 1 is much more acidic than another solution of pH 4. In other words, a solution of pH 1 will be a much more stronger acid than another acid having pH 4 (see Figure 26). The solutions having pH of 0, 1, 2 and 3 are usually considered to be strong acids. And the solutions having pH of 4, 5 and 6 are considered to be weak acid solutions. It is clear that the acidity of a substance is related to its pH. Strongly acidic substances have a very low pH. In fact, **lower the pH, the stronger the acid.** Please note that *all the solutions having pH less than 7 are acidic in nature and hence they turn blue litmus to red. They also turn methyl orange indicator red.*



(*a*) Hydrochloric acid : Strong acid (*b*) Acetic acid : Weak acid

Figure 26. In case of acids, lower the pH, stronger the acid.

3. Bases (or basic solutions) have a pH of more than 7. Whenever a solution has a pH of more than 7, it will be a *basic* solution or *alkaline* solution (or it will be a base or an alkali). For example, a solution having a pH of 11 will be basic in nature (or it will be a base). Please note that **the more basic a solution is, the higher will be its pH.** For example, a solution of pH 14 will be much more basic than another solution of pH 10. In other words, a solution of pH 14 will be a much more stronger base than another solution of pH 10 (see Figure 27). The solutions having pH values of 8, 9 and 10 are usually considered weak bases (or weak alkalis). And the solutions having pH values of 11, 12, 13, and 14 are usually considered strong bases (or strong alkalis). In fact, **the higher the pH, the stronger the base (or alkali).** *All the substances having pH more than 7 are basic in nature (or alkaline in nature) and hence they turn red litmus to blue. They also turn phenolphthalein indicator pink.*



(*a*) Magnesium hydroxide : Weak base (*b*) Sodium hydroxide : Strong base

Figure 27. In case of bases, higher the pH, stonger the base.

The common pH scale having pH values from 0 to 14 is given in Figure 28. At pH 7, a solution is neutral (see Figure 28). As the pH of solution decreases from 7 to 0, the hydrogen ion concentration in the solution goes on increasing and hence the strength of acid goes on increasing (see Figure 28). On the other hand, as the pH of solution increases from 7 to 14, the hydroxide ion concentration in the solution goes on increasing, due to which the strength of base (or alkali) also goes on increasing (see Figure 28).

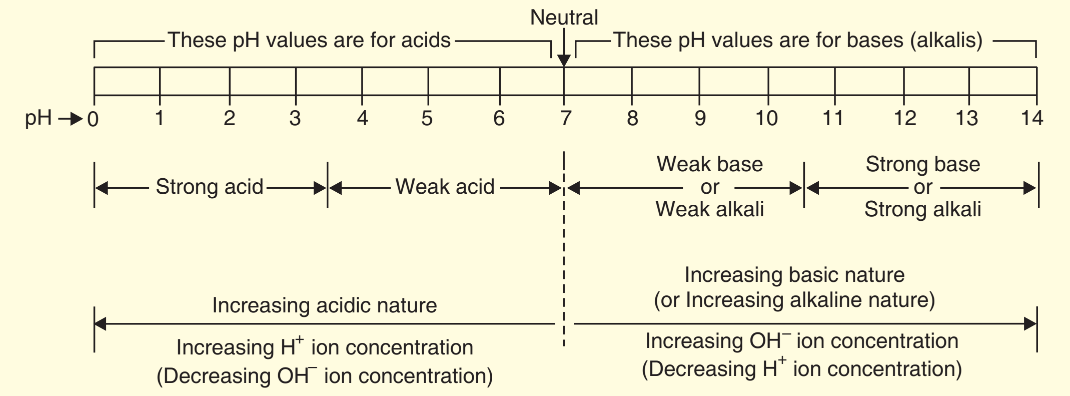


Figure 28. pH scale.

The pH values of some of the common substances from our everyday life are given below.

pH Values of Some Common Substances

Solution	*pH*	*Solution*	*pH*
1. Concentrated hydrochloric acid	0	11. Saliva (*before meals*)	7.4
2. Dilute hydrochloric acid	1.0	12. Saliva (*after meals*)	5.8
3. Gastric juices (*Digestive juices in stomach*)	1.4	13. Blood	7.4
		14. Eggs	7.8
4. Lemon juice	2.5	15. Toothpaste	8.0
5. Vinegar	4.0	16. Baking soda solution	8.5
6. Tomato juice	4.1	17. Washing soda solution	9.0
7. Coffee	5.0	18. Milk of magnesia	10.5
8. Soft drinks	6.0	19. Household ammonia	11.6
9. Milk	6.5	20. Dilute sodium hydroxide	13.0
10. Pure water	**7.0**	21. Concentrated sodium hydroxide	14

Universal Indicator

The common indicators (like litmus) can tell us whether the given substance is an acid or a base. They cannot tell us whether the given substance is a strong acid, a weak acid, a strong base or a weak base. In other words, **the common indicators cannot tell us the relative strengths of acids or bases.** For example, litmus can tell us that sulphuric acid and vinegar are both acidic but it cannot tell us that sulphuric acid is a stronger acid (or more acidic) than vinegar solution. We can, however, measure the strength of an acid solution or a base solution by using a special type of indicator called 'universal indicator' (which works by measuring the pH of a solution). Thus, **to obtain an idea of how acidic or basic a substance is, universal indicator is used**. This will become clear from the following discussion.

A common method of measuring the pH of a solution in the school laboratory is to use universal indicator. **Universal indicator is a mixture of many different indicators (or dyes) which gives different colours at different pH values of the entire pH scale.** Since the pH of a solution depends on the hydrogen ion concentration, so we can also say that the universal indicator shows different colours at different concentrations of hydrogen ions in the solution. When an acid or base solution is added to the universal indicator, the indicator produces a new colour. The colour produced by universal indicator is used to find the pH value of the acid or base solution by matching the colour with the colours on pH colour chart. And knowing the pH value, we can make out whether the given solution is a strong acid, weak acid, strong base or a weak base. The colours produced by universal indicator at various pH values are given below :

pH	*Colour*	*pH*	*Colour*	*pH*	*Colour*
0	Dark red	5	Orange yellow	10	Navy blue
1	Red	6	Greenish yellow	11	Purple
2	Red	**7**	**Green**	12	Dark purple
3	Orange red	8	Greenish blue	13	Violet
4	Orange	9	Blue	14	Violet

The colours produced by universal indicator paper at various pH values are shown in the chart given below :

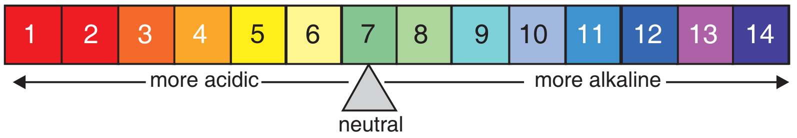


Figure 29. This pH colour chart shows how the colour of universal indicator paper changes with solutions of different pH values.

The makers of universal indicator provide a pH colour chart to compare the colour produced on the indicator paper (or solution) on adding acid or base solution and find out its pH value (see Figure 29). *Just like litmus, universal indicator can be used either in the form of a solution or in the form of universal indicator paper.* We will now describe how a universal indicator paper is used to measure the pH value of a solution.

A drop of the solution to be tested is put on a strip of universal indicator paper. The indicator paper will undergo a change in colour (where the solution has been put). The colour produced on indicator paper is then matched with a colour on the standard pH colour chart (available in the laboratory). We can read the pH value corresponding to this colour from the pH colour chart. And knowing the pH value, we can tell whether the given solution is a strong acid, a weak acid, a strong base or a weak base.

For example, if on putting the drop of a solution on the universal indicator paper, the paper turns dark red, then its pH will be around 0 (zero) and hence it will be a strong acid. On the other hand, if an orange colour is produced, then the pH will be about 4 and it will be a weak acid. There are also different colours produced with different basic solutions (or alkaline solutions). The weakly basic solutions produce blue colour whereas highly basic solutions give violet colour with universal indicator (see Figure 30). Please note that if a solution turns universal indicator green, then it will be a neutral solution (which is neither acidic nor basic). Thus, **water will produce a green colour with universal indicator**. Let us solve some problems now.

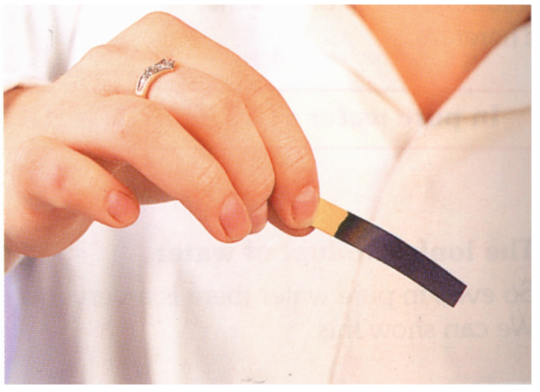


Figure 30. A solution has turned this universal indicator paper violet showing that it is a strong base (or strong alkali).

Sample Problem 1. You have two solutions A and B. The pH of solution A is 6 and pH of solution B is 8.

(*a*) Which solution has more hydrogen ion concentration ?

(*b*) Which of the solutions is acidic and which one is basic ? **(NCERT Book Question)**

Solution. (*a*) We know that the pH of a solution is inversely proportional to its hydrogen ion concentration. This means that *the solution having lower pH will have more hydrogen ion concentration.* In this case, solution A (having a lower pH of 6) will have more hydrogen ion concentration.

(*b*) Solution A is acidic and solution B is basic.

Sample Problem 2. Five solutions A, B, C, D, and E when tested with universal indicator showed pH of 4, 1, 11, 7 and 9, respectively.

(*a*) Which solution is : (*i*) neutral (*ii*) strongly alkaline (*iii*) strongly acidic (*iv*) weakly acidic, and (*v*) weakly alkaline ?

(*b*) Arrange the pH in the increasing order of hydrogen ion concentration. **(NCERT Book Question)**

Solution (*a*) (*i*) neutral : D (pH = 7); (*ii*) strongly alkaline : C (pH = 11); (*iii*) strongly acidic : B (pH = 1); (*iv*) weakly acidic : A (pH = 4); (*v*) weakly alkaline : E (pH = 9).

(*b*) The solution having highest pH (11) will have the minimum hydrogen ion concentration whereas the solution having the least pH (1) will have the maximum hydrogen ion concentration. So, the given solutions can be arranged in the increasing order of their hydrogen ion concentrations as follows :

C	E	D	A	B
(pH 11)	(pH 9)	(pH 7)	(pH 4)	(pH 1)

Decreasing order of pH
$\longrightarrow$
Increasing order of hydrogen ion concentration

IMPORTANCE OF pH IN EVERYDAY LIFE

The pH plays an important role in many activities of our everyday life. For example, pH of gastric juices in the stomach is important in the process of digestion; the pH changes in mouth can become a cause of tooth decay; the growth of plants and survival of animals also depends on the proper maintenance of pH; and many animals (like insects), and some plants make use of acidic and basic liquids for self defence purposes. Let us discuss all this in somewhat detail.

1. pH in Our Digestive System

Our stomach produces hydrochloric acid (of pH about 1.4). This **dilute hydrochloric acid helps in digesting our food** without harming the stomach. Sometimes, excess of acid is produced in the stomach due to various reasons (one being overeating). **The excess acid in the stomach causes indigestion** which produces pain and irritation. In order to cure indigestion and get rid of pain, we can take bases called 'antacids' ('antacid' means 'anti-acid'). Antacids are a group of mild bases which have no toxic effects on the body. **Being basic in nature, antacids react with excess acid in the stomach and neutralise it.** This gives relief to the person concerned. The two common antacids used for curing indigestion due to acidity are : **Magnesium hydroxide (Milk of Magnesia)** and **Sodium hydrogencarbonate (Baking soda)** (see Figure 31).

(*a*) Milk of magnesia is a medicine for indigestion. It contains magnesium hydroxide as antacid.

(*b*) Many antacid tablets used for curing indigestion contain sodium hydrogencarbonate as antacid.

Figure 31. Mild bases are used as antacids for curing indigestion.

