1.52 Final

End-Result

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Complete Chemistry Mega Revision Timetable

13 Life Changing 10k–10000

1 March	Coordination Compounds
3,4 March	Chemical Bonding
5 March	p–block (Class 12)
6 March	p–block (class 11) + Periodic Table
8 March	Metallurgy
10 March	s-block + Hydrogen
12 March	d & f-block
13 March	Surprise Gift

Complete Chemistry Mega Revision PYQs & Quiz Timetable

Less Percentile → Theory

2 March	4 March	5 March	7 March
Coordination Compounds	Chemical Bonding	p–block (Class 12)	p–block (class 11) and Periodic Table
PYQs	PYQs	PYQs	PYQs
Quiz	**Quiz**	**Quiz**	**Quiz**

11 March	12 March	13 March
Metallurgy	s-block + Hydrogen	d & f-block
PYQs	PYQs	PYQs
Quiz	**Quiz**	**Quiz**

I Love Chemistry


Samjho, dekho & yaad karo

Refining of Metals

Poling Process

Process
↓
Metal

This process is used for the purification of copper and tin.

(A) Purification of Impure Copper

Impure copper is remelted in a reverberatory furnace lined with SiO_2 and a blast of O_2 is blown into the furnace.

Fe is oxidised to FeO which forms a slag of $FeSiO_3$ with SiO_2 lining of the furnace. → density CuO ↓

Molten copper left behind contains CuO as impurity.

O_2 oxidises S, Sb and As to their respective oxides which, being, volatile, get volatilised and are thus removed.

Purification

This molten copper is treated with powdered anthracite and then stirred with a pole of green wood.

Reducing

Hydrocarbon

Green wood, at high temperature, liberates hydrocarbon gases, which are converted into methane (CH_4).

Reducing Agent

Green wood ⟶ Hydrocarbons ⟶ CH_4

$4CuO + CH_4 \longrightarrow 4Cu$ (pure metal) $+ CO_2 + 2H_2O$


$FeSiO_3$

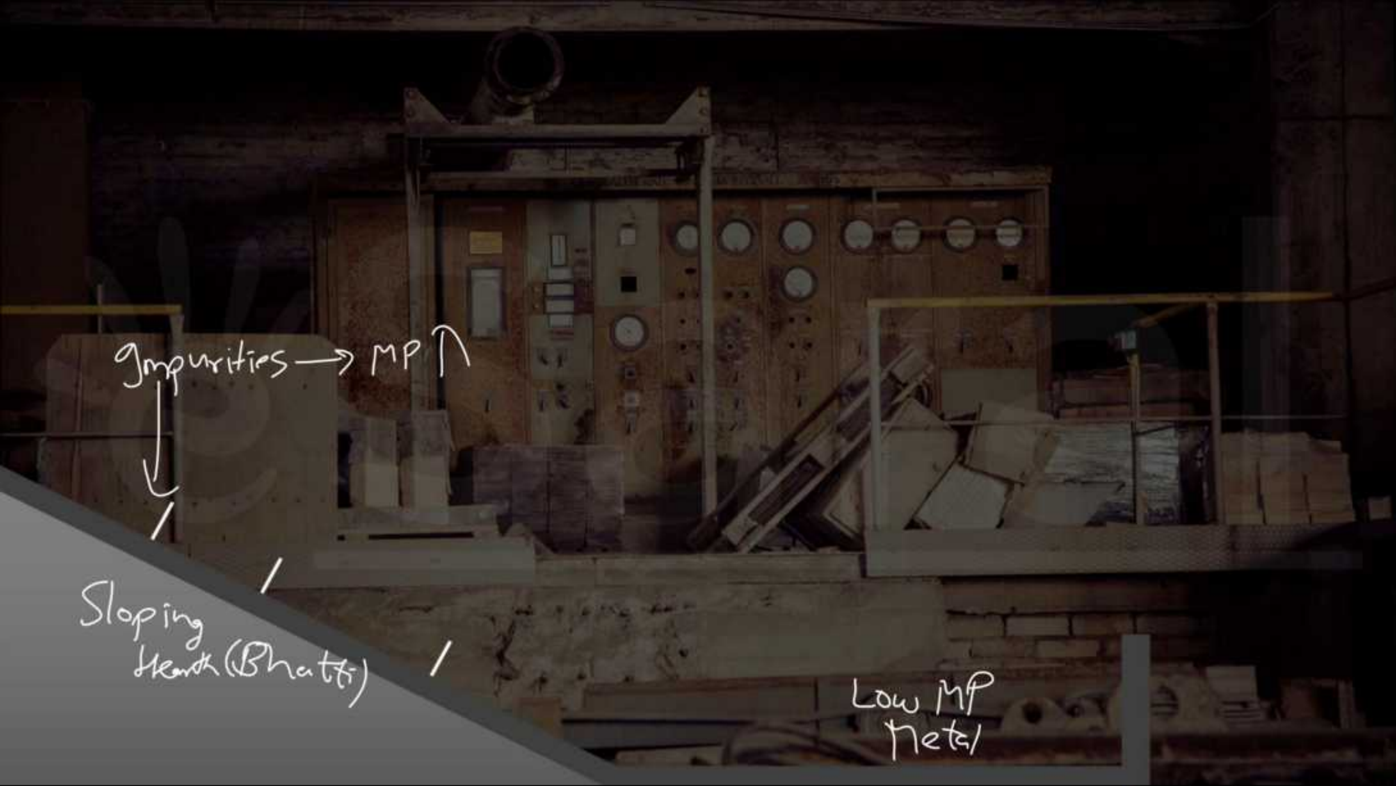
ii) Liquation

This method is used for the refining of metals having low melting point and are associated with high melting impurities.

