Metals and Alloys

Mineral :- A naturally occuring substance that has a characteristic chemical composition and, in general, a crystalline structure. Rocks are composed of mixtures of minerals which may be identified by the properties of their crystal system, hardness, relative density, lustre, colour, cleavage and fracture.

Ore :- A naturally occuring mineral from which a metal can be extracted, usually on a commercial basis. The metal may be present in the ore as the native metal, but more commonly it occurs in a combined form as an oxide, sulphide, sulphate, silicate etc.

Slag :- Material produced during the melting or refining of metals by reaction of the flux with impurities. On the other word, the combination of flux and gangue the fusible mass obtained is called as slag.

Flux :- The substance which is added from outside in the ore during the process of smelting to remove gangue is called flux.

If the gangue is acidic in nature basic flux used.

$$SiO_2 + CaO \longrightarrow CaSiO_3$$
(gangue) (flux) (slag)

Gangue (or Matrix) :- The unwanted impurities like sand, rock, clay etc. present in an ore are termed as Gangue.

If the gangue is basic in nature then acidic flux is used.

$$FeO + SiO_2 \longrightarrow FeSiO_3$$
(gangue) (flux) (slag)
basic acidic

Hence, the term gangue and flux are complementary to each other in smelting.

Metals :- Metals are the element which are generally lustures, solids, malleable, ductile, and good conductures of heat and electricity.
Two-third of the known elements are metals. Examples of metals which are of common use in our daily life are Fe, Cu, Al, Pb, Au, Ag, Hg etc.

Non-metals :- Non-metals are the elements which are generally non-lustrous brittle and poor conductor of electricity (graphite is an exception) of the common non-metals are O, H, C, S, P etc.

Metalloids :- Metalloids are the elements which have common characteristics of metals and non metals.
Eg are antimony, tin, arsenic, bismuth etc.

* All ores are minerals but all the minerals are not ores.

Eg:2 ⇒ A naturally occuring substance present in earth crust which contains metals in the free state or in combined state is called as mineral.

A mineral from which the metal can be extracted economically is called ore.

