ACIDS, BASES AND INDICATORS

INTRODUCTION

Various kinds of materials having different properties and uses are found in nature. Based upon their characteristic properties, these substances are grouped into acids, bases, and salts. Such type of grouping may be done based upon their taste or some other properties. Edible substances like lemon, tamarind, grapes, oranges etc., taste sour and are grouped as **acids**. The word acid is derived from Latin word 'acere' which means sour. Chemically these substances are acidic in nature. Substances like baking soda, bitter guard, neem stick, soaps, coffee, etc., are bitter in taste and feel soapy on touching and are grouped as **bases**. Chemically these substances are basic in nature. **Salts** are the substances which are formed by the reaction of an acid with a base. Chemically salts may be acidic or basic or neutral (neither acidic nor basic). Common salt, washing soda etc., are salts. **Indicators** are another variety of compounds used to identify the substances whether they are acids or bases. Turmeric and litmus are natural indicators

ACIDS

Substances like lemon juice, orange juice, sour milk etc., taste sour as they contain acids and hence they are acidic in nature. All acids are not eatable. Some acids are harmless and some acid are corrosive in action, cause burns or blisters on skin. Acids when added to water, they dissociate into ions as shown below:

$HCl \xrightarrow{water} H^+ + Cl^-$

Since H^+ ions can not exist as such, it combines with water to form hydronium ions.

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

Hydronium ion

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

Hydronium ion

All properties of acids are due to the presence of the hydronium ions $\left(H_3\overset{+}{O}\right)$ which are formed on ionization of acid in water.

Classification of acids

1) Acids are classified mainly into two types based on their sources from which they can be obtained.

They are, i) Organic acids

ii) Inorganic acids

Organic acids contain carbon as one of the major element and are derived from plants and animals.

For example,

i) Stings of bees, red ants and nettles contain formic acid (HCOOH)

ii) All citrus fruits contain citric acid

iii) Apple contains malic acid

iv) Proteins contain amino acids

v) Butter contains buteric acid

vi) Tea contains tannic acid

vii) Tamarind and grapes contain tartaric acid

viii) Tomato contains oxalic acid

ix) Vinegar is acetic acid

Inorganic acids are obtained by dissolving oxides of some elements which form minerals in earth's crust in water. These are also called mineral acids and do not contain carbon.
For example Sulphuric acid (H_2SO_4), Hydrochloric acid (HCl) Carbonic acid (H_2CO_3), Nitric acid (HNO_3) and Phosphoric acid (H_3PO_4) etc., are inorganic acids.

Exception: Carbonic acid (H_2CO_3) contains carbon but it is an inorganic acid.

2) Based upon the amount of water present, an acidic solution is classified into dilute acids and concentrated acids.
Dilute acids contain more percentage of water. **Concentrated acids** contain less percentage of water
Acids are diluted by adding acids to water drop wisely with continuous stirring.

3) It is known that when acids dissolve in water produce hydrogen ion. Some acids completely dissociate to produce more H^+ ions in water example- sulphuric ,hydrochloric and nitric acid are called **strong acids**.
Whereas some acids dissociate partially to produce less number of H^+ ion in water
Example:- Acetic acid, Oxalic acid, Citric acid are called **weak acids**

4) The number of H^+ ions produced by one molecule of acid in water is called basicity of the acid
Depending the basicity acid s are classified as.
Mono basic acid- The acid which can furnish one H^+ in water is called mono basic acid.
Example: hydrochloric acid, nitric acid, acetic acid
Dibasic acid- The acid which furnish two H^+ ion in water is called dibasic acid.
Example: – sulphuric acid, oxalic acid,
Tri basic acid:- the acid which furnish three H^+ ion in water is called tri basic acid.
Example – phosphoric acid.

Preparation of acids: Acids are prepared by the following processes.

1) From non-metallic elements
Non-metals like chlorine, fluorine or iodine directly combine with hydrogen to form hydrochloric acid, hydrofluoric acid, or hydroiodic acid respectively.

$$H_2 + Cl_2 \rightarrow 2HCl$$

2) From oxides of non-metals
Oxides of non-metals like carbon, nitrogen, sulphur and phosphorus etc., dissolve in water to form carbonic acid, nitrous acid or nitric acid, sulphurous acid and phosphoric acid respectively.

$$CO_2 + H_2O \rightarrow H_2CO_3$$
$$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$$

PROPERTIES OF ACIDS

Physical properties of acids

- Acids are sour to taste.
- Organic acids are weak acids and are less corrosive.
- Inorganic acids are strong acids and are highly corrosive in nature in concentrated form.
- Acids are good conductors of electrically in their aqueous solutions.

