INORGANIC CHEMISTRY

→ Inorganic chemistry is defined as the study of the materials from non-biological origins.

Or It is the study of the elements and their compounds except the compounds based on carbon.

→ Important classes of inorganic compounds are the oxides, the carbonates, the sulphates and the halides etc.

OCCURRENCE OF METALS IN NATURE :-

Metals in nature

- In free or Native state (gold, platinum, Silver etc)
- In combined state (Na, Ca, K, Al, Pb, Cu etc)

MINERALS :-

The natural materials in which the metal or their compounds occur in the earth are known as minerals.

Ex:- (1) Magnetite (Fe_3O_4), Haematite (Fe_2O_3) & Iron pyrites (FeS_2) are the minerals of Fe.

(2) Limestone ($CaCO_3$), gypsum ($CaSO_4 \cdot 2H_2O$) & Dolomite ($MgCO_3, CaCO_3$) are the minerals of Ca.

ORES :-

Ores are the minerals from which the metals can be extracted economically and profitably.

Ex:- Haematite (Fe_2O_3) & Magnetite (Fe_3O_4) are the ores of Fe.

* As Iron pyrites (FeS_2) contains Low percentage of Fe and higher percentage of impurities (Unwanted materials), it is not a ore of Fe.
* However, Fe_2O_3 & Fe_3O_4 contain higher percentage of Fe and lower percentage of impurities, so, they are ores of Fe.

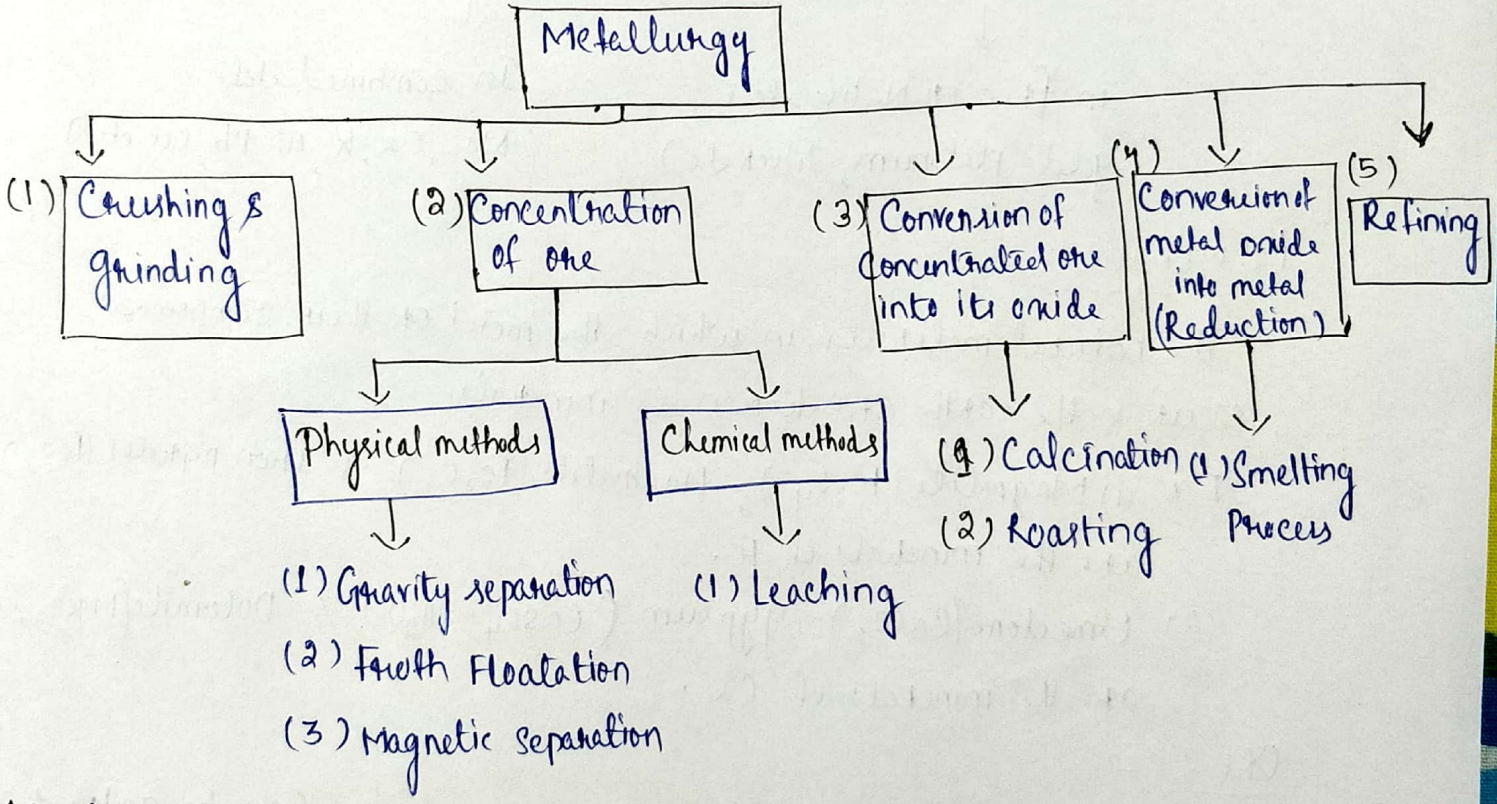
* Thus "All ores are minerals while all minerals are not ores."

