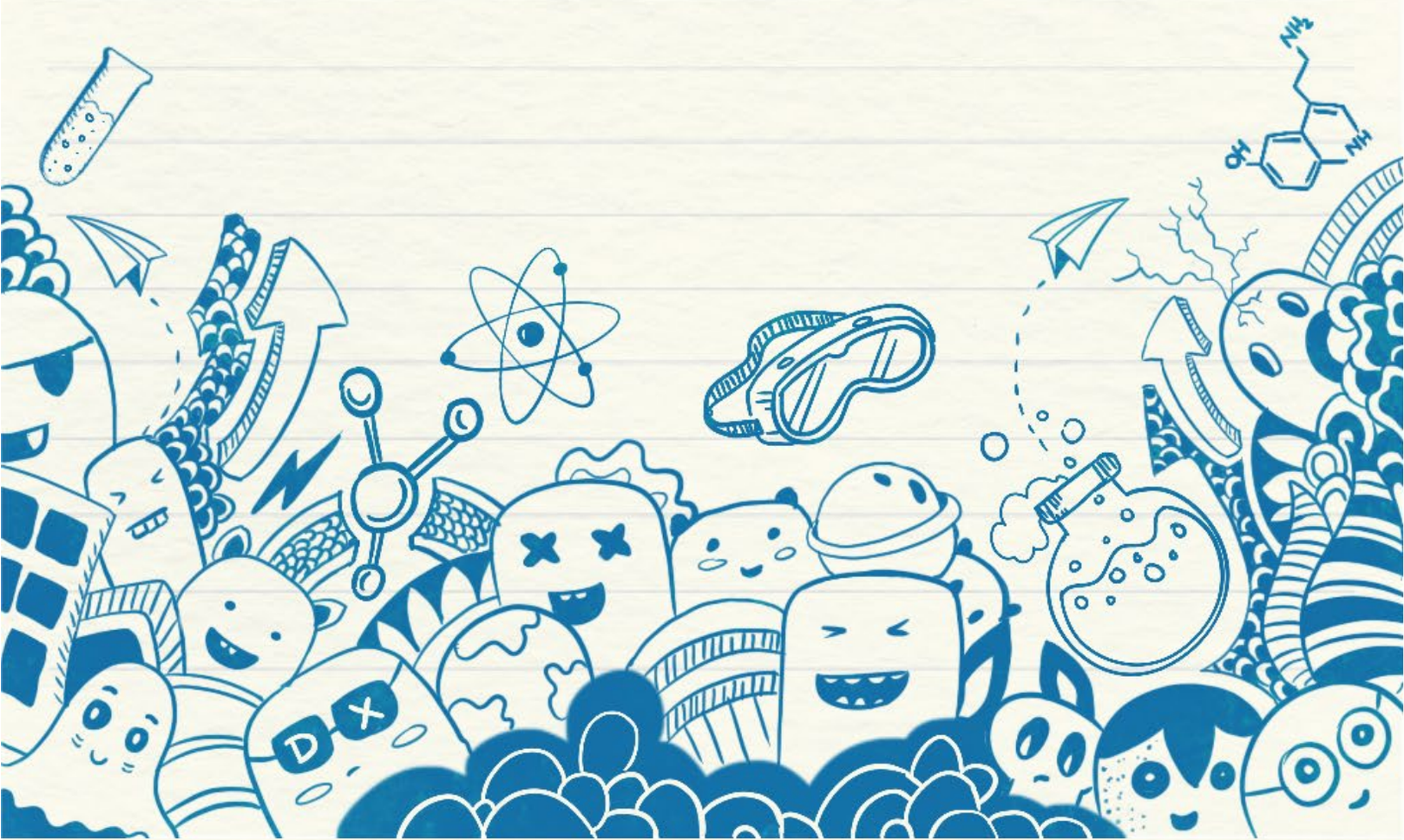
CHEMISTRY

BYJU'S

POST CLASS NOTES

# Metals and Non-metals



# Topics

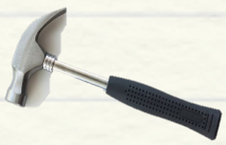
1. Properties of substances
2. Chemical properties of metals
3. Reactivity series
4. Bonding between metals and non-metals
5. Extraction of metals from ores
6. Corrosion

# 1. Properties of Substances

## 1.1 Lustre

Shines

## 1.2 Hardness



Retains its shape

## 1.3 Conductivity

Allows heat and electricity to pass through it easily

## 1.4 Ductility

Can be drawn into thin wires

## 1.5 Malleability

Can be pressed or rolled into thin sheets

## 1.6 Sonority

Ringing sound, when struck

## 1.7 Properties of Metals and Non-metals

Generally, metals show properties like lustre, hardness, ductility, malleability, conduction of heat and electricity, but non-metals do not show such properties