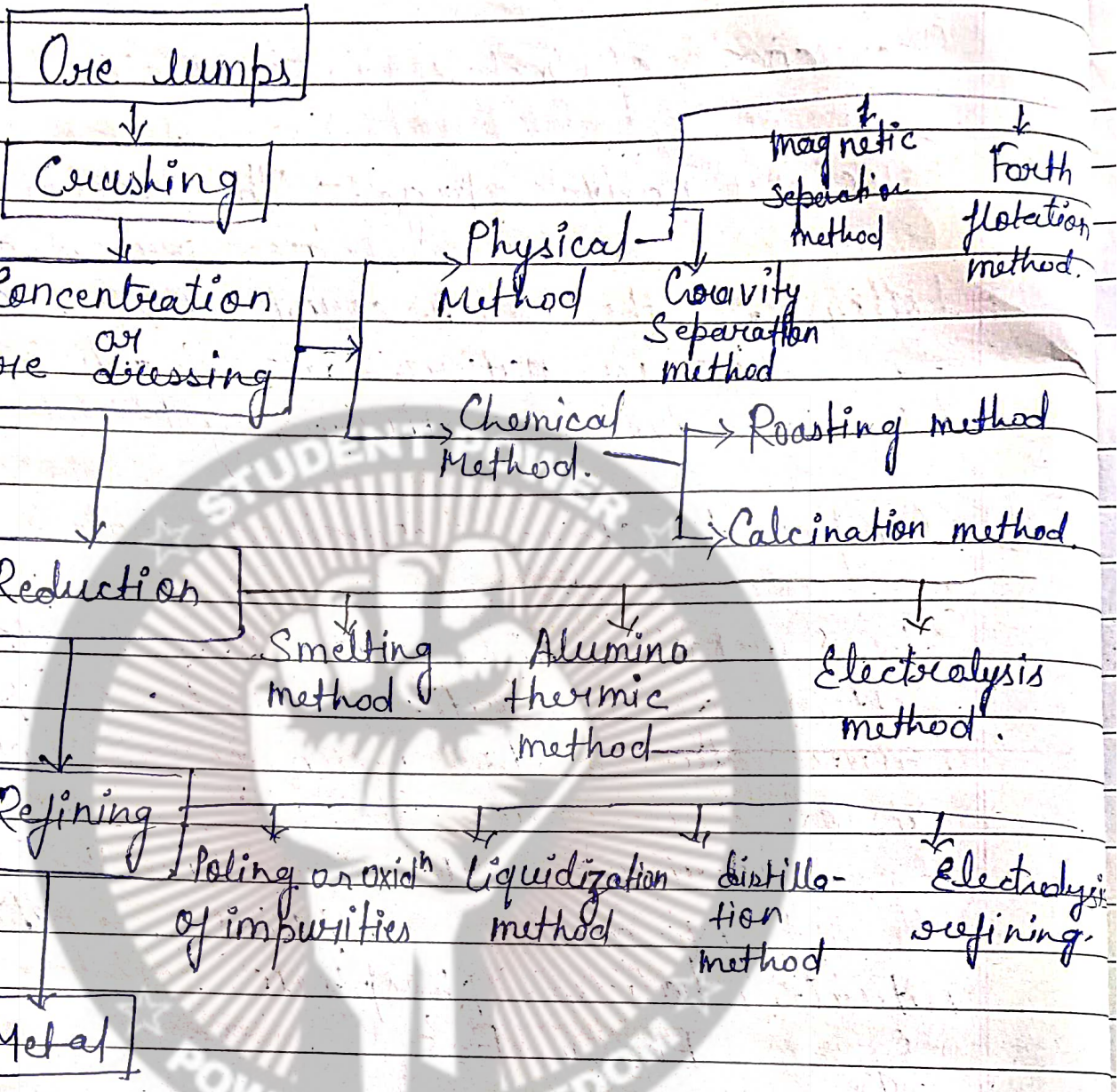
It is not possible to extract metal in a profitable amount from all the minerals of the same metal. Eg: clay and Bauxite are minerals of Aluminium but aluminium is extracted economically from clay. Therefore clay and bauxite are minerals but ore is only Bauxite. Therefore all the ores are mineral but all the minerals are not ore.

Occurance of metals in nature in two stages.

(a) Free or native stage :- The metal which are placed at the bottom of the earth crust which occur in free state in nature are inactive metals.
Eg :- Silver, platinum, gold etc.

(b) Compound stage (combined state)

The metal which are placed at the bottom of the earth crust in compound in nature due to the action of air, moisture, atmospheric gases etc.
Eg :- various metals are in the form of their oxides, sulphides, carbonates, nitrates, halides, phosphate.
Eg :- Fe_3O_4, FeS_2.



[diagram representation of metal extraction from ore].

VI

Mechanical Properties of Metal :

(a) Hardness : Hardness is the ability of the metal to resist wear or abrasion. Eg : tungsten is hardest metal.

(b) Toughness : A property of a metal by which it can resist repeated shocks or vibration without breaking. E.g : gold, silver is tough metals.

(c) Ductility : A property of metal by which it can be stretched in length without breaking and they can be drawn into wires. E.g : Gold, silver and platinum are more ductile.

(d) Malleability : A property by which virtue of which a metal can be hammered into shapes without cracking or rolled into thin sheets without tearing or breaking e.g : gold, silver, platinum.

(e) Tensile strength : The strength of metal is the ability of metal to carry load without breaking. Eg :- iron and tin.

(f) Machinability : A property due to which a metal ~~is the abibity of metal to carry load without~~ can be easily cut by cutting tools to produced a desired shape and surface finish on its surface. Eg :- Sawing, shaping, drilling etc.

