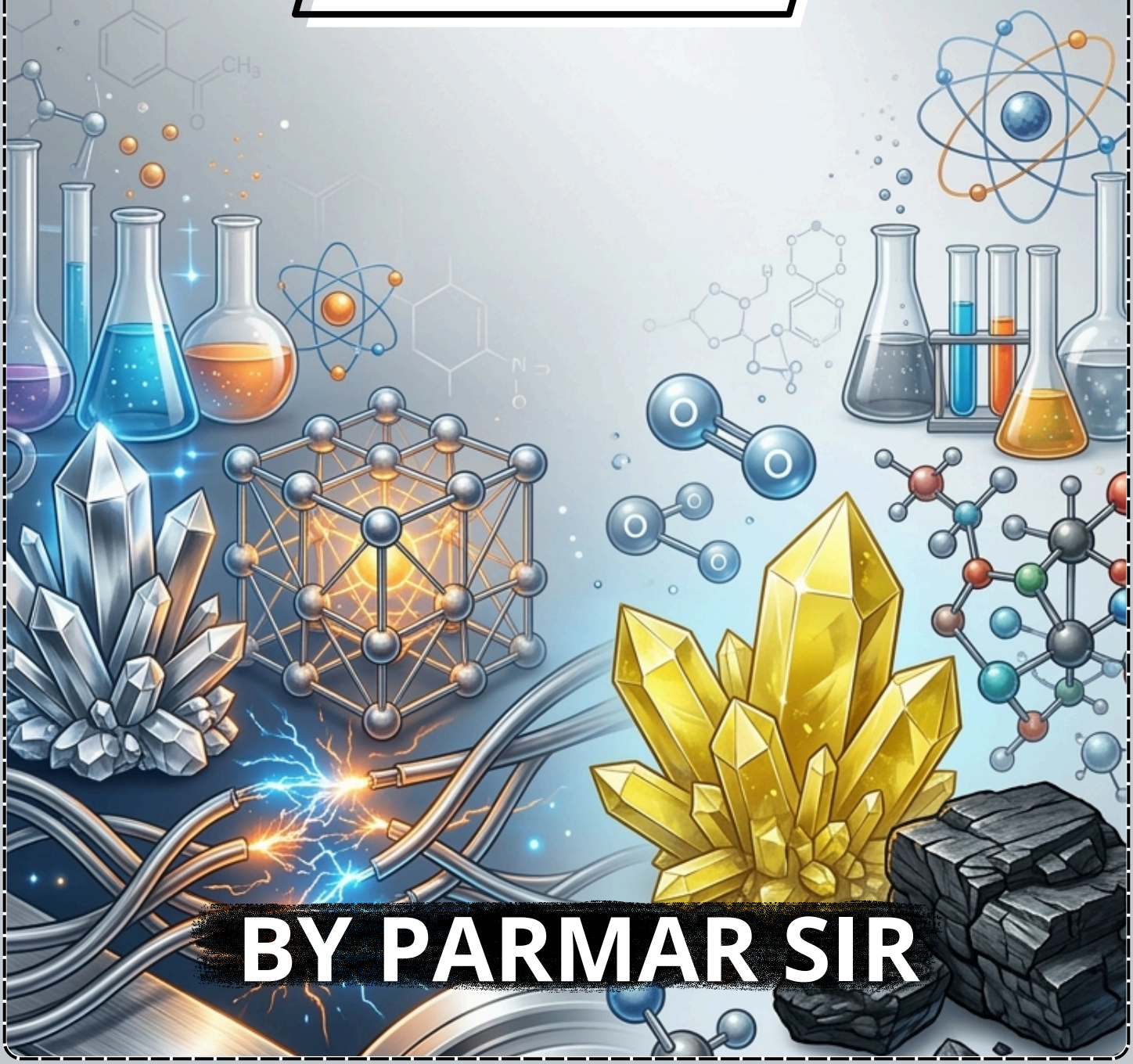
# PARMAR SSC

# METALS AND NON-METALS

## Lecture - 6



BY PARMAR SIR

# Properties of Metals

## Physical properties

1. They are generally solids.

**Exception:** Mercury (Hg) is liquid in room temperature, while Caesium (Cs) and Gallium (Ga) have melting points just above room temperature (28.5°C and 30°C, respectively).