Ex. Pb, Sn, Sb, Bi and Hg.

The impure metal is heated on the sloping hearth of a furnace.

The pure metal flows down leaving behind the non-fusible material on the hearth.


Impurities → MP ↑
Sloping Hearth (Bhatti)
Low MP Metal

iii) Distillation

Metals having low boiling point are refined by this method, for example, zinc, cadmium and mercury.

Purification of impure zinc

800°C 760°C

1000°C Zn

Impure zinc (B.P. ~ 920°C) contain impurities of cadmium (B.P. ~ 767°C), iron and platinum (B.P. > 1500°C).

iv) Vapour Phase Refining

Employed to get metal in very pure form of small quantities.

a) Van-Arkel Process

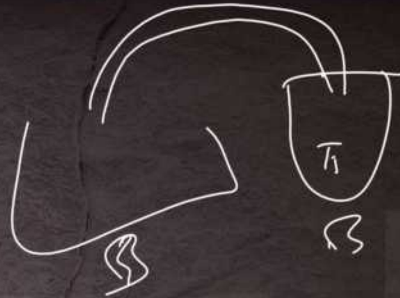
In this method, the metal is converted into a volatile unstable compound (e.g.iodide), and impurities are not affected during compound formation.

$$Ti(s) + 2I_2(g) \xrightarrow{523\ K} TiI_4(g)\uparrow$$

Impure

(i) Volatile in nature

(ii) Relatively thermally unstable



$$TiI_4(g) \xrightarrow{1700\ K} Ti(s) + 2I_2(g)$$

(b) Mond's process

Nickel is purified by using CO gas. This involves the formation of nickel tetracarbonyl.

$$Ni_{(Impure)} + 4CO \xrightarrow{\Delta} [Ni(CO)_4] \xrightarrow{\Delta} Ni_{(pure)} + 4CO$$

Complex

(i) Volatile in nature

(ii) Relatively thermally unstable

Van-Arkel Ti
Mond Ni
Learn

Which of the following ref proc incl complex formation

v) Zone Refining or Fractional Crystallisation

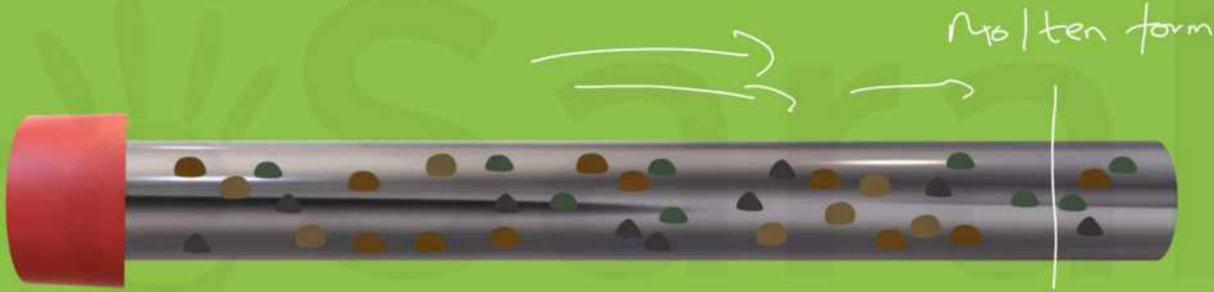
Metals of very high purity are obtained by Zone Refining.

This refining method is based on the fact that impurities tend to remain dissolved in molten state (Phase rule).

Ge, Si and Ga used as semiconductors are refined in this manner.

Semiconductors
↓
purify ?
↓
Zone Refining
This is all we can do


Impurity
Gangue
Melt


Molten form

Cupellation (removal of Lead from Silver or Gold)

In this process the molten impure metal is heated in a cupel, which is boat-shaped dish made of bone ash or cement, and a blast of air is passed over the molten metal.

The impurities are oxidized and the volatile oxides thus produced escape with the blast of air.

The pure metal remains behind in the cupel.

Pb present in Silver or Gold is removed by Cupellation process.

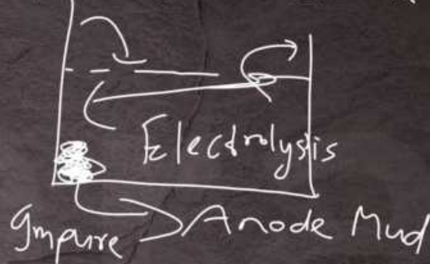
$$2\,Pb(g) + O_2 \longrightarrow 2\,PbO(g)$$

vii) Amalgamation Process

For noble metal Au, Ag from the native ore.

Ore powder + Hg $\xrightarrow{\text{Distilled}}$ Amalgam $\xrightarrow[920°C]{\Delta}$ Hg (vapour) + Metal (s)

Electro-refining of Metals



Metals such as Cu, Ag, Zn, Sn, Pb, Al, Ni, Au are refined by this method.

The impure metal is made the anode of a electrolytic cell, while cathode is thin plate of pure metal.

