



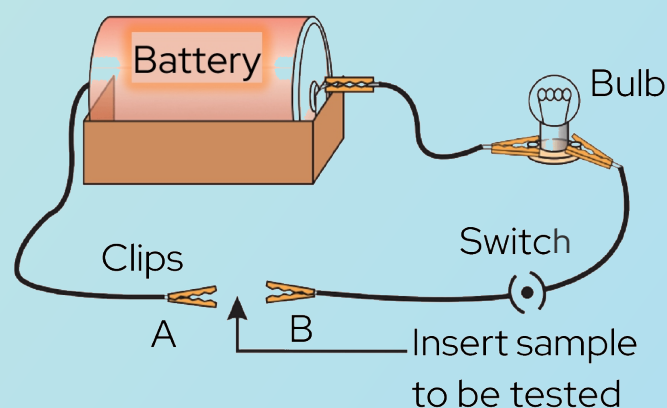
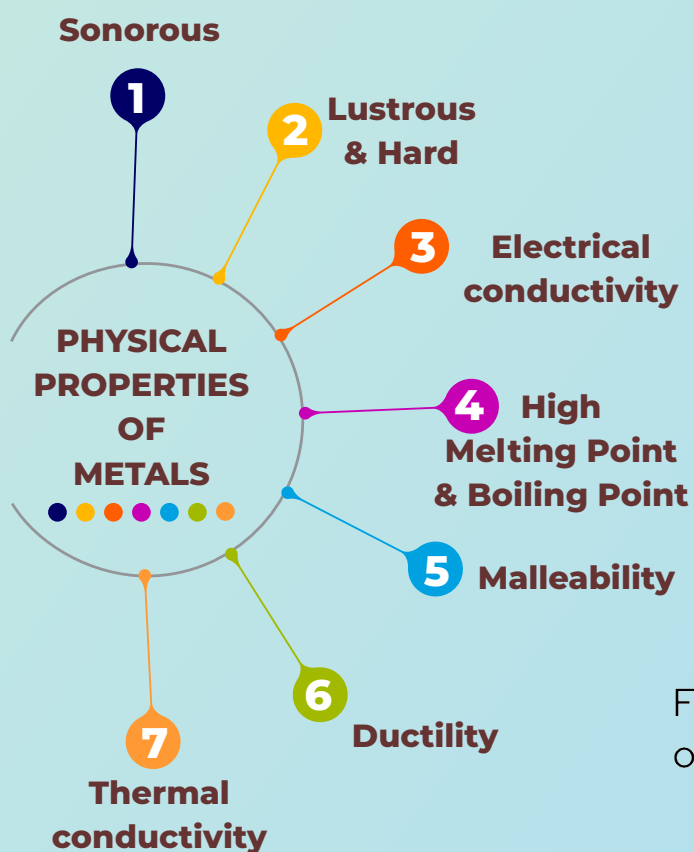
METALS AND NON-METALS



