Materials : Metals and Non-Metals

Physical Properties of Metals and Non-Metals

Do you know how many elements are there in our periodic table?

There are 118 elements in the modern periodic table. These elements can be broadly classified as metals and non-metals depending on their properties.

Elements that lose electrons to form compounds are called **metals** whereas elements that gain electrons to form compounds are called **non-metals**. Elements such as Si, Ge, As, Sb and Te show the characteristic properties of both metals and non-metals. They are called **semi-metals** or **metalloids**. Here, we will discuss metals and non-metals along with their physical properties in detail.

Metals

These elements are electropositive and contain less than or equal to three electrons in their valence shell. Metals such as aluminium, copper, and iron are widely used around us. Metals are used for the construction of bridges, automobiles, airplanes, ships, trains, etc. We will now discuss the physical properties of metals.

Physical properties of metals:

1. Metallic Lustre: The surface of most metals is shiny. The lustre associated with metals is known as **metallic lustre**. For example, iron, copper, gold, and silver are very shiny. Metals such as gold and silver are very lustrous. Therefore, they are used for making jewellery.

> Silver is used for making mirrors because of its excellent shine and reflective nature.

Do you know that metals like gold, silver, platinum, paladium and rhodium are known as **noble metals.** They occur in the elemental state in nature.

Some metals do not look very lustrous. This is because they either lose their lustre or their lustre gets reduced when exposed to air for a long time. This happens due to the formation of a layer of oxide, carbonate, and sulphide on their surface. If a metal surface is rubbed with sand paper, then this layer gets removed and the shiny surface of the metal can be seen. The layer formed in some cases is stable and sticks on the surface of the metal, but in other cases, it is unstable and falls off (as in the case of rusting of iron).

2. Hardness: Metals are generally hard in nature. However, this hardness varies from metal to metal. Most metals such as iron, aluminium, etc. are very hard and cannot be cut with a knife whereas some metals such as sodium and potassium are very soft and can be cut using a knife.

3. Malleability: Metals are malleable. Most metals such as iron, copper, silver, and gold can be hammered without breaking to form thin sheets. Aluminium, and silver are highly malleable metals and are often used for making foils, which are extensively used in the decoration of sweets, packing of food items, etc.

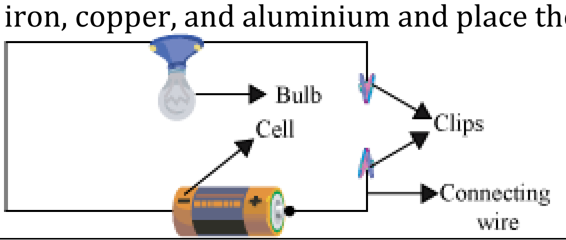
4. Ductility: Most metals are ductile, which means that they can be drawn into thin wires without breaking. For example, iron, copper, silver, and gold can be drawn into thin wires without breaking. For this reason, copper and aluminium are extensively used for making electrical wires.

Gold and silver are the most malleable and ductile metals. Hence, they are extensively used in jewellery.

5. Conduction of heat: Metals are generally good conductors of heat. This means that if one end of a metal rod is heated for some time, then the entire rod becomes hot. For example, aluminium, copper, and silver are good conductors of heat. Hence, copper and aluminium are generally used for making vessels. The following activity can be performed to explain that metals can conduct heat.

6. Conduction of electricity: Metals are good conductors of electricity i.e., they allow an electric current to pass through them easily. Silver, copper, and aluminium are the best conductors of electricity. For this reason, most electric wires are made of copper and aluminium. However, using silver for making electric wires is not cost effective. The following activity can be performed to explain that metals can conduct electricity.

Activity:
Take two electric wires and attach two clips to each wire (as shown in the given figure). Then, take a bulb fitted in a holder and connect it to a battery with the help of electric wires. Now, take pieces of iron, copper, and aluminium and place them one by one between the clips.



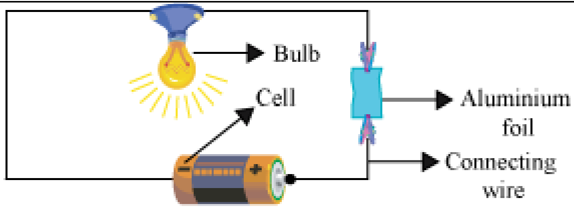


Figure 2: Conduction of electricity in metals
It will be observed that the bulb glows every time when the metal pieces are used to connect the two clips. This shows that metals are good conductors of electricity.

7. Melting and boiling points: Melting and boiling points of metals are usually high.

8. Physical state: All metals exist as solids at room temperature except mercury, which exists as a liquid.

9. Sonority: Metals such as iron and copper produce a sound on being struck. Hence, metals are said to be sonorous.

Non-metals

Many elements in the periodic table do not behave like metals. These elements are known as **non-metals**. These elements gain electrons to form compounds. These are electronegative and contain more than three electrons in their valence shell. Carbon, sulphur, iodine, oxygen, etc. are some examples of non-metals. Non-metals exist in all three physical states i.e., as solids, liquids, and gases. Bromine is the only non-metal, which exists as a liquid.

Physical properties of non-metals:

1. Lustre: Non-metals do not have a shiny surface. However, iodine is an exception, which has a very shiny surface.

2. Hardness: Non-metals generally exist as solids, liquids, or gases. Non-metals that exist in a solid state are very soft. For example, sulphur, which exists in solid state, is quite soft. Similarly, carbon, in the form of graphite, is quite soft. However, diamond, another allotrope of carbon, is very hard. It is in fact the hardest known natural substance.

3. Malleability and ductility: Non-metals that exist in solid states are not very strong. They are brittle and break when pressure is applied on them. Therefore, non-metals are neither malleable nor ductile.