### Exceptions

- Metals like sodium and potassium are soft
- Metals like mercury are liquid at room temperature
- Non-metals like iodine are lustrous
- Non-metals like carbon (diamond) are extremely hard
- Non-metals like carbon (graphite) are good conductors

# 2. Chemical Properties of Metals

## 2.1 Reaction of Metals with Oxygen

- Metals generally react with oxygen to form metal oxides

  Metal + Oxygen ⟶ Metal Oxide

- Different metals react differently with oxygen
- Metals like potassium and sodium react vigorously with oxygen
- Metals like silver and gold do not react with oxygen

## 2.2 Properties of Metal Oxides

- Generally, metal oxides are basic in nature and insoluble in water
- Some metal oxides dissolve in water to form alkalis

  $Na_2O(s) + H_2O(l) \longrightarrow 2NaOH(aq)$

- Some metal oxides, are amphoteric in nature i.e., show both acidic as well as basic behaviour. Examples: aluminium oxide, zinc oxide

- Anodising is an electrolytic process for producing thick oxide coating on metals such as aluminium
- The oxide layer on aluminium improves its resistance to corrosion

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## 2.3 Reaction of Metals with Water

- Metals generally react with cold water to form metal hydroxide and hydrogen gas
- Metals generally react with steam to form metal oxide and hydrogen gas

- Metals like potassium and sodium react violently with cold water
- Metals like aluminium, iron and zinc do not react with cold water but react with steam
- Metals like copper, silver and gold do not react with water at all

## 2.4 Reaction of Metals with Acids

- Metals generally react with acids to give a salt and hydrogen gas.

  Metal + Dilute Acid ⟶ Salt + Hydrogen

- Different metals react differently with dilute acids.
- Metals like copper, silver and gold do not react with dilute hydrochloric acid.
- Hydrogen gas is not evolved when a metal reacts with nitric acid.

## 2.5 Displacement Reaction

- A more reactive metal (X) displaces a less reactive element from its salt solution (Y).

  Metal X + Salt solution of Y ⟶ Salt solution of X + Metal Y

# 3. Reactivity Series

- A list of metals arranged in the order of their decreasing reactivities

Most reactive


| | |
|---|---|
| K | Potassium |
| Na | Sodium |
| Ca | Calcium |
| Mg | Magnesium |
| Al | Aluminium |
| Zn | Zinc |
| Fe | Iron |
| Pb | Lead |
| H | Hydrogen |
| Cu | Copper |
| Hg | Mercury |
| Ag | Silver |
| Au | Gold |

Least reactive

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

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

$Zn(s) + 2HCl(aq) \rightarrow ZnCl_2(aq) + H_2(g)$

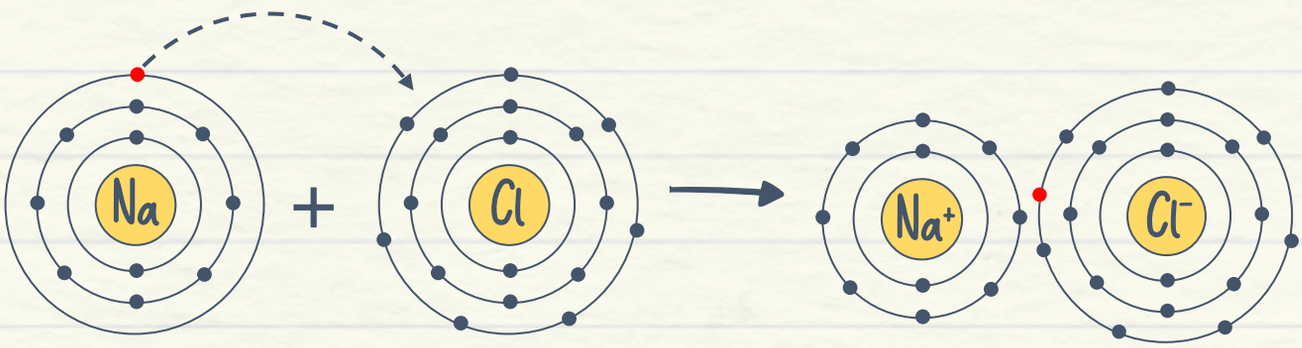
$2Cu(s) + O_2(g) \rightarrow 2CuO(s)$

- A metal placed at the top of the reactivity series can displace a metal placed lower to it in a displacement reaction
- Metals placed below hydrogen cannot displace it from dilute acids as hydrogen gas

