

Extractive metallurgy -
is a branch of metallurgy
that deals with method
the process and methods
of extraction of metals
from their ore.

The major divisions
of extractive metallurgy
may be classified as -

- i Pyrometallurgy.
- ii Hydrometallurgy.
- iii electrometallurgy.

EXTRACTIVE METALLURGY

INTRODUCTION :-

IMPORTANT TERM.

OCCURRENCE OF METALS

- Most of the metals are reactive so they occur in combined state in the form of their Oxides, Carbonates, Sulphides, Sulphates etc, mixed with impurities (mud, sand, clay and sh).
- Sodium and potassium occurs mainly as their Chlorides,
- Calcium and magnesium as Carbonates,
- aluminium as its Oxide,
- Zinc (Zn), lead (Pb), Copper (Cu), mercury (Hg) and Silver (Ag) are found as Sulphides.
- Metals which have low chemical reactivity are found in native / free state. Gold & platinum are found in free state (native state).

NOTE :-

Insoluble ores are found as rock while
Soluble ones like alkali Chloride are found
in sea water.

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NOTE:-

The history of man can be broadly classified into three divisions, namely

a. Stone age (Copper)

b. Bronze age

c. Iron age.

According to reactivity series lists the metals in the decreasing order of electropositivity. It might be expected that those at the top would combine with more electronegative elements in their minerals.

METALS

MAIN ORES

K

Carnallite ($KCl \cdot MgCl_2 \cdot 6H_2O$).

Na

Rock Salt ($NaCl$).

Ca

Limestone, Marble ($CaCO_3$), Calcium Sulfate dihydrate ($CaSO_4 \cdot 2H_2O$)
Gypsum ($CaSO_4$).

Mg

Carnallite, magnesium carbonate ($MgCO_3$).

Al

Bauxite ($Al_2O_3 \cdot 2H_2O$), Cryolite (Na_3AlF_6).

Zn

Zinc blende (ZnS), Calamine ($ZnCO_3$).

Fe

Hematite (Fe_2O_3)Magnetite (Fe_3O_4)

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METALS

MAIN ORES

Pb

Galena (PbS)

Cu

Copper pyrites ($CuFeS_2$)

Hg

Cinnabar (HgS)

● METALLURGY :

The process used for the extraction of metal in their pure form from their ores is referred to as Metallurgy.

Metallurgy deals with the production and purification of metals and manufacture of alloys.

● MINERALS :

The naturally occurring compounds of metals which are generally mixed with other materials such as soil, sand, limestone & rock are known as Minerals.

A mineral may be a single compound or a complex mixture.

● GANGUE (MATRIX):

Earthly impurities including silica (SiO_2) mud etc. associated with the ore are called Gangue or matrix.

Ores:-

Those minerals from which the metal are extracted commercially at a comparatively low cost and with minimum effort are called Ores.

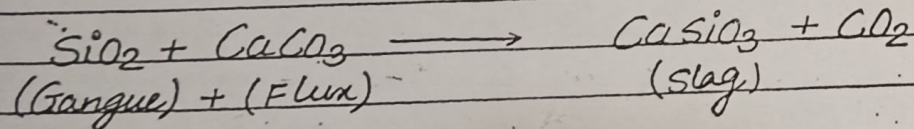
FLUX:-

A flux is a substance that is added to the charge in a furnace to remove the gangue.

Flux combines with the gangue to form a fusible mass called slag.

SLAG:-

It is the fusible product of flux react with gangue (impurities) during the extraction of metals.



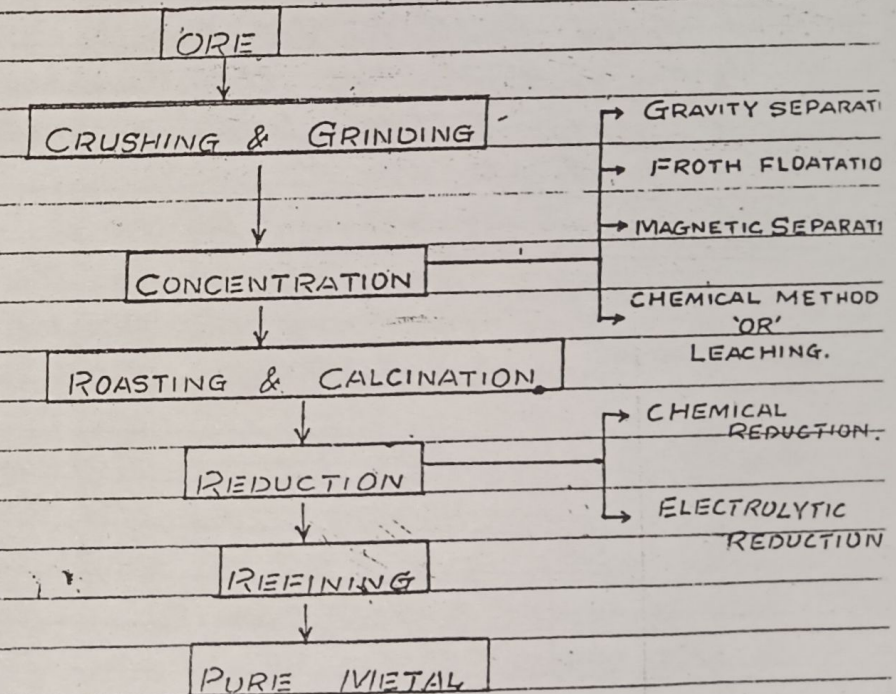
NOTE:-

All Ores are minerals, but all minerals are not ore.

* SMELTING:

Smelting is the melting process, Smelting is the process of reducing the roasted oxide ore and removing the gangue or impurities with the help of flux added with ore. It reduces the oxide ore to metals in the molten condition.

STEPS INVOLVED IN EXTRACTION



• CRUSHING & GRINDING :-

- Ores are crushed into a fine powder in big jaw crushers and ball mills. This process is called pulverisation.

• CONCENTRATION :-

- The process of removing gangue, the rocky impurities like SiO_2 present in an ore, is called Concentration of an ore or Ore dressing and the purified ore is called Concentrated ore.
- Concentration of the crushed ore is done mainly by the following methods :-

(i) GRAVITY SEPARATION :-

Principle: The difference in the densities of the ore and the gangue is the main criterion.

JET OF WATER

DENSER ORE PARTICLES

WATER

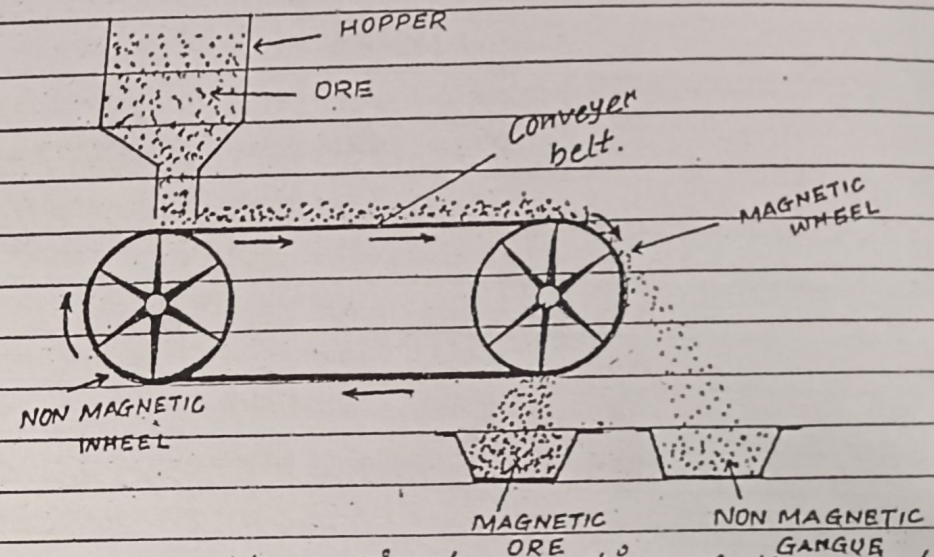
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ORE PARTICLES + GANGUE

Method: The ore is poured over a sloping, vibrating, corrugated table with grooves and a jet of water is allowed to flow over it.

- The denser ore particles settle down in the grooves and lighter gangue particles are washed down by water.

(ii) MAGNETIC SEPARATION :-



Principle: Magnetic properties of the ore.

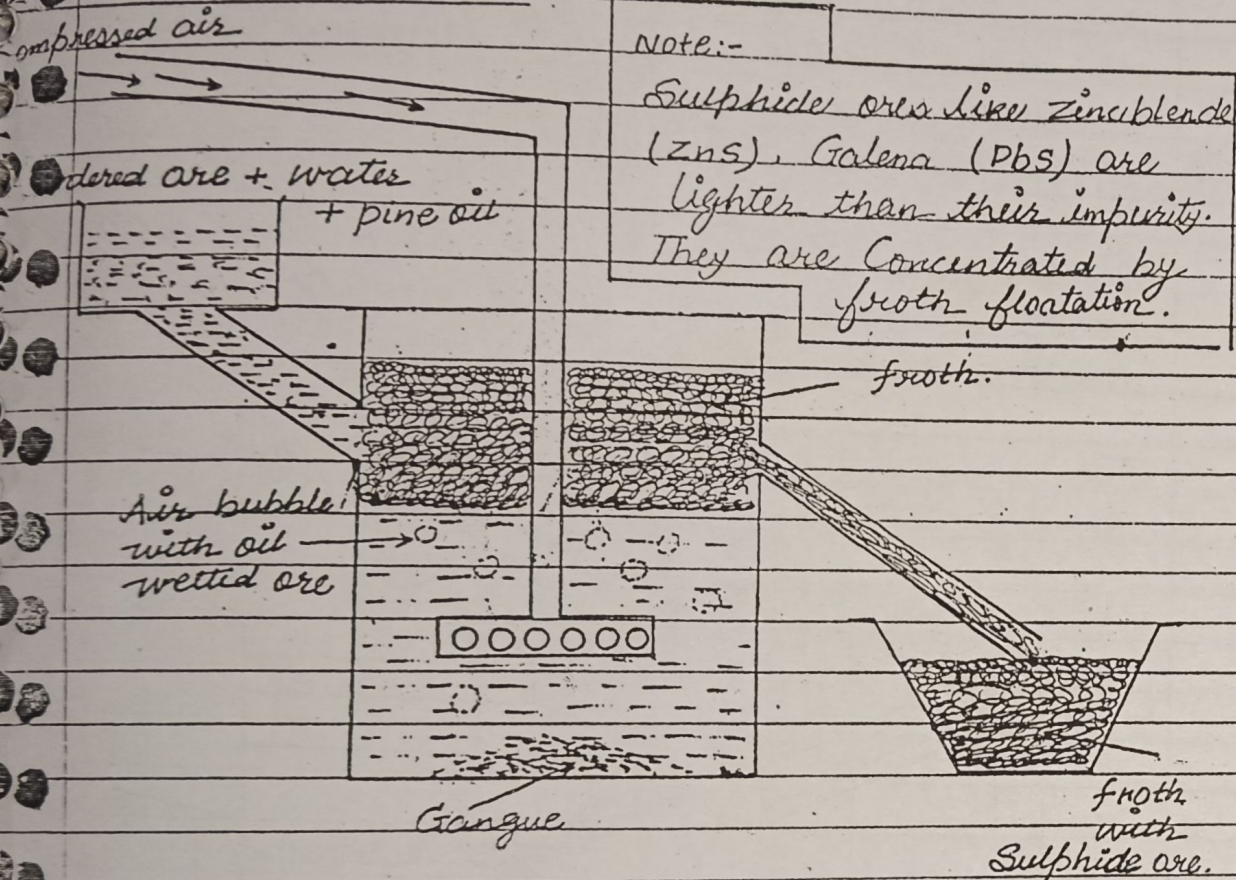
Method:

The crushed ore is placed over a conveyor belt, which rotates around two metal wheels, one of which is magnetic.

- The magnetic particles are attracted to the magnetic wheel & fall separately apart from the non-magnetic particles.

Magnetic Separation is also called Electromagnetic Separation.

Eg; Non-magnetic tin stone (SnO_2) ore is with magnetic impurities such as tungst of Fe and Mn.

DATE FROTH FLOTATION :-

Principle: This process depends on the preferential wettability of the ore with oil + Gangue by water.

Method:

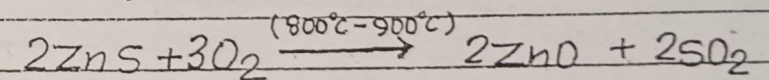
- The Crushed ore is taken in a large tank containing oil & water and agitated with a current of compressed air. The ore is wetted by the oil and gets separated from the gangue in the form of froth.
- Since the ore is lighter, it comes on the surface with the froth and impurities are

DATE (iv) CHEMICAL METHOD OR LEACHING :-

- The ore is treated with a suitable reagent (acid, base or some other reagent) such that the ore is soluble in it but the impurities are not. The impurities are removed by filtration. The solution of the ore, i.e., the filtrate is treated with a suitable reagent which precipitates the ore.

● ROASTING & CALCINATION# ROASTING :-

- The ore is heated in the excess of air.
- Generally, sulphide ores are roasted, so SO_2 is given off.



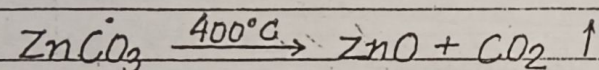
- Volatile impurities are removed as oxides (SO_2 , P_2O_5 , As_2O_3) and the ore becomes porous and more reactive.

NOTE:-

It converts sulphide ore into oxides.

CALCINATION :-

- The ore is heated in the limitation / absence of air. (Limited air is supplied)
- Carbonate & hydrated ores are calcined and CO_2 or water vapours are given off



- Moisture and organic impurities are removed and the ore becomes porous and more reactive.

● REFINING OF THE METAL :-

- It is the separation of the above extracted metal from the residual impurity.

The method of purification used depends upon the

- nature of the metal.
- nature of the impurities present in the metal
- purpose for which the metal is to be used.

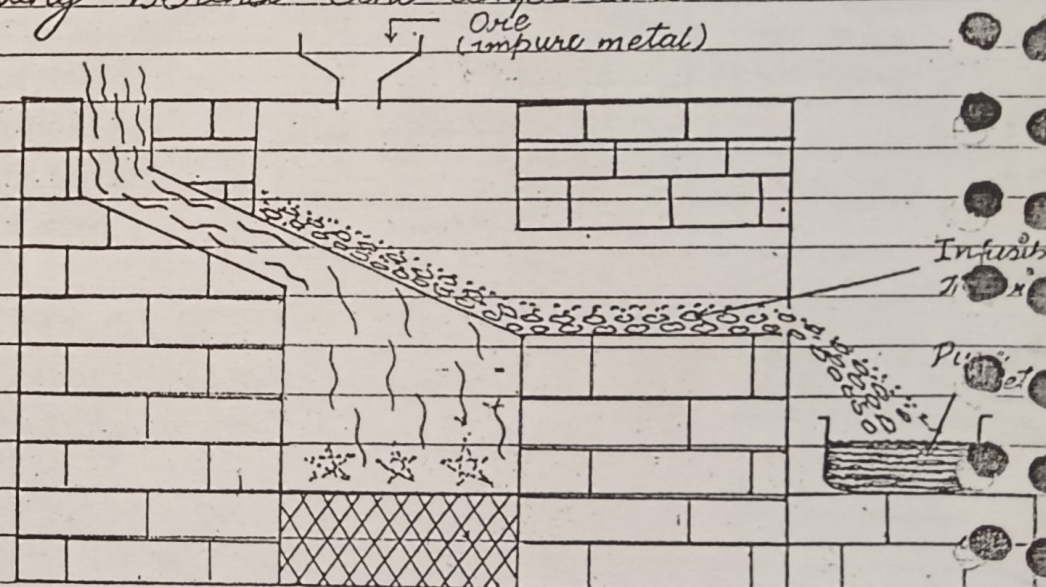
(i) DISTILLATION :- (Mercury & zinc.)

- Metals like lead Mercury and zinc which are volatile distil over in pure form and the non-volatile impurity remains behind.

(ii) LIQUATION :- (Lead & Sn)

Metals like lead and tin have low melting points, so they are heated on the sloping hearth of a furnace.

- The molten or fused metal flows away leaving behind the impurities.



(Liquation process)

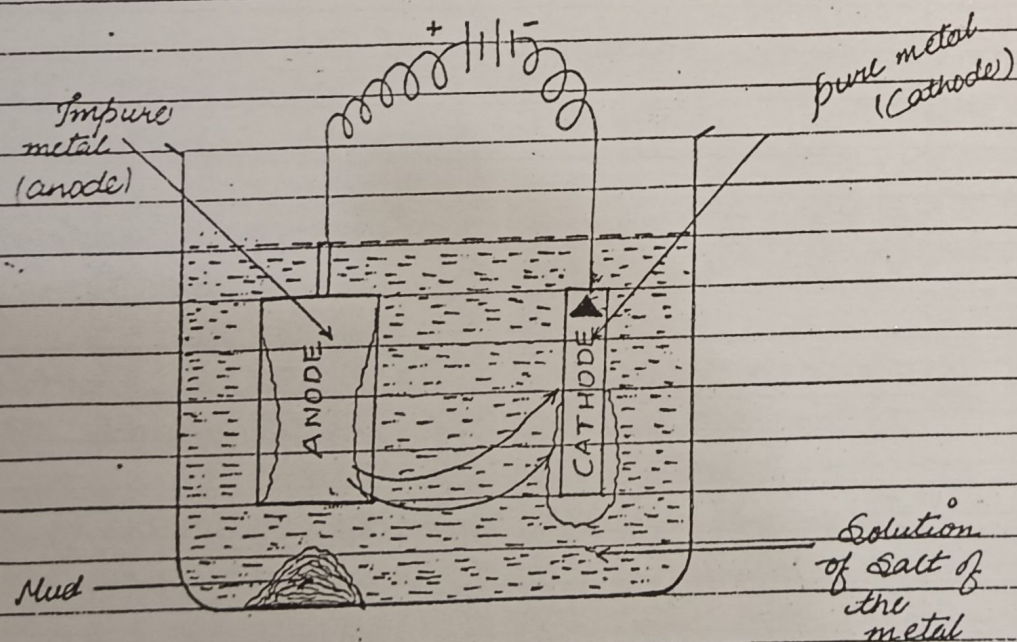
Cu, Zn & Al

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ELECTRO-REFINING :-

- The impure metal is made the anode, while a thin sheet of pure metal is made the Cathode.
- Electrolyte used is a salt solution of a metal, which is to be refined.
- Pure metal deposits at the Cathode and impurities settle down forming anode mud.
- Metals like Copper (Cu), aluminium (Al) and Zinc (Zn) refined by this process.



