Metallurgy

→ Extraction of pure metals from its ores.

- **Minerals** :- ~~Com~~ Naturally occuring substance in which metal exist in free form or combined form.

- **Ore** :- Mineral from which metal can be obtained easily & economically.

→ All mineral are not ore but all ore ~~min~~ are mineral.

- **Abundance** :- O > Si > Al > Fe
  Al → metal

  - Most abundant element → Oxygen
  - Most abundant metal → Aluminium.

$$Al_2O_3 \xrightarrow[\text{Most dificult process costly}]{\text{electrolytic redn}} Al.$$

- **Types of ore**

① Combined ore :- Reactive metal.

② Native / Free form :- Noble metal.
Au, Pt, Ag, कहिले कहि Free form
.. combined for

Cu - एउटा बाउमा Free for.

- **Combined form**
  - oxide को form मा
    Sulphide
    Halide
    Sulphate
    Carbonate

Abhishek

① Iron (Fe) :- Haemetite : Fe_2O_3

Magnetite: Fe_3O_4.
└ mixed oxide of FeO & Fe_2O_3.

Note: Magnesite → $MgCO_3$

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- Siderite → $FeCO_3$
- Fool's gold :- Iron pyrite → $Fe^{+2}S_2$ [$S-S$]

② Pb (lead):
Galena → PbS
Cerucite → $PbCO_3$
Anglesite → $PbSO_4$

③ Sn (Tin)
Casseterite → SnO_2
(Tinstone)

④ Ag
Argentite → Ag_2S
Horn silver → AgCl.

⑤ Mn
Pyrolusite → MnO_2

⑥ Cu
Copper pyrites → $CuFeS_2$
Cuprite → Cu_2O
Copper glance → Cu_2S
·Malachite green → $CuCO_3.Cu(OH)_2$
Azurite blue → $2CuCO_3.Cu(OH)_2$

Effect of atmosphere on metal

→ Cu $\xrightarrow[O_2]{H_2O, CO_2,}$ green color of $CuCO_3.Cu(OH)_2$ (Malachite green)

→ Fe $\xrightarrow{H_2O, O_2,}$ Rust ($Fe_2O_3.x.H_2O$)
brown color

→ Pb, Ag $\xrightarrow{H_2S}$ PbS, Ag_2S (Black ppt.)

⑦ Al
Bauxite → $Al_2O_3.2H_2O$
Diaspore → $Al_2O_3.H_2O$
Corandum → Al_2O_3.
Cryolite → Na_3AlF_6. (Sodium Aluminum fluoride)

AlF_3 → anhy. HF (covalent) → insoluble
AlF_3 → NaF (ionic) → soluble complex → $Na_3[AlF_6]$

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Q. Al is absent in:-

(a) Bauxite (b) Cryolite (c) clay (d) Feldspar (e) Fluorospar

clay → silicates → Al हुन्छ

Fluorospar → CaF_2

- **Matrix/Gangue** :- Unwanted impurities associated with ore.

Removal :-

(i) By concentration of ore

(ii) By slag formation.

$$\boxed{\text{Impurity/Gangue} + \text{substance/flux} = \text{slag.}}$$

- **Flux** :- Substance used to remove gangue from ore.

→ Impurity → non-fusible (melt नहुने) → slag → fusible (melt हुने), lighter, prevent molten metal from oxdn by air.

- **Types of Flux**

(1) **Acidic flux** :- acidic flux remove basic impurities.

e.g. SiO_2 (silica), Borex ($Na_2B_4O_7 \cdot 10H_2O$)

$$\xrightarrow{\Delta} NaBO_2 + B_2O_3 + 10H_2O$$

- FeO (basic) impurity from copper pyrites (ore) removed by using silica flux.

$$\underset{\text{gangue}}{FeO} + \underset{\text{Flux.}}{SiO_2} \longrightarrow \underset{\text{Slag.}}{FeSiO_3}.$$

(2) **Basic flux** :- Remove acidic impurities.

e.g. CaO, MgO, $CaCO_3$.

→ SiO_2 (silica) impurity from Haematite ore removed by limestone.

$$\underset{\text{impurity.}}{SiO_2} \xrightarrow[\Delta]{\text{flux.}\ CaCO_3} \underset{\text{slag.}}{CaSiO_3} + CO_2\uparrow$$

→ Role of lime stone during extraction of Fe is Flux.

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- During extraction of Fe from Haematite ore, chemical composition of slag is $CaSiO_3$.

