Introduction

A chemical substance is a kind of matter that cannot be separated into any other kind of matter by physical method. Pure substances have uniform composition and always have some properties like taste, smell, texture, etc.

We use several materials in our daily life for various purposes. Some of them are sweet in taste, some are salty, some are sour and some are bitter.

The sweet taste of a substance is due to sugar present in it. Why are certain food materials sour in taste like curd, vinegar, tamarind, lemon juice, green mango, tomatoes, orange, unripened grapes, others are sweet in taste whereas some are salty and some are bitter in taste ? What substance are present in which make them sour, bitter or salty ?

Acids

The term 'acid' has its origin in the Latin word *acidus*, meaning sour. In fact, anything that tastes sour contains an acid. For example, lemon juice, tomato, vinegar, etc., all taste sour. So, each of these substances must contain an acid. Some of the naturally occurring substances that contain acids are given in Table

Aqueous solutions of acids are generally sour in taste. Acids turn blue litmus red, conduct electricity and react with bases to form salts and water. [Bases and salts are discussed a little later.]

An acid may be defined in various ways. Here, we shall study the definition given by Liebig in 1838. According to Liebig, an acid is a compound which contains hydrogen that can be replaced partially or wholly by a metal or a group of elements acting like a metal, to produce a salt.

For example, sulphuric acid (H_2SO_4) is an acid because of the following reasons.

(i) It contains hydrogen atoms in its molecule.

(ii) The two hydrogen atoms present in its molecule can be replaced partially or wholly by a metal like sodium (Na) to produce sodium hydrogen sulphate or sodium sulphate.

The hydrogen atoms in H_2SO_4 can also be partially or wholly replaced by a group of elements, like an ammonium ion (NH_4^+) to form ammonium hydrogen sulphate (NH_4HSO_4) or ammonium sulphate ($(NH_4)_2SO_4$) respectively.

The substances $NaHSO_4$, Na_2SO_4, NH_4HSO_4 and $(NH_4)_2SO_4$ are all salts.

(iii) The acid dissolves in water to make a solution that turns blue litmus red.

(iv) It is sour in taste.

(v) It reacts vigorously with a base to produce a salt.

The hydrogen atoms present in an acid that can be replaced by a metal or a group of elements are called replaceable hydrogen or acidic hydrogen.

Strong and weak acids : The strength of an acid is determined by the amount of hydrogen ions (H^+) that the acid provides when dissolved in water.

Some of the acids, when dissolved in water, get almost completely dissociated to provide hydrogen ions. These acids are called strong acids. For example, hydrochloric acid (HCl), nitric acid (HNO_3) and sulphuric acid (H_2SO_4) are strong acids.

On the other hand, there are some acids which when dissolved in water, are only incompletely dissociated to give hydrogen ions. These are called weak acids. For example, carbonic acid (H_2CO_3) and acetic acid (CH_3COOH) are weak acids.

Basicity of an acid :

The basicity of an acid is the number of replaceable hydrogen atoms present in a molecule of the acid.

The acid which contains one replaceable hydrogen atom in its molecule is called a monobasic acid and its basicity is 1. The acids containing two or three replaceable hydrogen atoms in their molecules are called dibasic acids or tribasic acids and their basicities are 2 or 3.

Examples of a few acids with their basicities are given in the table below.

Acid	Basicity
HCl	1
HNO_3	1
H_2SO_4	2
H_3PO_4	3

General Properties of Acids :

1. They are sour in taste.
2. They turn blue litmus paper red.
3. Acids show acidic properties only in the presence of water. This can be demonstrated by the following activity.

   Dry hydrogen chloride gas does not produce H^+ ions in the absence of moisture/water. It produces H^+ ions only in the presence of moisture/water.

   $$HCl + H_2O \rightleftharpoons H_3O^+ + Cl^-$$

4. Their aqueous solutions conduct electricity.

5. They react with certain metals with the evolution of hydrogen gas.

Bases

Bases are substances that are soapy to touch and bitter in taste.

A base is a substance, usually the oxide or the hydroxide of a metal, which can react with an acid to produce salt and water.

For example, sodium oxide (Na_2O), calcium oxide (CaO), cupric oxide (CuO), iron oxides (FeO, Fe_2O_3 etc.), sodium hydroxide (NaOH) and calcium hydroxide ($Ca(OH)_2$ are all bases.