# 4. Bonding between Metals and Non-metals

## 4.1 Ionic Bond (Electrovalent Bond)

- Formed by transfer of electrons




Sodium (2,8,1) | Chlorine (2,8,7) | Sodium ion (2,8) | Chloride ion (2,8,8)

- Oppositely charged ions held together by strong electrostatic forces of attraction
- Example: Sodium chloride ($NaCl$), magnesium chloride ($MgCl_2$)

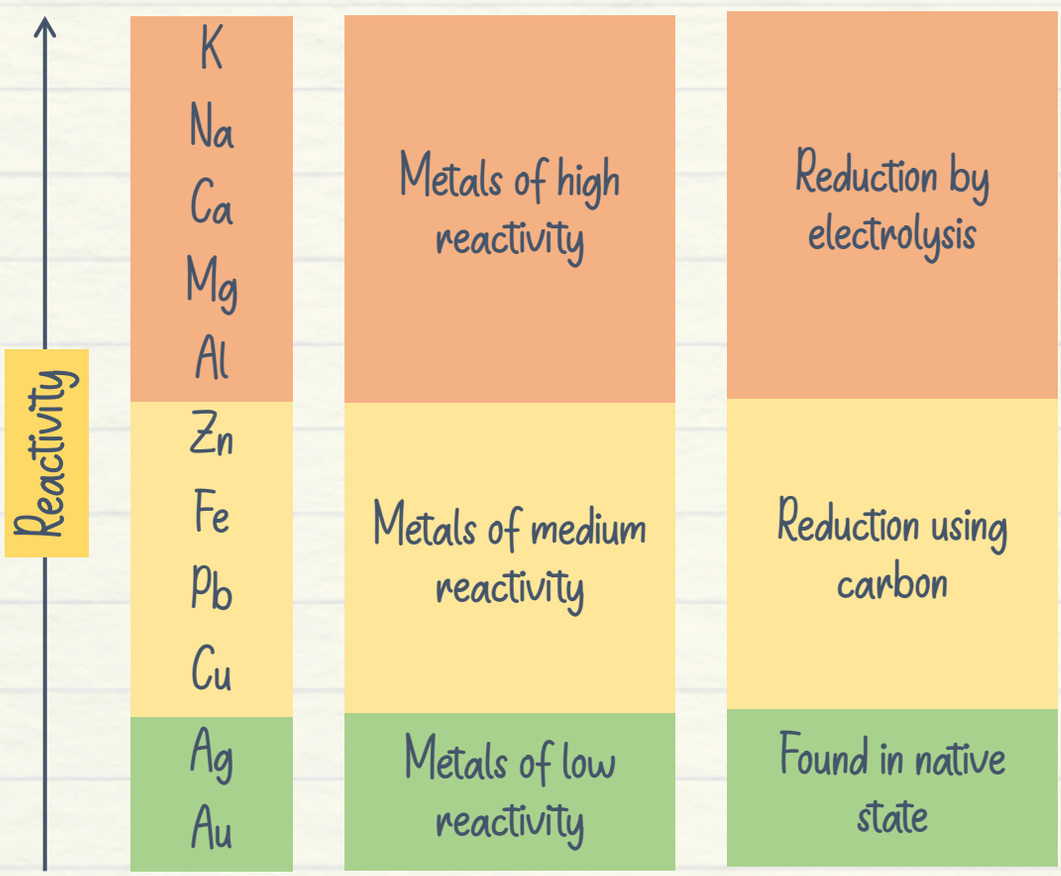
## 4.2 Properties of Ionic Bond

- Hard and brittle
- High melting and boiling point
- Soluble in water but insoluble in kerosene or petrol
- Do not conduct electricity in solid state, but conduct electricity in molten state or in aqueous solution