(g) Weld ability :- It is process of uniting two piece of metal by means of heat by bringing their ends in molten state.

(h) Forging :- It is the process of giving pre-determined shape to a piece of metal of at sufficiently high temperature when metal is in the plastic state it is known as forging.

(i) Soldering :- A method of joining a the metal surface by introducing a molten non-ferrous alloy with melting point below 400°C between them is known as soldering.

(j) Cast ability :- It is the process of pouring molten metal into a mould and allowing it to solidify is known as casting.

Process of extracting a metal from its ores.

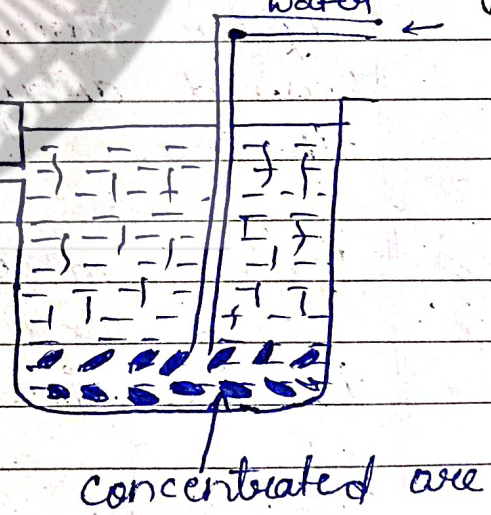
The ore is generally contaminated with non-metallic and rock impurities known as gangue. The following operation are carried out for obtaining the metal in the pure form.

1. Crushing of the ore.
2. Dressing or concentration of the ore.
3. Working up of the concentrated ore
4. Purification or refining of the metal.

Q. What is meant by "dressing" of the ore? Describe various processes carried out for the dressing or concentration of the ore.

Dressing or Concentration of the Ore.

Metallic ores are often found contaminated with non-metallic and rocky materials like quartz, felspar, mica and silicates.



Gravity Separation.

Before the ore is subjected to metallurgical processes it is

necessary to remove these unwanted impurities. This operation is known as ore dressing, beneficiation or concentration.

Various methods employed for concentration are described as under :-

(a) Gravity Separation :- The ore is concentrated making advantage of the difference in the specific gravities of the metallic ore and the earthy impurities. The ore after crushing in big jaw crushers and then grinding in a ball mill, a stamp battery or a rolar mill, is agitated in a running stream of water. The heavy ore settles down rapidly while the lighter earthy material or gangue is washed away. Oxides ores of iron and tin are concentrated by this method.

