Chapter -3

Metals and non Metals

Elements is a made up of same kind of atom. Total 118 elements, 92 naturally occurring 26 synthetic (in laboratory)

Types of ~~Metal~~ Elements

1) Metals :- Metals are the element that conduct heat and electricity and are malleable and ductile. or
Metals are the element (except hydrogen) which from positive ions by losing electrons.

Metals are known as electropositive elements because they can from positive ions by losing electrons.

Ese :- Aluminium, Iron, copper, silver, Gold etc.

2) Non Metals :- They do not conduct heat and electricity. They are brittle.
ese :- Oxygen, nitrogen, chlorine, Iodine etc.

Non Metal are the elements which from negative ions by gaining electrons.

Non metal are known as electronegative elements because they can from negative ions

by gaining electrons.

3) Metalloids : They have some properties of metals and some of non metals.
Some common ex:- Boron, silicon, Germanium Antimony, Arsenic & tellurium.

4) Noble gases :- They are unreactive & low concentration in atmosphere.
It is also known as Inert gases / Rare gases.
ex:
Helium, Neon, Argon, krypton, Xenon and radon

Physical properties of Metals :-

(i) Malliability :- ability of metals to be converted into their sheets on application of compressive force.
ex:- Aluminium sheets/foil, Gold sheets, silver.

(ii) Ductility :- ability of metals to be converted into their wire on application of tensile force.
ex:- Copper, Aluminium, iron, magnesium etc.
Generally metals are malleable & ductile.

(iv) Hardness :- They show resistance against cutting & scratching
ex: Iron, copper, Aluminium etc.

(v) Sonority :- ability of metals to produce ringing or clinging sound.
ex :- sitar, violin, bells etc.
Generally metals are hard and sonorous.

(vi) Lustre :- The property metal of having a shining surface is called metallic lustre/chamak
ex: Gold, silver ect.
Metals reflects light their surface appears shiny.

(vii) Good heat and electricity conduction

Good electricity conduction because of free electrons

Good heat conduction in solid → Atomic vibration
Phonon heat transfer

Role of electron is negligible.

Generally metals are lustrous & good conductors of heat & electricity.

IX Metals are solid at room temperature (except mercury which is a liquid metal)
ex :- Iron, copper, Aluminium etc.

Metals have high melting & boiling point.
except potassium and sodium have low melting and boiling points.

Metals are strog used in bridge, building railway. They can hold large weights without snapping or breaking.

Physical properties of Nonmetals.

* Metals and non-metals show different chemical properties.
* Physical properties of non-metals are just opposite of the physical properties of metals.

Exceptions exist → Generally.

1. Malleability :- Non metals are non Malleable.
2. Ductility :- Non metals are non ductile
3. Hardness :- They are soft.
4. Sonority :- They are non sonorous.
5. Lustre :- They are none-lustrous [Dull]
6. Heat and Electrical conduction. Bad conductors of heat & Electrical

Some exceptions of metal.

(i) The only metal found in liquid is Mercury.
(ii) Gallium and caesium have low melting points due to which they melts on human palm.
(iii) Metals are hard except alkali metals like Sodium, potassium, lithium which can

be cut with a knife
4. Gold is the most malleable metal while platinum is the most ductile metal.
5 Silver is the best conductor of electricity
6 Lead and mercury are relatively poor conductor of heat.

Some Exceptions of Non-metals
1 The only one non metal found in liquid is bromine
2 Diamond is the hardest naturally occurring substance and it is the best conductor of heat.
3 Graphite and iodine are lustrous.
4. Graphite is a good conductor of electricity
5 Usually non-metals have low melting point except Diamond

Chemical properties of Metals.

Metals and non metal show different chemical properties :-

* More reactive metal is one that loses electrons easily.
* Metal (A) that reacts at a lower temp. with other metal (B). It means metal (A) is more reactive than (B)
* The metal which reacts more vigorously and generates large amount of heat and light energy than another metal when reacting with a same substances is

more reactive.

Reaction of metals with Oxygen.

General form → metal + oxygen ⟶ metal oxide.

At room temp. 25°C

$$2Mg(s) + O_2(g) \rightarrow 2MgO(s)$$

Metal react with with oxygen to form metal oxide.