2. pH Change as the Cause of Tooth Decay

When we eat food containing sugar, then **the bacteria present in our mouth break down the sugar to form acids** (such as lactic acid). Thus, acid is formed in the mouth after a sugary food has been eaten. This acid lowers the pH in the mouth (making it acidic). **Tooth decay starts when the pH of acid formed in the mouth falls below 5.5.** This is because then the acid becomes strong enough to attack the enamel of our teeth and corrode it. This sets in tooth decay. Though tooth enamel is made of calcium phosphate (which is the hardest material in our body), but it starts getting corroded when the pH in the mouth is lower than 5.5 (see Figure 32).

The best way to prevent tooth decay is to clean the mouth thoroughly after eating food (by rinsing it with lots of clean water). Many toothpastes contain bases to neutralise the mouth acid (The pH of toothpaste being about 8.0). So, using the toothpastes (which are basic) for cleaning the teeth can neutralise the excess acid in mouth and prevent tooth decay (see Figure 33). A person can lessen the chances of suffering from tooth decay by changing his eating habits such as eating less of sugary foods like sweets, toffees, ice-cream, chocolates, and candy, etc.

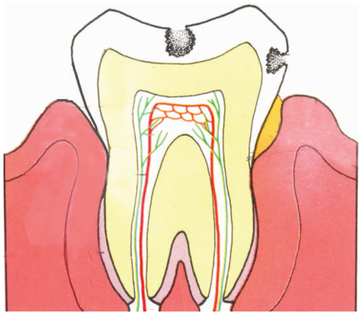


Figure 32. Tooth decay starts on the top of large back teeth and where one tooth touches another.

Figure 33. Toothpaste is slightly basic (or alkaline). It helps prevent tooth decay by neutralising the excess acid in our mouth.

3. Plants and Animals are Sensitive to pH Changes

The plants and animals are sensitive to pH changes in their environment. In fact, the growth of plants and survival of animals depends to a large extent on the availability of proper pH conditions which suit them.

(*i*) Soil pH and Plant Growth. Most of the plants grow best when the pH of the soil is close to 7. If the soil is too acidic or too basic (too alkaline), the plants grow badly or do not grow at all. The soil may be acidic or basic naturally. The soil pH is also affected by the use of chemical fertilisers in the fields. 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 (such as crops).

Most often the soil in the fields is too acidic. **If the soil is too acidic (having low pH), 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. Thus, a farmer should add lime (or slaked lime or chalk) in his fields when the soil is too acidic. Sometimes, however, the soil is too basic (or too alkaline) having a high pH. If the soil is too alkaline then its alkalinity can be reduced by adding decaying organic matter (manure or compost) which contains acidic materials.

Figure 34. Farmers add slaked lime in the fields to reduce the acidity of soil.

We can check the pH of a soil ourselves as follows : Take about 2 g of soil in a test-tube and add 5 mL of water to it. Shake the test-tube well. Filter the contents of the test-tube through a filter paper and collect the filtrate. Find the pH of this filtrate by using the universal indicator paper. This will give us the pH of the given sample of soil.

(*ii*) pH Change and Survival of Animals. 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. If, due to some reason, this pH range gets disturbed in the body of a person, then many ailments can occur. The aquatic animals (like fish) can survive in lake or river water within a narrow range of pH change. This will become clear from the following example. When the pH of rain water is about 5.6, it is called acid rain. Too much acid rain can lower the pH of lake water or river water to such an extent (and make it so acidic) that the survival of aquatic animals becomes difficult. The high acidity of lake water or river water can even kill the aquatic animals (like fish) (see Figure 35). Calcium carbonate is often added to acidic lake water to neutralise the acid that comes from acid rain (see Figure 36). This prevents the fish in the lake from being killed.

Figure 35. These fish have been killed by the high acidity of lake water caused by acid rain.

Figure 36. Calcium carbonate is usually added to lakes to neutralise the acid that comes from rain water.

Acids are also present on other planets. For example, the atmosphere of planet Venus is made up of thick white and yellowish clouds of sulphuric acid. So, life cannot exist on the planet Venus.

4. Self Defence by Animals and Plants Through Chemical Warfare

Many animals and plants protect themselves from their enemies by injecting painful and irritating acids and bases into their skin. For example, **when a honey-bee stings a person, it injects an acidic liquid into the skin** which causes immense pain and irritation. If the bee stings a person, then rubbing a mild base like **baking soda** solution on the stung area of the skin gives relief. This is because, being a base, **baking soda** neutralises the acidic liquid injected by bee sting and cancels its effect. **When a wasp stings, it injects an alkaline liquid into the skin**. So, if a wasp stings a person, then rubbing a mild acid like **vinegar** on the stung area of the skin gives relief. This is because, being an acidic substance, vinegar neutralises the alkaline liquid injected by the wasp sting and cancels its effect. Please note that a bee's sting is acidic whereas wasp sting is alkaline in nature. **An ant's sting injects methanoic acid into the skin of a person causing burning pain.** Being acidic, an ant's sting can be neutralised by rubbing a mild base like baking soda on the affected area of the skin.

Figure 37. Bee stings inject an acidic liquid into a person's skin whereas wasp stings inject an alkaline liquid (basic liquid) into a person's skin causing immense pain.

Figure 38. The stinging hair of nettle plant leaves inject methanoic acid into the skin of a person causing burning pain.

Plants are no better than animals ! Some plants also give painful stings. For example, nettle is a wild herbaceous plant found in the jungles. The nettle leaves have stinging hair. **When a person happens to touch the leaves of a nettle plant accidently, the stinging hair of nettle leaves inject methanoic acid into**

the skin of the person causing burning pain. The nettle sting, being acidic, can be neutralised by rubbing **baking soda** on the skin. Even nature itself has provided remedy for the nettle stings in the form of a 'dock' plant. So, a traditional remedy for the nettle leaf sting is to rub the stung area of the skin of the person with the leaf of a dock plant (which often grows beside the nettle plant in the jungle). Actually, the leaves of dock plant contain some basic chemical in them which neutralises the acidic sting of the nettle plant leaves and gives relief. We are now in a position to **answer the following questions :**

Very Short Answer Type Questions

1. Name the gas evolved when zinc granules are treated/heated with :
(*a*) hydrochloric acid solution
(*b*) sodium hydroxide solution
2. What is the common name of water soluble bases ?
3. What is common in all the water soluble bases (or alkalis) ?
4. Why does tooth decay start when the pH of mouth is lower than 5.5 ?
5. What is the pH of a neutral solution ?
6. Which is more acidic : a solution of pH = 2 or a solution of pH = 6 ?
7. Which is more basic (or more alkaline) : a solution of pH = 8 or a solution of pH = 11 ?
8. Name the scientist who developed the pH scale.
9. Name the indicator which can give us an idea of how strong or weak an acid or base is.
10. The pH of soil A is 7.5 while that of soil B is 4.5. Which of the two soils, A or B, should be treated with powdered chalk to adjust its pH and why ?
11. What is the name of the indicator which can be used for testing the pH of a solution ?
12. What colour will universal indicator show if you add it to the following substances ?
(*a*) potassium hydroxide, pH = 12
(*b*) soda water, pH = 5
(*c*) sulphuric acid, pH = 2
13. A beaker of concentrated hydrochloric acid has a pH of 1. What colour will full range universal indicator turn if it is added to this beaker ? Is it a strong or a weak acid ?
14. Two solutions X and Y are tested with universal indicator. Solution X turns orange whereas solution Y turns red. Which of the solutions is a stronger acid ?
15. Two solutions A and B have pH values of 3.0 and 9.5 respectively. Which of these will turn litmus solution from blue to red and which will turn phenolphthalein from colourless to pink ?
16. Two drinks P and Q gave acidic and alkaline reactions, respectively. One has a pH value of 9 and the other has a pH value of 3. Which drink has the pH value of 9 ?
17. Two solutions X and Y have pH = 4 and pH = 8, respectively. Which solution will give alkaline reaction and which one acidic ?
18. Fill in the following blanks with suitable words :
(*a*) Acids have a pH................than 7.
(*b*) Alkalis have a pH................ than 7.
(*c*) Neutral substances have a pH of ....
(*d*) The more acidic a solution, the .... the pH.
(*e*) The more alkaline a solution, the.................... the pH.

Short Answer Type Questions

19. Fresh milk has a pH of 6. When it changes into curd (yogurt), will its pH value increase or decrease ? Why ?
20. (*a*) What is a universal indicator ? For what purpose is it used ?
(*b*) How does a universal indicator work ?
(*c*) Water is a neutral substance. What colour will you get when you add a few drops of universal indicator to a test-tube containing water ?
21. Which chemical is injected into the skin of a person :
(*a*) during an ant's sting ?

(*b*) during the nettle leaf hair sting ?
How can the effect of these stings be neutralised ?

22. (*a*) Explain the pH change as the cause of tooth decay. How can tooth decay caused by pH change be prevented ?
(*b*) Explain how pH change in the lake water can endanger the lives of aquatic animals (like fish). What can be done to lessen the danger to the lives of aquatic animals in the lake ?

23. (*a*) What happens during a bee sting ? What is its remedy ?
(*b*) What happens during a wasp sting ? What is its remedy ?

24. (*a*) Why is it wrong to treat a bee sting with vinegar ?
(*b*) Why is it wrong to treat a wasp sting with baking soda solution ?

25. (*a*) What does the pH of a solution signify ? Three solutions A, B and C have pH values of 6, 4 and 10 respectively. Which of the solutions is highly acidic ?
(*b*) A farmer has found that the pH of soil in his fields is 4.2. Name any two chemical materials which he can mix with the soil to adjust its pH.

26. (*a*) The pH values of six solutions A to F are given below :
A = 0, B = 11, C = 6, D = 3, E = 13, F = 8
Which of the above solutions are (*i*) acids (*ii*) alkalis ?
(*b*) Name the acids or alkalis used to make (*i*) car batteries (*ii*) explosives (*iii*) soaps (*iv*) fertilisers.

27. (*a*) The pH of a cold drink is 5. What will be its action on blue and red litmus solutions ?
(*b*) The pH values of three acids A, B and C having equal molar concentrations are 5.0, 2.8 and 3.5 respectively. Arrange these acids in order of the increasing acid strengths.

28. Under what soil conditions do you think a farmer would treat the soil of his fields with quicklime (calcium oxide), or slaked lime (calcium hydroxide) or chalk (calcium carbonate) ?

29. Which acid is produced in our stomach ? What happens if there is an excess of acid in the stomach ? How can its effect be cured ?

30. The soil in a field is highly acidic. Name two materials which can be added to this soil to reduce its acidity. Give the reason for your choice.

31. What is meant by strong bases and weak bases ? Classify the following into strong bases and weak bases :
NH_4OH, $Ca(OH)_2$, $NaOH$, KOH, $Mg(OH)_2$

32. What ions are present in the solutions of following substances ? (write the symbols only)
(*i*) Hydrochloric acid (*ii*) Nitric acid (*iii*) Sulphuric acid (*iv*) Sodium hydroxide
(*v*) Potassium hydroxide (*vi*) Magnesium hydroxide

33. (*a*) What would you expect the pH of pure water to be ?
(*b*) What colour would the universal indicator show in an aqueous solution of sugar ? Why ?
(*c*) A sample of rain water turned universal indicator paper yellow. What would you expect its pH to be ? Is it a strong or a weak acid ?

34. (*a*) What do you think will be the pH in the stomach of a person suffering from indigestion : less than 7 or more than 7 ?
(*b*) What do you think will be the pH of an antacid solution : less than 7 or more than 7 ?
(*c*) How does an antacid work ?
(*d*) Name two common antacids.

35. Separate the following into substances having pH values above and below 7. How do these influence litmus paper ?
(*i*) Lemon juice (*ii*) Solution of washing soda (*iii*) Toothpaste (*iv*) Vinegar (*v*) Stomach juices

36. (*a*) Do basic solutions also have H^+ (aq) ions ? If yes, then why are they basic ?
(*b*) When a solution becomes more acidic, does the pH get higher or lower ?

Long Answer Type Questions

37. (*a*) Define an acid and a base. Give two examples of each.
(*b*) Give the names and formulae of two strong bases and two weak bases.
(*c*) What type of ions are formed :
(*i*) when an acid is dissolved in water ?

(*ii*) when a base (or alkali) is dissolved in water ?