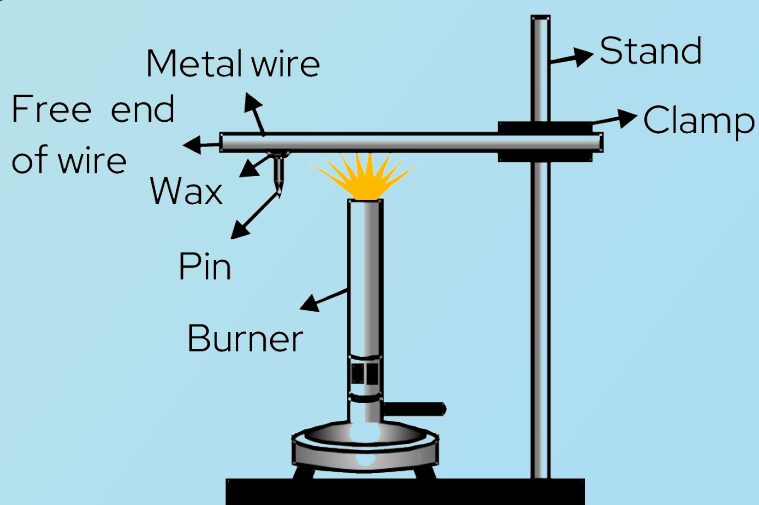
KEY POINTS

INTRODUCTION

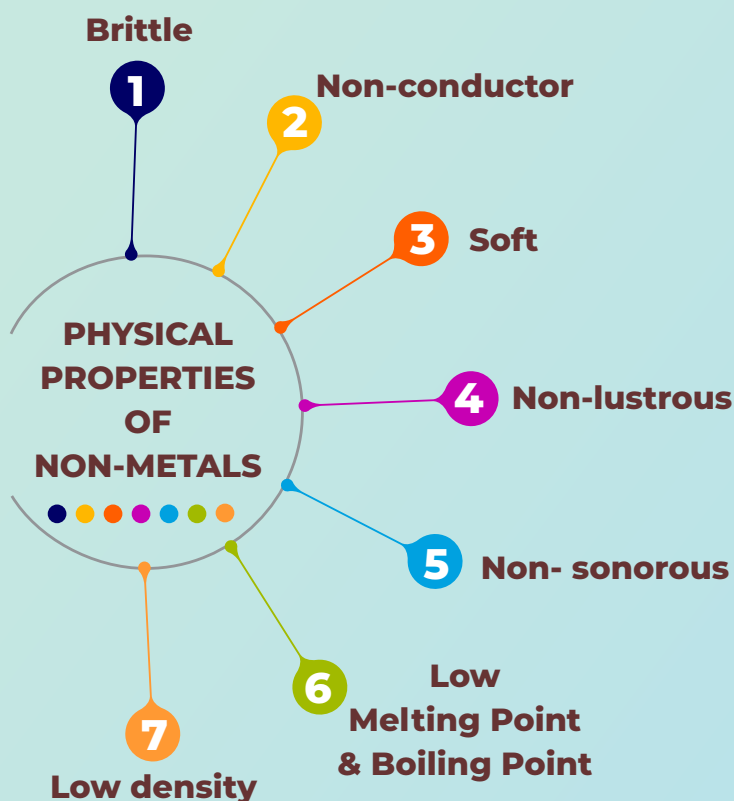
Everything around us is made up of different elements. These elements can be classified into metals or non-metals on the basis of their properties. A few elements have properties common to both metals and non-metals. These are called semi-metals or metalloids.



Metals conduct electricity



Metals conduct heat very easily



Diamond is Non-Metal but it is lustrous

SOME EXCEPTIONS

01

All metals except mercury are solid at room temperature. Gallium (Ga) and cesium (Cs) have very low melting points. These two metals will melt if we keep them on our palm.

02

Iodine is a non-metal but it is lustrous. Non-metals are generally bad conductor of heat and electricity. Exception : Graphite is a good conductor of electricity

03

Alkali metals such as lithium, sodium and potassium are so soft, that they can be easily cut with a knife i.e. they have low densities and low melting points. but it is lustrous.

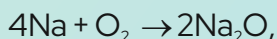
04

Carbon can exist in different forms. Each form is called an allotrope. Diamond is the hardest natural substance, which has very high melting and boiling point. Graphite is allotrope of carbon which is good conductor of electricity.

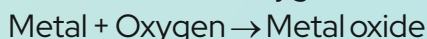


01 REACTION OF METALS WITH OXYGEN

Metals react with oxygen to form metal oxides which are basic in nature and some of them react with water to form alkaline solutions, which turn red litmus paper blue.



Almost all metals combine with oxygen to form metal oxides.



Sodium oxide is a basic oxide which reacts with water to form sodium hydroxide.



Nature of metallic oxide

Generally, metallic oxides are basic in nature except aluminium and zinc oxides which are amphoteric in nature. That means these oxides (Al_2O_3 , ZnO) react with base as well as acid.

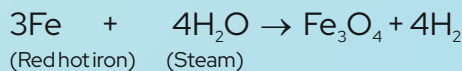
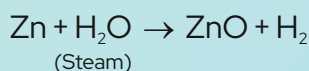
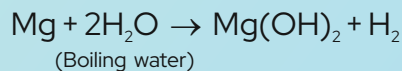
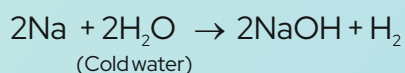
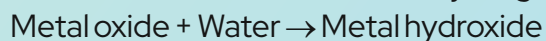
The basic oxide of metals react with acid to give salt.



