# Metallurgy

Metallurgy - the branch of chemistry which deals with the method of extraction of metals from their profitable means.

Metals - the element which tends to form positive ion is called a metal

Minerals :- the various compounds of metals which occur in the earth' crust and are obtained by mining are called minerals. In earth crust order of abundance of elements is O > Si > Al > Fe
A mineral

Ore: the mineral from which a metal can be extracted profitably and easily is called an ore.

Type of Ores :-

i) Combined ore: metals placed above H in electrochemical series are generally reactive i.e. why they generally found in combined state

a) Halide ore/ sulphate ore/ Oxy ore : metals are highly reactive (Li → Mg)

b) Oxide ore: Reactive metal (Al to Sn)

c) Sulphide ore : metal placed near H or below H (Pb, Hg, Cu, Ag)

ii) Native ore: metal placed below H in electrochemical series are generally found in native state. (Ag, Au, Cu, Pt etc)

Gangue or matrix: the undiserable impurities present in an ore are called gangue.

Types of Metallurgy

- Pyrometallurgy → temp is involved → For heavy metals → Fe, Zn, Cu, Hg, Sn etc.
- Hydrometallurgy → solution is involved → According to E.C.S. → for metals placed below H → Cu, Ag, Au
- Electro metallurgy → electricity involved → IA, II A, A l

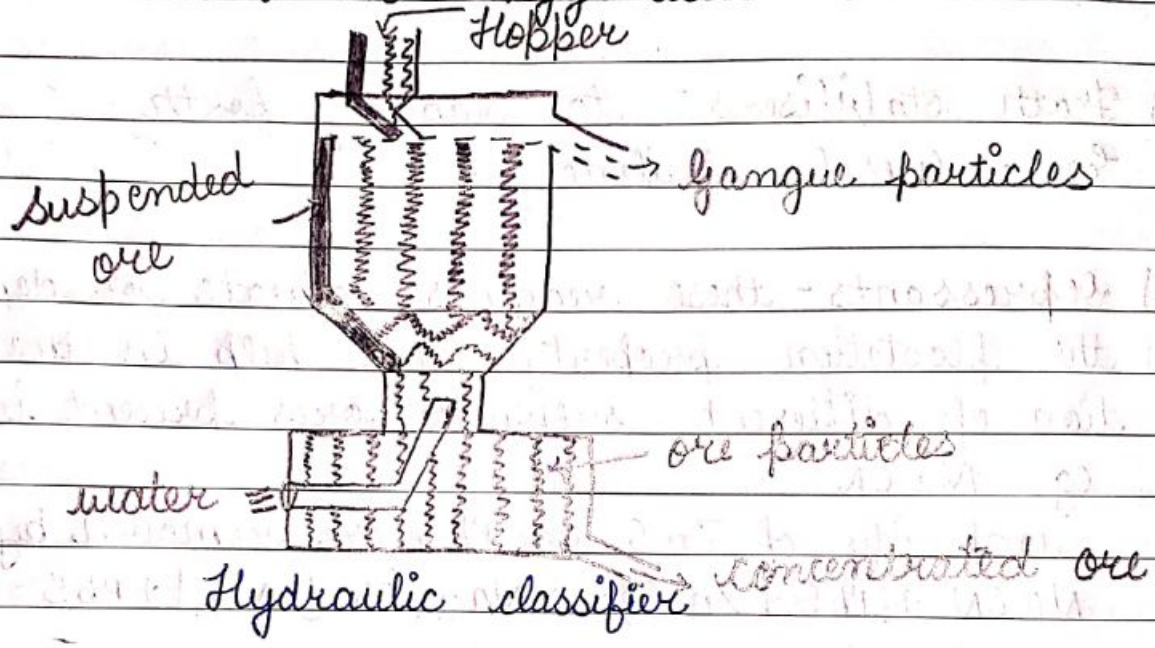
Steps involved in the extraction of metals
The extraction of a metal from its ore is complete in the following four steps

A) concentration of the ore
B) Conversion of concentrated ore into oxide form
C) Reduction of the metal
D) Refining of the metal

A) Concentration of the Ore or ore dressing or benefaction the removal of impurities from the ore is called its concentration or to increase the concentration of ore in ore sample.
Two process - 1) Physical 2) chemical

1) Physical :-
i) Gravity separation (Levigation) : this method of concentration of the ore is based on the difference

in the specific gravities of the ore and the gangue particles. Powdered ore is agitated with a running stream of water. The lighter gangue particles are taken away by water while heavier ore particles settle down. Ex - Oxygenated ore.