EXTRACTION OF METALS OR METALLURGY :—

→ The process of extracting metals from its ores is called metallurgy.

→ The ores contain worthless material (clay, sand, limestone etc) called gangue. It is, therefore very essential to eleminate the gangue from the ores.

→ Methods for the extraction of metals :—



(1) Crushing & grinding :—

→ Most of the ores are found in the form of huge lumps & it is difficult to treat the ores in this form.

→ So, the huge lumps are broken into smaller pieces with the help of Jaw Crushers and then the small pieces are change into a fine powder with the help of Stamp mill. The process is called Pulverization of the ore.

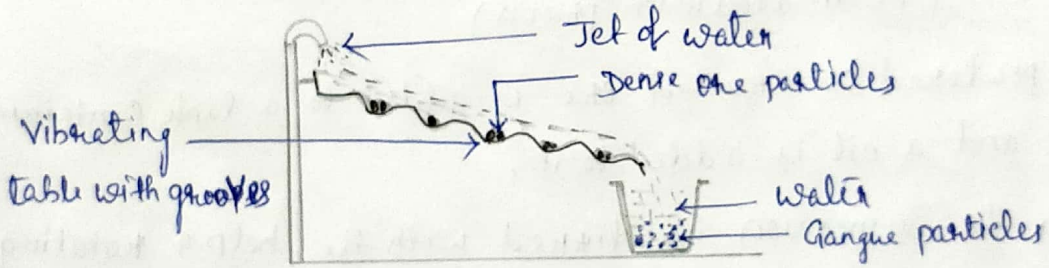
(2) Concentration of the ore :-

→ The process of removal of maximum gangue (impurities) from the ore is called concentration of the ore.

(i) Gravity separation method :-

→ This method is based on the difference in specific gravities of the ore and gangue particles.

→ Generally Carbonate and oxide ores are concentrated by this method because these ores are heavier than the impurities associated with them.



(Wilfly table)

Process :-

→ In this method, Crushed or powdered ores are spread on long tables having transverse grooves.

→ The table is kept slightly inclined position and is given rocking motion. When stream of water flown over them, the lighter gangue particles are carried out by water while the heavier ore particles get deposited in the grooves.

(ii) Froth Floatation process :—

→ This method is used for the concentration of sulphide ores such as ZnS, PbS, Cu_2S, etc.