(Electro-refining)

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Element M.P

Lead 327.5°C

Tin (Sn) 231.9°C

Cu 1083°C

Al 660.3°C

Zn 419.5°C

Mercury - 38.83°C

It

that material, which possess high hardness, high ductility, electrical Conductivities. Co, Ni, etc.

losses electron and provides metal.

e. three metals namely y in the photo history there are 90 metals.

in Solid state except

of Metal

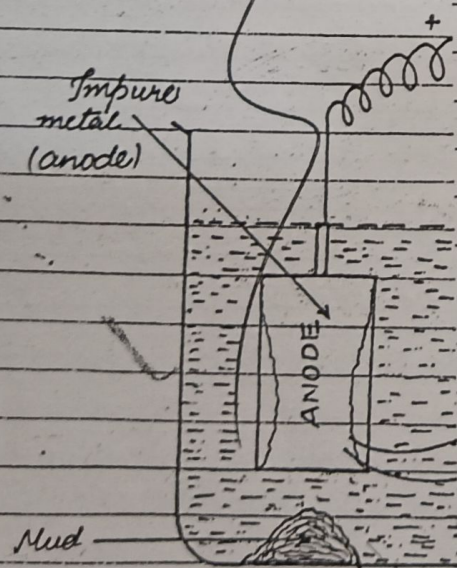
(b) Non-ferrous metal no iron present.

The metal in which iron element is known as

tracted / attracted by magnets iron, wrought iron &

(iii) ELECTRO-REFINING :

- The impure metal while a thin sheet made the Cathode
- Electrolyte used is metal, which is
- Pure metal deposits impurities settle at
- Metals like Copper and Zinc (Zn) refine



(Electro-refining)

I.

INTRODUCTION

- METAL :- Metal is that material, which possesses lusture, strength, high hardness, high ductile & high thermal & electrical Conductivities.
eg; Al, Cu, Zn, Fe, Co, Ni, etc.
- The element which losses electron and protons is called Metal. percent
percent
- Primatively there are three metals namely Cu, Ag, Au. Specially in the pre-historic era, but at present there are 90 metals.
- Metals are found in Solid state except Mercury (Hg).

Classification of Metal

(a) Ferrous metal.
Contains iron (Fe)

(b) Non-ferrous metal
no iron present

- (a) FERROUS METAL :- The metal in which iron is the principal element is known as ferrous metal.
These are directly extracted / attracted by magnets.
eg; Pig iron, Cast iron, wrought iron & steel etc.

(b) NON-FERROUS METAL :- The metal which does not contain iron is called non-ferrous metal.
eg; Al, Au, Zn, Ag, Cu, Sn, Pb, U etc.

Difference between Ferrous & Non-ferrous metal :-

<u>FERROUS METAL</u>	<u>NON-FERROUS METAL</u>
(a) It's Chief Constituent is iron. (Fe)	(a) It doesn't contain iron (Fe).
(b) It's colour is grayish.	(b) It is available in different colours.
(c) It's melting point is high.	(c) It's melting point is low.
(d) It has low resistance to corrosion.	(d) It has high resistance to corrosion.
(e) It is magnetic in nature.	(e) It is non-magnetic in nature.
(f) It is less costly.	(f) It is high costly.
eg; Cast iron, Pig iron	eg; Cu, Al, Zn, Pb, Sn, etc.

- Metals are often extracted from the earth by means of mining ores that are rich sources of the requisite elements.
Such as Bauxite ($Al_2O_3 \cdot xH_2O$), Hematite (Fe_2O_3) & Magnetite (Fe_3O_4) etc.

Extraction of Metals (Sources)

→ Surface mining :- that is used when the mineral is near the surface.

→ Underground mining :- that is used when the mineral is deep below the surface.

→ Sea as Sources of metals :- Sea water can be considered a dilute solution containing valuable minerals and chemical compounds.

- About 70 elements have so far been discovered in sea water.

Light metals - Al, Mg, Ca, Ba, Na, K, Li etc.

Heavy metals - Cu, Fe, Pb, Zn, Sn, Ni etc.

Noble metals - Ag, Au, Pt etc.

Refractory metals - Mo, W, Ti, La, Zr etc.

Radioactive metals - U, Ra, Po, Th etc.

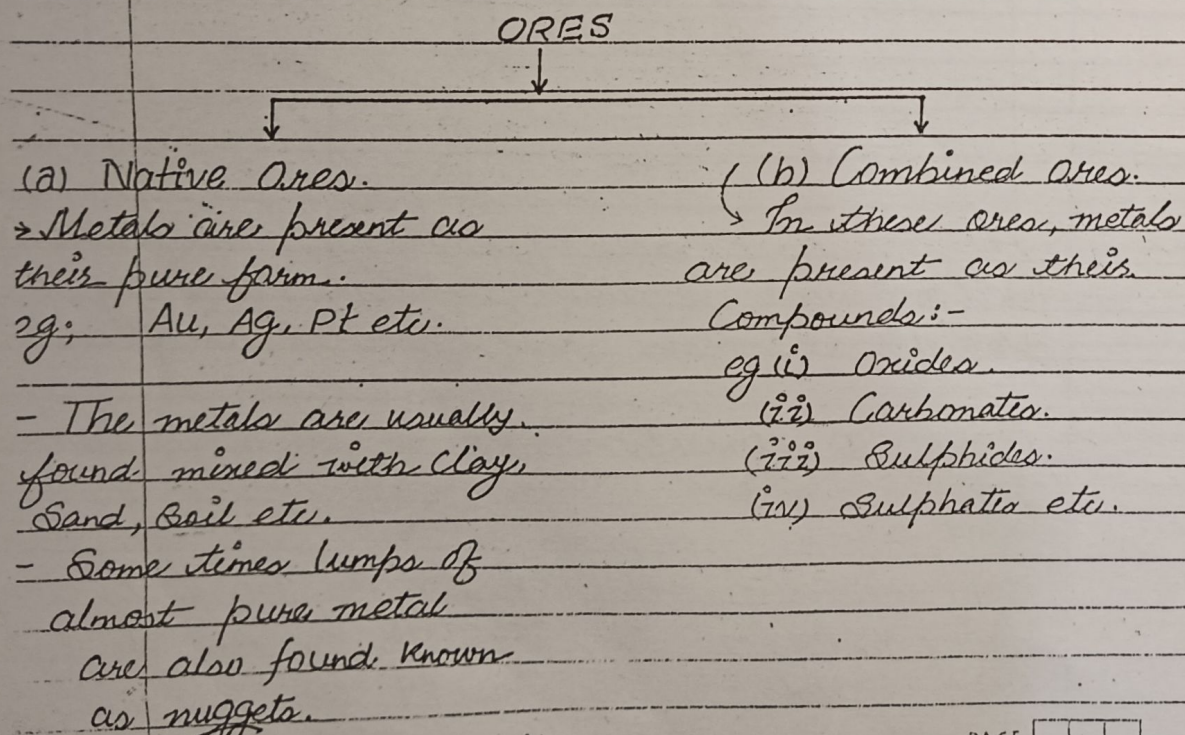
• MINERALS :-

- The naturally occurring Compounds of metals which are generally mixed with earthy impurities are called Minerals.
- A mineral may be a single compound or a complex mixture.

• ORES :-

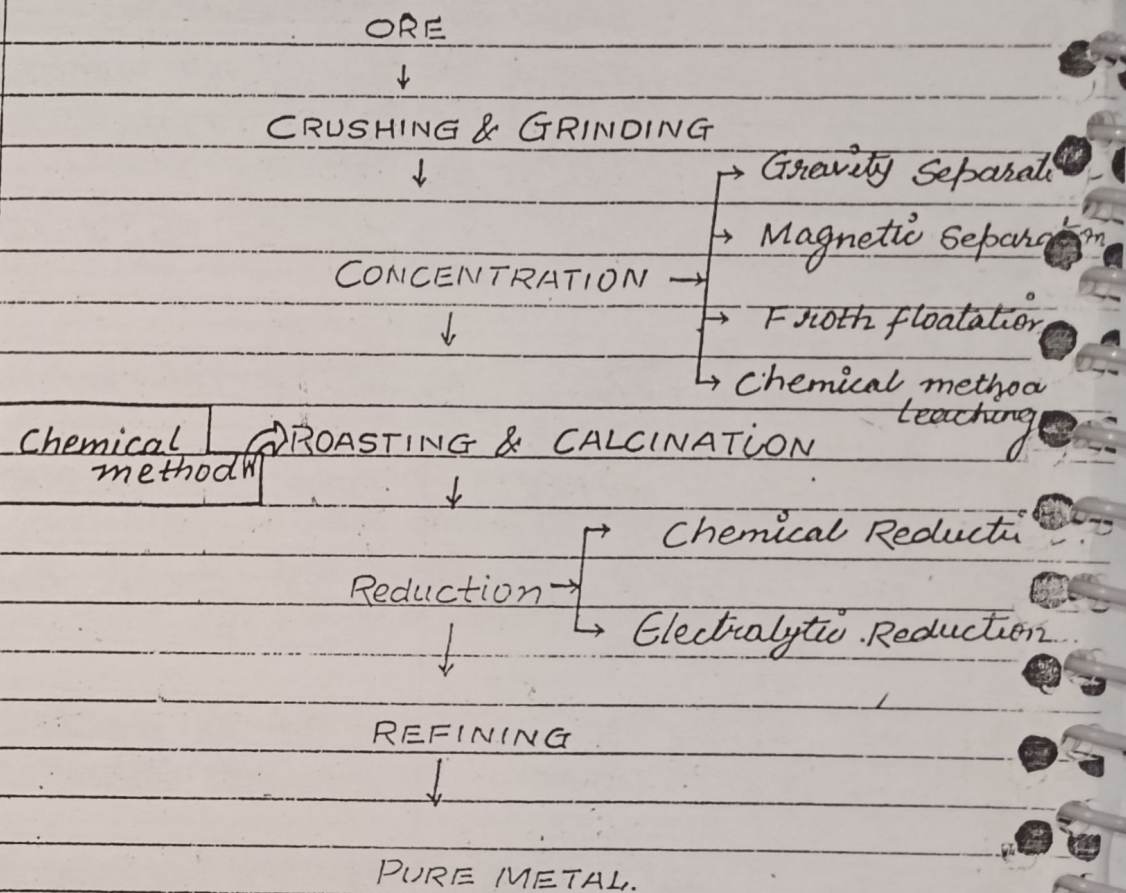
- Those mineral from which metal can be economically and easily extracted are called Ores.
- All ores are minerals but all minerals are not ores.

Classification of Ores.



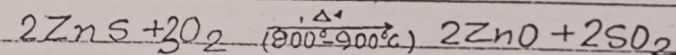
classmate

STEPS INVOLVED IN EXTRACTION



CHEMICAL METHOD :-

- **ROASTING :-** The ore is heated in the presence of regular supply of air.
- Sulphide ore are roasted, so SO_2 is given off



- Volatile impurities are removed as oxides (SO_2 , P_2O_5 , As_2O_3) and the ore becomes porous and more reactive.
- It converts sulphide ore into oxides.
- moisture is removed.

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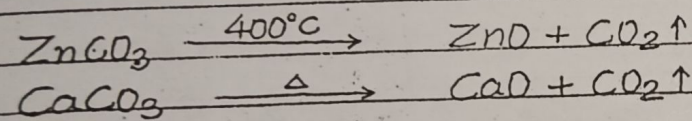
Def: - A substance used to cause a chemical reaction, especially in order to find out if another substance is present) 18
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CALCINATION :-

- The ore is heated in limitation supply of air / absence of oxygen.

- Carbonate & hydrated ores are calcined & CO₂ or water vapour are given off.



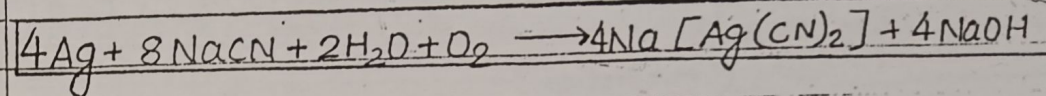
- Moisture and organic impurities are removed and the ore become porous and more reactive.

LEACHING :-

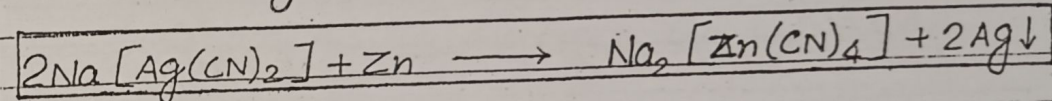
- In leaching process, the ore is dissolved in a suitable reagent so as to make it soluble, while impurities remain insoluble.
 - The ore is then recovered by a suitable chemical action.

e.g: Gold & Silver are also extracted from their native ores by leaching.

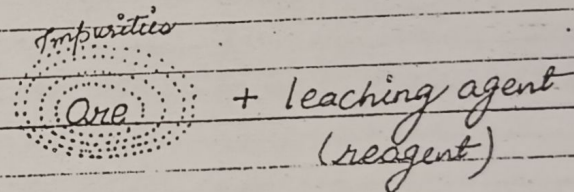
Both Silver & Gold particles dissolve in dilute solution of Sodium Cyanide (NaCN) in the presence of oxygen of the air forming complex cyanide.



Ag or Au is recovered from the solution by the addition of electropositive metal like Zn.



Chemical method of Concentration of ore



- It is based on reactivity of ore & impurities.
 - Ore are more reactive than impurities so, ore dissolved / soluble in reagent & impurities left behind.

Types of leaching :-

(a) leaching of alumina.

(b) leaching of Gold & Silver.

Difference between Roasting & Calcination

$$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O} + 2\text{NaOH} \longrightarrow 2\text{NaAlO}_2 + \text{FeO}$$

Red Bauxite
+ Fe₂O₃ (Impurities)

Red mud

$$\text{NaAlO}_2 + \text{excess of } \text{H}_2\text{O} \longrightarrow \text{Al}(\text{OH})_3$$
$$2\text{Al}(\text{OH})_3 \xrightarrow[\text{IKC}]{\Delta} \text{Al}_2\text{O}_3 + \text{H}_2\text{O}$$

(Alumina)

$$\begin{array}{ccc} \text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O} + \text{Na}_2\text{CO}_3 & \longrightarrow & \text{NaAlO}_2 \\ + & & \downarrow \text{H}_2\text{O} \\ (\text{Fe}_2\text{O}_3 + \text{SiO}_2) & & \text{Al(OH)}_3 \\ \text{Impurities} & & \downarrow \text{Heat} \\ & & \text{Al}_2\text{O}_3 \end{array}$$
$$\text{Al}_2\text{O}_3 + 2\text{NaOH} \rightarrow 2\text{NaAlO}_2 + \text{H}_2\text{O}$$

(impure) (soluble)

$$\text{NaAlO}_2 + 2\text{H}_2\text{O} \longrightarrow \text{Al(OH)}_3 + \text{NaOH}$$

(ii) It is the heating process of Sulphide ore in the excess of air.

Roasting $\xrightarrow[\text{-SO}_2]{\text{Sulphide}}$ Mo

(iii) SO_2 gas is evolved

eg;

$$(iv) \begin{cases} 2ZnS + 3O_2 \xrightarrow{\Delta} 2ZnO + 2SO_2 \\ ZnS + 3/2 O_2 \longrightarrow ZnO + SO_2 \uparrow \end{cases}$$

(i) The main purpose of Calcination is form of ore into metal oxide metal oxide.

(ii) It is the heating process of hydroxide & carbonate are in the absence of air.

Calcination $\rightarrow$ $\begin{cases} \text{Hydrated ore} \\ - \text{H}_2\text{O} \\ \text{Carbonate} \\ - \text{CO}_2 \end{cases}$

(iii) CO_2 & H_2O gas is evolved according to its pres.

eg;

$$(iv) \text{CaCO}_3 \rightarrow \text{CaO} + \text{CO}_2 \uparrow$$

$$\text{MgCO}_3 \cdot \text{CaCO}_3 \rightarrow \text{MgO} + \text{CaO} + 2\text{CO}_2$$

The three basic chemical processes for separating metals from their ores are:-

- * 1, HYDROMETALLURGY.
- * 2, PYROMETALLURGY.
- * 3, ELECTROMETALLURGY.

- HYDROMETALLURGY utilizes a chemical solvent to leach (dissolve or separate) the metal from the ore, forming a solution from which the metal may then be obtained.

- PYROMETALLURGY uses heat to obtain the metal. It is then heated the metal oxide (roasted) with a reducing agent such as coke or charcoal, which frees the metal.

- ELECTROMETALLURGY makes use of electrical energy which may be used directly, as in electrolysis of solution or fused salt mixtures.

= Most metals are produced using the following procedure:-

1. Mining:- removal of the ore from the earth's crust.

2. Beneficiation or Concentration:- Beneficiation reduces the ore bulk & leaves a high grade, concentrated product.

• HYDROMETALLURGY :- (Leaching)

Principle:- Hydrometallurgy is based on the principle that more electropositive metal displace less electropositive metal from their salt solution.

Procedure:- The ore is treated with such chemical reagents which convert it into soluble compound. By the addition of more electropositive metal to the filtrate, metal present in the ore can be precipitated.

- By this method precious metals like Au, Ag, Pt are extracted as well as Cu are also extracted.

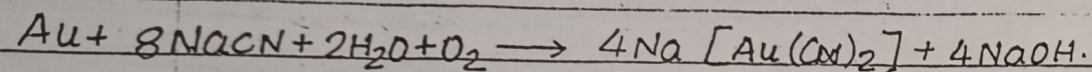
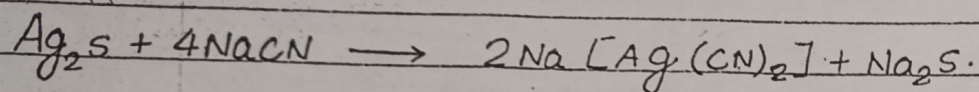
- In this process, powdered ore is first dissolved in a suitable solvent by complex formation.

