Introduction: All the chemical compounds can be classified on the basis of their chemical properties as acids, bases and salt. They have certain definite properties which distinguish these compounds from each other. Most of digestive fluids of humans and animals contain acids. The bitter taste of substances like bitter gourd, cucumber etc is due to the presence of base in them.

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. Acids turn blue litus red. Fruits contain acids. Aqueous solutions of acids conduct electricity and react with bases to form salts and water. An acid may be defined in various ways. 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.

1. Orange, lemon	Citric acid, ascorbic acid (vitamin C)
2. Apple	Malic acid
3. Tamarind (imli), grape	Tartaric acid
4. Vinegar	Acetic acid
5. Curd	Lactic acid
6. Tomato	Oxalic acid
7. Gastric juice	Hydrochloric acid
8. Tea	Tannic acid
9. Red ants	Formic acid

(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 hydrogensulphate or sodium sulphate.

Classification of Acids: Depending upon the elements present, acids may be classified as follows.

$$H_2SO_4 \xrightarrow[+Na]{-H} \underset{\text{sodium hydrogensulphate}}{NaHSO_4} \quad \text{(partial replacement)}$$

$$H_2SO_4 \xrightarrow[+2Na]{-2H} \underset{\text{sodium sulphate}}{Na_2SO_4} \quad \text{(complete replacement)}$$

1. Oxo acid: Acids that contain both hydrogen and oxygen are called oxo acids. For example, nitric acid (FINO3), sulphuric acid (H2 SO4) and phosphoric acid (H3 P04) are oxo acids.

2. Hydracid Acids that contain hydrogen and other nonmetallic element(s), except oxygen, are called hydracids. For example, hydrochloric acid (HC1) and hydrocyanic acid (HCN) are hydracids.

Acids may also be classified as follows.

1. Organic and inorganic acids: All sour things that we use in our daily food contain acids. These acids are organic acids. Some of the common acids that are generally used in the laboratory are hydrochloric acid (HC1), sulphuric acid (H2504) and nitric acid (HNO3). These are inorganic acids, also called mineral acids. Hydrochloric acid is also present in the gastric juice in our stomach.

2. Concentrated and dilute acids: An acid solution may be concentrated or dilute depending upon the amount of the acid present in the solution. Concentrated and dilute solutions of acids are generally used in laboratories. When the solution contains a larger amount of the acid, it is said to be concentrated, whereas a dilute solution contains smaller amount of the acid. Thus, concentrated and dilute solutions of an acid differ from each other only in the proportions of the acid and water in them. **Dilution of an acid**: Dilution of a concentrated acid by adding water is a highly exothermic process. The heat energy is so large that it may turn

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water into steam instantly resulting in the splashing of acid and may cause severe acid burns. So, a concentrated acid should never be diluted by adding water to the acid but by adding acid gradually to water. In doing so, the small amount of heat produced is safely absorbed by the large volume of water.

3. 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.

Chemical properties of Acids:

1. Reaction with metals: dilute acids (like HCl, H2SO4 but not HNO3) react with certain active metals like Zn, Fe to evolve h2 gas. Thus, these acids or substances containing these kind of acids should not be kept in metal containers.

$$2Na + 2HCl \rightarrow \underset{\text{sodium chloride}}{2NaCl} + H_2\uparrow_{\text{hydrogen}}$$

$$Fe + 2HCl \rightarrow \underset{\text{ferrous chloride}}{FeCl_2} + H_2\uparrow$$

$$Mg + H_2SO_4 \rightarrow \underset{\text{magnesium sulphate}}{MgSO_4} + H_2\uparrow$$

$$2Al + 3H_2SO_4 \rightarrow \underset{\text{aluminium sulphate}}{Al_2(SO_4)_3} + 3H_2\uparrow$$

Metal + Dilute Acid ⟶ Salt + H_2

2. Reaction with metal carbonate and hydrogen carbonate: limestone, chalk and marble are different forms of calcium carbonate. Acids react with metal carbonates and hydrogen carbonates to produce corresponding salt, carbon dioxide and water.

$$\underset{\text{sodium carbonate}}{Na_2CO_3} + 2HCl \rightarrow \underset{\text{sodium chloride}}{2NaCl} + \underset{\text{water}}{H_2O} + \underset{\text{carbon dioxide}}{CO_2\uparrow}$$

$$Na_2CO_3 + H_2SO_4 \rightarrow \underset{\text{sodium sulphate}}{Na_2SO_4} + H_2O + CO_2\uparrow$$

$$\underset{\text{calcium carbonate}}{CaCO_3} + 2HCl \rightarrow \underset{\text{calcium chloride}}{CaCl_2} + H_2O + CO_2\uparrow$$

$$NaHCO_3 + HCl \rightarrow NaCl + H_2O + CO_2\uparrow$$

Metal carbonate/ hydrogen carbonate + Acid ⟶ Salt + CO_2 + H_2O

3. Reaction with metal oxides: acids react with certain metal oxides (basic oxides) to form salt and water.

$$\underset{\text{sodium oxide}}{Na_2O} + 2HCl \rightarrow 2NaCl + H_2O$$

$$\underset{\text{cupric oxide}}{CuO} + H_2SO_4 \rightarrow \underset{\text{cupric sulphate}}{CuSO_4} + \underset{\text{water}}{H_2O}$$

$$CaO + 2HCl \rightarrow CaCl_2 + H_2O$$

4. Test for CO_2 gas: when CO_2 gas is passed through lime water, it turns milky due to formation of white precipitate of $CaCO_3$. But if excess CO_2 is passed, milkliness disapperas due to formation of $Ca(OH)_2$ which is soluble is water.