③ Neutral flux: Used during electrolysis of fused salt.
→ less melting point & ↑es conductivity.

Fused NaCl (molten 800°C) —electrolysis→ $Na^+ + Cl^-$
$Na^+ \downarrow e^-$ → Na → vapourize
$Cl^- \downarrow -e^-$ → $\frac{1}{2}Cl_2$.

So, $CaCl_2 + KF$
↓
Neutral flux.
↳ decreases m.p of NaCl to 600°C. → So, sodium doesnot vaporize.

Fused Al_2O_3 + cryolite (Na_3AlF_6) + Fluorospar (CaF_2) —Hall Herald electrolytic redn→ Al
→ less mpt of Al_2O_3 (2000°C → 1700°C) & ↑es conductivity.

Al_2O_3 - High mpt (2000°C) - due to high lattice energy.

Types of Metallurgy

① Pyrometallurgy:- Heat involve
→ calcination, roasting, redn process involve.
→ for less reactive metals.
e.g. Mn, Pb, Cu, Zn, Fe, Ni, Sn.

ore —Heat→ metal.

e.g. $ZnCO_3$ (calamine) —Δ, calcination→ $ZnO + CO_2\uparrow$
ZnO —C, Δ, redn→ $Zn + CO$
Zn (impure) —distillation, Δ→ Zn (pure)

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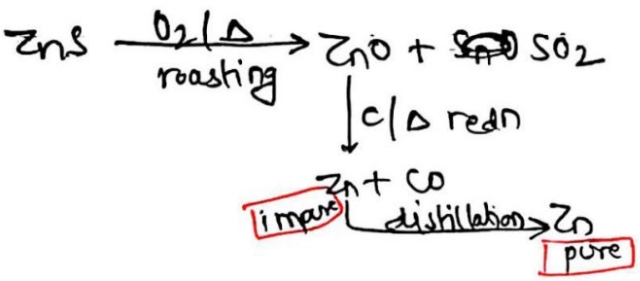
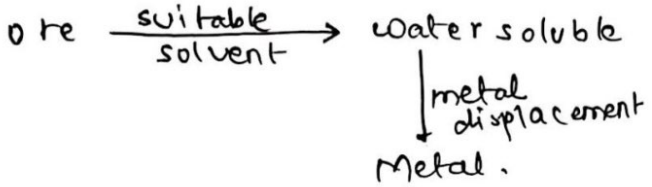
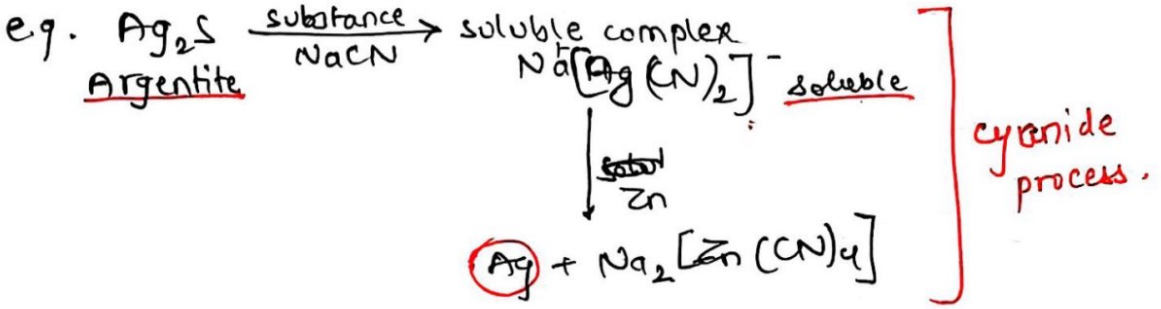


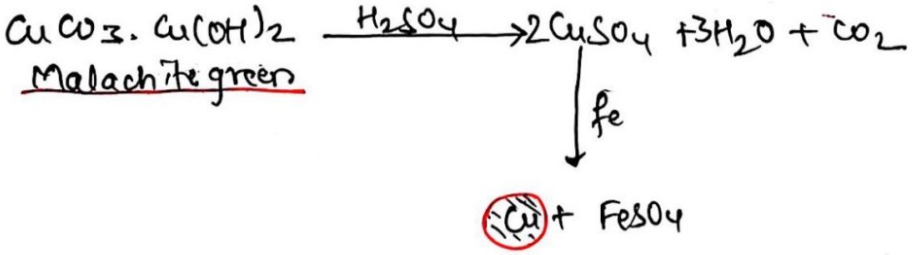
② Hydrometallurgy :- Ag, Au, Cu

→ aq. solution is used.