**Mad Hatter Disease:** This condition is caused by mercury (Hg). In the 18th and 19th centuries, hat makers used mercury in their trade, which led to neurological issues such as mental instability and tremors.




2. They have a metallic lustre (shine)

**Exception**: Lead (Pb).

3. They are generally hard.

**Exception:** Alkali metals like Lithium, Sodium, and Potassium are soft metals and can be cut with a knife.

4. They have high melting point and boiling point.

**Exception:** Gallium (Ga) and Caesium (Cs).

**Tungsten (W):** It has the highest melting point (3422°C) and boiling point of all metals. This is why it is used to make the filaments of electric bulbs.
**Mercury (Hg):** It has the lowest melting and boiling points among all metals.
**Helium (He):** Considering all elements (both metals and non-metals), helium has the lowest melting and boiling points. It boils very close to absolute zero.

5. They are malleable in nature (gold (Au) and silver (Ag) are most malleable metals).

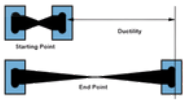
- **Malleability:** It is a physical property of metals that defines their ability to be hammered, pressed, or rolled into thin sheets without breaking.
- **E.g.:** Sweets coated with thin sheets of Ag foil. Similar to gold, silver is also highly malleable and can be shaped into various forms, including thin foils, and jewellery.




**Exception:** Mercury (Hg → liquid), Na (soft), K (soft), Zn (brittle).

6. They are ductile in nature (Au is most ductile)

- **Ductility:** It is a material's ability to be stretched or drawn into a thin wire or other elongated shape without breaking, meaning it can undergo significant deformation under tensile stress.
- **E.g.:** Gold, due to its high ductility; 1 gm gold can be drawn into a wire that is about 2 km long.



**Exception:** Hg, Na, K, Zn.

7. They are sonorous in nature. They make or produce sound.

**E.g.** School bells, temple bells, etc.

8. They have high density. Osmium has the highest density.

**Exception:** Sodium (Na) and Potassium (K) float in water.

9. They form alloys by combining with other metals or non-metals.

E.g. Stainless steel alloy of Nickel (Ni), Chromium (Cr), and Iron (Fe).

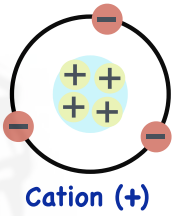
- German silver, also known as "Nickel silver" is an alloy of Copper (Cu), Zinc (Zn) and Nickel (Ni).

10. Metals are good conductors of heat and electricity (free electrons are required for conduction of electricity).

**Exception:** Pb and Hg.

11. They exhibit cationic properties.

- Metals form metal oxides when they react with oxygen.
- Generally, all metallic oxides are basic in nature.




## Properties of Non- Metals

**Physical properties**

1. They are generally solids or gases.

**Exception:** Bromine (liquid at room temperature).

2. They are non-lustrous in nature.

**Exception:** Iodine, Diamond, Graphite.

**Graphite:** It is used as a dry lubricant and is also used as a moderator in nuclear reactors.

3. They are brittle and generally soft in nature.

**Exception:** Diamond which is the hardest substances on earth.

4. They have low melting point and boiling point.

**Exception:** Diamond, Graphite, Silicon, Carbon, Boron.

5. They are not malleable in nature.

6. They are non-ductile in nature.

7. They are non-sonorous in nature.

8. They have low density.

**Exception:** Diamond.

9. They do not form Alloys.

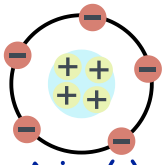
**Exception:** Carbon is alloyed with iron to form steel.

**10. They are bad conductor of heat and electricity.**

**Exception:** Graphite which is a good conductor of electricity.

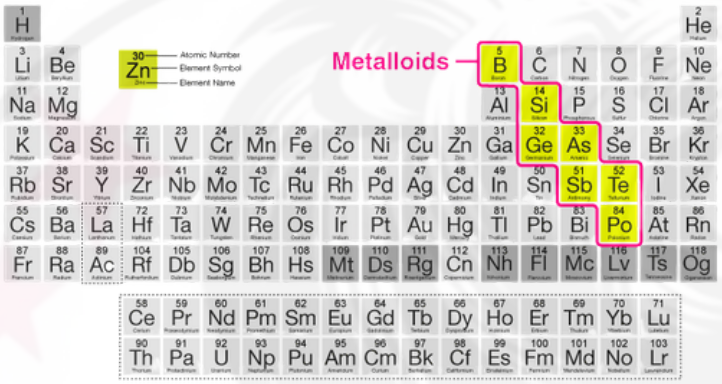
**11. They show anionic properties.**

- Non-metals form non-metal oxides when they react with oxygen.
- Generally, all non-metallic oxides are acidic in nature.