$$\underset{\text{Lime water}}{Ca(OH)_2(aq)} + \underset{\text{Carbon dioxide}}{CO_2(g)} \longrightarrow \underset{\text{Calcium carbonate (White ppt.)}}{CaCO_3(s)} + \underset{\text{Water}}{H_2O(l)}$$

$$\underset{\text{Calcium carbonate (Milkiness)}}{CaCO_3(s)} + \underset{\text{Water}}{H_2O(l)} + \underset{\text{Carbon dioxide (Excess)}}{CO_2(g)} \longrightarrow \underset{\text{Calcium bicarbonate (Soluble)}}{Ca(HCO_3)_2(aq)}$$

Bases: Bases are substances that are soapy to touch and bitter in taste. And turn red litmus blue.

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.

Chemical Properties of bases:

1. Reaction with metals: strong bases react with active metals to produce hydrogen gas. Thus, these bases should not be kept in metal container.

$$\underset{\text{Zinc}}{Zn(s)} + 2\underset{\text{Sodium hydroxide}}{NaOH(aq)} \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2(aq)} + \underset{\text{Hydrogen gas}}{H_2(g)}$$

Metal + base ⟶ Salt + Hydrogen Gas

2. Reaction with non – metallic oxide: bases react with non-metallic oxides (acidic oxides) to produce salt and water. This reaction proves that non-metallic oxides are acidic in nature. Base + Non-metallic oxides gives Salt + H_2O

$$\underset{\text{Carbon dioxide}}{CO_2(g)} + \underset{\text{Slaked lime}}{Ca(OH)_2(aq)} \longrightarrow \underset{\text{Calcium carbonate}}{CaCO_3(s)} + \underset{\text{Water}}{H_2O(l)}$$

Reaction between Acids and Bases: Acids react with base to produce salt and water. In this reaction, an acid neutralizes a base i.e. reduces its effect or vice – versa, thus the reaction is known as **neutralization reaction.** In general, it is expressed as: Acid + Base ⟶ Salt + Water

Acids/Bases in Water Solution: In presence of water, acids give H^+ ion. As H^+ ion cannot exist alone so it combines with water molecules and form H_3O^+ (Hydronium ion). So, we can say in presence of water, acids give H^+ and H_3O^+ ion. In the same way, in presence of water, bases give OH^- ion.

Exercise:

1. What happens when CO_2 gas is passed through lime water?
2. Give a chemical reaction to prove non metallic oxides are acidic in nature.
3. How H_3O^+ ion is formed in water solution.

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.

What property do acids and bases have in common? A solution conducts electricity due to the presence of ions in it. The solutions of acids and bases too, conduct electricity. In their aqueous solutions, acids produce H ions whereas bases produce OH ions. Substances like ethanol and glucose which do not furnish ions fail to conduct electricity. So, the ability to form ions in their aqueous solutions is the common property of acids and bases. For example, sodium oxide (Na_20), 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.

$$NH_4OH + HCl \rightarrow NH_4Cl + H_2O$$

A base may also be defined as follows: A base is a substance which in aqueous solution dissociates to give hydroxide ions, OH. For example, NaOH, KOH and $Ca(OH)_2$ are bases.

$$NaOH \rightarrow Na^+ + OH^-$$
$$KOH \rightarrow K^+ + OH^-$$
$$Ca(OH)_2 \rightarrow Ca^{2+} + 2OH^-$$

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], aluminium 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:

Oxides	Soluble hydroxides	Insoluble hydroxides
Sodium monoxide (Na_2O)	Sodium hydroxide (NaOH)	Ferric hydroxide [$Fe(OH)_3$]
Calcium oxide (CaO)	Potassium hydroxide (KOH)	Aluminium hydroxide [$Al(OH)_3$]
Cupric oxide (CuO)	Calcium hydroxide [$Ca(OH)_2$]	
Zinc oxide (ZnO)	Ammonium hydroxide (NH_4OH)	

Lime juice, baking soda and washing soda are all bases.

You can test the basic nature of a substance by using turmeric juice as indicator. Take a very dilute solution of washing soda in a spoon. Add a drop of yellow turmeric juice to it. The solution will turn reddish brown, indicating that the soap solution is basic. Toothpaste, soap, antacid are some of the substances that contain bases.