Chemical properties of acids

1) Reaction with metals: Acids react with metals to liberate hydrogen gas

$$Na + 2HCl \rightarrow NaCl + H_2 \uparrow$$

Dilute

2) Reaction with metal carbonates, and metal bicarbonates: Acids react with metal carbonates, and metal bicarbonates to liberate carbon dioxide

$$CaCO_3 + 2HCl \rightarrow CaCl_2 + H_2O + CO_2 \uparrow$$

3) Reaction with metal oxides. Acids react with metal oxides which are basic in nature to form salt and water.

Uses of Acids

Both organic and inorganic acids are found lot of domestic and industrial uses. Some of them are mentioned below.

1) Hydrochloric acid is used for cleaning
   a) Kitchen sinks and sanitary ware
   b) Metal surfaces before tinning or galvanizing
2) Sulphuric acid is used in the manufacture of fertilizers, dyes, and paints. It is the king of chemicals. It also acts as a dehydrating agent.
3) Nitric acid is used in the manufacture of fertilizers and explosives.
4) Acetic acid is used as food preservative
5) Tartaric acid is used in the making of baking powder.
6) Sulphuric acid is also use in batteries

Bases

Substances like baking soda, bitter guard and neem are bitter in taste as they contain bases and hence are basic in nature. All bases except few are highly corrosive. Oxides and hydroxides of metals are bases.
Sodium oxide (Na_2O), calcium oxide (CaO) and magnesium oxide (MgO) are bases.

Sodium hydroxide $(NaOH)$, calcium hydroxide $Ca(OH)_2$ and magnesium hydroxide $Mg(OH)_2$ are also bases. Some bases are water soluble and are called **Alkali's**. Sodium hydroxide (caustic soda) and Potassium hydroxide (caustic potash), calcium hydroxide, ammonium hydroxide are alkalis. Alkali comes from the Arabic 'Qali' meaning 'from the ashes'. Some metal hydroxides are not soluble in water for example aluminum hydroxide, Ferric hydroxide, Copper hydroxide are called bases not alkalis. So **"all the alkalis are bases but all the bases are not alkalis"**

Bases when added to water, they dissociate into ions as shown below.

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

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

The properties of most of the bases are due to the presence of OH^- ions which are formed on ionization of the base in water. Ammonia when added to water, it produces OH^- ions. So it is also a base.

Classification of bases

1) Based upon the amount of water present, a basic solution is classified into dilute and concentrated basic solutions.

i) **Dilute** basic solutions contain more percentage of water

ii) **Concentrated** basic solutions contain less percentage of water

Bases are dilute by adding bases to water or water to bases.

2) Bases are also classified as organic and in organic bases. All the metal oxide and hydroxides are inorganic bases. Organic bases are generally nitrogen containing bases.

Some bases are highly corrosive and produce more number of OH^- ion in water are called **strong bases**. Example – sodium hydroxide, potassium hydroxide.

Bases like magnesium hydroxide is dissociate partially in water and form less number of hydroxide ion in water is called **weak base**.

3)The number of hydroxide ion furnished by one molecule of base in water is called its acidity. Depending on the acidity bases are classified as.

Mono acidic base- The base which produces one OH^- ion in water is called mono acidic base for example- sodium hydroxide, and potassium hydroxide, ammonium hydroxide

Diacidic base- The base which furnishes two OH^- in water is called diacidic base.
Example:- calcium and magnesium hydroxide.

Tri acidic base- The base which furnish three OH^- ion in water is called tri acidic base.
Example:- aluminium hydroxide.