→ It involve disolution of metallic ore in a suitable solvent in which metallic ore is soluble and impurities are insoluble.





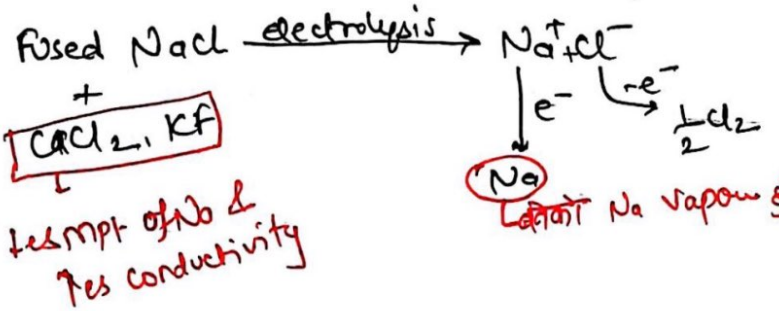


③ Electrometallurgy / Electrolytic reduction

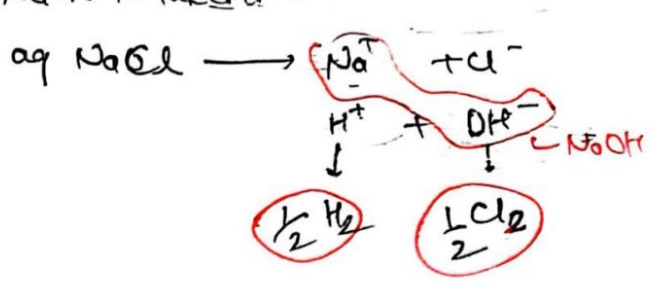
→ Electrolysis done.

→ For highly reactive metals (s-block & Al).

→ Fused / molten salt electrolysis.



If aq. NaCl is taken:-



Q. Na obtained by electrolysis of:-
(a) Fused NaCl (b) aq. NaCl (c) Brine solution (d) All

aq. NaCl → $NaOH + \frac{1}{2}H_2 + \frac{1}{2}Cl_2$

→ S' block metal obtained by electrolysis of fused / molten salt. If aq. is used than instead of metal, H_2 gas evolved because discharge potential of H^+ is less.

- Aq. NaCl $\xrightarrow{\text{electrolysis}}$ $H_2 + Cl_2 + NaOH$

Q. Ca obtained by:-
(a) Heating lime stone $CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$.
(b) electrolysis of aq. $CaCl_2$ → H_2 gas evolve
(c) electrolysis of Fused $CaCl_2$ → $Ca^{+2} + 2Cl^-$ (Ca^{+2} → Ca, Cl^- → Cl_2)
(d) Heating lime with coke.

$PbO \xrightarrow[\Delta]{C} Pb + CO$.

$CaO \xrightarrow[\Delta]{C} [Ca + CO]$ ✗

$CaO \xrightarrow[\Delta]{3C} CaC_2 + CO$ ✓ (CaC_2: calcium carbide)

Steps in Metallurgy

Ore → Metal.

① Crushing ② Concentration of ore:- Removal of impurities

③ Calcination / Roasting:- Carbone, Hydrate & Sulphide.
↳ metal oxide obtained.

④ Reduction:- $MO \xrightarrow{Red^n} M^{\oplus}$ (impure) $+ R.A.$

⑤ Purification:- M (impure) → M (pure)

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e.g. $PbCO_3$ (ore) $\xrightarrow{\text{Concentr.}}$ $PbCO_3$ $\xrightarrow[\text{calcination}]{\Delta}$ $PbO + CO_2$

$PbO \xrightarrow{C \text{ redn}}$ $Pb + CO$ (impure)

Pb (pure) $\xleftarrow{\text{liquifier purifier}}$ $Pb + CO$ (impure)

e → PbS (galena) $\xrightarrow{\text{Concent}}$ PbS $\xrightarrow[\text{Roasting}]{O_2 / \Delta}$ $PbO + SO_2$

$PbO \xrightarrow{\Delta \text{ Cr redn}}$ $Pb + CO_2$ (impure)

Pb (pure) $\xleftarrow{\text{purification}}$ $Pb + CO_2$ (impure)

② Concentration → also called dressing of ore / Benification of ore.

→ Removal of impurity.

→ done by 2 methods

- physical
  - Gravity sepr. method.
- chemical (Leaching)

(i) Gravity separation method / Lavigation / Hydrualic washing

→ Metallic ore and gangue have density difference.