Hydraulic classifier

ii) Froth Floatation method

This method is mainly employed for the concentration of sulphide ores

The method is based on the different wetting characteristics of the gangue and the sulphide ore with water and oil. The gangue preferentially wetted by the water and the ore by oil.

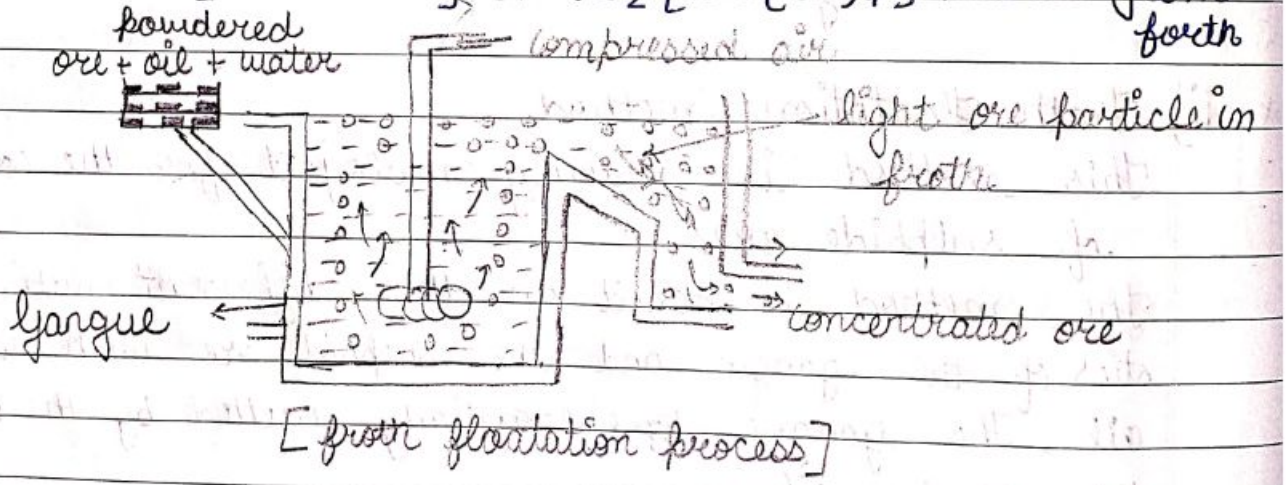
The crushed ore along with water is taken in a floatation cell. Various substances are added depending on the nature of the ore and a current of air is blown in. The substances added are usually of three types

a) Frothers :- they generate a stable froth which rises to the top of tank. Example of frother is pine oil, Eucalyptus oil, fatty acids etc.

collectors or floating agents :- these attach themsel by polar group to the granuels of the ores whic then become water repellent and pass on into the froth. Example : sodium ethyl xanthate, pine oil and fatty acid

Froth stabilisers : to stabilise forth.
Ex - cresol, Aniline etc.

Depressants - these reagents activate or depress the floatation property and help in the separation of different sulphide ores present in mixtu
eg :- NaCN
impurity of ZnS in PbS ore removed by NaCN
$NaCN + [PbS + ZnS] \longrightarrow Na_2[Zn(CN)_4] + PbS \rightarrow$ from forth




sometimes it is possible to separate 2 sulphide ores by adjusting proportion of oil to water or by using 'depressants'