Example:- Extraction of Copper
(a) Malachite ore is first ^{calcined} roasted
$$\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2 \rightarrow 2\text{CuO} + \text{H}_2\text{O} + \text{CO}_2$$

(b) Cupric oxide is dissolved in sulphuric acid
$$\text{CuO} + \text{H}_2\text{SO}_4 \rightarrow \text{CuSO}_4 + \text{H}_2\text{O}$$

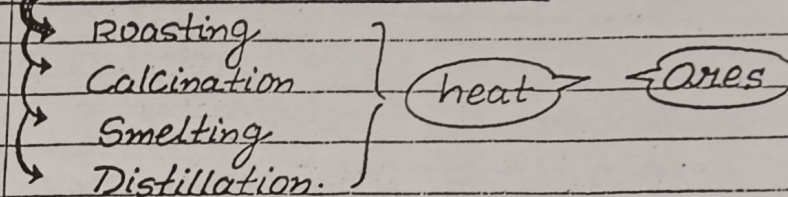
(c) Scrap iron is added in CuSO_4 solution
$$\text{CuSO}_4 + \text{Fe} \rightarrow \text{FeSO}_4 + \text{Cu}$$

Example:- Gold & Silver (Extraction)



- Strong electropositive metal is added to above salt solution from which metal is obtained.

• PYROMETALLURGY :-



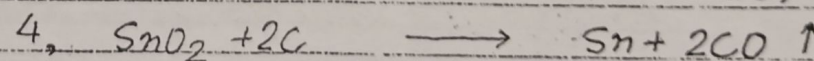
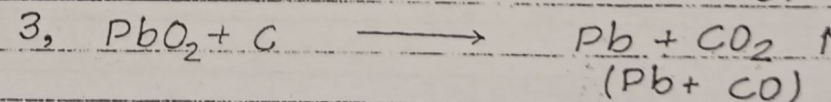
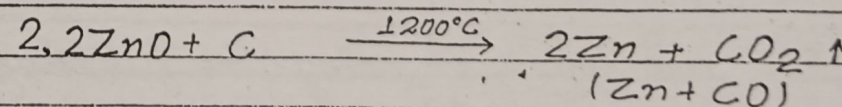
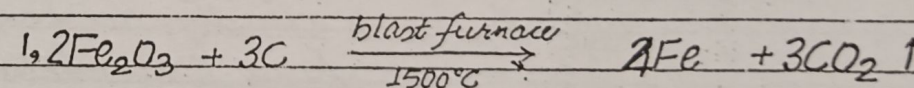
Principle:- In this method roasted or calcined ore is reduced into metal by using different reducing agent/method on the basis of different reducing agent used, different names are given.

- The extraction of a metal from its ore by a process involving melting is termed Smelting.

(i) Reduction by Carbon (Smelting):-

- Carbon is used to reduce metal oxide into metal.

Used for Fe, Co, Ni, Zn, Pb, Sn, Cu etc.



(ii) Reduction by Aluminium (Smelting):-

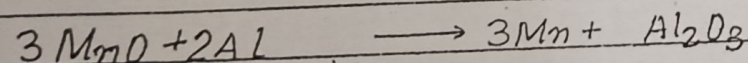
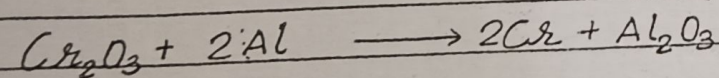
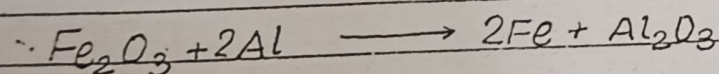
Aluminium are used to reduce metal oxide into metal. (Al as reducing agent)

This is also known as Aluminothermite process.

This process is employed in the case of those metals which have very high melting points and ore is to be extracted from their oxides.

Procedure:- A mixture of concentrated oxide ore and aluminium powder (thermite) is taken in a steel crucible placed in a bed of sand, the reaction is started by the use of ignition mixture containing magnesium powder & Barium peroxide.

Used for Fe, Co, Ni, Cr, Mn, W etc.

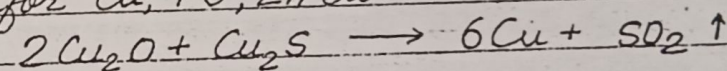


(iii) Self reduction process (Smelting):-

Metal oxide is reduced into metal by reacting it with compound of same metal.

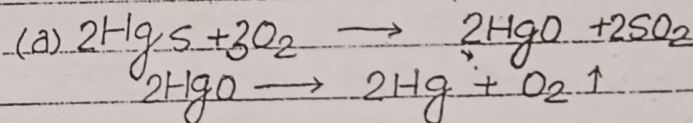
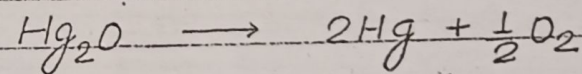
A number of metals occurs as sulphide (PbS, CuS) which may be roasted first in air to partially convert them to the oxide, and then further roasted in the absence of air, causing self reduction.

Used for Cu, Pb, Zn etc.



(iv) Thermal reduction process:-

Metal oxides of metals (like Hg, Au, Ag, Pt) are thermally unstable & hence metal can be directly obtained by heating.



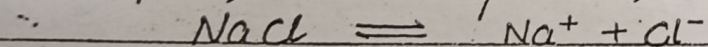
ELECTROMETALLURGY :-

- By this method strong electropositive metals like K, Na, Ca, Mg, Al, Cu are extracted.
- General process of metallurgy are not applicable for such metals because these metals are strong reducing agent and hence, other reducing agent can't reduce metal oxide into metal.

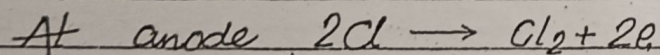
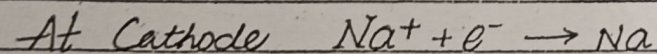
- Further, if Carbon is used as reducing agent then metal oxides convert into metal but the metal formed is so reactive that it combines with Carbon to form metal Carbide.

- The metal is liberated at Cathode.

Examples, (Down's process) on fusion



On electrolysis

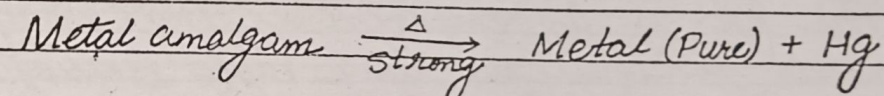
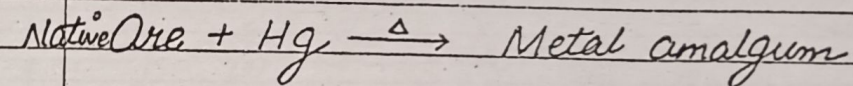


Note :-

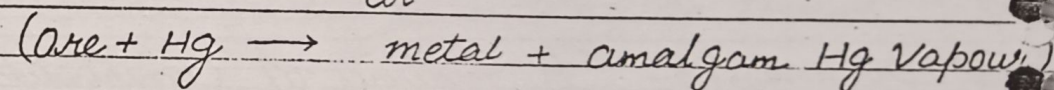
Molten / fused salt is taken as electrolyte because aqueous solution liberate H_2 at Cathode in place of metal.

AMALGAMATION PROCESS :-

- This method is used for the extraction of noble metals like Au, Ag etc., the finely ground ore is brought into contact with mercury, which takes up the metal is then recovered by distilling its amalgam.



"Ore"



- By this method Au, Ag & Pt are obtained / extracted.

PREPARATION OF ORE

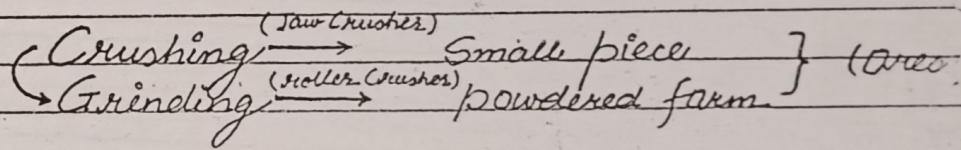
desired

* CRUSHER :- A Crusher is a machine designed to reduce large rocks into small rocks, gravel or rock dust (powdered form).
(or) (ins)

CRUSHING & GRINDING.

The big stones of ores are first crushed. Small pieces in Jaw Crusher & Gyratory Crusher (primary crusher) is called crushing and to powdered form with the help of roller (fine crusher) is called grinding.

This crushing & grinding process are called pulverisation of ore.



Types of Crusher :-

- a. Jaw Crusher
 - b. Gyratory Crusher
 - c. Cone Crusher
 - d. Roll Crusher
 - e. Impact Crusher
- } (primary crusher)
- } (fine crusher)
- } (secondary crusher)

(Classified according to size reduction factor.)

A Crusher may be considered as primary, secondary or fine crusher depending on the size reduction factor.

a. Primary Crusher:-

The raw material from mines is processed first in primary crusher.

The input of such crusher is relatively wider and the output products are coarse in size.
eg; Jaw Crusher & Gyratory Crusher.

b. Secondary Crusher:-

The crushed rocks from primary crusher are sent to secondary crusher for further size reduction.

eg; Cone Crusher, reduction Gyratory Crusher, Spring rolls, disk Crusher etc.

c. Fine Crusher:-

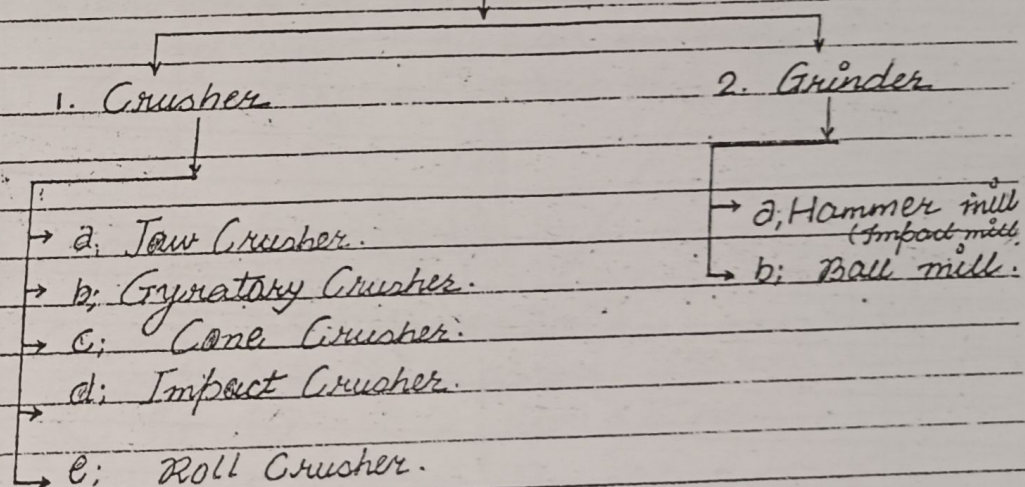
Fine crusher have relatively small opening, and are used to crush the feed material into more uniform and finer product.

eg; Gravity Stamp, roller etc.

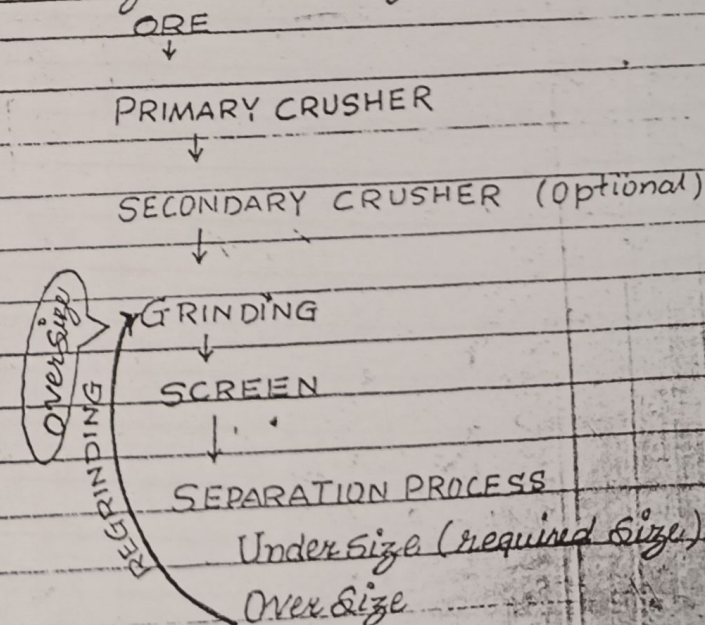
Types of Grinder

- ✓ a. Hammer mill.
- ✓ b. Ball mill.

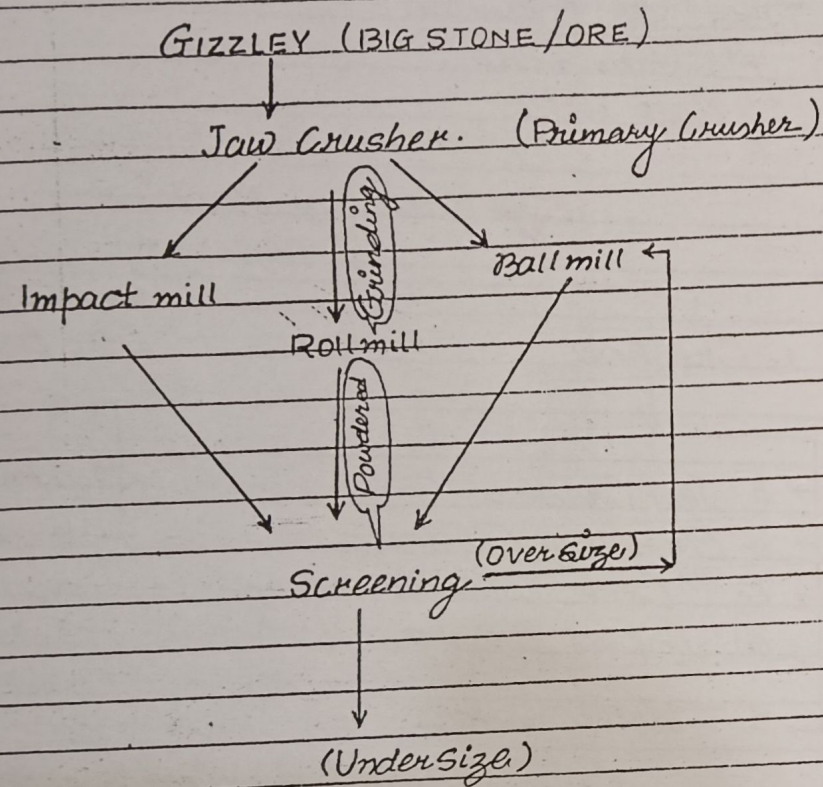
Size Reducing Machine



Crushing & Grinding

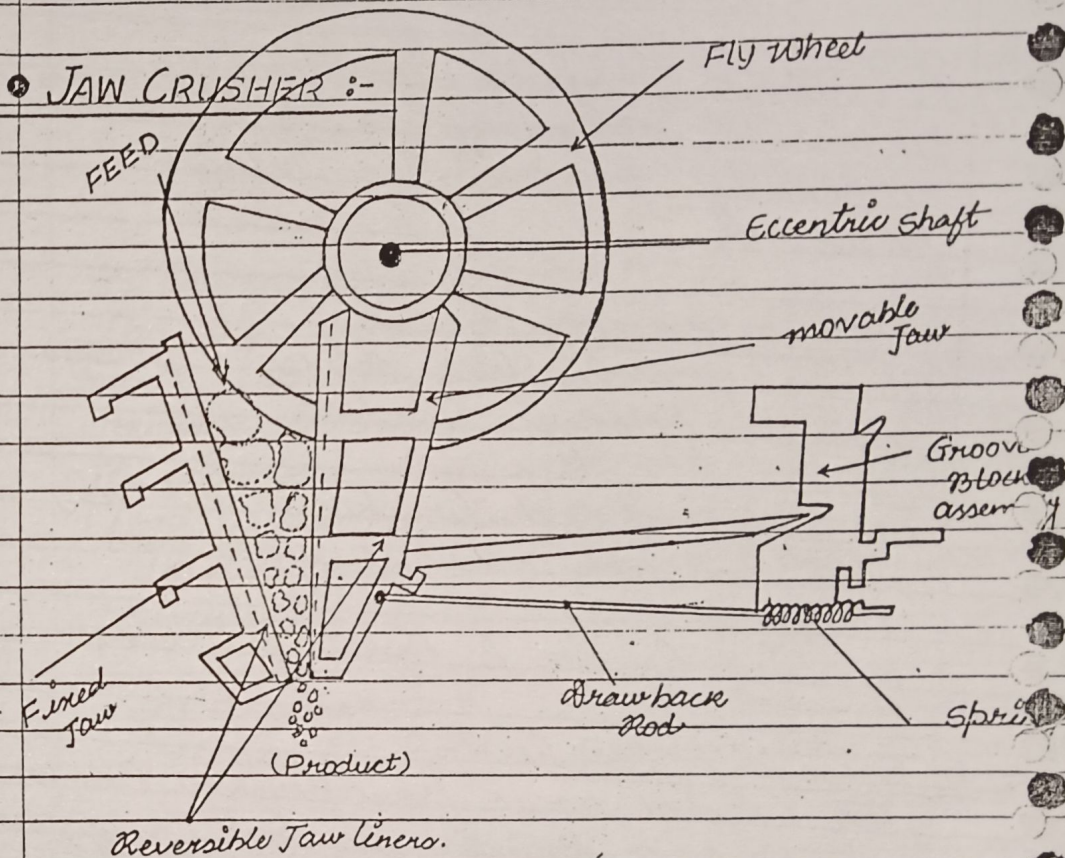


Usual Micro-scale Circuit (operation)



CRUSHER & IT'S WORKING PRINCIPLE

• JAW CRUSHER :-



FIELDS OF APPLICATION :-

- Jaw Crushers are used for primary crushing of a wide variety of materials in the mining, iron and steel and pit industries.

FEED MATERIAL :-

- Rock ranging from medium hard to extremely hard as well as different kind of ore and other hard materials.