On passing the electric current, pure metal from the anode dissolves and gets deposited at the cathode.

The soluble impurities go into the solution while insoluble or less electropositive impurities settle down below the anode as anode mud or sludge.

The anode mud might contain Au and Ag so care must be taken before throwing off the impurities.

The concentration of electrolyte remains same throughout the process.

Electrorefining of Cu

→ Electrolyte

→ Metal Salt

Anode	Impure copper
Cathode	Pure copper
Electrolyte	An aqueous solution of $CuSO_4$ + 5% dil H_2SO_4

Electrorefining of Pb (Bett's process)

Anode	Impure Lead
Cathode	Pure Lead
Electrolyte	A mixture of $PbSiF_6$ and H_2SiF_6

Thermodynamics of Reduction Processes (Ellingham Diagram)

ΔG must be -ve

For a spontaneous reaction, the free energy change ΔG must be negative.

$$\Delta G = \Delta H - T\Delta S$$

C

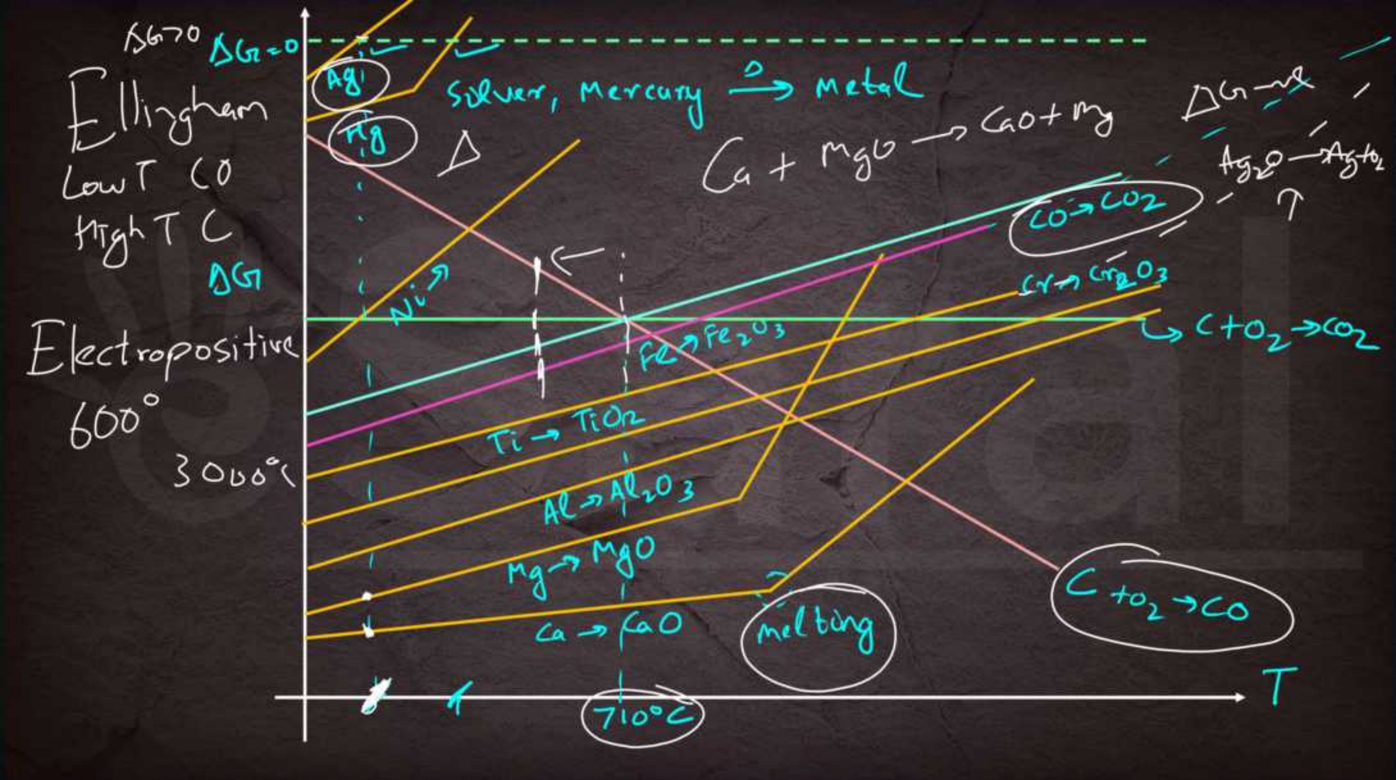
CO

Al

Mg

① Money

② ThermoD



Ellingham
Low T CO
High T C
ΔG
Electropositive
600°
3000°C
ΔG>0
ΔG=0
Ag
Hg
Silver, Mercury → Metal
Ca + MgO → CaO + Mg
Ag2O → Ag + O2
CO → CO2
Cr → Cr2O3
C + O2 → CO2
Fe → Fe2O3
Ni
Ti → TiO2
Al → Al2O3
Mg → MgO
Ca → CaO
melting
C + O2 → CO
710°C
T

(a) In the graph for metal oxide all slope upwards, because the free energy change increases with an increase of temperature

(b) All the free energy changes follow a straight line unless the materials melt or vaporize, when there is a large change in entropy associated with the change of state, which changes the slope of the line

1. CO good RA at low T
2. C " " at High T
3. Native metals break down at low T
4. jo neeche hai wo upar waale ko reduce kar dega

(c) When the temperature is raised, a point will be reached where the graph crosses the $\Delta G = 0$ line and the oxide becomes unstable, and should decompose into the metal and dioxygen.