Metallic ore → heavy; gangue → light.

(ii) Magnetic separation

Either ore or impurity is magnetic in nature.

e.g. SnO_2 (Tin stone / casetterite) ore या wolframite (magnetic)

SnO_2 → Non magnetic ore.

wolframite → impurity

$FeWO_4 + MnWO_4$ → ore of Tungsten

→ Fe_3O_4 (magnetic) + Impurities (non-magnetic) → Fe_2O_3 (magnet.) + impurities (non-mag.)

→ Chromite ore

$FeO.Cr_2O_3$ or $FeCr_2O_4$ → magnetic

+ Silica impurite → non-magnetic

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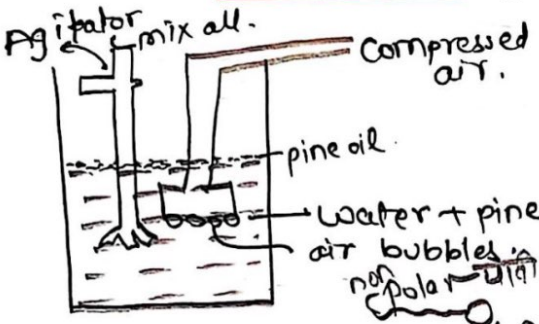
→ MnO_2 (pyrolusite) + impurities
Magnetic — non-magnetic

→ TiO_2 (Rutile) + chlorapetite
magnetic — $3Ca_3(PO_4)_2 \cdot CaCl_2$: non magnetic

(iii) Froth Flotation process

→ Mainly for sulphide ores except Ag_2S (Argentite).
By cyanide process. Chemical sepration.

→ Based on difference in wetting property of ore & impurity.
ore is wetted by pine oil.
impurities are wetted by water.



water + pine oil + ore + sod. ethyl xanthate
collecter को काम गर्छ
$C_2H_5-O-C(=S)-S^-Na^+$
non-polar — polar

non polar — पानी बाहिर
polar — पानी भित्र
oil.

Stabilizer → aniline & cresol.
air bubble बिच मैं नफुटेस ...

→ Based on adsorbtion process.

→ frother | foaming agent → pine oil | Fatty acid.

→ collecter → sod. ethyl xanthate.

• PbS + ZnS (impurity) (NaCN is used as depressent).
ore

no rxn

$PbS + ZnS + NaCN \longrightarrow PbS\uparrow + ZnS$
गाथि जोड़

$Na_2[Zn(CN)_4]$ — soluble.

$CuSO_4$ activator

$ZnS\uparrow + [Cu(CN)_4]^{-3}$

Chemical separation (Leaching)

→ Done for Ag, Au and Al.
└ cyanide process.

- ore + chemical substance → water soluble compound
  +
  impurity → remain insoluble

① Cyanide process | Mac-Arthur Forest process

Step:- (i) complex formation
(ii) metal displacement

$Ag_2S \xrightarrow[O_2]{2NaCN} Na^+[Ag(CN)_2]^- + Na_2S$

Argentite — make the rxn irreversible — sod. argento cyanide — sp — linear — $+O_2$ → Na_2SO_4

or

$AgCl \xrightarrow{2NaCN} Na[Ag(CN)_2]^- + NaCl$

Horn silver

$\downarrow$ Zn (reducing agent)

$Ag + Na_2[Zn(CN)_4]$ — sp^3

Note:- Zn is used during extraction of Ag & Au from cyano complex. not copper because Zn is more electropositive & cheap also.

→ ~~Ag & Au~~ If gold is taken:-
└ $Na[Au(CN)_2]$
sod. aurocyanide.

- Ag & Au treated with aq. NaCN solution in presence of O_2 & then metal displacement.

② Bauxite ore ($Al_2O_3 . 2H_2O$)

- Red Bauxite → Fe_2O_3 (impurity)
- white Bauxite → Silica (SiO_2) (impurity)

→ concentration by following ways:-

(a) Baeyer process $\xrightarrow{NaOH}$
(b) Hall process $\xrightarrow{Na_2CO_3}$
} Red Bauxite

(c) Serpeck process $\xrightarrow[coke]{C+N_2}$ } white Bauxite

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(a) Baeyer process

$Al_2O_3.2H_2O$ (amphoteric ore) + Fe_2O_3 impurity (base) + $NaOH$ (base) + H_2O $\longrightarrow$ $Na[Al(OH)_4]$ or $NaAlO_2$ (Soluble)

Sod. meta aluminate

$\downarrow CO_2$

$Al_2O_3 . xH_2O + NaHCO_3$ (Sod. bi carbonate)

$\downarrow \Delta$

Al_2O_3

$Al(OH)_3$ or Al_2O_3 $\xrightarrow{NaOH\ (base)}$ $Na[Al(OH)_4]$ or $NaAlO_2$ (Sod. meta aluminate)

→ $Al(OH)_3$ ppt. soluble in $NaOH$ due to formation of soluble comple meta aluminate (AlO_2^-).