The order of reactivity with oxygen is : $\text{K} > \text{Na} > \text{Mg} > \text{Al} > \text{Cu}$

02 REACTION OF METALS WITH WATER

Metal reacts with water and produce a metal oxide and hydrogen gas. Metal oxides that are soluble in water dissolve in it to form metal hydroxide. But all metals do not react with water.

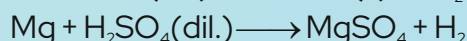
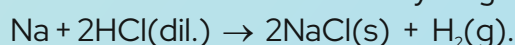
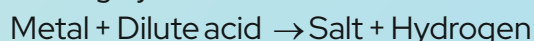


Copper do not react with water even under strong conditions.

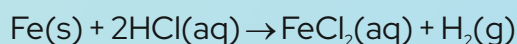
The reactivity order of these metals with water are : $\text{K} > \text{Na} > \text{Ca} > \text{Mg} > \text{Al} > \text{Zn} > \text{Fe} > \text{Cu}$

03 REACTION OF METALS WITH ACIDS

The highly reactive metals react with dilute acid to displace hydrogen from acid and give a salt.



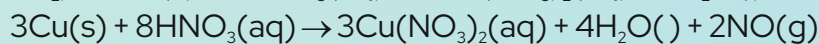
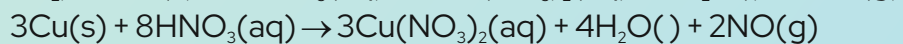
The reaction between Fe and acid is slow.



The order of reactivity with dilute HCl is : $\text{Mg} > \text{Al} > \text{Zn} > \text{Fe} > \text{Cu}$

NOTE :

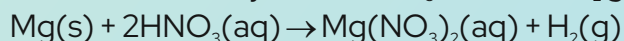
Hydrogen gas is not evolved when metals such as Zn, Fe, Cu and Al react with nitric acid. Because HNO_3 is strong oxidising agent. It oxidises, H_2 gas to water and is itself reduced to oxides of nitrogen (NO , N_2O and NO_2).



But copper reacts with hot concentrated sulphuric acid (H_2SO_4) to produce copper sulphate, sulphur dioxide and water.



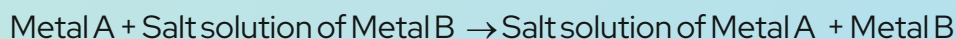
Only Mg and Mn reacts with very dilute HNO_3 to evolve H_2 gas.



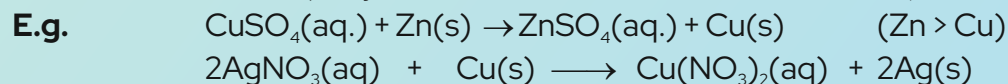
Aqua Regia (Royal water): Aqua regia is a Latin word it means "royal water". It is a freshly prepared mixture of concentrated hydrochloric acid and concentrated nitric acid in the ratio of 3 : 1. It is a highly corrosive, fuming liquid and is used to dissolve gold and platinum.

04 REACTION OF METALS WITH OTHER METAL SALT

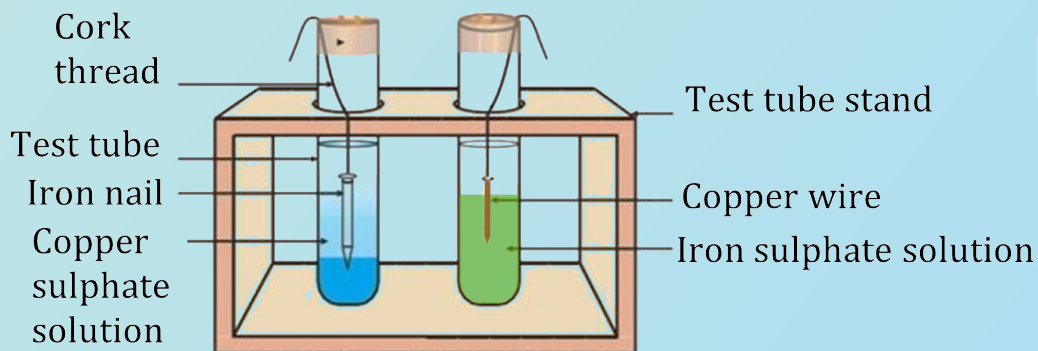
When a more reactive metal is placed in a salt solution of less reactive metal, then the more reactive metal displaces the less reactive metal from its salt solution. This reaction is also known as **Displacement Reaction**.



