SUBJECT-ENGINEERING CHEMISTRY

SEMESTER-1ST & 2ND

PREPARED BY-ITUSHREE RANI RATH

UNIT-2 **Chapter-7 (Metallurgy)**

Inorganic chemistry

The branch of chemistry that deals with inorganic compounds are called inorganic chemistry.

Minerals – The natural materials in which the metals are found in the earth's crust are called minerals.

Ex – Cu_2S, Fe_2O_3, Al_2O_3, ZnS, MnO_2 etc.

Ores – The minerals from which the metals can be extracted easily & profitably are called ores.

Ex – Fe_2O_3, Fe_3O_4, Al_2O_3, Cu_2O, PbS etc.

All ores are minerals but all minerals are not ores.

Metals	Chief ores
Iron (Fe)	Haematite (Fe_2O_3), Magnetite (Fe_3O_4)
Aluminium (Al)	Bauxite ($Al_2O_3 \cdot 2H_2O$), Corundum (Al_2O_3)
Copper (Cu)	Cuprite (Cu_2O), copper pyrites ($CuFeS_2$)
Manganese (Mn)	Pyrolusite (MnO_2)
Calcium (Ca)	Calcite ($CaCO_3$), Limestone ($CaCO_3$)
Magnesium (Mg)	Magnesite ($MgCO_3$), Dolomite ($CaCO_3 \cdot MgCO_3$)
Zinc (Zn)	Zinc blende (ZnS), Zincite (ZnO)
Lead (Pb)	Galena (PbS), Cerrusite ($PbCO_3$)
Mercury (Hg)	Cinnabar (HgS)
Tin (Sn)	Cassterite (SnO_2)

chromium ⟶ chromite ($Fe_2Cr_3O_4$)

Flux – The substance which combines with gangue to form light & easily fusible material, is called flux. It is 2 types.

Acidic flux –

If the impurities are basic then the flux employed is acidic.

Ex – $CaO + SiO_2 \longrightarrow CaSiO_3$

(Basic Impurity) (Acidic flux) (Slag)

Basic flux –

If the impurities are acidic then the flux employed is basic.

Ex – $SiO_2 + CaCO_3 \longrightarrow CaSiO_3 + CO_2\uparrow$

(Acidic Impurity) (Basic flux) (Slag)

Slag – The easily fusible material which is not soluable in molten metal is called slag.

Extraction of Metals –

The art of extraction of metals from its ore is called ~~extraction of metals~~ metallurgy.

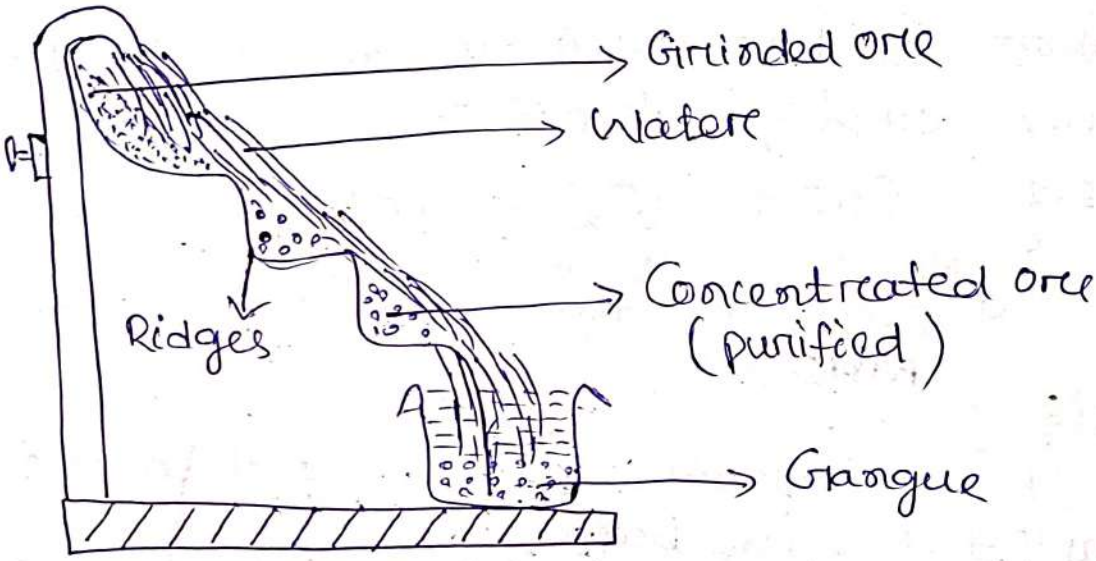
Concentration of ore –

Concentration is the process of removing maximum gangue from the ore.