4. Conduction of heat and electricity: Non-metals are poor conductors of heat and electricity. Examples include sulphur and phosphorus. However, there is an exception. Graphite, an allotrope of carbon, is a good conductor of electricity.

5. Physical state: Non-metals exist in all three physical states at room temperature. Non-metals such as carbon, sulphur, and phosphorus exist in solid states while oxygen, chlorine, and nitrogen exist in gaseous states. Bromine is the only non-metal that exists in a liquid state.

6. Melting and boiling points: Melting and boiling points of non-metals are quite low. For example, the melting point of phosphorus is 44.2°C. However, diamond, an allotrope of carbon, is the only non-metallic substance that has a very high melting and boiling point. The melting point of diamond is more than 3500°C.

7. Sonority: Non-metals are not sonorous.

The given table summarizes the properties of metals and non-metals.

Metals	**Non-metals**
Metals are very hard and strong.	Solid non-metals are soft and can be easily broken.
Metals have a shiny lustre.	Non-metals are not shiny and have a dull appearance.
Metals are sonorous.	Non-metals are not sonorous.
Metals are malleable and ductile.	Non-metals are neither malleable nor ductile.
Metals are good conductors of heat and electricity.	Non-metals are poor conductors of heat and electricity.

Reactions of Metals and Non-Metals with Oxygen and Water

Metals such as aluminium, copper, and iron are widely used around us. Metals are used for the construction of bridges, automobiles, airplanes, ships, trains etc.

We have earlier studied about the physical properties of metals. Now, let us try to learn about their chemical properties. Here, we will study about the reaction of metal with oxygen, water, and acids.

You must have observed that when a piece of iron is kept in the open for some time, it gets covered with a brownish substance. This brownish substance is called **rust** and the process is called **rusting**. Rust is formed when iron reacts with oxygen (present in air) to form iron oxide. Also, a ribbon of magnesium burns in air to form magnesium oxide. These reactions represent reactions of metals with oxygen. Hence, metals react with oxygen to produce metals oxides.

Metals react with oxygen to produce metal oxides which are basic in nature. These oxides thus turn red litmus paper blue, but have no effect on blue litmus paper.

Let us now study how non-metals react with oxygen.

Sulphur (S) is a non-metal. It reacts with oxygen to produce sulphur dioxide (SO_2), which is an acidic oxide. Sulphur dioxide then reacts with water to produce sulphurous acid (H_2SO_3), which changes blue litmus to red. The chemical equations involved in the reaction can be represented as:

$$\begin{array}{ccccc} S & + & O_2 & \rightarrow & SO_2 \\ \text{Sulphur} & & \text{Oxygen} & & \text{Sulphur dioxide} \end{array}$$

Non-metals react with oxygen to produce their oxides, which are generally acidic in nature.

We will now study the reaction of metals and non-metals with water.

While some metals react very vigorously with water, others react very slowly. However, there are some metals which do not react with water at all. For example, sodium metal reacts vigorously with water and iron reacts slowly with water.

Metals react with water to produce hydrogen gas and metal hydroxides. These metal hydroxides are basic in nature. However, non-metals usually do not react with water.

Do You Know:

- Sodium and potassium are very reactive metals. They react vigorously with oxygen and water to produce a lot of heat. Hence, to prevent their reaction with air and water, they are stored under kerosene.

- Non-metals react very vigorously with air, but generally do not react with water. Phosphorus is a very reactive non-metal, which catches fire when exposed to air. Hence, phosphorus is stored under water to prevent contact between phosphorus and air.

1. **Reaction of metals with oxygen**

   On heating, magnesium burns with a dazzling white flame to form magnesium oxide. Similarly, when aluminium is heated, it reacts with oxygen present in the air to form aluminium oxide.

$$\begin{array}{ccccc} 4Al(s) & + & 3O_2(g) & \rightarrow & 2Al_2O_3(s) \\ \text{Aluminium} & & \text{Oxygen} & & \text{Aluminium oxide} \end{array}$$

Almost all metals combine with oxygen to form metal oxides. The general reaction for the process is:

$$\text{Metal} + \text{Oxygen} \rightarrow \text{Metal oxide}$$

All metals are not equally reactive. Therefore, the reactivity of metals with oxygen also varies. Some metals such as sodium react with oxygen at room temperature. Metals such as magnesium do not react with oxygen at room temperature and require heating. On the other hand, metals such as zinc do not react with oxygen easily and require very strong heating. Silver and gold do not react with oxygen even at high temperatures.

All metal oxides are basic in nature and turn red litmus paper blue. These basic oxides react with acids to form salt and water. However, the oxides of aluminium and zinc show the properties of both acids and bases. **Chemicals that show both acidic and basic properties are said to be amphoteric in nature**. Hence, aluminium oxide and zinc oxide are amphoteric oxides. They react with both acids and bases to give their respective salts and water.

Almost all metal oxides are insoluble in water. However, the oxides of sodium and potassium dissolve in water to form hydroxides.

$$\underset{\text{Sodium oxide}}{Na_2O(s)} + \underset{\text{Water}}{H_2O(l)} \rightarrow \underset{\text{Sodium hydroxide}}{2\ NaOH(aq)}$$

$$\underset{\text{Potassium oxide}}{K_2O(s)} + \underset{\text{Water}}{H_2O(l)} \rightarrow \underset{\text{Potassium hydroxide}}{2\ KOH(aq)}$$

K2OsPotassium oxide + H2OlWater →2 KOHaqPotassium hydroxide

2. **Reaction of metals with water**

Do you know that sodium reacts explosively with cold water? The reaction results in the formation of their respective hydroxides and hydrogen gas. The reaction is so violent and exothermic that the evolved hydrogen catches fire. These metals give hydroxides with water as their oxides are soluble in water.