(b) Hall process

$Al_2O_3.2H_2O$ ore + Fe_2O_3 impurity $\xrightarrow{Na_2CO_3}$ $Na[Al(OH)_4]$ or $NaAlO_2$ (Soluble)

$\downarrow CO_2$

$Al_2O_3.xH_2O + NaHCO_3$

$\downarrow \Delta$

Al_2O_3.

(c) Serpeck process

Bauxite ore treated with coke + N_2.

$Al_2O_3.2H_2O$ ore + SiO_2 impurity + C (good Red. agent.) + N_2 $\longrightarrow$ $AlN + 3CO$

$\downarrow H_2O$

$Al(OH)_3 + NH_3$ (useful.)

$\downarrow \Delta$

Al_2O_3.

→ Useful biproduct of serpeck process is NH_3.

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③ Calcination and roasting

conc ore $\xrightarrow{\Delta}$ MO

Hydrated carbonate $\xrightarrow[\text{calcination}]{\Delta}$ MO

sulphide $\xrightarrow[\text{Roasting}]{\Delta}$ MO

#Calcination: - process of heating of ore at high temperature but below i m.pt in absence of air or limited supply of air.

e.g. For carbonate ore and hydrated ore

① $CaCO_3 \xrightarrow{\Delta} CaO + CO_2\uparrow$

$MgCO_3 \xrightarrow{\Delta} MgO + CO_2\uparrow$

$PbCO_3 \xrightarrow{\Delta} PbO + CO_2\uparrow$

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

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

$CuCO_3.Cu(OH)_2 \xrightarrow{\Delta} 2CuO + CO_2\uparrow + H_2O\uparrow$

malachite green

 # Roasting: - mainly sulphide ores heated in presence of O_2.

MS (metal sulphide.) $\xrightarrow{\Delta, O_2}$ MO + SO_2 (metal oxide.)

MS $\xrightarrow[\Delta]{O_2}$ $MSO_4 \xrightarrow{\Delta} MO + SO_2 + \frac{1}{2}O_2$

e.g. $2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2$

$PbCO_3 \xrightarrow{\Delta} PbO + CO_2$] - calcination

$PbS \xrightarrow[O_2]{\Delta} PbO + SO_2$

galena

$Cu_2S \xrightarrow[\Delta]{O_2} Cu_2O + SO_2$

Cop. glance

$As_2S_3 \xrightarrow[O_2]{\Delta} As_2O_3 + SO_2$

$Sb_2S_3 \xrightarrow{\Delta} Sb_2O_3 + SO$

→ During roasting of copper pyrite

$2CuFeS_2 \xrightarrow[O_2]{\Delta} Cu_2S + 2FeS + SO_2$ (partial roasting)

Copper pyrite

$Cu_2S \xrightarrow{O_2} Cu_2O$

$2FeS \xrightarrow{O_2} FeO$

* HgS (Hg: +2) cinnabar

$HgS \xrightarrow[\Delta]{O_2} HgO + SO_2$ (unstable)] no rxn.

$HgS \xrightarrow[\Delta]{O_2} 2Hg^{0} + SO_2$ ← reduction

• $Ag_2S \xrightarrow[\Delta]{O_2} Ag_2O + SO_2$ (unstable)] no rxn.

$Ag_2S \xrightarrow[\Delta]{O_2} 2Ag + SO_2$] redn.

Ag_2O, Au_2O, $Hg_2O \xrightarrow{\Delta} M + SO_2$

Q. During roasting, metal sulphide convert into MO. But which sulphide ore on roasting in ^nce of O_2 give metal.

(a) Galena PbS (b) copper glance Cu_2S (c) Zinc blende ZnS. (d) ~~Cinnabar~~ HgS.

• Advantage of Roasting

(1) Sulphide ore convert into oxide.

(2) P, S, As, Sb impurity remove in form of volatile oxide.

