



Handwritten Notes  
On  
Metallurgy

05/09/17

Chapter -

x

METAL Extraction

OR

METALLURGY

x MINERALS :

x

x ~~minerals~~ : Various comp. of metal present in Earth & that they are called minerals.

x

Ores : Minerals from which extraction of metal is chemically convenient and economically cheap they are called Ores. So that all ores are minerals, but all minerals not a ores.

x

Elements in Earth Crust (Top ten) :

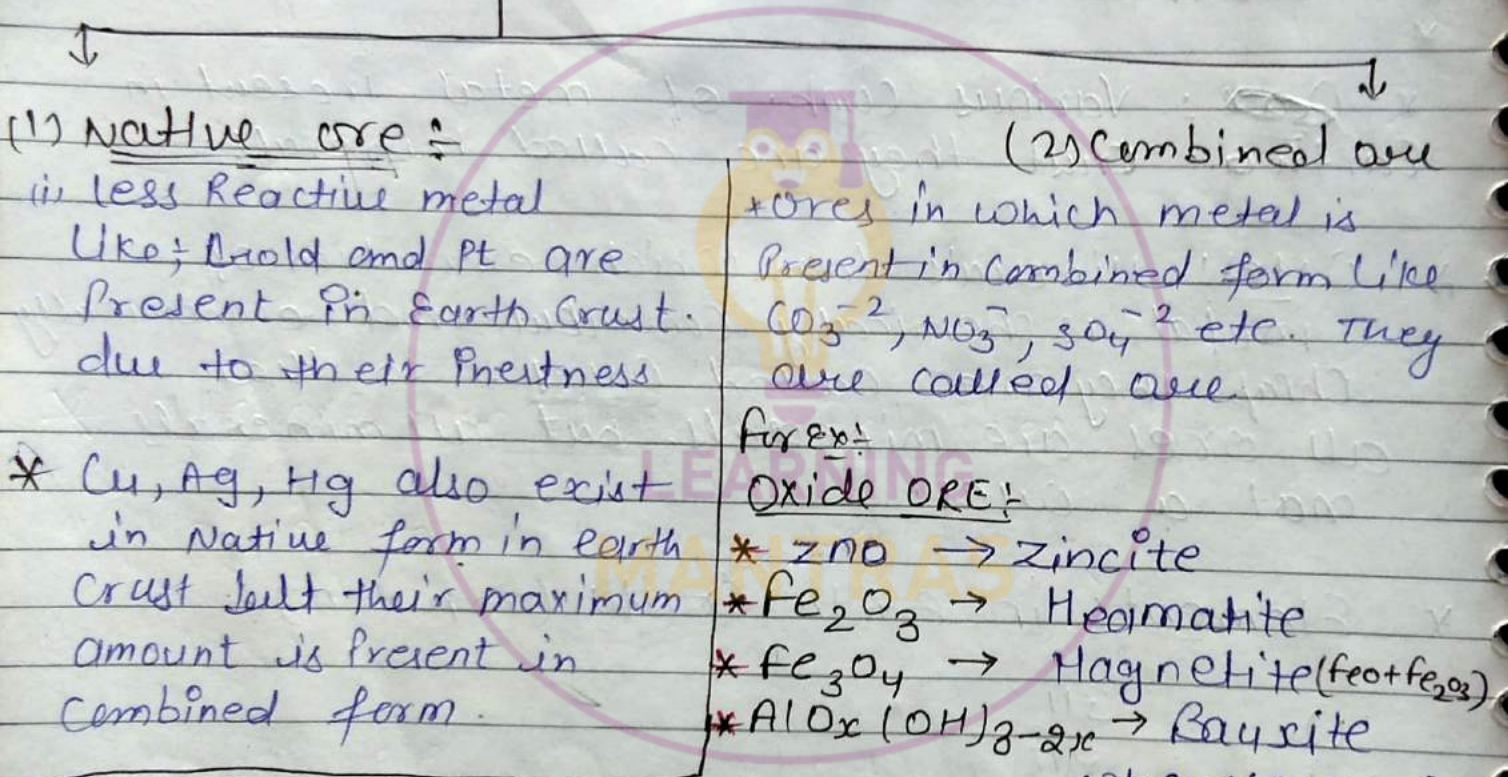
O	31.1
Si	27.7
Al	8.1
Fe	5.0
Ca	4.7
Mg	4.7
Na	2.8
K	2.6
Ti	0.6
H	0.1



Q. 1

- Q. Which of the following ores contain both Fe & Cu
- (A) Cuprite ( $Cu_2O$ )
  - (B) Chalcosite ( $Cu_2S$ )
  - (C) Chlopyrite ( $CuFeS_2$ )
  - (D) Malachite ( $CuCO_3 \cdot Cu(OH)_2$ ) (Basic Copper carbonate)

\* Types of Ores:



- \*  $Al_2(OH)_4Si_2O_5 \rightarrow$  Kaolinite (a form of clay)
- \*  $Fe_2O_3 \cdot 3H_2O \rightarrow$  Limonite
- \*  $Cu_2O \rightarrow$  Cuprite or Ruby Copper
- \*  $MnO_2 \rightarrow$  Pyrolusite
- \*  $SnO_2 \rightarrow$  Tinstone or Cassiterite
- \*  $TiO_2 \rightarrow$  Rutile
- \*  $Fe \cdot Cr_2O_4 \rightarrow (FeO + Cr_2O_3)$  Chromite ore (mix ore) ( $FeCr_2O_4$ )
- \*  $Na_2B_4O_7 \cdot 10H_2O \rightarrow$  Borax or Tincal
- \*  $Ca_2B_6O_{11} \cdot 5H_2O \rightarrow$  Colemanite

\*  $U_3O_8 \rightarrow$  Pitch Blende

\*  $FeO \cdot TiO_2 \rightarrow$  Ilmenite

### # Sulphurised ORE :-

\*  $PbS \rightarrow$  Galena

\*  $HgS \rightarrow$  Cinnabar

\*  $ZnS \rightarrow$  Zinc blende / Sphalerite

\*  $Cu_2S \rightarrow$  Copper glance / Chalcocite

\*  $CuFeS_2 \rightarrow$  Copper pyrite (Chalcopyrite)  $(Cu_2Fe_2S_4)$

\*  $FeS_2 \rightarrow$  Iron pyrite or fool's gold  $(Cu_2S + Fe_2S_3)$

\*  $Ag_2S \rightarrow$  Silver glance or Argentite  $(FeS + FeS_2)$

### # Halide ORE :-

\*  $NaCl \rightarrow$  Rock salt

\*  $CaF_2 \rightarrow$  Fluorspar

\*  $AgCl \rightarrow$  Horn silver

\* Mixture of  $KCl$  and  $NaCl$  (Sylvinit)

\*  $KCl \rightarrow$  Sylvite / Silvine

\*  $Na_3AlF_6 \rightarrow$  Cryolite

\*  $KCl \cdot MgCl_2 \cdot 6H_2O \rightarrow$  Carnallite

### # Oxy salt ORE :-

#### (i) Carbonate ORE :-

\*  $CaCO_3 \rightarrow$  Limestone

\*  $CaCO_3 \cdot MgCO_3 \rightarrow$  Dolomite

\*  $ZnCO_3 \rightarrow$  Calamine

\*  $Cu(OH)_2 \cdot CuCO_3 \rightarrow$  Malachite or Basic ~~concept~~ Copper carbonate

\*  $Cu(OH)_2 \cdot 2CuCO_3 \rightarrow$  Azurite

\*  $PbCO_3 \rightarrow$  Cerussite

## (2) Sulphate ORE:-

- \*  $\text{CaSO}_4 \cdot 2\text{H}_2\text{O} \rightarrow$  Gypsum
- \*  $\text{MgSO}_4 \cdot 7\text{H}_2\text{O} \rightarrow$  Epsom salt
- \*  $\text{PbSO}_4 \rightarrow$  Anglesite
- \*  $\text{BaSO}_4 \rightarrow$  Barite
- \*  $\text{Na}_2\text{SO}_4 \cdot 10\text{H}_2\text{O} \rightarrow$  Glauber salt.

## (3) Nitrate ORE:-

- \*  $\text{KNO}_3 \rightarrow$  Indian salt petre
- \*  $\text{NaNO}_3 \rightarrow$  Chile salt petre.

## \* Metals in living Entities:-

- Magnesium is found in chlorophyll.
- Potassium is present in plant roots.
- Manganese, Iron and copper are present in chloroplast.
- Zinc is present in eyes of cats and cows.
- Iron is present in haemoglobin.
- Calcium is present in bones.
- Vanadium is present in cucumbers.

(2) Chromium is present in Brown

(1) Cobalt is present in cyanocobalamin  
(Vitamin-B<sub>12</sub>)

### \* Types of Metallurgy:

(1) Pyro Metallurgy

(2) Electro Metallurgy

(3) Hydrometallurgy

#### \* 1) Pyrometallurgy:

Metallurgy Process  
in which metal is extracted  
using high temp. is called Pyro metallurgy

for ex: Extraction of Iron in Blast furnace

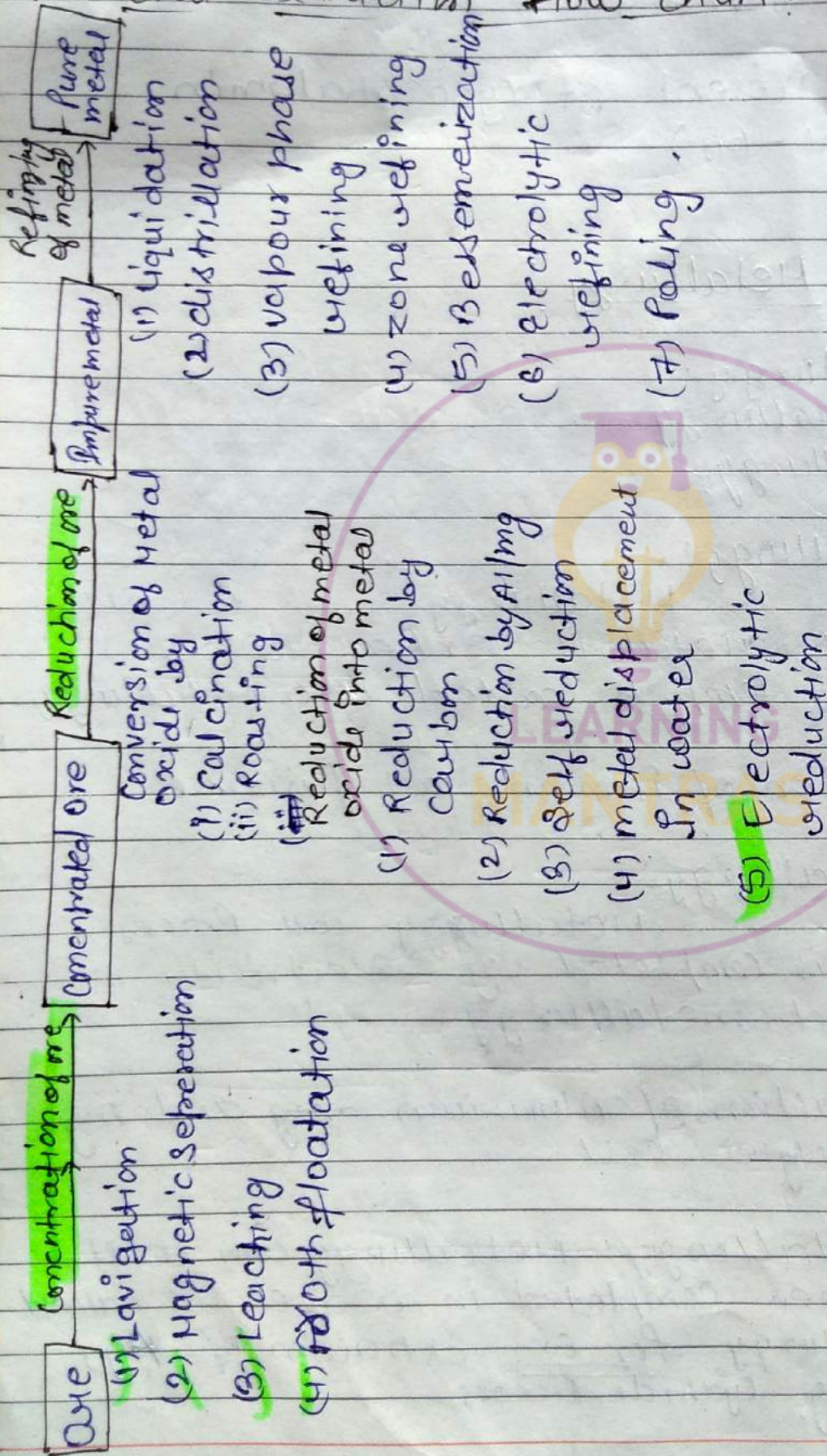
#### (2) Electrometallurgy:

Metallurgy will Process  
which is completed by Electricity is  
called electrometallurgy

for ex! Extraction of Aluminium and Mg  
in Electrolytic cell

(3) Hydrometallurgy: Metallurgy will  
process when completed in water is called  
hydrometallurgy for ex:- Extraction of Ag,  
Au, using cyanide process.

# \* Metal Extraction Flow Chart:



metal % ↑

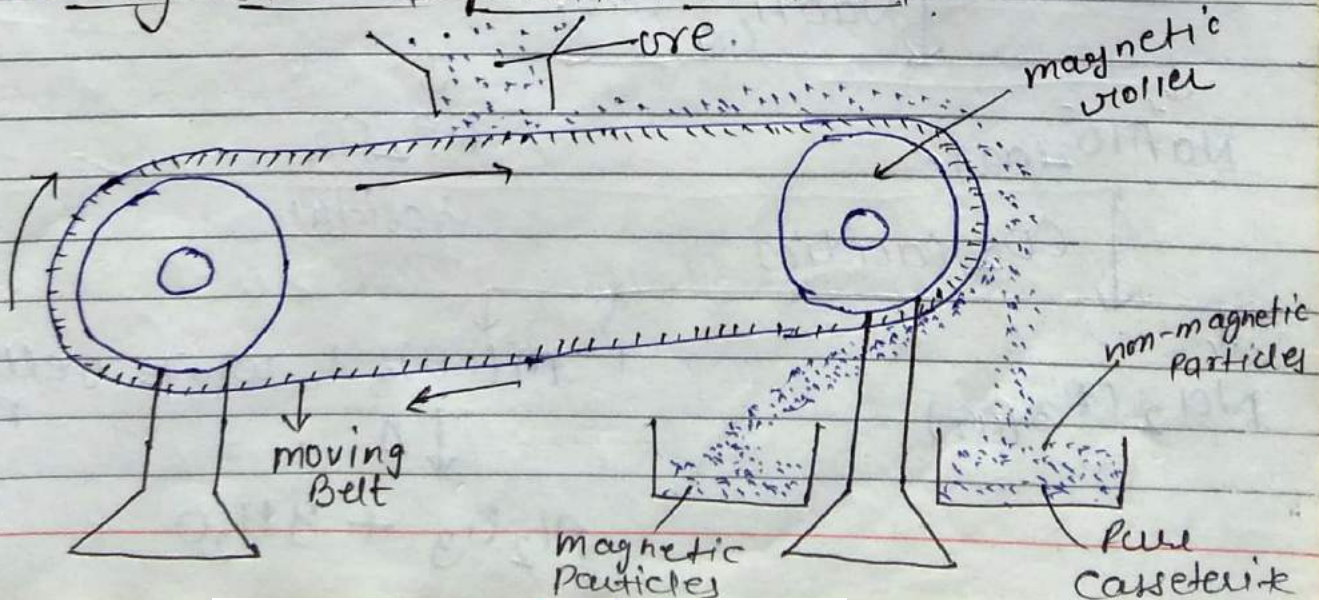
(A) Concentration of Ore :

(i) Lavigation : (gravity separation) :



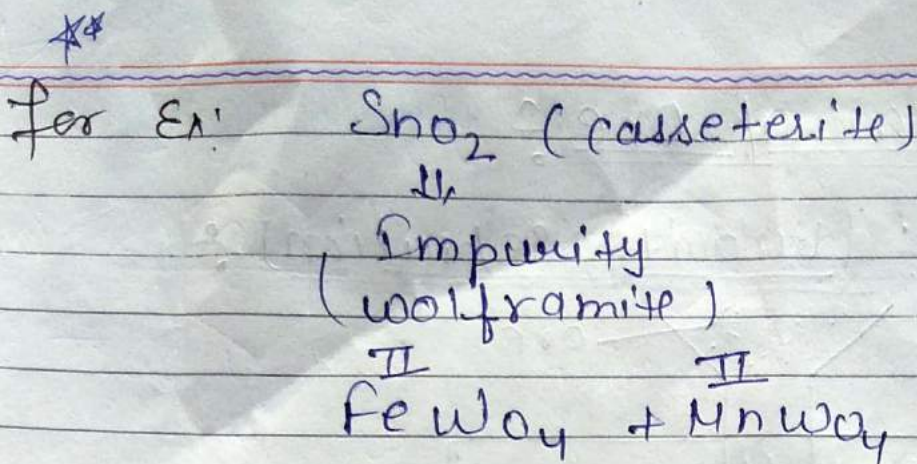
Lavigation is just hydraulic washing in which heavy ore particles are separated from lighter silicon or silicate impurities.

(ii) Magnetic Separation Method :





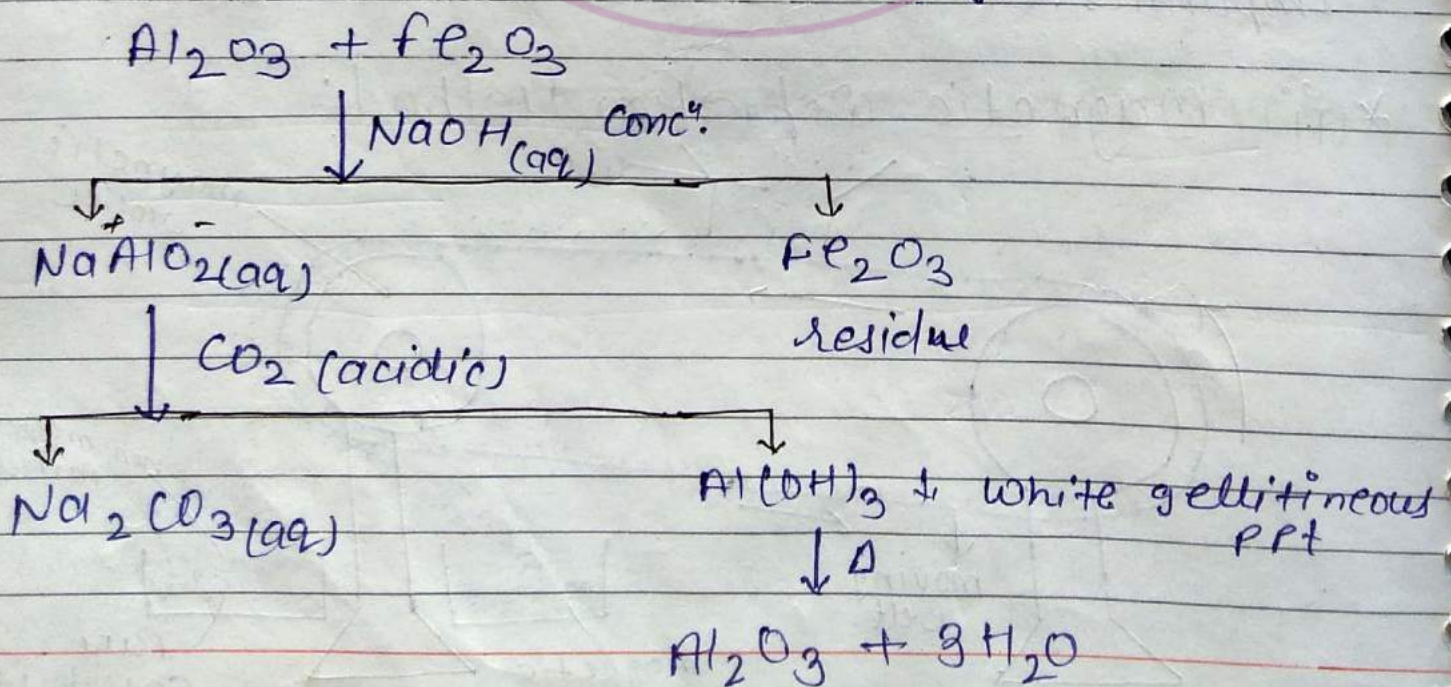
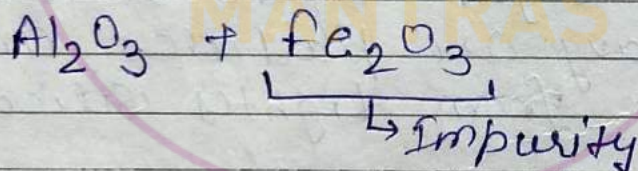
All hydroxide soluble in water.  $\text{CO}_2$  carbonate



Magnetic separation method for purification is applicable for purification of ore which contain non-magnetic impurities. non magnetic ore which contain magnetic impurities.

(iii) Leaching  $\frac{\circ}{\circ}$  (chemical separation).

(i) Purification of Red Bauxite (Bayer's Process)

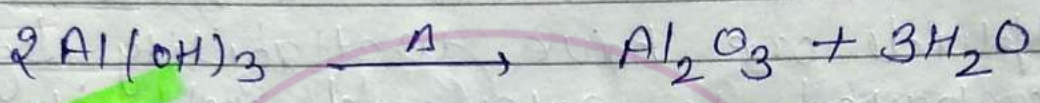
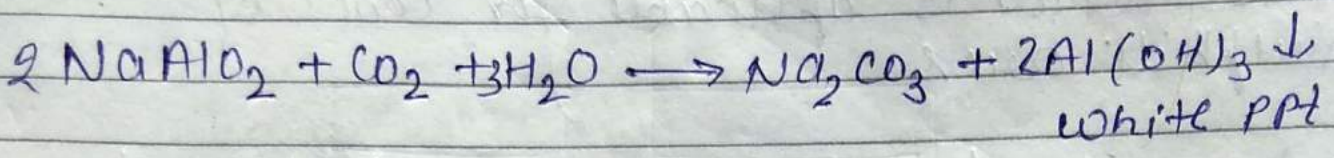
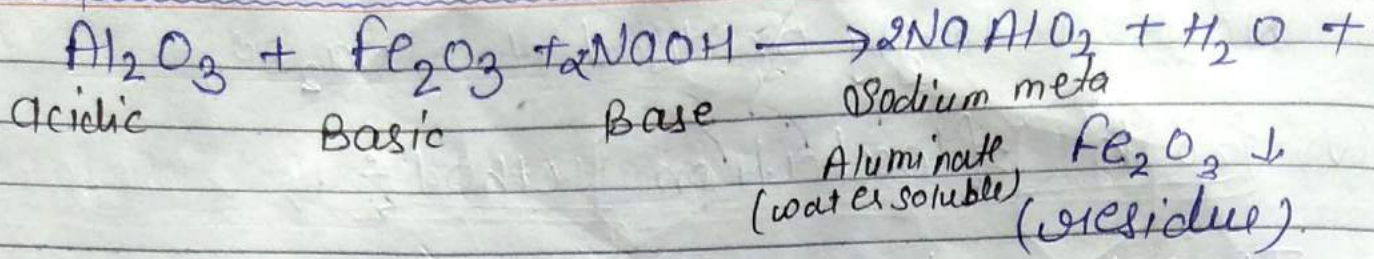


Redox Lec. Part 1  
Least NaOH

[0-1] 0-2, 5 and 5  
ore Learn. Race: 24,

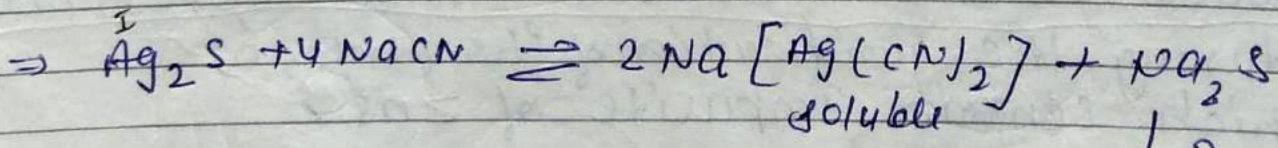
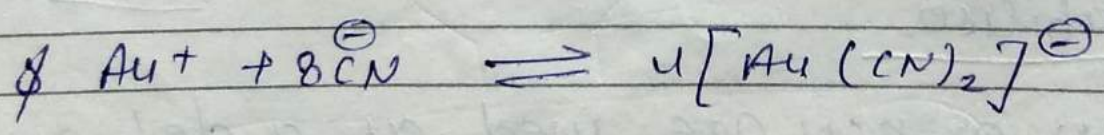
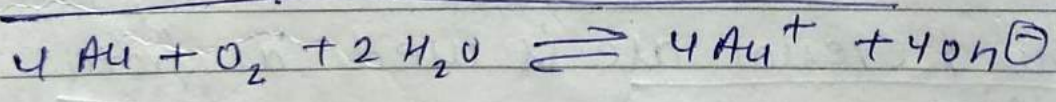
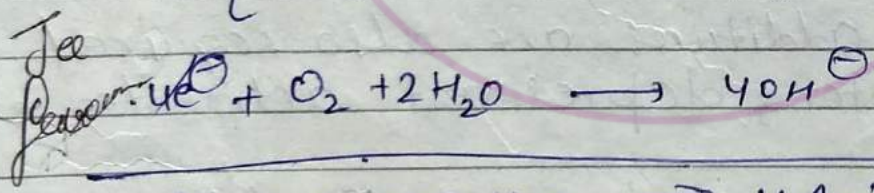
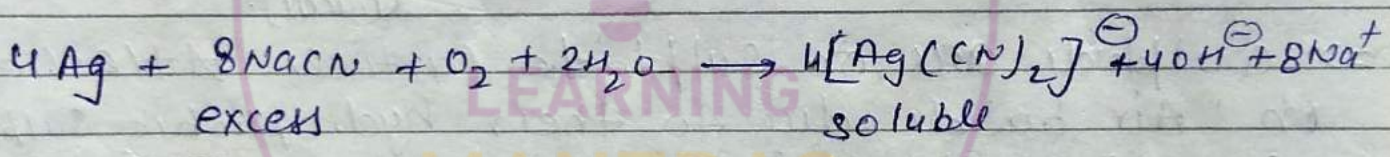
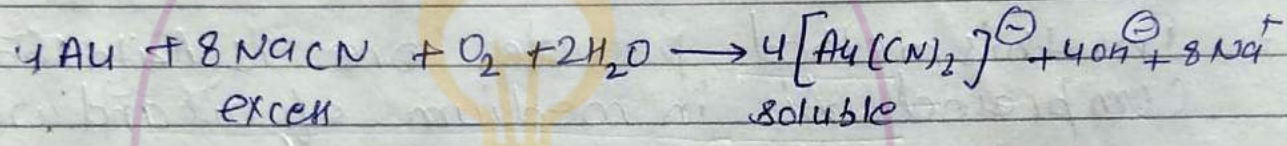
Amphibiotic

(ionic)



Full reaction 100%

### Leaching of Ag/Au (Cyanide Process):



$\xrightarrow{O_2}$   
 $Na_2SO_4 + S$   
 colloidal sulphur



$\text{Na}_2\text{S}$  is largely oxidised to  $\text{Na}_2\text{S}^{0}_4$

### (iv) Froth floatation Method

⇒ This Method is applicable for conc<sup>n</sup> of Sulphide ores

⇒ This method is based on the fact that Sulphide ore have wettability by oil as compared to water and impurity have more affinity for water.