## Metalloids

- Metalloids are elements that have properties of both metals and non-metals.
- **There are 7 metalloids:** Boron, Silicon, Germanium, Arsenic, Antimony, Tellurium, and Polonium.




## Chemical Properties of Metals

### I. Reaction with Oxygen

- Burning in air or formation of oxides (Combustion).
- Almost all metals combine with oxygen (or air) to form metal oxides.

$$4Al + 3O_2\ (g) \rightarrow 2Al_2O_3\ (s)$$

*Aluminium Oxide*

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

*Copper oxide*

Generally metal oxides are basic in nature.

### Amphoteric Oxides

- Amphoteric oxides are compounds that can react with both acids and bases, exhibiting both acidic and basic properties, and forming salts and water in these reactions.
- **Eg.** Zinc oxide, Aluminium oxide.

$$Al_2O_3 + HCl \rightarrow AlCl_2 + H_2O$$

*Acid* *Salt + Water*

$$Al_2O_3 + NaOH \rightarrow NaAlO_2 + H_2O$$

*Base* *Sodium Aluminate*

*Salt + Water*

- Most metal oxides are insoluble in Water.
- Some metal oxides are soluble in water and form alkali like Sodium Oxide ($Na_2O$) & Potassium Oxide ($K_2O$).

**Other examples with TRICK**

- **Suno**: $SnO_2$ (Tin oxide)
- **Be**: BeO (Beryllium oxide)
- **Zanabe**: ZnO (Zinc oxide)
- **Ali**: $Al_2O_3$ (Aluminium oxide)
- **Phir**: $PbO_2$ (Lead oxide)
- **Milenge**: $MnO_2$ (Manganese oxide)
- **Gali main**: $Ga_2O_3$ (Gallium oxide)

## 2. Reactivity of Different Metals towards Oxygen

### Sodium (Na) and Potassium (K)

- These two metals react vigorously with oxygen that they catches fire if kept in open. That why Na and Ka are kept in kerosene.

### Mg, Al, Zn, Pb




- At ordinary temperature, the surface of these metals gets covered with thin layer of oxides. This oxide layer protects them from further oxidation.

### Iron




- Iron does not burn on heating, but iron fillings burn vigorously when sprinkled in flame of burner.

### Copper




- Copper does not burn, but on heating, it forms a black layer of copper (II) oxide (CuO).

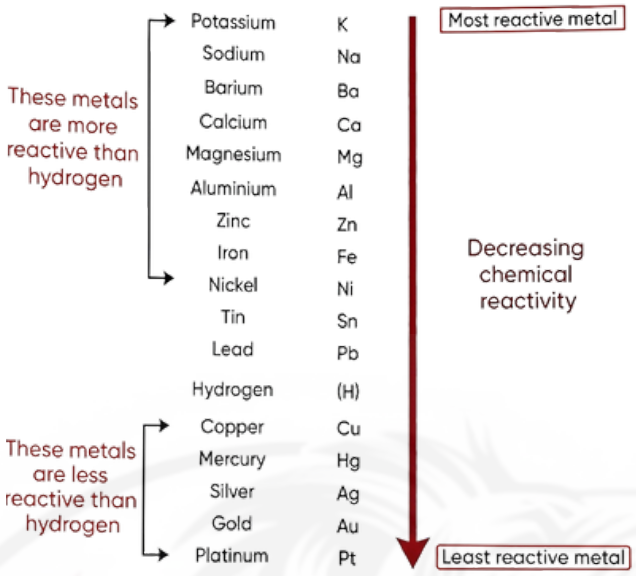
$$2Cu + O_2 \rightarrow 2CuO$$

- This black coating is responsible for tarnishing of copper objects over time.

### Silver (Ag) and Gold (Au)

- They do not react with oxygen even at high temperature.