Some Metal oxides / hydroxides are Basic & Amphoteric in nature.

(i) Sodium metal reacts with the oxygen of air at room temperature to form a basic oxide called Sodium oxide:

$$2Na(s) + O_2(g) \rightarrow 2Na_2O(s)$$

(ii) Potassium metal (K) also reacts with the oxygen (O_2) of air at room temperature to form a basic - oxide called potassium oxide.

$$4K(s) + O_2(g) \longrightarrow 2K_2O(s)$$

On Low temperature on heating dew in the presence of O_2 & strongly heating.

Metal	Product formed	color of product	colour of flame on low heat	high heat
Potassium	K_2O	Yellow	Lilac/pale Purple	+ same
Sodium	Na_2O	white	Orange / Golden yellow	

Calcium	CaO	White	↑	White dazzling
Magnesium	MgO	White	No flame at room	White flame
Aluminium	Al_2O_3	White	temp or low	White
Zinc	ZnO	White	heating	Light Blue
Iron	$FeSO_4$	Black	↓	Sparks (No flame)
Lead	PbO	Yellow		No flame.
Copper	CuO	Black		
Silver, Gold and Platinum.	← No reaction →			

Conclusion

(i) Potassium and Sodium are most reactive but which is more reactive both of them.

(ii) Silver, Gold and platinum are least reactive but which is more reactive amongst all of them.

(iii) Calcium, Aluminium and magnesium are reactive metals but which is most reactive amongst all of them.

(iv) Zinc, Iron, Lead and copper are less reactive than K, Na, Ca, Mg and Al. but which is more reactive amongst all of them.

Reaction of metals with water

Metal + water → metal oxide + Hydrogen.

$2Na + 2H_2O \rightarrow 2NaOH + H_2 + heat$

It is a metal-non metal displacement reaction

Displacement reaction are exothermic & redox.

Hydrogen gas catches fire.

* Na_2O, K_2O, CaO & MgO are water soluble & form their metal hydroxide.

Reaction of Metals with cold water

Metal + cold water → metal hydroxide + Hydrogen gas.

→ $2Na(s) + 2H_2O(l) \rightarrow 2NaOH(aq) + H_2(g) + heat$

→ $2K(s) + H_2O(l) \rightarrow 2K_2OH(aq) + H_2(g)$

* evolved gas catches fire
* K reacts faster than Na.

→ $Ca(s) + 2H_2O(l) \rightarrow Ca(OH)_2(aq) + H_2(g)$.

(i) Evolved hydrogen gas doesn't catch fire.

(ii) The tiny bubbles of hydrogen gas formed stick to the surface of the calcium and hence it starts floating on the water.

No other Metals reacts with cold water.

* Reaction of metals with hot water.

$K > Na > Ca > Mg$

Metal + Hot water → Metal hydroxide + Hydrogen gas.

$Mg(s) + 2H_2O(l) \rightarrow Mg(OH)_2(aq) + H_2(g) + heat$

(i) Evolved hydrogen gas doesn't catch fire.

(ii) The tiny bubbles of hydrogen gas formed to the surface of the magnesium, starts floating on water.

No other Metal reacts with hot water.

Reaction of metals with steam

Metal + steam → Metal oxide + hydrogen gas.

→ $2Al(s) + 3H_2O(g) \rightarrow Al_2O_3(s) + 3H_2(g)$

→ $Zn(s) + H_2O(g) \rightarrow ZnO(s) + H_2(g)$.

→ $3Fe(s) + 4H_2O(g) \rightarrow Fe_3O_4(s) + 4H_2(g)$

→ Pb, Cu, Ag, & Au don't react even with steam

Chemical properties of Non metals.

1 Reaction with Oxygen and water.

I Non metal + oxygen → non metal oxide

$C(s) + O_2(g) \rightarrow CO_2(g)$

$S(s) + O_2(g) \rightarrow SO_2(g)$

II Non metals oxide + water → Acid.