PREPARATION OF BASES

Bases are prepared from highly reactive metallic elements. Metals like sodium, potassium, magnesium are allowed to burnt in oxygen to form their corresponding oxides. These oxides when dissolved in water form respective bases or akalis as shown below.

$$4Na + O_2 \rightarrow 2Na_2O$$
$$Na_2O + H_2O \rightarrow 2NaOH$$

PROPERTIES OF BASES

Physical properties of bases

1) Strong bases are corrosive. They may cause irritation and blisters.
2) They are good conductor of electricity in aqueous solution.
3) Bases are bitter to taste
4) Slippery to touch like soaps

Chemical properties of bases

1) Bases react with acids to form salts and water. This reaction is called neutralization reaction.

$$NaOH + HCl \rightarrow NaCl + H_2O$$

Base Acid Salt water

2) Bases react with non metal oxides which are acidic in nature to form salts.
Carbon dioxide passed over calcium hydroxide solution(lime water) turns milky due to formation of calcium hydroxide

$$Ca(OH)_2 + CO_2 = CaCO_3 + H_2O$$

3) Strong alkalis react with metal oxides like zinc oxide, lead oxide, aluminium oxide to produce salt and water. Such metal oxide which react with both acids and bases to form salt and water are called
Amphoteric oxides

$$NaOH + ZnO = Na_2ZnO_2 + H_2$$

Uses of bases

1) Sodium hydroxide (caustic soda) is used in cleaning of grease and oily surfaces and machine parts. It is used in the manufacture of soap.
2) Magnesium hydroxide (milk of magnesia) is used as an 'antacid' for neutralizing excess acidity in stomach.
3) Potassium hydroxide (caustic potash) is used in making soft soaps. It is used to remove carbon dioxide from air or in some laboratory experiments.
4) Calcium hydroxide (slaked lime) is used in betel leaves along with betel nuts. It is mainly used for white washing walls. Acidic soils are neutralized by adding calcium hydroxide. It is obtained when quick lime (CaO) is added to water.s
5) Baking soda $(NaHCO_3)$ is used in cooking food.
6) Baking powder is used for making of cakes.
7) Sodium carbonate is used as a fire extinguisher.
8) Zinc carbonate (calamine) is used for neutralize the ant bites. Ant bites inject formic acid into the skin which is neutralized by calamine which is a base.
9) Tooth paste is basic in nature which removes the acid produced in the mouth and cleans.

INDICATORS

Most of the acids and bases are highly corrosive in nature and it is not advisable to taste all substances to identify them as acid or base. So, some special types of substances are there to identify whether a substance is an acid or a base. These substances are called indicators (simply) or acid base indicators.

Indicators show different colour in acidic and basic substances. Litmus, turmeric, red cabbage, china rose petals and beet root are some naturally occurring indicators and are neutral. Phenolphthalein is an acid-base indicator and is slightly acidic in nature.

Litmus

It is the most commonly used natural indicator and is obtained from lichens. When lichen is added to distilled water it gives a purple coloured solution. The purple colour changes to red and blue in acidic solution and basic solution respectively. Litmus is available either in the form of solution or in the form of strips of paper that is, red litmus paper and blue litmus paper. Acid turns blue litmus paper red whereas bases turn red litmus paper blue.

Red cabbage

Grated red cabbage is boiled with distilled water. This solution acts as an indicator. It turns red in presence of an acid and green in presence of a base.

Turmeric powder

Turmeric powder is made into a paste by adding distilled water to it. The paste is applied on a blotting paper or filter paper and then it is dried. The dried paper can be used as an indicator.

China rose

The petals of China rose are added to warm water. The water becomes coloured after sometime. This coloured water acts as an indicator.

Phenolphthalein

It is a colourless solution. It gives pink colour in basic solution and there is no colour change in acidic solution

Indicator	Colour in acid	Colour in alkali
Litmus	**Red**	**Blue**
Phenolphthalein	**Colourless**	**Pink**
Methyl orange	**Orange**	**Yellow**
Turmeric	**Yellow**	**Red**
Red cabbage	**Red**	**Green**
China rose	**Red**	**Green**
Beet root	**Pink**	**Yellow (strong alkali)**

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SALTS (NUTRALIZATION): When an acidic solution is mixed with a basic solution, both the solutions neutralize the effect of each other. When an acid solution and a basic solution are mixed in suitable amounts, both the acidic nature of acid and the basic nature of the base are destroyed. The resultant solution is neither acidic nor basic. In neutralization reaction heat is always produced or evolved. The evolved heat raises the temperature of the reaction mixture.