Some methods are used for concentration.

1. Gravity separation
2. Froth floatation
3. Magnetic separation
4. Leaching.

1. Gravity separation process -



(Wilfley washing table).

It includes,

(i) Washing the grinded ore with water.

(ii) Separation of gangue from ore by a proper medium.

Procedure -

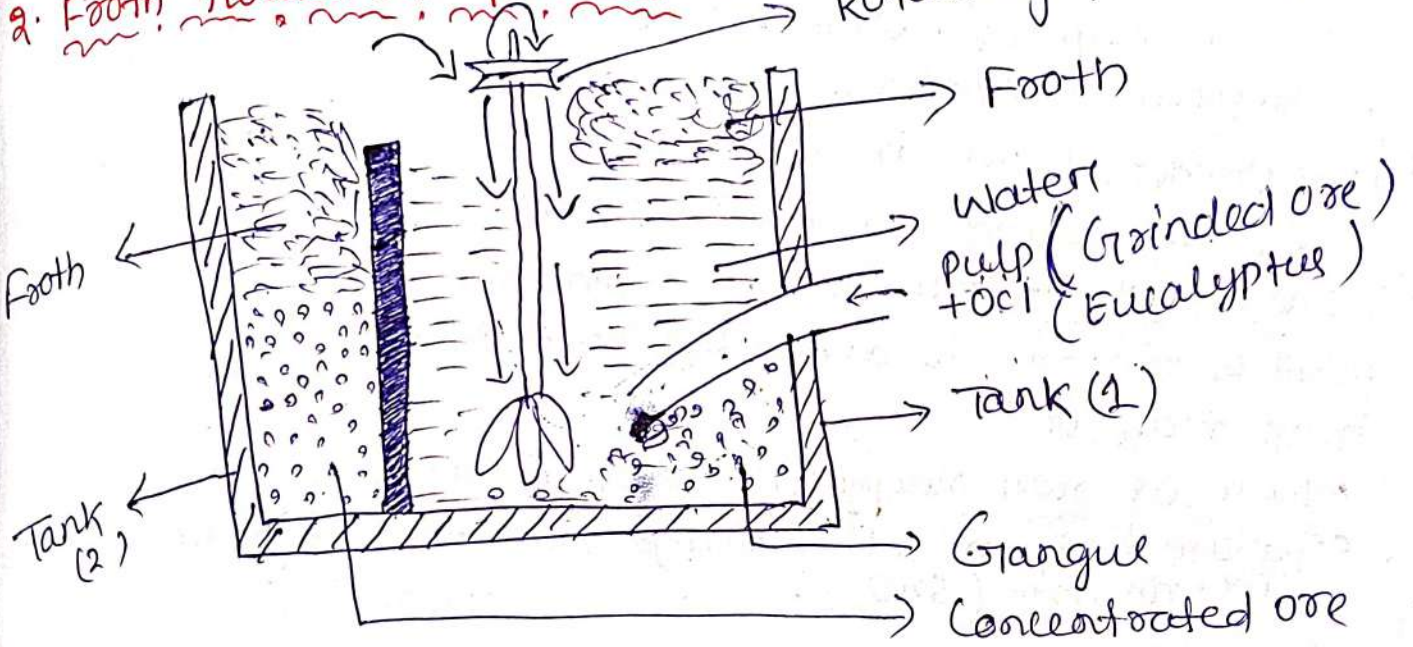
(i) The grinded ore obtained from preliminary treatment on a long table having ridges, called wilfley washing table.

(ii) The tables are given on rocking motion & lots of water flown over them.

(iii) The gangue is lighter & carried by the water while ore is detained by the ridges.

Ex- PbS (Galena).

2. Froth floatation process –



(Froth Floatation process)

(i) This method is used for the concentration of sulphide ores.

(ii) This method is based on the wetting properties of the ore by oil (Agent).

(iii) The grinded ore is added to a tank containing water.