$CO_2 + H_2O \rightarrow H_2CO_3$ Carbonic acid

$SO_2 + H_2O \rightarrow H_2SO_3$ Sulfurous acid

$SO_3 + H_2O \rightarrow H_2SO_4$ Sulfuric acid

$2NO_2 + H_2O \rightarrow HNO_2 + HNO_3$ → nitric acid

↓

nitrous acid

III Non metals + water → Generally no reaction.

∵ non metal can't displace hydrogen from water.

IV Non metals oxide are acidic and neutral.

acid → CO_2, SO_2, SO_3, NO_2 etc.

neutral → CO, NO, H_2O etc.

3 Reaction of non-metals with Dilute Acids.
Non metals are not react withe Dilute Acids because They do not displace hydrogen from acids.

4 Reaction of non metals with salt solutions.
A more reactive non metal displace a less reactive non metal from its salt solution.
ex $2NaBr(aq) + Cl_2(g) \longrightarrow 2NaCl(aq) + Br_2(aq)$
Sodium Bromide Chlorine Sodium chloride Bromeine

5 Reaction of non metal with chlorine.
Non metals react with chlorine to form covalent chlorides which are non-electrolytes.
(i) Non metals chlorides are usally liquids or gases.
1. Hydrogen :- $H_2(g) + Cl_2(g) \longrightarrow 2HCl(g)$ → Partialy covelent
Hydrogen Chlorine Hydrogen chloride
(covalent chloride
2 Phosphorous :- $P_4(s) + 6Cl_2(g) \longrightarrow 4PCl_3$ (l)
Phosphorous, Chlorine Phosphorous trichloride
(covalent chloride)

* Non metals form covalent chlorides because they cannot give electrons to chlorine atoms to form chloride ions.

6 Reaction of Non metal with Hydrogen.
Non metals react with hydrogen to form covalent Hydrides.

(i) Sulphur :- $H_2(g) + S(l) \rightarrow H_2S(g)$

Hydrogen + Sulphur → Hydrogen sulphide
(Non metal) (Covalent hydride)

(ii) Nitrogen :- $N_2(g) + 3H_2(g) \xrightarrow{Fe} 2NH_3(g)$

Nitrogen Hydrogen Ammonia
(Non metal) (covalent hydride).

Non metals form covalent hydrides because non metal atoms cannot give electrons to hydrogen atoms to form hydride ions.

7 Reaction of Metals with Dilute Acid

It can be understood in terms of the rate of the effervescence of hydrogen gas.

* When magnesium, aluminium, zinc, iron and lead reacts with dilute hydrochloric acid, the rate of formation of hydrogen bubbles follows the order.

$Mg > Al > Zn > Fe > Pb$

This means that the amount of heat evolved also decreases.

In some quantity & Same concentration of acid.

Observation in 0 second to 30 second.

→ Metal + dil. acid → Salt + Hydrogen gas.

Displacement Rxn / Redox / Exothermic.

Aqua Regia (Royal water)

Aqua regia which in latin means 'royal water' is a mixture of concentrated nitric acid and hydrochloric acid in the ratio of 1:3 by volume.

It is highly corrosive and fuming liquid & release fumes unpleasant smell gases that are harmful.

→ $3HCl + HNO_3 \longrightarrow \underbrace{NOCl + 2H_2O + 2Cl_2}$

responsible for yellow colour of aqua regia

8 Reaction of metal with solutions of other Metals

Metal (A) + Salt solution of metal(B) → Salt solution of metal(A) + Metal (B)

When reactivity of A > B

Confirmation that Lead is more reactive than copper

Reaction of lead with copper chloride solution:
When a strip of lead metal is introduced in the blue green solution of copper chloride, the solution ~~starts~~ turning colourless due to the formation of ~~copper~~ nitrate. lead chloride.

~~Cu (s) +~~

$Pb(s) + CuCl_2(aq) \rightarrow PbCl_2(aq) + Cu(s)$

Hence reactivity of Pb > Cu

2) $Ag + Cu(NO_3)_2 \longrightarrow$ No reaction.

$Au + Cu(NO_3)_2 \longrightarrow$ No reaction

Because the reactivity of copper is greater than Silver and Gold.