(Only if metal A is more reactive than Metal B)



Reactivity Series of Metals : The vertical arrangement of metals in order of decreasing reactivities is called reactivity series or activity series of metals.



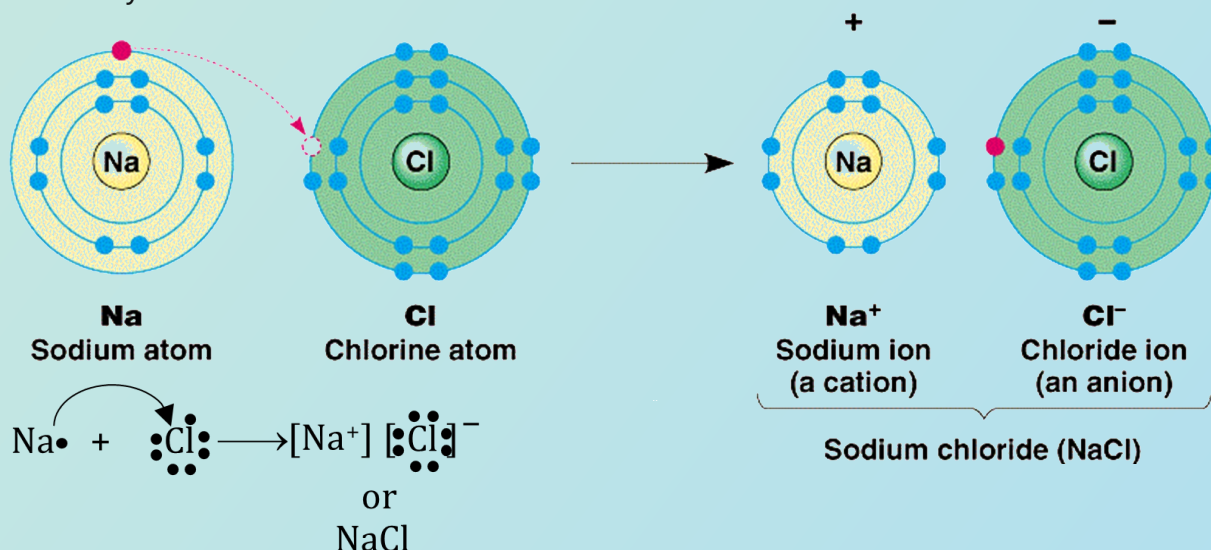
Potassium	K
Sodium	Na
Calcium	Ca
Magnesium	Mg
Aluminium	Al
Zinc	Zn
Iron	Fe
Lead	Pb
Hydrogen	H
Copper	Cu
Mercury	Hg
Silver	Ag
Gold	Au

Reactivity increases

Reactivity decreases

05 REACTION OF METALS WITH NON-METALS

- ▶ Metals are electron donors so they form cations and non-metals are electron acceptors therefore, they form anions to achieve nearest noble gas configuration and become stable.
- ▶ When a metal donates an electron and non-metal accepts the same electron, they get bound by strong electrostatic forces of attraction and form ionic bond or electrovalent bond. This can be represented by Lewis dot structure.



Electrovalent bond or ionic bond may be defined as the electrostatic force of attraction which holds the oppositely charged ions together. The number of electrons lost or gained by the atom is called its electrovalency.

PROPERTIES OF IONIC COMPOUNDS

- **Physical state:** They are solid, relatively hard, held together by strong electrostatic force of attraction and are generally brittle.
- **Solubility:** As ionic compounds are polar in nature, so they dissolve in polar solvent like water and are insoluble in non-polar solvents like kerosene.
- **Melting and Boiling Points:** As they are bound by strong electrostatic forces of attraction a large amount of energy is needed to break these bonds.
- **Conduction of electricity:** Ions do not move in solid state so, ionic compounds conduct electricity in molten or in aqueous solution only.
- **Colour to the flame:** Most metal salts when brought into the flame, impart characteristic colour to the flame.