(3) $S_8 + O_2 \xrightarrow{\Delta} SO_2\uparrow$

$P_4 + O_2 \xrightarrow{\Delta} P_4O_6\uparrow$

$As_4 + O_2 \xrightarrow{\Delta} As_4O_6\uparrow$

$Sb_4 + O_2 \xrightarrow{\Delta} Sb_4O_6\uparrow$ } volatile.

Reduction:-

$MO + \underset{\text{agent}}{\text{Reducing}} \xrightarrow{\Delta} M + \underset{\text{agent}}{\text{Reducing oxide}}$

$MO + C \xrightarrow{\Delta} M + CO$

$MO + CO \xrightarrow{\Delta} M + CO_2$

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① Reduction by carbon / coke [Smelting]

→ done for less electropositive metal oxide.

(Pb, Zn, Sn, Fe, Cu, Ni) heated with coke in +nce of Flux ← impurity हटाउन

$$\underset{\text{impurities}}{MO} + \underset{\text{R.A}}{C} + \text{flux} \xrightarrow{\Delta} \underset{\text{impure}}{M} + CO + \underset{\text{[Impurity + Flux]}}{\text{slag}}$$

$$MO + \underset{\text{reduc agent}}{C} \xrightarrow[\text{high temp}]{\Delta} M + CO$$

$$MO + \underset{\text{reduc agent}}{CO} \xrightarrow[\text{low temp}]{\Delta} M + CO_2$$

$$ZnO + C \xrightarrow[\text{high temp}]{\Delta} Zn + CO$$

$$ZnO + CO \xrightarrow[\text{low temp}]{\Delta} Zn + CO_2$$

Q. What happens when haematite ore heated with coke.

$$Fe_2O_3 + \underset{\text{R.A.}}{3C} \xrightarrow{\text{high T}} 2Fe + 3CO$$

$$Fe_2O_3 + \underset{\text{R.A.}}{3CO} \xrightarrow{\text{Low temp}} 2Fe + CO_2$$

- During reduction of haematite ore in blast furnace : Reducing agent is CO.
- 'S' block + Al (oxid) not reduced by C because it will form metal carbide at high tempr.

$$\underset{\text{S block}}{CaO} + C \xrightarrow[\text{high tempr}]{\Delta} \underset{\text{Calcium carbide}}{CaC_2} + CO.$$

$$MgO + C \xrightarrow[\text{high temp}]{\Delta} Mg_2C_3 + CO.$$

$$Al_2O_3 + C \xrightarrow{\text{"}} Al_2C_3 + CO.$$

V.V.I

Q. An ore after levigation (gravity sep.) is found to have oxidic impurities. Which of the following can be used as flux (basic flux) during smelting operation?

(a) H_2SO_4 (b) $CaCO_3$ (c) SiO_2 (d) Both (a) & (b)

$CaCO_3$ → basic flux

Q. Froth flotation process is based on:-

(a) wetting properties of ore particles (wetted by pine oil)

(b) Specific gravity of ore particles

(c) None

Q. Gold is extracted by hydro-metallurgical process, based on its property

(a) of being electro+ve (b) of being less reactive

(c) to form complex which are water soluble

(d) to form salt which are water soluble

Q. Cassiterite (SnO_2) ore is concentrated by:-

(a) levigation (b) Electromagnetic separation

(c) Flotation method (d) liquefication

Q. Which one of the following ore is not concentrated by froth flotation?

(a) copper pyrites (b) Argentite (Ag_2S) (c) Pyrolusite (MnO_2) (d) Zinc blende

(c) → 1st prior.

Q. Hydrometallurgy is used for the following metals:-

(a) Zn & Ag (b) Ag & Cu (pyro, hydro; Au also) (c) Zn & Hg (d) Hg & Cu.

Q. Which of the following is obtained by Hydrometallurgy?

(a) Cu (b) Ag (c) Au (d) All

(b), (c), (d) → cyanide process / leaching

Q. $Ag_2S + NaCN \xrightarrow{O_2} A$, $Na[Ag(CN)_2]$

$A + Zn \rightarrow B$, B is metal. Hence A & B are:-

(a) $Na_2[Zn(CN)_4]$, Zn (b) $Na_4[Ag(CN)_4]$, Ag

(c) $Na[Ag(CN)_2]$, Ag (d) $Na_3[Ag(CN)_4]$, Ag

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Q. Which of the following concentration is best by froth flotation :-

(a) Galena → PbS (b) Cassiterite → SnO_2 (c) Magnetite → Fe_3O_4 (d) Malachite → $CuCO_3 \cdot Cu(OH)_2$

Q. Extraction of silver from its ore involving NaCN, air & an active metal is known as :-

(a) Mond's method (b) Amalgamation method

(c) Mac Arthur-forest method (d) Van Arkel

Q.