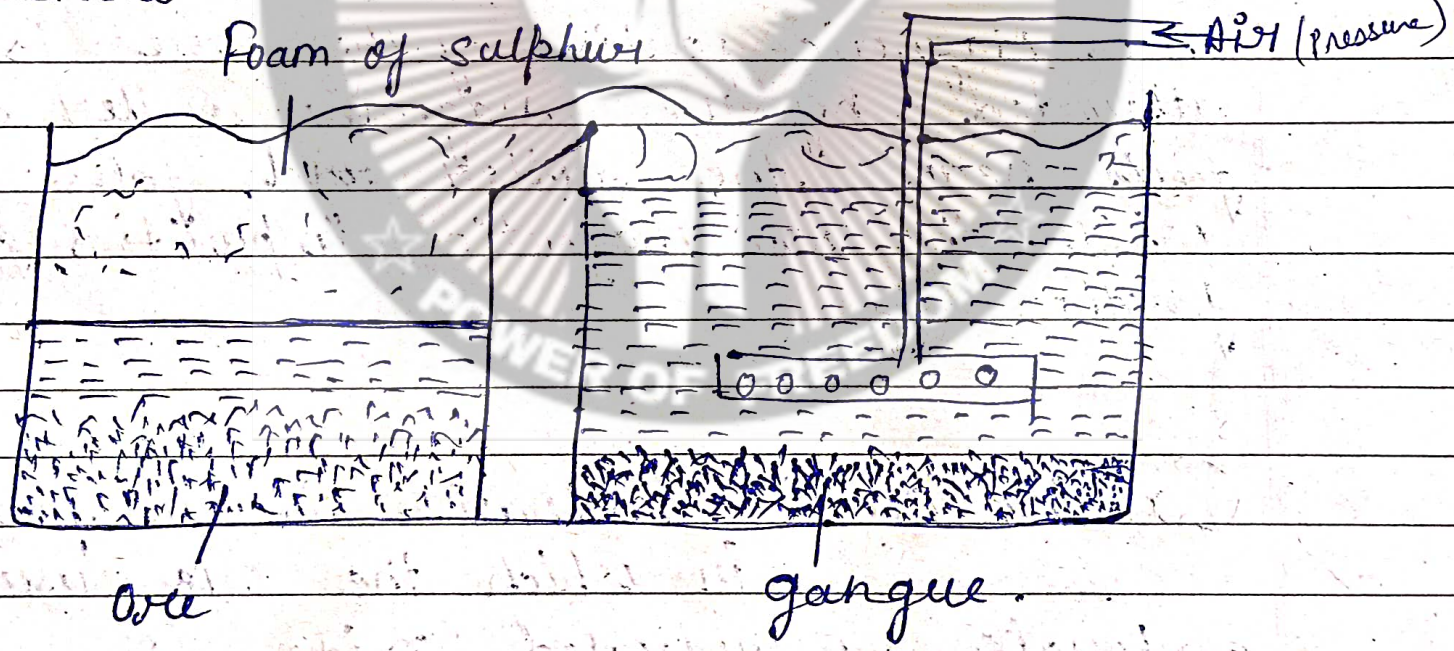
(b) VI. Forth Floation Process :- Metallic sulphides are wetted by certain oil like pine oil and not by water.

The finely divided ore is introduced into water containing small quantity of oil (e.g., pine oil). The mixture is agitated violently with air.

A froth is formed which carries away along with it the metallic particles on account of the surface tension forces. The froth is transferred to another bath where gangue-free ore settles down. As the heavy metallic material is floated upward with the froth, this process is known as froth floatation process.

The method is based upon preferential wetting of surfaces by liquids.

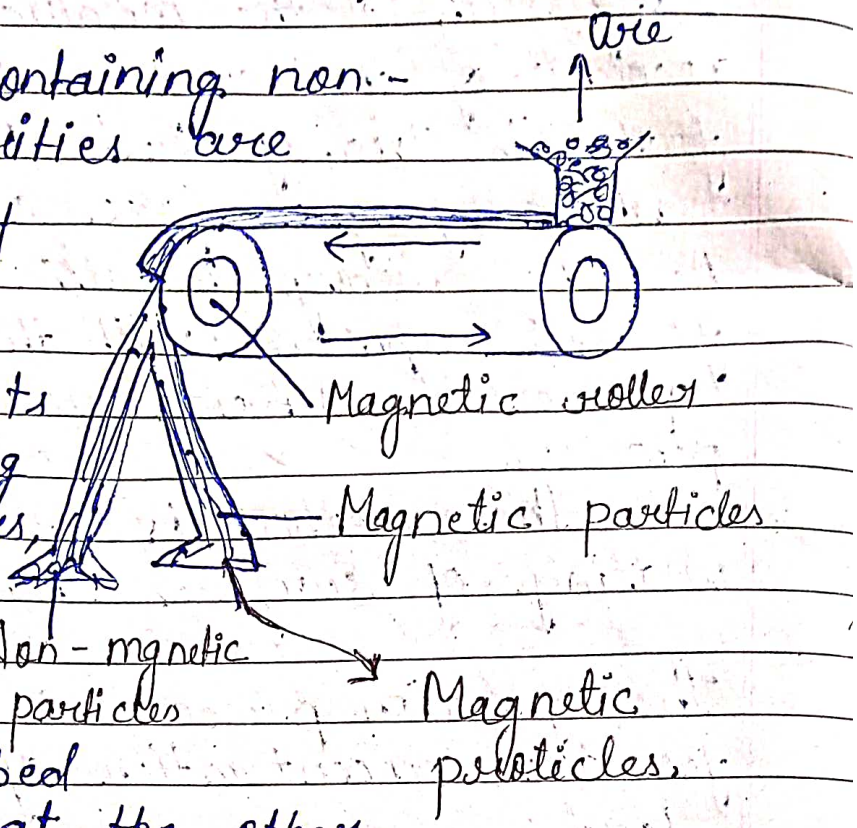
The floation process is commonly employed for the concentration of sulphides ores of lead.