$$\underset{\text{Sodium}}{2Na(s)} + \underset{\text{Water}}{2H_2O(l)} \rightarrow \underset{\text{Sodium hydroxide}}{2NaOH(aq)} + \underset{\text{Hydrogen}}{H_2(g)} + \text{Heat}$$

On the other hand, metals such as iron do not react with cold water or hot water. However, they react with steam to give their respective oxides and hydrogen gas.

$$\underset{\text{Iron}}{3Fe(s)} + \underset{\text{Steam}}{4H_2O(g)} \rightarrow \underset{\text{Iron (II, III) oxide}}{Fe_3O_4(aq)} + \underset{\text{Hydrogen}}{4H_2(g)}$$

Thus, metals react with water to form metal oxides and hydrogen gas. Some metal oxides are soluble in water. These metal oxides form hydroxides by reacting with one or more water molecules. The general reaction for the process is given as:

$$\text{Metal} + \text{Water} \rightarrow \text{Metal oxide} + \text{Hydrogen}$$
$$\text{Metal oxide} + \text{Water} \rightarrow \text{Metal hydroxide} \quad (\text{if metal oxide is soluble in water})$$

The vigour with which a metal reacts with water differs from metal to metal. Some metals react with cold water, others with hot water, while some react only with steam. There are also metals that do not even react with steam. For example, silver and gold do not react with water at all.

Reaction of non-metals with hydrogen.

Non-metals react with hydrogen under specific conditions to form their corresponding compounds containing hydrogen. Few examples are given below:

$O_2 + 2H_2 \rightarrow 2H_2O$ (Water)

$S + H_2 \rightarrow H_2S$ (Hydrogen sulphide)

$N_2 + 3H_2 \rightarrow 2NH_3$ (Ammonia)

$Cl_2 + H_2 \rightarrow 2HCl$ (Hydrogen chloride)

Unlike metals, non-metals do not react with water or dilute acids.

Reaction of Metals and Non-Metals with Acids and Bases

You know that the substances which turn blue litmus paper to red are called **acids,** and the substances which turn red litmus paper to blue are called **bases**. **Do you how these substances react with metals and non-metals?**

Let us study how metals and non-metals react with acids. The reaction of metals and non-metals with acids can be observed by performing the following experiment.

Therefore, it can be concluded that metals react with acids to release hydrogen gas, which burns with a ‘pop’ sound. On the other hand, non-metals do not react with acids.

Some Interesting Facts:

- Hydrogen gas is colourless and odourless. It has no effect on moist litmus paper. It burns with a characteristic ‘pop’ sound when a flame is introduced.
- Copper is a less reactive metal. It does not react with dilute hydrochloric acid, even on heating.

Let us now study how metals and non-metals react with bases by performing the following experiment.

Thus, metals react with bases to produce hydrogen gas. However, not all the metals react with bases to produce hydrogen gas. The reactions of non-metals with bases are complex.

- **Reaction of metals with acids**
  - Metals react with hydrochloric acid in the similar fashion as they do with sulphuric acid. Sodium reacts very vigorously with hydrochloric acid to form a salt, and hydrogen gas is evolved in the reaction.
    $$\underset{\text{Sodium}}{2Na(s)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \rightarrow \underset{\text{Sodium chloride}}{2NaCl(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$
  - Magnesium reacts vigorously with hydrochloric acid, but not as vigorously as sodium and potassium.
    $$\underset{\text{Magnesium}}{Mg(s)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \rightarrow \underset{\text{Magnesium chloride}}{MgCl_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$
  - Zinc and iron also react with dilute hydrochloric acid to give zinc chloride and iron (II) chloride respectively. These reactions are comparatively less vigorous than the reaction of hydrochloric acid with aluminium metal.
    $$\underset{\text{Zinc}}{Zn(s)} + \underset{\text{Hydrochloric acid}}{2HCl(aq)} \rightarrow \underset{\text{Zinc chloride}}{ZnCl_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

$$\underset{\text{Iron}}{Fe(s)} + \underset{\text{Hydrochloric acid}}{2\,HCl(aq)} \rightarrow \underset{\text{Iron (II) Chloride}}{FeCl_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

Thus, it can be concluded that metals react with acids to give a salt and hydrogen gas. The general equation for the process can be represented as:

$$\text{Metal} + \text{acid} \rightarrow \text{Salt} + \text{Hydrogen}$$

However, all metals do not react with dilute hydrochloric and sulphuric acids. Also, hydrogen gas is not evolved when a metal reacts with nitric acid. This is because nitric acid acts as an oxidizing agent and oxidizes hydrogen gas produced in the reaction to form water. At the same time, nitric acid itself gets reduced to form nitrogen oxides such as nitrous oxide (N_2O), nitric oxide (NO), and nitrogen dioxide (NO_2). However, there are some metals such as magnesium, which react with very dilute nitric acid to evolve hydrogen gas.

$$\underset{\text{Magnesium}}{Mg(s)} + \underset{\text{Nitric acid}}{2HNO_3(aq)} \rightarrow \underset{\text{Magnesium nitrate}}{Mg(NO_3)_2(aq)} + \underset{\text{Hydrogen}}{H_2(g)}$$

Metals such as gold and silver, which are very less reactive, do not react with acids. The only acid that dissolves gold is *aqua regia*. *Aqua regia* is the Latin name for 'holy water' or 'royal water'. It is called so because it is the only liquid that dissolves gold. It is prepared by mixing three parts of concentrated hydrochloric acid and one part of concentrated nitric acid. It is a highly corrosive and fuming solution having yellow or red colour. It can also dissolve platinum metal.

- **Reaction of metals with bases**

When metals react with base they forms hydrogen.

Displacement Reactions

We know that chemical reactions are primarily of five types. They are listed below.

