Acids, Bases and Salts

Chemistry 07

Acids, bases and salts are used for various activities in our day to day life. To inquire into your prior knowledge about acids, bases and salts, do the following assignment.

Assignment - 7.1

Given below are several substances which we frequently use in our day to day life. Classify them as acids, bases and salts and tabulate.
Lime juice, Jeewani solution, antacid tablets, milk of magnesia, toothpaste, vinegar, salt, lime, soap, vitamin C tablets, saline solution

7.1 Acids

When you were answering the assignment 7.1 above, you could have classified lime juice, vinegar and vitamin C in that list under the acids.

You have used various acids in the laboratory experiments also. Hydrochloric acid (HCl), nitric acid (HNO_3) and sulphuric acid (H_2SO_4) are some acids that are often used in the laboratory.

Figure 7.1 - Some acids that are being frequently used

When considering the formulae of the above acids it is clear that hydrogen (H) is a component element in all those acids.

• What is an acid?

An acid is a compound that releases hydrogen ions (H^+) in an aqueous medium. Hydrochloric acid ionises as follows in the aqueous medium and releases H^+ ions.

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

Based on the strength of releasing H^+ ions in the aqueous medium, acids are classified as **strong acids** and **weak acids**.

• Strong acids

The acids that release H^+ ions by complete ionisation in aqueous medium are strong acids. It means that all such acid molecules are dissociated into H^+ ions and the corresponding negative ions in water. For example, in a solution of hydrochloric acid which is a strong acid, there are only H^+ ions and Cl^- ions but no free HCl molecules.

Given below are a few examples for some strong acids and how they ionise in the aqueous medium.

- Hydrochloric acid (HCl)

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

- Sulphuric acid (H_2SO_4)

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

- Nitric acid (HNO_3)

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

• Weak acids

The acids which release H^+ ions in aqueous medium by incomplete or partial ionisation are called weak acids. This means that in aqueous medium, only a fraction of such acid molecules are dissociated into H^+ ions and relevant negative ions. The unionised molecules remain as molecules themselves in aqueous solution.

Examples for weak acids:

Acetic acid (CH_3COOH)

Carbonic acid (H_2CO_3)

Phosphoric acid (H_3PO_4)

Most of the acids in laboratory stores are **concentrated acids**. **Dilute acids** of required concentration can be prepared by mixing such concentrated acids with water. Acids of low concentration are known as dilute acids.

Properties of acids

★ Pay your attention to the warning symbol in Figure 7.2 seen in the label of the bottles containing concentrated acids. This is a warning about the corrosive nature of the relevant chemical. That is, when they come into contact with substances like wood, metals or cloth they corrode them and if spilled on the skin, they cause severe burns. This shows that acids have corrosive properties.

Figure 7.2

★ Recall the taste of lime juice. It is sour. A common feature of acids is that they have a characteristic sour taste.

Caution: You should not taste the acids used in the laboratory.

★ Dilute acids react with metals above hydrogen in the reactivity series forming the salt of the metal and hydrogen gas.

$$Mg\,(s) + 2HCl\,(aq) \longrightarrow MgCl_2\,(aq) + H_2\,(g)$$

★ Think back on the experiment carried out to prepare carbon dioxide gas in the laboratory. Carbon dioxide was prepared by adding diluted hydrochloric acid to calcium carbonate.

$$CaCO_3\,(s) + 2HCl\,(aq) \longrightarrow CaCl_2\,(aq) + H_2O\,(l) + CO_2\,(g)$$

Production of carbon dioxide by reacting with carbonates/bicarbonates is a characteristic feature of acids.

★ Acids react with bases to form salts and water.

The salt sodium sulphate (Na_2SO_4) and water are formed as the products of the following acid - base reaction.

$$H_2SO_4\,(aq) + 2NaOH\,(aq) \longrightarrow Na_2SO_4\,(aq) + 2H_2O\,(l)$$

★ Acids turn the colour of blue litmus red. This is a simple test used to identify acids.

• Uses of some acids

- **Hydrochloric acid**

★ Removal of rust in steel objects

★ Making gelatin from bony materials in food technology

★ Making aqua regia (aqua regia is a mixture of concentrated nitric acid and concentrated hydrochloric acid mixed in the proportion of 1 : 3. Aqua regia is used to dissolve metals like gold and platinum)

- **Sulphuric acid**

★ Production of fertilizers such as ammonium sulphate and triple superphosphate

★ Making battery acid (Battery acid is diluted sulphuric acid)

★ Production of paints, plastics and detergents

★ Concentrated sulphuric acid is used as a dehydrating agent

★ Drying gases (For drying a gas, the relevant gas is bubbled through concentrated sulphuric acid)

- **Acetic acid**

★ Processing food where vinegar is used

★ Coagulation of rubber latex

★ Production of photographic films

★ Used in the paper industry

★ Production of synthetic threads in textile industry

7.2 Bases

Pay your attention to the substances classified under bases in the table prepared during assignment 7.1. Milk of magnesia, toothpaste, soap and lime are examples for bases.

