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✡ General Principles of Extraction of Metals ✡

Metals:-

The elements which are hard, dense, malleable, ductile, good conductors of heat & electricity, electro +. in character & posses shining lustre and high melting and boiling points are called metals.

Ex- iron, copper, gold etc.

- Oxides → Basic Na_2O
- I.E → Low
- metallic Bond

Non- metals:-

The elements which are soft, less dense, dull in appearance, brittle, poor conductors of heat and electricity, electronegative in character & possess low melting and boiling points are called non-metals.

Ex- Sulphur, phosphorus, oxygen etc.

- Oxides → Acidic SO_2
- I.E → high
- covalent Bond

Metalloids:-

The elements which exhibit both metallic and non-metallic properties to some extent are called metalloids.

Ex- arsenic, antimony, bismuth etc.

Minerals:- The natural substances in which metals occur either in the native state or in the combined state are called minerals.

Ores:-

An ores is a mineral from which the metal can be economically and profitably extracted.

Ex- for Aluminium -

Correndum	Al_2O_3
Bauxite	$Al_2O_3 \cdot 2H_2O$
Cryolite	Na_3AlF_6
Alum	$K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$

Ores of Iron-

Heametite	Fe_2O_3
Magnetite	Fe_3O_4
Iron Pyrite	FeS_2

Ores of Copper-

Chalcopyrite	$CuFeS_2$
Chalcocite	Cu_2S
Covellite	CuS

◉ Metallurgy:-

The process of extracting metals from their ores is called metallurgy.

Types of metallurgy -

1. Pyrometallurgy: It is the process of extraction of metal from its concentrated ore by heating to high temperature.
   Ex- Fe_2O_3, $CuFeS_2$

2. Electrometallurgy: It is the process of extraction of metal from its concentracted ore by passing electric current through the solution of the ore at molten state.
   Ex- Na, K, Al.

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3. Hydrometallurgy: Hydrometallurg is the process of extraction of metal from its concentrated ore by dissolving the ore in a suitable chemical reagent & then precipitation of the metal by a more electro + metal.
Ex- Silver & gold.

▶ Gaingue / Matrix:-
The earthy impurities like sand, rocks, limestones, clay etc. associated with the ore are known as gangue / matrix. Ex- SiO_2, P_2O_5, CaO, FeO

▶ Flux: A flux is a substance which when added to the roasted or calcined ore helps in the removal of non-fusible impurities of earthy matter during smelting.

Flux + Gangue ⟶ Slag

$$\underset{\text{(Basic impurity)}}{FeO} + \underset{\text{(Acidic Flux)}}{SiO_2} \longrightarrow \underset{\text{(Fusible slag)}}{FeSiO_3}$$

$$\underset{\text{(Acidic impurities)}}{SiO_2} + \underset{\text{(Basic Flux)}}{CaCO_3} \longrightarrow \underset{\text{(Slag)}}{CaSiO_3} + CO_2\uparrow$$

◉ General methods for the extraction of Metals :-

1. Crushing and grinding or Pulverisation of the ore.
2. Concentration or purification of the ore.
3. Extraction of metal from concentrated ore.
4. Purification or Refining of metal.

⊥ Crushing: Ore is crushed into pieces by Jaw Crushers Pulverisation: Small pieces are powdered by Stamp Mills

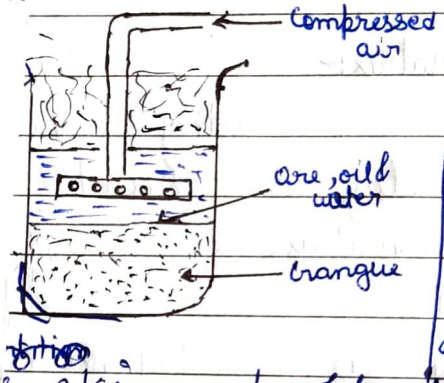
(2) Concentration : Process of removing impurities -

a) Levigation / Gravity Seperation : Method is used for ore being heavy and impurity lighter. - Ore is taken in tank and washed with water from one side. Lighter impurities are carried away.

b) Froth flotation process :-

This process is used for the concentration of sulphide ores.

It is based on the fact that sulphide ore particles are preferentially wetted by oil while the gangue and oxide particles are wetted by water only.



Ore + pine oil + water mixture is stirred by passing air via a pipe. Ore with oil form a froth and comes at the top where it is skimmed off. Heavier impurities settles down. eg ZnS, PbS, $CuFeS_2$.