⇒ In this method powdered ore is Agitated with Compressed Air in medium of oil and water (Pulver).  
(Pulver).

⇒ Sulphide ore or sulphide particles Attached on Air bubble due to their hydrophobic sulphate (cotting of oils)

⇒ Some other additives are also required for ex: Collector, depressant, activator etc.

⇒ Aniline & cresol are used as froth stabiliser

⇒  $\text{NaCN}$  or  $\text{KCN}$  are used as a depressant during the purification of Pbs (malena) which contain impurite of zns.

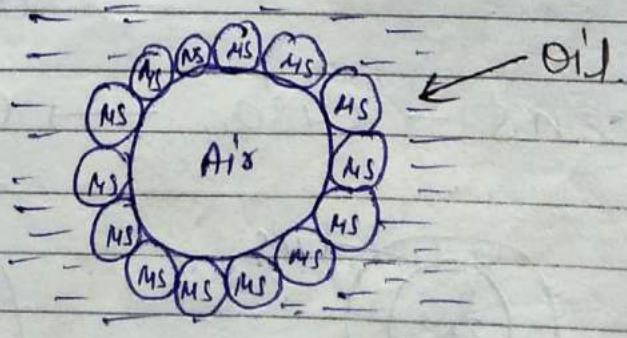
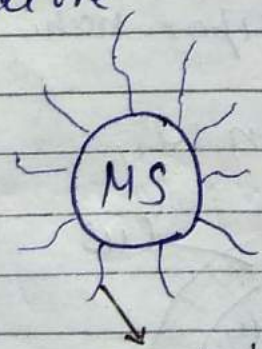
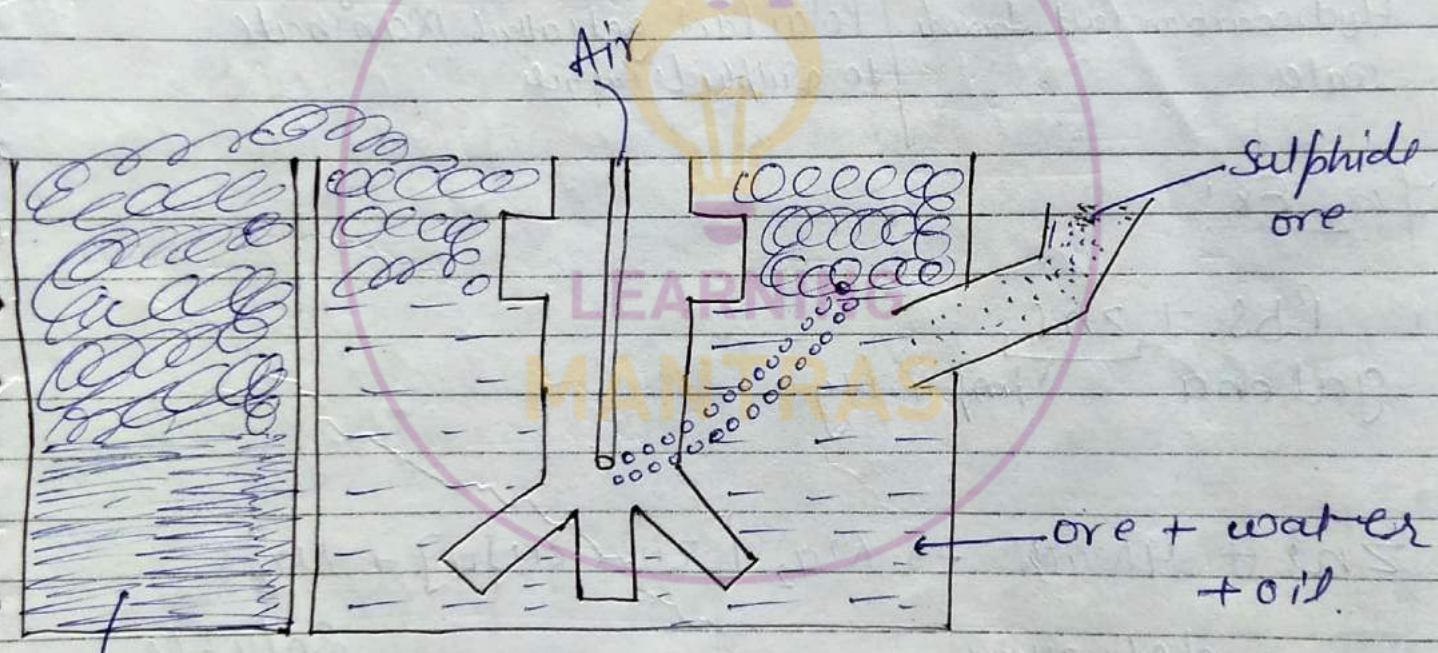
⇒ Sodium ethyl xanthate is use as a collector because it has to collect sulphide particle

on Air bubble.

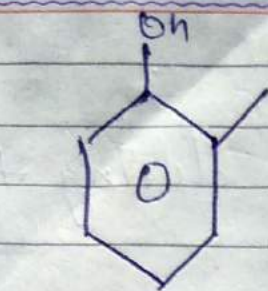
⇒  $CuSO_4$  is used as An activator during the Conc<sup>n</sup> of  $ZnS$

⇒ This method is also used for Non-sulphide ore using suitable activator

for ex! Melachite is conc<sup>n</sup> by this process using  $Na_2S$  as an activator.



fat Acid  
 which is present in oil gets attached to sulphide particles

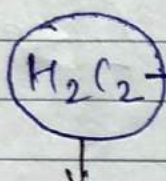


$C_7H_8O$   
Cressol

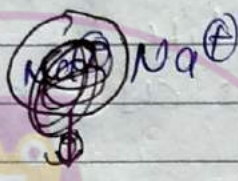
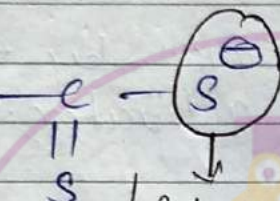


Amelene

both stabiliser



Hydrocarbon part towards water

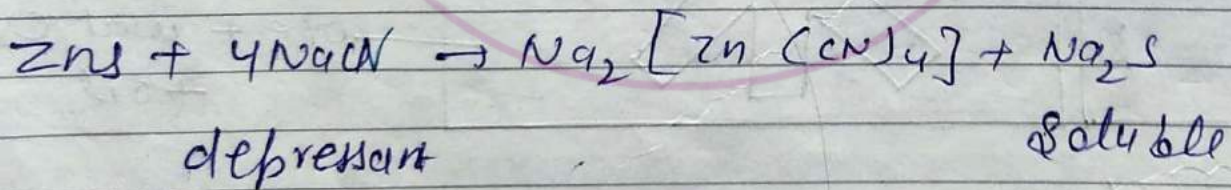


Sodium ethyl

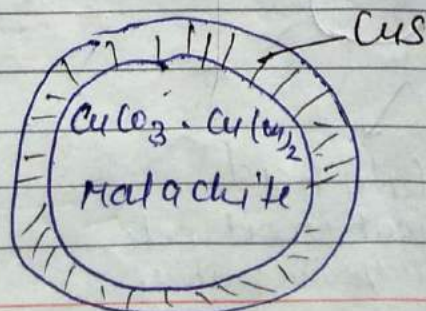
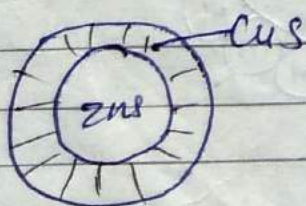
Polar Part gets attached to sulphide particle

For Ex 1

Pbs + zns  
galena Impurity

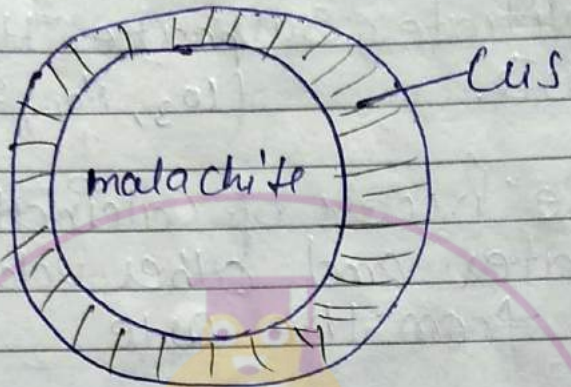
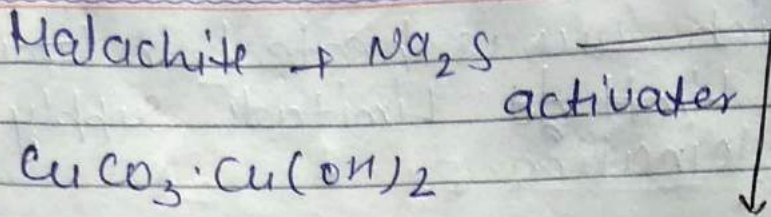


ab zns upar nahi ayega



Test Syllabus:-

Atomic Radius :- (4<sup>th</sup>)



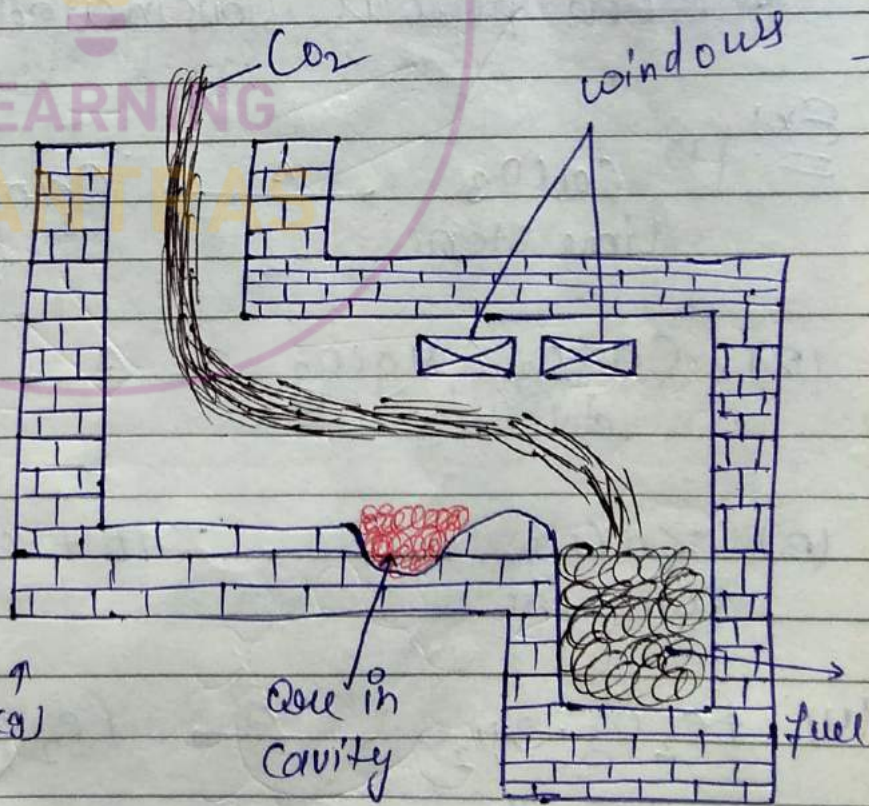
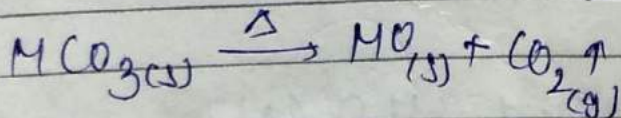
\* Conversion of metal into metal oxide by 1<sup>st</sup>

- (1) Calcination.
- (2) Roasting.

(1) Calcination!

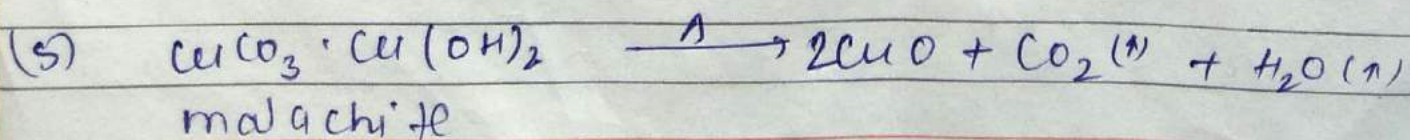
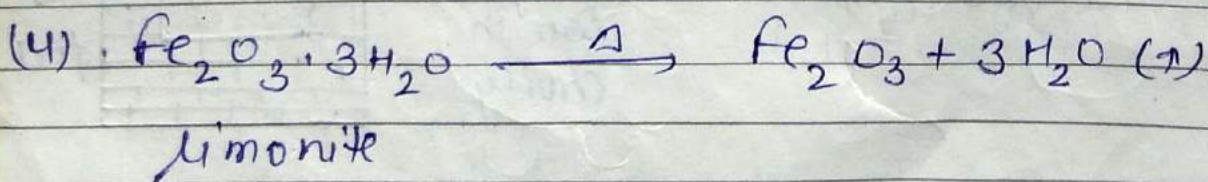
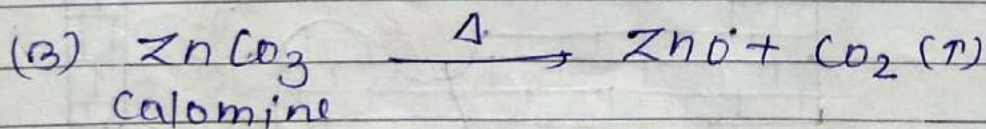
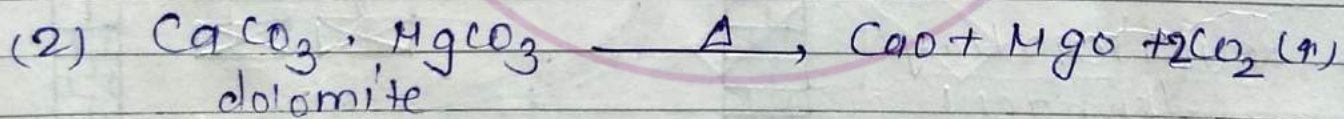
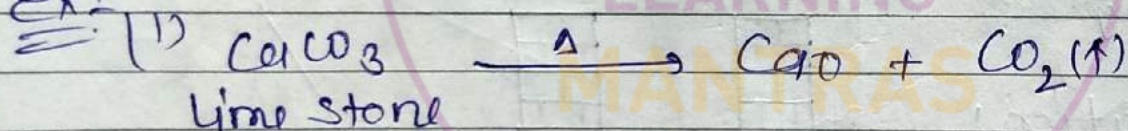
Reverberatory furnace!

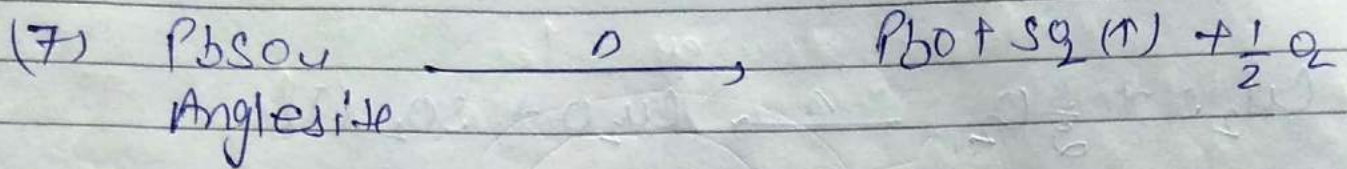
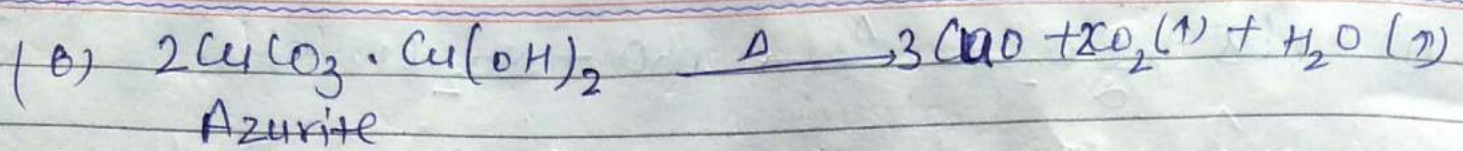
For ex<sup>l</sup>



- 1) Process in which ore is heated in limited absence of oxygen or limited supply oxygen is called calcination.
- 2) This method is used to decompose Carbonate, Nitrate, Sulphate, and Hydroxide ore to oxide ore.  $(CO_3, NO_3, SO_4, OH^{\ominus})$
- 3) During the process of calcination moisture, crystalline water and other volatile impurities are removed from the ore.
- 4) During the process of calcination ore is heated below its melting point to produce porous calcinated ore.

Ex:





\* Roasting :- (खोलना) (open the window)

1) Process in which ore is heated in presence of excess supply of oxygen is called roasting. Generally this method is completed in reverberatory furnace method.

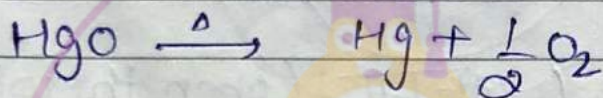
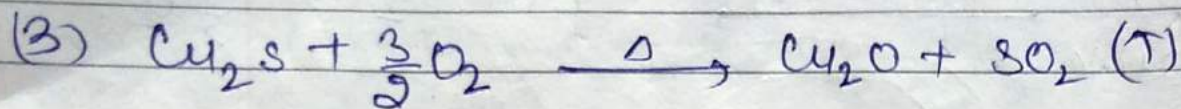
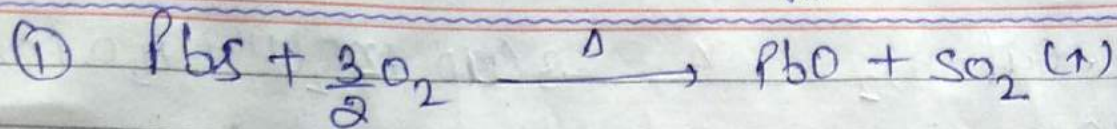
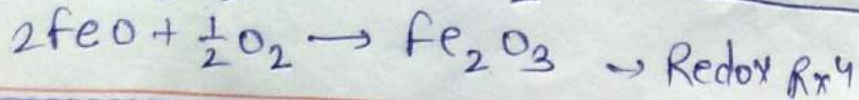
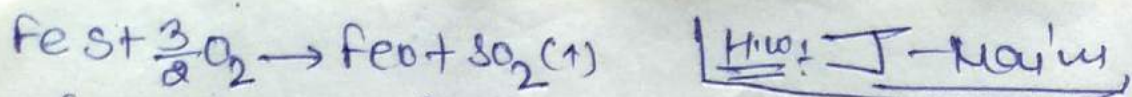
2) This method is specially applicable for sulphide ores to produce oxide ore.

3) During the process of roasting volatile impurities are removed at high temp. And non-volatile impurities are removed by the formation of volatile oxide.

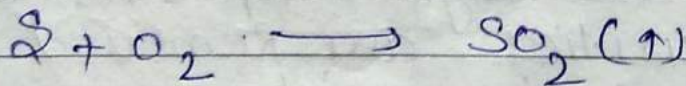
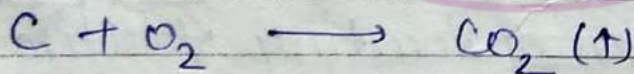
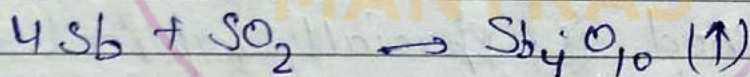
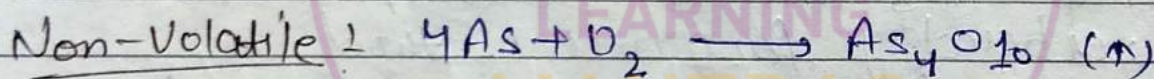
for ex: Various comp. of As & Sb

4) During the roasting organic metal is present in ore is removed due to combustion.





\* Cinnabar Produce Mercury Just on Roasting because less affinity of mercury for oxygen.