1. Combination reactions

2. Decomposition reactions

3. Displacement reactions

4. Double displacement reactions

5. Oxidation and reduction reactions

In this part, we will discuss displacement and double displacement reactions in detail.

In displacement reactions, a more reactive metal replaces a less reactive metal from the latter's salt.

Reactions in which a more reactive element replaces a less reactive element from the salt solution of the less reactive element are called displacement reactions.

Do you know that displacement reactions are of two types? They are:

1. Single Displacement Reactions
2. Double Displacement Reactions

Single Displacement Reactions can be better understood with the help of the following figure.

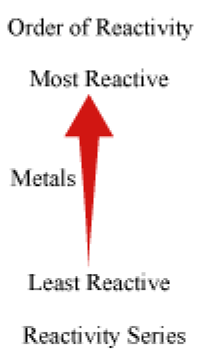
In the above figure, you have three blocks. It will be observed that while red and blue blocks are fixed in, green block is aloof. Now, if a blue block is detached from the red and fixed with the green, it will mean that the green block displaces the red block.

Thus, in a single displacement reaction, an uncombined single element replaces the other element present in a compound.

Another example of single displacement reaction is:

$$\underset{\text{Zinc}}{Zn\ (s)} + \underset{\text{Copper sulphate}}{CuSO_4\ (aq)} \rightarrow \underset{\text{Zinc sulphate}}{ZnSO_4\ (aq)} + \underset{\text{Copper}}{Cu\ (s)}$$

The reactivity of metals can be known from the reactivity series, which lists metals in their respective order of reactivity (most reactive at the top, least reactive at the bottom).



Now, consider the following figure.

Do you observe any difference from the first block sequence? In the above figure, there are four different blocks with different colours in two pairs. These blocks are detached. Then, the blue block is exchanged with the yellow block. This represents a double displacement reaction.

A Double Displacement Reaction is a bimolecular process in which parts of two compounds are exchanged to give two new compounds. The general equation used to represent double displacement reactions can be written as:

$AB + CD \rightarrow AD + BC$

Double Displacement Reactions have two common features:

- Firstly, two compounds exchange their ions resulting in the formation of new compounds.
- Secondly, one of the new products formed would be separated from the mixture in some way (commonly as a solid or gas).

Hands on activity

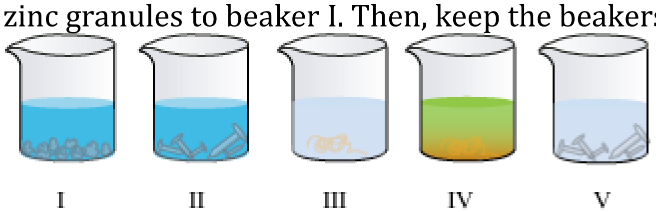
Activity - I

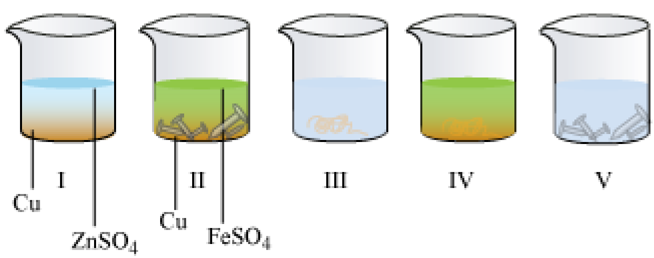
Take 2 mL each of lead nitrate and potassium iodide solution in two separate test tubes. Gently pour the potassium iodide solution into the lead nitrate solution.
As soon as you do this, you will observe the formation of a yellow precipitate. This yellow precipitate is of lead iodide. In this reaction, the two compounds lead nitrate and potassium iodide react by exchanging their ions to form new compounds, lead iodide and potassium nitrate.
The equation involved in this reaction is:

$$Pb(NO_3)_2 + 2KI \rightarrow PbI_2 + 2KNO_3$$

Activity - II

Take five 100 mL beakers and add 20 mL water in them. Label the beakers as I, II, III, IV, and V. Add 5 g copper sulphate to beakers I and II, 5 g zinc sulphate to III and V, and 5 g iron sulphate to beaker IV. Now, add some iron nails to beakers II and V, copper turnings to beakers III and IV, and zinc granules to beaker I. Then, keep the beakers undisturbed for some time and observe carefully.





You will observe that the colour of copper sulphate solution changes in beakers I and II. On the other hand, no change is observed in beakers III, IV, and V.
Can you explain these observations using the concept of displacement reactions?
In beaker I, zinc (Zn) replaces copper (Cu) from copper sulphate ($CuSO_4$) solution to form zinc sulphate ($ZnSO_4$) and copper. Because of this, the blue colour of copper sulphate disappears and a

reddish brown substance i.e. copper gets deposited at the bottom of the beaker. The chemical equation for the reaction can be represented as:

Zn (s) + $CuSO_4$ (aq) → $ZnSO_4$ (aq) + Cu (s)Zinc Copper sulphate Zinc sulphate CopperZn s + C uSO4 aq → ZnSO4 aq + Cu sZinc Copper sulphate Zinc sulphate Copper

Similarly, in beaker II, iron replaces copper from copper sulphate solution. Hence, the colour of the solution changes from blue to green and a reddish brown substance gets deposited on the iron nail.

Fe (s) + CuSO4 (aq) → $FeSO_4$ (aq) + Cu (s)Iron Copper sulphate Iron(II) sulphate CopperFe s + $CuSO_4$ aq → $FeSO_4$ aq + Cu sIron Copper sulphate Iron(II) sulphate Copper

Do you know why there are no changes in beakers III, IV, and V?

Since no change is observed in beakers III, IV, and V, it can be concluded that copper is less reactive than zinc and iron. Hence, copper can not replace zinc from zinc sulphate solution and iron from iron sulphate solution. Therefore, we can also say that iron is less reactive than zinc. Hence, iron cannot replace zinc from zinc sulphate solution.