Froth ~~floation~~ floatation Process.

(E) Magnetic separation :-

Magnetic ores containing non-magnetic impurities are concentrated by this method. A magnetic seperator consists of a belt moving over two rollers, one of which is magnetic. Non-magnetic powdered particles ore is dropped on the belt at the other end. Magnetic portion of the ore is attracted by the magnetic roller and falls near the roller and falls while the non-magnetic impurities fall farther off.



Calcination :- Calcination is a process in which the ore usually carbonate or hydrated oxide is subjected to the action of heat in order to expel water from hydrated of oxide and carbon dioxide from a carbonate.

For example, when limestone is heated carbon dioxide is given off and it is then said to be calcined. When bauxite is calcined at high temperatures, water is removed and anhydrous alumina is left. Similarly iron ore on calcination gives anhydrous iron oxide. The following equation represents calcination.

$$ZnCO_3 \longrightarrow ZnO + CO_2$$
$$CaCO_3 \longrightarrow CaO + CO_2$$
$$Al_2O_3 \cdot 2H_2O \longrightarrow Al_2O_3 + 2H_2O$$
$$2Fe_2O_3 \cdot 3H_2O \longrightarrow 2Fe_2O_3 + 3H_2O$$
$$CuCO_3 \cdot Cu(OH)_2 \longrightarrow 2CuO + CO_2 + H_2O$$

Calcination is generally done in a reverberatory furnace.

// Roasting :- Roasting is a process in which ore (usually sulphide ore) either alone or along with some other materials are subjected to the action of heat and or heat and air at temperatures below with some their melting points in order to bring about chemical changes in them. Calcination is also roasting but in this case we are concerned mainly with the changes due to the expulsion of some ingredients

Such as water, carbon dioxide and no other chemical change occurs. But during roasting chemical changes like oxidation, chlorination etc. take place. The following equations represent roasting.

$$2PbS + 3O_2 \longrightarrow 2PbO + 2SO_2$$
$$PbS + 2O_2 \longrightarrow PbSO_4$$
$$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2$$
$$ZnS + 2O_2 \longrightarrow ZnSO_4$$
$$CuS + 2O_2 \longrightarrow CuSO_4$$
$$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$$

Roasting is generally carried out in a reverberatory furnance or in a blast furnance.

Blast Furnance : It is used for smelting iron, copper and lead ores. It has a tall structure made of steel plates rivetted together lined inside with fire bricks. The furnance is provided with an arrangement for blowing air near the base, a slag hole, a tapping hole for removing the molten metal and an exit for waste gases near the top. The charge is introduced at the top. The mouth of the furnance is closed by a special

arrangement through which the charge is introduced. Size of the blast furnance varies with the ore.

(b) Reverberatary Furnance :- It is used for calcination, roasting or for smelting. The charge in the powdered form along with a flux is placed on the hearth of the furnance. The fuel is placed on greate and the flames are deflected from its low sloping roof. This furnance is used in case of copper, tin, lead, and wrought iron.