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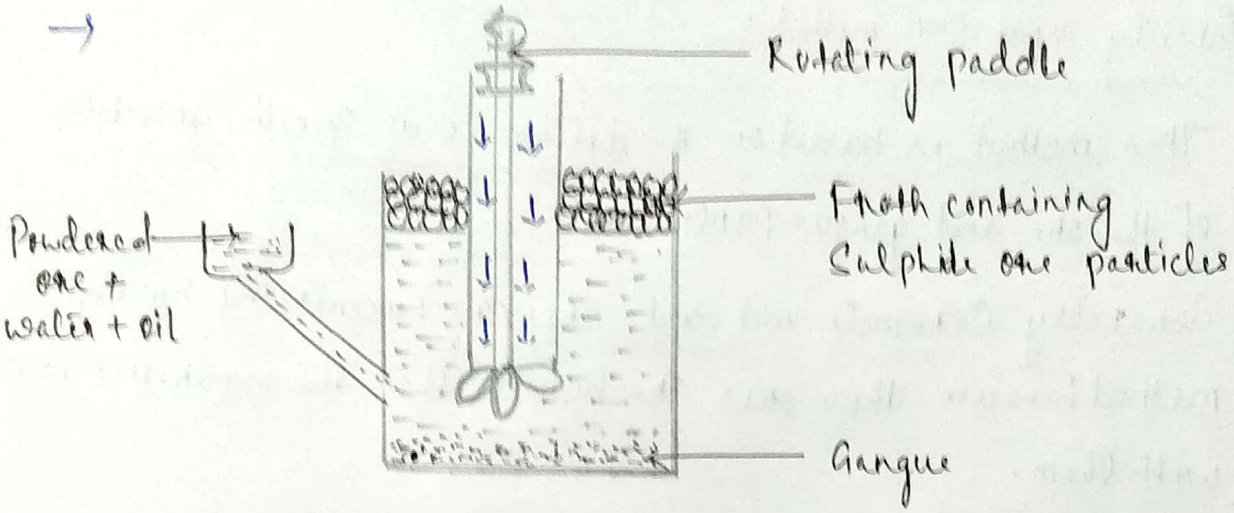


(Froth Floatation process)

→ The powdered or crushed ore is added to a tank containing water and a oil is added to it.

→ Then the suspension is stirred with the help of rotating paddle which draws in air and causing frothing.

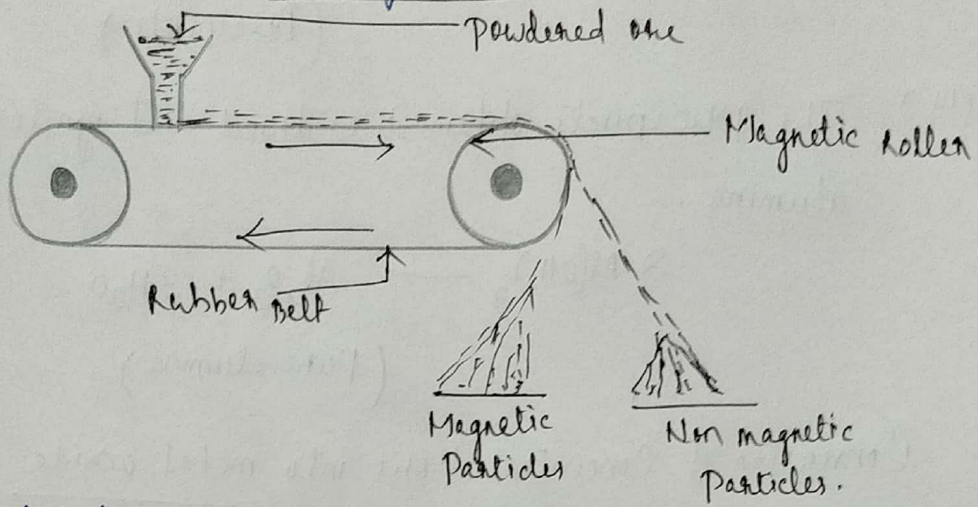
→ The ore particles which are preferentially wetted by oil become lighter and then rise to the surface along with the froth.

→ On the other hand, gangue particles which are preferentially wetted by water become heavier and settle down at the bottom.

→ Then the froth containing sulphide ores is kept in another tank for sometime, allowed to collapse and finally dried to get the concentrated ore.

(iii) Magnetic Separation method :—

→ This method is used for Concentration of such ores which differ from their impurities in magnetic character.



→ The powdered ore is dropped over a belt revolving around the two rollers, one of the rollers being a magnet.

→ The magnetic part of the ore is attracted by the magnetic roller and forms a heap near it, where as the non magnetic part of the ore forms a separate heap a little away from the magnetic particles.

(iv) Leaching :—

→ This is a chemical method for the concentration of ores, in which the powdered ore is treated with a suitable reagent which dissolves the ore and not the impurities.

For ex:- Concentration of Bauxite ore ($Al_2O_3 \cdot 2H_2O$)

→ Bauxite is an ore of Aluminium and it is Concentrated by leaching process.