(*d*) Write the neutralisation reaction between acids and bases in terms of the ions involved.

(*e*) Write any two important uses of bases.

38. (*a*) What happens when zinc granules are heated with sodium hydroxide solution ? Write equation of the reaction which takes place.

(*b*) What happens when bases react with non-metal oxides ? Explain with the help of an example. What does this reaction tell us about the nature of non-metal oxides ?

39. (*a*) What effect does the concentration of H^+ (aq) ions have on the nature of a solution ?

(*b*) What effect does the concentration of OH^- ions have on the nature of a solution ?

(*c*) Someone put some universal indicator paper into vinegar. The pH is 3. What does this tell you about the vinegar ?

(*d*) Someone put some universal indicator paper onto wet soap. The pH is 8. What does this tell you about the soap ?

(*e*) State whether a solution is acidic, alkaline or neutral if its pH is :

(*i*) 9 (*ii*) 4 (*iii*) 7 (*iv*) 1 (*v*) 10 (*vi*) 3

Multiple Choice Questions (MCQs)

40. One of the following is a medicine for indigestion. This is :

(*a*) sodium hydroxide (*b*) manganese hydroxide

(*c*) magnesium hydroxide (*d*) potassium hydroxide

41. Bee sting contains :

(*a*) an acidic liquid (*b*) a salt solution (*c*) an alkaline liquid (*d*) an alcohol

42. Wasp sting contains :

(*a*) a sugar solution (*b*) an acidic liquid (*c*) a salt solution (*d*) an alkaline liquid

43. One of the following does not inject an acidic liquid into the skin through its sting. This is :

(*a*) honey bee (*b*) ant (*c*) wasp (*d*) nettle leaf hair

44. A solution turns red litmus blue. Its pH is likely to be :

(*a*) 1 (*b*) 4 (*c*) 5 (*d*) 10

45. A solution turns blue litmus red. Its pH is likely to be :

(*a*) 7 (*b*) 5 (*c*) 8 (*d*) 14

46. A solution turns phenolphthalein indicator pink. The most likely pH of this solution will be :

(*a*) 6 (*b*) 4 (*c*) 9 (*d*) 7

47. The colour of methyl orange indicator in a solution is yellow. The pH of this solution is likely to be :

(*a*) 7 (*b*) less than 7 (*c*) 0 (*d*) more than 7

48. Bee stings can be treated with :

(*a*) vinegar (*b*) sodium hydrogencarbonate

(*c*) potassium hydroxide (*d*) lemon juice

49. Wasp stings can be treated with :

(*a*) baking soda (*b*) vinegar (*c*) washing soda (*d*) milk of magnesia

50. It has been found that rubbing vinegar on the stung area of the skin of a person gives him relief. The person has been stung by :

(*a*) wasp (*b*) ant (*c*) honey bee (*d*) nettle leaf hair

51. Fresh milk has a pH of 6. When milk changes into curd, the pH value will :

(*a*) become 7 (*b*) become less than 6 (*c*) become more than 7 (*d*) remain unchanged

52. The acid produced naturally in our stomach is :

(*a*) acetic acid (*b*) citric acid (*c*) hydrochloric acid (*d*) sulphuric acid

53. The daffodil plants grow best in a soil having a pH range of 6.0 to 6.5. If the soil in a garden has a pH of 4.5, which substance needs to be added to the soil in order to grow daffodils ?

(*a*) salt (*b*) lime (*c*) sand (*d*) compost

Questions Based on High Order Thinking Skills (HOTS)

54. A milkman adds a very small amount of baking soda to fresh milk.
(*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 ?

55. Which of the following elements would form oxides which would indicate pH values less than seven, using moist pH paper ?
Magnesium, Carbon, Sulphur, Hydrogen , Copper

56. The pH values of five solutions A, B, C, D and E are given below :

A	1
B	5
C	7
D	11
E	13

Which solution is (*i*) weakly alkaline (*ii*) neutral (*iii*) strongly acidic (*iv*) strongly alkaline, and (*v*) weakly acidic ?

57. Potatoes grow well on Anhad's farm which has soil with a pH of 5.5. Anhad decides to add lot of lime to soil so that he can grow broccoli in the same farm :
(*a*) Do potatoes grow better in acidic or alkaline soil ?
(*b*) Does broccoli grow better in acidic or alkaline soil ?

58. Here are some results of solutions tested with universal indicator paper :

Sulphuric acid	:	Red
Metal polish	:	Dark blue
Washing-up liquid	:	Yellow
Milk of magnesia	:	Light blue
Oven cleaner	:	Purple
Car battery acid	:	Pink

Arrange the solutions in order of their increasing pH values (starting with the one with the lowest pH).

59. Solution A turns universal indicator blue to purple whereas solution B turns universal indicator orange to red.
(*a*) What will be the action of solution A on litmus ?
(*b*) What will be action of solution B on litmus ?
(*c*) Name any two substances which can give solutions like A.
(*d*) Name any two substances which can give solutions like B.
(*e*) What sort of reaction takes place when solution A reacts with solution B ?

60. A first-aid manual suggests that vinegar should be used to treat wasp stings and baking soda for bee stings. What does this information tell you about the chemical nature of :
(*a*) wasp stings ?
(*b*) bee stings ?

61. (*a*) Explain why the pH in a person's mouth becomes lower after each meal.
(*b*) What damage could be caused while the pH is low ?
(*c*) How could the person change his eating habits to lessen chances of suffering from tooth decay ?

62. A group of students measured the pH of some substances they found in their homes. Their results are given in the following table :

Substance	*pH*	*Substance*	*pH*
Apples	3.0	Salt	7.0
Baking soda	8.5	Sugar	7.0
Black coffee	5.0	Toothpaste	9.0
Household ammonia	12.0	Vinegar	3.0
Lemon juice	2.5	Washing soda	11.5
Milk	6.5		

(*a*) What would the students have used to measure the pH ?
(*b*) Which solution is the most acidic ?

(*c*) Which solution is the most alkaline ?

(*d*) Which solutions are neutral ?

(*e*) Which solution can be used to treat wasp stings ?

(*f*) Which solution can be used to treat bee stings ?

63. Hydrochloric acid reacts with a metal X to form a gas Y which burns with a 'pop' sound. Sodium hydroxide solution also reacts with the same metal X (on heating) to form the same gas Y.

(*a*) Name X and Y

(*b*) Write the chemical equation of the reaction of metal X with (*i*) hydrochloric acid, and (*ii*) sodium hydroxide solution.

ANSWERS

1. (*a*) Hydrogen (*b*) Hydrogen **6.** Solution of pH = 2 **7.** Solution of pH = 11 **9.** Universal indicator **10.** Soil B ; To reduce its acidity **12.** (*a*) Dark purple (*b*) Orange yellow (*c*) Red **13.** Red ; Strong acid **14.** Solution Y **15.** Solution A : Litmus from blue to red : Solution B : Phenolphthalein from colourless to pink **16.** Drink Q **17.** Alkaline reaction : Solution Y ; Acidic reaction : Solution X **18.** (*a*) lower (*b*) higher (*c*) 7 (*d*) lower (*e*) higher **19.** pH value will decrease ; Acid is formed **20.** (*c*) Green colour **25.** (*a*) Solution B (*b*) Slaked lime ; Chalk **26.** (*i*) Acids : A, C and D (*ii*) Alkalis : B, E and F **27.** (*a*) Turns blue litmus red ; No action on red litmus (*b*) A < C < B **28.** When the soil is too acidic

33. (*a*) 7 (*b*) Green ; Neutral solution (*c*) Between 5 and 6 ; Weak acid **34.** (*a*) Less than 7 (*b*) More than 7 **35.** Solutions having pH values above 7 : Solution of Washing soda and Toothpaste (They turn red litmus paper blue) ; Solutions having pH values less than 7 : Lemon juice ; Vinegar and Stomach juices (They turn blue litmus paper red) **36.** (*b*) pH gets lower **39.** (*a*) As the concentration of H^+ (aq) ions increases, the solution becomes more acidic (*b*) As the concentration of OH^- ions increases, the solution becomes more basic (*c*) Vinegar is acidic (*d*) Soap is basic (*e*) (*i*) Alkaline (*ii*) Acidic (*iii*) Neutral (*iv*) Acidic (*v*) Alkaline (*vi*) Acidic **40.** (*c*) **41.** (*a*) **42.** (*d*) **43.** (*c*) **44.** (*d*) **45.** (*b*) **46.** (*c*) **47.** (*d*) **48.** (*b*) **49.** (*b*) **50.** (*a*) **51.** (*b*) **52.** (c) **53.** (*b*) **54.** (*a*) Milk is made slightly alkaline so that it may not become sour easily due to the formation of lactic acid in it (*b*) The alkaline milk takes a longer time to set into curd because the lactic acid being formed has to first neutralise the alkali present in it. **55.** Carbon and Sulphur : They form acidic oxides **56.** (*i*) D (*ii*) C (*iii*) A (*iv*) E (*v*) B **57.** (*a*) Acidic soil (*b*) Alkaline soil **58.** Sulphuric acid < Car battery acid < Washing-up liquid < Milk of magnesia < Metal polish < Oven cleaner **59.** (*a*) Solution A turns litmus blue (*b*) Solution B turns litmus red (c) Milk of magnesia and Sodium hydroxide solution (*d*) Lemon juice and Hydrochloric acid (*e*) Neutralisation reaction **60.** (*a*) Wasp stings are alkaline (*b*) Bee stings are acidic **62.** (*a*) Universal indicator paper (*b*) Lemon juice (*c*) Household ammonia (*d*) Salt solution and Sugar solution (*e*) Vinegar (*f*) Baking soda **63.** (*a*) Metal X is zinc ; Gas Y is hydrogen

SALTS

A salt is a compound formed from an acid by the replacement of the hydrogen in the acid by a metal. Here is an example. Hydrochloric acid is HCl. Now, if we replace the hydrogen (H) of this acid by a metal atom, say a sodium atom (Na), then we will get a salt NaCl. This is called sodium chloride. It is a salt. In some salts, however, the hydrogen of acid is replaced by an ammonium group (NH_4) as in the case of ammonium chloride, NH_4Cl. The best known salt is sodium chloride (NaCl) which is usually known as common salt. Please note that **'salt' is a general name and it does not refer only to sodium chloride**. In fact, sodium chloride is just one member of a huge family of compounds called 'salts'. So, in addition to sodium chloride, we have a large number of other salts too.

Figure 39. All these substances are salts.

Salts are formed when acids react with bases. In a way, we can say that a salt has two parents : an acid and a base. So, the name of a salt consists of two parts : the first part of the name of salt is derived from the name of base, and the second part of the name of the salt comes from the name of acid. For example, the name of a salt called 'sodium chloride' comes from sodium hydroxide base and hydrochloric acid. Please note that :

(*i*) **The salts of 'hydrochloric acid' are called 'chlorides'.**
(*ii*) **The salts of 'sulphuric acid' are called 'sulphates'.**
(*iii*) **The salts of 'nitric acid' are called 'nitrates'.**
(*iv*) **The salts of 'carbonic acid' are called 'carbonates'.**
(*v*) **The salts of 'acetic acid' are called 'acetates',** and so on.

The names of some of the important salts and their formulae are given below :

Some Important Salts and their Formulae

Salt	*Formula*	*Salt*	*Formula*
Sodium chloride	$NaCl$	Zinc sulphate	$ZnSO_4$
Calcium chloride	$CaCl_2$	Copper sulphate	$CuSO_4$
Magnesium chloride	$MgCl_2$	Ammonium sulphate	$(NH_4)_2SO_4$
Zinc chloride	$ZnCl_2$	Sodium nitrate	$NaNO_3$
Sodium sulphate	Na_2SO_4	Potassium nitrate	KNO_3
Potassium sulphate	K_2SO_4	Sodium carbonate	Na_2CO_3
Calcium sulphate	$CaSO_4$	Calcium carbonate	$CaCO_3$
Magnesium sulphate	$MgSO_4$	Zinc carbonate	$ZnCO_3$
Aluminium sulphate	$Al_2(SO_4)_3$	Sodium acetate	CH_3COONa

Salts are mostly solids. They have high melting points and boiling points. Salts are usually soluble in water. **Just like acids and bases, solutions of salts in water conduct electricity.** That is, salts are electrolytes. Salt solutions conduct electricity due to the presence of ions in them. **Salts are ionic compounds.** Every salt consists of a positively charged ion (cation) and a negatively charged ion (called anion). For example, sodium chloride salt (NaCl) consists of positively charged sodium ions (Na^+) and negatively charged chloride ions (Cl^-).