Hence, it can be concluded that in displacement reactions, a more reactive metal replaces a less reactive metal from its salt solution, whereas a less reactive metal cannot replace a more reactive metal.

Types of double displacement reaction: A Double Displacement Reaction is of three types.

- **Precipitation reaction**

In precipitation reaction, soluble ions in separate solutions are mixed together to form an insoluble compound that settles out of the solution as a solid. This insoluble compound is called a precipitate.

Example:

If an aqueous solution of sodium sulphate is mixed with barium chloride, it will be observed that a white insoluble substance is formed. The white insoluble substance is called a **precipitate**. Here, barium chloride reacts with sodium sulphate to produce barium sulphate (white insoluble precipitate) and sodium chloride. Thus, this is an example of a double displacement reaction. The chemical equation involved in the reaction is

BaCl2 (aq) + Na2SO4 (aq) → BaSO4 (s) + 2NaCl (s)

Barium chloride Sodium sulphate Barium sulphate Sodium chlorideBaCl2 aq + Na2S O4 aq → BaSO4 s + 2NaCl sBarium chloride Sodium sulphate Barium sulphate Sodi um chloride

- **Neutralisation reaction**

Neutralisation reaction is a chemical reaction in which an acid and a base react to produce salt and water (H_2O).

Example:

2NaOH (aq) + H2SO4 (aq) → Na2SO4 (s) + 2H2O (l)
Sodium hydroxide Sulphuric acid Sodium sulphate Water
2NaOH aq + H2SO4 aq → Na2SO4 s + 2H2O lSodium hydroxide Sulphuric acid Sodium sulphate Water

- **Gas forming reaction**

Gas forming reactions are those reactions in which either, one of the product is formed in gaseous state or a product decomposes instantly to form a gaseous compound.

Example:

2HNO3 (aq) +Na2SO3 (aq) →2NaNO3 (aq) + H2O (l) + SO2 (g)
Nitric acid Sodium sulphite Sodium nitrate Water Sulphur dioxide

Uses of Metals and Non-Metals

We are familiar with a number of substances, which are very hard and shiny in nature such as iron, aluminium, gold, silver, and copper. You must have observed that these materials produce a sound on being struck. Such substances are called **metals**.

Substances which are dull in appearance and not very hard are called **non-metals** such as carbon, sulphur, iodine, etc.

There are 92 naturally occurring elements, which are classified into metals and non-metals. Among them, most elements are metals with less than 20 elements as non-metals. Here, we will discuss the properties and uses of metals and non-metals.

Metals are hard and shiny in appearance. They are malleable, ductile, and good conductors of heat and electricity. As a result of all these properties, metals have many uses.

1. Metals such as gold and silver are very shiny in appearance. These metals are quite ductile and malleable in nature. Also, these metals are expensive and do not corrode easily (though silver becomes black after some time due to corrosion). Hence, these metals are used in making jewellery.

2. Metals such as copper and aluminium are used to make wires as they are very good conductors of electricity. Also, they are very ductile. Copper and aluminium wires are widely used in electrical fittings in houses.

3. Metals such as iron, copper, and aluminium are good conductors of heat. Hence, they are used for making cooking utensils and water boilers.

4. Metals are malleable. Hence, they can be hammered into very thin sheets. For example, silver and aluminium foils are made by hammering these metals. Silver foils are used for decorating food items, whereas aluminium foils are used for wrapping food items such as chocolates and many such materials.

5. Metals are hard and rigid. Hence, they can be used in making machinery, automobiles, aeroplanes, trains, satellites etc. Aluminium is used for making parts of aeroplanes as it is very light in comparison to other metals.

Do You Know:

Silver is shiny and is a good reflector. It reflects about 90 percent of light falling on it. Hence, it is used for making high reflecting mirrors.

Like metals, non-metals also have various uses. We will now discuss the uses of non-metals.

1. Oxygen, which is a non-metal, is essential for life. It is used by plants and animals for the process of respiration. Oxygen is also used in factories, homes etc. as it supports combustion.

2. Nitrogen, a non-metal, is used in fertilizers to enhance the growth of plants.

3. Chlorine has the ability to kill germs. Hence, it is used in water purification as a disinfectant.

4. Tincture iodine is a solution of iodine in alcohol, which is used as an antiseptic.

5. Non-metals are also used in manufacturing crackers.

Some Common Uses of Metals

Uses of aluminium

- Aluminium is cheap and resistant to corrosion, so it is used for making cooking vessels, picture frames and household fittings.
- It is used in high-voltage electric transmission wires.
- Aluminium foils are used for packing purposes.
- It is used for making alloys like duralumin and magnalium.
- It is also used in paints.
- It is used in making mirrors of telescopes as it is an excellent reflector of light.
- It is used in thermite welding.

- Thermit (a mixture of 3 parts of Fe_2O_3 and 1 part of Al powder) is covered with an ignition mixture (Potassium chlorate and magnesium powder) in a crucible.
- The ignition mixture is ignited using a fuse of burning magnesium.
- In the reaction, Fe_2O_3 is reduced to Fe with the evolution of a large amount of heat.
- The molten Fe falls between the broken pieces and solidifies, joining the pieces in turn.
- $Fe_2O_3 + 2\ Al \rightarrow \quad Al_2O_3 + 2\ Fe + Heat$

Curiosity Corner

Aluminium-air batteries, also called **Al-air** batteries, are batteries in which the reaction of oxygen present in the air with aluminium is used to produce electricity.

Uses of magnesium

Magnesium is a silvery white metal.

- A mixture of powdered magnesium and potassium chlorate is used in fireworks.
- It is used as a fuse wire in thermite welding.
- It is used as a reducing agent in the extraction of metals.
- It is also used for the preparation of alloys like magnalium.