(i) It is treated with dil. NaOH solution which dissolves the bauxite ore and form soluble sodium meta aluminate.

$$Al_2O_3 \cdot 2H_2O + 2NaOH \longrightarrow \underset{\text{(Sod. meta aluminate)}}{2NaAlO_2} + 3H_2O$$

(ii) Then the solution is filtered to remove insoluble impurities and a small amount of $Al(OH)_3$ is added to the filtrate.

$$2NaAlO_2 + 2H_2O \longrightarrow Al(OH)_3\downarrow + 2NaOH$$

(Precipitate)

(iii) The precipitate obtained is dried and ignited to get pure alumina.

$$2Al(OH)_3 \longrightarrow Al_2O_3 + 3H_2O$$

(Pure alumina)

(3) Conversion of Concentrated ore into metal oxide :— (Oxidation)

(A) Calcination :—

→ The process of converting an ore into its oxide by heating it strongly below its melting point in absence or limited supply of air is called Calcination.

→ This method is commonly used to convert metal carbonates and hydroxides to their respective oxides.

→ It removes moisture and volatile impurities like As, Sb, etc.

$$Al_2O_3 \cdot 2H_2O \xrightarrow{\Delta} Al_2O_3 + 2H_2O\uparrow$$

$$Fe_2O_3 \cdot 3H_2O \xrightarrow{\Delta} Fe_2O_3 + 3H_2O\uparrow$$

→ It decomposes carbonates into their oxides by loss of CO_2.

$$CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$$

$$CaCO_3 \cdot MgCO_3 \xrightarrow{\Delta} CaO + MgO + 2CO_2\uparrow$$

(B) Roasting :—

→ The process of converting an ore into its oxide by heating it strongly in controlled supply of air is called roasting.

→ This process is commonly used for sulphide ores.

→ It removes moisture and volatile impurities like S, P, As, Sb etc.

$$S + O_2 \longrightarrow SO_2 \uparrow$$

$$4As + 3O_2 \longrightarrow 2As_2O_3 \uparrow$$

$$P_4 + 5O_2 \longrightarrow 2P_2O_5 \uparrow$$

→ Sulphide ores converted into metallic oxides.

$$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2 \uparrow$$

$$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2 \uparrow$$

(4) Conversion of metal oxide to metal :- (Reduction)

(i) Smelting (Reduction by Carbon) :—

→ The process of heating roasted or calcinated ore above its melting point with carbon (in form of coal, charcoal & CO) is called smelting.

→ During this process, metal oxides are reduced to their respective metals by a reducing agent.

→ In this process less electropositive metals like Zn, Fe, Cu etc are reduced with the help of reducing agents like C, CO, water gas etc.

$$PbO + C \longrightarrow Pb + CO \uparrow$$

$$ZnO + C \longrightarrow Zn + CO \uparrow$$

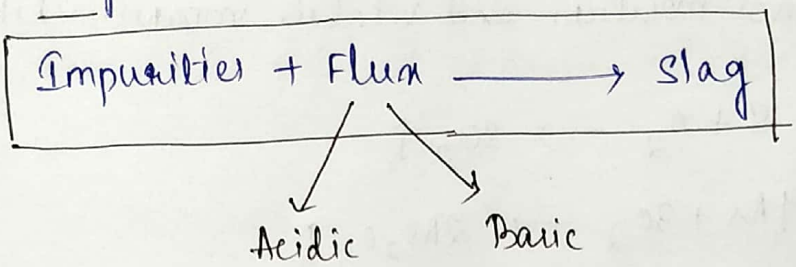
$$ZnO + CO \longrightarrow Zn + CO_2 \uparrow$$

$$Fe_2O_3 + 3C \longrightarrow 2Fe + 3CO \uparrow$$

$$CuO + CO \longrightarrow Cu + CO_2 \uparrow$$

→ During the smelting process, an additional substance is added to the ore which reacts with the impurities still present in the ore to form a fusible product.

→ The additional substance is called flux and the fusible product is called slag.



Types of flux :-

→ The types of flux depends upon the nature of the impurities present in the ore.