THE MODE OF OPERATION :-

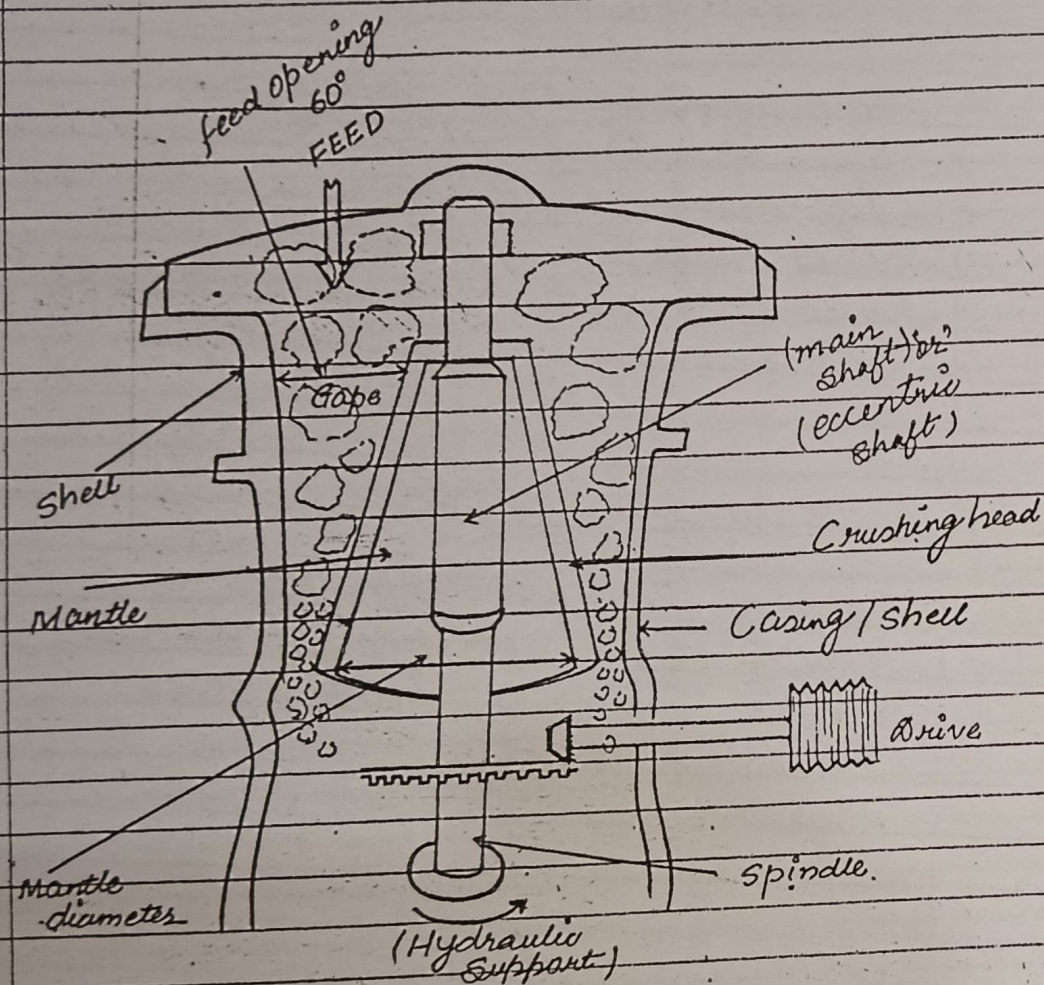
- Jaw Crushers are equipment with one fixed and one movable crushing jaw, both of which support crushing plates in several versions.
- Walls of the crushing zone are made of replaceable wearing sheets. Crushing is done between the two crushing jaws. The moving jaw of the single toggle jaw crusher moves elliptically.
- A pendulum motion is being carried out by the double toggle jaw crusher.
- The crushing force is produced by an eccentric shaft, then it is transferred to the crushing zone via a toggle plates system and supported by the back wall of the housing of the machine.
- A flywheel is provided in the form of a pulley.
- Due to the favourable angle of dip between the crushing jaws, the feeding material can be reduced directly after entering the machine.
- The final grain size distribution is influenced by both, the adjustable crusher setting & the suitability of the tooth form selected for

ADVANTAGES :-

- High and Constant Capacity.
- High operational reliability.
- Long Service & Lifetime.
- Broad range of application.
- easy replacement of wear & spare parts.
- Low maintenance requirements.

SCOPE OF APPLICATION :-

- Capacity - upto $450 \text{ m}^3/\text{h}$.
- Feeding Size - upto approx 1250 mm.
- Size of final grain - upto $< 20 \text{ mm}$
- Reduction ratio - 1:7
- Required power - upto 200 kW.

* GYRATORY CRUSHER :-

- Gyratory Crushers are used for primary crushing of wide variety of materials in the mining.

- Feed material - hard rock (ores)

- Gyratory Crushers are crushing equipment. Crushing head, are made up of hard materials.

lined Carbide steel or hard steel.

- Shell (casing) - Stainless Steel.

- Crushing ^{head} are moved by the help of main shaft or eccentric shaft.

- eccentric shaft are rotated by the help of power supply or electricity.

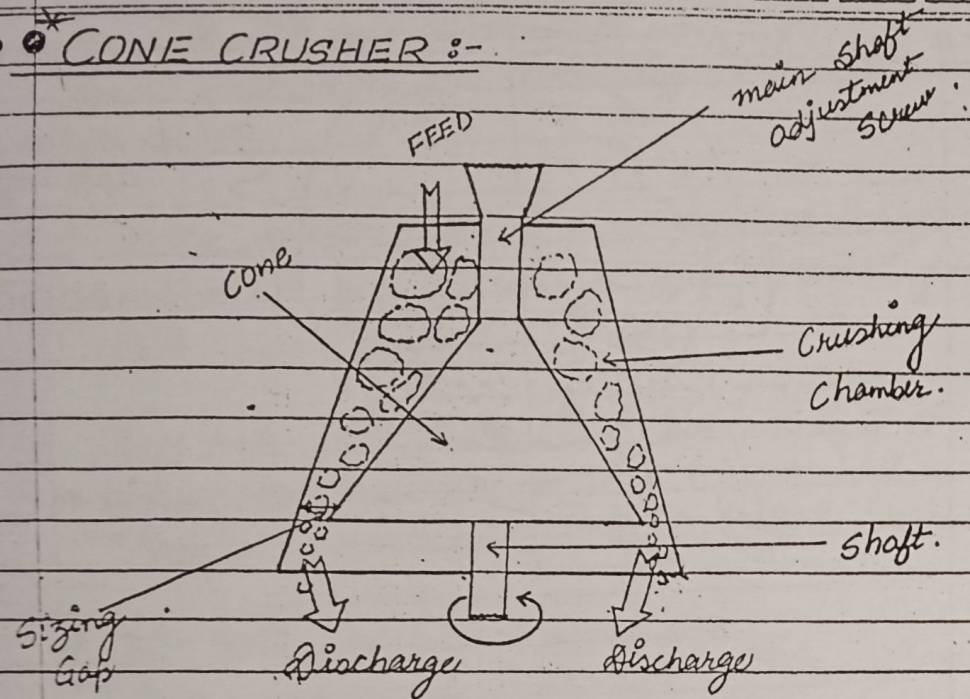
- moving rate of crushing head are 125-425 RPM.

- Big Stone are feed from the hopper & the feed ores are crushed between the shell & crushing head.

- Gyratory Crushers Convert big stone into small stone.

- During crushing, the lumps are crushed continuously. At the desired size and after the desired size ball are discharge through the discharge gap between the shell & the (bottom portion) crusher head.

- Capacity 4500 tonne/hours.

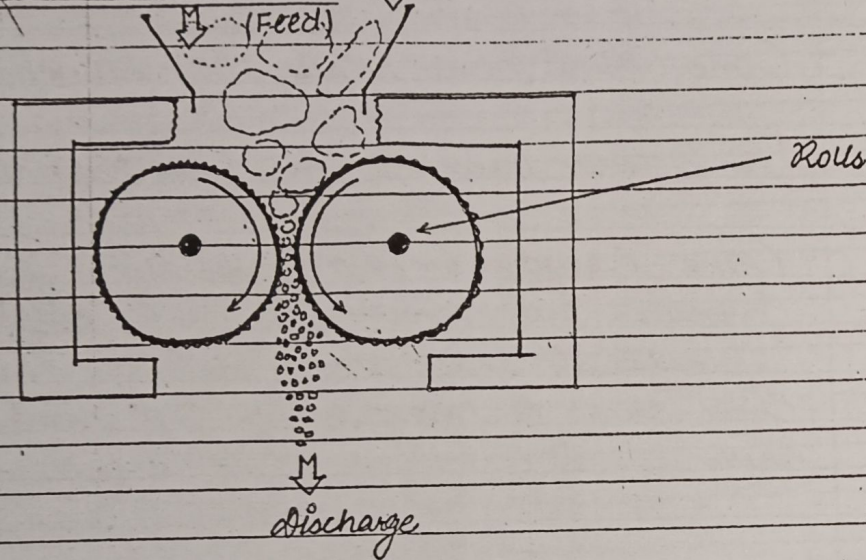
DATE * CONE CRUSHER :-

- Cone Crusher are used for both primary & optional crushing of the big lump or stone to reduce its size.
- Cone Crushers are crushing equipment, used for producing small desire size particles or stone.
- Cone (shaft) rotates at high speed and crushed the lump into small particles.
- Feed are inlet from the top or hoppers & product are discharge from the bottom of the equipment.

DATE

- Cone (shaft) are rotate 100-150 Rpm.
- Lump are crushed in crushing chamber.
- Cone Crusher, the crushing force is produced by an main shaft (cone), then transferred into the crushing chamber via cone and supported by the wall of the shell.
- The required material/product are discharge through the gap between the cone and the wall of the shell.
- Shell - stainless steel.
- Capacity - 3000 tonne/hours.

• ROLL CRUSHER :-



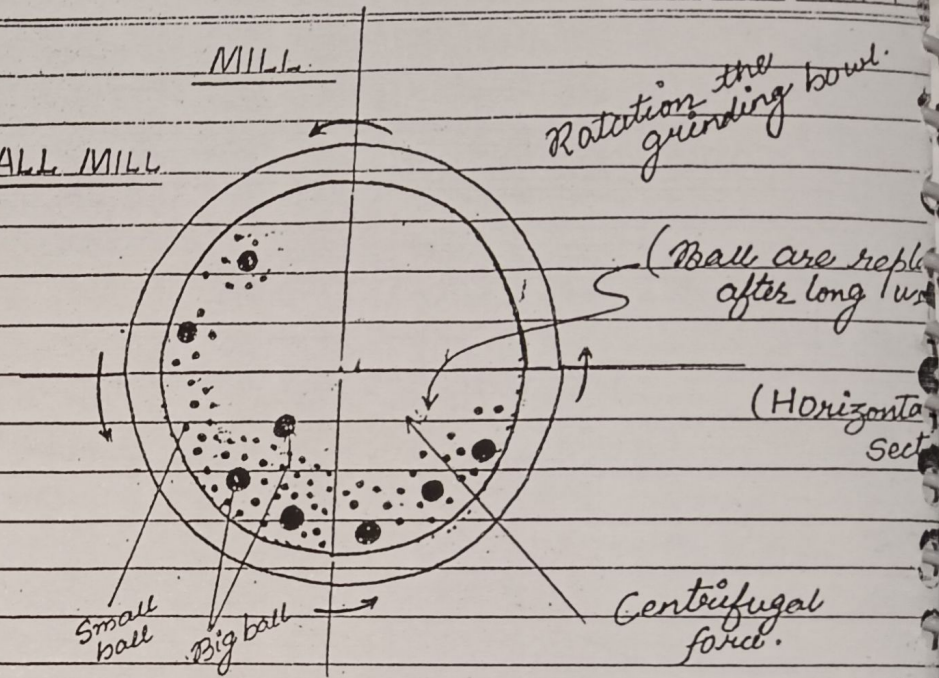
- In this operation, the roller are moves in opposite direction.
- Roll Crushers are used for both primary, Secondary, or final Crusher.
- The Size of Crushing produced is Very Small than feed.
- Feed are dropped from hopper.
- Feed Size 25-75 mm
- Product Size 10-20 mm

NOTE:-

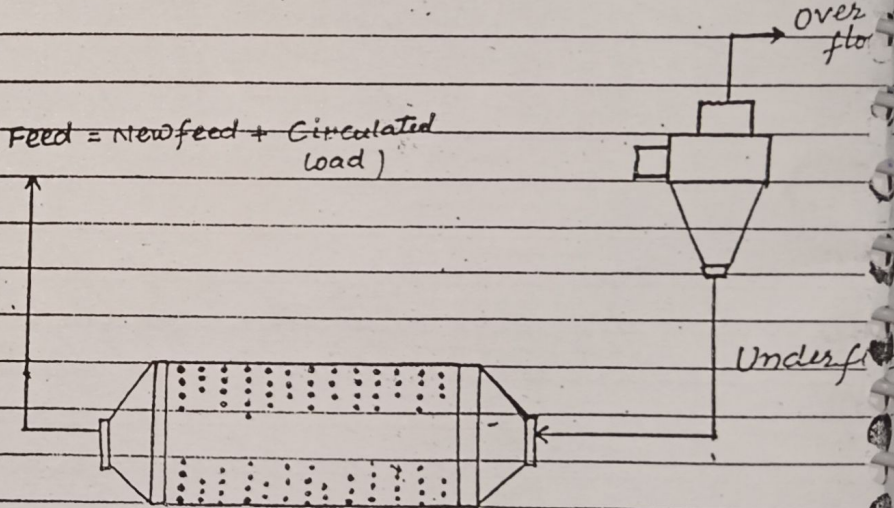
MESS NO. - (Per linear inch, no. of holes (holes-rectangular/circle))

classmate

* • BALL MILL



(Feed = New feed + Circulated load)

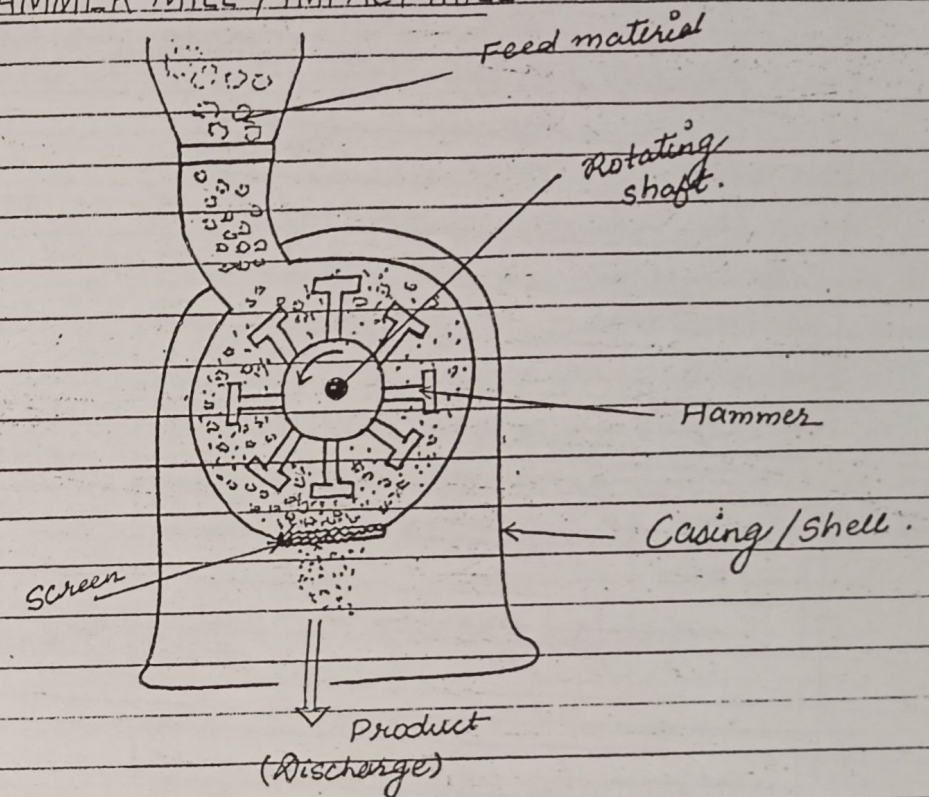


- Ball mill is most economical Grinding equipment.
- Ball mill Convert Crushed product into powdered form.

classmate

- Ball are used for grinding the Crushed product.
- Two or three types of ball are used in this equipment for grinding the Crushed product or feed.
- Ball ball used to Convert big ball into Small ball of the feed material & the Small ball used to Convert Small ball into powdered form.
- 30-50% ball are used for grinding the feed, ball are made up of hard Steel or Carbide Steel.
- Angle hopper are better than straight hopper because in angle hopper the feed flow easily or smoothly.
- Grinding capacity $\rightarrow$ 1-50 tonne/hour.
- Drive gear are used to adjust the speed of rotation.
- Crushed product Convert into powdered form due to abbration between steel ball & feed. Centrifugal force are worked.

HAMMER MILL / IMPACT MILL :-



- Shell - Stainless Steel.
- After Crushing the big lump, the feed or Crushed product sent to the ball mill or Impact mill for further operation.
- Feed are Crushed or abbrased between Shell and hammer.
- Centrifugal force are worked during grinding
- final product or powdered ore are discharge through Screen.
- Over Size again grinding untill to required mess size.

IMPORTANT TERM:-

Density :- The ratio of mass to Volume

$$\text{Density} = \frac{\text{mass}}{\text{Volume}}$$

(Mass is the amount of inertia or substance
 & Volume is the space occupied $\square$ (l x b x h))

Specific Gravity :-

Is the ratio of the density of object to the density of water.

$$\text{Specific gravity} = \frac{\text{Substance density}}{\text{density of water}}$$

Notice - the units Cancel out.

Note:-

$$\text{The density of water} = \frac{1000 \text{ kg/m}^3}{1 \text{ g/mL}}$$

$$1 \text{ cm}^3 = 1 \text{ mL}$$

cm^3 Vs mL

If the substance is a Solid - cm^3

If the substance is a liquid - mL

COPPER

element (d-block element)
 it is element of great
 tactical importance. it
 strength, malleability,
 resistance and its
 electricity and heat).

Color - Brown. m.p. - 1082°
 b.p. - 2310°

Atomic number - 29

Atomic weight - 63.54

Oxidation state (+2)

Period - Group - 11
 period - 4

Electronegativity - 8.95

Classified as:-

CuFeS_2 (chief ore)

Cu_2S

Other - Cu_2O

$\text{CuCO}_3 \cdot \text{Cu(OH)}_2$

$\text{CuSO}_4 \cdot 3\text{Cu(OH)}_2$

DATE IMPORTANT TERM:-

- Jharkhand is rich in mineral resources such as Coal

Density :- The Fe (27.3% of India's reserves),

Density = iron ore (26% of India's

- reserves), Copper ore (18.5

(Mass is the amount percent of India's reserves),

& Volume is the of Uranium, mica, bauxite,

granite, limestone, Silver,

graphite magnetite and

dolomite.

Specific Gravity:-

Is the ratio of the

the density of w - Jharkhand is the only state in India to produce

Specific gravity = Coking Coal, Uranium and pyrite.