(3) a) Conversion of concentrated ore to its oxide form:-

a) Roasting

b) Calcination.

Roasting :- Roasting is a process of heating the ore strongly in the presence of excess of air at a temp. below its melting point. It is commonly used for concentration of sulphide ores.

$$2ZnS + 3O_2 \longrightarrow 2ZnO + 2SO_2 \uparrow$$

(Zinc blende)

Calcination :- Calcination is the process of heating the concentrated ore strongly in the absence or limited supply of air at a temp below its melting point. eg Carbonate Ores

$$ZnCO_3 \longrightarrow ZnO + CO_2 \uparrow$$

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b) • Conversion of the oxide of metal to metallic form :-

1. Reduction / Smelting (Pyrometallurgy) :-

In this process, the roasted or the calcined ore is mixed with a calculated quantity of carbon & heated to a temp. above its melting point in a blast furnace where the oxide of the metal is reduce to the molten metal.

$$ZnO + C \longrightarrow Zn + CO$$
$$SnO_2 + 2C \longrightarrow Sn + 2CO$$
$$PbO + C \longrightarrow Pb + CO$$

2. Electrolytic reduction (Electrometallurgy) :-

The oxide of certain highly electropositive metal like Na, Mg & Al etc. are commonly extracted by the electrolysis of their fused salts.

$$\underset{(\text{molten})}{NaCl} \longrightarrow Na^+ + Cl^-$$

At Cathode : $Na^+ + e^- \longrightarrow Na$

At Anode :- $Cl^- \longrightarrow Cl + e^-$

$Cl + Cl \longrightarrow Cl_2 \uparrow$

4 • Refining of Metal :-

(1.) Electrolytic Refining -

This is the best method of refining metals like Cu, Ag, Sn & Al etc.
In this method, the solution of soluble salt of

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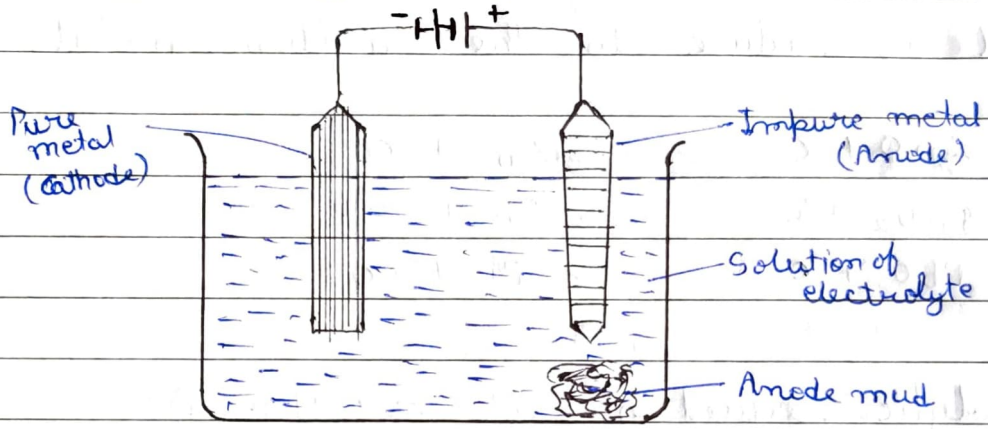
the metals is used as electrolyte. The thin sheet of pure metal acts as cathode, while impure metal is made as anode. On passing electric current, pure metal from electrolyte deposits on the cathode & an equivalent amount dissolves from anode. The impurities present generally fall at the bottom as 'anode mud'.



At cathode: Cu^{2+} (from electrolyte) $\xrightarrow[\text{reduction}]{+2e^-}$ Cu (Deposits at Cathode)

At Anode: Cu (from impure Anode) $\xrightarrow[\text{oxidation}]{-2e^-}$ Cu^{2+} (Goes into electrolyte)

* **Alloys**: An Alloy is a homogeneous mixture of two or more metals or metals and non-metals.

Alloys containing mercury as the constituent element are called amalgams. e.g; sodium-amalgam is alloy of sodium & mercury.

⊙ Types of Alloys-

(a). Ferrous Alloys: Alloys having iron as main constituent are called ferrous Alloys. Ex- steel is an alloy of iron & carbon.

(b). Non-Ferrous Alloys: Alloys which do not have iron as one of the main constituent are called non-ferrous alloys. Ex- brass is an alloy of copper & zinc. other examples are gun metal, duralumin, magnalium etc.