Family of Salts

The salts having the same positive ions (or same negative ions) are said to belong to a family of salts. For example, sodium chloride (NaCl) and sodium sulphate (Na_2SO_4) belong to the same family of salts called 'sodium salts' (because they both contain the same positively charged ions, sodium ions, Na^+). Similarly, sodium chloride (NaCl) and potassium chloride (KCl) belong to the same family of salts called 'chloride salts' (because they both contain the same negatively charged ions, chloride ions, Cl^-). We can have as many families of salts as the positively charged ions and negatively charged ions (which make up the salts). Some of the important families of salts are : Sodium salts, Calcium salts, Magnesium salts, Zinc salts, Potassium salts, Aluminium salts, Copper salts, Ammonium salts, Chloride salts, Sulphate salts, Nitrate salts, Carbonate salts and Acetate salts. Let us solve one problem now.

Sample Problem. Write the formulae of the salts given below and identify the acids and bases from which these salts may be obtained : Potassium sulphate, Sodium sulphate, Calcium sulphate, Magnesium sulphate, Copper sulphate, Sodium chloride, Sodium nitrate, Sodium carbonate, Ammonium chloride. How many families can you identify among these salts ? **(NCERT Book Question)**

Solution. The formulae of the above given salts and the acids and bases from which these salts may be obtained are given below.

Name of salt	*Formula*	*Base and Acid*
1. Potassium sulphate	K_2SO_4	KOH and H_2SO_4
2. Sodium sulphate	Na_2SO_4	NaOH and H_2SO_4
3. Calcium sulphate	$CaSO_4$	$Ca(OH)_2$ and H_2SO_4

4. Magnesium sulphate	$MgSO_4$	$Mg(OH)_2$ and H_2SO_4
5. Copper sulphate	$CuSO_4$	$Cu(OH)_2$ and H_2SO_4
6. Sodium chloride	NaCl	NaOH and HCl
7. Sodium nitrate	$NaNO_3$	NaOH and HNO_3
8. Sodium carbonate	Na_2CO_3	NaOH and H_2CO_3
9. Ammonium chloride	NH_4Cl	NH_4OH and HCl

Ten families of salts can be identified in the above given salts. These are : Potassium salts, Sodium salts, Calcium salts, Magnesium salts, Copper salts, Ammonium salts, Sulphate salts, Chloride salts, Nitrate salts and Carbonate salts.

The pH of Salt Solutions

A salt is formed by the reaction between an acid and a base, so we should expect that the solution of a salt in water will be neutral towards litmus. **Though the aqueous solutions of many salts are neutral (having a pH of 7), but some salts produce acidic or basic solutions (alkaline solutions) when dissolved in water.** The pH values of some of the salt solutions are given below :

Salt solution	*pH*	*Nature*
Sodium chloride solution	7	Neutral
Ammonium chloride solution	6	Acidic
Sodium carbonate solution	9	Basic (or Alkaline)

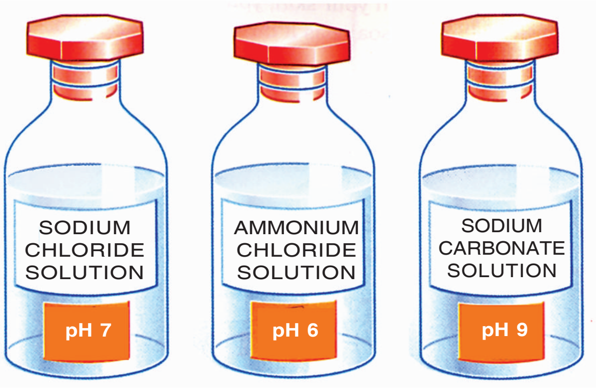


Figure 40. An aqueous solution of sodium chloride is neutral, an aqueous solution of ammonium chloride is acidic whereas an aqueous solution of sodium carbonate is basic (or alkaline).

We can see that an aqueous solution of *sodium chloride is neutral,* an aqueous solution of *ammonium chloride is acidic*; whereas an aqueous solution of *sodium carbonate is basic* in nature (or *alkaline* in nature). **The acidic nature and basic nature of some salt solutions can be explained on the basis of hydrolysis of salts.** Please note that hydrolysis means splitting up of a compound by the action of water.

(*i*) The salts of strong acids and strong bases give neutral solutions (having pH = 7). Let us take the example of sodium chloride salt to understand this point. Sodium chloride salt (NaCl) is formed from a strong acid hydrochloric acid (HCl), and a strong base sodium hydroxide (NaOH). Since sodium chloride is formed from a strong acid and a strong base, therefore, an aqueous solution of sodium chloride is neutral. It does not have any action on litmus. Another example of a salt which gives a neutral solution is potassium sulphate (K_2SO_4). It is formed from a strong acid sulphuric acid (H_2SO_4) and a strong base potassium hydroxide (KOH).

(*ii*) The salts of strong acids and weak bases give acidic solution (having pH less than 7). Let us take the example of ammonium chloride. Ammonium chloride (NH_4Cl) is the salt of a strong acid hydrochloric acid (HCl), and a weak base ammonium hydroxide (NH_4OH), so an aqueous solution of ammonium chloride is acidic in nature. This can be explained as follows.

When ammonium chloride is dissolved in water, it gets hydrolysed to some extent to form ammonium hydroxide and hydrochloric acid :

$$\underset{\text{Ammonium chloride}}{NH_4Cl\ (s)} + \underset{\text{Water}}{H_2O\ (l)} \xrightleftharpoons{\text{Hydrolysis}} \underset{\substack{\text{Ammonium hydroxide} \\ (\textit{Weak base})}}{NH_4OH\ (aq)} + \underset{\substack{\text{Hydrochloric acid} \\ (\textit{Strong acid})}}{HCl\ (aq)}$$

Now, hydrochloric acid is a strong acid which is fully ionised and gives a large amount of hydrogen ions [$H^+(aq)$]. On the other hand, ammonium hydroxide is a weak base which is only slightly ionised and gives a small amount of hydroxide ions [$OH^-(aq)$]. Since ammonium chloride solution contains more of hydrogen ions than hydroxide ions, it is acidic in nature. It turns blue litmus red. Another example of a salt which gives an acidic solution is ammonium sulphate $(NH_4)_2SO_4$. It is formed from a strong acid sulphuric acid (H_2SO_4) and a weak base ammonium hydroxide (NH_4OH).

(*iii*) The salts of weak acids and strong bases give basic solutions (or alkaline solutions) (having pH more than 7). Let us take the example of sodium carbonate. Sodium carbonate (Na_2CO_3) is the salt of a weak acid carbonic acid (H_2CO_3) and a strong base sodium hydroxide (NaOH), so an aqueous solution of sodium carbonate will be basic in nature (or alkaline in nature). This can be explained as follows.

When sodium carbonate is dissolved in water, it gets hydrolysed to some extent and forms sodium hydroxide and carbonic acid :

$$\underset{\text{Sodium carbonate}}{Na_2CO_3\,(s)} + \underset{\text{Water}}{2H_2O\,(l)} \xrightleftharpoons{\text{Hydrolysis}} \underset{\substack{\text{Sodium hydroxide} \\ (\textit{Strong base})}}{2NaOH\,(aq)} + \underset{\substack{\text{Carbonic acid} \\ (\textit{Weak acid})}}{H_2CO_3\,(aq)}$$

Now, sodium hydroxide is a strong base which is fully ionised and gives a large amount of hydroxide ions [OH^-(aq)]. On the other hand, carbonic acid is a weak acid which is only slightly ionised and hence gives a small amount of hydrogen ions [H^+(aq)]. Since the sodium carbonate solution contains more of hydroxide ions than hydrogen ions, it is basic in nature (or alkaline in nature). It turns red litmus to blue. Another example of a salt which gives a basic solution (or alkaline solution) is sodium acetate (CH_3COONa). It is formed from a weak acid acetic acid (CH_3COOH), and a strong base sodium hydroxide (NaOH).

COMMON SALT (SODIUM CHLORIDE)

The common salt is a white powder which is used in preparing food, especially vegetables and pulses, etc. (see Figure 41). Common salt is also known as just 'salt'. **The chemical name of common salt is sodium chloride (NaCl)**. Common salt (or sodium chloride) is a *neutral* salt.

Sodium chloride can be made in the laboratory by the combination of sodium hydroxide and hydrochloric acid :

$$\underset{\text{Sodium hydroxide}}{NaOH\,(aq)} + \underset{\text{Hydrochloric acid}}{HCl\,(aq)} \longrightarrow \underset{\substack{\text{Sodium chloride} \\ \text{(Common salt)}}}{NaCl\,(aq)} + \underset{\text{Water}}{H_2O\,(l)}$$

The sodium chloride solution formed here can be evaporated to obtain solid sodium chloride salt. But sodium chloride (or common salt) is *never* made in this way on a large scale. This is because sodium chloride (common salt) is present in nature in abundance. This is discussed below.

How Common Salt is Obtained

Common salt (sodium chloride) occurs naturally in *sea-water* and as *rock salt*. Common salt occurs in dissolved form in sea-water. On the other hand, common salt occurs in solid form as rock salt.

(*i*) Common Salt from Sea-Water. Sea-water contains many dissolved salts in it. The major salt present in sea-water is common salt (or sodium chloride). **Common salt is obtained from sea-water by the process of evaporation**. This is done as follows : Sea-water is trapped in large, shallow pools and allowed to stand there (see Figure 42). The sun's heat evaporates the water slowly and common salt is left behind. This common salt is impure because it has some other salts mixed in it. It is purified to obtain pure common salt (or sodium chloride). The huge quantities of common salt required by industry come from sea-water.

(*ii*) Common Salt from Underground Deposits. Underground deposits of common salt are found in many parts of the world. The large crystals of common salt found in underground deposits are called rock salt (see Figure 43). Rock salt is usually brown due to the presence of impurities in it. **Rock salt is mined from the underground deposits just like coal**. The rock salt which we dig out today from the earth was formed when the ancient seas dried up by evaporation, thousands of years ago.

Figure 41. Common salt (sodium chloride).

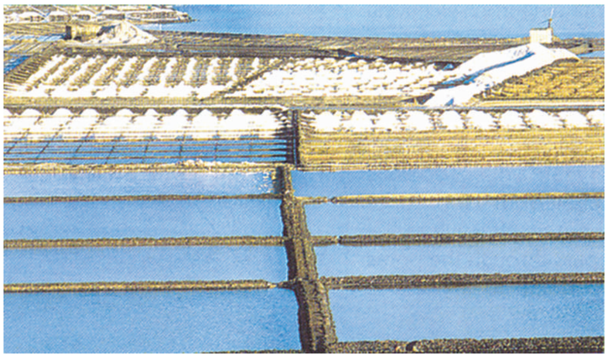


Figure 42. Common salt is obtained by the evaporation of sea-water by sun's heat.

Figure 43. Rock salt is obtained from underground deposits by mining.

Uses of Common Salt (or Sodium Chloride)

Some of the important uses of common salt (or sodium chloride) are given below.

1. Common salt (sodium chloride) is used as a raw material for making a large number of useful chemicals in industry such as : sodium hydroxide (caustic soda), sodium carbonate (washing soda), sodium hydrogencarbonate (baking soda), hydrochloric acid, hydrogen, chlorine, and sodium metal.

2. Common salt (sodium chloride) is used in cooking food. It improves the flavour of food. Sodium chloride is required by our body for the working of nervous system, the movement of muscles, and the production of hydrochloric acid in the stomach for the digestion of food.

3. Common salt (sodium chloride) is used as a preservative in pickles, and in curing meat and fish (preserving meat and fish).