(1) **Acidic flux :-**

When basic impurities like CaO is present in the ore, then acidic flux like SiO_2 is used.

$$\underset{\text{Impurities (Basic)}}{CaO} + \underset{\text{Flux (Acidic)}}{SiO_2} \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

(2) **Basic flux :-**

When acidic impurities like SiO_2 is present in the ore, the basic flux like CaO is used.

$$\underset{\text{Impurities (Acidic)}}{SiO_2} + \underset{\text{Flux (Basic)}}{CaO} \longrightarrow \underset{\text{Slag}}{CaSiO_3}$$

→ Smelting process is carried out in a tall cylindrical blast furnance which is made of steel plates and lined inside with heat resisting bricks.

→ Slag and molten metal are removed from the base of tower where slag floats over molten metal.

(4) Refining :-

→ The process of the removal of impurities from a crude metal is called refining.

(i) Distillation method :-

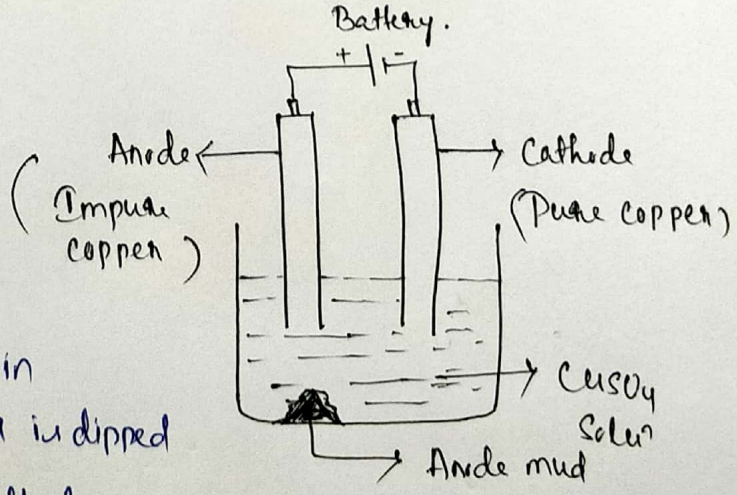
→ This method is used for the purification of volatile metals like Hg, Zn, Pb etc. which contain non-volatile impurities.

→ In this process, the impure metal is heated in a distillation flask attached with a water condenser.

→ During heating the volatile metal get evaporated and condensed which is collected in a separate container while the non-volatile impurities left at the bottom of the distillation flask.

(ii) Electrorefining :-

→ Less electropositive metals like Cu, Al, Zn, Pb and Sn are purified by this method.



→ A suitable electrolyte is taken in the electrolytic cell. Pure metal is dipped into the electrolyte and made the cathode.

→ The impure metal is made the anode and a suitable emf is applied.

→ During the process of electrolysis, the pure metal from the electrolyte gets deposited on the cathode while an equivalent

amount of the metal from anode goes into the solution.

$CuSO_4 \rightleftharpoons Cu^{2+} + SO_4^{2-}$

At anode :- (oxidation)

$Cu \longrightarrow Cu^{2+} + 2e^-$

At cathode :- (Reduction)

$Cu^{2+} + 2e \longrightarrow Cu$

ALLOYS AND AMALGAMS

Definition: An alloy is a homogeneous solid obtained by melting together two or more metals or metals and non-metals.

Examples of common alloys:

- **Steel:** A combination of iron (metal) and carbon (non-metal)
- **Bronze:** A combination of copper (metal) and tin (metal)
- **Brass:** A mixture of copper (metal) and zinc (metal)

Classification of alloys:

Alloys can be classified into two types:

1. **Ferro alloys**: Alloys in which iron present as one of the constituent is known as ferro alloys.

Ex-Nickel steel ,chrome steel etc.

2. **Nonferro alloys**: Alloys in which iron does not present as one of the constituent is known as nonferro alloys.

Ex: Brass, bronze, bell metal, gun metal etc.

Composition and uses of some important alloys:

NAME	COMPOSITION	USES
Brass	Cu-60-80%, Zn-40-20%	Utensils, condenser tubes
Bronze	Cu-75-90%, Sn-25-10%	Utensils, coins, statues
Duralumin	Al-95%,Cu-4%,Mn-0.5%, Mg-0.5%	For making airships
Alnico	Steel-50%,Ni-21%,Al-20%,Co-1%	For making permanent magnet

Amalgams: These are formed by treating metal such as tin, zinc, gold, silver, sodium etc, with mercury.

Ex: sodium amalgam, copper amalgam, tin amalgam.