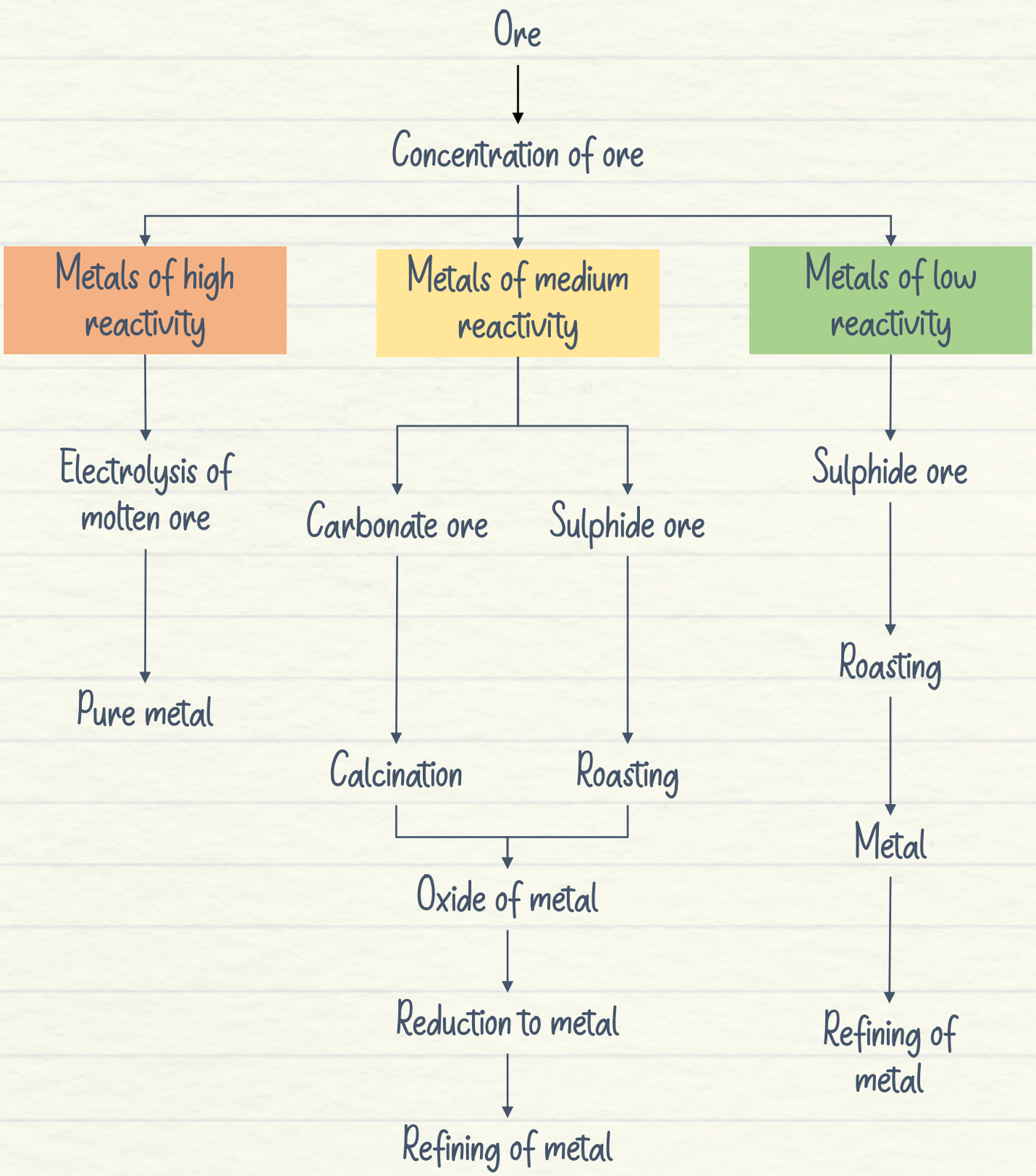
# 5. Extraction of Metals from Ores

## Processes involved in extraction of metals

| | |
|---|---|
| Concentration of ore | Removal of impurities (gangue) |
| Conversion to metal oxide | Conversion of metal carbonate or sulphides to metal oxide |
| Reduction to metal | Conversion of metal oxide to metal |
| Refining to pure metal | Purifying impure metal |



# Steps involved in extraction of metals



## 5.1 Concentration of Ore

- The process of removing of impurities (gangue) from ores
- Depends on physical and chemical properties of the gangue and the ore

## 5.2 Conversion to Metal Oxide

- Metals are easier to obtain from their oxides as compared to their sulphides and carbonates
- The process of converting carbonate ores into oxides by heating strongly in limited air is called calcination

$$2ZnCO_3(s) \xrightarrow{\text{Heat}} 2ZnO(s) + CO_2(g)$$

- The process of converting sulphide ores into oxides by heating strongly in the presence of excess air is called roasting

$$2ZnS(s) + 3O_2(g) \xrightarrow{\text{Heat}} 2ZnO(s) + 2SO_2(g)$$

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# 5.3 Reduction of Metal Oxide to Metal

Depends on position of metals in the reactivity series

## Metals low in the reactivity series

- Reduced to metals by heating alone (roasting)