Many bases are encountered as solids. Ammonia is a gas showing basic properties. Aqueous solutions prepared by dissolving bases in water are used in laboratory experiments. Sodium hydroxide (NaOH), potassium hydroxide (KOH) and ammonia solution (NH_4OH) can be given as the bases frequently used in the laboratory.

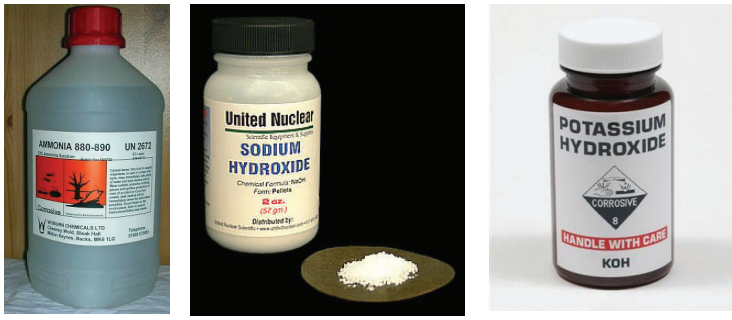

Figure 7.3 - Some frequently used bases

What is a base?

A base is a chemical compound that increases the hydroxyl ion (OH^-) concentration of an aqueous solution. For instance, in aqueous solution, sodium hydroxide (NaOH) ionises as follows and contributes to raise the OH^- ion concentration.

$$NaOH\ (aq) \longrightarrow Na^+\ (aq) + OH^-\ (aq)$$

Strong bases

The bases that completely ionise in aqueous solution are called strong bases. Examples for some strong bases and how they ionise in aqueous solution are given below.

- Sodium hydroxide

$$NaOH\ (aq) \longrightarrow Na^+\ (aq) + OH^-\ (aq)$$

- Potassium hydroxide

$$KOH\ (aq) \longrightarrow K^+\ (aq) + OH^-\ (aq)$$

Weak bases

The bases which partially ionise in aqueous solution are known as weak bases.

Ex : Ammonia solution (NH_4OH)

Properties of bases

★ They have a slimy texture as in soap.

Caution : Do not touch bases in the laboratory.

★ Bases react with acids to give salts and water.

$$2NaOH\ (aq) + H_2SO_4\ (aq) \longrightarrow Na_2SO_4\ (aq) + 2H_2O\ (l)$$

★ Bases turn red litmus blue. This is a simple test used to identify bases. Of the bases, those that readily dissolve in water are called alkalis.

Ex :- Sodium hydroxide (NaOH)

Potassium hydroxide (KOH)

Ammonia solution (NH_4OH)

Uses of some bases

- **Sodium hydroxide**

★ Production of soap, paper, artificial silk and paints

★ Used in the laboratory as a strong base

★ Refining petroleum products

- **Magnesium hydroxide**

★ Magnesium hydroxide suspension (milk of magnesia) is used as an antacid to relieve gastritis (acidity in stomach)

★ Purification of molasses in sugar industry

Identification of acids and bases by indicators

Activity 7.1

Identification of acids and bases by indicators

Materials required :- Blue litmus, red litmus, methyl orange, phenolphthalein, lime juice, dilute hydrochloric acid, dilute sulphuric acid, vinegar, dilute sodium hydroxide solution, soap solution

Add the given indicators to the solutions given above and record the observations.

Table 7.1

Solution	Litmus red/blue	Methyl orange	Phenolphthalein
Dilute hydrochloric acid			
Lime juice			
Dilute sulphuric acid			
Vinegar			
Dilute sodium hydroxide			
Soap solution			

Compare your observations with the following table and identify the relevant solution as an acid or a base.

Table 7.2

Indicator	Acid colour	Base colour
Litmus	Red	Blue
Phenolphthalein	Colouress	Pink
Methyl orange	Red	Yellow

Identification of acids and bases by indicators is not a very accurate method. Moreover, by using it, a value for the strength of acids or bases cannot be obtained. Indicators help to identify a given substance as an acid or a base approximately.

• pH scale

The pH scale is used to indicate how acidic or basic a given solution is.The scale generally consists of a series of numbers from 0 to 14. Each number corresponds to a colour.

