

# Principles of Metallurgy

## Metals in free state

Metals which are found in earth's crust and they are least reactive are said to be metals occurring in free state, e.g., gold, silver, platinum etc. Sometimes, copper and silver may also be found in the free state. Such metals are not acted upon by air or water.

## Definition

## Metals in combined state

The metals are said to occur in the combined state if they are found in nature in the form of their compounds. Generally, the reactive metals occur in the form of their compounds. In the combined state the metals are found in the crust of the earth as oxides, carbonates, sulphides, silicates, phosphates etc.

## Definition

## Gangue

Gangue is the commercially worthless material that surrounds, or is closely mixed with, a wanted mineral in an ore deposit. It is thus distinct from overburden, which is the waste rock or materials overlying an ore or mineral body that are displaced during mining without being processed.

## Definition

## Process involved during metallurgy

1. Concentration of ore- by Magnetic separation, Froth Floatation method, Hydrolytic method, Chemical method.
2. Concentrated ore to oxide- by Roasting and Calcination.
3. Reduction of metallic oxides- by Electrolysis, Reducing agents and Thermal decomposition.
4. Refining impure metal- by Distillation, Liquation, Oxidation and Electrolytic methods.

## Definition

## Mining

Mining is the process of removal or extraction of coal and minerals from the earth crust.

Manganese, copper, tin, nickel, bauxite, iron ore, gold, silver, and diamonds are just some examples of what is mined.

## Example

## Ores of chromium

A most common ore of chromium is iron chromium oxide ( $\text{FeCr}_2\text{O}_4$ ). Chromite

## Definition

## Metallurgy

The process of extracting metals from their ores is called metallurgy.

Common ores of aluminium, zinc, iron

Ores of Aluminium: Bauxite, Cryolite, Corundum

Ores of Zinc: Zinc Blende, Calamine, Zincite

Ores of Iron: Haemetite, Magnetite, Iron pyrites and Spathic iron ore

## Important metallurgical operations

The various metallurgical operations :

1. Concentration of ores
2. Conversion of ores into oxides or other desired compounds.
- 3.Reduction of ores to form crude metal
4. Refining of metals

## Enrichment of ores

Enrichment of ores include:

1. Hydraulic washing or gravity separation
2. Froth floating process
3. Electromagnetic separation

## Definition

Processes in concentration of ore

Hydraulic washing:

Hydraulic washing process is done by washing the ores with streams of water. If an ore is heavier or denser than the gangue, then the gangue particles are washed away with the stream.

Froth floating process:

This process is used for sulfide ores. Sulfide ores are first ground to powder and water is added. Then pine oil is added and the emulsion is agitated by passing compressed air. Oil and froth float on the surface along with the sulfide ore.

Magnetic separation:

This method of concentration can be applied when the gangue and the ore particles have different magnetic properties.

Chemical separation:

Different chemical affinity between the ore and the gangue is utilized for concentrating the ore.

## Definition

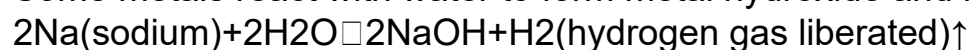
Reaction with oxygen

Both metals and non-metals when burnt in oxygen form their oxides. Oxides of metals are basic in nature and oxides of non-metals are acidic in nature.

## Definition

Reaction with water

Some metals react with water to form metal hydroxide and hydrogen gas.

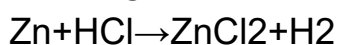


Less active metals react with boiling water. Generally non-metals do not react with water

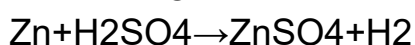
## Reaction of metals with acids

Reaction with dilute acid:

With HCl: Metals form their chloride and liberate H<sub>2</sub> when react with HCL



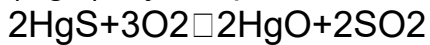
With H<sub>2</sub>SO<sub>4</sub>: Metals form their sulphates when react with H<sub>2</sub>SO<sub>4</sub>



same reaction with conc. H<sub>2</sub>SO<sub>4</sub>.

Extraction of metals which are low in the activity series

Metals that are low in the activity series are very un-reactive. The oxides of these metals can be reduced to metals by heating alone. For example, mercury is obtained from its ore, cinnabar (HgS), by the process of heating.



Extraction of metals which are in the middle of activity series

Metals such as iron, zinc, lead, copper, etc., are in the middle of the reactivity series. These are moderately reactive metals and are usually present as sulphides or carbonates. A metal is obtained from its ore by the processes of reduction or by electrolysis. In the reduction process, it is the oxide ore that is reduced.

It is easier to reduce an oxide ore as compared to its sulphides and carbonates. If the ore is not an oxide ore, it is first converted to the oxide by the process of calcination or by roasting.

Extraction of metals which are towards the top of the reactivity series

Metals such as sodium, magnesium, calcium, aluminium high up in the reactivity series are very reactive and cannot be obtained from their compounds by heating with carbon. This is because these metals have more affinity for oxygen than carbon. These metals are obtained by electrolytic reduction.

For Na, K, Ca, Mg, Al, all these metals cannot be reduced by coke or carbon monoxide.

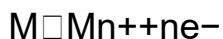
Electrolytic method is the only way to reduce these metals

Electrolytic refining

Electrolytic refining: It is the process of refining of metal in which impure metal is made the anode and a thin sheet of pure metal is made the cathode of an electrolytic cell containing an aqueous solution of the metal salt. When an electric current of a suitable voltage is passed, impure metal at the anode gets dissolved to deposit the pure metal at the cathode.



Metal ions from the anode enter the electrolyte as follows:



The impurities are left behind as anode mud near the anode. The anode finally disintegrates while the cathode gains in weight due to the collection of pure metal.

Roasting

Roasting is a step of the processing of certain ores. More specifically, roasting is a metallurgical process involving gas-solid reactions at elevated temperatures with the goal of purifying the metal component.

Calcination

Process of heating the concentrated ore in a limited supply of air or in absence of air at a temperature just below the melting point or not sufficient to melt the ore.

