

METALLURGY

01
CONCENTRATION

LEVIGATION
Hydraulic washing/Gravity separation
Cassiterite (tin stone - SnO_2)

05
OXIDATION

CALCINATION
Heating in absence of air
Hydroxides, Carbonates, Hydrates are calcined
 $\text{ZnCO}_3 \rightarrow \text{ZnO} + \text{CO}_2$
 $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O} \rightarrow \text{Al}_2\text{O}_3 + 2\text{H}_2\text{O}$

9
REFINING

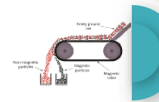
DISTILLATION
For low boiling metals
Zn, Cd & Hg

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REFINING

VAPOUR PHASE REFINING
For Zr, Ni, Ti & Th
Mond process
 $\text{Ni} + 4\text{CO} \xrightarrow{300-350^\circ\text{C}} \text{Ni}(\text{CO})_4$
 $\text{Ni}(\text{CO})_4 \xrightarrow{450-500^\circ\text{C}} \text{Ni} + 4\text{CO}$
van Arkel method
 $\text{Zr} + 2\text{I}_2 \xrightarrow{270^\circ\text{C}} \text{ZrI}_4$
 $\text{ZrI}_4 \xrightarrow{1800^\circ\text{C}} \text{Zr} + 2\text{I}_2$

02
CONCENTRATION

MAGNETIC SEPARATION
Cassiterite
Pyrolusite (MnO_2)
Chromite ($\text{FeO} \cdot \text{Cr}_2\text{O}_3$)
Magnetite (Fe_3O_4)



06
OXIDATION

ROASTING
Heating in presence of air
Sulphides ores are roasted
 $2\text{ZnS} + 3\text{O}_2 \rightarrow 2\text{ZnO} + 2\text{SO}_2$
 $2\text{PbS} + 3\text{O}_2 \rightarrow 2\text{PbO} + 2\text{SO}_2$

10
REFINING

LIQUATION
For low melting metals
Sn, Pb & Bi

14
REFINING

CHROMATOGRAPHY
Based on adsorption
 Al_2O_3 is the adsorbent in column chromatography

03
CONCENTRATION

FROTH FLOTATION METHOD
Concentration of sulphide ore
Frothers - Pine oil, Eucalyptus oil
Collectors - Pine oil, Xanthates
Stabilisers - Cresol, Aniline

07
REDUCTION

SMELTING
Heating before with coke or CO in presence of flux
Done in Blast furnace
Flux + Gangue \rightarrow Slag
 SiO_2 FeO/CaO/MgO
FeO $\text{SiO}_2/\text{P}_2\text{O}_5$

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REFINING

ELECTROLYTIC REFINING
Anode : Impure metal
Cathode : Pure metal
Electrolyte : Metal salt solution
Cu, Sn, Pb, Zn, Mn, Cr, Ni, Ag & Au
Au, Ag, Pt, etc are obtained from anode mud of Cu

04 extraction of iron

FE

Ore - Fe_2O_3
Concentration: Froth Flotation
Extraction is done in blast furnace
Raw Materials: Ore + lime stone + coke
Pig Iron (4% Carbon)
Cast Iron (3% Carbon)
Steel (0.2 - 2% Carbon)
Wrought Iron (0.2% Carbon)
Alloys
Stainless Steel (Fe + Cr + Ni + C)

1. Combustion Zone
 $\text{C} + \text{O}_2 \rightarrow \text{CO}_2 + \text{Heat}$
2. Fusion Zone
 $\text{CO}_2 + \text{C} \rightarrow 2\text{CO} + \text{Heat}$
3. Slag Formation Zone
 $\text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2$
 $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$
4. Reduction Zone
 $\text{Fe}_2\text{O}_3 + \text{CO} \rightarrow 2\text{FeO} + \text{CO}_2$
 $\text{Fe} + \text{CO} \rightarrow \text{Fe} + \text{CO}_2$

04
CONCENTRATION

LEACHING
Based on solubility in solvents
Bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$) - Bayer's process (NaOH is leaching agent)
Silver & Gold ores (NaCN/KCN - leaching agent)

08
REDUCTION

ELECTROLYTIC REDUCTION
Oxides of highly reactive metals
Alkali metals
Alkaline earth metals
Aluminium

12
REFINING

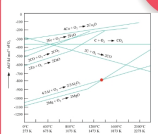
ZONE REFINING
To prepare semi-conductors & metals of high purity
Si, Ge, Ga, B & In

HOTS

Bauxite - $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
Cryolite - Na_3AlF_6
Kaolinite (a form of clay) - $[\text{Al}_2(\text{OH})_4\text{Si}_2\text{O}_7]$
Haemattite - Fe_2O_3
Magnetite - Fe_3O_4
Siderite - FeCO_3
Iron pyrites - FeS_2
Copper pyrites - CuFeS_2
Malachite - $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$
Cuprite - Cu_2O
Copper glance - Cu_2S
Zinc blende or Sphalerite - ZnS
Calamine - ZnCO_3
Zincite - ZnO

ore

HOTS



Element represented by lower line can reduce compound represented by upper line

ellingham diagram

ZN

Ore - ZnS
Concentration : Gravity separation
Froth flotation method

$\text{ZnS} \xrightarrow{\text{Roasting}} \text{ZnO} \xrightarrow[\text{ZnO}]{\text{Product}} \text{ZnO} + \text{C} \rightarrow \text{Zn} + \text{CO}$

Refining : Distillation

Alloys : Brass (Cu+Zn)
German silver (Ni+Cu+Zn)

01
extraction of zinc

Q. Which one is malachite from the following?
(a) $\text{Cu}(\text{OH})_2$ (b) Fe_2O_3
(c) $\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$ (d) CuFeS_2

Q. Considering Ellingham diagram, which of the following metals can be used to reduce alumina?
(a) Mg (b) Zn (c) Fe (d) Cu

Q. Extraction of gold and silver involves leaching with CN^- ion. Silver is later recovered by
(a) Liqutation (b) Distillation
(c) zone refining (d) displacement with Zn

CU

Ore - CuFeS_2
Concentration : Froth flotation method

$\text{CuFeS}_2 \xrightarrow{\text{Roasting}} \text{Cu}_2\text{S} + \text{FeS} \xrightarrow[\text{FeS}]{\text{Reduction}} \text{Cu} \xrightarrow[\text{Cu}]{\text{Impure}} \text{Cu}$

Refining : Electrolysis
Alloys : Constantan (Ni+Cu)
Monel metal (Ni+Cu+Fe)
Bell metal (Cu+Sn)
Bronze (Cu+Sn)

02
extraction of copper

Q. Which can be used to obtain highly pure metal which is liquid at room temperature?
(a) Electrolysis (b) Chromatography
(c) Distillation (d) Zone refining

AL

Ore - $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$
Concentration : Leaching (Bayer's)

$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O} \xrightarrow{\text{Calcination}} \text{Al}_2\text{O}_3 \xrightarrow[\text{Al}_2\text{O}_3]{\text{Hall Heroult Electrolysis}} \text{Al}$

Electrolyte : $\text{Al}_2\text{O}_3 + \text{Na}_3\text{AlF}_6 + \text{CaF}_2$
Anode : Graphite rod
Cathode : Carbon lining
Alloys: Aluminium bronze (Al+Cu)
Duralumin (Al+Cu+Mg+Mn)
Alnico (Al+Ni+Co+Fe)

03
extraction of aluminium

Q. The maximum temperature that can be achieved in blast furnace is
(a) Upto 1200 K (b) Upto 2200 K
(c) Upto 1900 K (d) Upto 5000 K