(d) Any metal (M_1) will reduce the oxide of other metals (M_2) (which lie above it in the Ellingham diagram) because the free energy will become more negative by an amount equal to the difference between the two graphs at that particular temperature.

$$M_1 + M_2O \longrightarrow M_2 + M_1O \text{ ; } [\Delta G = -ve] \text{ overall}$$

Extraction of Gold (Au)

(i) Crushing & Grinding

(ii) Leaching Process

Gold is extracted by the cyanide process (Macarthur-Forrest / cyanide process).

$$4Au + 8NaCN + 2H_2O \xrightarrow{\text{In presence of air}} 4Na[Au(CN)_2] + 4NaOH$$

$$2Na[Au(CN)_2] + Zn \longrightarrow Na_2[Zn(CN)_4] + 2Au(\text{Impure})$$

Extraction of Silver (Ag)

(A) From Argentite (Ag_2S)

(i) Concentration

As it is a sulphide ore, so froth flotation process is used.

(ii) Leaching and reduction (Macarthur Forrest / Cyanide process)

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

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

(iii) Refining

(a) Amalgamation process

$Hg\text{-}Ag \uparrow \xrightarrow{\Delta} Hg \uparrow$

(b) Purification by electrolytic method

Pure Ag $\longrightarrow$ Cathode

Impure Ag $\longrightarrow$ Anode

Electrolyte $\longrightarrow$ $AgNO_3$

Extraction of Copper (Cu)

Main Ore

Copper pyrites ($CuFeS_2$)

Extraction from pyrites by pyrometallurgical process (Smelting Process)

It also occurs as

Copper glance Cu_2S

Malachite $Cu(OH)_2.CuCO_3$

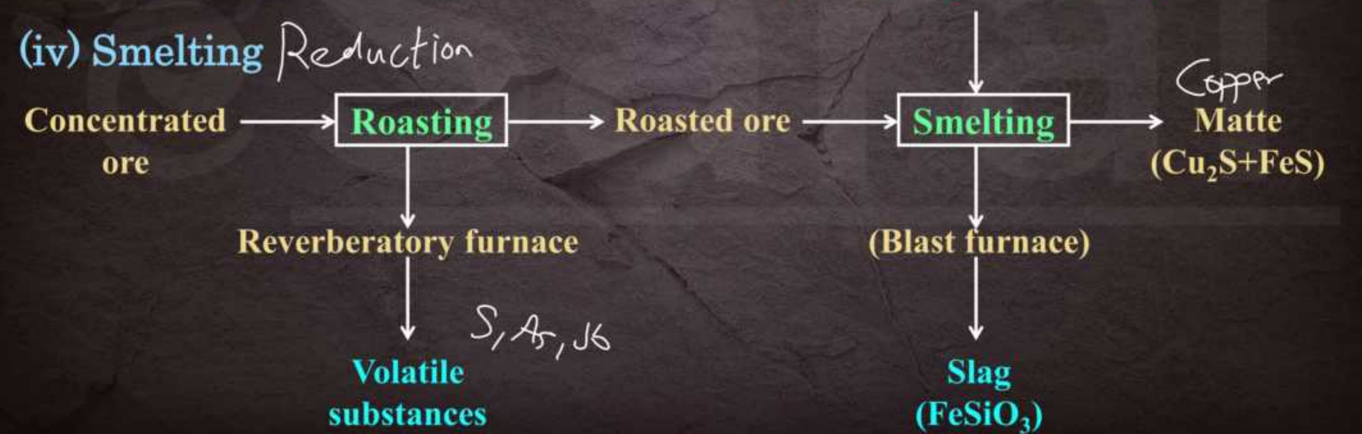
Azurite $Cu(OH)_2.2CuCO_3$

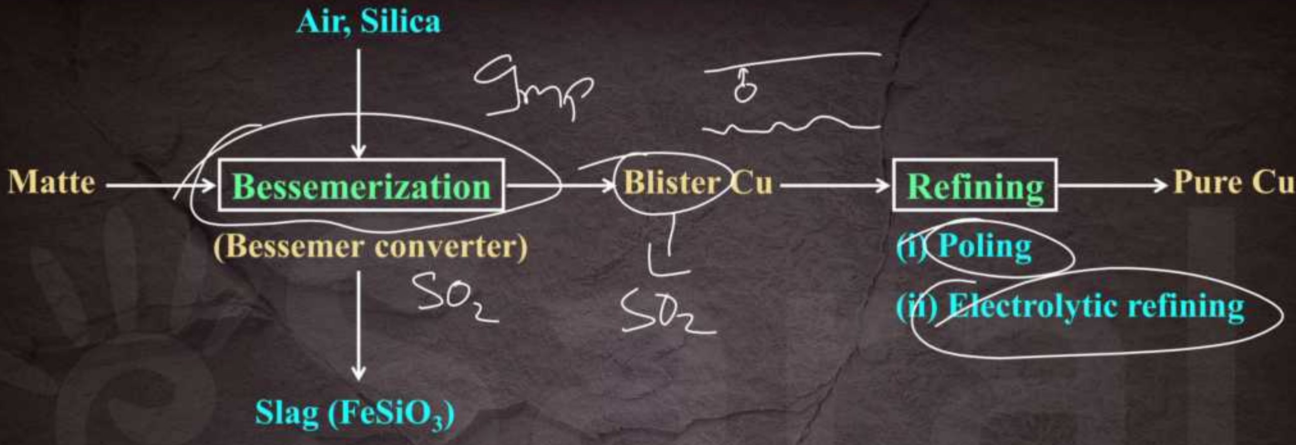
(i) Crushing & Grinding

(ii) Concentration

(iii) Roasting

(iv) Smelting Reduction




Air, Silica
Matte
Bessemerization
(Bessemer converter)
Slag ($FeSiO_3$)
Blister Cu
Refining
(i) Poling
(ii) Electrolytic refining
Pure Cu