Uses of mercury

- It is used as a thermometric liquid in labs.
- It is used in thermometers.
- It is also used as an amalgam in dentistry for filling tooth cavities.

DO YOU KNOW?

As a liquid mirror, mercury is used as an alternative to big telescopes.

Uses of zinc

- It is used for galvanising iron.
- It is used for making containers of the dry cell.
- It is used in the preparation of alloys.
- It is also used in the extraction of gold and silver.

DO YOU KNOW?

The most exploited zinc ore is sphalerite or zinc sulfide; the largest exploitable deposits are found in Germany, Canada and the United States

Uses of iron

- Wrought Iron (carbon content 0.1 - 0.25%) is used for making tin roofing, buckets, trunks and electromagnets.
- Cast iron (carbon content 2.5 - 5%) is used for making drain pipes, manhole covers and machinery.
- It is also used for manufacturing steel.

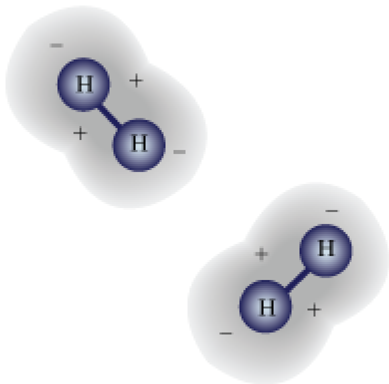
Uses of copper

- It is used for making electric transmission wires.
- It is used in the coils of electric motors and electric generators.
- It is used for making alloys such as brass and bronze.
- It is used in the radiators of automobiles.
- It is also used for making coins and printed circuits.

Some Common Uses of Non-metals

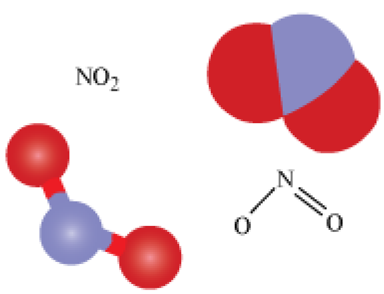
Hydrogen - It is the lightest element. It is found in the gaseous state.

- It is used as a non-polluting fuel. It is present in coal gas and water gas.
- Oxy-hydrogen flame is used for cutting and welding metals.
- It is also used for filling weather observation balloons.



Nitrogen

- It dilutes the activity of oxygen, so it is used for controlling the rate of combustion.
- It helps plants manufacture proteins.
- It is used in the manufacture of ammonia gas.
- It is also used for preserving packaged food.



Oxygen

- It is essential for the respiration of living beings. It is also needed for artificial respiration.
- It is required for the combustion of fuels and is also used in rocket fuels.
- As dissolved oxygen, it keeps water fresh and is used for respiration by marine organisms.
- It is also used for cutting and welding purposes.

Do you know?

The diamagnetic form of molecular oxygen (O_2) is commonly known as molecular oxygen.

Chlorine

- It is used in bleaching powders.
- It is used for sterilising drinking water.
- It is also used in pesticides and acids.

Do you know?

Insecticides and pesticides are used for killing insects. They include fungicides, larvicides and rodenticides.

Iodine

- In the form of sodium iodide or potassium iodide, it is required for the proper functioning of the body.
- In the form of silver iodide, it helps in making photographic films.
- It is also used for dressing wounds.
- In the form of iodoform, it is used in medicines.

Do you know?

Iodoform is a compound of iodine with the chemical formula CHI_3. It is a pale-yellow solid which was quite commonly used in antiseptics and disinfectants.

Carbon

- It is used in the electrodes of electrolytic cells.
- In the form of graphite, it is used as a dry lubricant, and as pencil lead.
- Graphite is also used as electrode material in electrolytic cells because it is a good conductor of electricity.
- It is used for making heat-resistant crucibles.
- It is employed in nuclear reactors.
- It is used in carbon arc lamps.
- Coal is used as a fuel in homes, industries, pharmaceutical and textile sectors.
- Diamond is the most crystalline form of carbon and is used as a precious gem. The impure gem is used for grinding hard substances and drilling heads.

Do you know?

Coke is the dry solid material left after heating coal to a very high temperature.

Sulphur

- It is used in the chemical industry for manufacturing sulphuric acid, sodium thiosulphate, carbon disulphide, etc.
- It is used in insecticides and fungicides
- It is used in medicines.
- It is also used for vulcanising rubber.

Do you know?

Natural rubber is sticky, easily deforms when warm and is brittle when cold**.** **Vulcanisation** refers to a specific process which involves heating rubber to high temperatures and adding sulphur or other equivalent curatives.

Some Common Uses of Metalloids

Silicon

- It is used for making solar cells, microchips and transistors.
- It is used for manufacturing polymers, also called silicones.
- It is used for manufacturing ferro-silicon, a special form of steel and silicon carbide. It is one of the hardest substances known.
- It is a very important component of cement and glass.

Do you know?

A **solar cell** or **photovoltaic cell** is a device that converts light into electric energy.

Germanium

- Germanium is commonly used as a semiconductor.
- It is used as a transistor in many electronic applications when mixed with arsenic, gallium, etc.
- It is used to form alloys and as a phosphor in fluorescent lamps.

Noble gases

- Noble gases are very non-reactive gases and are therefore used to provide the inert environment.
- **Helium:** for filling weather observation balloons
- **Argon:** For filling electric bulbs

The metals that are not acted upon by mild acids and alkalis, and occur in nature in the free state are called **noble metals**. Thus, they are resistant to corrosion and oxidation. These metals are very precious.

They include –

- Silver
- Gold
- Platinum
- They also include ruthenium, rhodium, palladium, osmium and iridium.

Do you know?