Notice - the units can

Note:-

The density of water

$1 \text{ cm}^3 = 1 \text{ mL}$

cm^3 Vs mL

If the substance is

If the substance is

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DATE

3. extraction of copper

Copper - Metallic element (d-block element)
(Copper is a metallic element of great technological & historical importance. It is valued for its strength, malleability, ductility, corrosion resistance and its ability to conduct electricity and heat).

Colour - Reddish Brown.	m.p. - 1083°C
Symbol - Cu	b.p. - 2310°C
Latin name - Cuprum.	
Atomic number - 29	
Atomic mass - 63.54	
Valency - +1, (+2)	
Placed in Periodic table - Group - 11	period - 4
Specific gravity - 8.95	

Main Ores:

Ores of Copper are classified as:-

Sulphide Ores

- (i) Copper pyrite - CuFeS_2 (chief ore)
or Chalcopyrite
- (ii) Copper glance - Cu_2S
or Chalcocite

Oxidized Ores

- (i) Cuprite (ruby copper) - Cu_2O
- (ii) Malachite - $\text{CuCO}_3 \cdot \text{Cu(OH)}_2$
- (iii) Brochantite - $\text{CuSO}_4 \cdot 3\text{Cu(OH)}_2$

NOTE :-

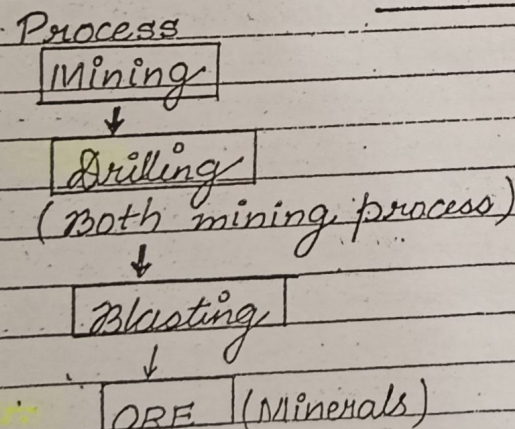
Occurrence:- The largest and the best known deposits are USA, Canada, Chile & India (Bihar / Jharkhand, Rajasthan, Tamil Nadu,

NOTE:-

NOTE:-
The two major method of obtaining Copper ore from the ground are:-

- (i) Openpit mining.
- (ii) Underground mining.

- Open pit mining is more extensively used today, since its costs are less than underground mining.

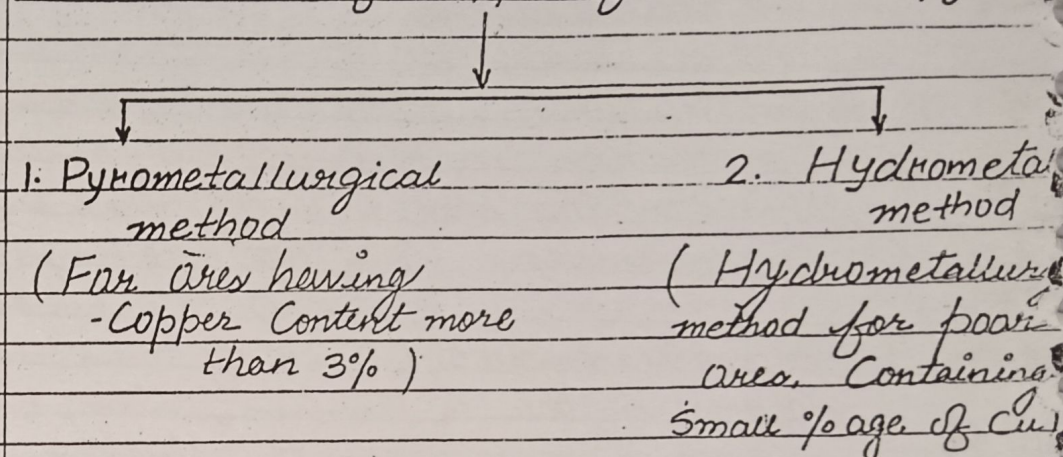


NOTE :- Mainly Copper ore found in Mosabari mines in Singhbhum district of Jharkhand & Khetri mines of Rajasthan

PAGE

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Extraction of Copper from Copper pyrite.



● PYROMETALLURGICAL METHOD :-

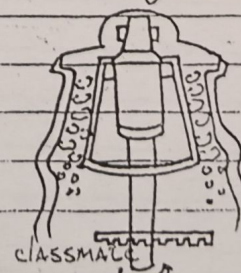
- Various steps involved in getting metal from copper ore are:

1. Crushing & Grinding :-

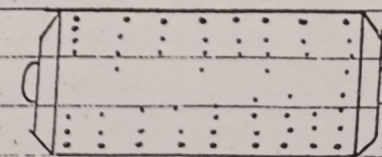
- The Sulphide Ores may Contain only 0.4 - 1% Cu.

These are Crushed & Grinding, the size of the pieces of ore is reduced, first of all to about that of fine sand.

- Primary Crushing & Secondary reduction process by the help of Jaw Crushers or Gyratory Crushers & ball mill.



Reduce the
one size



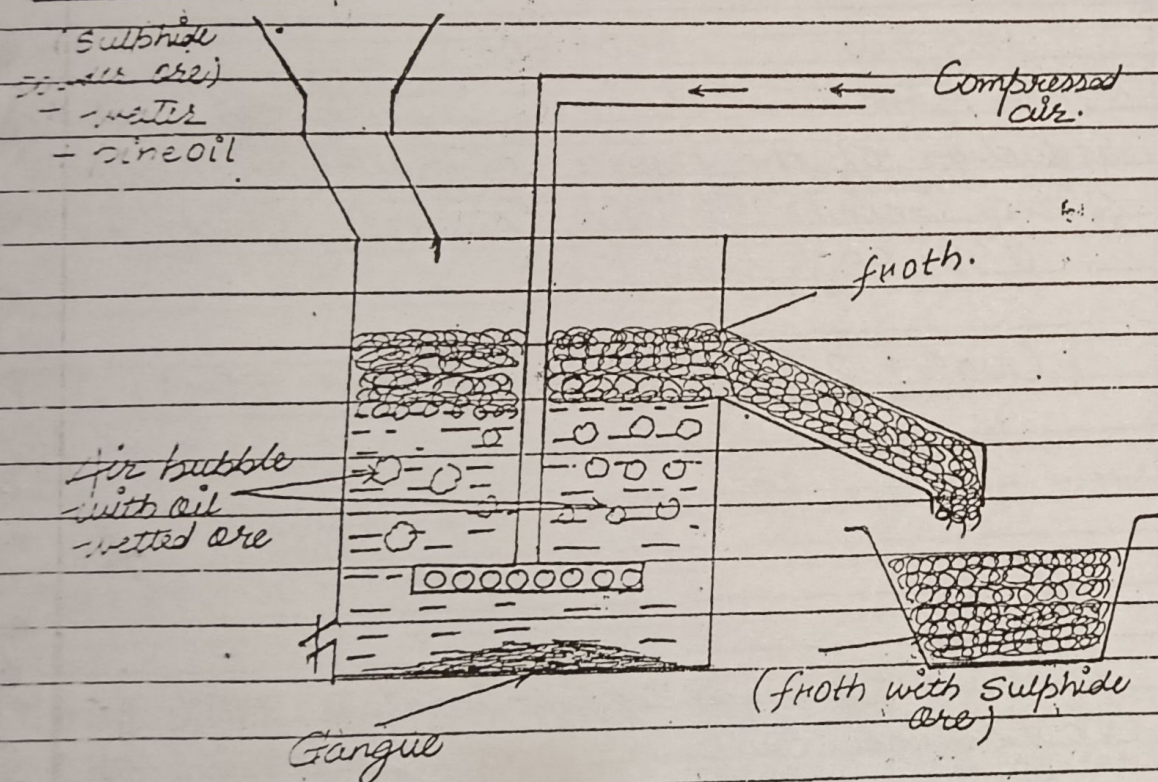
(Ball mill)

powder
for

2. Concentration :-

Concentration - elimination of waste material or gangue present in ore in order to increase the metal content of the product.

Froth flotation process :-



- Froth flotation process is used to separate the useful material from the waste matter.

- When air is blown into water, bubble form and rise to the surface. The ore particles adhere to these bubbles and the gangue gets wetted by water.

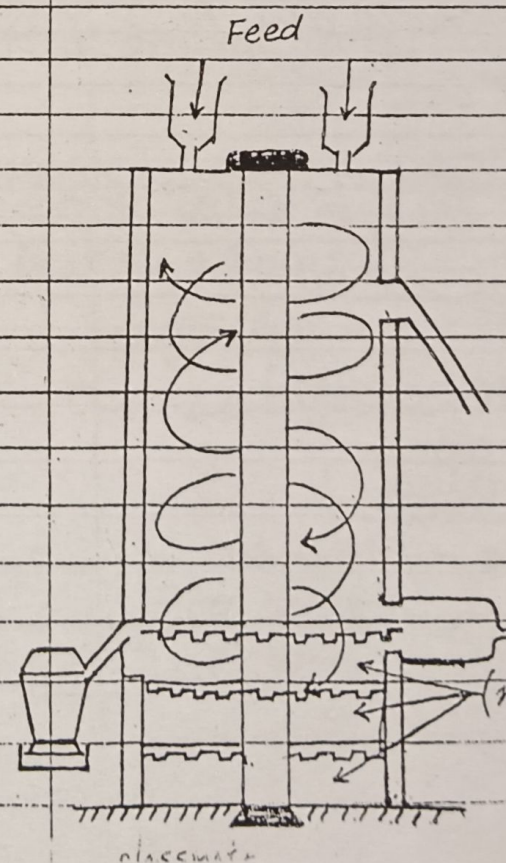
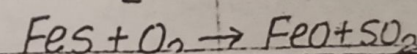
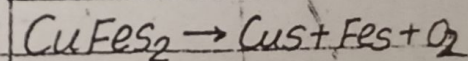
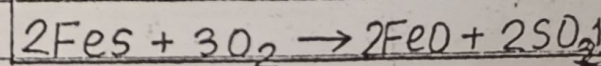
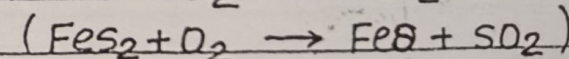
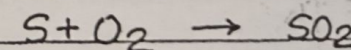
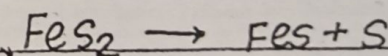
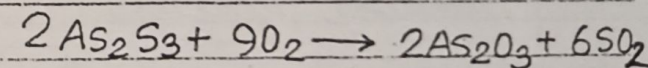
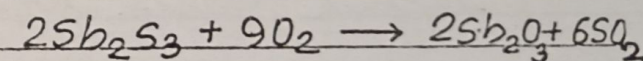
- Froth flotation, giving a concentrated ore with 15% - 25% Cu. PAGE

3. Roasting :-

Roasting is the operation of heating sulphide ores in air to convert into oxide.

- The dried concentrated ore as received from froth flotation process & roasted in a multiple-hearth furnace or reverberatory furnace.
- (a) Excess sulphur & such elements as arsenic and antimony which form volatile oxides burn off.
- (b) Much of iron oxide is formed from iron sulphide.
- (c) Desired % of sulphur remains in concentrated ore.
- (d) Ore particles do not fuse.

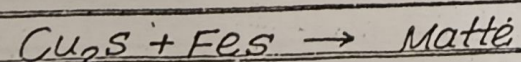
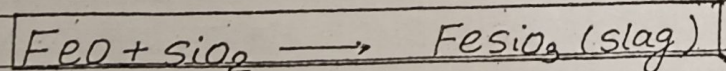
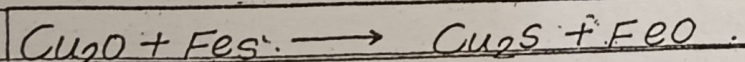
- Roaster reactions :-



4, Smelting :-

- Smelting is carried out in a reverberatory furnace ^(blast furnace) heated by coal, oil or gas to temperature between 1370°C & 1480°C .
- Roasted ^{Calcined} ore melts and much unwanted matter is change into slag.
- Copper Compounds are converted to cuprous sulphide, and a considerable portion of iron changes to ferrous sulphide.
- Cuprous sulphide & ferrous sulphide dissolved in each other in the molten state to form matte. Which contains 45% Cu.
- Slag being less dense floats over the matte and is periodically removed from the smelting operation. Matte also be tapped when required.

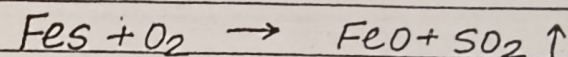
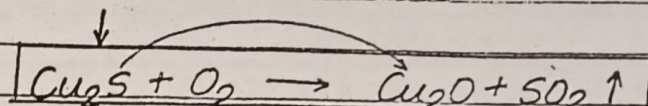
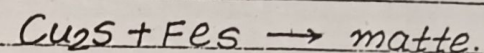
Smelting reaction :- (Sand is added to remove the iron as iron silicate)



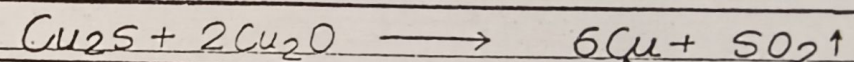
Matte - 45% Cu

5, Converting / Bessemerisation :-

- Bessemerisation / Converting operation produces raw copper (Blister Copper) from matte which is the product from smelting operation.



- After some time the air is turn off and reduction of the oxide & sulphide occurs giving impure "blister copper" which is 98-99% pure Cu.



Blister Copper
98-99% pure

- Blister Copper is approximately 98% pure. It contains sulphur, iron & arsenic as the main impurities.

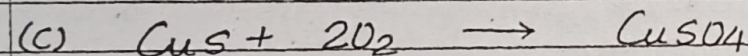
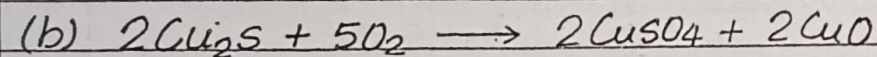
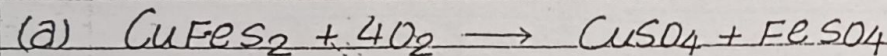
- As the molten Cu solidifies, a considerable quantity of gas is given off. The gas bubbles break at the surface of Cu and leave marks resembling those of broken blister. That is way, the copper is known as Blister Copper.

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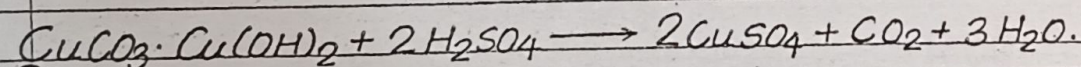
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● HYDROMETALLURGICAL METHOD :- (WET PROCESS) :

- Low grade ore is crushed and exposed to air and water when Copper Sulphide is oxidised to CuSO_4 .

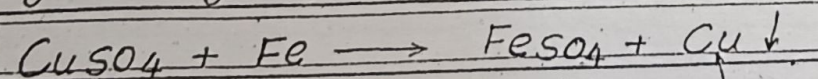


- In non-sulphide ores, the crushed ore is leached with dilute sulphuric acid.



(leaching) (Malachite) (dilute sulphuric acid)

- Copper is precipitated from CuSO_4 solution by adding scrap iron.



NOTE:-

Oxygen is not harmful, the effect of oxygen on the mechanical properties of copper is minimum. However, impurities such as sulphur, bismuth, antimony are harmful effect on mechanical & electrical properties of Cu. and have to be removed during refining.

Copper is precipitated

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DATE

Jharkhand is famous for its rich mineral resources like Uranium, Mica, Bauxite, Coal (32% of India) Iron, Copper (25% of India) etc.

ALUMINIUM

very white metal

m.p - 659.8°C b.p - 2200°C

Jharkhand is also known for its vast forest resources

Group-13, period-

is most abundant metal

discovered by Oersted

most reactive metal (free in nature)

amphoteric metal, with base as well

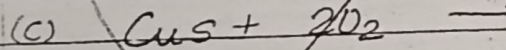
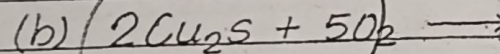
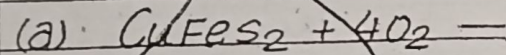
other elements:-

Sn	Pb	Al
(Tin)	(lead)	(Aluminium)
(stannum)	(plumbum)	

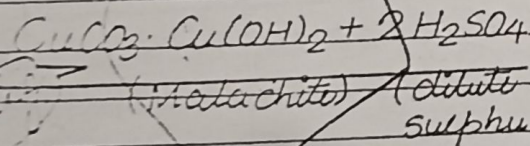
CLASSMATE

• HYDROMETALLURGIC (WET PROCESS):

- Low grade ore is to air and water is oxidised to Cu



- In non-sulphide ore is leached with acid.



- Copper is precipitated by adding scrap



NOTE:-

Oxygen is not harmful, the effect of on the mechanical properties of copper minimum. However, Impurities like Sulphur, bismuth, antimony are harmful on mechanical & electrical properties

ये Acid और Base के साथ React कर सकते हैं।
इसलिए इसे Amphoteric कहते हैं।

4.
EXTRACTION OF ALUMINIUM

Aluminium - metallic element.

Symbol - Al

Colour - Silvery white metal

Specific gravity - 2.7

atomic no. - 13

atomic mass - 27

Valency - +3

m.p - $659.8^\circ C$

b.p - $2200^\circ C$

Position in periodic table - Group-13, period-3.

- Aluminium is the most abundant metal in the earth crust.

- Aluminium was discovered by Oersted in 1825.

(Aluminium is a most reactive metal and so does not occur free in nature.)

Note:-

Aluminium is Amphoteric metal, Aluminium react with base as well as with acids.

Trick to learn Amphoteric elements:-

संक्ष	ज	कि	आश	सुनो	प्रभु	अल्ल
↓	↓	↓	↓	↓	↓	↓
Sb	Zn		As	Sn	Pb	Al
(Antimony)			(Arsenic)		(lead)	
(Stibium)	(Zinc)			(Tin)	(plumbum)	(Aluminium)
				(stannum)		

NOTE:-

Aluminium is the most abundantly occurring metal in the earth's crust.

- After Oxygen and Silicon this is the third element which occurs so abundantly in large amount.

- The main ore of it is Bauxite, Aluminium is mainly extracted from bauxite by the means of electrolytic process.

- The chemical name of bauxite is hydrated alumina.

$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$ - (Aluminium ore) Bauxite	hydrated Alumina (chemical name)
---	-------------------------------------

- Aluminium Ores occur in India, Aluminium Ore occurs in Madhya Pradesh, Maharashtra, Kashmir, Madras, Tharukhand & Bihar etc.