(iv) A cheap oil like eucalyptus oil is added to it.

(v) Now this suspension is violently agitated with the help of rotating paddle.

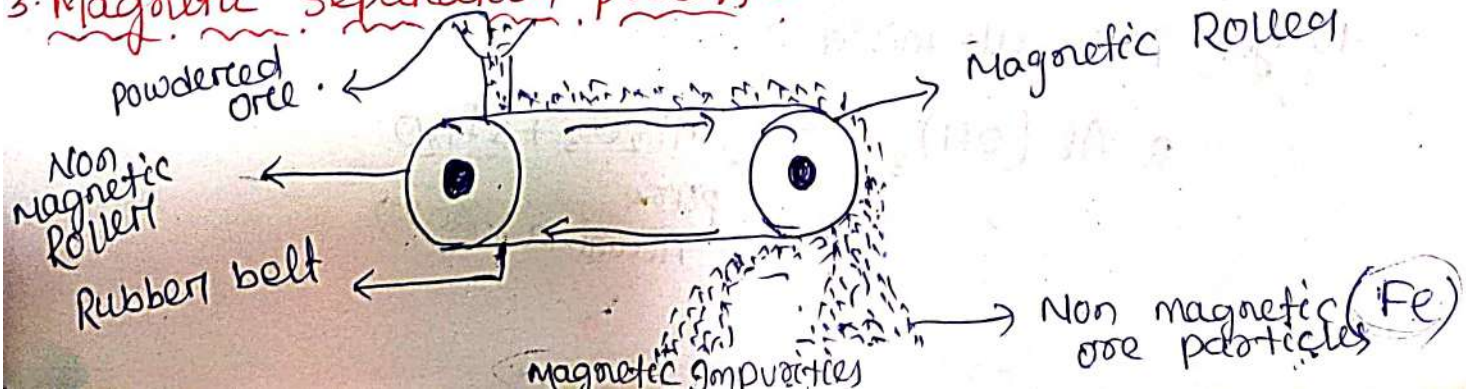
(vi) The sulphide ore particles ~~stick~~ rise to the froth & rise to the surface ~~with froth~~.

(vii) The gangue particles are left in tank-1 & the sulphide particles is kept in tank-2 for sometime.

(viii) After sometime, froth settles down & concentrated sulphide ore is obtained.

Ex- ZnS, PbS, $CuFeS_2$ etc.

3. Magnetic separation process –



(i) This method is applicable for the concentration of ores of such compounds which is differ from their impurities in magnetic character.

(ii) The powdered ore is dropped on the belt which is revolving round two rollers.

(iii) One of the rollers being a magnet & the magnetic part of the ore is attracted by this roller & forms a heap near it.

(iv) Where as non magnetic part of the ore forms a separate heap a little away from the magnetic impurities.

Ex- Tin stone (SnO_2).

4. Leaching –

(i) It is a chemical method for the concentration of the ore.

(ii) The powdered ore is treated with a suitable reagent which dissolves the ore & not the impurities.

(iii) Then, the ore is recovered from the solution by suitable chemical.

(iv) Bauxite is an ore of aluminium & it is concentrated by leaching process.

(v) Bauxite is leached with 45% soln of NaOH when Al_2O_3 goes into soln forming soluble sodium meta-aluminate.

$$Al_2O_3 + 2NaOH \longrightarrow 2NaAlO_2 + H_2O$$

(Sodium meta aluminate)

(vi) The soln is filtered to remove insoluble impurities. Aluminium hydroxide is freshly precipitated.

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

(vii) The precipitate is separated by filtration, dried to get pure alumina.

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

(pure Alumina)

Extraction of the metal from the Concentrated ore -

The extraction of the metal from the concentrated ore involves these steps.

(a) Conversion of the concentrated ore into its oxide. It is usually done by Roasting or Calcination process.

(b) Conversion of metal oxide to metal by reduction process.

Conversion of ore into metal oxide -

<A> **Calcination** - It is a process of heating the concentrated ore in absence of air or in the limited supply of air at a temperature just below its melting point.

The process helps to remove moisture, volatile impurities like As, Sb etc. Also Carbonate ores decompose to form oxide.