⊙ Purpose of Alloying :-

(1). To improve the hardness of metals.

(2) To lower the melting point of metals

(3) To increase the tensile strength

(4). To increase corrosion resistance

(5). To modify colour.

(6). To modify chemical activity

(7). To reduce malleability & ductility.

	Can't be welded	✓	✓

alloy use

Duralumin: Best light weight alloy used in aircraft and automobile sector.

Composition: Al - 95%, Cu - 4%, Mg 0.5%, Mn - 0.5%

Prop: 1. Strong, tough, ductile, corrosion resistant
2. Strong but 1/3 heavy as steel.
3. Worked easily.

Stainless steel: Fe + Cr + Ni + Mo.

Martensitic
Cr 0–14%.
Prop: Magnetic
Use:- Surgical Instrument, Pumps.

Ferritic
14–18%.
ductile.
Decorative Work
furnace
Petroleum Industry

Astentic steel
15–20%.
Ni – 7–10%.
C = 0.5%.
~~Fe~~ –.
good corrosion resistance.
Cooking Utensil
Heat Exchangers.
Railway Carts

Steel: manufactured from Cast Iron by Bessemer process which remove impurities by Oxidation with air by adding C, Mn, Cr.

properties:-

	Mild steel	Medium steel	Hard Steel.
% C	0.1 – 0.4% C	0.2 – 0.5% C	0.5 – 1.5% C
use	wires & sheets making	for making rails, wheels & building	for making machinery parts

properties based on heat treatment (4)

1. Quenching: steel is heated to red heat 1123 K and cooled.
2. Tempering:- Quenched steel is reheated to 503 – 573 K and cooled slowly.
3. Annealing: steel is heated to temp above red heat and cooled slowly.

(Fe) Iron Extraction — Fe_2O_3 Haemitete ore.

1. Concentration: done by gravity Seperation and then by magnetic seperation.
2. Calcination / Roasting: Heated in presence of excess of air to remove moisture and impurities
3. Smelting / Reduction: Ore is heated with Carbon in blast furnace

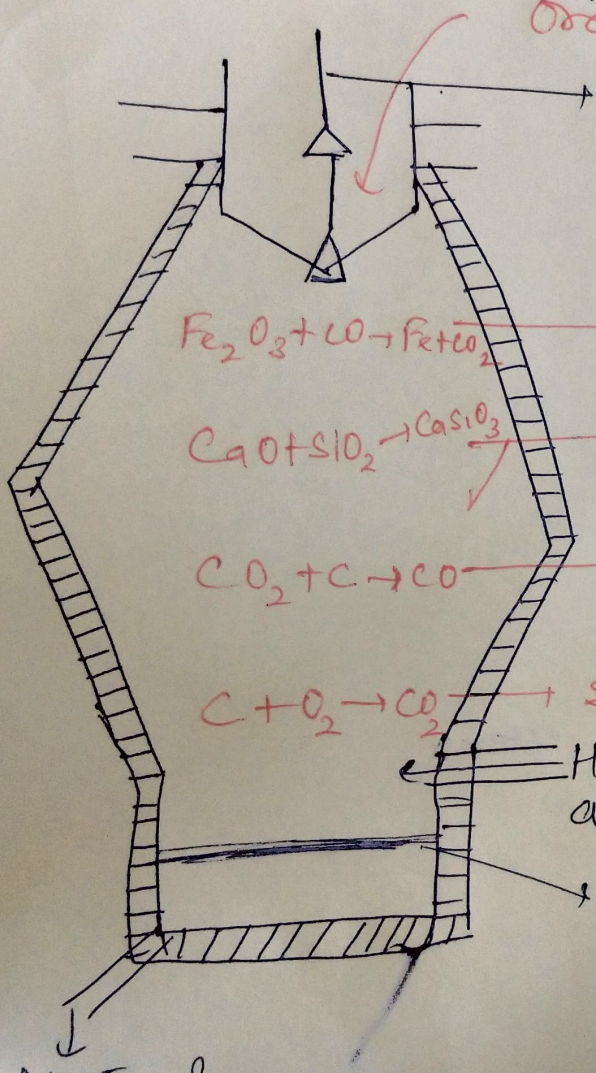


Diagram of Blast furnace.

Cast Fe ⟶ Wrought Fe

Cast is heated with Fe_2O_3 which oxides C to Carbon Monoxide.

$$Fe_2O_3 + C \longrightarrow Fe + CO$$