Reactivity Series of metal

Metal name	Symbol	Trick	Reaction of metal.
Potassium	K	Kudi	with Oxygen & water
Sodium	Na	Naal	
Magnesium (Mg Mang)	Ca	Car	
Aluminium	Al	Alto	with dilute acid
Zinc	Zn	Zinko	
Iron	Fe	Fir	
Lead	Pb	Lekar	
Hydrogen	H	Hum	
Copper	Cu	chale	with salt solution of another metal
Mercury	Hg	Mathura	
Silver	Ag	Nath	
Gold	Au	Gharamme	
Platinum	Pt	Pratick	

Chemical Bond :- The force which ~~links~~ the (or ions) in a molecule is called a chemical Bond.

Inertness of noble gases.

Some elements are not combine with other element these are Helium, Neon, Argon, krypton, Henon, Radan. They are known as noble gases.

They do not form chemical words.

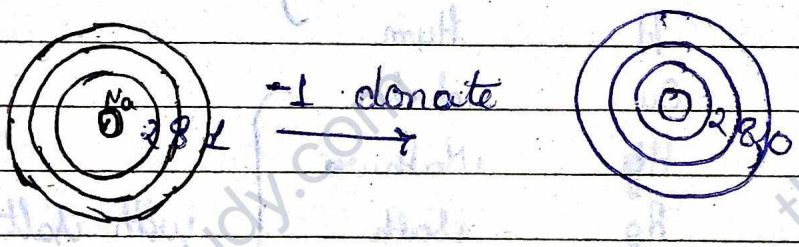
Octet Rule → of outermost shell / Valence shell other than K. Element becomes want 8 electron to stable by losing / gaining and sharing electrons

Ions :- An ion is an electrically charged atom. An ion is formed by the loss or gain of electrons by an atom, so it contains an unequal number of electrons and protons.

Cation → Positive (from metal)
Except NH_4

Anion → negative (form non-metal.)

Ex



Sodium (Na) → Sodium ion Na^+

$+11 - 10 = +1$

Lewis Electron - Dot Representation.

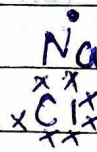
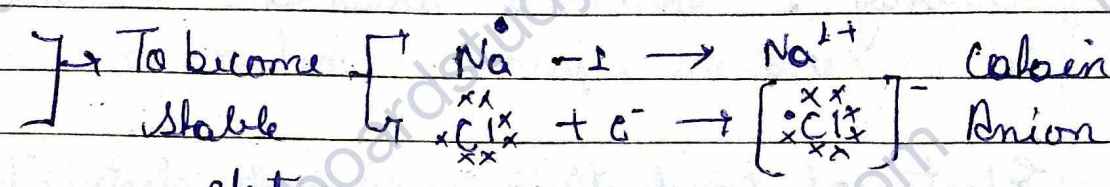
I It is a way to represent formation of ion ionic / electrovalent compound

II Representation of valence electrons with the help of dot (·) or cross (×)

III The bond / force between cation and anion is called strong electrostatic force of attraction.

Sodium chloride

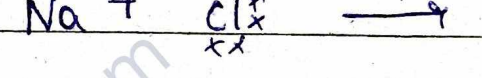
Symbol	Proton no/z	No of electron	K L M
Na	11	11	2 8 1 → 
Cl	17	17	2 8 7 →

 → To become stable electron 

Cation

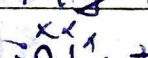
Anion

Lewis dot / cross symbol - NaCl

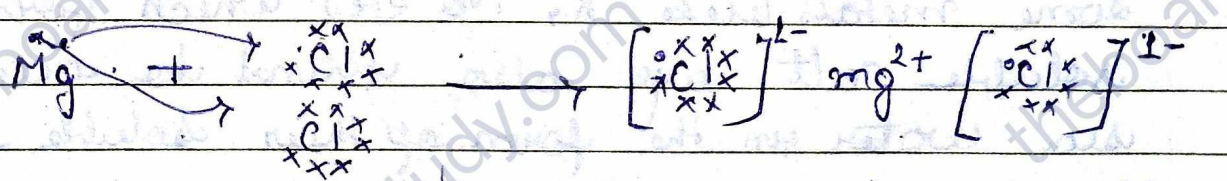


Sodium chloride

Magnesium chloride

Symbol	Z	no. of electron	K L M	Valence electron
Mg	12	12	2 8 2	
Cl	17	17	2 8 7	

Lewis electron dot / cross symbol of $MgCl_2$



magnesium chloride

Properties of Ionic compound.