Ex - $Fe_2O_3 \cdot 3H_2O \longrightarrow Fe_2O_3 + 3H_2O$

25% $CuCO_3 \longrightarrow CuO + CO_2$

100% $2Al(OH)_3 \longrightarrow Al_2O_3 + 3H_2O$

<B> **Roasting** - It is a process of heating the concentrated ore in a limited supply of oxygen in a reverberatory furnace to get metal oxide.

This process is generally used to convert Sulphide ores into metallic oxides. The main functions are (i) It removes moisture in the form of steam.
(ii) It removes volatile impurities like As, Sb etc.

Ex- $2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$

$S + O_2 \longrightarrow SO_2$

$4FeCO_3 + O_2 \longrightarrow 2Fe_2O_3 + 4CO_2$

Conversion of metal oxide into metal -

The metal oxide formed in the process of calcination or roasting is reduced to the metal by some methods. This method is called reduction of metal oxide.

Smelting -

→ In this method, the roasted ore is mixed with the suitable quantity of coke or charcoal which acts as a reducing agent.

→ The mixture is heated to a high temperature above its melting point.

→ For the extraction of metals (which is less electro-positive) like Pb, Zn, Fe etc, some powerful reducing agents such as (C, H_2, CO, water gas, Na, Mg, Al) may be used.

Ex- $PbO + C \longrightarrow Pb + CO$

$CuO + CO \longrightarrow Cu + CO_2$

$BeCl_2 + 2Na \longrightarrow Be + 2NaCl$

$CaI_2 + 2K \longrightarrow Ca + 2KI$

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

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

→ If the impurities are basic, then the flux is acidic.

$CaO + SiO_2 \longrightarrow CaSiO_3$ (Slag)

(Basic Impurity) (Acidic flux)

If the impurities are acidic, then the flux is basic.

$SiO_2 + CaO \longrightarrow CaSiO_3$

(Acidic impurities) (Basic flux) (Slag)

Refining –

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

Some methods of Removal of unwanted impurities are –

a. Distillation –

(i) Some volatile ~~impurities~~ metals like mercury, Zinc, Lead etc. Contains some non volatile impurities.

(ii) For the purification of such metals, distillation process is done.

(iii) The pure metals volatilise while the impurities are left behind in the retort.

b. Electro-refining –

→ A suitable electrolyte is chosen & put into an electrolytic cell.

→ Now pure metal plate is dipped into the electrolyte & made the cathode.

→ The impure metal is made the anode & a e.m.f is applied.

→ The pure metal from the electrolyte gets deposited on the cathode & some quantity of the metal from anode goes in to the solution.

→ The metals with less electropositive ~~than the metal~~ do not undergo in solution. But get separated as anode mud.

→ Metals like Cu, Al, Zn, Pb & Sn are purified by this method.

chapter-8 ALLOYS & AMALGAMS

ALLOY – An alloy is a homogeneous solid obtained by melting together.

(i) Two or more metals

(ii) Metals and non metals.

There are two types of alloys are there.

A. Ferro Alloy

B. Non-Ferro Alloy

A. **Ferroalloys** – Which Contain iron as one of the constituents are called Ferroalloys.

EX- Nickel, Chrome etc.

B. **Non-Ferroalloys** – Which do not contain iron as one of the constituents are called non-ferroalloys.

EX- Brass, Bronze etc.

Amalgam

When one of the constituent metal of an alloy is mercury. It is known as Amalgam.

(i) Copper amalgam is used for filling dental cavities.

(ii) Tin amalgam is used for silvering cheap mirrors.

Iron does not form amalgam with mercury.

Composition –

Name.	Composition	uses
1. Brass	Cu = 60-80%, Zn = 20-40%	Cartridges, utensils, ~~cartridges~~.
2. Bronze	Cu = 75-90%, Sn = 10-25%	utensils, coins
3. Aluminium Bronze	Cu = 90%, Al = 10%	coins, ornaments
4. German Silver	Cu = 50%, Zn = 25%, Ni = 25%	utensils, ornaments.

5. steel → Fe = 73 %
Cr = 18 %
C = 1.3 %
Ni = 7.7 %
→ utensils, cycle & automobile parts

6. Duralumin → Al = 95 %
Cu = 4 %
Mn = 0.5 %
Mg = 0.5 %
→ For making airships.

7. Alnico → steel = 50 %
Ni = 26 %
Al = 20 %
Co = 4 %
→ For making permanent magnet.