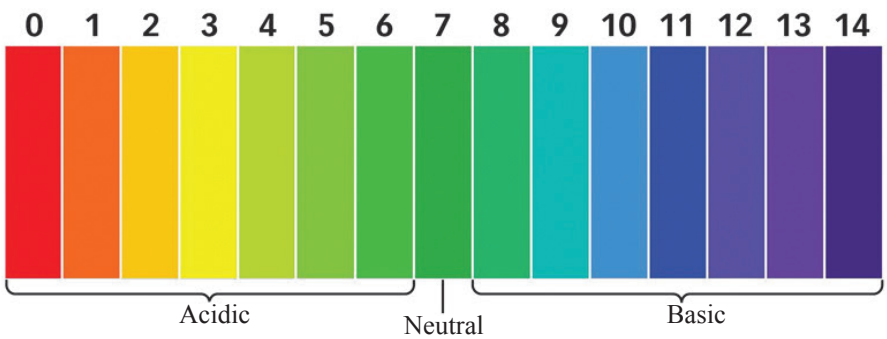

Figure 7.4 - pH scale and colour code of pH papers

According to this scale the pH value of neutral substances such as water is 7. The pH value of acidic solutions is less than 7 whereas the pH value of basic solutions is greater than 7. Acidity decreases from 0 to 6 while the basicity increases from 8 to 14.

• pH papers

Like the litmus papers, these are available in the form of books or rolls in the laboratory. These have been prepared by mixing several indicators. The pH value can be found by dipping a pH paper in the relevant solution and comparing the colour of the paper with the colour code. Accordingly, the acidity, basicity or the neutrality of the solution can be identified. Further, it gives an idea about the strength of the acid or the base.

7.3 Salts

The common salt (NaCl) that we use in our day to day life is a salt. The Jeewani solution given during ailing condtions such as diarrhoea and the saline solution given to patients are mixtures containing salts.

Acids react with bases to form salts.

Ex :- Hydrochloric acid reacts with sodium hydroxide forming sodium chloride.

$$NaOH\,(aq) + HCl\,(aq) \longrightarrow NaCl\,(aq) + H_2O\,(l)$$

Hydrochloric acid reacts with potassium hydroxide to form potassium chloride.

$$KOH\,(aq) + HCl\,(aq) \longrightarrow KCl\,(aq) + H_2O\,(l)$$

Nitric acid upon reacting with magnesium hydroxide gives magnesium nitrate.

$$Mg(OH)_2\,(aq) + 2HNO_3\,(aq) \longrightarrow Mg(NO_3)_2\,(aq) + 2H_2O\,(l)$$

Depending on the strength of the acid or the base reacting, the salt shows acidic, basic or neutral properties.

Ex : The salts formed by the reaction between a strong acid and a strong base show neutral properties.

Sodium hydroxide is a strong base. Hydrochloric acid is a strong acid. Sodium chloride formed by the reaction between them is a neutral salt.

$$NaOH\,(aq) + HCl\,(aq) \longrightarrow NaCl\,(aq) + H_2O\,(l)$$

Salts are crystalline, solid compounds. Most of the salts dissolve in water. Generally salts have high melting points and boiling points.

• Uses of some salts

- **Sodium chloride**

★ Used to flavour food during their preparation

★ Used as a food preservative

★ Used to produce chemicals such as chlorine, and hydrochloric acid, to produce sodium hydroxide to produce sodium carbonate by solvay process, to glaze earthenware to, make soap and also used in tanning

Figure 7.5 - Sodium chloride

- **Copper sulphate**

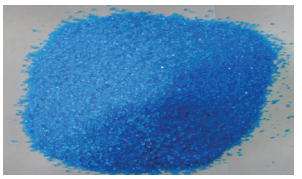

Figure 7.6
Copper sulphate

- ★ Used as a fungicide in agriculture
- ★ Used in making chemical reagents (Benedict solution and Fehling solution)
- ★ Used in electroplating
- ★ Used in paint industry

7.4 Neutralisation

You know that antacid tablets which contain a basic substance are used to relieve the discomfort caused by the acidity in stomach. Have you inquired into the reason for it?

You have studied the fact that when acids react with bases, salts and water are produced. Let's consider the reaction between hydrochloric acid and sodium hydroxide again.

$$HCl\,(aq) + NaOH\,(aq) \longrightarrow NaCl\,(aq) + H_2O\,(l)$$

Let's investigate how water was formed as a product in the above reaction. The H^+ ions released by the ionisation of the acid combine with the OH^- ions given by the ionisation of the base to form water molecules. it can be represented by a chemical equation as follows.