Physical nature :- Generally brittle solids and breaks into pieces when pressure is applied.

Melting and boiling points :- High melting and boiling point as a sufficient amount of energy is required to break the strong electrovalent bonds

Solubility :- Soluble in water and insoluble in solvents like kerosene, petrol, and more.

Electrical conductivity :- conducts electricity in molten and aqueous form. it dose not conduct electricity in solid form as the ions are immobile in the solid state

Occurrence of metals

* Metal found in two states
  ① free state / Native state : less reactive Elemental form.
  ② combine state all high reactive Compound form

→ Major sources of metals (whether in the free state or the combine state) in the earth crust. Some metals (like K, Na etc.) which form soluble salt are also found to occur in sea water in the form of their soluble salt.

Minor sources of metals found in the seawater.

* All the metal which are placed above copper in the reactivity series are found in nature only in the form of their compounds

* Cu, Hg, Ag Metals of low reactive found in free as well as combin
* Mete Au, Pt Metals of least reactivity found free state / Element

Oxygen is the most abundant element / Non metal in the earth's crust.
Aluminium is the most abundant metal and third most abundant element in the earth crust.
Hydrogen is the most abundant element followed by helium in the universe.
Astatine is the rarest element in the earth crust

Minerals and ores

→ Metals occur naturally in the form of elements or compounds in the earth's crust or sea-water and are called minerals

→ Those minerals from which the metals can be extracted conveniently and profitably are called ores.

→ The earthly and rocky impurities that are associated with the minerals are called gangue or matrise.

→ All the ores are mineral but all ores minerals

ore not ores.

Extraction of metals

To obtain a metal from its ore is called the extraction of metals.

- Metallurgy :- The various process involved in the extraction of metals from their ores and refining are known as metallurgy.

* Step I : Crushing and Grinding of ore for extraction of metal from its ore.

(i) Crushing of ore
Impact force crushes ore into smaller pieces

(ii) Grinding of ore
In Grinder the smaller pieces of ore kept the Attrition force / shear force crushed ore into pulverised ore / Powdered form.

It is common step in each metal or element.

Step II : Concentration / Benefaction / Enrichment / Dressing of ore.

↛ Before extracting the metal, it is important to remove gangue or matrix.

☆ After this process as some impurities are removed concentration of ore relatively increase

↛ It is common step in each metal.

Principle of separation of gangue from: The differences between the physical or chemical properties of the gangue and the ore.

One such method is magnetic separation.

Extraction of metal on the basis of reactivity series.

1. Extraction of low reactivity metals - Cu, Hg & Au
2. Extraction of medium reactivity metals Zn, Fe, Pb
3. Extraction of high reactivity metals (K, Na, Ca, Mg, Al)
4) Least reactivity metals like Gold and platinum are found in the free / native state

Extraction of metal from concentrated ore.
(Metals of low reactivity)

Hg, Cu and Ag are less reactivity. Cu and Hg are extracted from their most common ores i.e. sulphide ore

	Copper	mercury
Sulphide ore →	copper glance	Cinnabar
	Cu_2S	HgS

Easy to extract a metal from its oxide ore rather than sulphide or carbonate. So, carbonate or sulphide ores are first converted into oxides.

Step (i) Crushing and grinding of ore.
Step (ii) Concentration of ore.
Step (iii) Roasting: strongly heating the sulphide

ore in excess of air below melting point of metal

→ In case of metals of low reactivity the metal oxide automatically reduces to metal on action of heat.

Metal sulphide + oxygen $\xrightarrow{heat}$ metal oxide + Sulphur dioxide

Metal oxide $\xrightarrow{\text{reduction of } O_2}$ Metal + oxygen.

Here auto reduction, No reducing agent.