Reaction involved in Bessemer Converter

Basic

$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$ Learn

Acidic flux

$FeO + SiO_2 \longrightarrow FeSiO_3$ (slag)

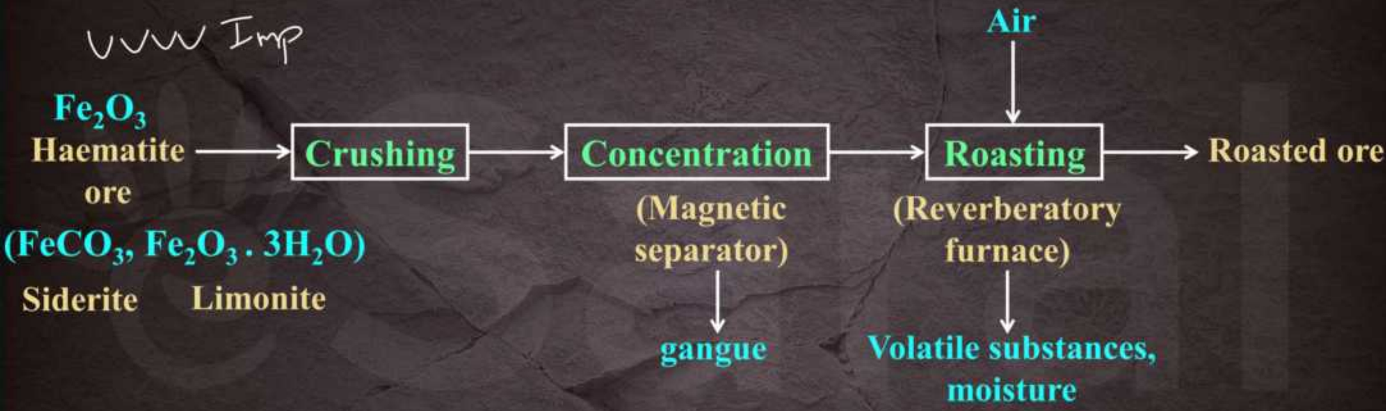
$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

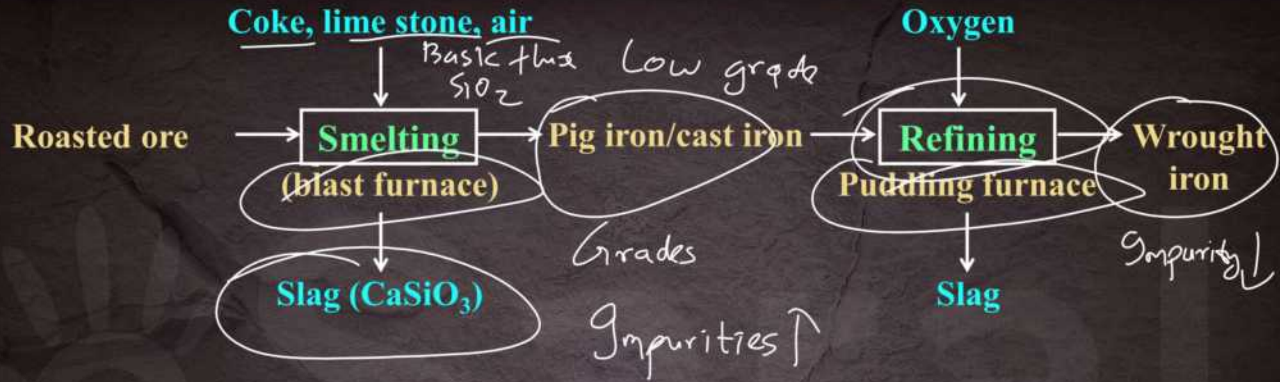
$2Cu_2O + Cu_2S \xrightarrow[\text{Reduction}]{\text{Self}} 6Cu + SO_2 \uparrow$