4. Common salt (sodium chloride) is used in the manufacture of soap.

5. Common salt (sodium chloride) is used to melt ice which collects on the roads during winter in cold countries.

CHEMICALS FROM COMMON SALT

Common salt is a raw material for making many chemicals. We will now describe the preparation, properties and uses of some of the important chemicals (chemical compounds) which are obtained from common salt (or sodium chloride) by various methods. These chemicals are : Sodium hydroxide (Caustic soda), Sodium carbonate (Washing soda), and Sodium hydrogencarbonate (Baking soda). Let us start with sodium hydroxide.

Figure 44. This is solid sodium hydroxide (caustic soda) in the form of pellets.

SODIUM HYDROXIDE

Sodium hydroxide is commonly known as **caustic soda**. The chemical formula of sodium hydroxide is NaOH. Sodium hydroxide is a very important basic chemical which is used as a starting material for making many other chemicals. It is used in many industries and hence produced on a large scale.

Production of Sodium Hydroxide

The raw material for producing sodium hydroxide is sodium chloride (or common salt). **Sodium hydroxide is produced by the electrolysis of a concentrated aqueous solution of sodium chloride (which is called brine).**

When electricity is passed through a concentrated solution of sodium chloride (called brine), it decomposes to form sodium hydroxide, chlorine and hydrogen :

$$\underset{\substack{\text{Sodium chloride}\\ \text{(Brine)}}}{2NaCl\,(aq)} + \underset{\text{Water}}{2H_2O\,(l)} \xrightarrow[\text{(Electrolysis)}]{\text{Electricity}} \underset{\substack{\text{Sodium hydroxide}\\ \text{(Caustic soda)}}}{2NaOH\,(aq)} + \underset{\text{Chlorine}}{Cl_2\,(g)} + \underset{\text{Hydrogen}}{H_2\,(g)}$$

During electrolysis, **chlorine gas is produced at the anode** (positive electrode) and **hydrogen gas is produced at the cathode** (negative electrode). **Sodium hydroxide solution is formed near the cathode**. All the products of electrolysis of sodium chloride solution, chlorine, hydrogen and sodium hydroxide, are collected and stored separately.

The process of electrolysis of sodium chloride solution is called chlor-alkali process because of the products formed : chlor for chlorine and alkali for sodium hydroxide. **The three very useful products obtained by the electrolysis of sodium chloride solution called brine (or chlor-alkali process) are sodium hydroxide, chlorine and hydrogen**. These three products have a large number of uses. We will now describe the important uses of sodium hydroxide, chlorine and hydrogen, one by one.

Uses of Sodium Hydroxide

1. Sodium hydroxide is used for making soaps and detergents.
2. Sodium hydroxide is used for making artificial textile fibres (such as rayon).
3. Sodium hydroxide is used in the manufacture of paper.
4. Sodium hydroxide is used in purifying bauxite ore from which aluminium metal is extracted.
5. Sodium hydroxide is used in de-greasing metals, oil refining, and making dyes and bleaches.

Figure 45. Sodium hydroxide is used in the manufacture of paper.

Uses of Chlorine

1. Chlorine is used to sterilise drinking water supply, and the water in swimming pools. This is because chlorine is a disinfectant (which kills germs like bacteria present in water and makes it safe).
2. Chlorine is used in the production of bleaching powder.
3. Chlorine is used in the production of hydrochloric acid.
4. Chlorine is used to make plastics such as polyvinyl chloride (PVC), pesticides, chlorofluorocarbons (CFCs), chloroform, carbon tetrachloride, paints and dye-stuffs.
5. Chlorine is used for making solvents for drycleaning (such as trichloroethane).

Uses of Hydrogen

1. Hydrogen is used in the hydrogenation of oils to obtain solid fats (called vegetable *ghee* or margarine).
2. Hydrogen is used in the production of hydrochloric acid.
3. Hydrogen is used to make ammonia for fertilisers.
4. Hydrogen is used to make methanol (CH_3OH).
5. Liquid hydrogen is used as a fuel for rockets.

The two products of chlor-alkali process, hydrogen and chlorine, combine to produce another very important chemical called hydrochloric acid (HCl). So, we will now give some of the uses of hydrochloric acid.

Uses of Hydrochloric Acid

1. Hydrochloric acid is used for cleaning iron sheets before tin-plating or galvanisation.

Figure 46. Hydrochloric acid is used in making polyvinyl chloride (PVC) plastic. All these products are made from PVC.

2. Hydrochloric acid is used in the preparation of chlorides such as ammonium chloride (which is used in dry cells).
3. Hydrochloric acid is used in medicines and cosmetics.
4. Hydrochloric acid is used in textile, dyeing and tanning industries.
5. Hydrochloric acid is used in making plastics like polyvinyl chloride (PVC).

The two products of chlor-alkali process, sodium hydroxide and chlorine, combine together to produce another chemical called sodium hypochlorite (NaClO). Sodium hypochlorite is a bleaching agent which is used in making 'household bleaches' and for 'bleaching fabrics'.

WASHING SODA

Washing soda is sodium carbonate containing 10 molecules of water of crystallisation. That is, washing soda is sodium carbonate decahydrate. The formula of washing soda is $Na_2CO_3.10H_2O$. Sodium carbonate which does not contain any water of crystallisation is called anhydrous sodium carbonate, Na_2CO_3. Anhydrous sodium carbonate (Na_2CO_3) is commonly known as 'soda ash'. Washing soda is an important chemical obtained from sodium chloride (or common salt).

Production of Washing Soda

Washing soda is produced from sodium chloride (or common salt) in the following three steps :

(*i*) A cold and concentrated solution of sodium chloride (called brine) is reacted with ammonia and carbon dioxide to obtain sodium hydrogencarbonate :

$$\underset{\substack{\text{Sodium chloride}\\\text{(Common salt)}}}{NaCl} + \underset{\text{Ammonia}}{NH_3} + \underset{\text{Water}}{H_2O} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2} \longrightarrow \underset{\substack{\text{Sodium hydrogen-}\\\text{carbonate}}}{NaHCO_3} + \underset{\substack{\text{Ammonium}\\\text{chloride}}}{NH_4Cl}$$

Sodium hydrogencarbonate formed is only slightly soluble in water, so it precipitates out as a solid.

(*ii*) Sodium hydrogencarbonate is separated by filtration, dried and heated. On heating, sodium hydrogencarbonate decomposes to form sodium carbonate :

$$\underset{\text{Sodium hydrogencarbonate}}{2NaHCO_3} \xrightarrow{\text{Heat}} \underset{\substack{\text{Sodium carbonate}\\\text{(Soda ash)}}}{Na_2CO_3} + \underset{\substack{\text{Carbon}\\\text{dioxide}}}{CO_2} + \underset{\text{Water}}{H_2O}$$

The anhydrous sodium carbonate obtained here is called soda ash.

(*iii*) Anhydrous sodium carbonate (soda ash) is dissolved in water and recrystallised to get washing soda crystals containing 10 molecules of water of crystallisation :

$$\underset{\substack{\text{Anhydrous sodium carbonate}\\\text{(Soda ash)}}}{Na_2CO_3} + \underset{\text{Water}}{10H_2O} \longrightarrow \underset{\substack{\text{Sodium carbonate decahydrate}\\\text{(Washing soda)}}}{Na_2CO_3.10H_2O}$$

Properties of Washing Soda

1. Washing soda is a transparent crystalline solid.
2. Washing soda is one of the few metal carbonates which are soluble in water.
3. The solution of washing soda in water is alkaline which turns red litmus to blue.

4. **Detergent Properties (or Cleansing Properties).** Washing soda has detergent properties (or cleansing properties) because it can remove dirt and grease from dirty clothes, etc. Washing soda attacks dirt and grease to form water soluble products, which are then washed away on rinsing with water.

Uses of Sodium Carbonate (or Washing Soda)

1. Sodium carbonate (or washing soda) is used as a "cleansing agent" for domestic purposes like washing clothes. In fact, sodium carbonate is a component of many dry soap powders.

2. Sodium carbonate is used for removing permanent hardness of water.

3. Sodium carbonate is used in the manufacture of glass, soap and paper.

4. Sodium carbonate is used in the manufacture of sodium compounds such as borax.

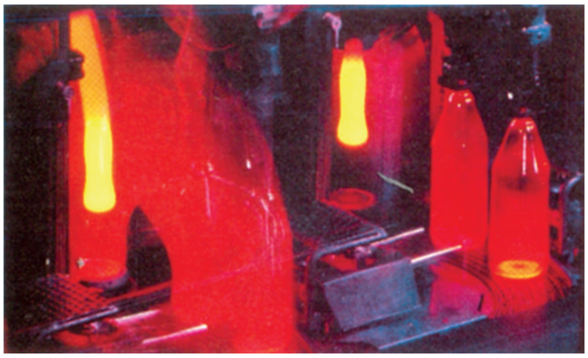


Figure 47. Sodium carbonate is used in the manufacture of glass.

BAKING SODA

The chemical name of baking soda is sodium hydrogencarbonate. The formula of baking soda is $NaHCO_3$. It is also called sodium bicarbonate. Baking soda is sometimes added for faster cooking of food such as gram (*chana*).

Production of Sodium Hydrogencarbonate

Sodium hydrogencarbonate is produced on a large scale by reacting a cold and concentrated solution of sodium chloride (called brine) with ammonia and carbon dioxide :

$$\underset{\substack{\text{Sodium chloride}\\ \text{(Common salt)}}}{NaCl} + \underset{\text{Ammonia}}{NH_3} + \underset{\text{Water}}{H_2O} + \underset{\substack{\text{Carbon}\\ \text{dioxide}}}{CO_2} \longrightarrow \underset{\substack{\text{Sodium hydrogen-}\\ \text{carbonate}\\ \text{(Baking soda)}}}{NaHCO_3} + \underset{\substack{\text{Ammonium}\\ \text{chloride}}}{NH_4Cl}$$

Properties of Sodium Hydrogencarbonate (or Baking Soda)

1. Sodium hydrogencarbonate consists of white crystals which are sparingly soluble in water.

2. Sodium hydrogencarbonate is a mild, non-corrosive base. The solution of sodium hydrogencarbonate in water is mildly alkaline.

3. **Action of Heat.** When solid sodium hydrogencarbonate (or its solution) is heated, then it decomposes to give sodium carbonate with the evolution of carbon dioxide gas :

$$\underset{\substack{\text{Sodium hydrogencarbonate}\\ \text{(Baking soda)}}}{2NaHCO_3} \xrightarrow{\text{Heat}} \underset{\substack{\text{Sodium}\\ \text{carbonate}}}{Na_2CO_3} + \underset{\substack{\text{Carbon}\\ \text{dioxide}}}{CO_2} + \underset{\text{Water}}{H_2O}$$

The above reaction takes place when sodium hydrogencarbonate (or baking soda) is heated during the cooking of food. Since sodium hydrogencarbonate gives carbon dioxide gas on heating, it is used as a constituent of baking powder (to aerate the dough), and in effervescent drinks.

Uses of Sodium Hydrogencarbonate (or Baking Soda)

1. Sodium hydrogencarbonate is used as an antacid in medicine to remove acidity of the stomach. Being alkaline, sodium hydrogencarbonate neutralises the excess acid present in the stomach and relieves indigestion.

2. Sodium hydrogencarbonate (or baking soda) is used in making baking powder (used in making cakes, bread, etc.). Baking powder is a mixture of baking soda (sodium hydrogencarbonate) and a mild, edible acid such as tartaric acid. When baking powder mixes with water (present in dough made for baking cake or bread), then sodium hydrogencarbonate reacts with tartaric acid to evolve carbon dioxide gas :

$$\underset{\substack{\text{Sodium hydrogen-}\\ \text{carbonate}\\ \text{(Baking soda)}}}{NaHCO_3\,(aq)} + \underset{\substack{\text{Hydrogen ions}\\ \text{(From tartaric}\\ \text{acid)}}}{H^+\,(aq)} \longrightarrow \underset{\substack{\text{Sodium ions}\\ \text{(From sodium}\\ \text{tartarate salt)}}}{Na^+\,(aq)} + \underset{\text{Carbon dioxide}}{CO_2\,(g)} + \underset{\text{Water}}{H_2O\,(l)}$$

The carbon dioxide gas produced gets trapped in the wet dough and bubbles out slowly making the cake (or bread) to 'rise' and become soft and spongy. If, however, baking powder is not added in the preparation of cake (or bread), then the cake (or bread) obtained will be hard and quite small in size.