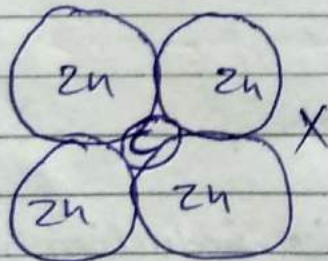


## \* Reduction of ore :

Li	} ⇒ Electrolytic reduction
Na	
Mg	
Al	
Zn	} ⇒ Reduction by Al
Cr	
Mn	
Fe	} ⇒ Reduction by Carbon
Sn	
Pb	
Cu	} ⇒ self reduction
Hg	
Ag	} ⇒ Hydrometallurgy
Au	

Ques: Why Zn o can be reduce by Carbon reduction method

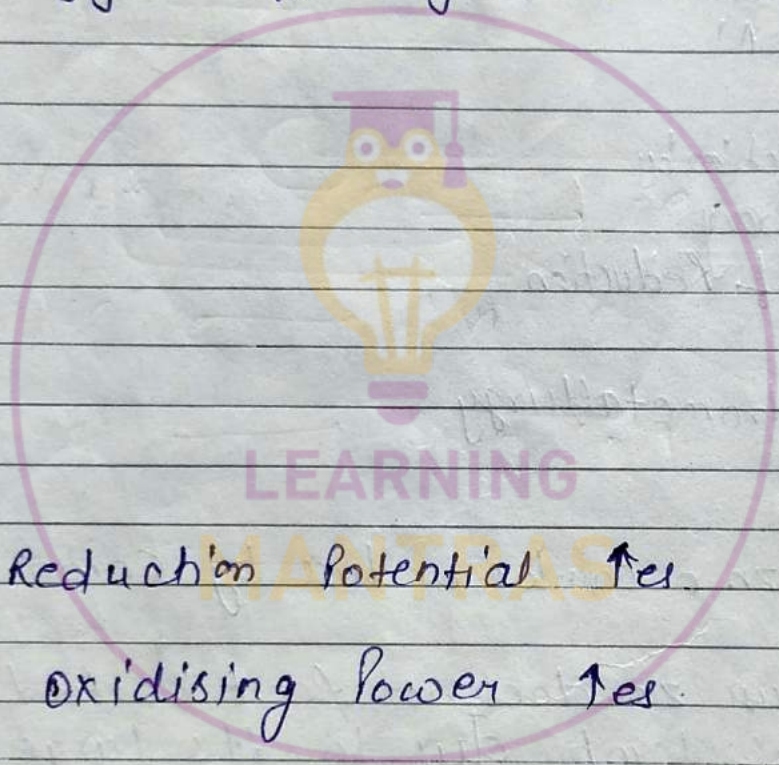
Ans: because Zn does not form carbide with Carbon at high temp. due to its large size



Reactivity Series:

Reactivity ↑

Li	↑	Oxidation potential ↑ es, Reducing power ↑ es (Khud oxidise hone ki tendency ↑ es)	↑
K			
Ca			
Na			
Mg			
Al			
Mn			
Zn			
Cr			
Fe			
Cd	↓	Reduction potential ↑ es Oxidising power ↑ es	↓
Co			
Ni			
Sn			
Pb			
H <sub>2</sub>			
Cu			
Hg			
Ag			
Au			

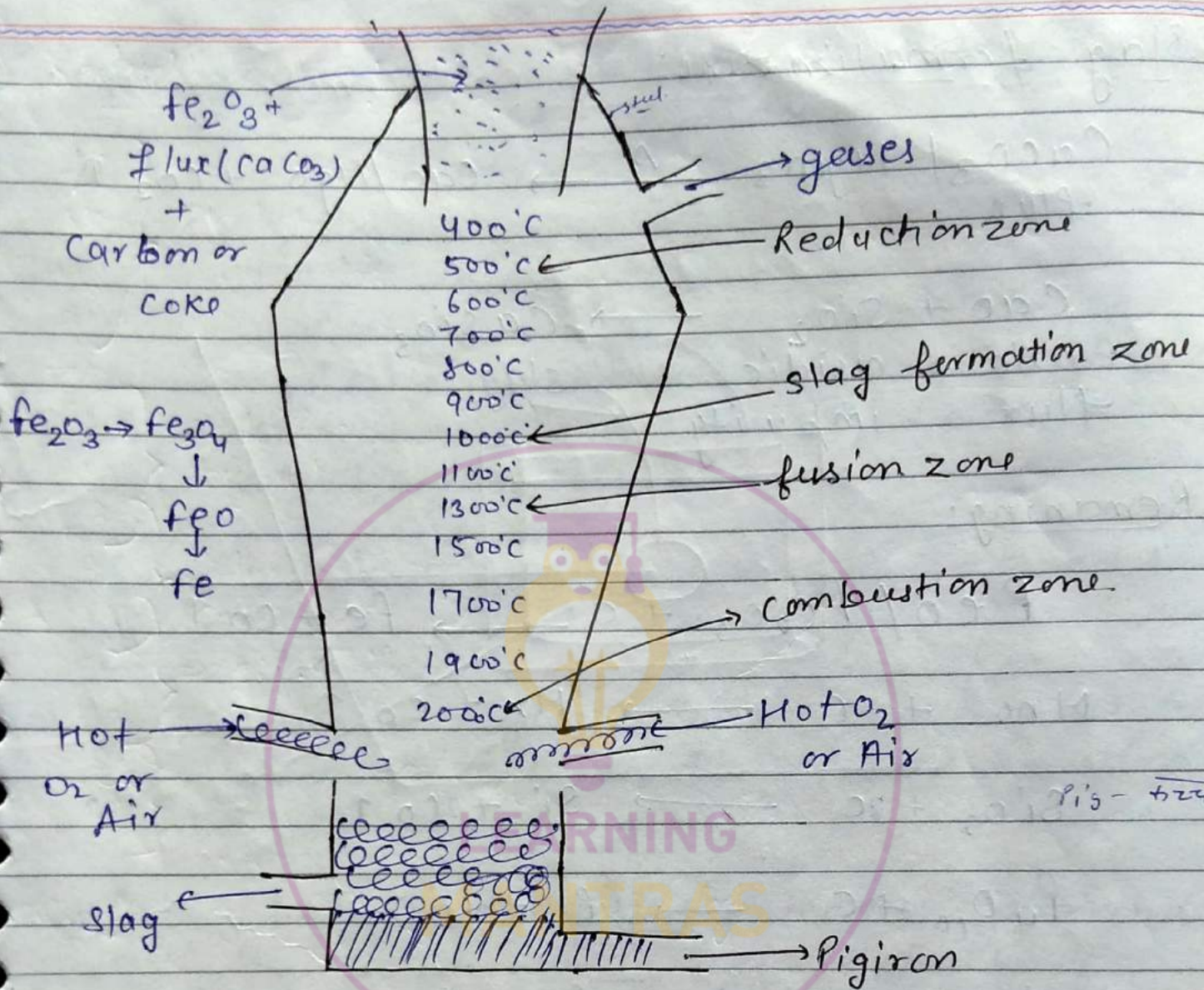


\* Reduction of ore:

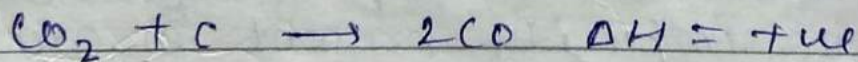
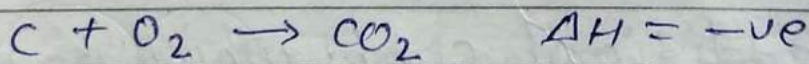
- (i) Carbon Reduction Method or Reduction by carbon:
- \* Extraction of Iron in Blast furnace:

# Remove Oxygen

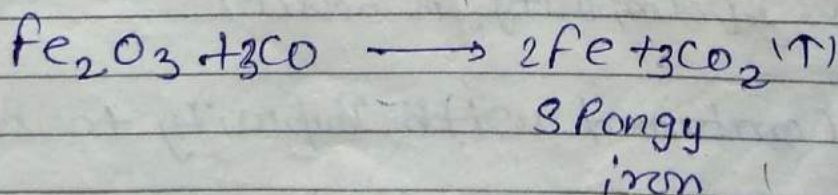
H.W - J.A.  
NCERT



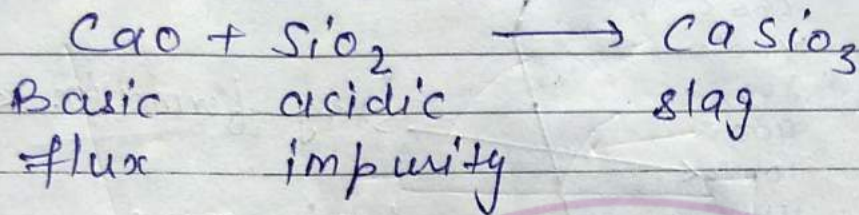
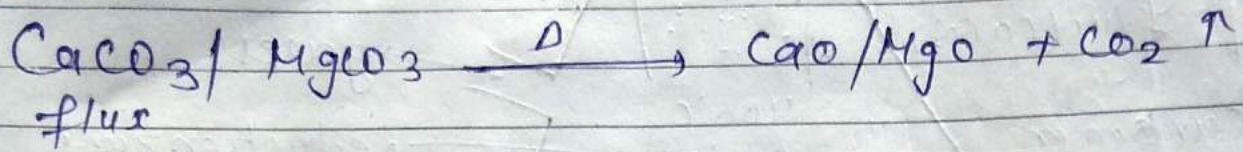
## Combustion zone:



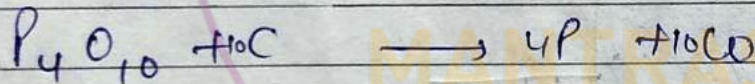
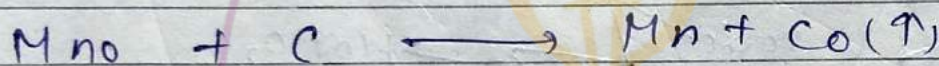
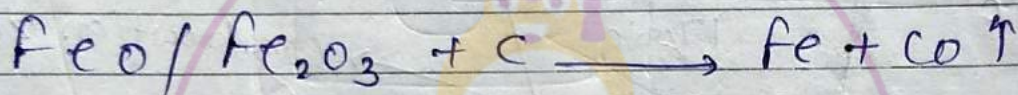
## Reduction zone:



## Slag formation zone:



## Remaining:



⇒ Extraction of iron from Hematite ( $\text{Fe}_2\text{O}_3$ ) maximum amount of ore is reduced by CO

⇒ flux is additional comp. which is required to remove impurity present in ore  
( $\text{CaCO}_3$  is used as a basic flux if impurity is acidic or  $\text{SiO}_2$  is a acidic flux used as a acidic flux if impurity is basic)

⇒ flux is combined with impurity to produce slag

↳ High Fe<sub>2</sub>O<sub>3</sub>

⇒ In fusion zone remaining FeO/Fe<sub>2</sub>O<sub>3</sub>, MnO, SiO<sub>2</sub> etc are reduced by carbon and gaseous products are mixed in iron

⇒ Impurity containing iron melt at nearly 300°C which is collected at the bottom of furnace (melting point of iron is 1535°C but in blast furnace iron is melted at nearly 300°C due to impurity present in it).

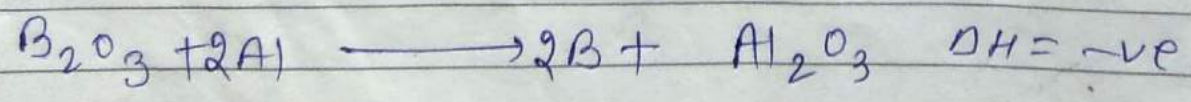
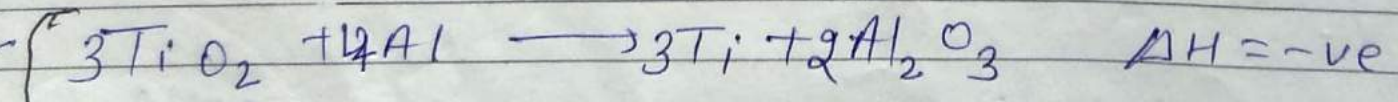
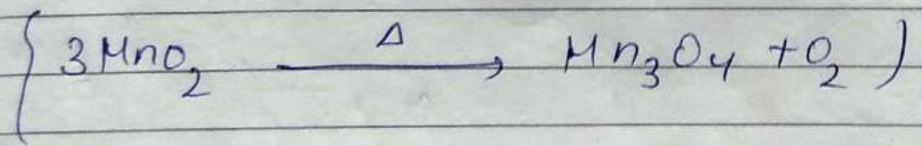
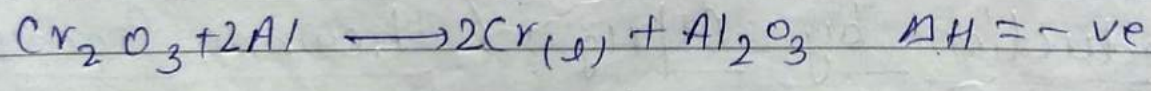
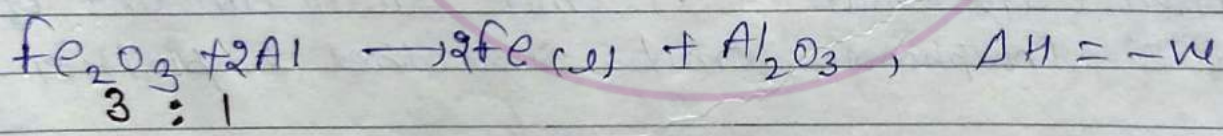
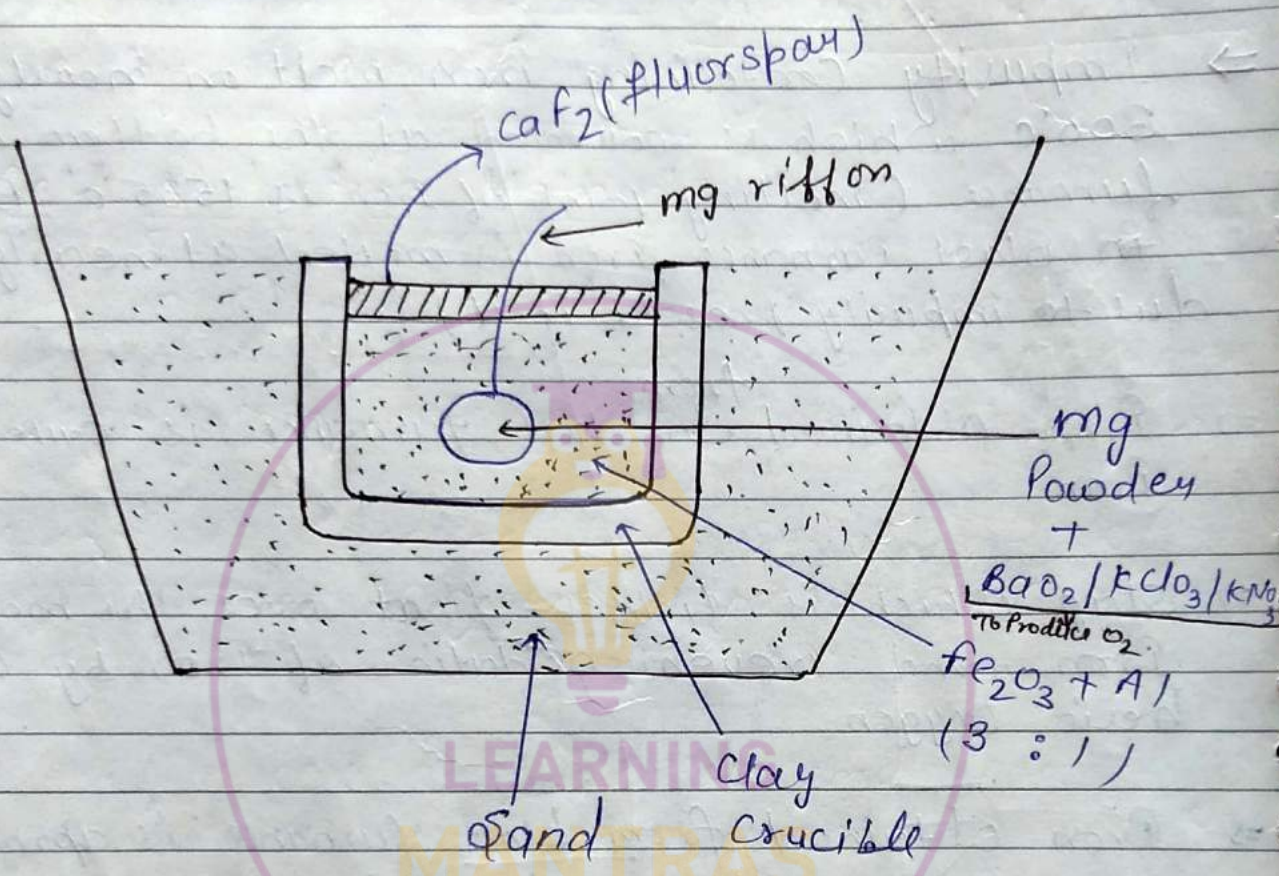
⇒ Iron obtained <sup>from</sup> in blast furnace is called pig iron

⇒ Slag which is lighter float over the molten iron and prevent oxidation of iron by atmospheric oxygen

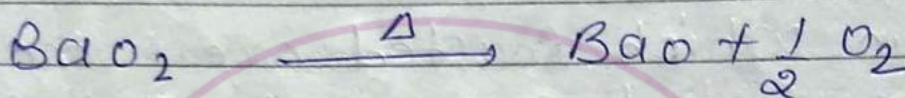
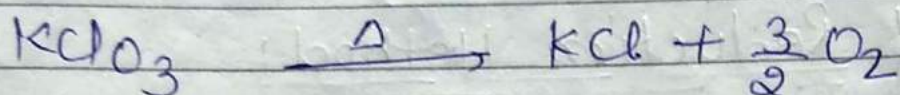
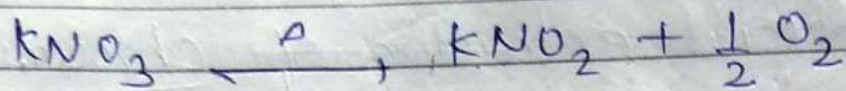
⇒ Iron obtained from blast furnace is approximately 95% pure which contains major impurity of carbon (approximately 4%) and small amount of Mg, Si, Phosphorus, and some other impurities

\* Reduction by Al/Mg: (thermite process)

(2) Reduction by Al/mg (thermite process)!



source of oxygen!



it is used in thermite welding  
(for steel steel joining)

Kroll Process



⇒

⇒ Thermite process is applicable for extraction of metal which have less affinity of oxygen as compared to Al.

⇒ In thermite process mg wire or ribbon is used as a initiator



⇒  $BaO_2$  /  $KClO_3$  /  $KNO_3$  are used to supply oxygen in mg wise

⇒ Commercial extraction of Chromium, Mn, Ti, is done by Thermite Process.

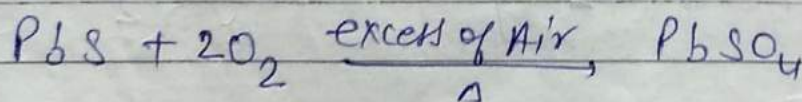
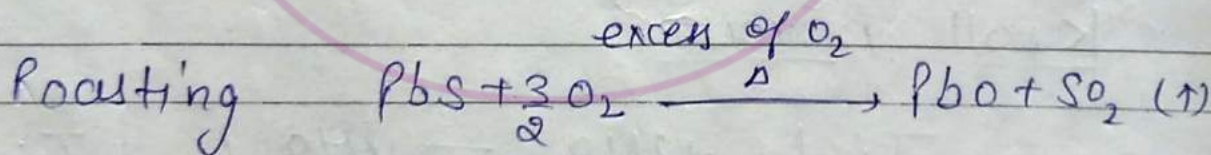
### \* 3] Self Reduction Method:

\* Process in which roasted ore is treated with unroasted ore in absence of oxygen at high temp. is called Self Reduction

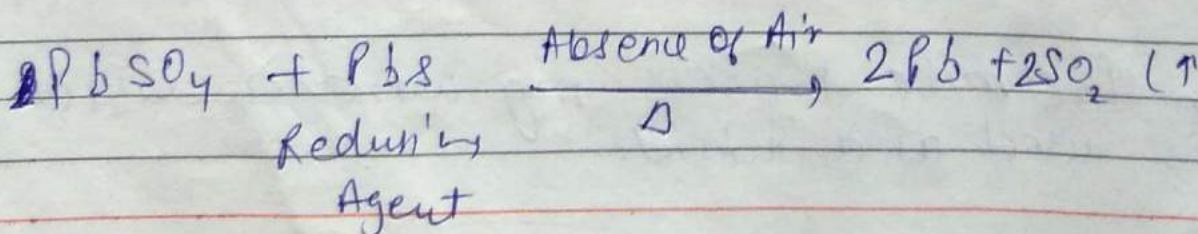
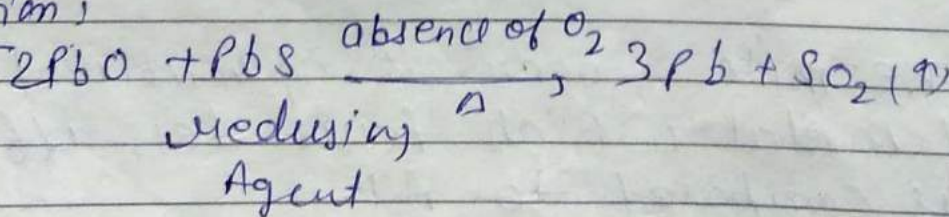
\* This rx<sup>n</sup> is processed because affinity of Sulphur for oxygen is more as compared to metal

\* In this process sulphide ore and unroasting ore act as reducing agent.

ex (1)

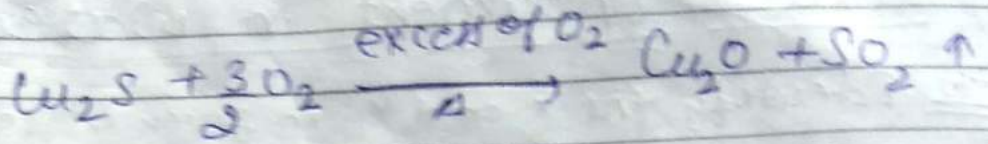


Self reduction,

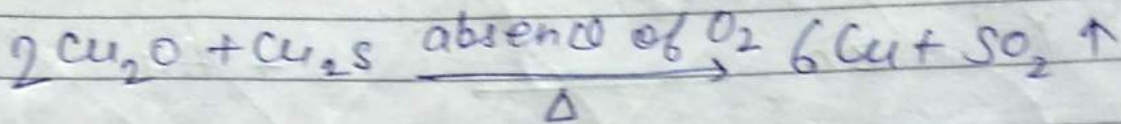


Ex 1 2

Roasting



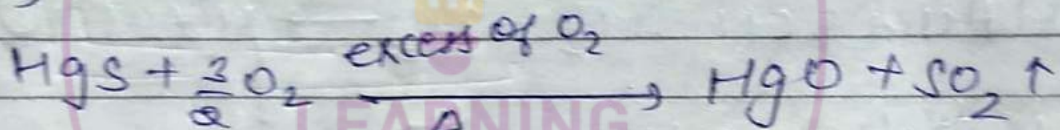
Self reduction



Blister Cu  
(98%)

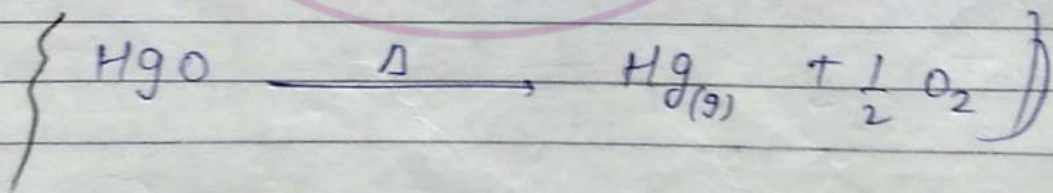
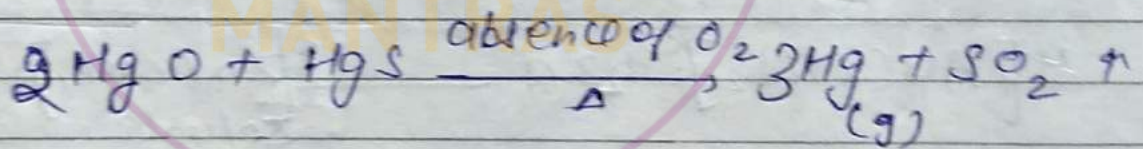
Ex 3

Roasting



Self

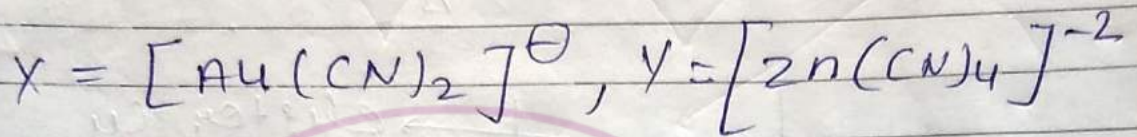
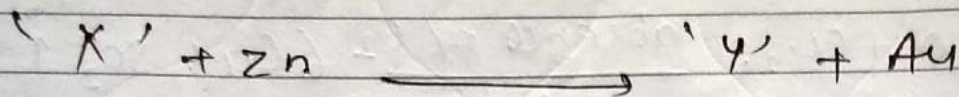
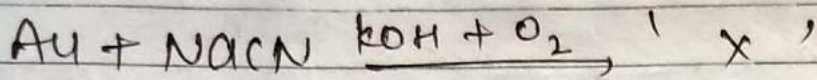
reduction



\* This method is not applicable for extraction of zinc from ZnS because zinc have more affinity for oxygen as compared to sulphur

(4) Metal displacement in water: (Hydrometallurgy)

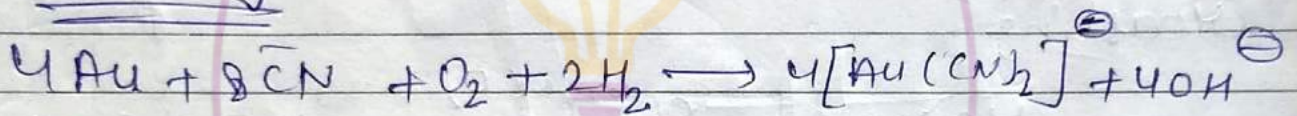
Q3a Identify the x and y in given rxn sequence



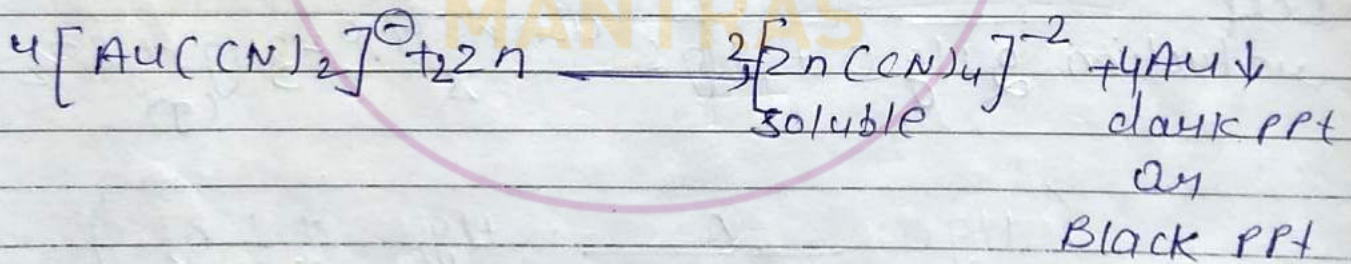
OR

\* Mac Arthur forest Cyanide Process:

Ex 1 Leaching

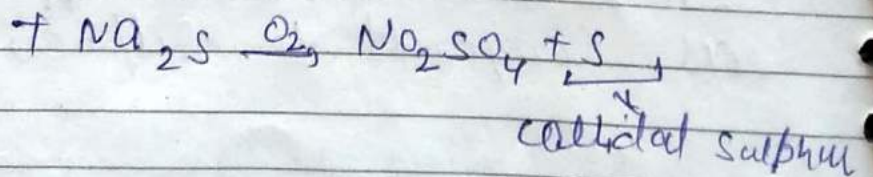
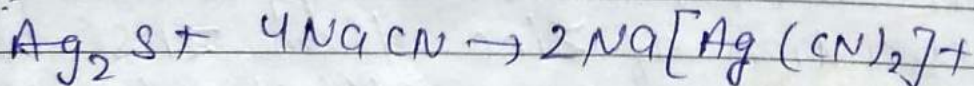


Metal displacement:

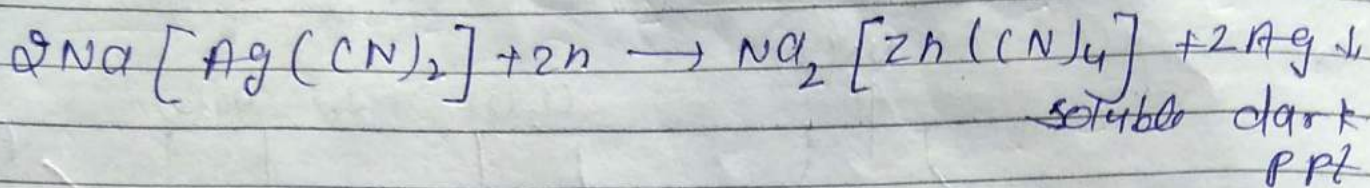


Ex 2

Leaching:



## Metal displacement:



Q.) Which of the following is the best method for the extraction of sodium

- A) Carbon Reduction method
- B) Electrolysis of aqueous salt.
- C) Metal displacement in water
- D) Electrolysis of Molten salt.