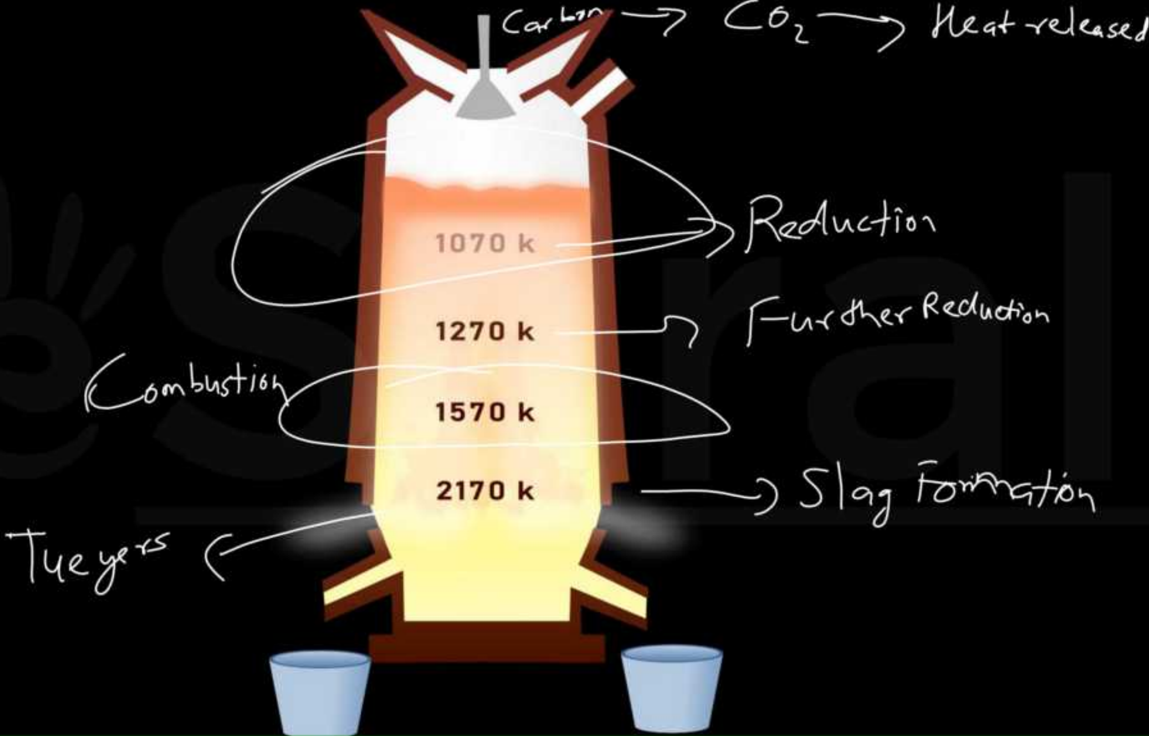
unreacted   Blister copper

Extration of Iron (Fe)

vvv Imp




Coke, lime stone, air
Basic flux
SiO_2
Roasted ore
Smelting
(blast furnace)
Slag ($CaSiO_3$)
Pig iron/cast iron
Low grade
Grades
Impurities ↑
Oxygen
Refining
Puddling furnace
Slag
Wrought iron
Impurity ↓



Carbon → CO_2 → Heat released
1070 k
Reduction
1270 k
Further Reduction
Combustion
1570 k
2170 k
Slag Formation
Tueyers

(a) Zone of combustion (1500 - 1600°C)

This zone is near at the bottom of the furnace and little above the tuyers.

It increases temperature of the furnace because of exothermic reactions.

$$2C + O_2 \longrightarrow 2CO$$

$$C + O_2 \longrightarrow CO_2$$

(b) Zone of reduction (400 - 700°C) → CO reducing

Extraction of Iron

Major reduc Agent?

CO

$\overset{+3}{Fe_2O_3}$ → $\overset{8/3}{Fe_3O_4}$ → $\overset{+2}{FeO}$ → $\overset{0}{Fe}$

It is near the top of the furnace.
Here the calcined ore is reduced to FeO or Fe_3O_4 mostly by rising CO.

$$Fe_2O_3 + CO \longrightarrow 2FeO + CO_2\uparrow$$

$$Fe_3O_4 + CO \longrightarrow 3FeO + CO_2\uparrow$$

(c) Zone of slag formation and reduction (800 - 1000°C)

$CaO + SiO_2 \rightarrow CaSiO_3$

This is the middle part of the furnace. Here rising CO_2 is reduced to carbon monoxide.

$$CO_2 + C \longrightarrow 2CO$$

$$Fe_3O_4 + CO \longrightarrow 3FeO + CO_2\uparrow$$

$$FeO + CO \longrightarrow Fe + CO_2\uparrow$$

(d) Zone of fusion (1200 - 1300°C)

It is just above the zone of combustion. Here the iron melts and trickles down in the hearth while the slag being lighter floats over the molten metal and thus prevents oxidation of Fe by blast of air.