Copper

Step 4 :- $2Cu_2S(s) + 3O_2(g) \xrightarrow{\Delta} 2Cu_2O(s) + 2SO_2(g)$

↳ Autoreduction $2Cu_2O(s) + Cu_2S(s) \xrightarrow{\Delta} 6Cu(s) + SO_2(g)$

Step 5 :- Refining / purification of metal

↳ $2HgS(s) + 3O_2(g) \xrightarrow{\Delta} 2HgO(s) + 2SO_2(g)$

$HgS(s) + 2HgO(s) \xrightarrow{\Delta} 3Hg(l) + SO_2(g)$

$2HgO(s) \xrightarrow{\Delta} 2Hg(l) + O_2(g)$

* Extraction of metals of medium reactivity

Zn, Fe, Pb (ore. metals) which are found in the form of their, sulphides or carbonates, oxides.

→ Extraction of metal zinc.

Ore → Zinc blende (ZnS)

First two steps are same.

Step 3 → Roasting

$$2Zn(s) + 3O_2(g) \xrightarrow{\Delta} 2ZnO(s) + 2SO_2(g)$$

2nd ore of zinc called $ZnCO_3$ (calamine)

first 2 steps are same.

Third step is calcination

$$ZnCO_3 \xrightarrow{\Delta} ZnO(s) + CO_2(g)$$

Note :- No roasting / calcination is done if ore is metal oxide.

ex :- Hematite (Fe_2O_3) etc.

Step 4 :- Reduction of metal oxide to metal by reducing agents like carbon, aluminium etc. are used.

Reduction of metal oxide by carbon (coke) - Smelting. (in smelter)

Porous (holes) and amorphous (taking of fixed shape) form of carbon.

In case of zinc oxide

$$ZnO(s) + C(s) \xrightarrow{\Delta} Zn(l) + CO(g)$$

Step 5 → Refining of metal

Extraction of Iron from Haematite (Fe_2O_3)

Ores → Iron Haematite (Fe_2O_3)

Step 1 and 2 are same.

Step 3 No ~~reaction~~ roasting & calcination

because ore is metal oxide.
→ so the reduction of metal oxide to metal. (using reducing agent)

$$Fe_2O_3(s) + 3C(s) \xrightarrow{\Delta} 2Fe(l) + 3CO(\uparrow)$$
(Coke)

This rx reaction is smelting in smelter.
It is a redox reaction also.

Step 4 → Refining / purification of metal.
for removal of Gangue SiO_2 from iron ore
During smelting of Fe_2O_3, $CaCO_3$ can be added.

$$Fe_2O_3(s) + 3C(s) + CaCO_3 \xrightarrow{\Delta} 2Fe(l) + 3CO(\uparrow) + CaO + CO_2$$

further $CaO(s) + SiO_2(s) \longrightarrow CaSiO_3(s)$
$CaSiO_3$ is a slag [floats on molten metal]
$CaCO_3$ limestone called flux.

Extraction of medium reactivity metals.
Metals that are more reactive than zinc (Zn)
Reduction of metal oxide by aluminium - Aluminothermy.
Ore → Magnesium pyrolusite (MnO_2)

$$MnO_2(s) + 4Al(s) \longrightarrow 3Mn(l) + 2Al_2O_3(s) + heat$$
(Pyrolusite).

It is metal - metal displacement rxn or redox rxn or exothermic rxn.

ore → iron hematite Fe_2O_3

$$Fe_2O_3(s) + 2Al(s) \xrightarrow{\text{Ignited by magnesium}} 2Fe[l] + Al_2O_3(s) + Heat$$

The reaction is therefore used for welding the broken parts of iron machinery, railway tracks etc. The reaction is known as thermite reaction.

Extraction of high reactive Metals

K, Na, Ca, Mg, Al are metals of high reactivity. They are extracted from chlorides or oxides

Sodium ore → NaCl Sodium chlorides.

The oxides / chlorides of highly reactive metals are quite stable, cannot be reduced by any reducing agent. They have more affinity for oxygen / halogen chlorides.

* A special reduction process ie electrolytic reduction is used for highly reactive metals like K, Na, Ca, Mg and Al.

Electrolytic reduction :- The electrolytic is a type of electrolysis. The oxides and chlorides of metals in fused / molten state are electrically reduced by using this method.