## (5) Electrolytic Reduction!

\* Extraction of reactive metal is very difficult by Carbon Reduction method because they can form Carbide when react with carbon at high temp.

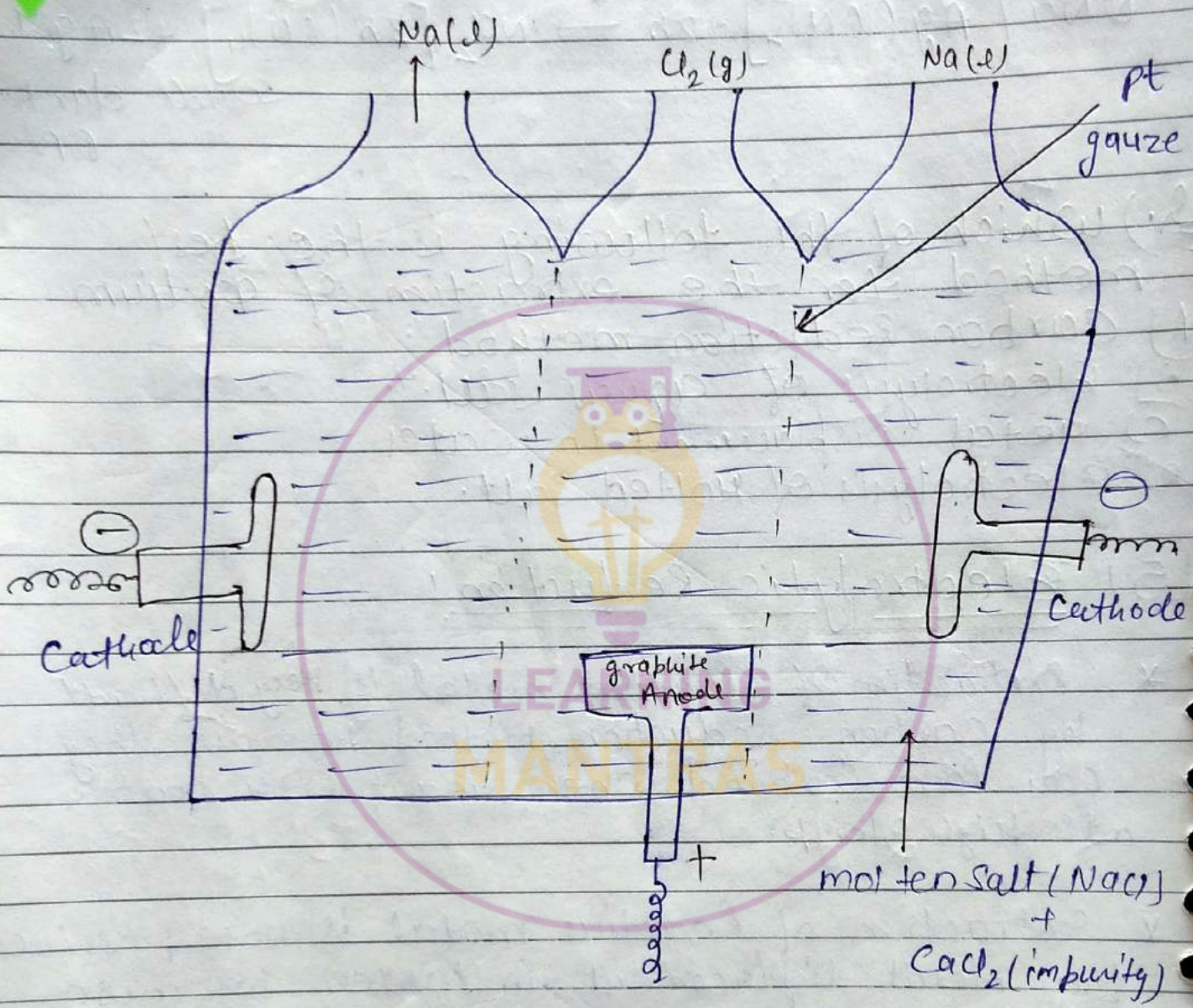
\* Extraction of reactive metal is not possible by metal displacement in water because they react with water.

\* Extraction of reactive metal is not possible by aqueous salt Electrolysis because H<sub>2</sub> is produce at Cathode

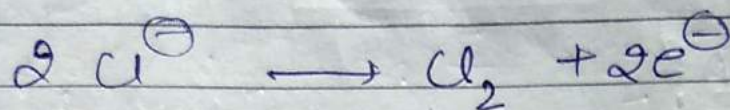
\* Molten salt electrolysis is the best method for the extraction of Na or reactive metals.

ecdy

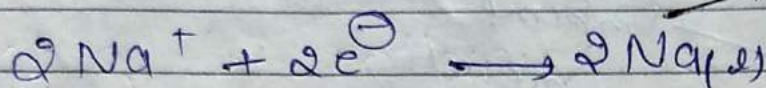
# Down cell



at anode (+)  $\Rightarrow$



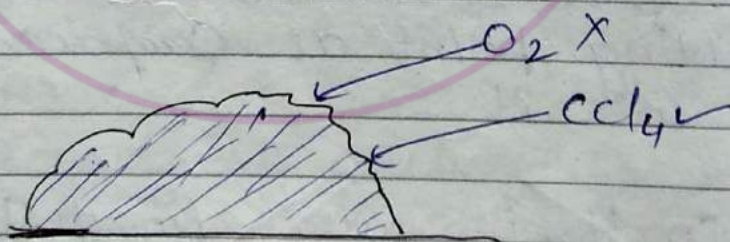
at cathode: (-)  $\Rightarrow$



$\xrightarrow{\text{on cooling NaCl}}$

\* In down cell Sodium (Na) is extracted by electrolysis of molten NaCl

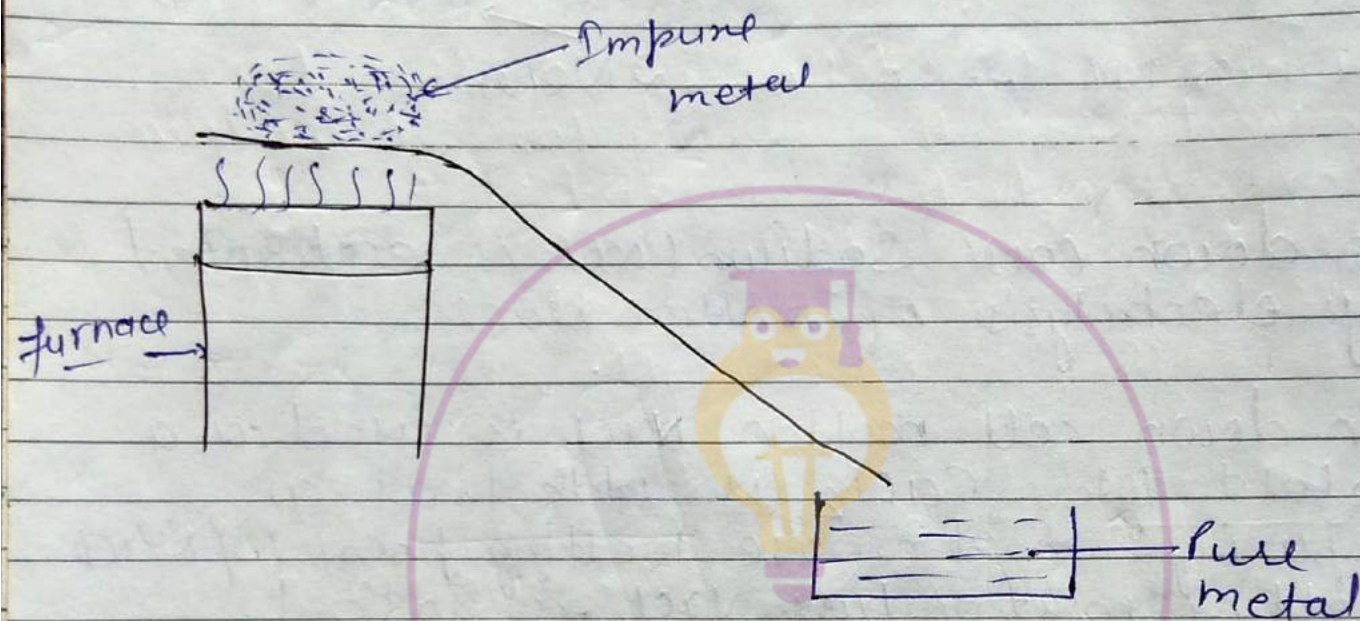
\* In down cell molten NaCl is used as a electrolyte.  $\text{CaCl}_2$  is added as an impurity to decrease melting point of NaCl (melting point of pure NaCl is  $803^\circ\text{C}$ )



Spray of  $\text{CCl}_4$  on reactive metal to prevent fire

(e) Refining of ~~ore~~ metal :-

(i) Liquidation :-



\* Liquidation method is applicable for refining of metal which have relatively low melting point as compared to impurity present in it.

For Ex: Sn, Pb, Bi are refined by this process.

Learn

\* (3) Distillation :-

In Distillation, impure metal is heated upto vapourisation to separate non-volatile impurities.

\* Impure zinc is called spelter which is separated from impurity of Fe and Pb by distillation.

\* By distillation low boiling point metals are ~~meta~~ refined by

for ex: Zn, Cd, Hg

for ex! Impure Zn  $\Rightarrow$  spelter

Impurity  $\left\{ \begin{array}{l} \text{Fe} = 2750^\circ\text{C (B.P)} \\ \text{Pb} = 1751^\circ\text{C (B.P)} \end{array} \right.$

Pure Zn  $\Rightarrow$   $903^\circ\text{C (B.P)}$

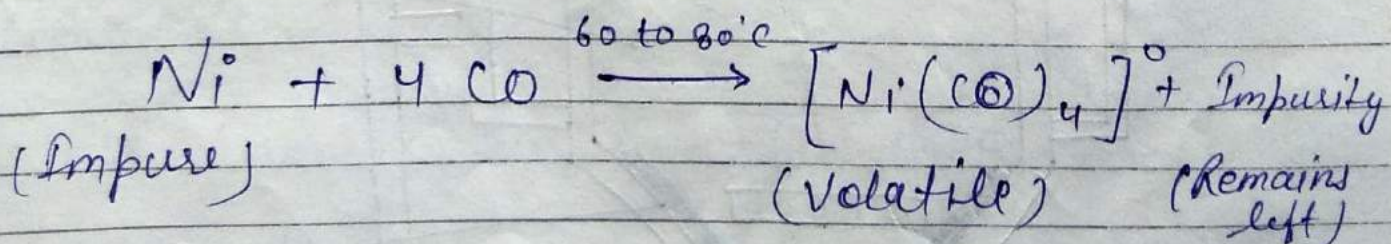
\* (iii) \* Vapour phase refining:

v. Imp.

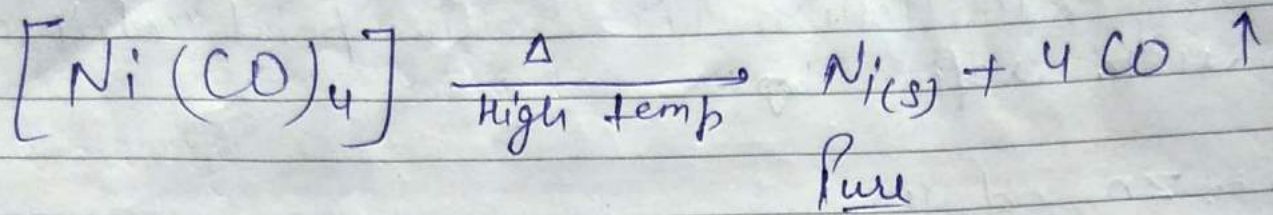
(P) Mond's Process:

\* Ni is purified by this method

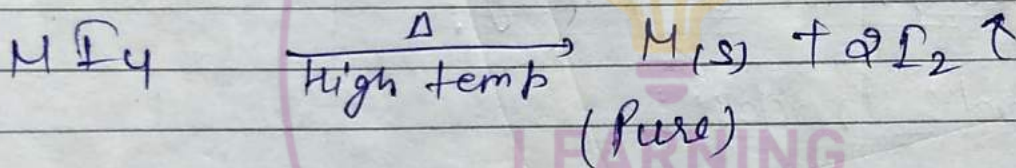
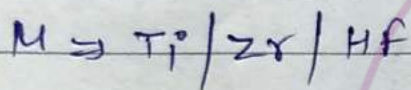
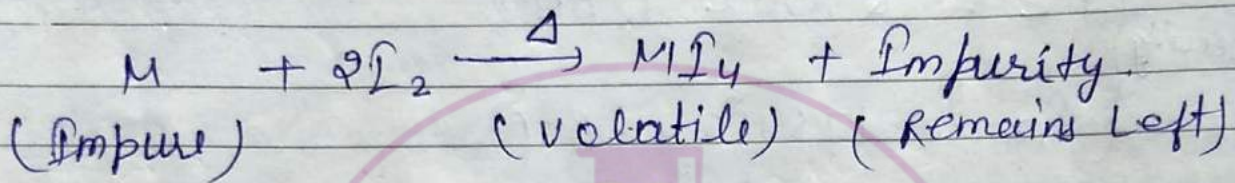
In this process Impure Ni is treated with CO at 60 to 80°C to produce Volatile Compound Ni Carbonyl Complex. Ni Carbonyl Compound decompose at 180°C to form Pure Ni



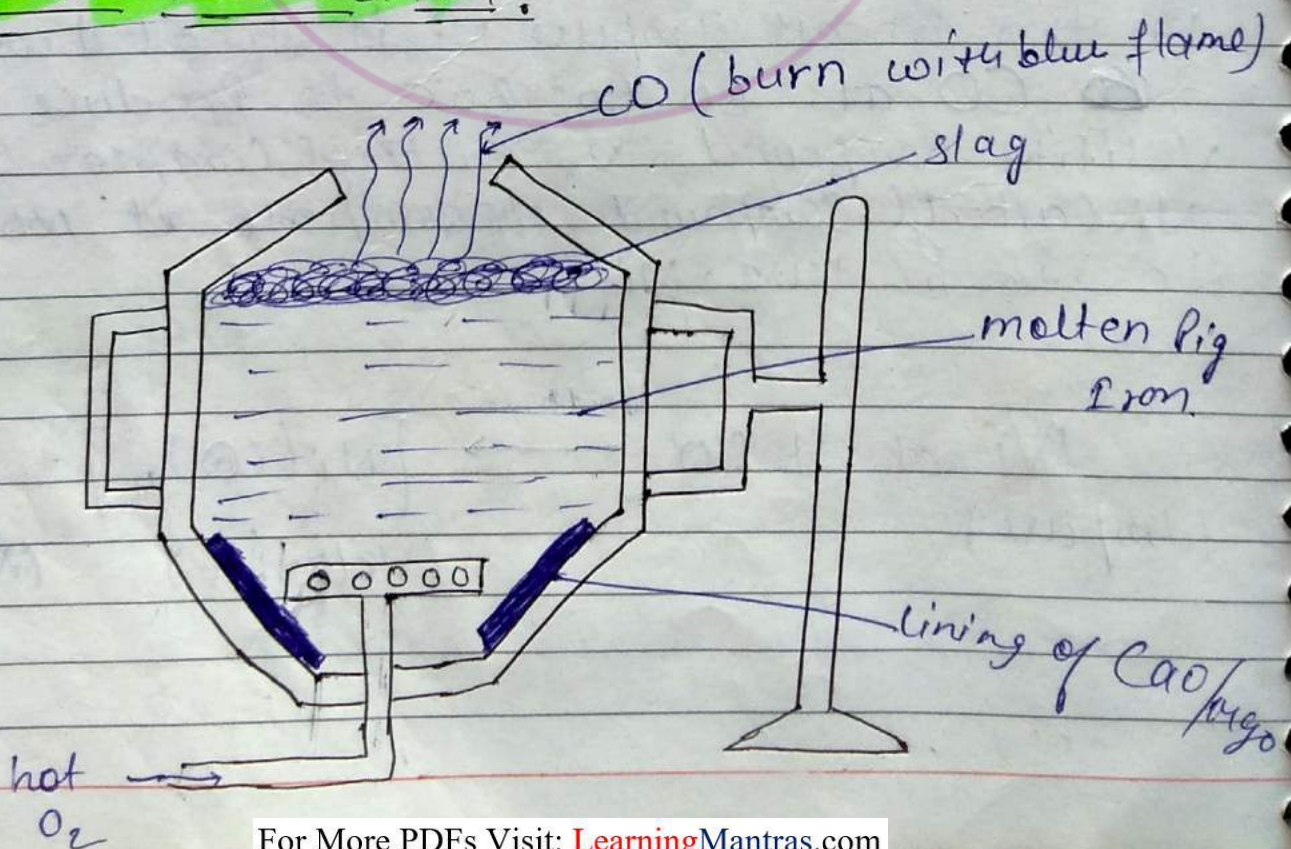


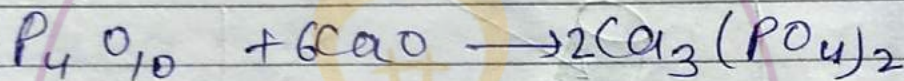
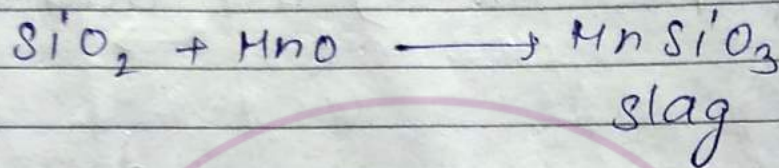
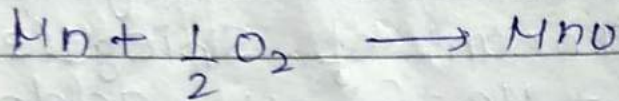
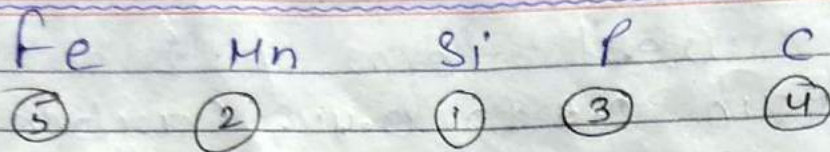


### (ii) Van Arkel Process :-

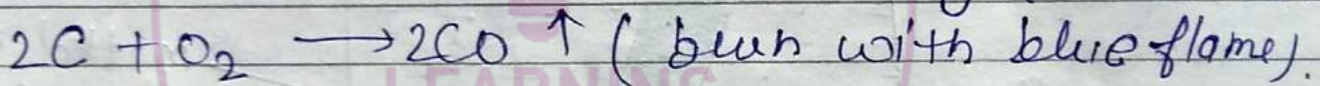


### (iv) Bessemerization :-





thomas slag (fertilizer)



\* The impure metal is heated in a furnace and a blast of compressed air long through the molten mass the impurities get oxidised

\* Bessemerization process is applicable when impurity present in metal have more affinity for oxygen as compared to metal

\* Pig Iron is refined by this process

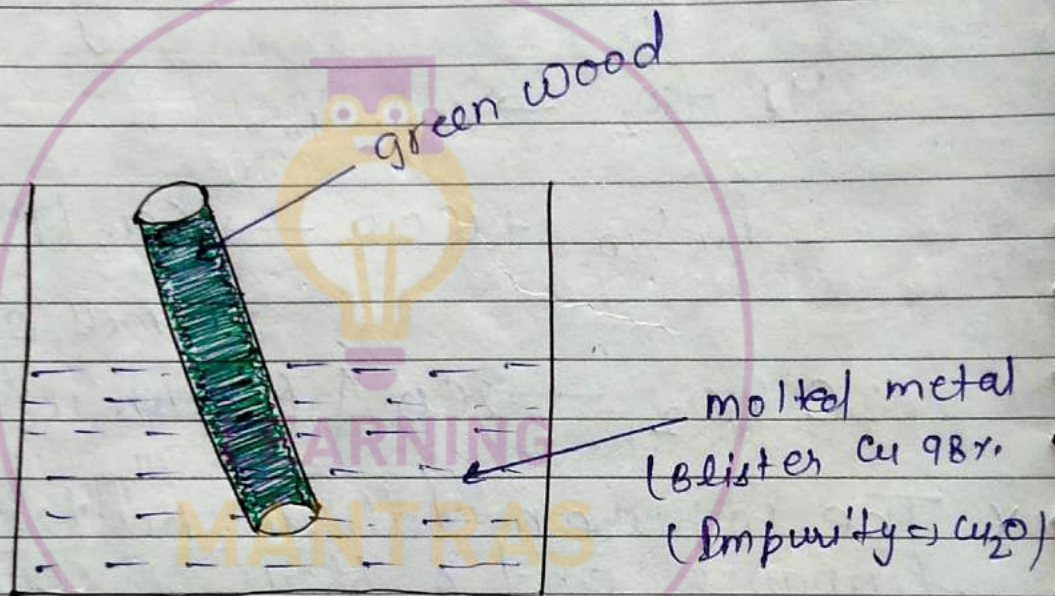
\* Iron obtained from Bessemerization is called wrought iron.

Roll: 28, 29,  
sheet  $\Rightarrow$  93, Diagram  
Read.

It is the purest form of Iron.  
which contain 0.2 to 0.4% Carbon as an  
Impurity

\* To Prepared steel from wrought iron.  
calculated amount of spiegeleisen  
(alloy of Fe + Mn + C) is added

\* Poling



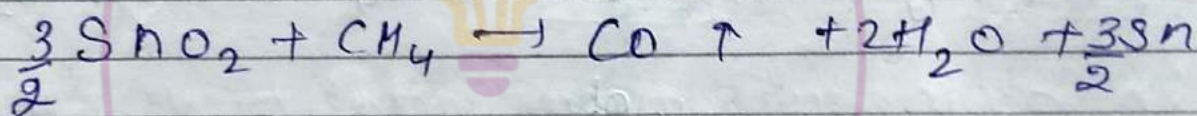
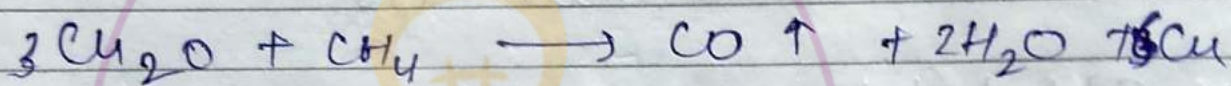
$\Rightarrow$  The impure metal containing oxide as an  
impurity are purified by this. Can be purified  
by this method

The molten metal stirred with green pole  
of wood. the green pole of wood released  
the hydrocarbon gases which reduced the  
oxide impurities

⇒ This method is applicable for refining of metals which contain impurity of same metal oxide

⇒ Poling method is applicable for refining of copper which contain  $\text{Cu}_2\text{O}$  and  ~~$\text{SnO}_2$~~   
 $\text{Sn}$  which contain  $\text{SnO}_2$

⇒ Hydrocarbons are produced by green wood which act as reducing agent for metal oxide



### \* vi Electrolytic Refining :

\* Metals such as,  $\text{Sn}$ ,  $\text{Cu}$ ,  $\text{Zn}$ ,  $\text{Ag}$ ,  $\text{Al}$ ,  $\text{Cr}$ ,  $\text{Ni}$ , etc. are refined by this process.

\* The impure metal is made the anode the electrolytic cell. while cathode is thin plate of pure metal and electrolyte is double salt of metal

\* on passing electric current pure metal from the anode dissolve and get deposited at the cathode.