In India, pure gold is denoted as 24 carats. The gold that is generally used for making ornaments is 22 parts of pure gold alloyed with 2 parts of either silver or copper. This mixture is known as 22 carat gold.

Let us study the uses of noble metals.

Uses of silver

Silver is a shiny, heavy metal, and the best conductor of electricity.

- It is used for making silver ornaments and expensive utensils such as glasses, mugs, etc.
- It is used for making coins.
- Salts of silver like silver chloride are used for making photographic films.

- Silver foils are used for decorating sweets.
- Silver is also used for making mirrors using a process called sputtering.

Uses of gold

Gold is bright yellow and a highly malleable and ductile metal.

- Gold is used as the index of wealth. The countries which have more gold reserve are considered to be wealthy.
- It is used for making ornaments.N
- It is used for making high-value coins and medals.
- It is used for covering the mainframe of artificial satellites.

Uses of platinum

Platinum is silvery white, a highly malleable and ductile metal**.**

- It is used for making ornaments and watches.
- It is used as a catalyst in the manufacture of sulphuric acid and nitric acid.
- It is used in platinum catalytic converters.
- It is also used in chemical laboratories.

Do you know?

The word 'platinum' has been derived from the Spanish term *platina del Pinto*.

Alloys

Alloys are homogeneous mixtures of two or more elements (at least one of which is metal). They are made to improve the properties of metals such as their malleability, ductility, strength, and hardness.

Purpose of making alloys:
(a) To change the property of metal
(b) To achieve a specific objective

Reason to make alloys:
The process of alloying the metals alters their properties such as:
(a) Enhanced appearance
(b) Altered chemical reactivity

(c) Lowered melting point
(d) Modified casting ability
(e) Increased hardness
(f) Enhanced tensile strength
(g) Increases electrical resistant

Characteristics of an alloy:
(a) It enhances the hardness of metals.
(b) It increases the tensile strength of metals.
(c) It improves the corrosion resistance of metals.
(d) It changes or modifies the colour.
(e) It improves the castability of metals.

How do we prepare alloys?

Alloys are obtained by melting two or more elements in fixed proportions and then cooling them to room temperature.

We will now discuss some common alloys.

1. **Stainless steel**

   Stainless steel is obtained by combining carbon, chromium, and nickel in iron. The composition of various elements in steel is:

   Fe(73%) + Cr(18%)+Ni(8%) + C(1%)

   Stainless steel has many advantages over iron. The most important is that unlike iron, it does not rust. Hence, it is widely used for making utensils, cutlery, surgical instruments, and ornamental articles. It is also stronger than iron.

2. **Alloyed gold**

   Did you know that although gold is a very soft metal, it has a very high melting point of 1064ºC? Therefore, it is very difficult to work upon. Metals such as silver or copper are added to gold in small quantities to make it harder.

3. **Duralumin**

   Duralumin is obtained by combining copper, manganese, and magnesium in aluminium. The composition of various elements in duralumin is:

   Al (95%) + Cu(4%) + Mn (.5%) + Mg (.5%)

It is very lightweight, yet very hard and strong. Therefore, it is used for making frames of aircrafts, automobiles, and speedboats.

It is also used for making household articles.

4. **Brass**

   Brass is obtained by mixing zinc and copper. The composition of various elements in brass is:

   Zn (40-30%) + Cu (60-70%)

   It is used for making electric switches, statues, utensils, and ammunition.

5. **Bronze**

   Bronze is obtained by mixing tin and copper. The composition of various elements in bronze is:

   Cu(80%) + Sn(18%) + Zn(2%)

   It is very resistant to corrosion. Therefore, it is used for making coins, statues, and utensils.

Alloys of iron and zinc

Alloys are homogeneous mixtures of two or more metals. Alloys are prepared to enhance the properties of metals.

Some alloys of iron are steel, stainless steel, tungsten steel, nickel, chrome steel, etc. Steel contains carbon. The constituents of stainless steel are Fe, C, Cr, and Ni. It is used in automobiles, cycles, pens, utensils, etc. Tungsten steel, which contains 20% tungsten, is used in high speed machinery. Nickel steel, which contains 36% nickel, is used for making cables, automobiles, aeroplane parts, pendulum, measuring tapes, etc. Chrome steel is used for cutting tools and crushing machines.

The table given below discusses some more important alloys:

Primary Metal	**Name of the Alloy**	**Composition of the Alloy**	**Properties of the Alloy**	**Uses of the Alloy**
Aluminium	Magnalium	Al (90-95 %) Mg (10-5%)	(a) Corrosion resistant (b) Light and strong	(a) Making aircrafts (b) Making scientific instruments (c) Making mirrors

				(d) Making household appliances
Aluminium	Alnico	Al, Ni, Co, Fe	(a) Corrosion resistant (b) Light and shiny	(a) Making magnets
Iron	Manganes steel	Fe (85%) Mn (14%) C (1%)	(a) Durable (b) Hard	(a) Making safes (b) Making rock drills (c) Making armour
Iron	Tungsten steel	Fe (84%) W (5%) C (1%)	(a) Hard	(a) Making cutting tools for high-speed lathes
Iron	Nickel steel	Fe (95-98%) Ni (5-3%)	(a) Hard (b) Elastic (c) Corrosion resistant	(a) Making electric wires (b) Making automobile parts
Iron	Invar	Fe (63%) Ni (36%) C (1%)	(a) Negligible expansion	(a) Making metre scale (b) Making scientific equipment
Copper	German silver	Cu (50%) Zn (30%) Ni (20%)	(a) Silvery light alloy (b) Malleable (c) Ductile (d) Electricity resistant	(a) Making decorative items (b) Making electric heaters (c) Making rheostat (d) Making resistors
Copper	Bell metal	Cu (78%) Sn (22%)	(a) Hard (b) Brittle (c) Sonorous	(a) Making bells (b) Making gongs (c) Making statues
Copper	Gun metal	Cu (88%) Sn (8%) Zn (1%) Pb (1%)	(a) Hard (b) Brittle (c) Easily cut	(a) Making barrels of canons (b) Making bearings (c) Making gears
Lead	Solder (Fuse metal)	Pb Sn	(a) Low melting point (b) High tensile strength	(a) For welding purposes (b) For making fuse
Lead	Type metal	Pb (75%) Sb (15%) Sn (10%)	(a) Low melting point (b) Easy to cast	(a) For making printing blocks