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

In all acid - base reactions, the above common reaction occurs. This process is known as neutralisation.

Neutralisation is the combination of H^+ ions released by an acid with OH^- ions released by a base to form water molecules.

Hence, when an acid reatcs with a base their acidic properties as well as the basic properties disappear.

Applications of the acid - base neutralisation reactions

- ⋆ Milk of magnesia or such an antacid (a weak base) is used to neutralise the acidity in the stomach.
- ⋆ Basic substances such as ash and quicklime (calcium oxide) are added to soil to reduce soil acidity.
- ⋆ Bee sting is painful because of an acidic poisonous substance injected into the skin. By applying a weak basic substance such as baking soda ($NaHCO_3$) or calcium carbonate ($CaCO_3$) on the place of the sting, the pain is releived.
- ⋆ Wasp sting is basic. Application of a weak, dilute acid such as lime juice or vinegar on the place of sting reduces the venomous nature as well as the pain.

Summary

- The substances that release H^+ ions in aqueous solution are called acids.
- The substances that increase the OH^- ion concentration in aqueous solution are known as bases.
- An acid reacts with a base to form salt and water.
- The acids that release H^+ ions undergoing complete ionisation in aqueous solution are strong acids whereas the acids that release H^+ ions by partial ionisation are weak acids.
- The bases that increase the OH^- concentration undergoing complete ionisation in aqueous medium are called strong bases. The bases that increase the OH^- concentration by partial ionisation in aqueous solution are weak bases.
- Both acids and bases change the colour of indicators.
- An acid has a low pH value while a base has a higher pH value.
- Acids react with many matals liberating hydrogen gas. Acids react with carbonates or bicarbonates with the evolution of carbon dioxide gas.
- By reacting an acid with a base, salts are formed.
- A salt shows acidic or basic or neutral properties. It depends on the strength of the acid or the base contributed to form the salt.
- In the reaction between acids and bases, the combination of H^+ ions released by the acid with the OH^- ions released by the base, to form water molecules is called neutralisation.
- Hydrochloric acid, sulphuric acid and acetic acid are frequently used acids for various purposes.
- Sodium hydroxide and magnesium hydroxide are two bases used in various tasks.
- Sodium chloride and copper sulphate are two salts used for various tasks.

Exercises

01. Complete the following sentences.

i. Sodium hydroxide and ..... acid react to form sodium chloride and water.

ii. Calcium carbonate and hydrochloric acid react liberating ..... gas.

iii. Potassium hydroxide and sulphuric acid react to form ..... and..... .

iv. ..... acid and ..... hydroxide react giving magnesium nitrate.

v. ..... acid reacts with magnesium liberating ..... gas and forming the salt .....

02. You are provided with three unlabelled solutions of sodium hydroxide, dilute hydrochloric acid and sodium chloride. You are given only blue litmus papers. Using only them how do you identify the above three solutions?

03. Fill in the blanks with the solutions selected from the following list of solutions.

$H_2SO_4(aq)$, HCl (aq), $NH_3(aq)$, $H_2O(l)$, $Ca(OH)_2$ (aq), $CH_3COOH(aq)$

i. ..... and ..... turn red litmus blue.

ii. ..... and ..... act as strong acids.

iii. In ..... and ....., pH is greater than 7.

iv. Vinegar used at home is diluted..... .

v. ..... causes severe burns in the skin when spilled.

vi. Calcium sulphate salt is formed by the reaction between ..... and ..... .

04.

i. Arrange the following solutions in the ascending order of pH.

sodium hydroxide, sulphuric acid, water, vinegar

ii. Of the solutions dilute hydrochloric acid, dilute sodium hydroxide and acetic acid, which does not react with sodium carbonate?

iii. When somebody comes into contact with the plant (kahambiliya), it causes itching and a severe burning sensation due to formic acid it contains. Suggest a suitable substance to apply on the skin to relieve that sensation.

Glossary				
Acid	-	අම්ලය	-	அமிலம்
base	-	භස්මය	-	மூலம்
Salt	-	ලවණ	-	உப்பு
Neutralisation	-	උදාසීනකරණය	-	நடுநிலையாக்கம்
Strong acid	-	ප්‍රබල අම්ලය	-	வன்னமிலம்
weak acid	-	දුබල අම්ලය	-	மென்னமிலம்
Strong base	-	ප්‍රබල භස්මය	-	வன் மூலம்
weak base	-	දුබල භස්මය	-	மென் மூலம்
pH scale	-	pH පරිමාණය	-	pH அளவுத்திட்டம்
pH papers	-	pH කඩදාසි	-	pH தாள்