Metal	Colour of flame
Sodium	Yellow
Barium salts	Green
Potassium	Lilac/violet

OCCURRENCE OF METALS

- ▶ The earth's crust is the major source of metals. They are present in nature in the free state (Native state) as well as in combined state.

Minerals

- ▶ The elementary state of the compounds in the form of which the metals occur in nature are called minerals.

Ores

- ▶ The minerals from where metals can be conveniently and profitably extracted are called ores.

For example, Copper occurs in nature in the form of several mineral like copper pyrites(CuFeS_2), copper glance (Cu_2S) and cuprite (Cu_2O). We obtain copper metal profitably from copper pyrites mineral, so it is called ore of copper.

Note: All ores are minerals but all minerals are not ores.

K	
Na	Highly reactive metals
Ca	(Top of the activity series)
Mg	Never found in the free state.
Al	
Zn	
Fe	Moderately reactive metals
Ni	(Middle of the activity series)
Sn	Found in combined state.
Pb	
Cu	Less reactive metals
Ag	(Just below hydrogen)
	Found in the free state as well as combined state.
Pt	Less reactive metals
Au	(Bottom of the activity series).
	Found in the free state.

EXTRACTION OF METALS

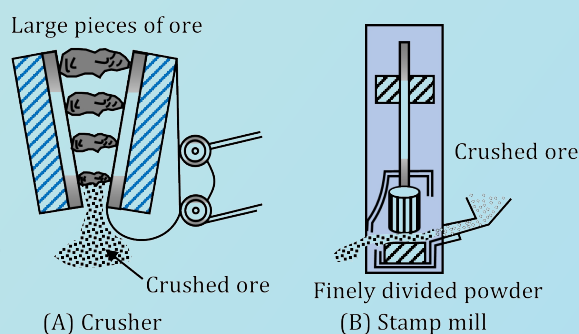
► The process through which a pure metal is extracted from its ores is known as extraction of metals. The series of various processes involved in the extraction of metals from their ores, followed by refining of the metal is known as metallurgy.

Various steps involved in the extraction of metals or metallurgical process :

1. Crushing and grinding of the ore.
2. Concentration of the ore or enrichment of the ore.
3. Extraction of metal from the concentrated ore.
4. Refining or purification of the impure metal.

1. Crushing and grinding of the ore

Most of the ores in nature occur as big rocks. They are broken into small pieces with the help of crushers. These pieces are then reduced to fine powder with the help of a ball mill or a stamp mill. This process is known as pulverization of the ore.



2. Enrichment of ore or concentration of ore

The ores mined from the earth's crust contain a number of impurities, such as soil, sand, etc. called gangue or matrix. The process of removal of impurities (gangue) from the ore is called enrichment of ore or concentration of ore.

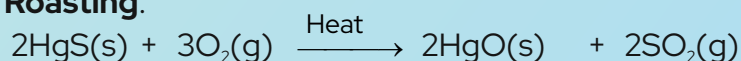
3. Extraction of metal from the enriched ore

The method used for extraction of the metal from the concentrated ore depends upon the nature of metal. Based on the reactivity, the metals have been grouped into the following three categories:

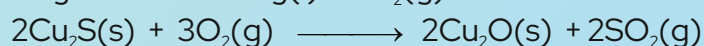
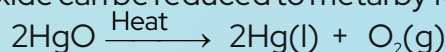
- (I) Metals of low reactivity.
- (II) Metals of medium reactivity.
- (III) Metals of high reactivity.

(I) Extraction of metals low in the activity series (Cu, Hg, Ag, Pt, Au)

These metals are either found in native state or in the form of sulphide ores. E.g., Cinnabar (HgS). These sulphide ores can be converted to oxide ores on heating in the presence of excess of air called **Roasting**.



This oxide can be reduced to metal by further heating.



The reaction in which one of the reactant (Cu₂S) carries the reduction of the product (Cu₂O) is known as **auto reduction** or **self-reduction**.

(II) Extraction of metals in the middle of the activity series (Fe, Zn, Pb, etc.)