In neutralization new substance formed are salt and watert.

Thus salt is formed when H+ of the acid is replaced by a metal in acid. Salts can be classified as

Normal salts, acid salts, basic salts and hydrated salts

1) The salt containing no replaceable hydrogen atom is called **normal salt** for example- sodium sulphat, (Na_2SO_4), sodium chloride NaCl, calcium carbonate $CaCO_3$, Potasium Carbonate K_2CO_3.

2) The salt which contains one replaceable hydrogen atom is called **acid salt** for example-potasium hydrogen sulphate $KHSO_4$, magnesium hydrogen carbonate $Mg(HCO_3)_2$, sodium hydrogen suphite $NaHSO_3$.

3) The salts which contains one replaceable hydroxyl group is called **basic salt** for example-basic copper chloride Cu(OH)Cl, basic copper nitrate $Cu(OH)NO_3$,

4) The salts containing water of crystallization in it are called **hydrated salts**.

Example- Ccopper sulphate (Blue vitriol) : $CuSO_4.5H_2O$
Ferrous sulphate (Green vitriol) : $FeSO_4.5H_2O$
Zinc sulphate (White vitriol : $ZnSO_4.7H_2O$
Calcium sulphate (Gypsum salt) : $CaSO_4.2H_2O$
Magnesium sulphate (Epsom salt) : $MgSO_4.7H_2O$

ASSIGNMENTS

EXERCISE

SUBJECTIVE

1. Complete the following table.

SOLUTION	RED LITMUS	BLUE LITMUS	PHENOLPHTHALEIN
Ammonium chloride		Red	
Sodium sulphate	Red		
Sodium acetate			
Potassium hydroxide			Pink

2. How the acidity of soil is neutralized? Give the main cause of acid rain.

3. Why Milk of magnesia is used as an antacid? Explain the chemical nature of magnesia.

4. Pickles should not be stored in metallic containers. Give reason.

5. What is vinegar?

6. Concentrated acids are diluted by adding acid to water but not water to acid. Give reason.

7. Give the method of preparation of acids and bases with suitable chemical equations.

8. Why baking powder is added in cake preparation?

9. Explain the working of Sodium carbonate as a fire extinguisher.

10. Why the wooden shelves containing sulphur acid bottles become charred?

11. Why distilled water is preferred in the preparation of indicators?

12. Test whether the following solutions are acidic, basic or neutral with the help of red and blue litmus paper, salt solution $(NaCl)$, sugar solution, soap solution, lemon juice, vinegar, baking soda solution, washing soda solution, rain water.

OBJECTIVE

1. Which one of the following is inorganic acid?
   (A) Citric acid (B) Tartaric acid (C) carbonic acid (D) Acetic acid

2. Acids containing less percentage of water are called
   (A) strong acids (B) weak acids (C) concentrated acids (D) dilute acids

3. Which of the following is used to neutralize the acidity of soil?
   (A) baking powder (B) quick lime (C) slaked lime (D) both ((B) and ((C)

4. Chemical nature of phenolphthalein is
   (A) strongly acidic (B) strongly basic (C) slightly acidic (D) neutral

5. Among the following, the one that is responsible for acid rain is
   (A) CO_2 (B) SO_2 (C) NO_2 (D) all of these

6. When phenolphthalein is added to potassium hydroxide the colour of the solution becomes _____.
   (A) milky white (B) pink (C) red (D) orange

7. Select the correct statement.
   (A) acids turn red litmus paper blue (B) sodium hydroxide is highly soluble in water
   (C) sodium hydroxide is highly soluble in water (D) generally indicators are neutral

8. The colour of red cabbage solution turns _____ and _____ respectively in presence of an acid and base.
   (A) red, blue (B) blue, green (C) red, green (D) yellow, green

9. When Phenophthalene is added to sodium chloride solution, the colour of the solution changes to
   (A) red (B) pink (C) no change in colour (D) white

10. Name the gas that is evolved when sodium carbonate is treated with H_2SO_4
    (A) H_2 (B) O_2 (C) CO_2 (D) N_2

ANSWERS

OBJECTIVE

1.	**C**	2.	**C**	3.	**D**	4.	**C**
5.	**D**	6.	**B**	7.	**C**	8.	**C**
9.	**C**	10.	**C**				