We usually use antacid tablets to remove acidity (burning sensation) in the stomach.

Preparation of Bases

Bases can be prepared by the following methods.

1. By the direct union of a metal with oxygen

Some metals when heated in air or oxygen form the oxides of the metals. These oxides when dissolved in water make the hydroxides of metals.

$$4Na + O_2 \rightarrow 2Na_2O \quad \text{(sodium oxide)}$$
$$4K + O_2 \rightarrow 2K_2O \quad \text{(potassium oxide)}$$
$$2Ca + O_2 \rightarrow 2CaO \quad \text{(calcium oxide)}$$

$$Na_2O + H_2O \rightarrow 2NaOH$$
$$K_2O + H_2O \rightarrow 2KOH$$
$$CaO + H_2O \rightarrow Ca(OH)_2$$

2. By heating carbonates of some metals

When calcium carbonate is heated, calcium oxide and carbon dioxide are formed.

$$CaCO_3 \rightarrow CaO + CO_2\uparrow$$

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Similarly, when zinc carbonate is heated, zinc oxide and carbon dioxide are formed.

$$ZnCO_3 \rightarrow ZnO + CO_2\uparrow$$

General Properties of Bases

1. The solutions of bases in water give a soapy touch. When dissolved in water they produce hydroxide ions (0H) in solution. Due to the presence of ions, the aqueous solutions of bases, too, can conduct electricity.
2. They turn red litmus paper blue. Bases show their basic properties in the presence of water only. For example, dry ammonia (a base) does not turn red litmus blue, but its aqueous solution (ammonium hydroxide) turns red litmus blue.
3. They react with acids to produce salt and water: In these reactions, the acid and the base neutralize each other. Therefore, these reactions are called neutralization reactions.

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.

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

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

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

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. When a base is heated with an ammonium salt, ammonia gas, another salt and water are produced. For example, when sodium hydroxide is heated with ammonium chloride, the products formed are sodium chloride, water and ammonia gas.

$$NaOH + \underset{\text{ammonium chloride}}{NH_4Cl} \rightarrow \underset{\text{sodium chloride}}{NaCl} + H_2O + \underset{\text{ammonia}}{NH_3\uparrow}$$

Ammonia gas is recognized by its pungent smell.

Indicator: a substance that assumes different colours in acidic, basic and neutral solutions. Litmus, methyl orange, phenolphthalein are some most common acid base indicators.

Indicator	Acid solution	Basic solution	Neutral solution
Blue litmus solution	Red	No change in colour	No change in colour
Red litmus solution	No change in colour	Blue	No change in colour
Methyl orange	Red	Yellow	Orange
Phenolphthalein	Colourless	Red	Colourless

Litmus It is a natural dye made from small plants called lichens. The lichen extract, called litmus solution, is itself neutral and purple in colour. The extract when acidified gives red litmus solution whereas blue litmus solution is obtained when the extract is made alkaline.

Litmus paper: Blue or red litmus paper is prepared by dipping a strip of filter paper in blue or red litmus solutions. The paper is then removed from the solution and dried. Blue litmus paper turns red in an acidic solution and red litmus paper blue in a basic solution.

Phenolphthalein: It is a colourless compound. An alcoholic solution of phenolphthalein is used as an indicator. It is colourless in an acidic solution, but becomes pink (red) in basic solution.

Methyl orange: A very small amount of solid methyl orange is dissolved in hot water and filtered. The filtrate is used as an indicator. It turns red in acid solutions and yellow in basic solutions. Methyl orange and phenolphthalein are synthetic indicators.

Household indicators:

(i) Turmeric juice: It is yellow in colour. It remains yellow in an acidic or neutral solution but turns deep brown in a basic solution.

(ii) Red-cabbage juice: Itself purple in colour, it turns red in an acid solution, but green in a basic solution.

The household indicators may be used to test whether some of the substances of daily use as listed below are acidic or basic.

Acidic substances	Basic substances
Vitamin C tablets (ascorbic acid)	Antacids
Lemon juice	Toothpaste
Orange juice	Soap solution
Tomato juice	Washing soda solution
Vinegar	

Olfactory indicators: There are substances like onion juice, vanilla essence and clove oil which by change of their smell indicate whether the sample solution is acidic or basic. These are called olfactory indicators.

Onion: A few strips of cloth and finely cut pieces of onion are taken together in a polythene bag. The open end of the polythene bag is tied tightly with a thread and kept as such in a fridge for about 12 hours. During this period the cloth strips become saturated with the odour of onion. Two of the strips are now picked up. Over one of the strips 2—3 drops of an acidic solution are dropped. The strip acquires a characteristic smell. The other strip is similarly treated with a basic solution. This time the strip loses its smell.

Vanilla essence: When 1—2 drops of vanilla essence are added to 1 ml of an acidic solution taken in a test tube, the smell of the vanilla essence does not change. But, when a basic solution is similarly treated, the smell of the vanilla essence disappears.

Clove oil: Clove oil gives different smells with acidic and basic solutions.

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