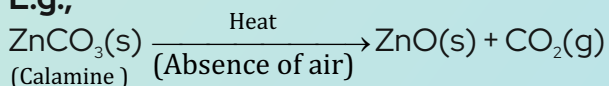
These metals are found in the form of their oxides, sulphides and carbonates. For easy extraction, sulphide and carbonate ores are first converted into the oxide.

(a) Conversion into metal oxide

(i) Calcination:

For the conversion of carbonate ores into oxides. It is the process of heating the ore strongly in the absence of air.

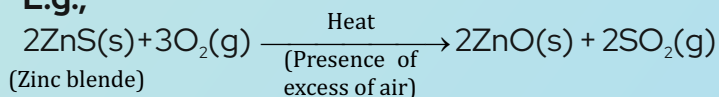
E.g.,



(ii) Roasting:

For the conversion of sulphide ores into oxides. It is the process of heating the ore strongly in the presence of excess of air.

E.g.,



(b) Reduction of the metal oxide to metal

For reduction suitable reducing agents are used, like carbon, carbon monoxide, aluminium, sodium or calcium.

(i) Reduction by heating with carbon (coke)

When zinc oxide is heated with carbon, zinc metal is produced.



(ii) Reduction with CO

Iron is obtained from ferric oxide by heating with CO.

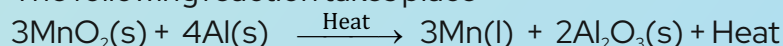


(iii) Reduction by aluminium

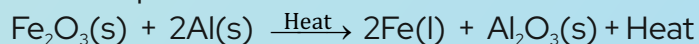
Certain metal oxides are reduced by aluminium to metals. This method is known as aluminothermy or thermite process. These displacement reactions are highly exothermic, so metals are produced in the molten state.

For example, Chromium, manganese, vanadium metals are obtained by the reduction of their oxides with Al powder.

The following reaction takes place



Thermite reaction - is used to weld railway tracks or cracked machine parts.



The mixture of iron oxide and aluminium powder is called thermite.



The thermite reaction gives off so much heat that the iron formed is molten

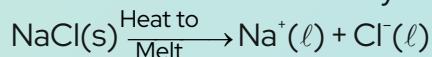
(III) Extraction of metals high up in the activity series: (K, Ca, Na, Mg and Al)

The highly reactive metals such as K, Na, Mg have strong affinity for oxygen, so they can not be reduced with the help of carbon. Hence these metals are obtained by electrolysis of their molten or fused oxides or chlorides, this method is called electrolytic reduction.

On electrolysis, metal ions, being positive, are liberated at the cathode (negative electrode) where they gain electrons and convert in the metal atoms.

For examples,

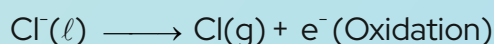
- (i) Sodium metal is obtained by electrolysis of molten sodium chloride.



At Cathode:



At Anode:



Thus, sodium metal is obtained at cathode whereas chlorine gas is obtained at the anode.

(4) Refining of impure metals

The metals produced by various reduction processes described above are not very pure. They contain impurities, which must be removed to obtain pure metals.

The most widely used method for refining of impure metals is electrolytic refining.

Process

- In this process, the impure metal is made the anode and a thin strip of pure metal is made the cathode.
- A solution of the metal salt is used as an electrolyte. On passing the electric current through the electrolyte, the pure metal from the anode dissolves into the electrolyte.
- An equivalent amount of pure metal from the electrolyte gets deposited on the cathode. The soluble impurities go into the solution, leaving the insoluble impurities which settle down at the bottom of the anode.

At Anode :



At cathode:

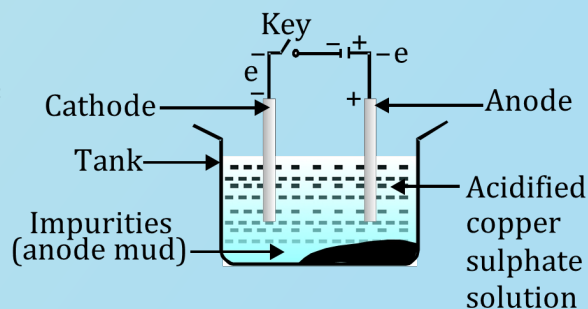


Anode mud / anode sludge

The soluble impurities present in the impure metal pass into solution whereas insoluble impurities fall below the anode as anode mud.