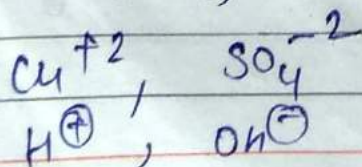
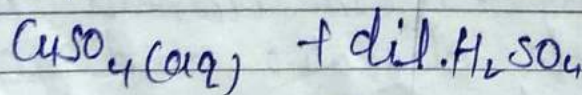
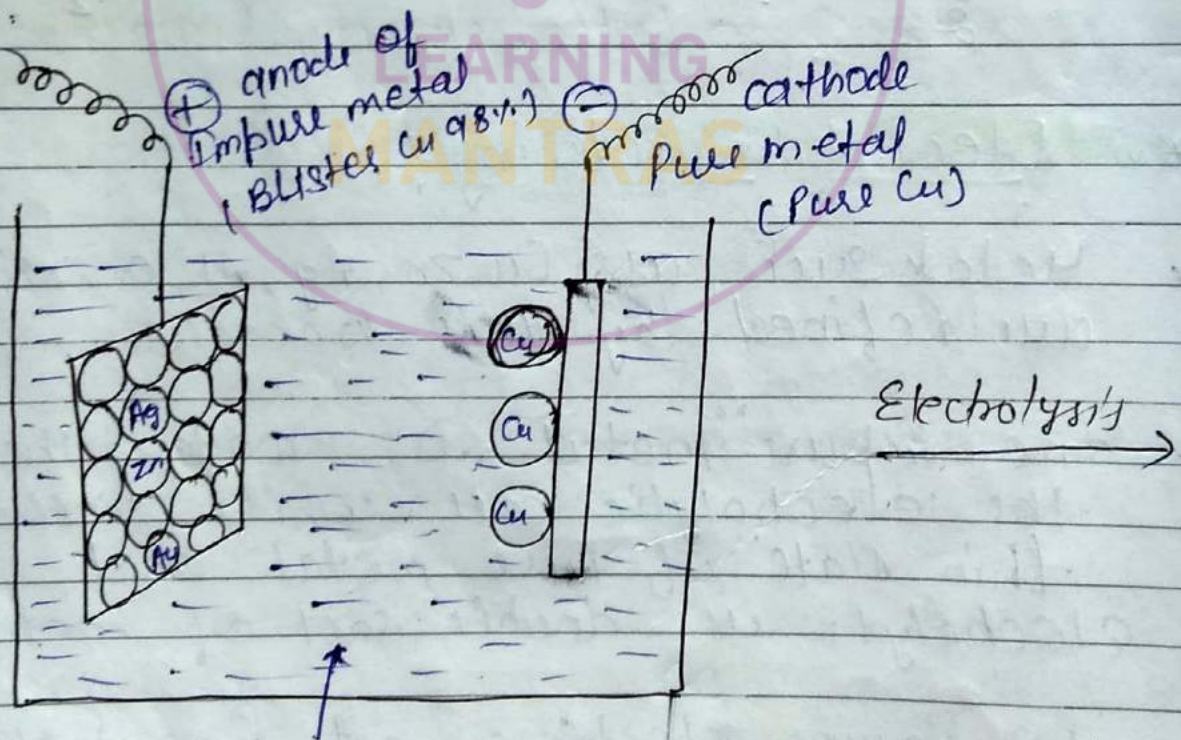
\* The Soluble impurities go into the sol<sup>n</sup> and Insoluble and less electro positive impurities settle down below the anode as anode mud or sludge.

For Ex: electrolytic refining of Cu.

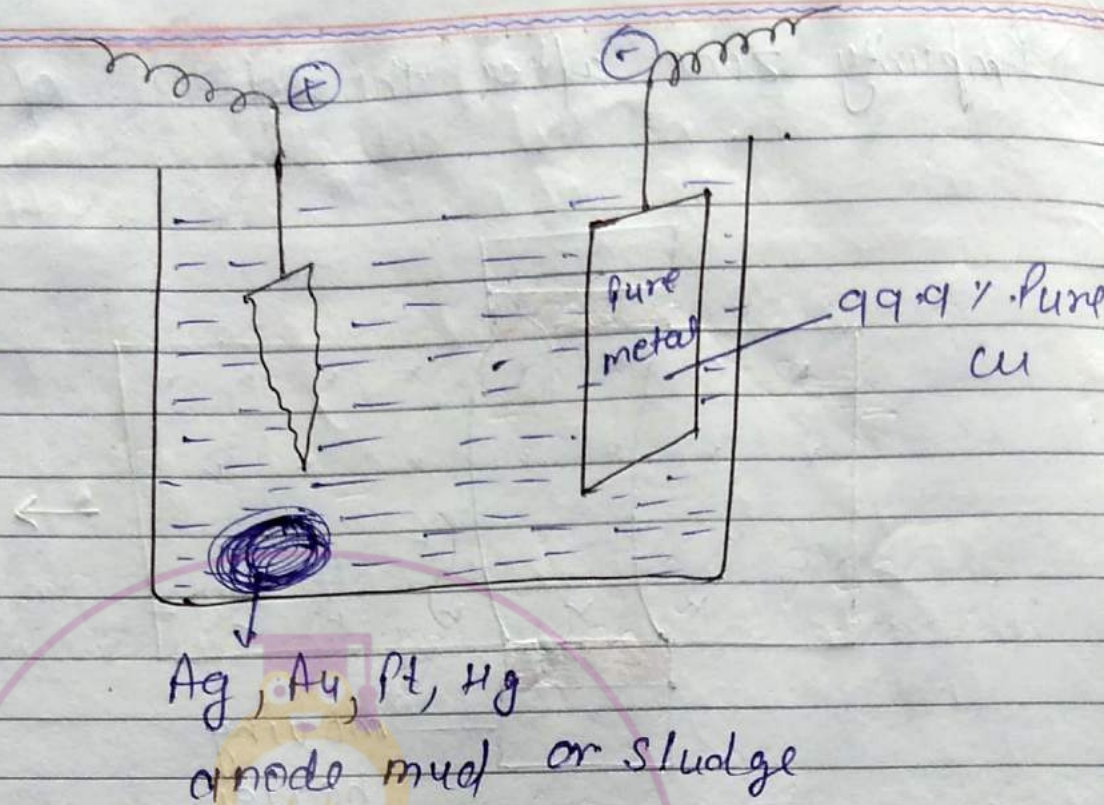
Anode (+)  $\Rightarrow$  Impure metal  
(Blister Cu 98%)

Cathode (-)  $\Rightarrow$  Pure metal  
(Pure Cu).

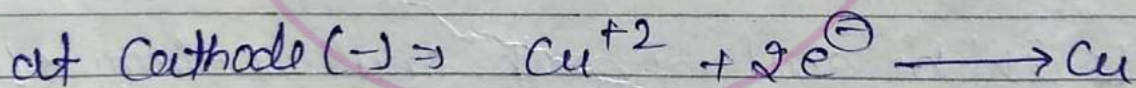
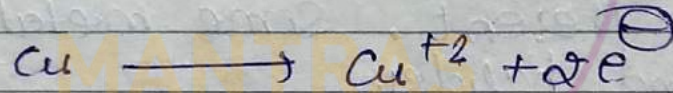
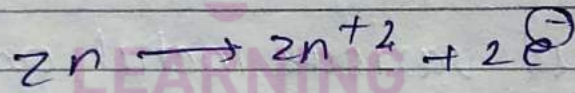
Electrolyte  $\Rightarrow$  15% CuSO<sub>4</sub> + 5% dil. H<sub>2</sub>SO<sub>4</sub>



Electrolysis



at anode (+) ⇒



\* Zone Refining :

\* This method is applicable to prepare ultra pure metal like Ga, Ge, Si, As, & B, In

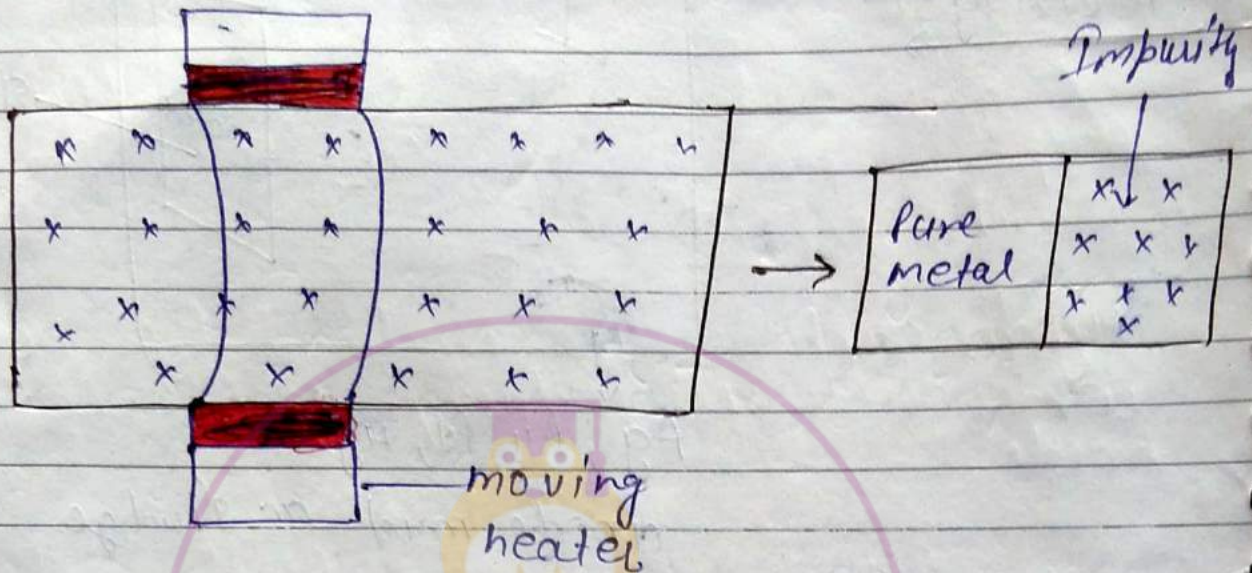
\* This method is Based on fractional distillation

\* This method is Based on the fact that impurities have more solubility in molten form of metal as compared to solid form so that their presence

entropy & randomness of particle

Law:

Impurity zone after the repetition of process

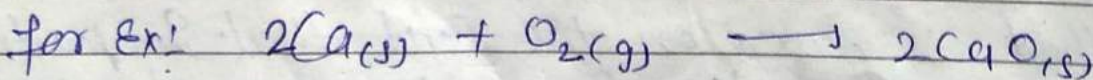


### \* Ellingham Diagram

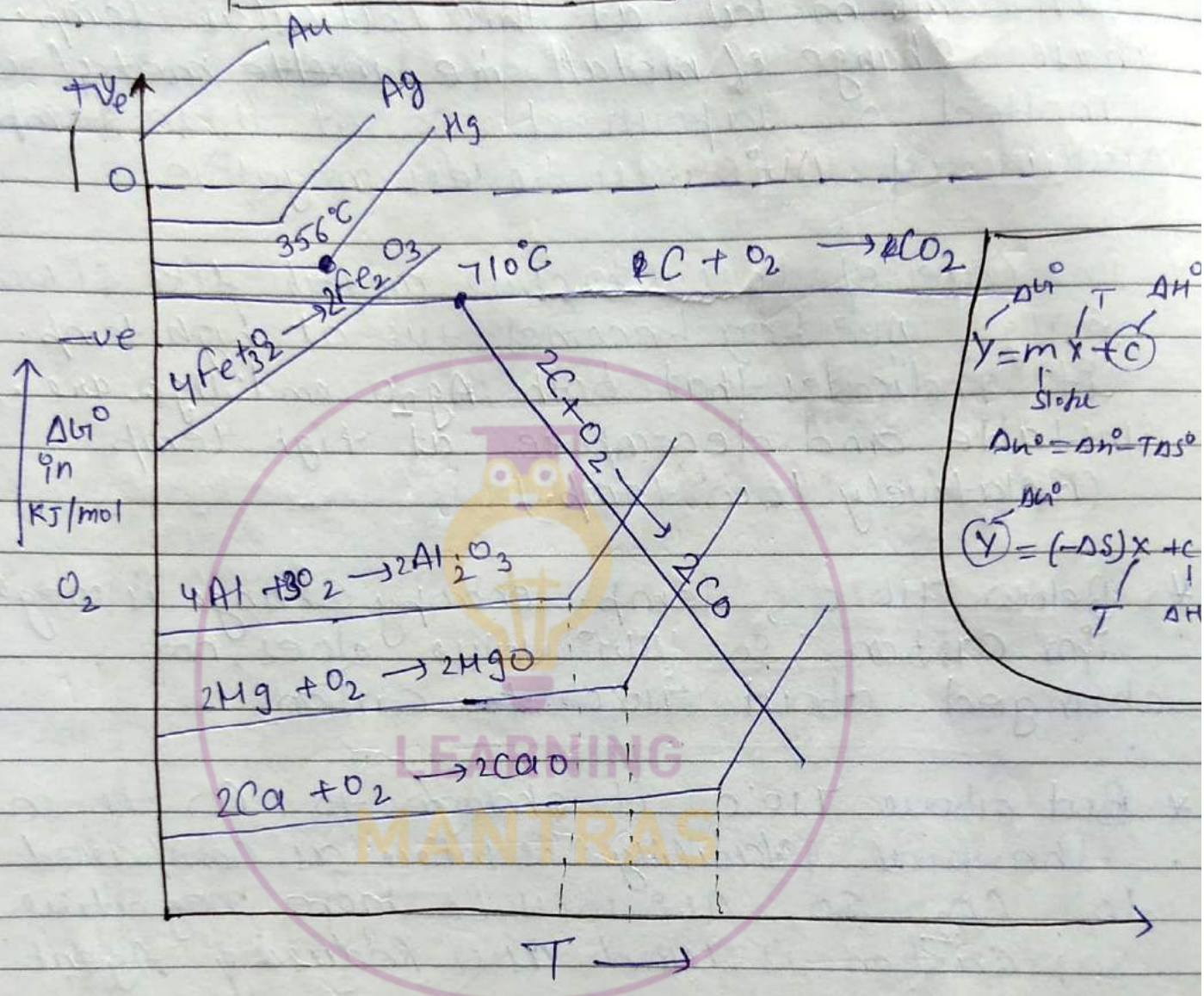
\* In earth crust various metal oxide and oxy anions are present. Some metals exist in their sulphides and halides.

\* Metals which exist in earth crust in form of sulphide and oxy anions are converted in their oxides by calcination and roasting, so,  $\Delta H$  vs  $T$  graph or Ellingham diagram is important for formation of oxides of metal.

\* entropy decreases when metal is converted into their oxide for ex: Ca



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



$$y = mx + c$$

Slope

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

$$y = (-\Delta S) x + c$$

T      ΔH

\* Metal oxides which have more thermal stability can be used as reducing agent for oxides of other metals which lie above it in the Ellingham diagram.

\* It is observed by Ellingham diagram when the temp. increases a point will be reached where the graph crosses the  $\Delta G = 0$  line, metal oxides are converted into metal.



\* A Particular Temp., Slope will be changed for some metal at this particular temp. Phase change of metal i.e. metal is melted or vapourised so at these temp. values of  $\Delta G^\circ$  will be less negative

\* In case of less reactive metal like silver (Ag)  $\Delta G^\circ$  becomes +ve at high temp. It indicates that both  $Ag_2O$  and  $HgO$  are unstable and decompose at high temp. (Relatively low temp.)

\* Below  $710^\circ C$ , temp. entropy change is negligible for carbon, so  $\Delta G^\circ$  value does not change about  $710^\circ C$  for carbon.

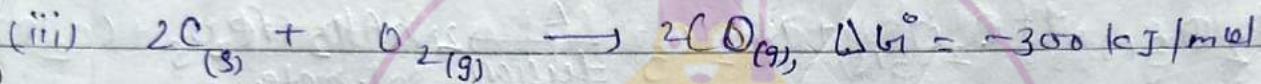
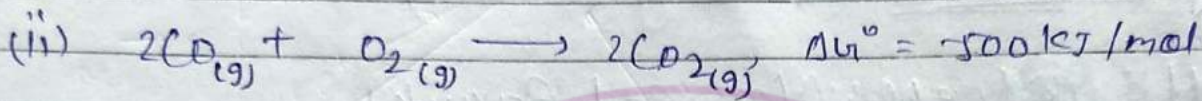
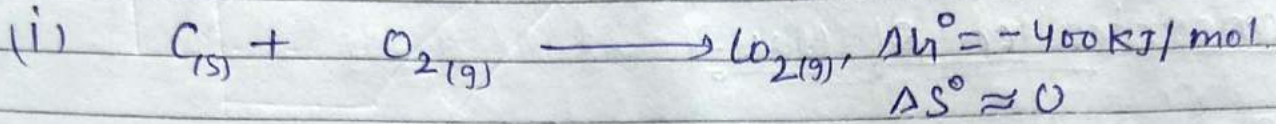
\* But above  $710^\circ C$  it changes to CO these thermal stability is more as compared to  $CO_2$ . So,  $\Delta G^\circ$  will be more negative so, carbon is used as a reducing agent.

\* Metal which have high +ve charge density or more electropositive their oxides are not reduced by carbon because temp. of  $M^{n+}$  is very high and more electropositive oxides from carbide react with carbide.

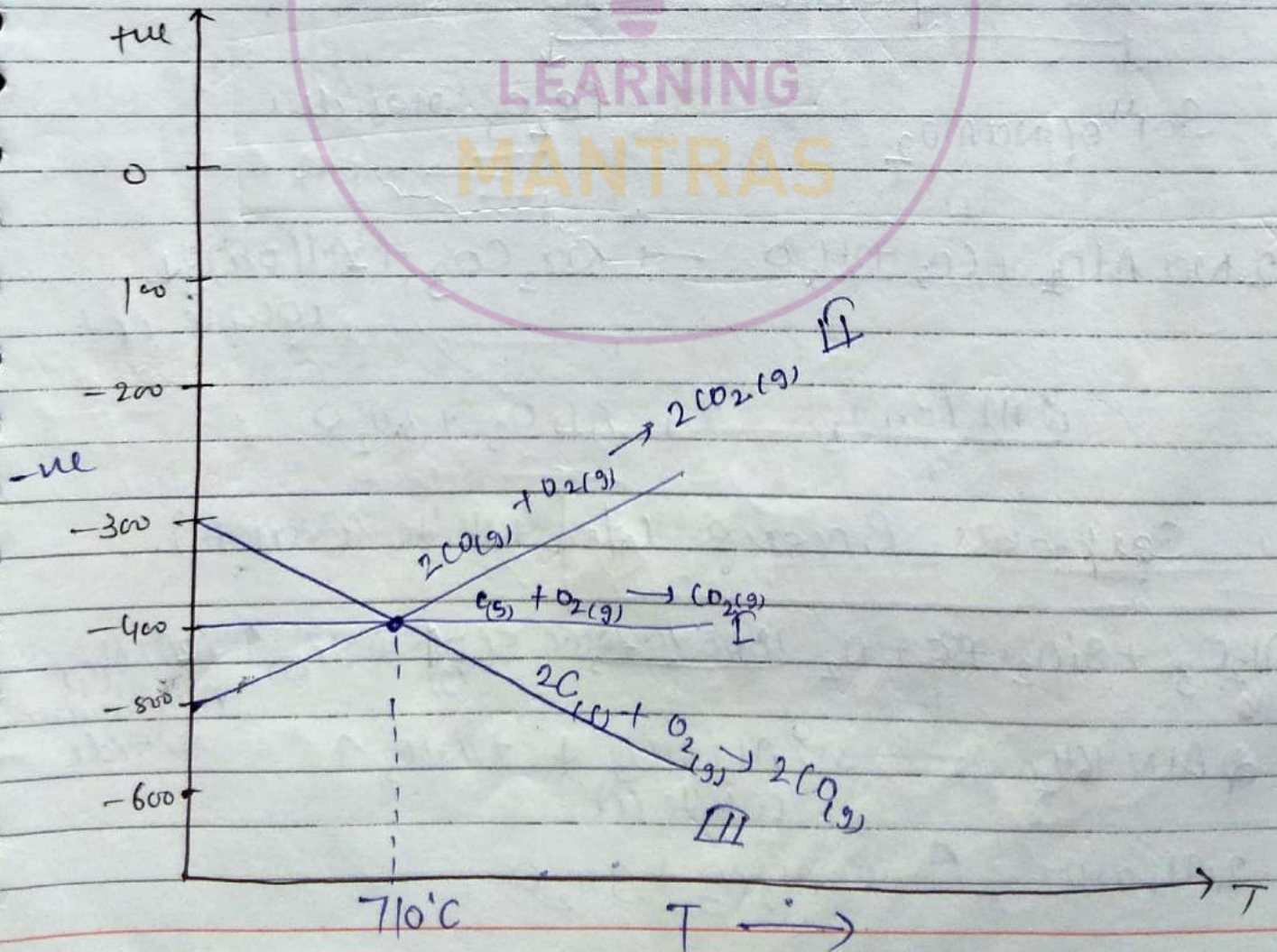
$$\Delta G^\circ = m \left( \overset{\text{slope } T}{\Delta H^\circ} + C \right) - \Delta H^\circ$$

$$\Delta G^\circ = \Delta H^\circ - T$$

Q. below 710°C CO is better reducing Agent as compared to Carbon. But reverse is also true above 710°C, Explain.



\* graph of ~~Burning~~ <sup>Burning</sup> Carbon!



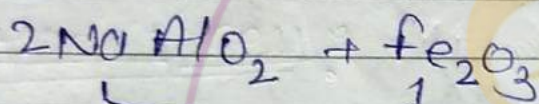
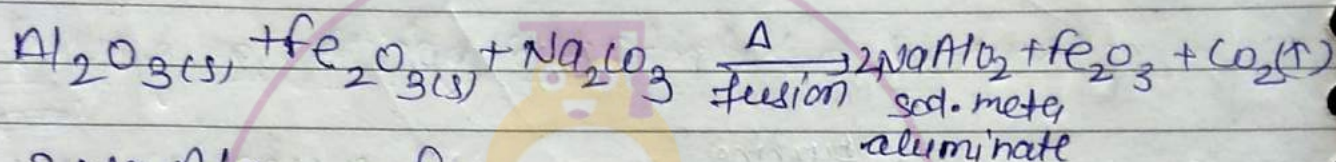
## \* Individual Metallurgy°

### (i) Extraction of Al from Bauxite! (Al<sub>2</sub>O<sub>3</sub>)

#### (A) Concentration of Ore°

(i) Bayer Process! (for Red Bauxite)

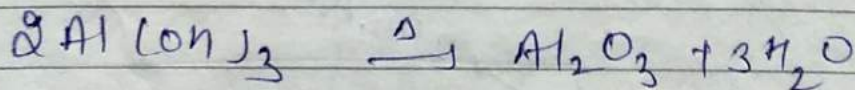
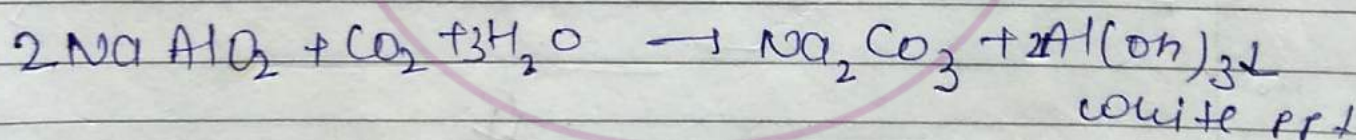
(ii) Hall's Process! (for Red Bauxite)



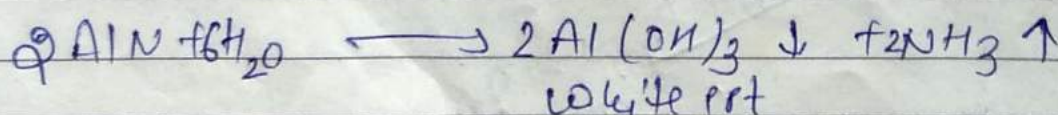
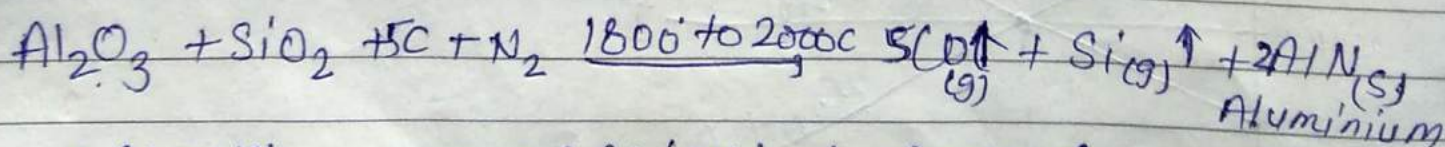
↓ + water

↓  
Sol<sup>n</sup> of NaAlO<sub>2</sub>

↓  
Fe<sub>2</sub>O<sub>3</sub> residue



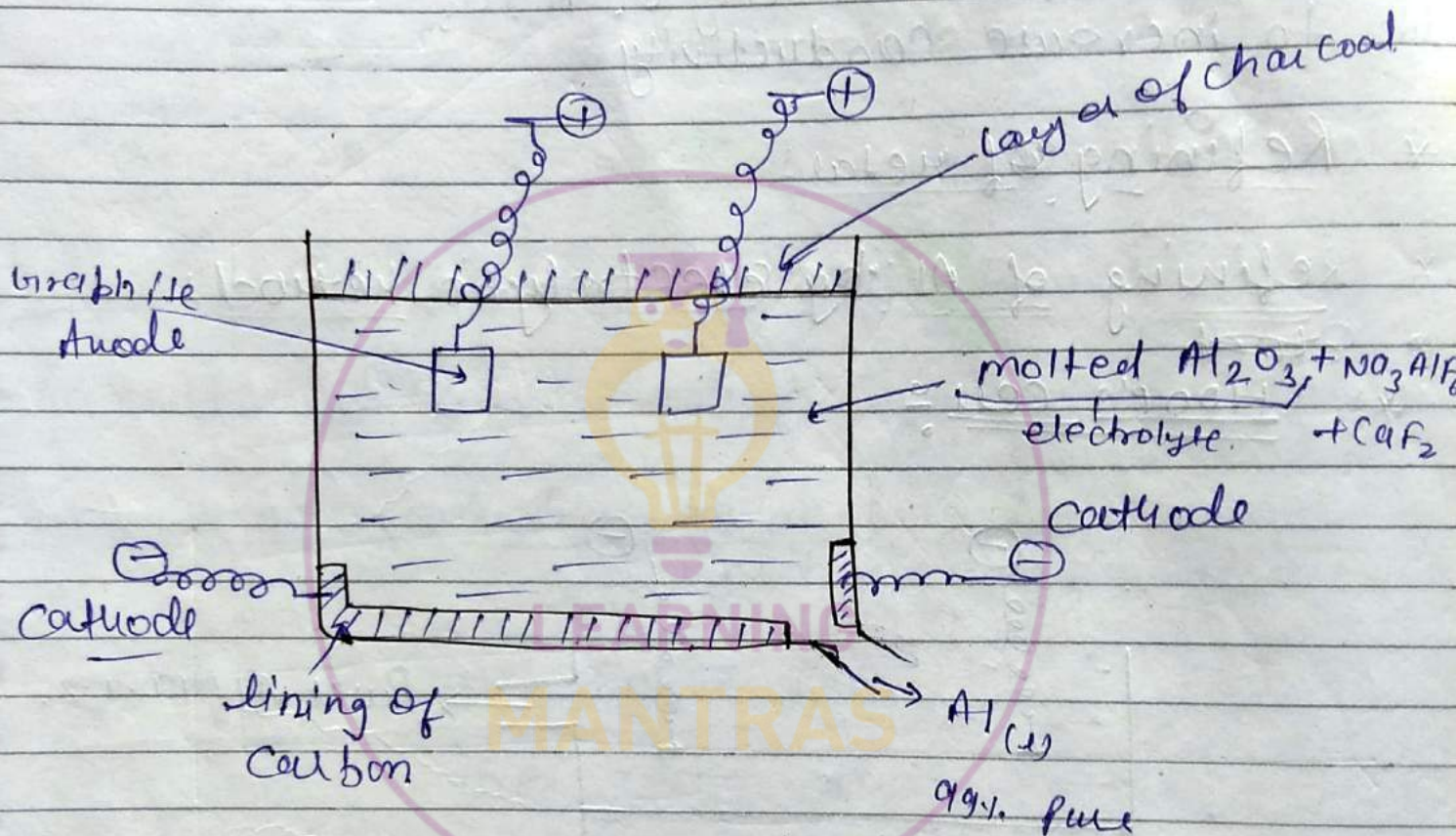
(iii) Serpent's Process° (for white Bauxite)



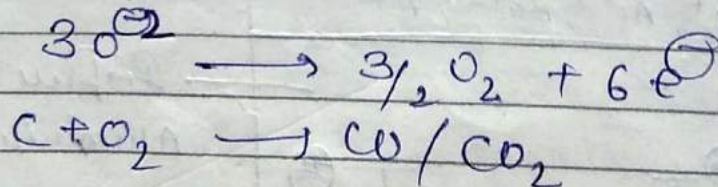
## (B) Reduction of Ore

Reduction of  $Al_2O_3$  by Electrolytic Method.