Some people think that alloys were the first discovery of modern science. **But do you know that alloys are not at all a discovery of modern science?**

History of alloys

The first alloy created by man was bronze. It got its name from the Italian word 'bronzo' or the Persian word 'birinj'. Bronze, an alloy of copper and tin, came into use from as early as 3000 BC. In the third millennium BC, the Sumerians developed bronze to make tools and weapons for ruling their neighbours.

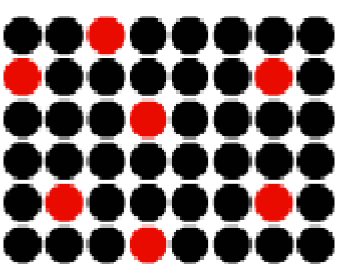
In Asia, some mines produced good quality alloys that were used to make better musical instruments and mirrors. In the 16th century BC, Persians developed carbon steel and started the Iron Age.

In the 20th century BC, the Romans developed their own gold substitute. Under the reign of Caesar Augustus, they developed brass, containing 75% copper and 25% zinc.

About 125 years ago, white gold was developed. This alloy was called German Silver or Mock Platinum. In the 12th century, silversmiths in Germany started using Sterling Silver alloy for coinage.

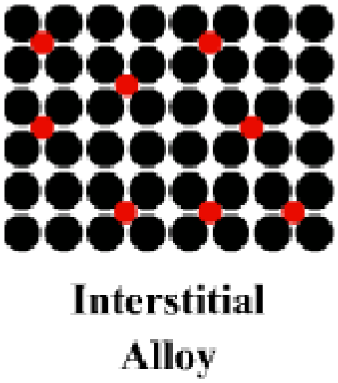
The first official coinage system of Lydia was developed by King Croesus during the period 560–546 BC, using a naturally occurring alloy of gold and silver called electrum.

On the basis of composition, alloys are of two types. They are as follows:



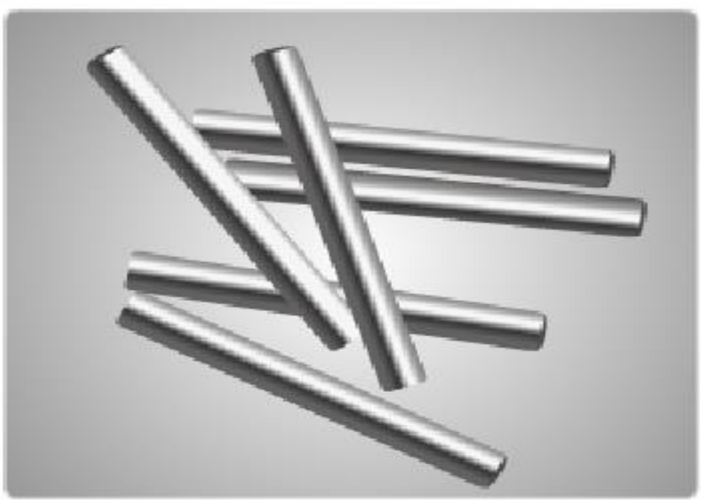
Substitution Alloy

(a) Substitutional alloy: In this kind of alloy, an atom of one metal randomly replaces the atom of the other.



(b) Interstitial alloy: In this kind of alloy, small atoms of elements like hydrogen, boron, carbon and nitrogen occupy the holes in the crystal structure of the metal.

On the basis of their constituents or elements, alloys can be of two types. They are as follows:



(a) Ferrous alloy: Alloys which contain iron as the base metal are known as ferrous alloys. For example steel, alnico (used for making magnets), etc.

(b) Non-ferrous alloy: Alloys which does not contain iron as the base metal are known as non-ferrous alloy. For example brass, bronze, duralumin, etc.

Uses of different alloys:

Bell metal	Copper: 77 %	Casting of bells
Duralumin	Aluminium: 95% Copper: 4% Manganese: Less than 1 % Magnesium: 0.5%	Aircraft parts, boats, railroad cars, ships and nails
Brass	Mainly copper Zinc: Up to 50%	Hose nozzles, screws, inexpensive jewellery, window and door fittings
Bronze	Mainly copper Tin: Up to 12%	Coins, medals, heavy gears, statues, machine parts
Solder	Lead: 50% Tin: 50%	In electrical and plumbing industries to join two metals together
Steel	Iron, carbon, chromium, nickel and tungsten	Cooking utensils, household articles, construction of bridges and buildings
Sterling silver	Silver: 92.5% Copper: 7.5%	jewellery, art objects
Alnico	Iron, aluminium, nickel and cobalt	Magnets which are much stronger than ordinary magnets

Do you know?

Certain elements are added to steel to enhance its properties. Some of them are mentioned in the table below.

Alloying Agent	Property	Use
Nickel	It increases strength and hardness. It also makes steel resistant to corrosion.	Turbine blades, engine parts, etc.

Chromium	It resists wear and tear and enhances its resistance to corrosion. It also enhances the hardness and toughness of steel.	This alloy is known as stainless steel. It is mainly used for making kitchen utensils and surgical instruments.
Vanadium	Increases strength and toughness of steel, including its resistance to wear and tear.	Crankshaft, hand tools, surgical instruments, etc.