→ MnO_2, Cr_2O_3 } for this reduction, very high temp is required. So, reduction by Al is done.

* During smelting of copper pyrites.

roasted copper ore
Cu_2S, FeS, Cu_2O, FeO $\xrightarrow[C,\ \Delta]{O_2}$ copper matte ($Cu_2S + FeS$)

C → act as fuel. not as R.A.

② Reduction by Al / Thermite process :-

→ Al is used as reducing agent.

→ $MO + Al \xrightarrow{\Delta} \underset{\text{impure}}{M} + Al_2O_3$

$Cr_2O_3 + Al \xrightarrow{\Delta} 2Cr + Al_2O_3$

$MnO_2 + Al \xrightarrow{\Delta} Mn + Al_2O_3$

$Fe_2O_3 + Al \xrightarrow{\Delta} 2Fe + Al_2O_3$

$Al_2O_3 + Cr \longrightarrow Al + Cr_2O_3$ → not thermite rxn.

← Thermite rxn.

③ Auto reduction / self reduction

for Cu, Pb, Hg

→ No external reducing agent required.

→ Roasted ore + unroasted ore $\xrightarrow{\Delta}$ metal + SO_2

$MS \xrightarrow[\Delta]{O_2} MO + SO_2$ (X)

$MO + MS \xrightarrow{\Delta} M + SO_2$

MO → roasted, MS → unroasted

e.g. $PbS + PbO \xrightarrow{\Delta} Pb + SO_2$

PbS → unroasted, PbO → roasted

Galena (PbS)

Galena ore PbS $\xrightarrow{\text{concentration (froth floation)}}$ PbS (concentrated ore) $\xrightarrow[O_2, \Delta]{\text{roasting}}$ $PbO + SO_2$

$PbO \xrightarrow[C, \Delta]{\text{carbon redn}} Pb + CO$ (impure)

$PbO \xrightarrow[PbS, \Delta]{\text{self redn}} Pb + SO_2$ (impure)

Both impure Pb → Purification → Pb (pure metal)

* Bassemerization → self redn process

During extraction of copper from copper pyrite ($CuFeS_2$).

Copper matte

$Cu_2S + FeS \xrightarrow[\text{Sand}/\Delta]{O_2} Cu + SO_2\uparrow$

Cu → Blister copper

$Cu_2S + FeS \xrightarrow[\Delta]{O_2, \text{sand}} Cu + SO_2\uparrow$

sand act as flux.

④ Reduction by metal displacement

aq. $CuSO_4 \xrightarrow{Fe} Cu + FeSO_4$.

$TiCl_4 \xrightarrow{Mg} Ti + MgCl_2$ → Kroll process

$K[Ag(CN)_2] \xrightarrow{Zn} Ag + K_2[Zn(CN)_4]$

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⑤ Reduction by H_2 :- generally not use because metal hydride form at high temp.

$$MO + H_2 \xrightarrow{\Delta} M + H_2O.$$

⑥ Electrolytic reduction

- for highly electro +ve metal.
- 's' block + Al.
- fused salt electrolysis along with substance
  - ↓s M.Pt
  - ↑es conductivity.

• Down cell process:-

Fused NaCl $\longrightarrow$ $Na^+ + Cl^-$

$Na^+ \downarrow e^-$; $Cl^- \downarrow -e^-$

Na ; $\frac{1}{2} Cl_2$

↳ बनेको Na vaporize हुन्छ.

↳ so, $CaCl_2$ + KF use गरिन्छ

↳ ↓es Mpt & ↑es conductivity

• Hall Heroult electrolytic redn

- Al को लागि गरिन्छ from Al_2O_3.
- fusion temp of Al_2O_3 is very high (2050°C) i.e greater than B.pt of Al (1050°C).

$$Al_2O_3 \longrightarrow Al^{+3} + 3O^{-2}$$

$Al^{+3} \downarrow$ Al

+

Cryolite Na_3AlF_6

Fluorspar CaF_2

↳ Neutral.

↳ vaporize हुन्छ

↓es Mpt & ↑es conductivity

So, use हुन्छ.

Purification / Refining of metal

M (impure) ⟶ M (pure)

- Removal of impurity from metal. [from ore → concentration].
- On the basis of difference in property of metal & impurity.

