★ METALLURGY ★

OXIDE ORE

1) Cuprite – Cu_2O
2) Haemetite → Fe_2O_3
3) Magnetite – Fe_3O_4
4) Bauxite – Al_2O_3
5) Cassitarite – SnO_2 or Tin stone
6) Zincite – ZnO
7) Rutile – TiO_2
8) Pyrolusite – MnO_2
9) Chromite – $FeO.Cr_2O_3$
10) Kaolinite ↳ $Al_2(OH)_4Si_2O_5$

CARBONATE ORE

1) Lime stone – $CaCO_3$
2) Magnesite – $MgCO_3$
3) Malachite – Green ↳ $CuCO_3 \cdot Cu(OH)_2$
4) Siderite → $FeCO_3$
5) Azurite – Blue ↳ $2CuCO_3 \cdot Cu(OH)_2$
6) Calamite – $ZnCO_3$
7) Cerusite – $PbCO_3$
8) Dolamite ↳ $CaCO_3 \cdot MgCO_3$

SULPHIDE ORE

1) Galena – PbS
2) Zinc blende – ZnS or Sphalerite
3) Cinnabar – HgS
4) Chalcocite – Cu_2S
5) Chalcopyrite ↳ $CuFeS_2$
6) Argentite – Ag_2S
7) Fool's gold or Iron pyrite ↳ FeS_2

HALIDE ORE

1) Rock salt – $NaCl$
2) Fluospar – CaF_2
3) Cryolite – Na_3AlF_6
4) Carnalite ↳ $KCl \cdot MgCl_2 \cdot 6H_2O$
5) Silvine – KCl
6) Etorn Silver – $AgCl$

Chile saltpetre ↳ $NaNO_3$

Indian saltpetre ↳ KNO_3

- Pig Iron → 4% C, S, P, Mn, Si
- Cast iron → 3% C, hard & brittle
- Wrought iron → Commercial iron's purest form

Prep ↳ Cast iron oxi. in reverb. furnace lined with Fe_2O_3

- Copper matte → $Cu_2S + FeS$

Concentration of Ore – Gangue Removal

i) **Hydraulic Washing**
- density difference
- Used for heavy metals ↳ Sn, Pb, Fe, etc.

ii) **Froth floatation**
- for sulphide ores ↳ eg:- Cu_2S, FeS_2, PbS

→ **Froth stabilizers**
- pine oil or Eucalyptus oil

→ **Collectors**
- non-wetability of ores with H_2O
- Pine oil, Salty, Xanthates, K/Na-ethyl Xanthate

→ **Depressant** → NaCN → Prevent ZnS

$PbS + NaCN \rightarrow$ No Rxn.

$ZnS + NaCN \rightarrow Na_2[Zn(CN)_4]$

(iii) **Electromagnetic Separation**

(iv) Leaching

$$Al_2O_3 \cdot 2H_2O + conc.\ NaOH \xrightarrow[35-36\ bar]{473-523K} Na[Al(OH)_4]$$

$\downarrow CO_2$; ↗ ppt

$$Al_2O_3 + 2H_2O(g) \xleftarrow[1470K]{\Delta} Al_2O_3 \cdot 2H_2O + NaHCO_3$$

Mac Arther Forrest Cyanide Process

↳ for Ag / Au

$$Ag_2S + NaCN + O_2 \rightarrow Na[Ag(CN)_2] + Na_2S$$

$Zn \downarrow$

$$Ag + Na_2[Zn(CN)_4]$$

Reduction of Ore

1) Roasting → Reverberatory furnace
- O_2 present ; Sulphide ore Red^n
- below metal m.p → heated ore → porous & dry

Sulphide ore → oxide ores

$ZnS + O_2 \rightarrow ZnO + SO_2\uparrow$

Self Reduction → Impurity

$Cu_2S + O_2 \rightarrow Cu_2O + SO_2$

$Cu_2O + Cu_2S \rightarrow Cu\downarrow + SO_2\uparrow$

Blister Copper → Cu↓ → 98% copper (pure)

2) Calcinat^n → O_2 ✗
- ore - high temp.
- Reducing carborates & Hydroxides ores
- Remove volatile impurities

3) Smelting → O_2 ✓
- metal oxide → metal
- R.A → CO, C, Al

Gold Schmidt aluminothermite Process
- Al + metal oxide → Metal
- Used for Cr, Fe, Mn, Si

$Al + \Delta \rightarrow Cr_2O_3 \rightarrow Cr\downarrow$, $Fe_2O_3 \rightarrow Fe\downarrow$, $SiO_2 \rightarrow Si\downarrow$, $Mn_3O_4 \rightarrow Mn\downarrow$ + Al_2O_3

metallic oxides me convert → Red^n → Metals

Blast-furnace
- low temp. → 500 - 800 K

$CaCO_3 \rightarrow CaO + CO_2$ (Lime stone → flux)

$Fe_2O_3 + CO \rightarrow Fe_3O_4 + CO_2$ (iron ore)
- High temp. → 900 - 1500 K

$FeO + CO \rightarrow Fe + CO_2$

$CO_2 + C \rightarrow CO$

$CaO + SiO_2 \rightarrow CaSiO_3$ → Slag
- Coke Burning

$C + O_2 \rightarrow CO_2$

$FeO + C \rightarrow Fe + CO$

Refining of Ore

1) Liquation
→ Used for metals with low m.p → eg. Sn, Pb, Si

2) Distillation
→ for metals with low bp
eg.:- Zn, Hg, Cd (bp diff. ≥ 25)

3) Electrolysis Refining
- For Cu, Zn
- Cathode → Pure metal
- Anode → Impure metal
- Oxi. → Impurities nikal jayengi

4) Chromatography
↳ Useful → Column chromatography

5) Zone Refining
→ Impurities → more soluble in melt form
→ for Semiconductors
↳ Eg.:- Ge, Si, Ga, Be, In
→ Impurities dissolve hoti hai
Leaching - metal dissolve hota hai

(6) Vapour Phase refining
Metal → volatile compound → decompose

- Mond's: $Ni + CO \xrightarrow{350K} Ni(CO)_4 \xrightarrow{470K} Ni\downarrow + CO\uparrow$
- Vanacral: $Zr + I_2 \xrightarrow{870K} ZrI_4 \xrightarrow[\Delta]{1800K} Zr + I_2$

Ni → Zr → Ti → metal

$Ti + I_2 \xrightarrow{500K} TiI_4 \xrightarrow{1400K} Ti + I_2\uparrow$

- $Al_2O_3.xH_2O \xrightarrow[\text{Bayer's process}]{\text{conc.}} Al_2O_3$

$Al^{3+} \rightarrow Al$ (pure)

Alumina → $Al_2O_3 + Na_3AlF_6 + CaF_6$

Na_3AlF_6 → Alumina mp low krta
CaF_6 → conductivity / fluidity ↑se krta hai

Cathode → Iron container with C Lining

Anode → Graphite

Hall - Heroult's Process → Al (99%)

Cathode → $Al \rightarrow Al^{3+} + 3e^-$

Anode → $Al^{3+} + 3e^- \rightarrow Al$

Hoope's Method → Al (99.99%)

Zn conc. → $ZnS \xrightarrow{\text{roasting}} ZnO + C$

Rapid chilling (Distillat^n) ← $Zn + CO$ ← Belgian Process