Figure 48. Sodium hydrogencarbonate is used (in the form of baking powder) as a raising agent in making cakes.

If only sodium hydrogencarbonate (baking soda) is used in making cake (or bread), then sodium carbonate formed from it by the action of heat (during baking) will give a *bitter taste* to cake (or bread). The advantage of using baking powder is that tartaric acid present in it can react with any sodium carbonate formed and neutralise it. And the sodium tartarate salt formed by neutralisation has a pleasant taste. Please note that *as long as baking powder is dry, the sodium hydrogencarbonate and tartaric acid present in it do not react with each other*. They react only in the presence of *water*. Another point to be noted is that many times we confuse between baking soda and baking powder. *Baking soda is a single compound : sodium hydrogencarbonate.*On the other hand, *baking powder is a mixture of sodium hydrogencarbonate and a solid, edible acid such as tartaric acid (or citric acid).*

3. Sodium hydrogencarbonate (or baking soda) is used in fire extinguishers. Soda-acid type fire extinguishers contain a solution of sodium hydrogencarbonate and sulphuric acid in separate containers inside them. When the knob of the fire extinguisher is pressed (or when the fire extinguisher is inverted), then sulphuric acid mixes with sodium hydrogencarbonate solution to produce a lot of carbon dioxide gas. The pressure of this carbon dioxide gas forces a stream of liquid to fall on the burning substance. The carbon dioxide gas (coming out alongwith the liquid) forms a blanket around the burning substance and cuts off the supply of air to the burning substance. Since the supply of air is cut off, the process of burning stops and fire gets extinguished. The stream of liquid falling on the burning substance also helps in putting off fire by cooling the burning substance to below its ignition temperature.

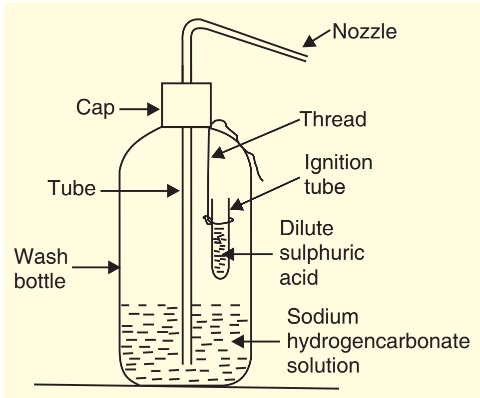


Figure 49. Making a soda-acid fire extinguisher.

We can make a soda-acid fire extinguisher ourselves as follows.

(*i*) Take a wash bottle and put about 20 mL of sodium hydrogencarbonate solution in it.

(*ii*) Suspend an ignition tube containing dilute sulphuric acid in the wash bottle with the help of a thread (One end of thread is tied to the ignition tube and its other end is held in the cap of the wash bottle) (see Figure 49).

(*a*) A soda-acid fire extinguisher

(*b*) A fireman demonstrates the use of a fire extinguisher

Figure 50.

(*iii*) Close the mouth of the wash bottle tightly by turning on the cap.
(*iv*) Tilt the wash bottle to one side so that acid of the ignition tube mixes with sodium hydrogencarbonate solution in it.
(*v*) We will see a stream of carbon dioxide gas coming out of the nozzle of the wash bottle.
(*vi*) Direct the stream of carbon dioxide on the flame of a burning candle.
(*vii*) The burning candle flame gets extinguished.

Before we go further and describe bleaching powder, we should know the meaning of two terms : 'bleaching agent' and 'disinfectant'. **A substance which removes colour from coloured substances and makes them colourless is called a bleaching agent.** In other words, a bleaching agent decolourises coloured substances. **A substance which is used to kill germs or bacteria is called a disinfectant.** Keeping these points in mind, we will now study bleaching powder.

BLEACHING POWDER

Bleaching powder is calcium oxychloride. The chemical formula of bleaching powder is $CaOCl_2$. It is also called chloride of lime.

Preparation of Bleaching Powder

Bleaching powder is prepared by passing chlorine gas over dry slaked lime :

$$\underset{\substack{\text{Calcium hydroxide}\\\text{(Slaked lime)}}}{Ca(OH)_2} + \underset{\text{Chlorine}}{Cl_2} \longrightarrow \underset{\substack{\text{Calcium oxychloride}\\\text{(Bleaching powder)}}}{CaOCl_2} + \underset{\text{Water}}{H_2O}$$

Properties of Bleaching Powder

1. Bleaching powder is a white powder which gives a strong smell of chlorine.

2. Bleaching powder is soluble in cold water. The small insoluble portion always left behind is the lime present in it.

3. **Bleaching powder reacts with dilute acids to produce chlorine.** When bleaching powder is treated with an excess of a dilute acid, all the chlorine present in it is liberated. For example, when bleaching powder is treated with an excess of dilute sulphuric acid, all the chlorine present in it is liberated :

$$\underset{\substack{\text{Calcium oxychloride}\\\text{(Bleaching powder)}}}{CaOCl_2} + \underset{\substack{\text{Sulphuric acid}\\\text{(Dilute)}}}{H_2SO_4} \longrightarrow \underset{\text{Calcium sulphate}}{CaSO_4} + \underset{\text{Chlorine}}{Cl_2} + \underset{\text{Water}}{H_2O}$$

The chlorine produced by the action of a dilute acid on bleaching powder acts as a bleaching agent. Thus, *the real bleaching agent present in bleaching powder is chlorine.* The bleaching action of chlorine is due to its oxidising property. Some coloured substances turn colourless when oxidised by chlorine. Actually, bleaching powder is an arrangement for storing chlorine. This is because chlorine gas itself is difficult to store and utilise. We have given above the reaction of bleaching powder with dilute sulphuric acid. Dilute hydrochloric acid also reacts with bleaching powder in a similar way to liberate chlorine.

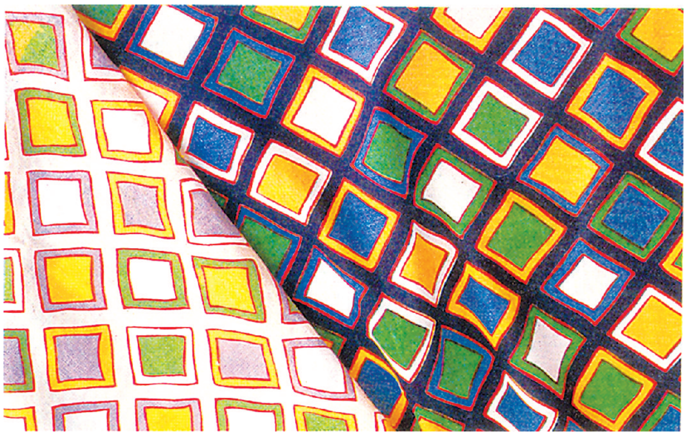


Figure 51. This picture shows a piece of cloth which has been bleached by bleaching powder compared with an unbleached piece of the same cloth.

Uses of Bleaching Powder

1. Bleaching powder is used for bleaching cotton and linen in textile industry and for bleaching wood pulp in paper industry. It is also used for bleaching washed clothes in laundry

(Laundry is a place where clothes are washed and pressed). The bleaching action of bleaching powder is due to the chlorine released by it.

2. Bleaching powder is used for disinfecting drinking water supply. That is, for making drinking water free from germs.
3. Bleaching powder is used for the manufacture of chloroform ($CHCl_3$).
4. Bleaching powder is used for making wool unshrinkable.
5. Bleaching powder is used as an oxidising agent in many chemical industries.

PLASTER OF PARIS

Plaster of Paris is calcium sulphate hemihydrate (calcium sulphate half-hydrate). The formula of plaster of Paris is $CaSO_4.\frac{1}{2}H_2O$. The name plaster of Paris came from the fact that it was first of all made by heating gypsum which was mainly found in Paris. Initially, plaster of Paris was used in a massive way in the construction industry but now it has many other uses which we will learn after a while. Plaster of Paris is commonly known as P.O.P.

Preparation of Plaster of Paris

Plaster of Paris is prepared from gypsum. Gypsum is calcium sulphate dihydrate, $CaSO_4.2H_2O$. That is, gypsum is calcium sulphate containing 2 molecules of water of crystallisation.

Plaster of Paris is prepared by heating gypsum ($CaSO_4.2H_2O$) to a temperature of 100°C (373 K) in a kiln. When gypsum is heated to a temperature of 100°C (373 K) , it loses three-fourths of its water of crystallisation and forms plaster of Paris :

$$\underset{\text{Gypsum}}{CaSO_4.2H_2O} \xrightarrow[(373\,K)]{\text{Heat to }100°C} \underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + \underset{\text{Water}}{1\frac{1}{2}H_2O}$$

In the preparation of plaster of Paris, heating of gypsum should be controlled carefully. The temperature during the heating of gypsum should not be allowed to go above 100°C (or above 373 K). This is because if gypsum is heated above 100°C (or above 373 K), then all its water of crystallisation is eliminated and anhydrous calcium sulphate ($CaSO_4$) called dead burnt plaster is formed. The anhydrous calcium sulphate (or dead burnt plaster) does not set like plaster of Paris on adding water.

Note. In the formula of plaster of Paris ($CaSO_4.\frac{1}{2}H_2O$) given in the above equation, we have shown only half a water molecule ($\frac{1}{2}H_2O$) as the water of crystallisation. Please note that it is not possible to have half a molecule of water. The formula $CaSO_4.\frac{1}{2}H_2O$ actually means that two molecules (or two formula units) of $CaSO_4$ share one molecule of water so that the effective water of crystallisation for one $CaSO_4$ unit comes to half molecule of water. The formula of plaster of Paris can also be written as $2CaSO_4.H_2O$. In fact, we can multiply the whole equation (given above) by 2 and write another equation for the preparation of plaster of Paris as follows :

$$\underset{\text{Gypsum}}{2(CaSO_4.2H_2O)} \xrightarrow[(373\,K)]{\text{Heat to }100°C} \underset{\text{Plaster of Paris}}{2CaSO_4.H_2O} + \underset{\text{Water}}{3H_2O}$$

Please note that whether we write plaster of Paris as $CaSO_4.\frac{1}{2}H_2O$ or as $2CaSO_4.H_2O$, it is just the same thing.

Properties of Plaster of Paris

1. Plaster of Paris is a white powder.

2. **Plaster of Paris has a very remarkable property of setting into a hard mass on wetting with water.** So, when water is added to plaster of Paris, it sets into a hard mass in about half an hour. The setting of plaster of Paris is due to its hydration to form crystals of gypsum which set to form a hard, solid mass :

$$\underset{\text{Plaster of Paris}}{CaSO_4.\frac{1}{2}H_2O} + \underset{\text{Water}}{1\frac{1}{2}H_2O} \longrightarrow \underset{\substack{\text{Gypsum} \\ \text{(sets as hard mass)}}}{CaSO_4.2H_2O}$$

The setting of plaster of Paris is accompanied by a slight expansion in volume due to which it is used in making casts for statues, toys, etc.

Plaster of Paris should be stored in a moisture-proof container. This is because the presence of moisture can cause slow setting of plaster of Paris by bringing about its hydration. This will make the plaster of Paris useless after some time.

Uses of Plaster of Paris

1. Plaster of Paris is used in hospitals for setting fractured bones in the right position to ensure correct healing. It keeps the fractured bone straight. This use is based on the fact that when plaster of Paris is mixed with a proper quantity of water and applied around the fractured limbs, it sets into a hard mass. In this way, it keeps the bone joints in a fixed position. It is also used for making casts in dentistry.

2. Plaster of Paris is used in making toys, decorative materials, cheap ornaments, cosmetics, black-board chalk and casts for statues.

3. Plaster of Paris is used as a fire-proofing material.

Figure 52. A broken bone being set by using plaster of Paris.

4. Plaster of Paris is used in chemistry laboratories for sealing air-gaps in apparatus where air-tight arrangement is required.

5. Plaster of Paris is used for making surfaces (like the walls of a house) smooth before painting them, and for making ornamental designs on the ceilings of houses and other buildings.