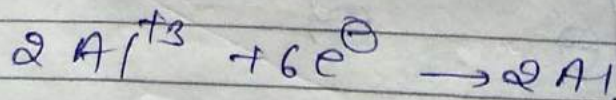
### (i) Hall Heroult Cell



At anode (+)  $\Rightarrow$



at cathode (-)  $\Rightarrow$



In Hall Heroult cell reduction of  $Al_2O_3$ ,  $Na_2K_2H_6$  is added with along with  $CaF_2$  -

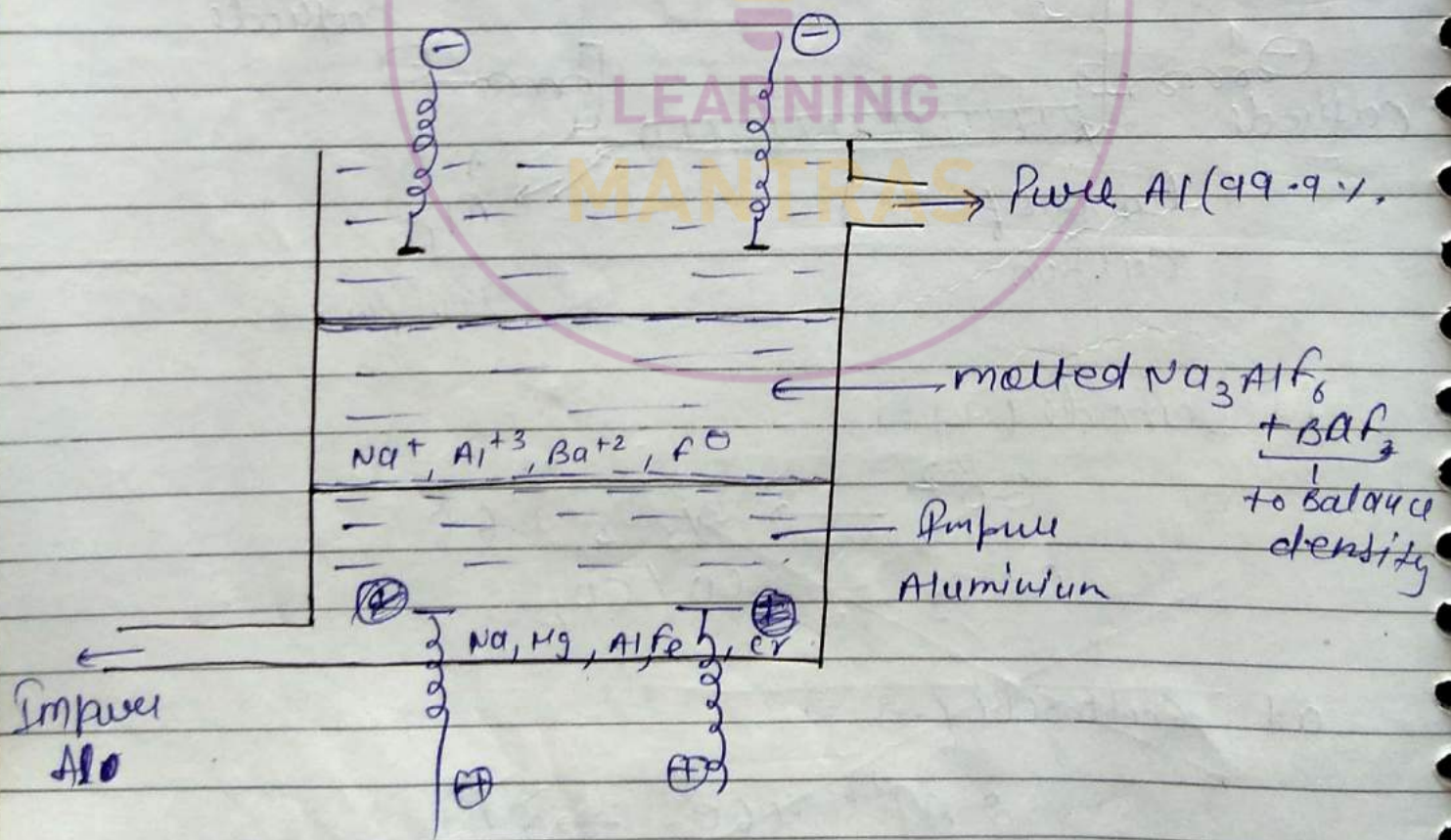
- i) to decrease melting point of  $Al_2O_3$
- ii) to decrease viscosity of  $Al_2O_3$
- iii) to increase conductivity

\* Refining of metal

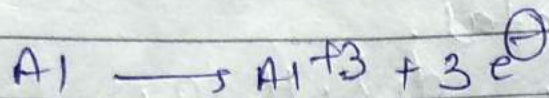
\* Refining of Al by electrolytic method

\* Electro

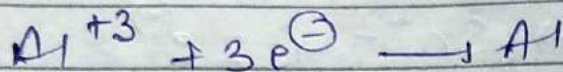
(\*) Hoope's cell



at anode (+) ⇒



at cathode (-)

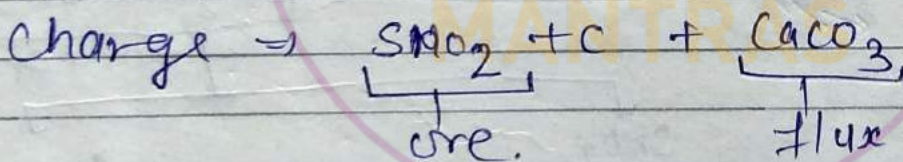


(2) Extraction of Sn from SnO<sub>2</sub> :

\* Concentration of Ore : (By magnetic separation)

Reduction of Ore : (Reduction by Carbon)

Carbon Reduction (smelting)  
(melting + slag formation)



(C) Refining :

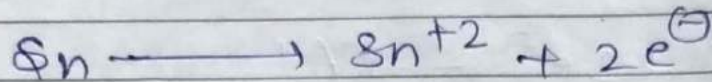
(i) By liquitation.

(ii) By Poling.

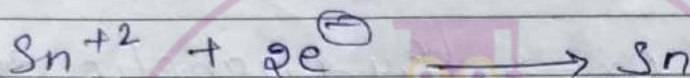
(iii) electrolytic refining.

Anode (+)  $\Rightarrow$  Impure metal  
 Cathode (-) = Pure metal.  
 Electrolyte  $\Rightarrow$   $\text{SnSO}_4 + \text{dil. H}_2\text{SO}_4$

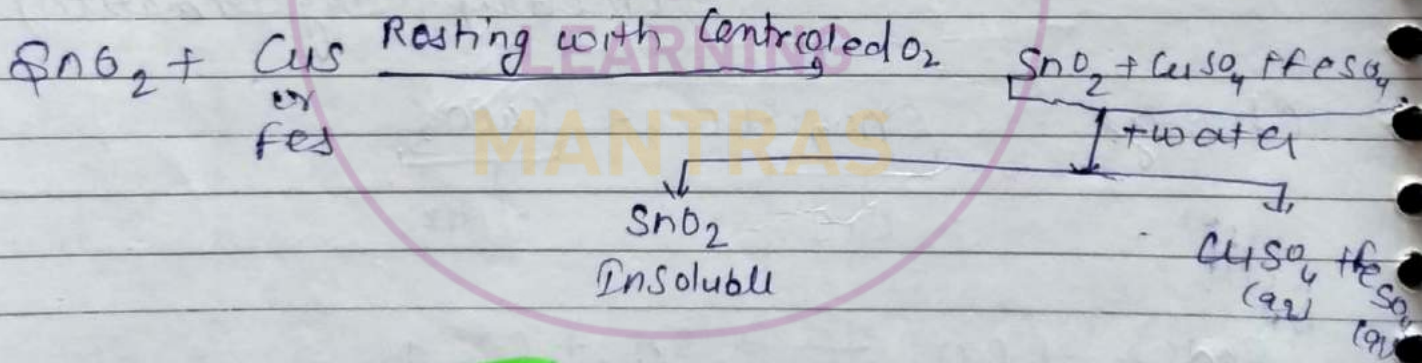
at anode (+)  $\Rightarrow$



at Cathode (-)  $\Rightarrow$

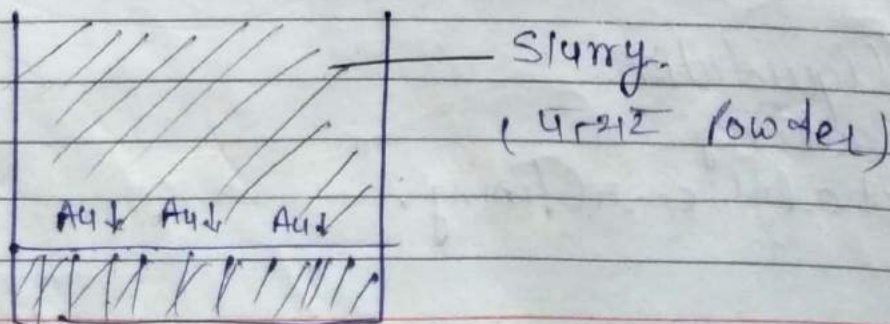


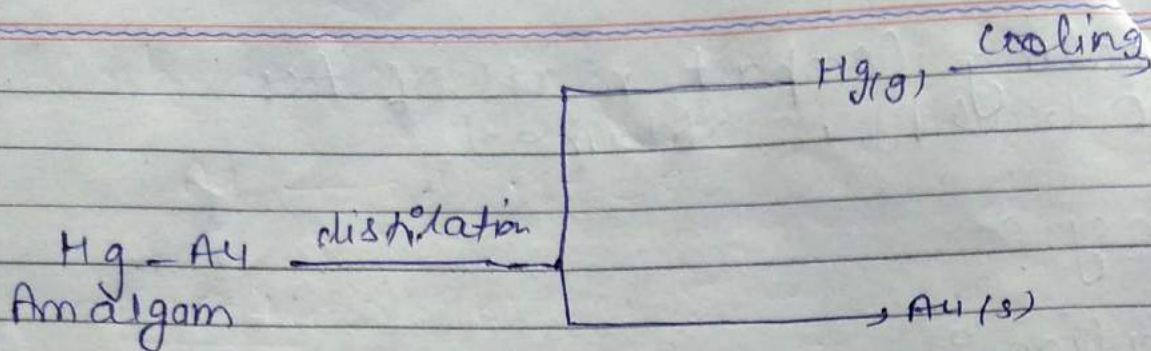
Note! Some time  $\text{SnO}_2$  contain impurity of FeS and CuS in that condition following step are involve before the magnesite separation



(3) Extraction of Au from Aluvial Rock or Auriferous quartz

- (a) concentration
- (b) Amalgamation Process!

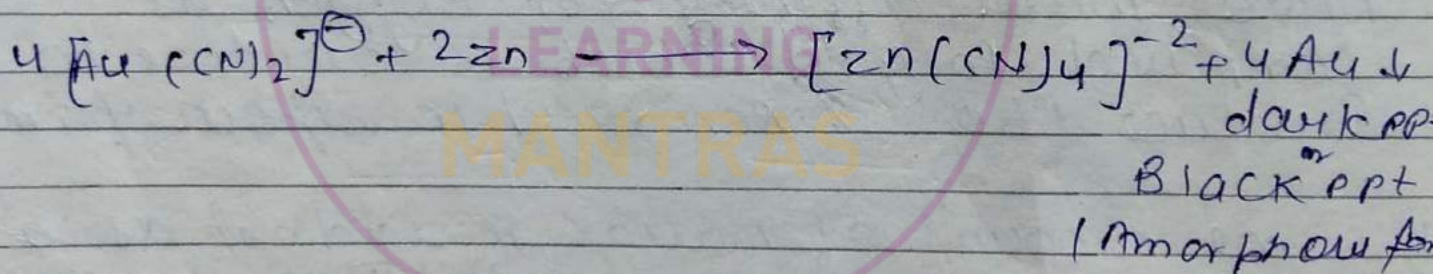




\* Fe & Pt doesn't form Amalgam.

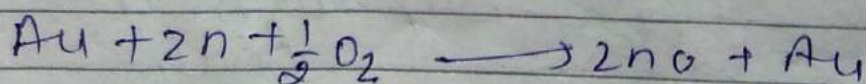
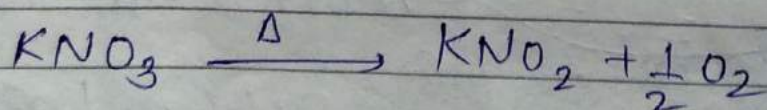
\* 70 to 80% gold in slurry extracted by Amalgamation process and remaining Au is extracted by cyanide process.

(B) Cyanide Process: (Hydrometallurgy or metal displacement in water)



\* Amorphous Au is obtained by Cyanide Process which is heated with  $\text{KNO}_3$  up to melting

oxygen is produced by decomposition of  $\text{KNO}_3$ , which is oxidised the impurity of Zn and other metals.





\* After cooling compact mass of Au (Metallic Gold) is obtained

(c) Refining :

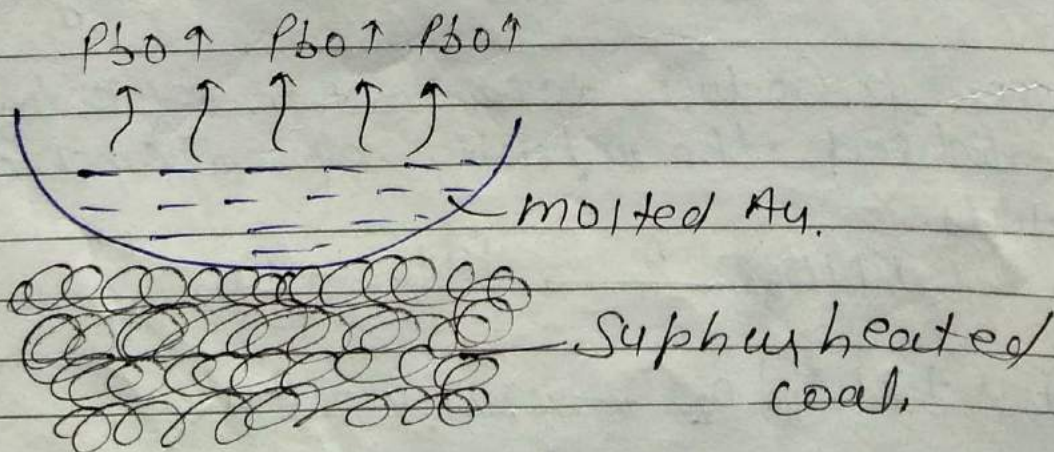
(i) Cupellation :

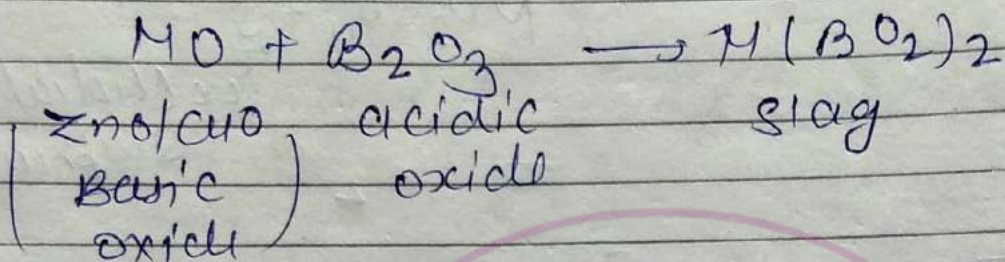
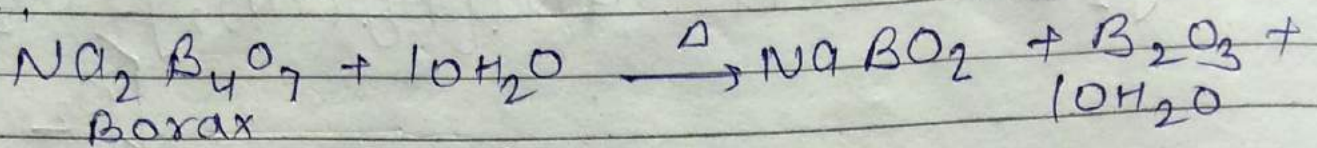
This method is applicable for removal of Pb present in gold.

\* In this method cupel is cup shaped crucible which is made by porous cement & Bone ash

In this method gold is heated with oxygen. In this process impurity of Pb have more affinity for oxygen as compared to gold which is oxidized to produce  $PbO$  & removed in vapour form.

\* Some amount of Borax is added as a flux to remove non-volatile impurity as a slag.





## (ii) Electrolytic Refining

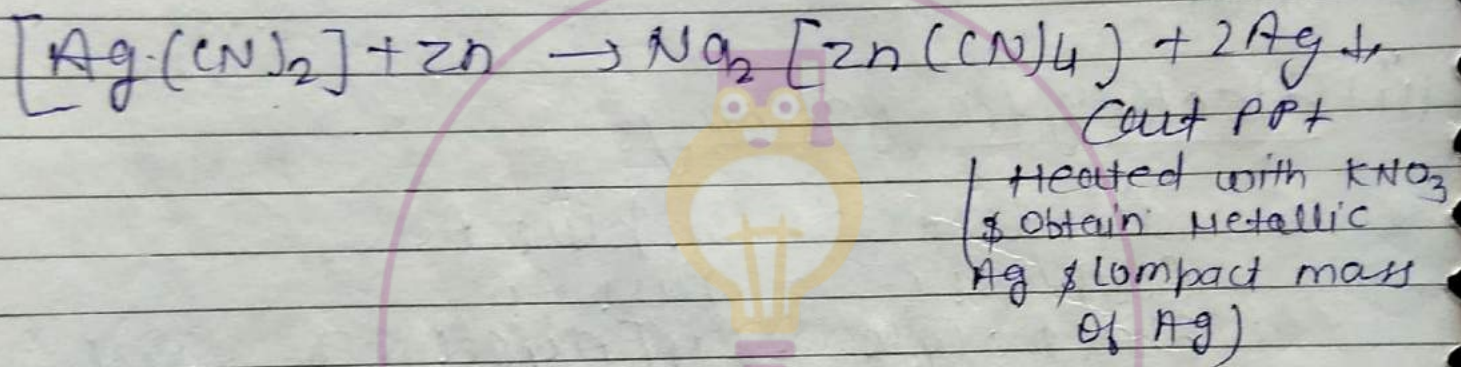
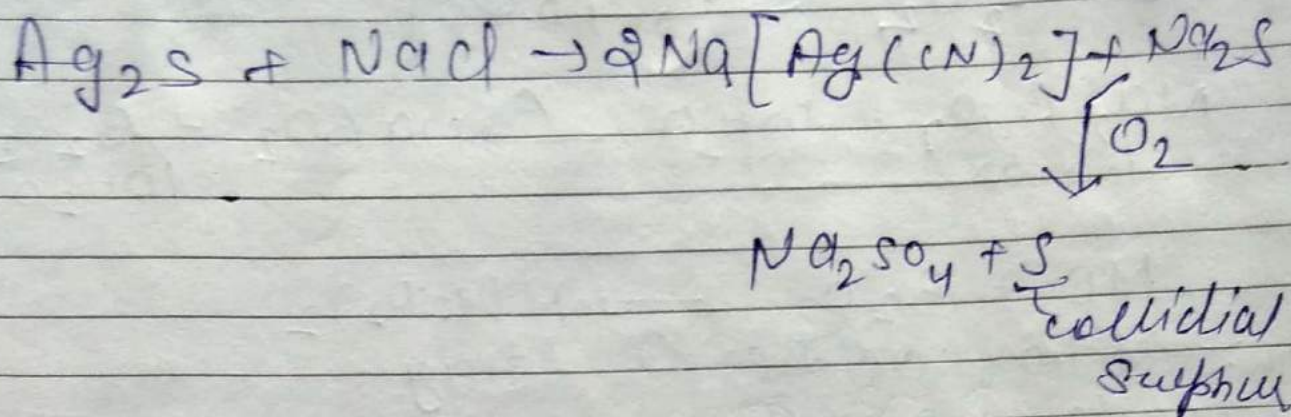
Anode (+)  $\Rightarrow$  Impure Au  
 Cathode (-)  $\Rightarrow$  Pure Au  
 Electrolyte  $\Rightarrow$   $H[AuCl_4]_{aq} + HCl_{(aq)}$

## \* Extraction of Ag from Argentite

(A) Concentration of ore

(i) By froth floatation method

(ii) Reduction: { cyanide process, by chromite  
 allurgy & metal displacement in  
 water



(c) Refining

(i) Cupellation



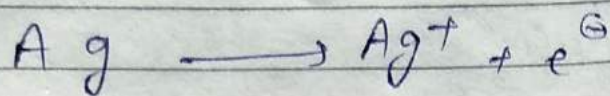
(ii) Electrolyte Method or Refining

Anode  $\Rightarrow$  Impure Ag.

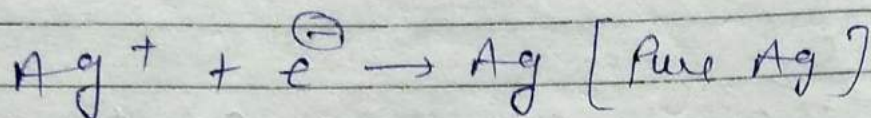
Cathode  $\Rightarrow$  Pure Ag.

Electrolyte  $\Rightarrow \text{AgNO}_3(\text{aq}) + \text{HNO}_3(\text{aq})$

At Anode: (+):



At Cathode: (-):



\* Extraction of PbS:

(A) Concentration of ore

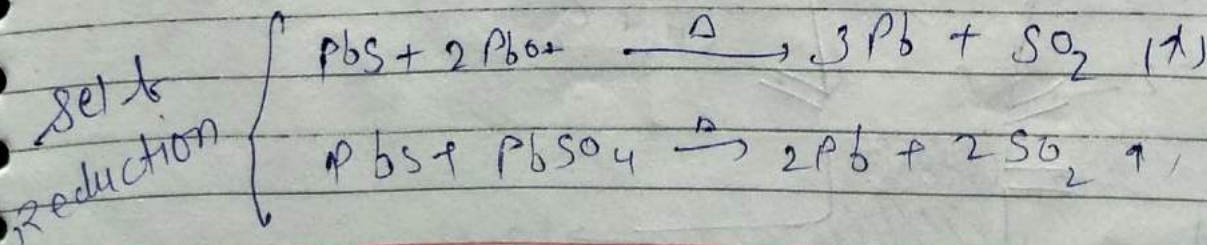
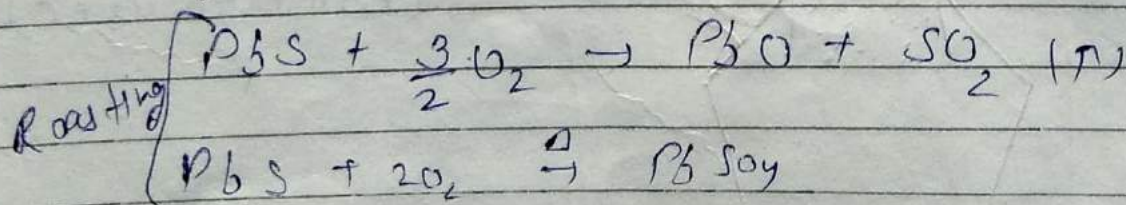
(i) By floatation floatation Method.

