Chapter- 4 Materials: Metals and Non-metals

Physical Properties of Metals

Physical Properties of Non-metals

Chemical Properties of Metals and Non-metals

Uses of Metals

Uses of Non-metals

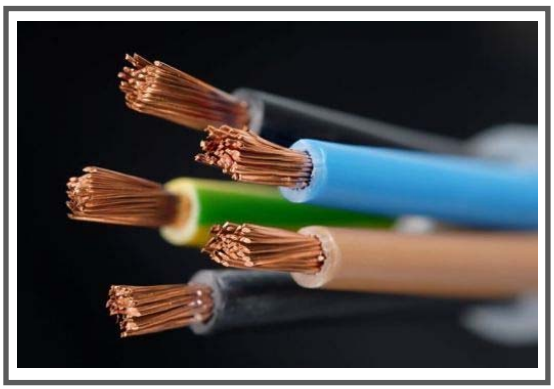
Physical Properties of Metals

A metal is a chemical element whose atoms readily lose electrons to form positive ions (cations), and form metallic bonds between other metal atoms and ionic bonds between non-metal atoms.

Physical properties of metals

Gold coins

- Metals in their pure state give a shiny appearance or metallic **luster**. Metals like gold, silver and platinum are used for making jewellery.
- Metals are usually **hard** except for sodium and potassium which are very soft and can be cut with a knife.
- All metals are **solid** at room temperature except for mercury which is liquid at room temperature. It is used in thermometers.
- **High melting and boiling points** - Metals have high melting and boiling point except for sodium, potassium, gallium and mercury which have low melting and boiling points. Tungsten has the highest melting point.
- **Good conductors of heat and electricity** - Silver, copper and aluminium are good conductors of heat and used in making utensils.
- **Good conductors of electricity** – Metals are good conductors because they have free electrons. Silver and copper are the two best conductors of heat and electricity. Lead is the poorest conductor of heat. Bismuth, mercury and iron are also poor conductors.



Copper used in electric wires

- **Malleability:** Metals have the ability to withstand hammering and can be made into thin sheets or foils.
- **Ductility:** Metals can be drawn into wires. 100 gm of silver can be drawn into a thin wire about 200 meters long.

Physical Properties of Non-metals

Elements which form negative ion by gaining electrons and are non malleable, non ductile, non sonorous and bad conductors of heat and electricity are called non-metals. For example sulphur, chlorine, nitrogen. Non-metals are quite abundant in nature. Nitrogen which is a non metal is the main constituent of atmosphere.

- Oxygen, nitrogen and noble gases are present in the air.
- **Nature:** Non-metals are very brittle, and cannot be rolled into wires or pounded into sheets.
- **Reactivity:** They generally form acidic or neutral oxides with oxygen.
- Hydrogen and oxygen are present as water and chlorine as chlorides in oceans.
- They are **bad conductors** of heat and electricity except for graphite which is an allotrope of carbon.
- They are **non-lustrous** and non sonorous except for graphite and iodine which have lustre.
- Non metals are either **solids** or **gases** at room temperature excluding bromine which is liquid at room temperature.
- Non-metals are **soft** like phosphorus which can be easily cut with a knife. Diamond is an exceptional non-metal and the hardest substance known.

Black phosphorus

Chemical Properties of Metals and Non-metals

Reaction with Oxygen

Metals

Most metals react with oxygen to metal oxide which is basic in nature. These basic oxides combine with water to form bases, which turns red litmus paper to blue. Sodium oxide is a basic oxide which reacts with water to form sodium hydroxide.

Na_2O + $H_2O \rightarrow$ $2NaOH$

Sodium oxide *water* *Sodium hydroxide*

Mg does not react with oxygen at room temperature. On heating, Mg burns in air with intense light and heat to form MgO.

$2Mg\ (s)$ + $O_2\ (g)$ $\rightarrow$ $2MgO\ (s)$

Magnesium + *Oxygen* *Magnesium oxide*

MgO + H_2O $\rightarrow Mg\ (OH)_2$

Magnesium oxide *Water* *Magnesium hydroxide*

Some metals like aluminium, zinc and tin form amphoteric oxides which are both acidic and basic in nature.

When a copper vessel is exposed to moist air for long, it acquires a dull green coating. The green material is a mixture of copper hydroxide ($Cu(OH)_2$) and copper carbonate ($CuCO_3$). The following is the reaction.