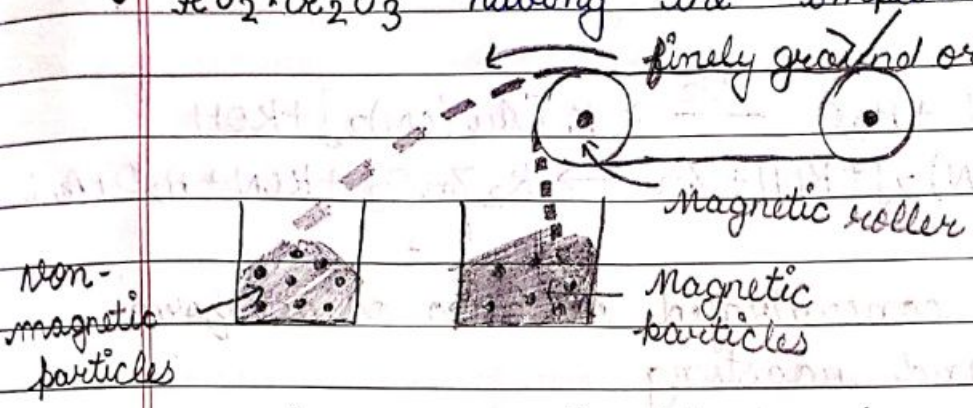
For example, in case of an ore containing ZnS and PbS, the depressant used is NaCN. It selectively prevents ZnS from coming to the forth but allows PbS to go along with the forth

iii) Magnetic separation:

If either the ore or gangue (one of these two) is capable of being attracted by a magnetic field, then such separations are carried out (eg: in case of iron ores)

eg • $SnO_2$ having the impurities of $FeWO_4 + MnWO_4$ (Wolframid)

• $FeO_2 \cdot Cr_2O_3$ having the impurities of $SiO_2$.




Chemical separation (leaching): - In this process we use suitable agent which react with ore to form water soluble complex while impurities remain insoluble.

Applicable for Al, Ag, Au

a) Aluminium:
- Red Bauxite $\rightarrow Al_2O_3 \cdot 2H_2O + Fe_2O_3$ (Major impurity)
- White Bauxite $\rightarrow Al_2O_3 \cdot 2H_2O + SiO_2$ (Major impurity)

i) Red Bauxite: two processes

i) Bayer's process: NaOH is used

$$Al_2O_3 + NaOH \longrightarrow NaAlO_2 \xrightarrow{\text{excess } H_2O} Al(OH)_3 + NaOH$$

$FeO + NaOH \longrightarrow$ insoluble

↓ basic

ii) Hall's process: $Na_2CO_3$ is Used.

$$Al_2O_3 + Na_2CO_3 \rightarrow 2NaAlO_2 \xrightarrow[CO_2]{HOH} Al(OH)_3 + Na_2CO_3$$

ii) White Bauxite: one process

Serpeck's process: $C + N_2$ is used

$$Al_2O_3 + N_2 \xrightarrow[-CO\uparrow]{1800^\circ C} AlN \xrightarrow{H_2O} Al(OH)_3 + NH_3\uparrow$$

$$C + SiO_2 \longrightarrow CO_2\uparrow + Si\uparrow$$

b) Ag and Au (cyanide process)

(I) Ag $\quad Ag_2S + 4NaCN \xrightarrow{2O_2} 2Na[Ag(CN)_2] + Na_2SO_4$

$$2Na[Ag(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Ag\downarrow$$

(II) Au $\quad Au + KCN + H_2O \xrightarrow{O_2} K[Au(CN)_2] + KOH$

$$K[Au(CN)_2] + KOH + Zn \longrightarrow K_2ZnO_2 + KCN + H_2O + Au$$

B) conversion of concentrated ore into oxide form calcination and roasting

Ore

↓

crushing and grinding

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concentration → Gravity separation method
→ Magnetic separation
→ Froth floatation
→ Leaching

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Roasting & calcination

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Reduction → reduction by carbon
→ reduction by electrolysis
→ reduction by CO
→ reduction by Al Aluminothermic process
→ reduction by Heat alone.

↓

Refining → distillation
→ liquification
→ oxidation
→ electro - refining

↓

Pure metal