(B) Reduction of ore:

(i) Self Reduction - when ore contain less amount of impurity & higher amount of Pb relatively.

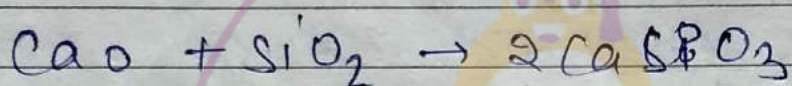
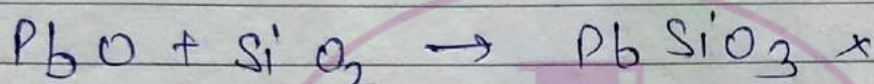
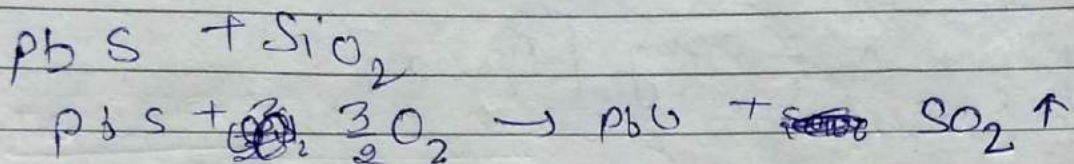
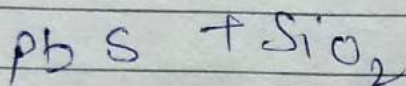
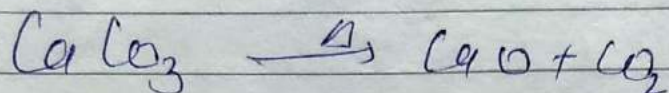
(ii) Carbon Reduction - ore which contain higher amount of impurity & less amount of Pb relatively.

\* Self Reduction:



## Carbon Reduction

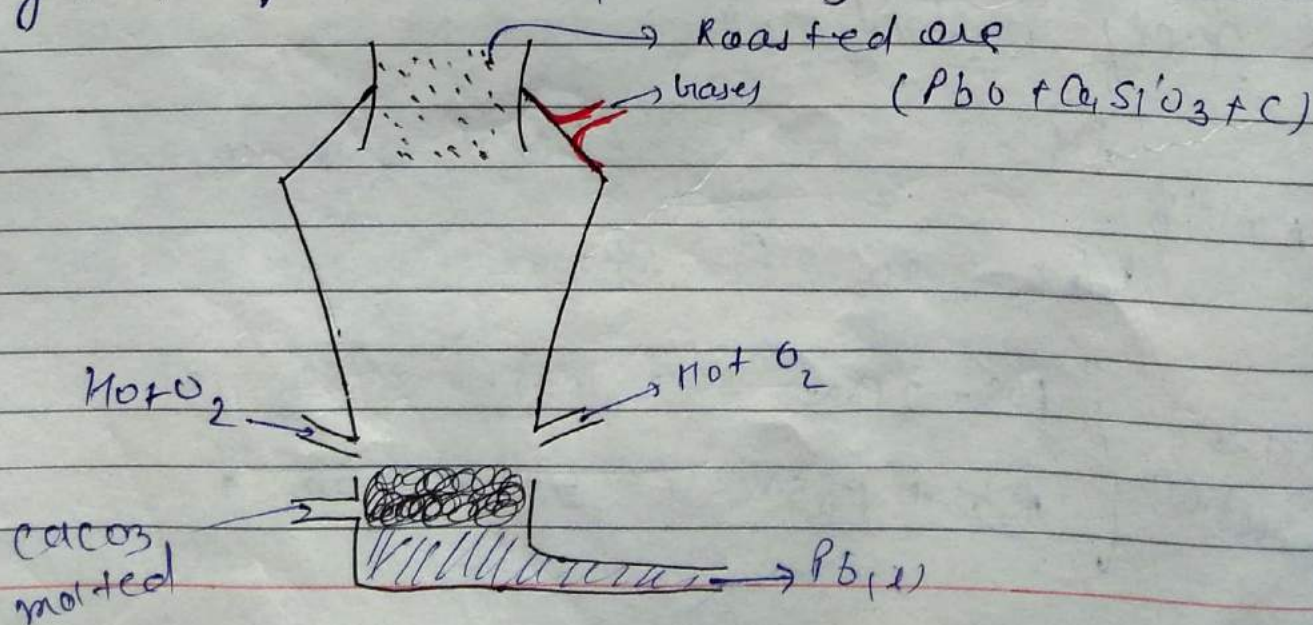
(i) Roasting with  $\text{CaCO}_3$  :



\*  $\text{CaO}$  is added because it is more basic than  $\text{PbO}$  & it stops the formation of  $\text{PbSiO}_3$

(ii) By Blast furnace (Smelting) :

Reduction of oxide ore by Carbon at high temp. called smelting.



- (c) Refining;
- (i) Liquidation;
- (ii) Electrolytic refining;

Anode: Impure Pb

Cathode: Pure Pb

Electrolyte:  $H_2[SiF_6]_{aq} + Pb[SiF_6]_{conc}$

→ Desilverization of Argentiferous lead :

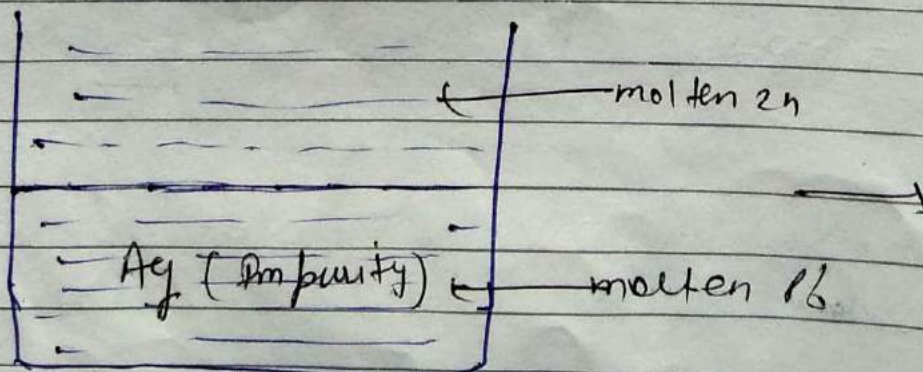
(1) Parkes Process :

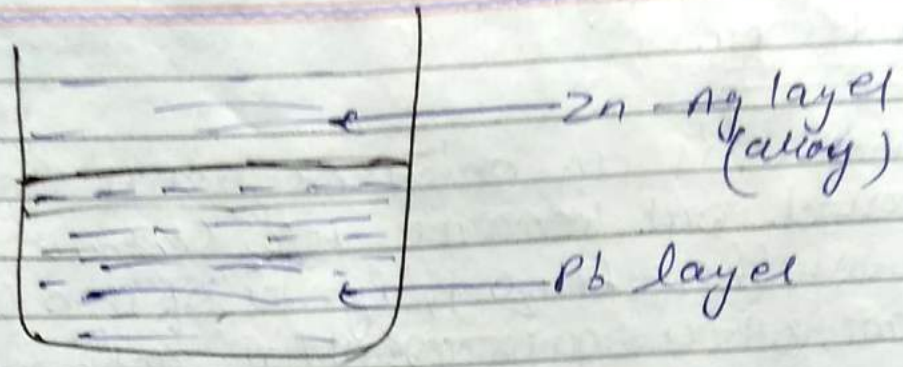
Parkes process is applicable for removal of Ag from Pb by the concept of solvent extraction and distribution law

\* molten zinc is not soluble in molten Pb. But silver is soluble in both.

\* Solubility of Ag is higher in molten zinc as compared to Pb.

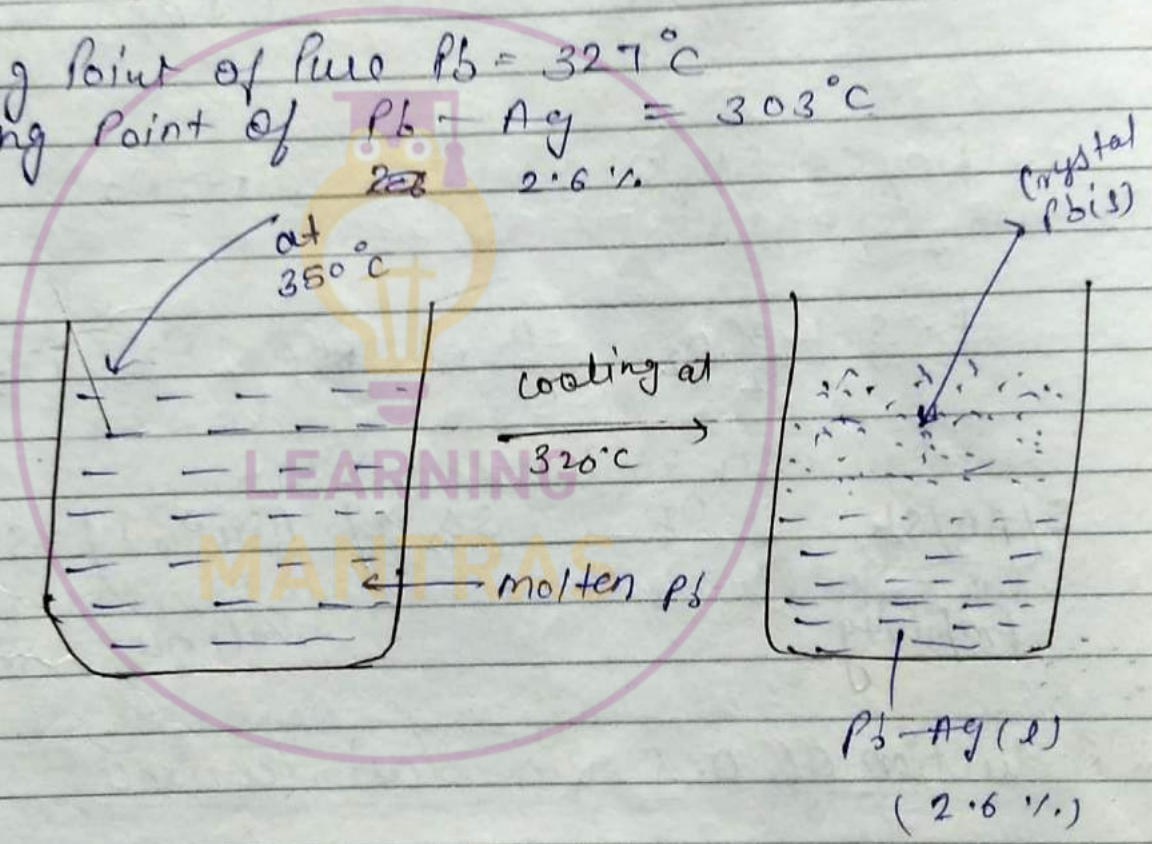
\* Extraction of Ag or separation of Ag by distillation of Zn-Ag alloy



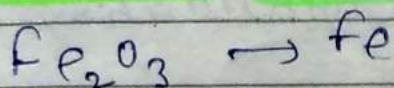


(ii) Pattinson Process

- \* Melting point of pure Pb =  $327^{\circ}\text{C}$
- \* melting point of Pb-Ag =  $303^{\circ}\text{C}$



\* 6) Extraction of Fe from Hematite



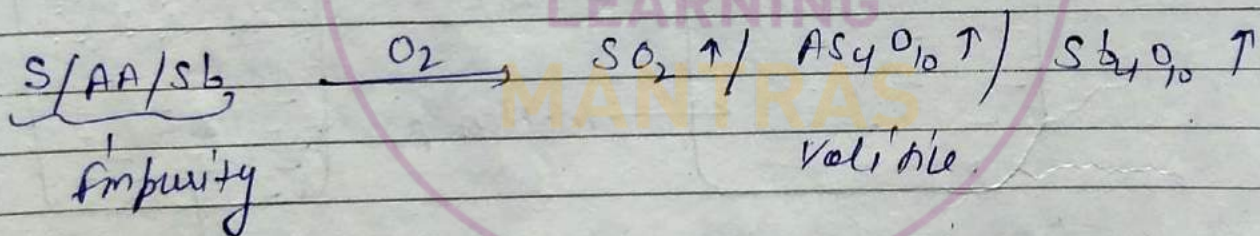
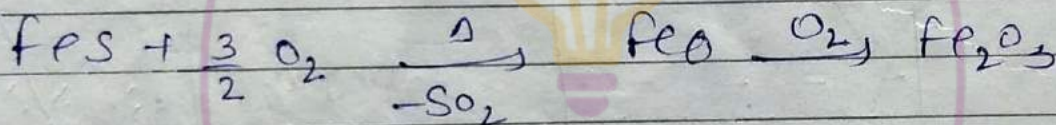
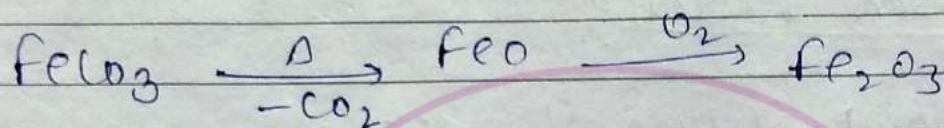
(A) Concentration of ore by magnetic separation method

(B) Reduction of ore



## (i) Roasting:

( $Fe_2O_3$ ) Hematite, is an oxide ore, still roasting is carried out because  $Fe_2O_3$  contains  $FeCO_3$  (siderite), Limonite ( $Fe_2O_3 \cdot 3H_2O$ ), Pyrites of iron ( $FeS$ ) and some other arsenic, sulphur, antimony and some other sulphur.

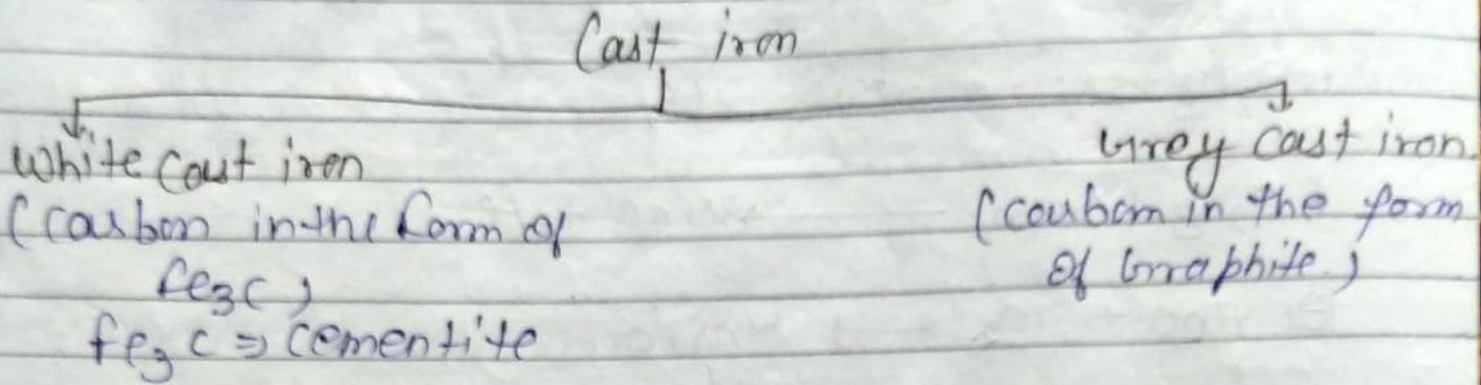


## (ii) Reduction of ore in Blast furnace:

- \* Iron (Fe) obtain from blast furnace is called pig iron and is converted to cast iron on remelting and re-crystallisation.
- \* % of iron in cast iron is nearly (3%) same as pig iron but physical property is different.

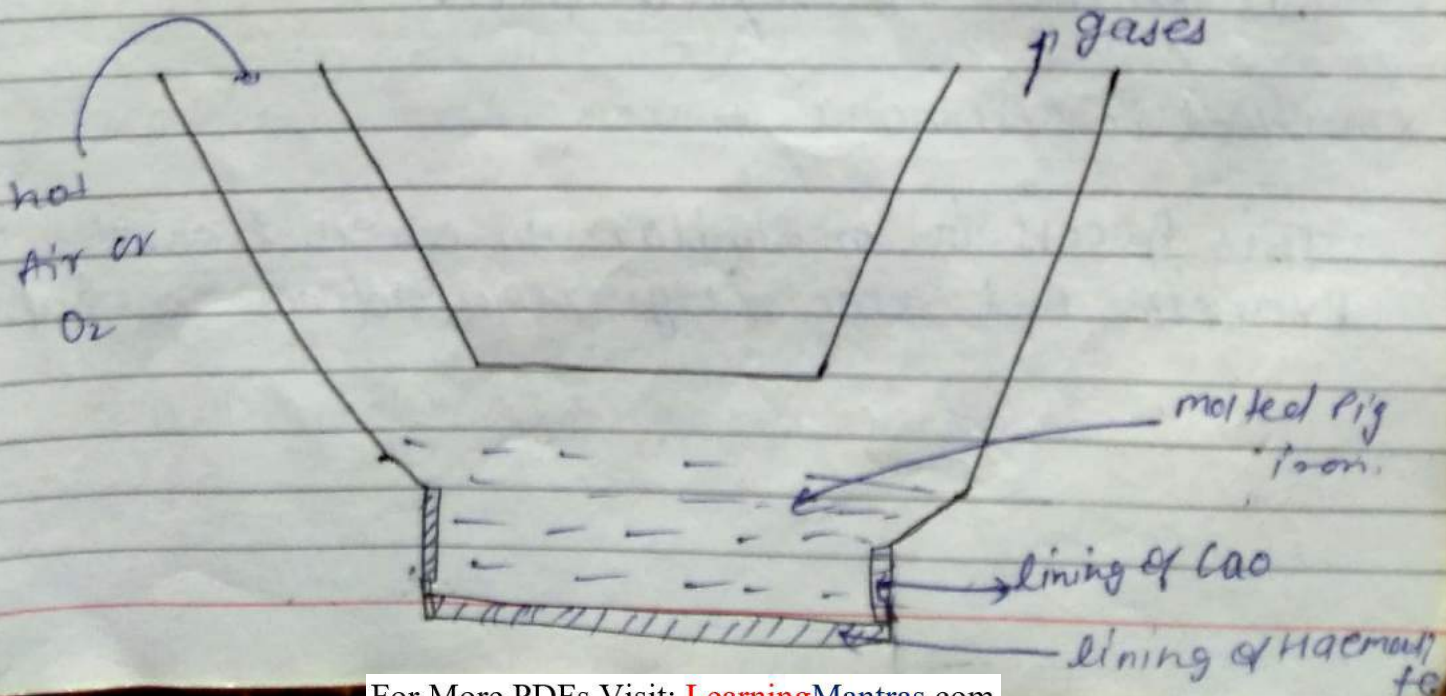


These are of two types of Cast iron.

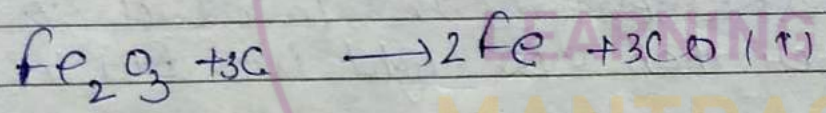
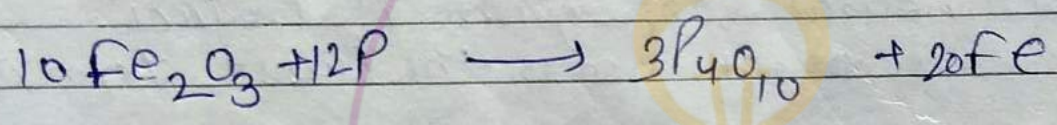
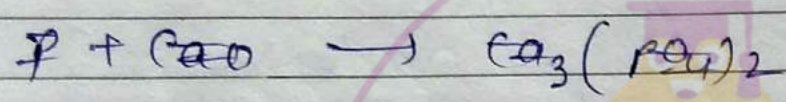
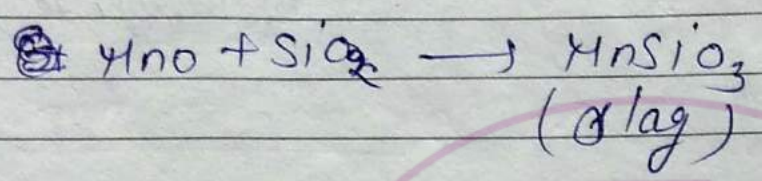
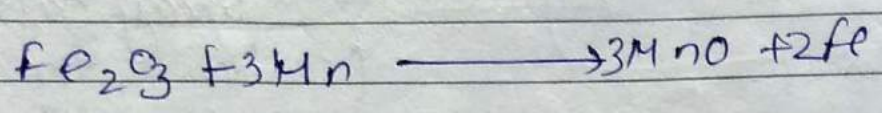
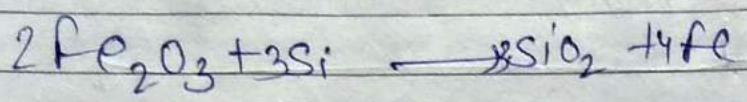


\* Refining :

- \* After the Bessemerization of pig iron it produces wrought iron. Wrought iron is the purest form of iron.
- \* Steel is commercial variety of iron in which % of carbon is higher than wrought iron but less than cast iron.
- ⇒ steel is prepared by following method.
  - 1) Bessemerization.
  - 2) Open Hearth process :



Fe Mn Si P C  
 (5) (2) (1) (3) (4)



\* In open hearth process impurities are oxidised by hematite <sup>to form wrought iron</sup> and then calculated amount of spiegeleisen (Fe + Mn + C alloy) is added to prepare steel.

\*3) Electric furnace process:

This process is similar to open hearth process but electricity is used as a fuel.

(iv) L.D Process / B.O.P (Basic oxygen Process)  
(Lintz & Donawitz)

In this method pure oxygen is used to oxidise the impurities present in iron in special type of Converter.

\* Heat treatment of steel:

(i) Annealing:

The steel is heated to red hot temp. and then cooled slowly. It makes steel soft.

(ii) Quenching or hardening: Steel is heated to red hot temp. and is then cooled suddenly by plunging into either cold water or oil. It makes steel hard and brittle.

(iii) Tempering:

If quenched steel is heated to temp. b/w 500 to 575 K and then cooled slowly, it becomes quite hard but brittleness disappears. The process is called tempering.

\* Surface treatment of steel:

(i) Nitriding: Process of heating steel at 500 K in an atmosphere of  $NH_3$ . This gives hard coating of iron nitride on the surface.

(ii) Case hardening!

Process of giving a thin coating of hardened steel, by heating steel in contact with charcoal followed quenching in oil.

It is used for axles of railway wagons.

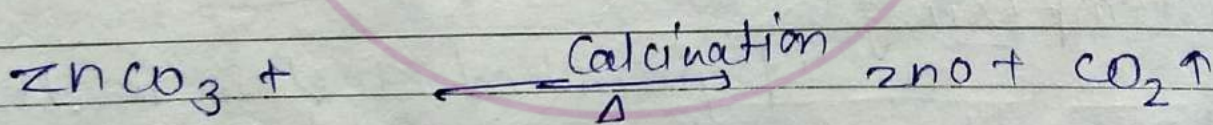
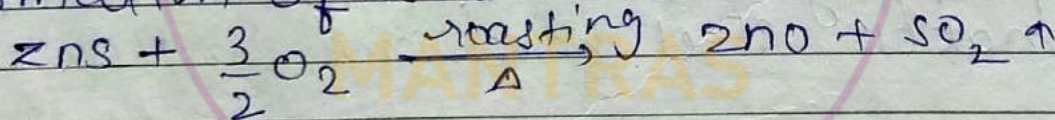
(7) Extraction of zinc from  $ZnS / ZnCO_3$ !

(A) Conc<sup>n</sup> of ore  
 $ZnS$  froth floatation Method.

$ZnCO_3 \Rightarrow$  gravity separation or levigation.