WATER OF CRYSTALLISATION : HYDRATED SALTS

There are some salts which contain a few water molecules as an essential part of their crystal structure. **The water molecules which form part of the structure of a crystal (of a salt) are called water of crystallisation.** The salts which contain water of crystallisation are called **hydrated salts.** Every hydrated salt has a 'fixed number' of molecules of water of crystallisation in its one 'formula unit'. For example :

(*i*) Copper sulphate crystals contain 5 molecules of water of crystallisation in one formula unit and hence written as $CuSO_4.5H_2O$. It is called copper sulphate pentahydrate ('Pentahydrate' means 'five molecules of water').

(*ii*) Sodium carbonate crystals (washing soda crystals) contain 10 molecules of water of crystallisation per formula unit and hence written as $Na_2CO_3.10H_2O$. This is called sodium carbonate decahydrate ('Decahydrate' means 'ten molecules of water').

(*iii*) Calcium sulphate crystals (gypsum crystals) contain 2 molecules of water of crystallisation in one formula unit and hence written as $CaSO_4.2H_2O$. It is called calcium sulphate dihydrate ('Dihydrate' means 'two molecules of water').

(*iv*) Iron sulphate crystals contain 7 molecules of water of crystallisation per formula unit and hence written as $FeSO_4.7H_2O$. It is called iron sulphate heptahydrate ('Heptahydrate' means 'seven molecules of water').

From the above discussion we conclude that some of the hydrated salts (which possess water of crystallisation) are : Copper sulphate, $CuSO_4.5H_2O$; Sodium carbonate crystals (Washing soda), $Na_2CO_3.10H_2O$; Calcium sulphate (or Gypsum), $CaSO_4.2H_2O$; and Iron sulphate, $FeSO_4.7H_2O$. **It should be noted that water of crystallisation is a part of 'crystal structure' of a salt. Since water of crystallisation is not free water, it does not wet the salt.** Thus, the salts containing water of crystallisation appear to be perfectly dry.

The water of crystallisation gives the crystals of the salts their 'shape' and, in some cases, imparts them 'colour'. For example, the presence of water of crystallisation in copper sulphate crystals imparts them a *blue* colour. Thus, $CuSO_4.5H_2O$ is blue in colour. Similarly, the presence of water of crystallisation in iron sulphate crystals imparts them a *green* colour. So, $FeSO_4.7H_2O$ is green in colour. Sodium carbonate crystals ($Na_2CO_3.10H_2O$) and calcium sulphate crystals ($CaSO_4.2H_2O$) are, however, *white.*

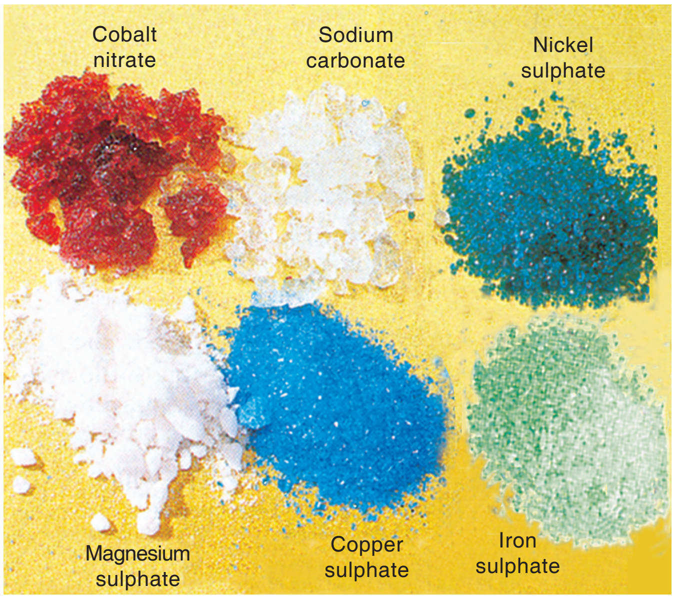


Figure 53. Some hydrated salts.

Action of Heat on Hydrated Salts

When hydrated salts are heated strongly, they lose their water of crystallisation. By losing water of crystallisation, the hydrated salts lose their regular shape and colour, and become colourless powdery substances. **The salts which have lost their water of crystallisation are called anhydrous salts.** Thus, the anhydrous salts have no water of crystallisation. When water is added to an anhydrous salt, it becomes hydrated once again, and regains its colour. This will become more clear from the following example.

Copper sulphate crystals ($CuSO_4.5H_2O$) are *blue* in colour. When copper sulphate crystals are heated strongly, they lose all the water of crystallisation and form anhydrous copper sulphate (which is *white*) :

$$\underset{\substack{\text{Hydrated copper sulphate} \\ \text{(Blue)}}}{CuSO_4.5H_2O} \xrightarrow{\text{Heat}} \underset{\substack{\text{Anhydrous copper sulphate} \\ \text{(White)}}}{CuSO_4} + \underset{\substack{\text{Water} \\ \text{(Goes away)}}}{5H_2O}$$

Thus, **on strong heating, blue copper sulphate crystals turn white** (due to the loss of water of crystallisation).

The dehydration of copper sulphate crystals is a reversible process. So, when water is added to anhydrous copper sulphate, it gets hydrated and turns blue due to the formation of hydrated copper sulphate :

$$\underset{\substack{\text{Anhydrous copper sulphate} \\ \text{(White)}}}{CuSO_4} + \underset{\text{Water}}{5H_2O} \longrightarrow \underset{\substack{\text{Hydrated copper sulphate} \\ \text{(Blue)}}}{CuSO_4.5H_2O}$$

Thus, **anhydrous copper sulphate turns blue on adding water.** This property of anhydrous copper sulphate is used to detect the presence of moisture (water) in a liquid. A few drops of the liquid (to be tested) are added to white anhydrous copper sulphate powder. The appearance of blue colour in anhydrous copper sulphate indicates the presence of moisture (water) in the liquid.

We will now describe an experiment to show the action of heat on copper sulphate crystals.

(*i*) Take some copper sulphate crystals in a dry boiling tube (These are blue in colour).

(*ii*) Heat the crystals strongly by keeping the boiling tube over the flame of a burner for sometime (see Figure 54).

(*iii*) On heating, the blue copper sulphate crystals turn white and a powdery substance is formed. We can also see tiny droplets of water in the boiling tube (These droplets have formed from the water of crystallisation which was removed from copper sulphate crystals during heating).

(*iv*) Cool the boiling tube and add 2 or 3 drops of water on the white copper sulphate powder formed above.

(*v*) The blue colour of copper sulphate crystals is restored. They become blue again.

The changes in colour which take place on heating blue coloured copper sulphate crystals to form 'white' anhydrous copper sulphate and regaining blue colour on adding water will become more clear from the following pictures :

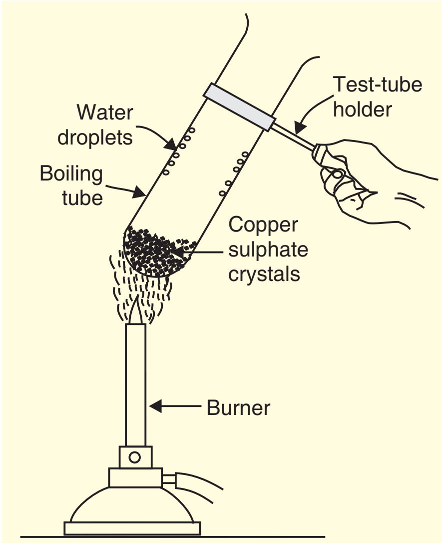


Figure 54. Action of heat on copper sulphate crystals.

(*a*) This boiling tube contains blue coloured hydrated copper sulphate

(*b*) On heating, blue colour disappears due to the elimination of water of crystallisation and 'white' anhydrous copper sulphate is formed

(*c*) The 'white' anhydrous copper sulphate turns blue again when water is added to it

Figure 55.

We are now in a position to **answer the following questions :**

Very Short Answer Type Questions

1. What is the chemical formula of (*a*) baking soda, and (*b*) washing soda ?
2. Write the chemical formula of (*i*) soda ash, and (*ii*) sodium carbonate decahydrate.
3. State whether the following statement is true or false :
   Copper sulphate crystals are always wet due to the presence of water of crystallisation in them.
4. Which of the following salt has a blue colour and why ?
   $CuSO_4.5H_2O$ or $CuSO_4$
5. What would be the colour of litmus in a solution of sodium carbonate ?
6. State the common and chemical names of the compound formed when plaster of Paris is mixed with water.
7. With which substance should chlorine be treated to get bleaching powder ?
8. What is the commercial name of calcium sulphate hemihydrate ?

9. Name the product formed when Cl_2 and H_2 produced during the electrolysis of brine are made to combine.
10. Name a calcium compound which hardens on wetting with water.
11. Name a sodium compound which is a constituent of many dry soap powders.
12. Name a metal carbonate which is soluble in water.
13. Name an acid which is present in baking powder.
14. Name the metal whose carbonate is known as washing soda.
15. Which compound is used as an antacid in medicine : $NaHCO_3$ or Na_2CO_3 ?
16. What is the common name of (*a*) $NaHCO_3$ and (*b*) $Na_2CO_3.10H_2O$?
17. Write the chemical name and formula of (*a*) common salt, and (*b*) caustic soda.
18. What are the two main ways in which common salt (sodium chloride) occurs in nature ?
19. Name the major salt present in sea-water.
20. How is common salt obtained from sea-water ?
21. Why is sodium chloride required in our body ?
22. Name three chemicals made from common salt (or sodium chloride).
23. Give any two uses of common salt (sodium chloride).
24. What name is given to the common salt which is mined from underground deposits ? How was this salt formed ?
25. Name the salt which is used as a preservative in pickles, and in curing meat and fish.
26. Name the raw material used for the production of caustic soda.
27. The electrolysis of an aqueous solution of sodium chloride gives us three products. Name them.
28. During the electrolysis of a saturated solution of sodium chloride, where is :
(*a*) chlorine formed ?
(*b*) hydrogen formed ?
(*c*) sodium hydroxide formed ?
29. Fill in the following blanks :
(*a*) Common salt is obtained from sea-water by the process of ....
(*b*) Rock salt is mined just like ....
(*c*) Chemical formula of washing soda is...............
(*d*) Sodium hydrogencarbonate is.....................soda whereas sodium carbonate is....................soda.
(*e*) The chemical formula of plaster of Paris is...................
30. Complete and balance the following chemical equations :

(*a*) $NaCl\ (aq) + H_2O\ (l) \xrightarrow{\text{Electricity}}$

(*b*) $NaHCO_3 \xrightarrow{\text{Heat}}$

(*c*) $NaCl + NH_3 + H_2O + CO_2 \longrightarrow$

(*d*) $Ca(OH)_2 + Cl_2 \longrightarrow$

Short Answer Type Questions

31. What is washing soda ? State two properties and two uses of washing soda.
32. Write the formulae of sodium chloride and sodium carbonate. Explain why an aqueous solution of sodium chloride is neutral but an aqueous solution of sodium carbonate is basic (or alkaline). Write chemical equations of the reactions involved.
33. Write the chemical formula of ammonium chloride. Explain why an aqueous solution of ammonium chloride is acidic in nature ? Illustrate your answer with the help of a chemical equation.
34. What is baking soda ? Write the chemical name of baking soda. Give the important uses of baking soda. How does baking soda differ chemically from washing soda ?
35. Describe how sodium hydrogencarbonate (baking soda) is produced on a large scale. Write equation of the reaction involved.
36. What happens when a cold and concentrated solution of sodium chloride reacts with ammonia and carbon dioxide ? Write the chemical equation of the reaction which takes place.

37. (*a*) What is meant by "water of crystallisation" in a substance ? Explain with an example.
(*b*) How would you show that blue copper sulphate crystals contain water of crystallisation ?
(*c*) Explain how anhydrous copper sulphate can be used to detect the presence of moisture (water) in a liquid.

38. (*a*) What is the common name of sodium hydrogencarbonate ?
(*b*) What happens when a solution of sodium hydrogencarbonate is heated ? Write equation of the reaction involved.
(*c*) Explain why, sodium hydrogencarbonate is used as an antacid.

39. (*a*) What will happen if heating is not controlled while preparing plaster of Paris ?
(*b*) Write an equation to show the reaction between plaster of Paris and water.