- Bauxite Contains 60% Al_2O_3 , the rest being Sand, ferric oxide and Titanium oxide etc.

- An Indian bauxite contains:-

Al_2O_3	-	60%	Aluminium oxide
Fe_2O_3	-	5%	ferric oxide
SiO_2	-	1%	Silicon oxide
TiO_2	-	12%	Titanium oxide
H_2O	-	22%	Water

di hydrogen monoxide

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Occurrence:-

- Bauxite occurs as large isolated deposits in tropical regions.

Bauxite producing Countries are:-

USA

France

Greece

Australia

India

Hungary

Queensland

Guyana

Jamaica

Surinam etc.

भारत में

MP

Tharukhand & Bihar

Kashmir

Maharashtra

Tamil nadu

Aluminium Ores:-

Na_3AlF_6 sodium Hexa-fluoroaluminate.

Ore	Formula	Chemical name
1. Bauxite (chief)	$\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$	Hydrated alumina
2. Gibbsite	$\text{Al}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$	
3. Cryolite	Na_3AlF_6	Sodium aluminium
4. Corundum	Al_2O_3	Anhydrous aluminium oxide
5. Kaolin	$\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$	

NOTE:-

Bauxite is generally contaminated with ferric oxide (Fe_2O_3) & silica (SiO_2).

- The Critical Impurities is silica (SiO_2).

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EXTRACTION OF ALUMINIUM

- Hall & Heroult in 1885, developed the process for the extraction of aluminium.
- In around 1886 the introduction of the Hall & Heroult electrolytic process made the way clear for the industrial production of Aluminium.

Trick to learn purification of Bauxite:-

- Bayer's process (If iron oxide is present as a major impurities) $[Fe_2O_3]$
- Serpeck's process (If silica as a major impurities) $[SiO_2]$
- Hall's process (Impurities present are $Fe_2O_3 + SiO_2 + TiO_2$)

Comminution:- (Crushing & Grinding)

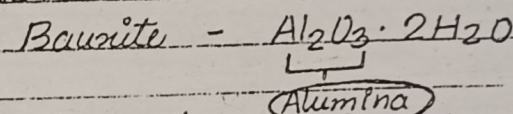
- The Ore is Crushed and the impurities are removed from ores by Concentration process. This step is referred to as Comminution.

ORE $\rightarrow$ Crushing & Grinding $\rightarrow$ Concentrated (removed impurities)

* Purification of Bauxite ore:- 301 Al

1. Bayer's process:- (Fe_2O_3 as a major Impurities)
(Concentration of ore or purification of ore i.e., Conversion of Bauxite into Alumina)

NOTE:-



First of all:-

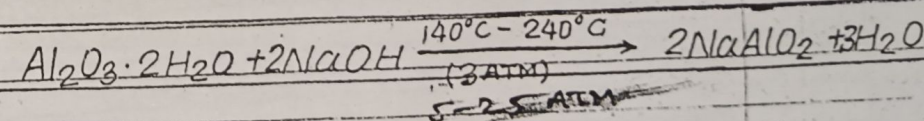
Crushing & Grinding and then Bauxite ore purified by leaching process

- The process employed on leaching depends on types of Impurities present in $Al_2O_3 \cdot 2H_2O$. Impurities present are $Fe_2O_3 + SiO_2 + TiO_2$

- There are 3 process used in leaching

Step-I

- Bauxite is grinding finely and heated to remove Volatile impurities. (3 atm (3.5 atm))
- It is then heated under pressure (3 atm) with Conc. Caustic Soda ($NaOH$) solution for 2 to 8 hours at $140^\circ C - 240^\circ C$.

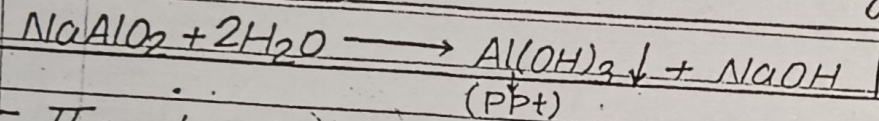


Bauxite dissolved and forms Sodium aluminate, leaving behind insoluble impurities called Red mud. Red mud consist of ferric oxide, sand etc, which are removed by filtration.

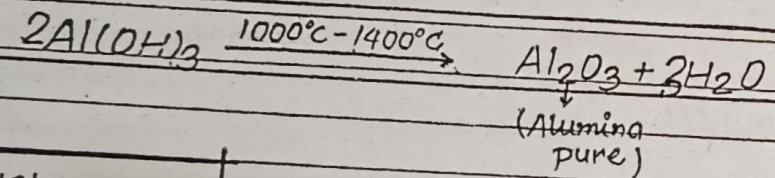
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On diluting Sodium aluminate with water and cooling 50°C , Sodium aluminate is hydrolysed to give aluminium hydroxide as a precipitate.

The impurities dissolved in sodium hydroxide.



The precipitate is filtered, washed, dried and ignited at $(1000^{\circ}\text{C} - 1400^{\circ}\text{C})$ to get alumina.

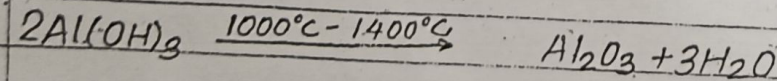
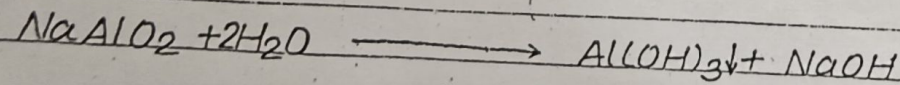
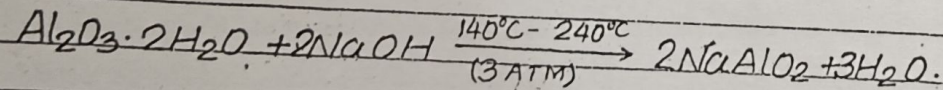


Note:-

The filtrate containing sodium hydroxide (NaOH) is again used to extract alumina from Bauxite.

Summary:-

Main reaction in this process may be summarised as follows:-



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Further process:-

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From pure Al_2O_3 , Al is obtained by electro. The main difficulty in extraction of Al is:-
(i) Al_2O_3 has very high m.p. (2100°C)
(ii) Al_2O_3 has highly covalent in nature
Both of these difficulties have been removed by adding large amount of flux as Cryolite (is) & (CaF_2) Fluorspar (About 80%)

Electrolytic reduction of fused alumina

Hall-Heroult's process:-

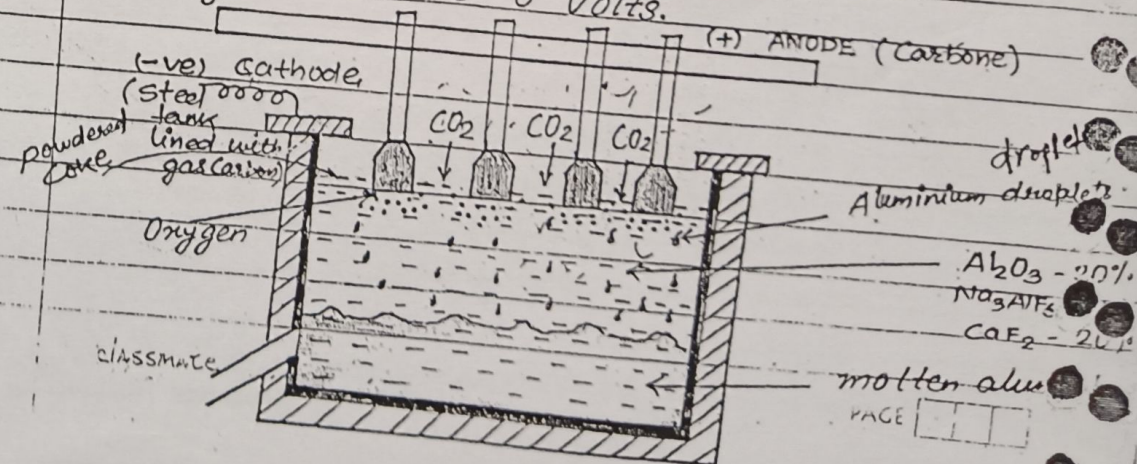
Electrolytic Cell: Rectangular steel tank with sloping bottom. The sloping bottom of the tank facilitates the removal of the molten alumina. The tank is lined with gas carbon.

Electrolyte: It is a mixture of molten:-
Alumina (Al_2O_3) - 20%
Cryolite (Na_3AlF_6) - 60%
Fluorspar (CaF_2) - 20%
1:3:1

OIL - Loss of
PAD - +ve, Anode
NCR - -ve, Cathode
RIG

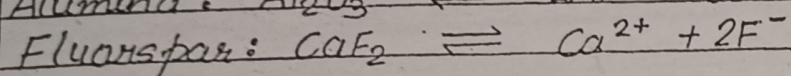
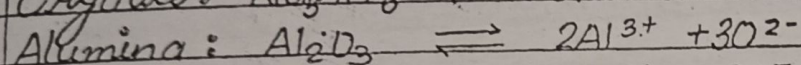
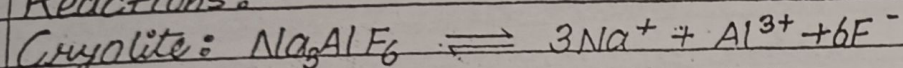
Temperature: 950°C

Voltage used: 5-6 Volts.



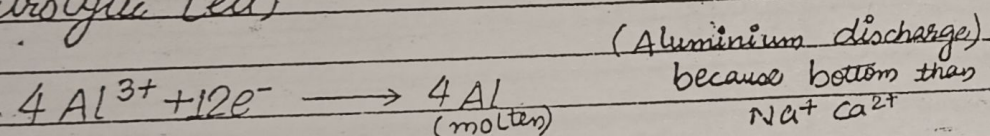
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Reactions:-

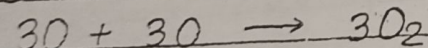
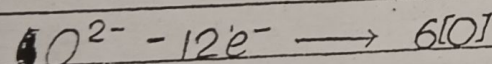


- Positive ions formed in the solution are Na^+ , Ca^{2+} & Al^{3+} while negative ions formed in the solution are F^- & O^{2-} .
- Aluminium being lower in electrochemical series is preferentially discharged at the cathode while oxygen at the anode.

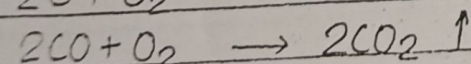
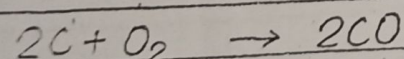
Cathode:- (Inner Carbon lining of the electrolytic cell)



Anode:- (Thick rod of graphite are suspended into the fused electrolyte)



Anode is oxidised to Carbon monoxide, which further forms Carbon dioxide.



NOTE:-

Anode has got to be replaced from time to time as it gets oxidised.

- When the supply of alumina decreases, the voltage suddenly jumps from 40-60 volts. If a bulb is attached to the apparatus, it will glow.

- Aluminium obtained is 95-99% pure.

Further purification can be done by electrolysis.

- Aluminium extracted from Hall and Heroult's process is further refined to about 99.99% by Hoop's process.

• Hoop's process:- (Re-finishing process)
(electrolytic refining of Aluminium)

- Further purification of aluminium may be done by Hoop's process.

- The electrolytic cell consists of 3 liquid layers of different specific gravity.

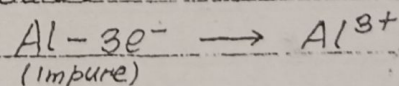
(a) Top layer: Pure aluminium, acts as Cathode.

(b) Middle layer: mixture of fluorides of sodium, barium and aluminium.

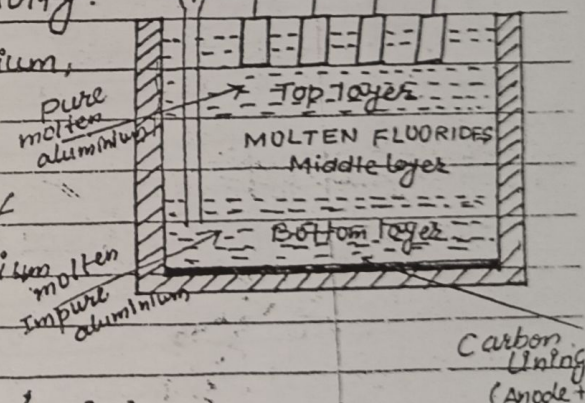
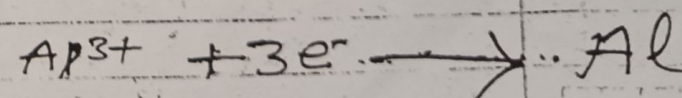
(c) Bottom layer: Impure aluminium, acts as anode.

Reaction:-

Anode:-



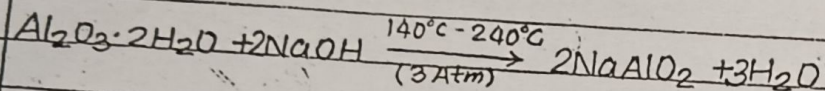
at Cathode:-



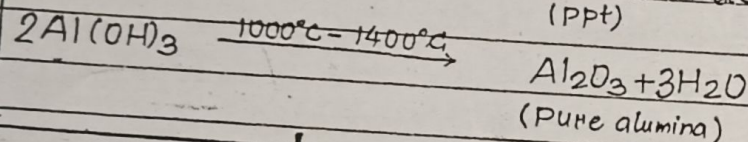
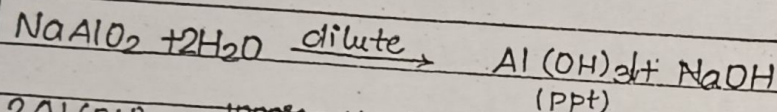
Flow chart for extraction of aluminium.

ORE - Bauxite $\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$

Concentration by NaOH to obtain Al_2O_3 .



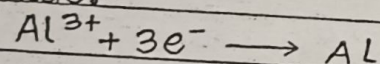
(BAEYER'S process.)



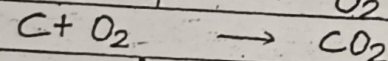
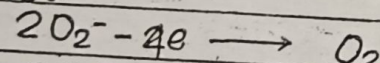
Electrolytic reduction of alumina.

Electrolyte: Alumina: Cryolite: Fluorspar

Cathode:-



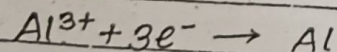
Anode:-



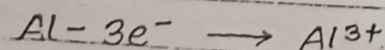
(Hall-Heroult's process)

Refining of Aluminium
electrolyte:- Fluorides

Cathode:-



Anode:-



classmate

PAGE

AL

↓ ALN

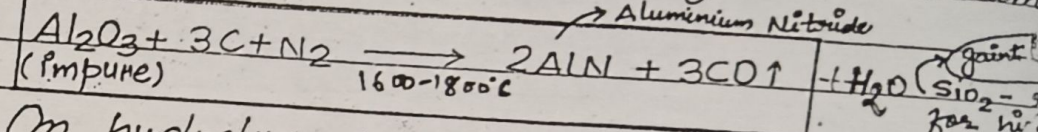
(Si+N₂)

Sludge DATE

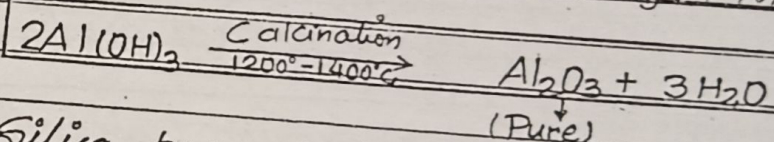
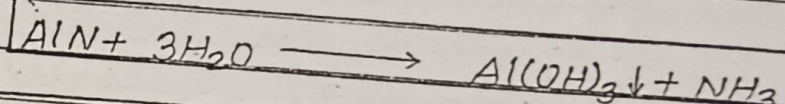
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2. Serpeck's process :- (If SiO_2 is present as major impurity)

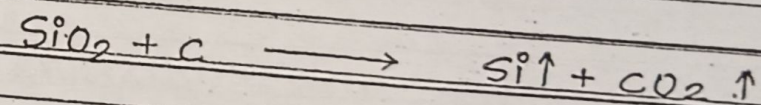
The powdered ore is heated with Al_2 and Carbon at $1600^\circ\text{C} - 1800^\circ\text{C}$ to form aluminium nitride.



On hydrolysis AlN from $\text{Al}(\text{OH})_3$ which on Calcination from pure Al_2O_3 .



Silica present is reduced to Si which volta off.



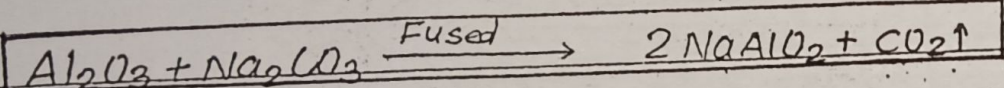
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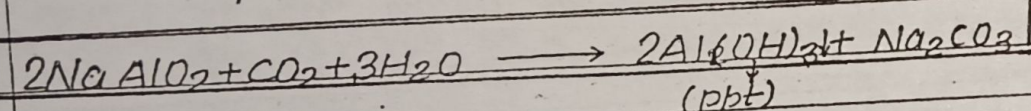
3. Hall's process:- (All impurities are present) ($\text{Fe}_2\text{O}_3 + \text{SiO}_2 + \text{TiO}_2$)

- Bauxite is fused with Sodium Carbonate (Na_2CO_3) Al_2O_3 combines with Sodium Carbonate forming Sodium meta aluminate.

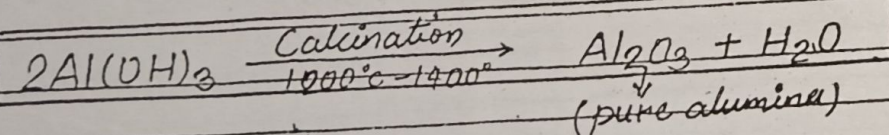
The fused mass is extracted with water where Fe_2O_3 & SiO_2 remains insoluble in the residue.



- The solution containing Sodium meta-aluminate is warmed to $50-60^\circ\text{C}$ and Carbon dioxide is circulated through it. $\text{Al}(\text{OH})_3$ separates out as precipitate.



- The precipitate is filtered, washed and dried. The solution of Na_2CO_3 is concentrated and used again.



OF ZINC:-

element (metal)

blue.

79

7.13

crystal - Hexagonal 

table - Group - 12, period - 4.

used for galvanising, alloying, making electrical purposes, are bearing metals, die-casting alloys.