Certain substances are also called bases, though they do not fit into the above definition. For example, ammonia (NH_3). It forms salt with an acid without giving water. So, it should not be treated as a base. But ammonium hydroxide (NH_4OH), the aqueous solution of NH_3, is a base as it reacts with an acid to give salt and water

$$NH_4OH + HCl \leftrightharpoons NH_4Cl + H_2O$$

Alkalis:

Bases that are soluble in water are called alkalis. For example, sodium hydroxide, potassium hydroxide, calcium hydroxide are soluble in water. Therefore, they are alkalis. But bases like copper hydroxide ($Cu(OH)_2$ ferric hydroxide ($Fe(OH)_3$), aluminum hydroxide ($Al(OH)_3$ do not dissolve in water. They are, therefore, not alkalis.

Hence, all alkalis are bases, but all bases are not alkalis. Some of the bases are listed here in Table.

Lime water, baking soda and washing soda are all bases

General Properties of Bases

1. The solutions of bases in water give a soapy touch. When dissolved in water they produce hydroxide ions (OH^-) in solution.

   $NaOH \xrightarrow{H_2O} Na^+ + OH^-$

   $Ca(OH)_2 \xrightarrow{H_2O} Ca^{2+} + 2OH^-$

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

2. They turn red litmus paper blue.

   Take some soap solution in a test tube. Dip the tip of a red litmus paper into it. You will see that red litmus paper turns blue. This indicates that the soap solution contains a base.

3. They react with acids to produce salt and water.

   $NaOH + HCl \longrightarrow NaCl + H_2O$

   $2KOH + H_2SO_4 \longrightarrow CuSO_4 + 2H_2O$

   $Cu(OH)_2 + H_2SO_4 \longrightarrow CuSO_4 + 2H_2O$

   In these reactions, the acid and the base neutralize each other. Therefore, these reactions are called neutralization reactions.

   Thus, a neutralization reaction may be defined as a reaction between an acid and a base, producing salt and water.

This neutralization reaction may be explained as follows. You know, all acids provide H^+ ions and all bases provide OH^- ions in aqueous solution. Let us see what happens when HCl and NaOH react together.

$HCl + NaOH \longrightarrow NaCl + H_2O$

or $H^+ + Cl^- + Na^+ + OH^- \longrightarrow Na^+ + Cl^- + H_2O$

or $H^+ + OH^- \longrightarrow H_2O$

Thus, during neutralization of an acid with a base or vice versa H^+ ions (from acid) and OH^- ions (from base) combine to produce H_2O molecules.

4. The oxides which produce acids in aqueous solutions are called acidic oxides which are usually the oxides of nonmetals. Acidic oxides react with bases to give salts and water.

$$2NaOH + \underset{\text{Carbon dioxide}}{CO_2} \rightarrow \underset{\text{sodium carbonate}}{Na_2CO_3} + \underset{\text{water}}{H_2O}$$

$$Ca(OH)_2 + \underset{\text{Carbon dioxide}}{CO_2} \rightarrow \underset{\text{calcium carbonate}}{CaCO_3} + \underset{\text{water}}{H_2O}$$

5. Bases react with certain salts to produce another salt and another base. For example, when NH_4OH is added to a solution of $Al_2(SO_4)_3$, $(NH_4)_2SO_4$ and $Al(OH)_3$ are produced.

$$\underset{\text{ammonium hydroxide}}{6NH_4OH} + \underset{\text{aluminium sulphate}}{Al_2(SO_4)} \rightarrow$$

$$\underset{\text{aluminium hydroxide}}{2Al(OH)_3} + \underset{\text{aluminimum sulphate(salt)}}{3(NH_4)_2SO_4}$$

Strong Bases and Weak Bases :

The strength of a base is determined by the amount of hydroxide ions (OH^-) that the base provides when dissolved in water.

Some of the bases, when dissolved in water, get almost completely dissociated to provide hydroxide ions. These bases are called strong bases. (Bases soluble in water are also called alkalis.) For example, sodium hydroxide and potassium hydroxide are strong bases.

But there are bases which, when dissolved in water, get only partially dissociated to give hydroxide ions. These are weak bases. For example, magnesium hydroxide and ammonium hydroxide are weak bases.

Acidity of a Base:

The acidity of a base is defined as the number of hydroxyl (OH) groups present in a molecule of the base.

In each molecule of NaOH, KOH and NH_4OH only one hydroxyl group is present. Therefore, the acidity of all these bases is 1.

In $Ca(OH)_2$ and $Ba(OH)_2$ there are two hydroxyl groups present in each molecule. Hence, their acidity is 2.

Similarly, the acidity of $Fe(OH)_3$ and $Al(OH)_3$ is 3.

The base containing one hydroxyl group in a molecule is said to be mono acidic base, that containing two hydroxyl groups is called diacidic base, and that containing three hydroxyl groups is called triacidic base. Thus, NaOH, $Ca(OH)_2$ and $Fe(OH)_3$ are monoacidic, diacidic and triacidic bases respectively.