Refining

Purification of Fe can be done by different method which are as follows

(a) Puddling Process

(b) Bessemerisation Process

(c) Open hearth Process

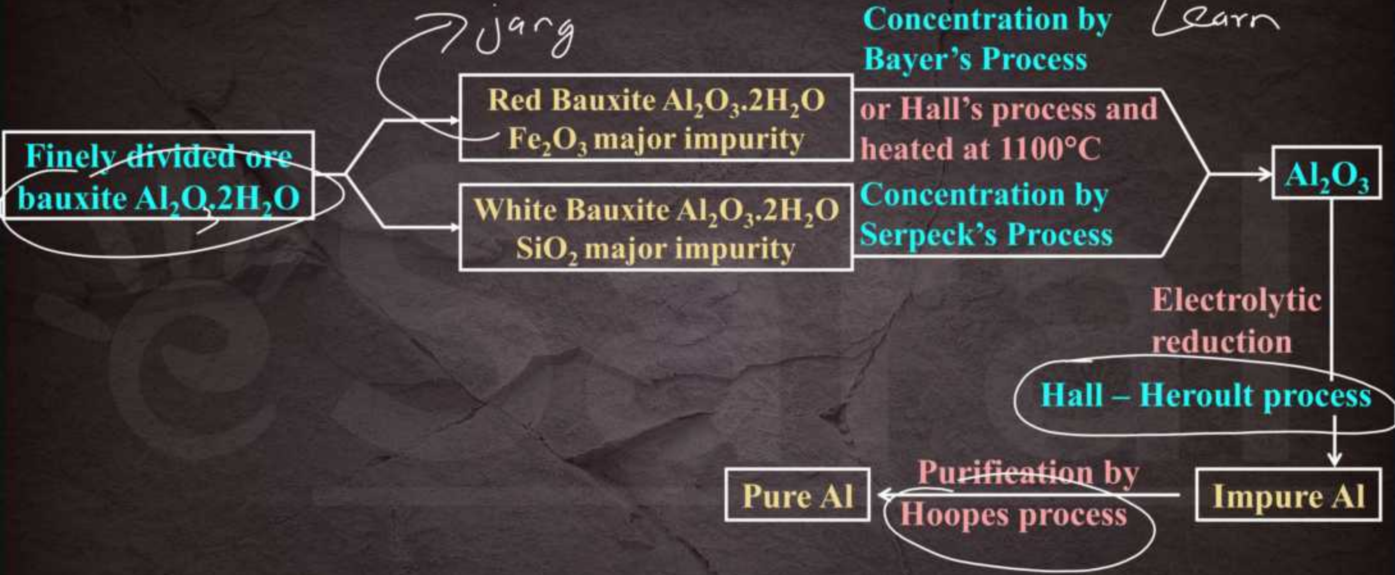
(d) L. D. Process

Learn

Thus we get pure iron.

Extraction of Aluminium (Al)

Flow chart of Al from $Al_2O_3.2H_2O$ (Bauxite)



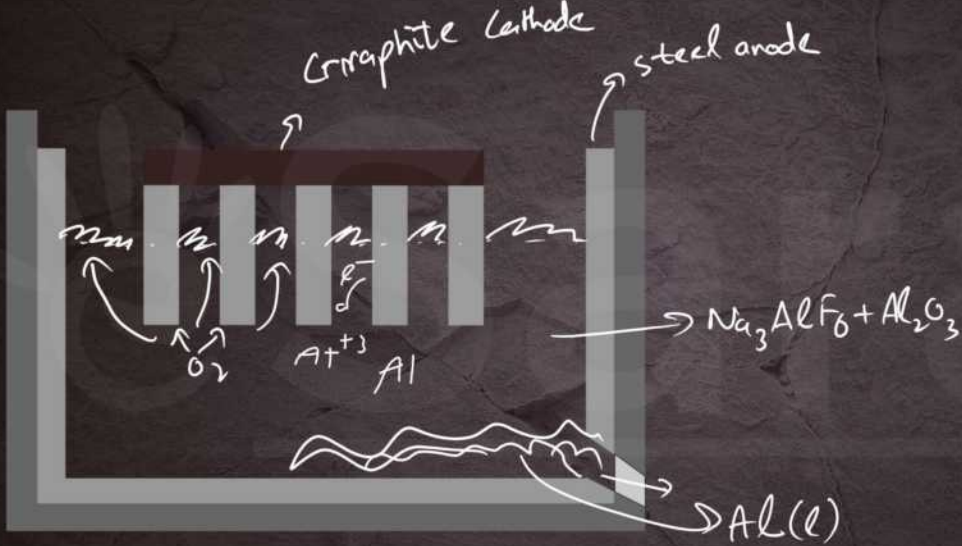
Electrolytric reduction (Hall-Heroult process)

≈ 2100°C

The purified Al_2O_3 is mixed with Na_3AlF_6 (cryolite) or CaF_2 (fluorspar) which lowers the melting point of the mixture and brings conductivity.

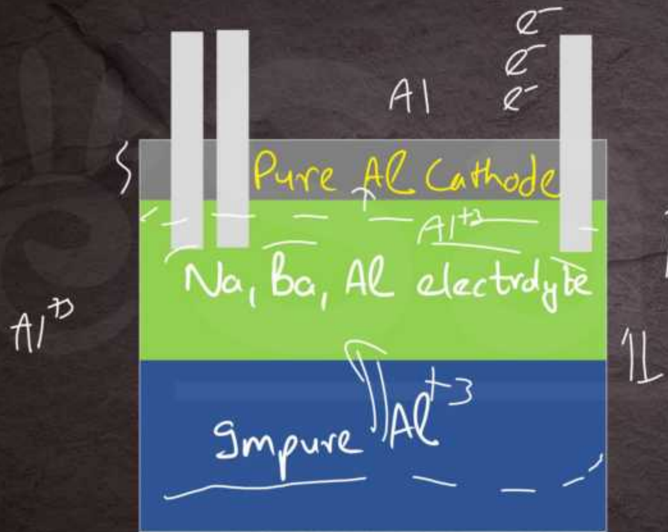
The fused matrix is electrolysed. Steel cathode and graphite anode are used.

Al_2O_3
+
Na_3AlF_6
or
CaF_2


Graphite cathode
steel anode
O_2
Al^{+3}
Al
$Na_3AlF_6 + Al_2O_3$
Al(l)

Electrorefining of aluminium (Hoopes process)

Le chatalier



Molten

Impure aluminium mixed with copper melt is taken in an iron tank with graphite lining.