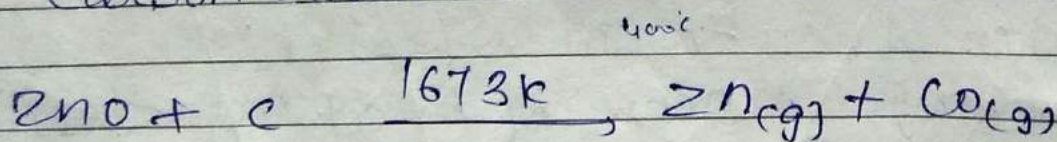
(B) Reduction of ore:

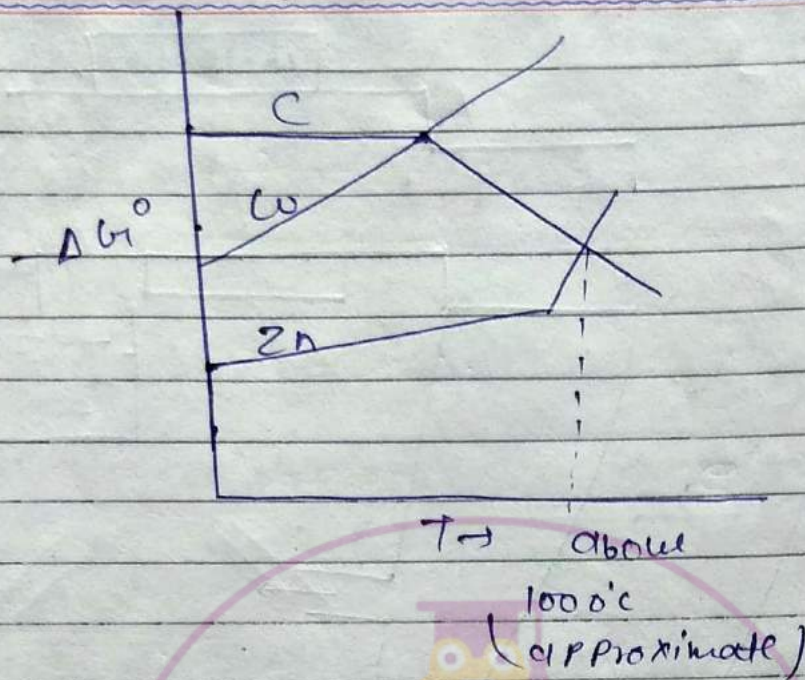
(i) formation of  $ZnO$



(ii) Reduction of  $ZnO$

Carbon reduction



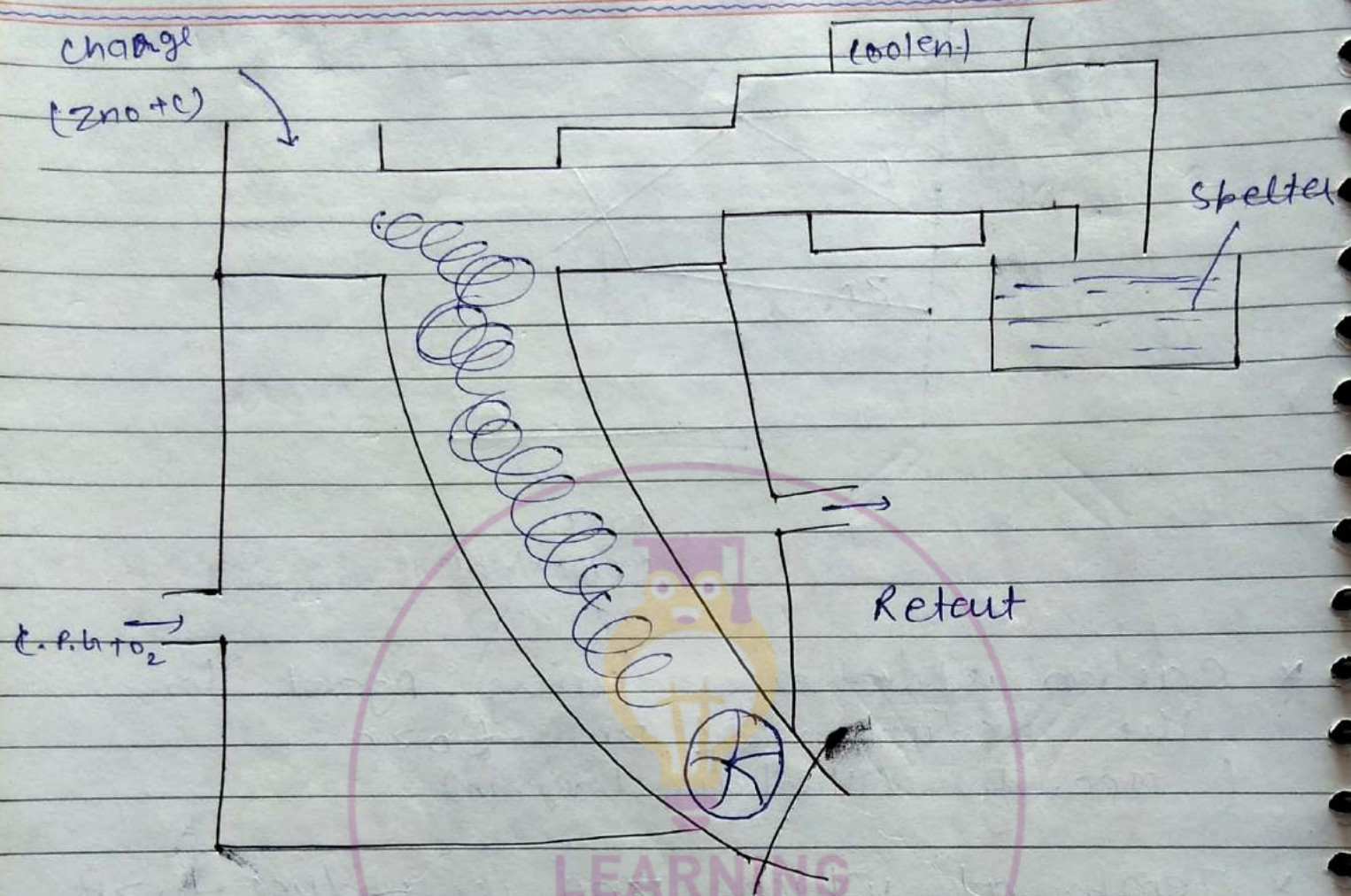


\* Carbon is the better reducing agent for the reduction of  $\text{ZnO}$  to  $\text{Zn}$  (acc. to Ellingham diagram)

\* Temp. at which  $\text{ZnO}$  is reduced to  $\text{Zn}$  is higher than boiling point of  $\text{Zn}$ . So that  $\text{Zn}$  is obtained in vapour form, which is collected at the top of Retort

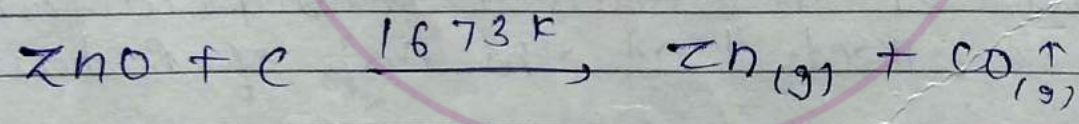
\*\* During the process partial fusion is required for  $(\text{ZnO} + \text{C})$  is called Sintering (1919)

\* Impure  $\text{Zn}$  is obtained by carbon reduction which is called spelter which contains major impurity of  $\text{Pb}$ ,  $\text{Fe}$ ,  $\text{Cd}$  &  $\text{Hg}$



LEARNING  
MANTRAS

Muffle furnace

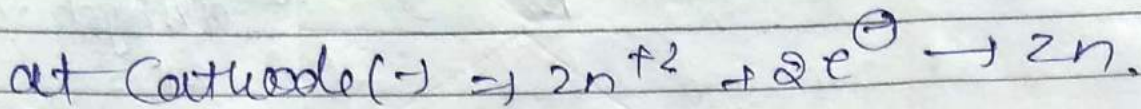
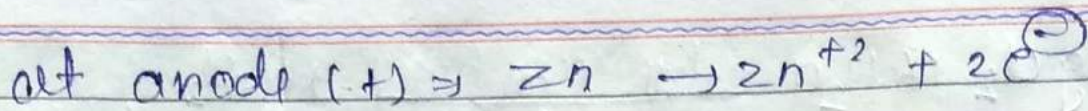


- (c) Refining :-  
 (i) Distillation.  
 (ii) Electrolytic Refining

anode (+) ⇒ Impure zinc

cathode (-) ⇒ Pure zinc

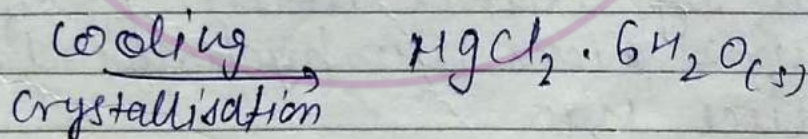
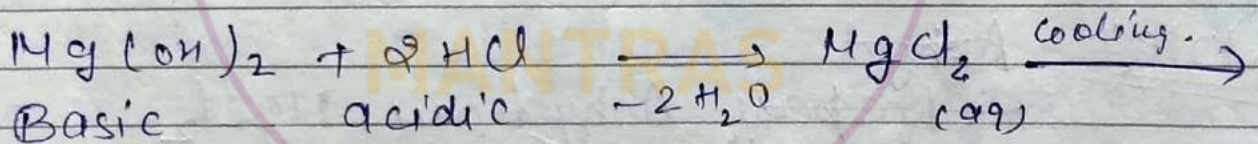
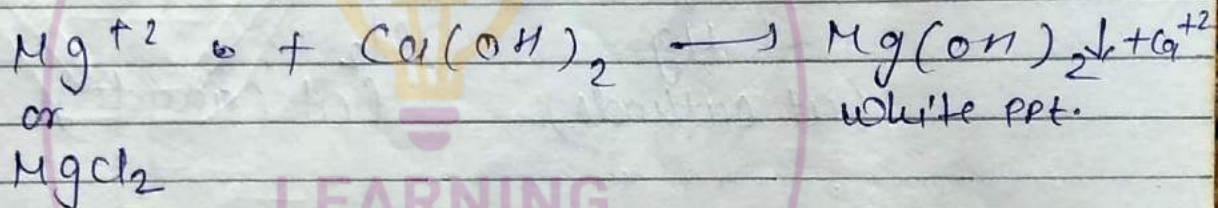
electrolyte ⇒  $\text{ZnSO}_4(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq})$



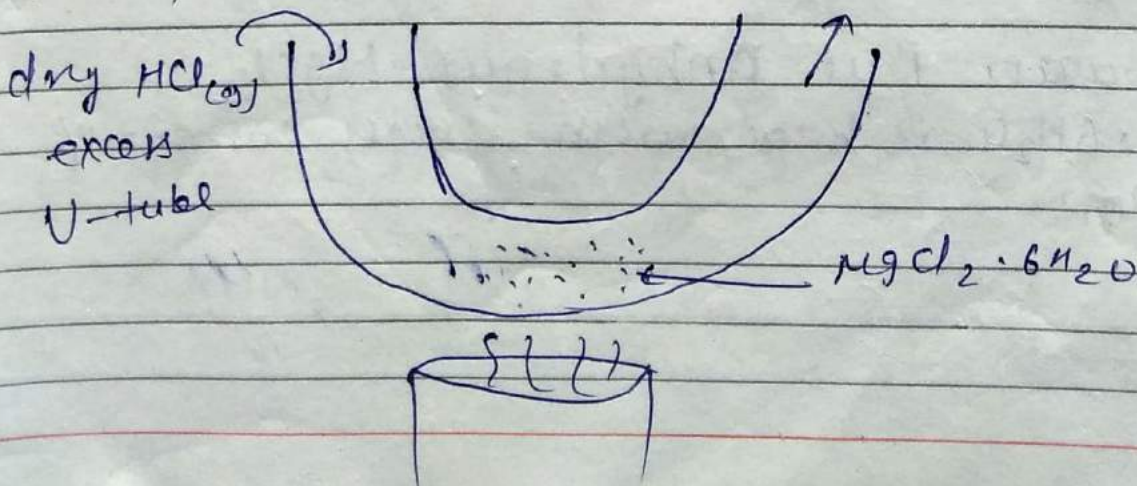
18) Extraction of Mg from sea water +  
'Dow's Process'

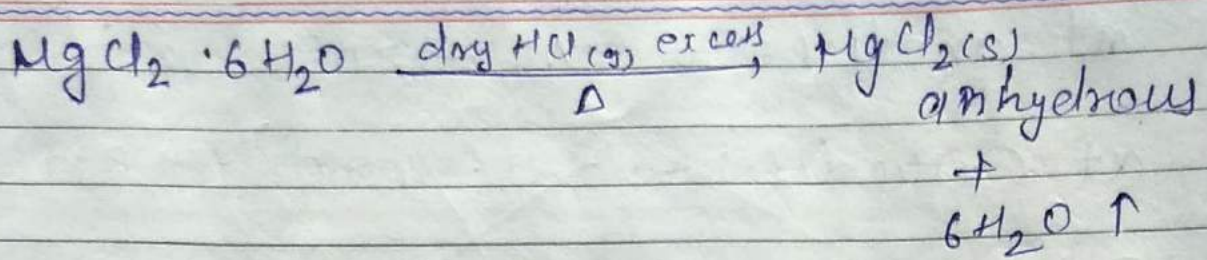
In sea water Mg is of 0.13%. Mg present in form of  $\text{Mg}^{+2}$  ( $\text{MgCl}_2$  and  $\text{Mg sulfate MgSO}_4$ ).

A) ~~Conc of sea~~  
Separation of  $\text{Mg}^{+2}$  from sea water.

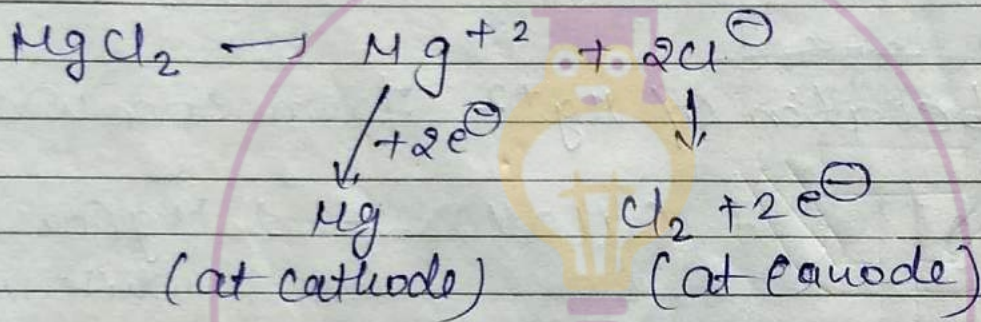
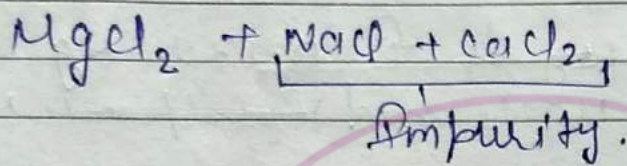


(B) formation of Anhydrous  $\text{MgCl}_2$  :-

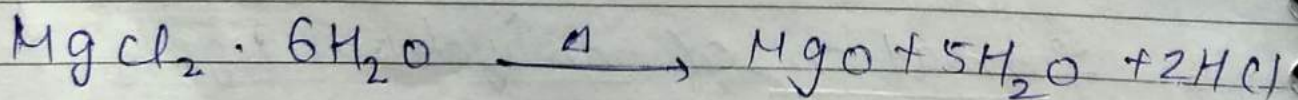




(C) Electrolysis of Molten  $\text{MgCl}_2$  :-



Note: ~~Anhyd~~ To prepare Anhydrous  $\text{MgCl}_2$  is not prepared by direct heating of  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$  because  $\text{Mg}^{+2}$  ions are hydrolysed by  $\text{H}_2\text{O}$  and produce  $\text{MgO}$ .

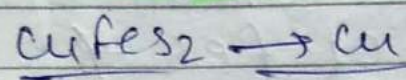


To prepare pure Anhydrous  $\text{MgCl}_2$ ,  $\text{MgCl}_2 \cdot 6\text{H}_2\text{O}$  is heat with excess current of dry  $\text{HCl}$ .



Imp

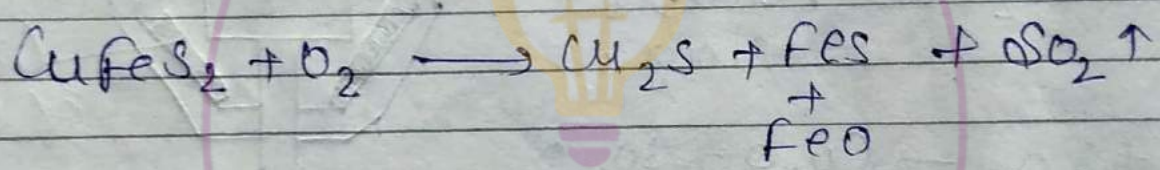
# ① Extraction of Cu from Chalcopyrite ( $CuFeS_2$ )



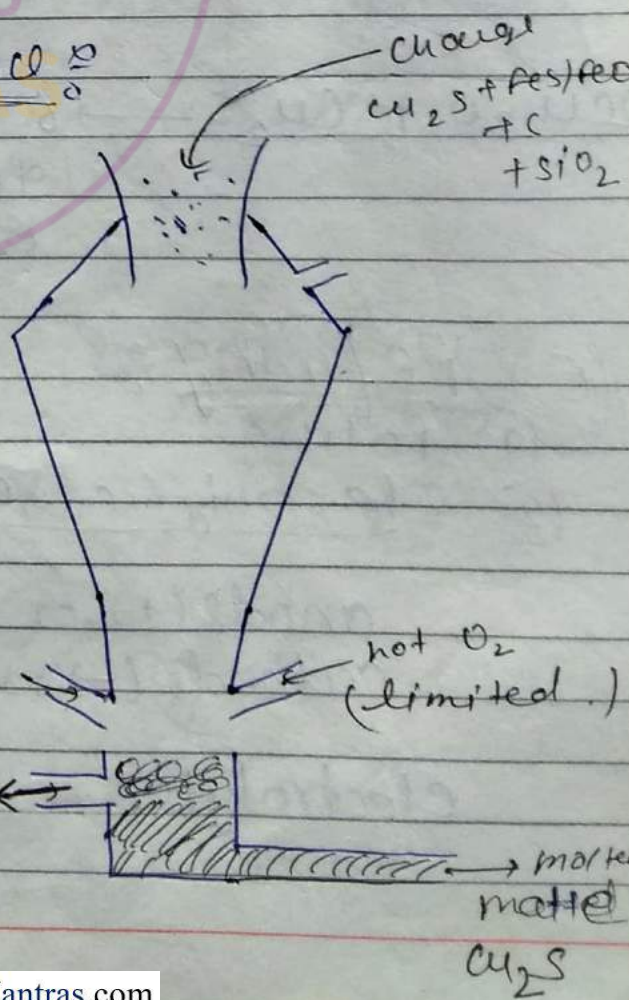
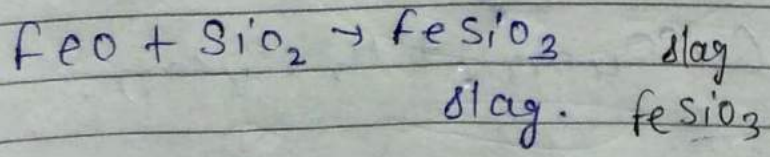
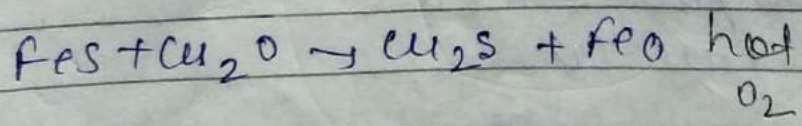
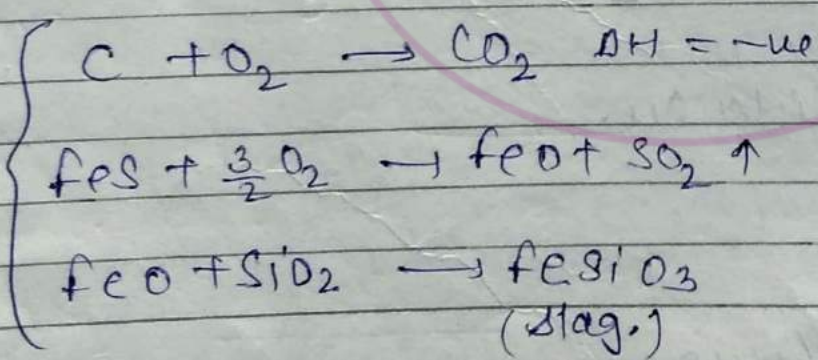
A) Conc'n of ore by ~~float~~ froth floatation method

B) ~~Reduction of ore~~  
Separation of  $Cu_2S$  from  $CuFeS_2$

i) Partial Roasting

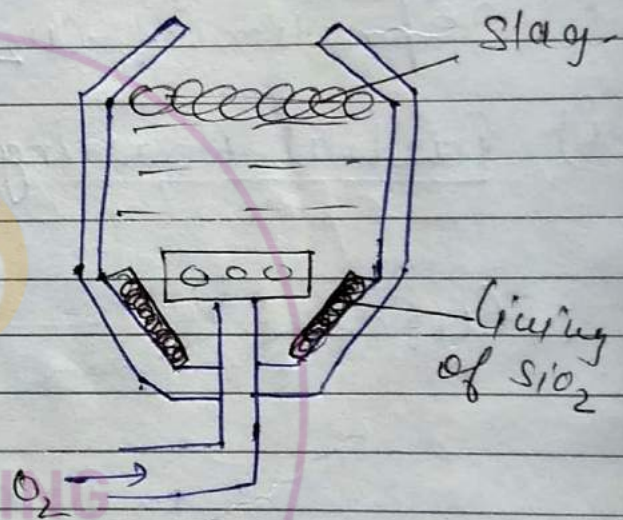
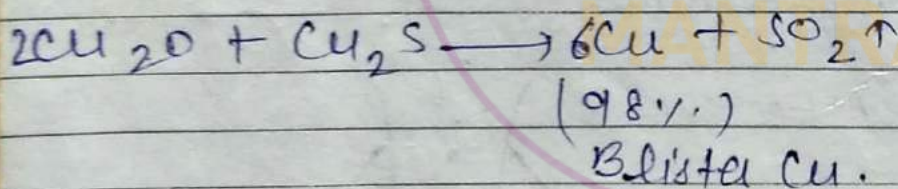
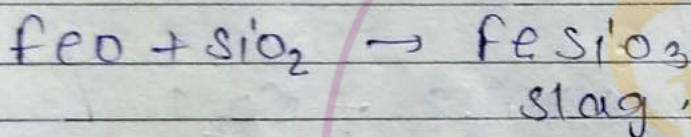


(ii) Smelting in Blast furnace



⇒ Molten Matte is obtained by blast furnace which contains major amount of  $\text{Cu}_2\text{S}$  and small amount of  $\text{FeS}$  &  $\text{FeO}$ .

⇒ (iii) Separation of Cu from matte in silica lined converter (self reduction or Bessemerization)



(c) Refining :

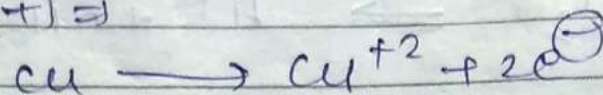
① Poling

② Electrolytic Refining :

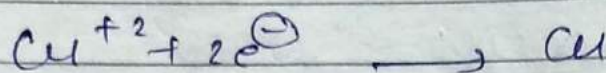
anode (+) ⇒ Impure ~~zinc~~ Cu  
cathode (-) ⇒ Pure Cu

electrolyte ⇒  $\text{CuSO}_4(\text{aq}) + \text{H}_2\text{SO}_4(\text{aq})$ .

at anode (+) =



at cathode (-) =

(10) Extraction of Na<sup>o</sup>

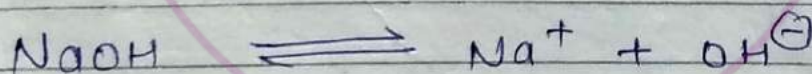
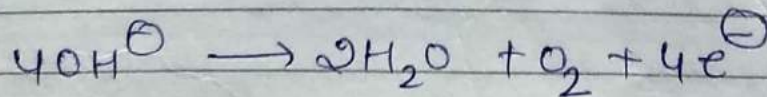
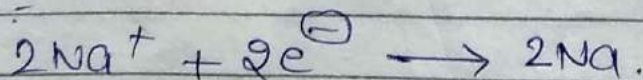
Na is extracted by two process

i) Castner's process

ii) Down's process

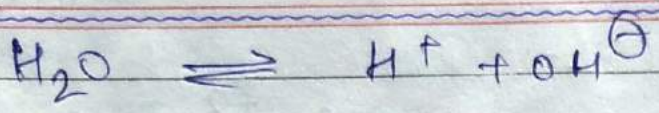
(1) Castner's process

In this process, electrolysis of fused sodium hydroxide carried out at 330°C using iron as cathode and Ni as anode.

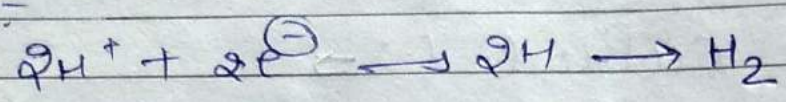
At anode (+):At cathode (-):

\* During electrolysis oxygen and H<sub>2</sub>O are produced. Water formed at anode gets partially evaporated and broken down and hydrogen is discharge at cathode.

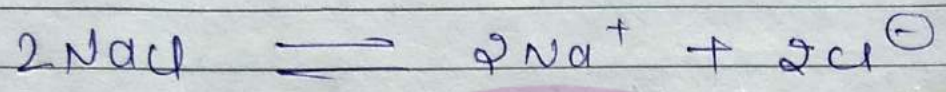
↓ M.P  
CCl<sub>4</sub>    CaCl<sub>2</sub>



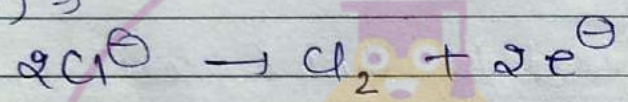
at cathode (-) :



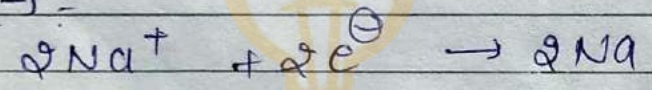
(ii) Down's Process:



At anode (+) :



at cathode (-) :



Learning Mantras  
Our Guidance, Your Success