40. (*a*) What happens when copper sulphate crystals are heated strongly ? Explain with the help of an equation.
(*b*) What happens when a few drops of water are added to anhydrous copper sulphate ? Explain with the help of an equation.

41. (*a*) Name two constituents of baking powder.
(*b*) How does baking powder differ from baking soda ?
(*c*) Explain the action of baking powder in the making of cake (or bread). Write equation of the reaction involved.

42. (*a*) What is the chemical name of bleaching powder ?
(*b*) What is the chemical formula of bleaching powder ?
(*c*) What are the materials used for the preparation of bleaching powder ?
(*d*) State one use of bleaching powder (other than bleaching).

43. What does a soda-acid type fire extinguisher contain ? How does it work ? Explain the working of a soda-acid fire extinguisher with the help of a labelled diagram.

44. (*a*) Name a sodium compound used for softening hard water.
(*b*) Which compound of calcium is used for disinfecting drinking water supply ?
(*c*) Name a metal compound which has detergent properties (cleansing properties).
(*d*) Name one compound of calcium which is used for removing the colour of a coloured cloth.
(*e*) State a peculiar (or remarkable) property of plaster of Paris.
(*f*) Name the substance obtained by the action of chlorine on solid (dry) slaked lime.

45. (*a*) What is gypsum ? What happens when gypsum is heated to 100°C (373 K) ?
(*b*) Name a sodium compound which is used for making borax and glass.
(*c*) Name the compound which is used in hospitals for setting fractured bones.
(*d*) Which is the real bleaching agent present in bleaching powder ?

46. (*a*) What is "baking powder"? How does it make the cake soft and spongy ?
(*b*) In addition to sodium hydrogencarbonate, baking powders contain a substance X. Name the substance X. What is the role of substance X in the baking powder ?

47. State two uses each of the following compounds :
(*a*) Sodium hydroxide (*b*) Chlorine (*c*) Hydrogen (*d*) Hydrochloric acid

48. (a) What is the common name of the compound $CaOCl_2$?
(*b*) Name the raw material used for the preparation of plaster of Paris.
(*c*) Which property of plaster of Paris is utilised in making casts for broken limbs in hospitals ?
(*d*) Explain why chlorine is used for sterilising drinking water supply.

Long Answer Type Questions

49. (*a*) What happens when a concentrated solution of sodium chloride (brine) is electrolysed ? Write the equation of the reaction involved.
(*b*) Why is the electrolysis of a concentrated solution of sodium chloride known as chlor-alkali process ?
(*c*) Name three products of the chlor-alkali process. State two uses of each of these products.

50. (*a*) Describe how washing soda is produced starting from sodium chloride (common salt). Write equations of all the reactions involved.

(*b*) State whether an aqueous solution of washing soda is acidic or alkaline ? Give reason for your answer.
(*c*) What is meant by saying that washing soda has detergent properties ?
(*d*) Give two important uses of washing soda (or sodium carbonate).

51. (*a*) What is bleaching powder ? How is bleaching powder prepared ? Write chemical equation of the reaction involved in the preparation of bleaching powder.
(*b*) What happens when bleaching powder reacts with dilute sulphuric acid ? Give equation of the reaction involved.
(*c*) State two important uses of bleaching powder.

52. (*a*) What is plaster of Paris ? Write the chemical formula of plaster of Paris.
(*b*) How is plaster of Paris prepared ? Write chemical equation of the reaction involved.
(*c*) Explain why plaster of Paris should be stored in a moisture-proof container.
(*d*) State two important uses of plaster of Paris.

53. (*a*) What is a salt ? Give the names and formulae of any two salts. Also name the acids and bases from which these salts may be obtained.
(*b*) What is meant by 'a family of salts' ? Explain with examples.
(*c*) What is meant by 'hydrated' and 'anhydrous' salts ? Explain with examples.
(*d*) Write the names, formulae and colours of any two hydrated salts.
(*e*) What will be the colour of litmus in an aqueous solution of ammonium chloride salt ?

Multiple Choice Questions (MCQs)

54. The salt which will give an acidic solution on dissolving in water is :
(*a*) KCl (*b*) NH_4Cl (*c*) Na_2CO_3 (*d*) CH_3COONa

55. One of the following salts will give an alkaline solution on dissolving in water. This is :
(*a*) Na_2CO_3 (*b*) Na_2SO_4 (*c*) NaCl (*d*) $(NH_4)_2 SO_4$

56. The salt which will give a neutral solution on dissolving in water will be :
(*a*) CH_3COONa (*b*) NH_4Cl (*c*) KCl (*d*) Na_2CO_3

57. The products of chlor-alkali process are :
(*a*) NaCl, Cl_2 and H_2 (*b*) H_2, Cl_2 and NaOH (*c*) Cl_2, Na_2CO_3 and H_2O (*d*) NaOH, Cl_2 and HCl

58. The number of molecules of water of crystallisation present in washing soda crystals is :
(*a*) five (*b*) two (*c*) ten (*d*) seven

59. The salt whose aqueous solution will turn blue litmus to red is :
(*a*) ammonium sulphate (*b*) sodium acetate (*c*) sodium chloride (*d*) potassium carbonate

60. The aqueous solution of one of the following salts will turn red litmus to blue. This salt is :
(*a*) potassium sulphate (*b*) sodium sulphate (*c*) sodium chloride (*d*) potassium carbonate

61. The salt whose aqueous solution will have no effect on either red litmus or blue litmus is
(*a*) potassium sulphate (*b*) sodium carbonate (*c*) ammonium sulphate (*d*) sodium acetate

62. The aqueous solution of one of the following salts will turn phenolphthalein indicator pink. This salt is :
(*a*) KCl (*b*) K_2SO_4 (*c*) K_2CO_3 (*d*) KNO_3

63. The formula of baking soda is :
(*a*) K_2CO_3 (*b*) $KHCO_3$ (*c*) $NaHCO_3$ (*d*) Na_2CO_3

64. Which of the following is treated with chlorine to obtain bleaching powder ?
(*a*) $CaSO_4$ (*b*) $Ca(OH)_2$ (*c*) $Mg(OH)_2$ (*d*) KOH

65. Plaster of Paris is prepared by heating one of the following to a temperature of 100°C. This is :
(*a*) $CaSO_3.2H_2O$ (*b*) $CaCl_2.2H_2O$ (*c*) $CaCO_3.2H_2O$ (*d*) $CaSO_4.2H_2O$

66. A salt whose aqueous solution will have a pH of more than 7 will be :
(*a*) K_2CO_3 (*b*) K_2SO_4 (*c*) NaCl (*d*) NH_4Cl

67. A salt is dissolved in water and the pH of this salt solution is measured with a universal indicator paper. If the pH of solution is less than 7, the salt is most likely to be :
(*a*) CH_3COONa (*b*) Na_2CO_3 (*c*) KCl (*d*) NH_4Cl

68. Which of the following salts will give an aqueous solution having pH of almost 7 ?
(*a*) NH_4NO_3 (*b*) NH_4Cl (*c*) $CaCl_2$ (*d*) KCl

Questions Based on High Order Thinking Skills (HOTS)

69. P and Q are aqueous solutions of sodium chloride and sodium hydroxide, respectively. Which of these will turn :

(*a*) blue litmus red ?

(*b*) red litmus blue ?

70. The metal salt A is blue in colour. When salt A is heated strongly over a burner, then a substance B is eliminated and a white powder C is left behind. When a few drops of a liquid D are added to powder C, it becomes blue again. What could be A, B, C and D ?

71. When the concentrated aqueous solution of substance X is electrolysed, then NaOH, Cl_2 and H_2 are produced. Name the substance X. What is the special name of this process ?

72. Consider the following substances :

NaCl, $Ca(OH)_2$, $NaHCO_3$, NH_3, Na_2CO_3, H_2O, Cl_2, CO_2, $CaSO_4.2H_2O$, $2CaSO_4.H_2O$, $CaOCl_2$

(*a*) Which two substances combine to form bleaching powder ?

(*b*) Which four substances are utilised in the production of washing soda ?

(*c*) Which compound represents plaster of Paris ?

(*d*) Which compound is a part of baking powder ?

(*e*) Which compound is used as an antacid ?

73. Give one example each of a salt which gives an aqueous solution having :

(*a*) pH less than 7

(*b*) pH equal to 7

(*c*) pH more than 7

74. A compound X which is prepared from gypsum has the property of hardening when mixed with a proper quantity of water.

(*a*) Identify the compound X

(*b*) Write the chemical equation for its preparation

(*c*) For what purpose is it used in hospitals ?

75. Consider the following salts :

Na_2CO_3, NaCl, NH_4Cl, CH_3COONa, K_2SO_4, $(NH_4)_2SO_4$

Which of these salts will give :

(*a*) acidic solutions ?

(*b*) neutral solutions ?

(*c*) basic solutions (or alkaline solutions) ?

76. A white powdery substance having strong smell of chlorine is used for disinfecting drinking water supply at waterworks. Identify the substance. Give its chemical name and write the chemical reaction for its preparation.

77. A salt X when dissolved in distilled water gives a clear solution which turns red litmus blue. Explain the phenomenon.

78. A person found that the cake prepared by him is hard and small in size. Which ingredient has he forgotten to add that would have caused the cake to rise and become light ? Explain your answer.

79. A white chemical compound becomes hard on mixing with proper quantity of water. It is also used in surgery to maintain joints in a fixed position. Name the chemical compound.

80. When chlorine and sodium hydroxide being produced during the electrolysis of brine are allowed to mix, a new chemical is formed. Name this chemical and write its uses.

81. Write the name and formula of one salt each which contains :

(*a*) two molecules of water of crystallisation

(*b*) five molecules of water of crystallisation

(*c*) ten molecules of water of crystallisation

82. How many molecules of water of crystallisation (per formula unit) are present in :

(*a*) copper sulphate crystals ?

(*b*) washing soda ?

(*c*) gypsum ?

ANSWERS

3. False **14.** Sodium **24.** Rock salt **29.** (*a*) evaporation (*b*) coal (*c*) $Na_2CO_3.10H_2O$ (*d*) baking ; washing (*e*) $CaSO_4.\frac{1}{2}H_2O$ **44.** (*a*) Sodium carbonate (*b*) Bleaching powder (*c*) Sodium carbonate (*d*) Bleaching powder (*e*) It sets into a hard mass on mixing with a proper quantity of water (*f*) Bleaching powder **46.** (*b*) Substance X is tartaric acid **54.** (*b*) **55.** (*a*) **56.** (*c*) **57.** (*b*) **58.** (*c*) **59.** (*a*) **60.** (*d*) **61.** (*a*) **62.** (*c*) **63.** (*c*) **64.** (*b*) **65.** (*d*) **66.** (*a*) **67.** (*d*) 68. (*d*) **69.** (*a*) No solution will turn blue litmus to red (*b*) Solution Q (sodium hydroxide) will turn red litmus blue **70.** A is copper sulphate pentahydrate, $CuSO_4.5H_2O$; B is water, H_2O ; C is anhydrous copper sulphate, $CuSO_4$; D is water, H_2O **71.** Sodium chloride ; Chlor-alkali process **72.** (*a*) $Ca(OH)_2$ and Cl_2 (*b*) NaCl , NH_3, H_2O and CO_2 (*c*) $2CaSO_4.H_2O$ (*d*) $NaHCO_3$ (*e*) $NaHCO_3$ **73.** (*a*) Ammonium chloride, NH_4Cl (*b*) Sodium chloride, NaCl (*c*) Sodium carbonate, Na_2CO_3 **74.** (*a*) Plaster of Paris **75.** (*a*) NH_4Cl, $(NH_4)_2SO_4$ (*b*) NaCl, K_2SO_4 (*c*) Na_2CO_3, CH_3COONa **76.** Bleaching powder, $CaOCl_2$ **77.** Salt X is like sodium carbonate, Na_2CO_3, which is made from a strong base and a weak acid. On dissolving in water, salt X gets hydrolysed to form some strong base and some weak acid. The strong base thus formed makes the solution alkaline which turns red litmus blue. **78.** Baking powder **79.** Plaster of Paris **80.** Sodium hypochlorite, NaClO ; Used in making household bleaches and for bleaching fabrics.