U.S.A, Canada, Australia, Spain, Sweden & India

is 4th largest / Zinc

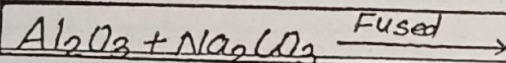
23.

is the main producer

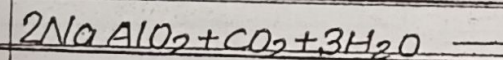
3. Hall's process:-

(present) $(Fe_2O_3 + SiO_2 -$

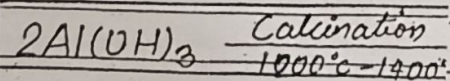
- Bauxite is fused with Al_2O_3 . Combines with sodium sodium meta aluminate. The fused mass is e where. Fe_2O_3 & SiO_2 re in the residue.



- The solution containing is warmed to $50-60^\circ C$ is circulated throu out as precipitate.



- The precipitate is dried. The solution concentrated and u



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DATE

5. Extraction of Zinc

* EXTRACTION OF ZINC

Zinc - Metallic element (metal)

Symbol - Zn

colour - White blue.

Atomic no - 30

Atomic mass - 65.39

Specific gravity - 7.13

Crystal structure - Hexagonal 

m.p - $420^\circ C$

b.p - $907^\circ C$

Valency - +2

Place in periodic table - Group - 12, period - 4

NOTE:-

- Zinc metal is used for galvanising, alloy, chemical utensil making, electrical purposes.
- The main zinc alloy are bearing metals, solder alloys and die-casting alloys.

Occurrences:-

Zinc Ore found in U.S.A, Canada, Australia, Germany, Italy, Spain, Sweden & India etc.

NOTE:-

India is the world's 4th largest Zinc reserve as in 2003.

Hindustan Zinc Limited is the main producer of Zinc in India.

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Manganese (Mn) is the world's second largest zinc producer) Udaipur (Rajasthan) 70

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DATE

The largest producer of Zinc in India

- Rajasthan
- Andhra Pradesh
- Bihar / Jharkhand
- Odisha
- Maharashtra States

- Most of the resources are available in Rajasthan.

• Important ores:- (Zinc)

- (1) Zinc Blende - ZnS (Chief ore)
- (2) Calamine - $ZnCO_3$
- (3) Zincite - ZnO (red oxide)
- (4) Willemite - Zn_2SiO_4

Extraction of Zinc from Zinc Blend:-

- Zinc can be extracted from its ore by

- Pyrometallurgical process &
- Hydrometallurgical process and purification by electrolysis.

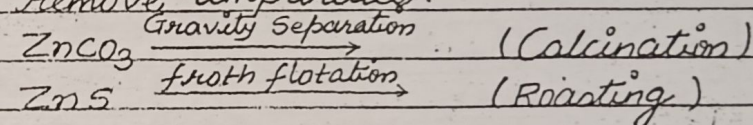
• PYROMETALLURGICAL PROCESS

OR

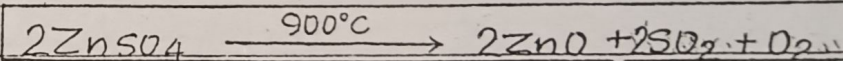
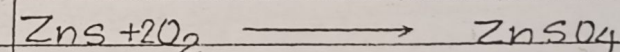
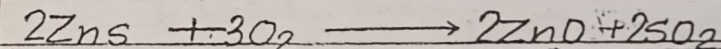
CARBON - REDUCTION PROCESS :-

Step 1: Concentration of the ore:

Concentration of the ore is done by froth flotation process. In case of Calamine ore concentration is done by gravity process, to remove impurities.



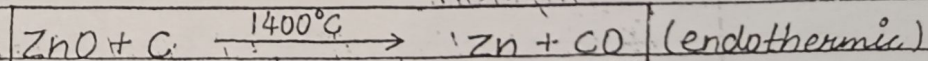
Step 2: Roasting:



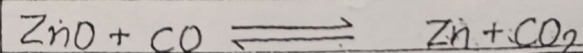
Step 3: Smelting (Reduction by Coke):

(Ore + Coke + Limestone) - Zinc blast furnace.

[Roasted ore + Coke + $CaCO_3$ + Heat]



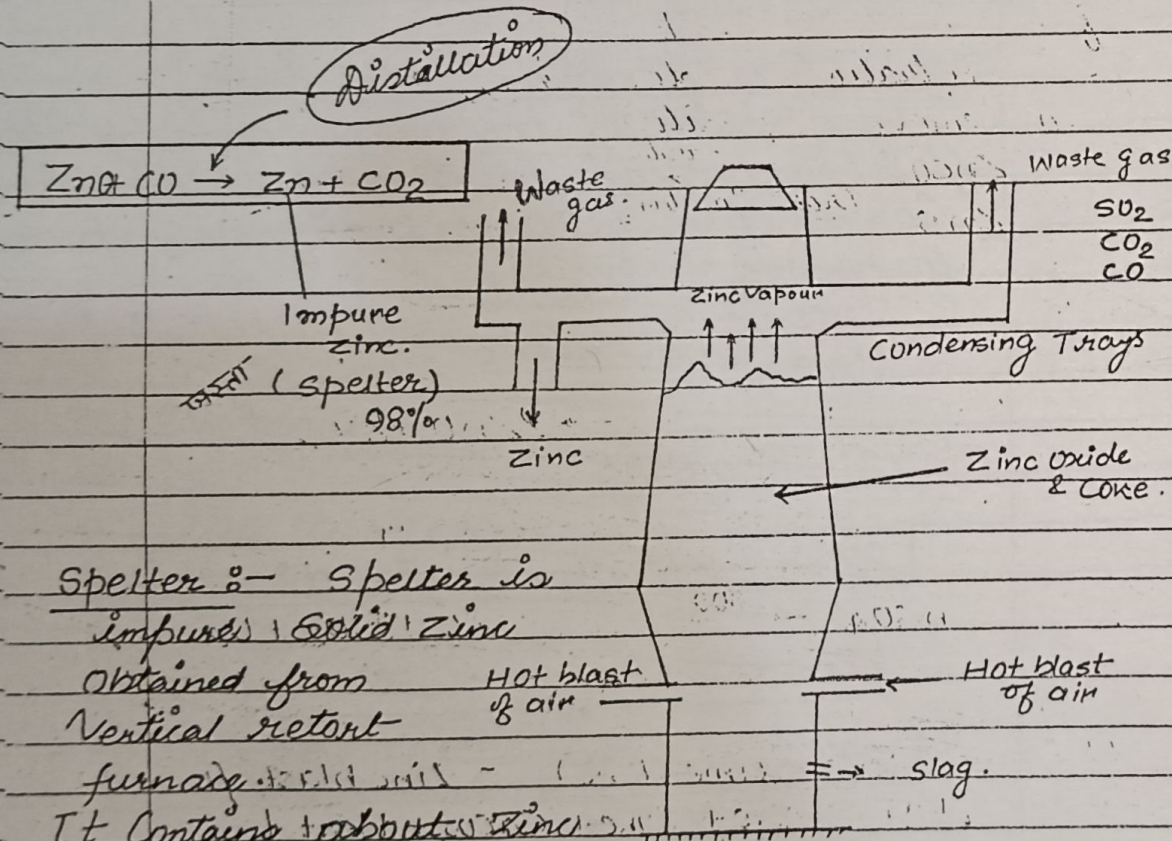
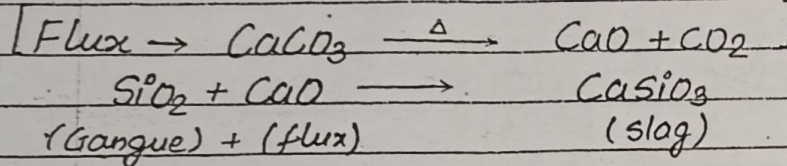
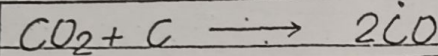
The reaction is endothermic and therefore a very high temperature is required. Carbon dioxide is also formed if C is less.



This reaction is reversible and to prevent this reaction

3. Hall's process

Come Copper, lead and iron.



Spelter :- Spelter is impure solid zinc obtained from vertical retort furnace.

It contains about 2% zinc and rest are impurities (Zinc blast furnace). Such as Pb, Cd, Fe, As, Si and Carbon.

Step 4: Electrolytic Refining of Zn.

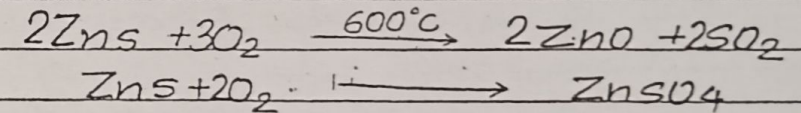
Electrolytic refining of Zn using ZnSO_4 as an electrolyte.

HYDROMETALLURGY PROCESS & REFINING BY ELECTROLYTIC PROCESS :-

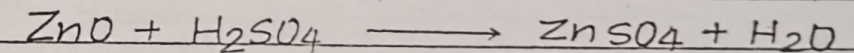
Step 1: Concentration :-

Concentration by froth floatation process.

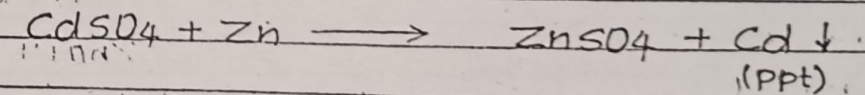
Step 2: Roasting



Step 3: Extraction as ZnSO_4 using H_2SO_4



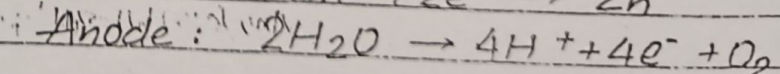
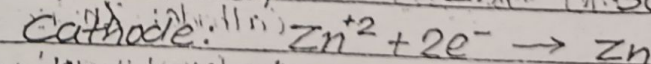
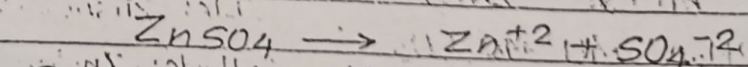
Cadmium as an impurity also forms CdSO_4 . Then zinc dust is added to precipitate Cd .



Step 4: Electrolysis :-

Pure ZnSO_4 is acidified with H_2SO_4 and electrolysed between pure Zn as Cathode and impure zinc as anode.

Pure Zn will deposit at Cathode. The reactions are:



Flow sheet for production of Zinc Using

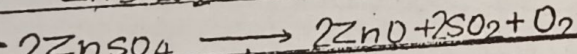
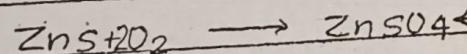
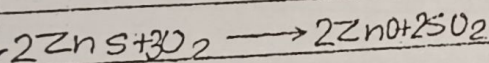
(a) Carbothermic reduction.

(b) Electrolytic extraction.

ORE - Zinc blend (Zns)

CONCENTRATION
flth flotation

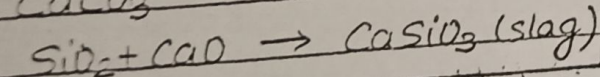
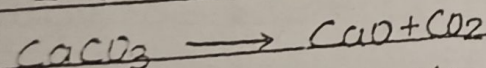
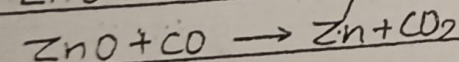
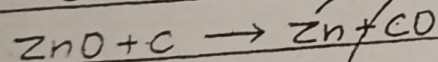
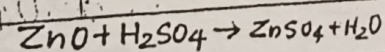
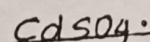
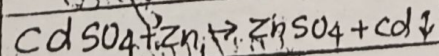
ROASTED



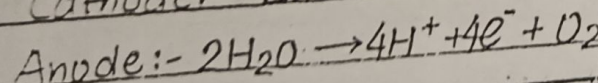
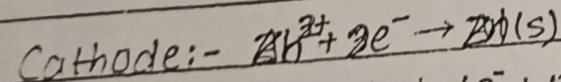
(Carbon reduction)

(Electrolytic extraction)

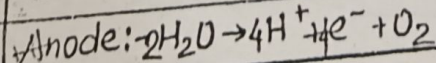
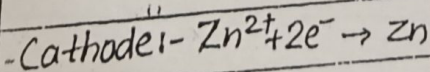
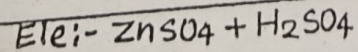
SMELTING

(Spelter)
98%
pureEXTRACTION
(LEACHING)Cadmium as an impurity
also formedZinc dust is added
to ppt Cd

ELECTROLYTIC REFINING

Electrolyte:- ZnSO_4 & H_2SO_4 

ELECTROLYSIS



The major downfall of any of the pyrometallurgical process is that only 98% pure.

Standard Composition:-

Lead (Pb) - 1.3%

Cadmium (Cd) - 0.2%

Iron (Fe) - 0.03%

& Zinc (Zn) - 98.5%

The process starts by charging solid sinter and heated coke into the top of the blast furnace. Preheated air at $190^\circ - 1050^\circ\text{C}$ is blown into the bottom of the furnace.

Zinc vapour and sulfides leave through the top and enter the condenser. Slag and lead collect at the bottom of the furnace and are tapped off regularly.

The zinc is scrubbed from the vapour in the condenser via liquid zinc. The liquid zinc is separated from the impurities in the cooling circuit.

Lead

DATE

Lead - Soft metal
Symbol - Pb
Atomic No. - 82
Atomic mass - 207

classmate

PAGE

DATE

6, * EXTRACTION OF LEAD

Lead - Soft metal.
Symbol - Pb
Colour - Bluish gray
Atomic no. - 82
Atomic mass - 207
Valency - +2, +4
Specific gravity - 11.34
m.p - 327.5°C
b.p - 1740°C

Place in periodic table - Group - 14, period - 6.

- # It is used for making
- (a) Grids and plates for storage.
 - (b) Pigments and points.
 - (c) Cable sheathing.
 - (d) Solder alloys.
 - (e) Antifriction bearings.

Occurrence :-

Lead is found in many Countries throughout the world. Biggest producers are:-

- A. U.S.A
- B. Mexico
- C. Australia
- d. Canada
- E. U.S.S.R & India etc.

The U.K production is very small.

classmate

PAGE

In India :-

The important deposits of lead are in the states of :-

- Rajasthan.
- Andhra Pradesh.
- Gujarat.
- Bihar / Jharkhand.
- Orissa.
- West Bengal etc.

LEAD [Pb] :

Important ores:

- (1) Galena PbS (chief ore)
- (2) Cerussite $PbCO_3$ (Carbonate ore)
- (3) Anglesite $PbSO_4$

NOTE:-

Ore containing 2-20% lead.

= Extraction Of Lead from Galena:

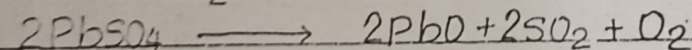
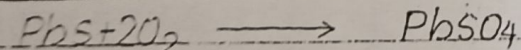
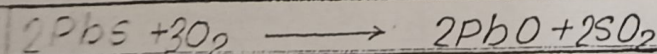
Step 1: Concentration

Concentration of ore by froth floatation process.

The concentrated ore contains 50-60% lead.

Step 2: Roasting

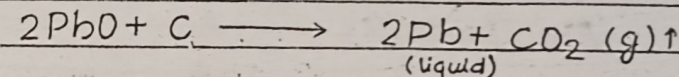
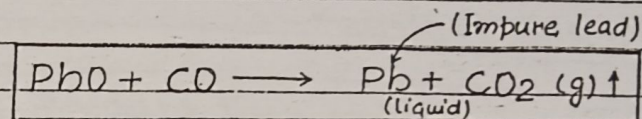
PbS is roasted in air to give PbO in a reverberatory furnace.



Step 3: Smelting (Reduction)

(Sintered or roasted ore + coke + limestone)

Reduction of PbO with coke or CO in a blast furnace.



Blast furnace slags consist essentially of iron and calcium silicates containing :-

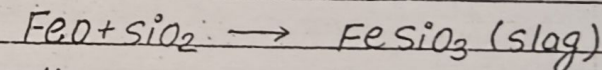
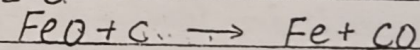
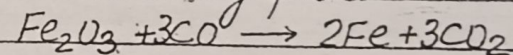
SiO_2 - 18-35%

FeO - 30-35%

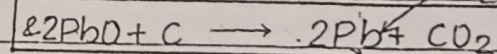
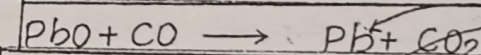
CaO - 5-25%

& plus small amounts of alumina, magnesia & sulphur etc.

Reaction taking place in blast furnace:-



Main reaction:



base bullion

98% pure lead

Base bullion :- lead is a semi-finished product called base bullion, which may contain small amount of Au , Ag , Cu , Zn , Sb , As , Bi & other impurities. These are removed by refining -

Step 4: Refining :-

Refining → (a) Fire refining / Parkes process
(b) Electrolysis / Betts process.

* (a) Parkes Process :-

The most widely used refining process is parkes process.

- Lead is heated in a reverberatory furnace. Traces of Sb & As, impurities which harden lead, are oxidized by a blast of air, and the oxides are skimmed off.

- After softening, the lead goes to 'desilverizing'. Small amount of Zn are added. Gold & Silver are more soluble in zinc than in lead; Consequently if these metals are present in lead, they immediately leave it in favour of the zinc.

- Since zinc is lighter than lead, the zinc float on the surface, and when the temperature is lowered, it solidifies and is skimmed off.

(b) Electro-refining :-
(Betts process)

Anode:- Impure metal

Cathode:- a sheet of pure metal

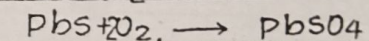
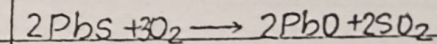
Electrolyte:- a solution of lead silico fluo. (PbSiF₆) containing 8-10% H₂SiF₆

Flow sheet for production of lead :-

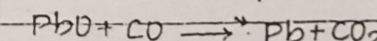
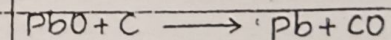
ORE - Galena (PbS)
Crushing & Grinding

CONCENTRATION
(froth flotation)

ROASTING
(Reverberatory furnace)



SMELTING
(Carbon-reduction)



→ Base bullion
(98% Pb)

REFINING

(a) Parkes process

(Reverberatory furnace)

Disilverizing - remove of Au & Ag by adding small amount of Zn.