E.g., Electrolytic refining of copper.

Electrolytic refining of copper. The electrolyte is a solution of acidified copper sulphate. The anode is impure copper, whereas the cathode is a strip of pure copper. On passing electric current, pure copper is deposited on the cathode.



CORROSION

- The process of slowly eating up of metals due to their conversion into oxides, carbonates, sulphide, sulphates, etc. by the action of atmospheric gases and moisture is called corrosion.

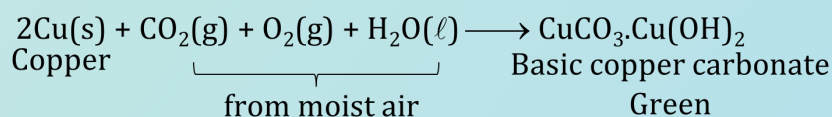
In case iron is the metal involved in the chemical process, then corrosion is called rusting.

Factors which promote corrosion

- (a) Position of metal in the reactivity series: Active metals placed above hydrogen are easily corroded as compared to metals which are placed below hydrogen.
- (b) Presence of water vapours and gases like CO_2 , SO_2 , etc. in the air.
- (c) Presence of salts or electrolyte in water promotes corrosion.
e.g. Rusting of iron is faster in sea water than in ordinary or distilled water.

Example of corrosion

- (i) When iron is exposed to moist air for a long time, its surface acquires a brown flaky substance called rust and the process is known as rusting. Rust is a mixture of Fe_2O_3 and $\text{Fe}(\text{OH})_3$.
- (ii) Copper reacts with CO_2 in the air and slowly loses its shiny brown surface and acquires a green coating of basic copper carbonate in moist air.



- (iii) Silver articles become black after sometime when exposed to air. [Due to reaction with H_2S in the air to form a black coating of silver sulphide (Ag_2S).]
- (iv) Lead or stainless steel lose their lustre due to corrosion.

PREVENTION OF CORROSION

- | | | |
|-----------------------|-------------------|-----------------------|
| ► By painting | ► Self prevention | ► Cathodic protection |
| ► Oiling and greasing | ► Electroplating | ► By alloying |

ALLOYS

An alloy is a homogeneous mixture of two or more metals or non-metal. It can be prepared by first melting the metal and then dissolving the other elements (metal or non-metal) in proper proportions. The physical properties of an alloy are different from the constituent metals (from which it is made).

SOME OF THE COMMON ALLOYS ARE

► Steel

Iron is the most widely used metal. But it is never used in its pure state. This is because pure iron is very soft and stretches easily when hot. But, if it is mixed with a small amount of carbon (about 0.05%) it becomes hard and strong.

When iron is mixed with nickel and chromium to form stainless steel which is hard and does not rust.

► Amalgam

An alloy of mercury and one or more other metals is known as an amalgam. It may be solid or liquid. A solution of sodium metal in liquid mercury metal is called sodium amalgam, which is used as a reducing agent. Amalgam of silver, tin and zinc is used by dentists for filling in teeth.

► Brass

Brass is an alloy of copper (Cu) and Zn. It contains 80% copper and 20% zinc. It is more malleable and more stronger than pure copper. Brass is used for making cooking utensils, condenser sheets, pipe, screws, bolts, wire, scientific instruments, ornaments, etc.

► Bronze

It is also the alloy of copper. It contains 90% of copper and 10% tin. It is highly resistant to corrosion and used for making utensils, statues, coins, hardware, etc.

► Solder

It is an alloy of lead (50%) and tin (50%). It is used for soldering (or welding) electrical wires together as it melts at a low temperature.

► Alloys of Gold

The purity of gold is expressed in terms of 'carats'. Pure gold is known as 24 carats gold. It is very soft due to which, it is not suitable for making jewellery. It is alloyed with either silver or copper to make it hard and more suitable for making ornaments. In India, gold ornaments are usually made of 22 carats gold. It is an alloy of gold with silver or copper.

carat gold is an element. It contains only gold atoms. 14-carat and 18-carat gold are alloys. They contain a mixture of different atoms.