Green coating on copper

$2Cu$ + H_2O + CO_2 + O_2 $\rightarrow$ $Cu(OH)_2$ + $CuCO_3$

Copper Water Carbon Dioxide Oxygen Copper hydroxide Copper carbonate

Non- metals

The name of the product formed in the reaction of sulphur and oxygen is sulphur dioxide gas. When sulphur dioxide is dissolved in water sulphurous acid is formed. The reaction can be given as follows:

SO_2	+	H_2O	→	(H_2SO_3)
Sulphur dioxide		Water		Sulphurous acid

The sulphurous acid turns blue litmus paper red. Generally, oxides of non-metals are acidic in nature.

Reaction with water

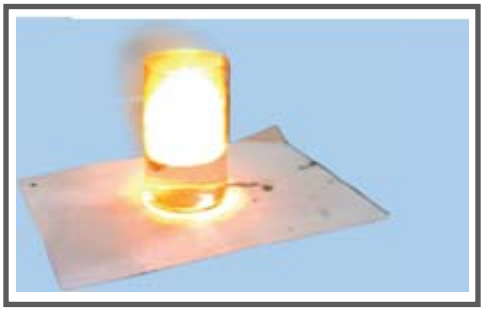
Metals

Sodium and potassium are highly reactive metals. They rapidly catch fire when exposed to air and hence kept in kerosene. Some other metals do not do so. For example, iron reacts with water slowly.

Na	+	H_2O	→	$NaOH$ +	$H_2\uparrow$	
Sodium		water		Sodium hydroxide	Hydrogen gas	

Sodium reacts vigorously with cold water forming sodium hydroxide and hydrogen.

Generally, non-metals do not react with water though they may be very reactive in air. Such non-metals are stored in water. For example, phosphorus is a very reactive non-metal. It catches fire if exposed to air. To prevent the contact of phosphorus with atmospheric oxygen, it is stored in water.



Sodium in water

Reaction with acids

Metals

Potassium, sodium, lithium and calcium react violently with dilute H_2SO_4 and dilute HCl, forming the metal salt (either sulphate or chloride) and hydrogen gas.

The reaction is similar to the reaction with water.

Zn	+	$2H_2SO_4$	→	$ZnSO_4$ +		H_2 ↑	
Zinc		Sulphuric acid		Zinc sulphate		Hydrogen	
Fe	+	$2HCl$	→	$FeCl_2$	+	H_2 ↑	
Iron		Hydrochloric acid		Iron chloride		Hydrogen	

Reaction with bases

Metals react with sodium hydroxide to produce hydrogen gas.

Activity

Prepare a fresh solution of sodium hydroxide in a test tube by dissolving 3-4 pellets of it in 5 mL of water. Drop a piece of Aluminium foil into it. Bring a burning match stick near the mouth of the test tube. Observe carefully. The 'pop' sound indicates the presence of hydrogen gas.

Reactions of non-metals with bases are complex.

Displacement reaction

The arrangement of metals in order of decreasing reactivity is called reactivity series

Reactivity series of metals is
Potassium > Sodium > Barium > calcium > Magnesium > Aluminium > Zinc > Iron > Copper > Mercury > Silver > Gold


Displacement reaction

Zinc (Zn) replaces copper (Cu) from copper sulphate ($CuSO_4$). The blue colour of copper sulphate disappears and a powdery red mass of copper is deposited at the bottom of the beaker.

The reaction can be represented as follows:

(CuSO4)	+	*(Zn)*	→	$ZnSO_4$	+	*(Cu)*	
Copper Sulphate (Blue)		Zinc		Zinc Sulphate (Colourless)		Copper (Red)	

Uses of Metals

- Metals are used in every sphere of life. They are used in bridges, railways, aeroplans, electric mobile units and in daily use items like utensils, toys etc.
- Metals and their alloys have wide spread use in atomic energy, jet engines and high grade steel.
- Metals like gold and silver are used in jewellery making.
- Copper and aluminum are used in electrical wires.
- Sodium:-compounds are used as common salt, chemicals etc.
- Calcium :-compounds are used for making cement, glass etc.

Uses of Non-metals

- Non-metal used in the purple coloured solution which is applied on wounds as an antiseptic,
- Non-metals used in crackers.
- Sulphur:-is used for making sulphuric acid, salts of metals etc.
- Oxygen:-is used for respiration by living things, burning of fuels etc.
- Nitrogen:-is used for making ammonia which is used for making fertilizers.
- Hydrogen:-is used for making ammonia which is used for making fertilizers, as fuel in rockets, for welding etc.
- Chlorine:-is used to kill germs in water.
- Iodine:-is used as tincture iodine which is an antiseptic