At Anode [Oxidation - loss of electrons]

$Cl^- \rightarrow Cl + e^-$

$2Cl^- \rightarrow Cl_2 + 2e^-$

At Chatode [reduction - Gain of electrons]

$Na^{1+} + e^- \rightarrow Na$

Aluminium ore → Al_2O_3

step 1 and 2 are same.

step 3 → electrolytic reduction

At anode → oxidation

$O^{2-} \rightarrow O + 2e^-$

$2O^{2-} \rightarrow O_2 + 4e^-$

at cathode → Reduction

$Al^3 + 3e^- \rightarrow Al$

Refining of Metals / Purification of metals

We remove all impurities from metal and obtain pure metal.

* It is a last step for metals of medium & low reactivity.

→ Metals obtained after extraction still contains some impurities which are removed by:

(i) Electrolytic refining for Cu, Zn, Ag, Au, Ni etc.

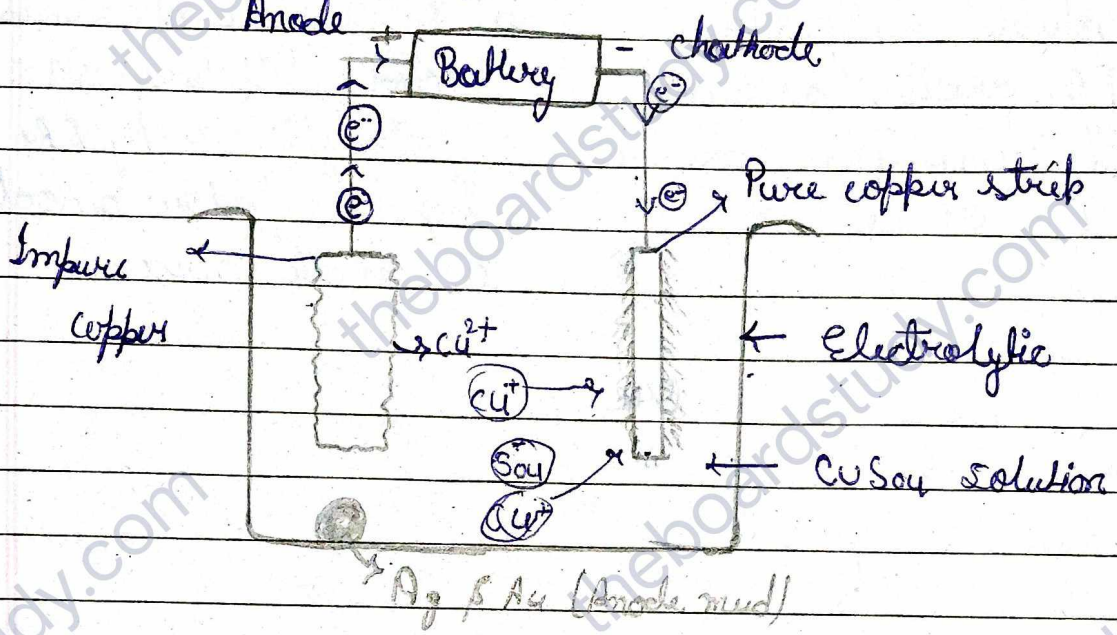
(ii) Distillation

(iii) liquefaction or other.

→ Electrolytic refining of copper.

(i) The set up consists of an electrolytic tank that contains acidified copper sulphate solution.

↳ Metal salt taken as electrolyte ⇢ will be of metal whose refining is done.
Here - $CuSO_4(aq)$



(ii) A thick block of impure copper metal is connected to the positive terminal, i.e. it will behave as anode.

(iii) Electrolytic Refining of copper.
A thin strip of pure copper metal is connected to the negative terminal i.e it will behave as cathode.

Electrolyte ⇢ $CuSO_4(aq)$
$CuSO_4(aq) \rightarrow Cu^{2+}(aq) + SO_4^{2-}(aq)$
Cu^{2+} go towards the cathode [Reduction - Gain of electrons)
$Cu^{2+} + 2e^- \rightarrow Cu$
At Anode [Oxidation loss of electrons]
$Cu \rightarrow Cu^{2+} + 2e^-$

As process continues anode will become thinner