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

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

## Metals in the middle of the reactivity series

- Reduced to metals by reducing agents like carbon

$$ZnO(s) + C(s) \xrightarrow{\text{Heat}} Zn(s) + CO(g)$$

- Reduced to metals by highly reactive metals like sodium, calcium and aluminium (displacement reaction)

$$3MnO_2(s) + 4Al(s) \longrightarrow 3Mn(l) + 2Al_2O_3(s) + \text{Heat}$$

## Metals in the top of the reactivity series

- Reduced to metals by electrolytic reduction

$$2NaCl(l) \xrightarrow{\text{Electrolysis}} 2Na(l) + Cl_2(g)$$

At cathode: $2Na^+(l) + 2e^- \longrightarrow 2Na(l)$ (reduction)

At anode: $2Cl^-(g) \longrightarrow Cl_2(g) + 2e^-$ (oxidation)

### Thermite reaction

- Displacement reaction between a metal and a metal oxide
- Highly exothermic
- Used to join railway tracks or cracked machine parts

$$Fe_2O_3 + 2Al \longrightarrow 2Fe + Al_2O_3 + Heat$$

## 5.4 Refining to Pure Metal

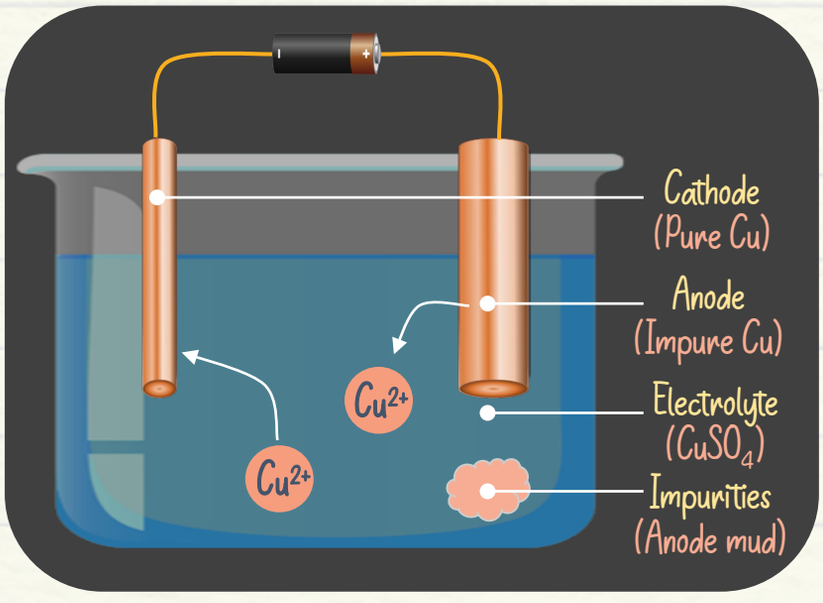
- Removing impurities from metals obtained from various reduction process to obtain pure metal

**RED CAT** — Reduction at cathode

**AN OX** — Oxidation at anode

### Electrolytic refining

- Used for refining metals such as copper, zinc, silver and gold
- Anode: Impure metal
- Cathode: Pure metal
- Electrolyte: Solution of metal salt
- Anode mud: Insoluble impurities which settle down at the bottom of the anode




Electrolytic refining of copper

# 6. Corrosion

## 6.1 Corrosion vs Rusting

- Corrosion is a natural chemical process that converts a pure metal into its compound leading to its degradation

Corrosion of copper

Rusting of iron

- Rusting is formation of a brown flaky coating (rust) due to corrosion of iron
- Both air (oxygen) and moisture are required for rusting

## 6.2 Methods for Prevention of Rusting

- Painting
- Greasing
- Chrome plating
- Alloying
- Oiling
- Galvanising
- Anodising

## 6.3 Alloys

- An alloy is a mixture of metal with metal or non-metals
- Alloying is a very good method of improving the properties of a metal

# Mind Map

- Metals and non-metals
  - Physical properties
    - Sonority
    - Conductivity
    - Hardness
    - Malleability
    - Lustre
    - Ductility
  - Chemical properties
    - Reactivity series
    - Displacement reaction
    - Reaction of metal with acid
    - Reaction of metal with water
    - Reaction of metal with oxygen
  - Bonding between metals and non-metals
    - Ionic bond
    - Properties of ionic bond
  - Extraction of metals from ores
    - Concentration of ore
    - Conversion to metal oxide
    - Reduction to metal
    - Refining to pure metal
  - Corrosion
    - Corrosion vs Rusting
    - Prevention of corrosion
    - Alloys