The layer of pure Al acts as the cathode. The graphite rods at the top are essential for electrical connection.

At the anode $Al \longrightarrow Al^{3+} + 3e$

At the cathode $Al^{3+} + 3e \longrightarrow Al$

Extraction of Lead (Pb)

Crushing & Grinding

Froth Flotation

Galena (PbS) There are mainly two types of process used in the extraction of Lead.

Ore – Galena Pbs

- → **(a) Carbon reduction process**
- → **(b) Self reduction process**

$$2PbO(s) + C \xrightarrow{\Delta} 2Pb(\ell) + CO_2(g)$$

$$FeO + SiO_2 \xrightarrow{\Delta} FeSiO_3\ (Slag)$$

$$CaCO_3 + SiO_2 \xrightarrow{\Delta} CaSiO_3\ (Slag) + CO_2(g)$$

$$PbS + O_2 \longrightarrow PbO + SO_2$$

$$PbS + 2PbO \longrightarrow 3Pb + SO_2$$

Parallel reaction

$$PbS + 2O_2 \longrightarrow PbSO_4$$

$$PbS + PbSO_4 \longrightarrow 2Pb + 2SO_2$$

(C) Refining process

(i) Liquation

(ii) Bett's Electrorefining

Anode ⟶ Impure Pb

Cathode ⟶ Pure Pb

Ionic Mobility ↑

Electrolyte ⟶ $Pb[SiF_6] + H_2SiF_6$ + Gelatine (to adjust viscosity)

on the electrolysis Pb is deposited at cathode which gives 99.95% pure metal.

(a) Lead Extraction from Anglesite($PbSO_4$)

(i) Crushing & Grinding

(ii) Concentration by Levigation → Gravity separatio

(iii) Calcination

(iv) Carbon Reduction

(iv) Bett's Process

Extraction of Magnesium (Mg) → $MgCl_2$

(A) Preparation of hydrated Magnesium Chloride

(i) From Carnallite ($KCl.MgCl_2.6H_2O$)

The solution of Carnallite on concentration and crystallisation gives the crystals of KCl and solution of $MgCl_2$.

After filtration, filtrate ($MgCl_2$ solution) on concentration and crystallisation, this time gives the crystals of $MgCl_2.6H_2O$.

(ii) From Magnesite($MgCO_3$) → $MgCl_2$

$$MgCO_3 \xrightarrow[\text{Strongly}]{\text{Heated}} MgO + CO_2$$

$$MgO + C + \underset{\text{dry}}{Cl_2} \xrightarrow{\Delta} MgCl_2 + CO$$

The magnesium chloride is fused and then electrolysed.

(iii) From Sea water (Dow's process)

$MgCl_2 \cdot 6H_2O \xrightarrow{\Delta} MgO$

Sea water contains 0.13% magnesium as chloride and sulphate.

dhyaan

$$MgCl_2 + Ca(OH)_2 \longrightarrow Mg(OH)_2 + CaCl_2$$

$$Mg(OH)_2 + 2HCl(aq) \longrightarrow MgCl_2 + 2H_2O$$

$$MgCl_2 \cdot 6H_2O \xrightarrow[\text{Dry HCl(g)}]{\Delta \text{ (Calcination)}} MgCl_2 + 6H_2O$$

$$MgCl_2 \cdot 6H_2O \xrightarrow{\Delta} MgO + 5H_2O + 2HCl$$

It is not made anhydrous by simple heating because it gets hydrolysed

(C) Electrolysis of fused anhydrous $MgCl_2$

Magnesium Chloride obtained by any of the above methods is fused and mixed with Sodium Chloride and Calcium Chloride in the temperature range of 973 – 1023 K.

$$MgCl_2 \longrightarrow Mg^{2+} + 2Cl^-$$

At cathode $Mg^{2+} + 2e^- \longrightarrow Mg$ (99% pure)

At anode $2Cl^- \longrightarrow Cl_2 + 2e^-$

Extraction of Tin (Sn)

Main Ore

Cassiterite or Tinstone (SnO_2) + Major impurities like SiO_2, Sulphides of Fe & Cu & Wolframite ($FeWO_4 + MnWO_4$)

→ magnetic

(i) Crushing and concentration

(ii) Electromagnetic separation

(iii) Roasting

$SnO_2 \rightarrow$ Roasting

The impurities of pyrites of Copper and Iron are converted into their respective oxides and sulphates

$$CuS + 2O_2 \longrightarrow CuSO_4$$

$$FeS + 2O_2 \longrightarrow FeSO_4$$

(iv) Leaching

(v) Washing

The ore is washed with running water to remove the fine iron oxide produced in roasting.

Thus obtained ore contains 60 – 70% SnO_2 and is called as black tin.

(vi) Carbon reduction method

$SnO_2 + 2C \longrightarrow$ Sn (Molten) + 2CO

$CaO + SiO_2 \longrightarrow CaSiO_3$(Slag)

Revision Samapt

(a) Liquation

(b) Poling

(c) Electrorefining

Anode $\longrightarrow$ Impure Sn

Cathode $\longrightarrow$ Pure Sn

Electrolyte $\longrightarrow$ ($SnSO_4$ solution + dil. H_2SO_4)

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