(b) Electro-refining

Anode:- Impure lead

Cathode:- pure lead

electrolyte:- (PbSiF₆ + H₂SiF₆)

DATE

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DATE

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TRICK (Reactivity Series)

Elements	Trick	Activities.
		most Reactive

Potassium (K)	please
Sodium (Na)	Stop
Calcium (Ca)	Call
Magnesium (Mg)	me
Aluminium (Al)	a
Zinc (Zn)	Zebra
Iron (Fe)	I
Lead (Pb)	Like
Hydrogen (H)	her
Copper (Cu)	Call
Silver (Ag)	Smart
Gold (Au)	Goat
Platinum (Pt)	Papu

decreasing reactivity

Least Reactive.

7

URANIUM & THORIUM

Uranium - Radioactive element (Actinides)

Symbol - U (f block element)

Colour - [Lustrous White metal (Pure U) & Yellow]

Atomic no. - 92

Atomic mass - 238 (235)

Specific gravity - 18.95

m.p. - 1132°C b.p. - 3818°C

Place in periodic table:- Group - 3rd period - 7

Valency - +2, +3, +4 (+5)

- This is the most radioactive element which occurs naturally. It is a rarely found element in nature and it doesn't occur in free state.

- The main ore of Uranium is pitch blende (UO_2) from which it is extracted.

NOTE:-

Isotopes of Uranium: There are 3 Isotopes of Uranium -

${}_{92}^{234}\text{U}$, ${}_{92}^{235}\text{U}$ & ${}_{92}^{238}\text{U}$. The most abundant

occurring Uranium is ${}_{92}^{238}\text{U}$ (99.28%) which

${}_{92}^{235}\text{U}$ (0.71%) & ${}_{92}^{234}\text{U}$ (0.006%) occur in very small amount. The Isotope ${}_{92}^{235}\text{U}$ is used in nuclear (atomic) reactors as a nuclear fuel.

DATE DATE # Uranium production Countries:-

- Kazakhstan Mine production: 23,800 tonnes (28%)
- Canada 13,325 tonnes (20%)
- Australia 5,672 tonnes (16%)
- Niger 4,057 tonnes (8%)
- Russia 7%
- Namibia 6%
- Uzbekistan 5%
- U.S.A 3%
- China 2%
- India 1%
- South Africa 1%

Uranium found in India:-

- Jharkhand (Jamsbedpur)
Jagus (Jaduguda Uranium Mine)

- Andhra Pradesh (Tumalapalli)
(Tummalapalle Mine)

• Jaduguda Uranium Mine:-

(UCIL - Uranium Corporation of India Limited)

- The Jaduguda Mine is a Uranium mine in India at Jaduguda Village in the Purbi Singhbhum district of Indian State Jharkhand.

- It Commenced operation in 1967 and was the first Uranium Mine in India.

Jaduguda Mine:-

- (a) Bhatin Mine (3 km west of Jaduguda)
- (b) Narwapahar Mine (12 km west of Jaduguda)

• Mineralogical & Chemical Analysis of Jaduguda Ore:-

U ₃ O ₈	0.06-0.07%	TiO ₂	0.7%
SiO ₂	67.2%	MnO	0.3%
FeO	6.4%	CaO	5.4%
Fe ₂ O ₃	7.9%	MgO	2.2%
Al ₂ O ₃	5.5%	P ₂ O ₅	1%
		S	0.8%

• Tummalapalle Mine:-

- The Tummalapalle Mine is a Uranium mine in Tumalapalli Village located in Kadapa of the Indian State of Andhra Pradesh.

- One of the Largest reserves of Uranium in the world.

URANIUM [U]Important ore:-

- (1) Uraninite or Pitchblende - UO₂ (chief)
- (2) Brannerite - UTi₂O₆

Uses of Uranium :-

1. The main use for Uranium today is for fuel in Nuclear power plants. Nuclear power plants generate power by causing a Controlled fission chain reaction using Uranium.
2. Uranium is also used by the military to power nuclear Submarines and in Nuclear Weapons.
3. Uranium are used in drugs manufacturing Industries.
4. Nitrate & acetate of Uranium are used in photography etc.

THR

THORIUM (Th)

Thorium - Radioactive element (f-block)

Colour - Silvery White

Symbol - Th

Atomic no. - 90

Atomic mass - 232

Valency - +3 (+4)

Specific gravity - 11.72

m.p - 1750°C b.p - 4790°C

place in periodic table - Group - 3rd, period

Occurrence & extraction of Thorium :-

- This is a radioactive element (metal) doesn't occur in free state but occurs naturally & abundantly in the ore of monazite sand, the sea shore.

- Thorium is mainly extracted from Monazite ore (ThPO_4).

Thorium production Countries :-

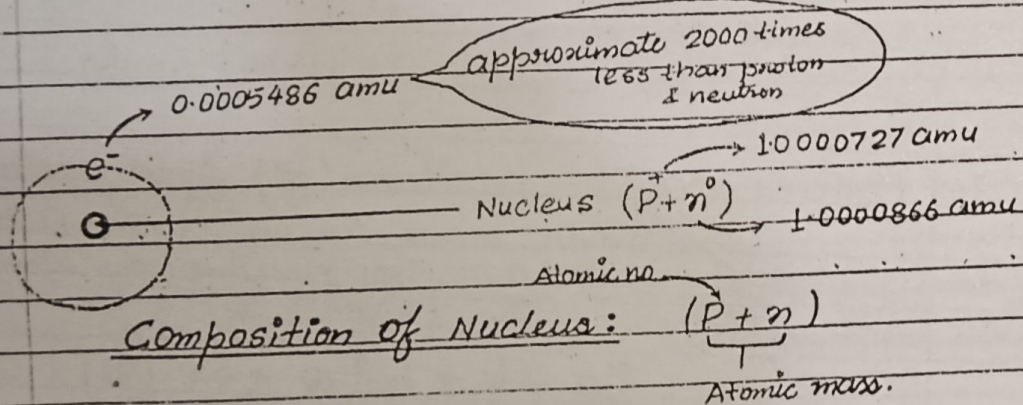
- Australia (18.7%)
- U.S.A (15.3%)
- Turkey (13.2%)
- India (12.2%)

- India is the fourth largest thorium producing country with 12.2%

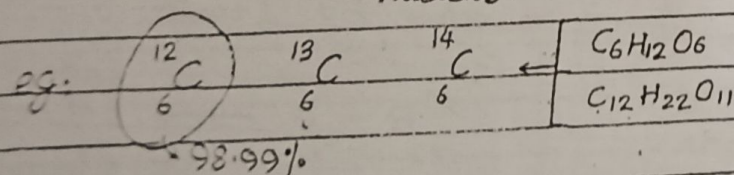
Uses of thorium:-

1. Thorium is used in the production of nuclear energy.
2. Tungsten filament of arc lamp.
3. As a catalyst in the organic chemistry

NUCLEAR CHEMISTRY

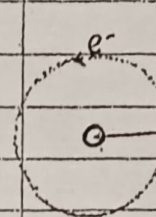


Isotopes (आइसोटोप) → Same atomic no. different atomic mass. due to different no. of neutron present in nucleus.



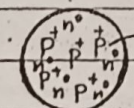
3:1

Size & Stability of Nucleus:-



Radius of Atomia = $r_0 A^{1/3}$.

Very small: r_0 is a Constant
 $r_0 = 1.4 \times 10^{-13} \text{ cm}$ ($1.4 \times 10^{-15} \text{ m}$)



Special Nuclear attractive force.

$P \rightleftharpoons P$

$n \rightleftharpoons n$

$P \rightleftharpoons n$

+1-10.
 Eukawa:- π mesons
 (Scientist)

Nucleus is stable due to π mesons

Stability of Nucleus:-

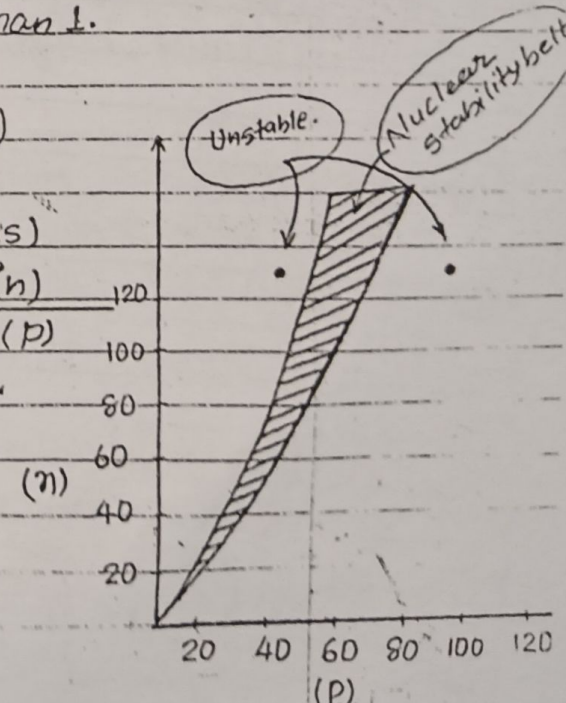
Nucleus Containing neutron to proton ratio (n/p) less than 1 is less stable than nucleus with (n/p) ratio equal or more than 1.

$\frac{n}{p} \geq 1$ (stable nucleus)

$\frac{n}{p} = 1$ (1-1.54)

$\frac{n}{p} < 1$ (Unstable nucleus)

$\frac{\text{Number of neutron (n)}}{\text{Number of proton (p)}}$



- α -particle
- β -particle
- γ -particle / radiation
- positron
- electron capture.

DATE

Radioactivity: Behaviour of Unstable Nuclei.

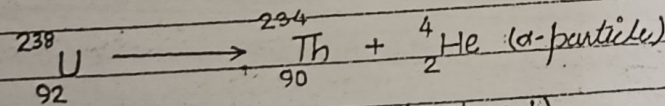
- **Radioactivity**:- The phenomenon of spontaneous and continuous emission of powerful invisible radiation by the disintegration of an element or a substance, which affect the photographic plate, is called natural radioactivity.

- The rate of disintegration is independent of pressure, temperature, states of existence or presence of catalyst etc.

Eg: Uranium, radium, thorium etc.

• Radioactive decay:-

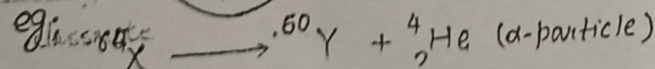
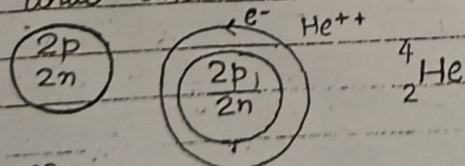
Disintegration of a nucleus of an atom spontaneously with the loss of either α -particle or β -particle or both, results in the formation of new elements (called daughter element).



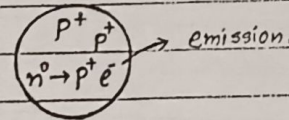
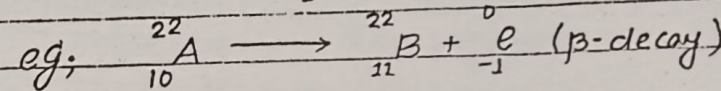
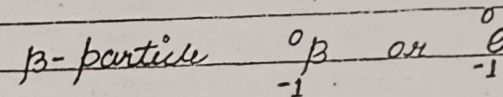
(Parent element) (Daughter element)

Types of Radioactive decay:-

- (i) α -particle:- α -decay causes decrease of atomic no. by 2 units and mass number by 4 units.

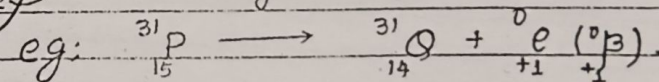
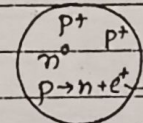


- (ii) β -particle (decay):- β -decay causes increase of atomic no. by 1 unit and no change in mass.

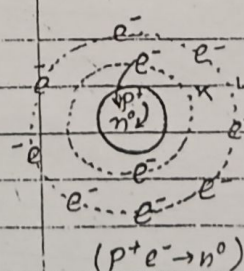


- (iii) γ -ray:- Emission of γ -rays (${}_0^0\gamma$) cause no change in atomic number and mass number. Since it represents the energy lost.

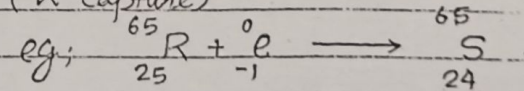
- (iv) Positron decay:- positron (${}_1^0e$) is a particle having the same mass as an electron, but +ve charge. Emission of a positron decreases the atomic number by 1 unit.



- (v) Electron Capture:- Capture of an electron decreases the atomic number by 1 unit.



(K Capture)



PAGE

CLASSMATE

case of
mass

DATE

• Nuclear Reactions:-

- Energy changes in nuclear reactions: The energy changes associated with nuclear reaction are about million times more than those associated with chemical reactions. These are generally, determined by using Einstein's mass-energy equation:-

$$E = mc^2.$$

no change
it

• Mass defect & Binding energy:-

e have
at +ve charge
number

- Mass defect:- The mass defect is nothing, but the loss of mass during the formation of the nucleus of the isotope.
- Binding energy:- Loss of mass during the formation of the nucleus from nucleons is converted into energy.

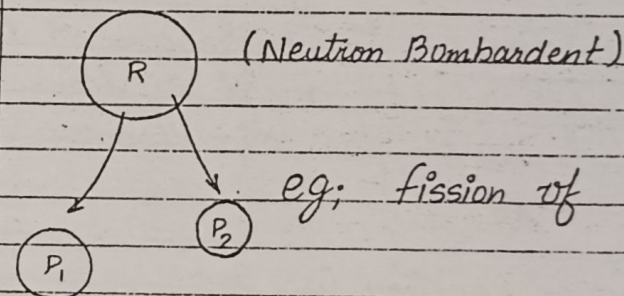
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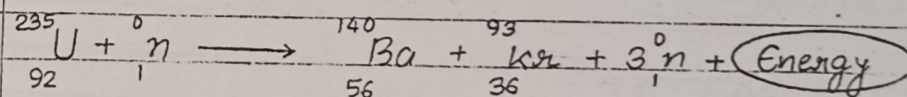
"Nuclear Reaction"

Nuclear fission & Nuclear fusion.

- NUCLEAR FISSION:- Is the process of splitting of heavy nucleus into two or more small nucleus, with simultaneous liberation of a huge amount of energy.

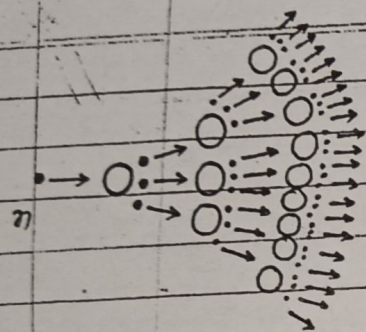


eg; fission of U-235 by neutron.



Following facts about nuclear fission of Uranium:-

- (1) ${}_{92}^{238}\text{U}$ generally splits, when bombarded by slow or fast neutrons.
- (2) In all cases, neutrons were emitted.
- (3) In all cases, Very large disintegrating energy are liberated.
- (4) Fission fragments are all radioactive.
- (5) Fission reaction is a self-propagating chain-reaction, because fission product contain neutrons



(chain propagation in fission process)
(fast reaction)

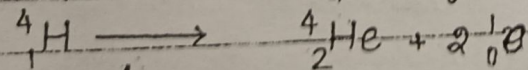
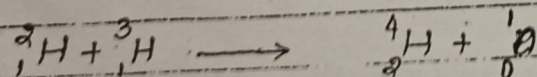
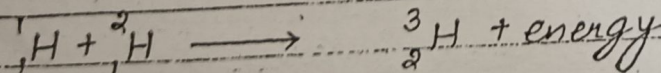
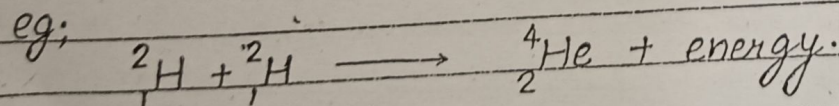
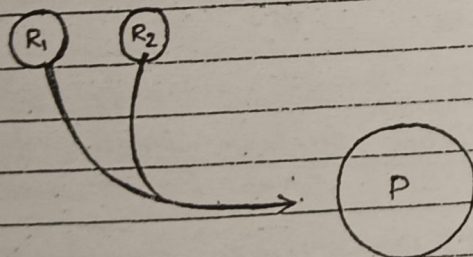
Atom Bomb.

NOTE:-

Complete fission of 1 kg of Uranium provides the energy equivalent of about 2×10^7 'kWh'. Such an enormous amount of energy can be obtained by burning of about 3,000 tonnes (i.e. 3×10^6 kg) of high grade coal.

• NUCLEAR FUSION:- is a process of combination of light-weight nuclei to form heavier nuclei, with the simultaneous release of energy.

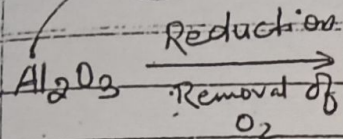
eg, Fusion reaction in Sun.



electrolytic reduction

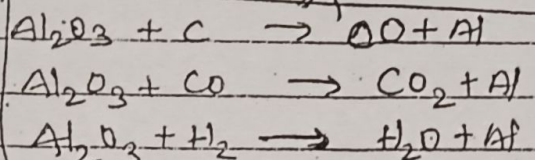
DATE

DATE



Aluminium

X

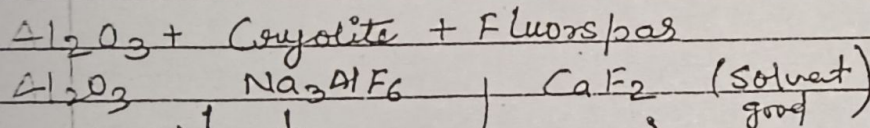
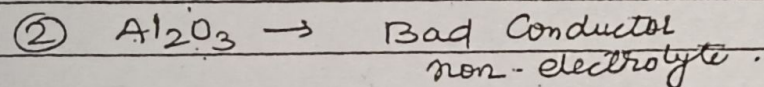
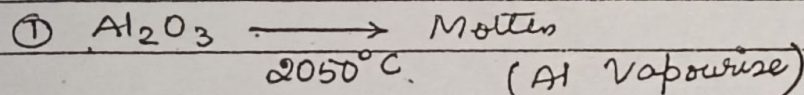


- Stable oxide
- Reactive metal
- Bad with oxygen very strong

* Hall and Heroult

Problem: -

Aluminium



non-electrolyte

It lowers the melting temp of alumina (950°C)

Increases Conductivity