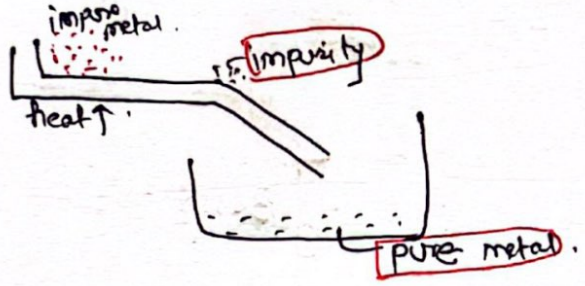
Methods

1. physical
2. chemical
3. Electro refining
4. thermal decomposition (vapor phase refining)

(1) Physical

A. Liquation: metal having low melting point and impurity having high melting point.

→ for Sn, Pb, Bi.



B. Distillation:- Metal having low Boiling point.
└volatile metal: (Zn, Cd, Hg).

- impure metal

Zn + Fe
(Zn: low Bpt; Fe: impurity high Bpt)

He, Ne, Ar, Kr, Xe — inert gas separated by distillation due to difference in B.pt.

C. Zone refining:-

→ very high pure metal.
→ semi conductor. refine शोधित
eg, Si, Ge

→ impurity are more soluble in molten zone than metal.

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② Chemical method

Ⓐ Cupellation :- for Ag, & Au. refine गरिन्छ।

→ Impurity has more affinity with oxygen as compared to metal & remove in form of volatile oxide.

- Lead impurity present in Ag is remove in form of PbO ← volatile

impure Ag ↓ Pb impurity] $\xrightarrow[O_2]{\Delta}$ PbO↑ + Ag
PbO ↑ → volatile. Ag ← pure metal.

Ⓑ Poling :- Metal has their own oxide as impurity.

↳ Cu & Pb. को लागि.

→ impure molten metal heated with pole of green wood & hydrocarbon gas reduces impurity.

impure Cu.

$Cu + \boxed{Cu_2O} \xrightarrow[\text{green wood बालदा}]{CH_4} 4Cu + 2CO + H_2$

Copper matte

$Cu_2S + FeS \xrightarrow[\text{sand} \to \boxed{SiO_2}]{O_2 +} Cu + SO_2$ (Cu ← blister copper)] Bassemerization

Cu ↓ poling

Cu (Tough pitch copper) → electrorefining → very pure Cu.

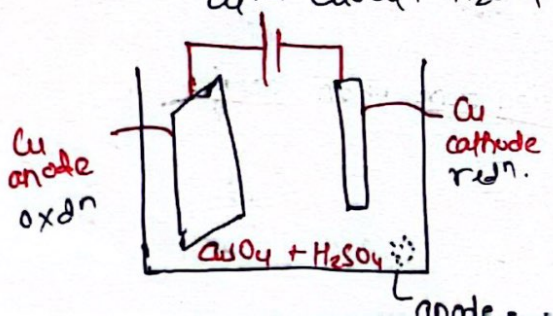
3. Electrorefining

for Zn, Cu, Ag, Au, Pb, Sn, Ni, Al - -

- impure anode → Thick plate
- pure cathode → thin plate

electrolyte :- metal salt + acid.

$Cu \rightarrow CuSO_4 + H_2SO_4$



anode ... Ag Au Pt.

- Pure metal gets deposited on cathode and impurity settled down as anode mud.
  - Ag, Au, Pt.

$Cu \rightarrow CuSO_4 + H_2SO_4$ (conductivity बढ़ाने)

$Ag \rightarrow AgNO_3 + HNO_3$

[$Al \rightarrow Na_3AlF_6 + CaF_2$] → Hoope process.

④ Thermal Decomposition / Vapor phase refining

Impure metal $\xrightarrow[\Delta]{\text{substance}}$ compound (unstable) $\xrightarrow{\Delta}$ metal (pure)

A. Van-Arkel process:-

- High purity of metal.
- For Ti, Zr, Hf.
- During this process, compound बनते i.e. metal iodide.

$$Ti_{\text{impure}} \xrightarrow[\Delta]{I_2} \underset{\text{unstable}}{TiI_4} \xrightarrow{\Delta} Ti_{\text{pure}} + 2I_2$$

B. Mond's process

- purification of Nickel.
- Metal carbonyl – compound बनते.

$$Ni_{\text{impure}} \xrightarrow[\Delta]{CO} \underset{\text{unstable}}{Ni(CO)_4} \xrightarrow{\Delta} Ni_{\text{pure}} + 4CO$$