# Reactivity Series of Metals




## 3. Reaction of Metal with Water

**Metals + Water → Metal Oxide + $H_2$ (g)**

- All metals do not react with water

**Metal Oxide + Water → Metal Hydroxide**

- At ordinary temperature, the surface of these metals gets covered with thin layer of oxides. This oxide layer protects them from further oxidation.

| Metals | Cold Water | Hot Water | Steam |
|---|---|---|---|
| K, Na | Reacts vigorously + Exothermic (evolved $H_2$ gas catches fire) | ✓ | ✓ |
| Ca | Less violent reaction + Exothermic | ✓ | ✓ |
| Mg | ✗ | Mg starts floating because the bubbles of $H_2$ gas formed in the reaction stick to the surface of the metal | ✓ |
| Al, Fe, Zn | ✗ | ✗ | ✓ |
| Pb, Cu, Ag, Au | ✗ | ✗ | ✗ |

## 4. Reactivity of Different Metals with Water

$$2K\ (s) + 2H_2O \rightarrow 2KOH\ (aq) + H_2\ (g) + Heat$$
$$2Na\ (s) + 2H_2O \rightarrow 2NaOH\ (aq) + H_2\ (g) + Heat$$
$$Ca\ (s) + 2H_2O \rightarrow Ca(OH)_2\ (aq) + H_2\ (g)$$
$$2Al\ (s) + 3H_2O \rightarrow Al_2O_3\ (aq) + 3H_2\ (g)$$
$$3Fe\ (s) + 4H_2O \rightarrow Fe_3O_4\ (s) + 4H_2\ (g)$$

## 5. Reaction of Metal with Acids

- Except a few less reactive metals (such as Cu, Hg, Ag, Au, Pt, etc.), all metals react with dilute sulphuric acid ($H_2SO_4$) and hydrochloric acid (HCl) to produce salt and hydrogen gas.

**Metal + Dilute acid → Salt + Hydrogen**

**(M) (A) (S) + (H)**

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

## 6. Reaction of Metal with Dilute Nitric Acid ($HNO_3$)

- Hydrogen gas is not evolved when a metal reacts with nitric acid.
- This is due to strong oxidising nature of nitric acid.
- It oxidises the hydrogen, produced to water and itself gets reduced to any of the nitrogen oxide (NO, $NO_2$, $N_2O$).
- Magnesium (Mg) and Manganese (Mn) react with dilute $HNO_3$ to evolve $H_2$.

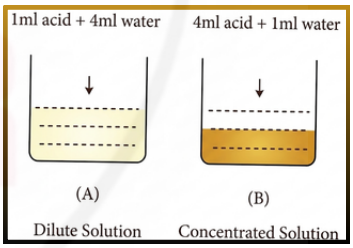
**Metal + $HNO_3$ → Salt + $NO/N_2O/NO_2$**

**(Exceptional case: only for Mn and Mg)**

**Metal (Mn/Mg) + $HNO_3$ → Salt + $H_2$**

- **Note:** Copper does not react with dilute HCl

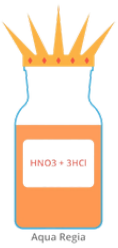
- **$N_2O$ (Nitrous Oxide)** is commonly known as "**laughing gas**" .
- **$H_2S$ (Rotten-smelling gas):** Hydrogen sulfide is a colorless, flammable gas with an odor similar to rotten eggs.
- **Bhopal Gas Tragedy:** The 1984 Bhopal gas tragedy was caused by the leak of methyl isocyanate (MIC) gas.




## Aqua Regia (Royal Water)

- It is a mixture of two strong acids in the ratio:

**Concentrated $HNO_3$ : Concentrated HCl = 1 : 3**




- It is highly corrosive in nature.
- Aqua regia is able to dissolve gold and platinum.

## 7. Reaction of Metals with solutions of other Metal Salt

**$Metal_1$ + $Metal_2$ Salt → $Metal_1$ Salt + $Metal_2$**

**Displacement Reaction**

$$Cu\ (s) + 2AgNO_3\ (aq) \rightarrow Cu(NO_3)_2\ (aq) + 2Ag\ (s)$$

- The more reactive metal replaces the less reactive metal

# Chemical Properties of Non Metals

## I. Reaction with Oxygen

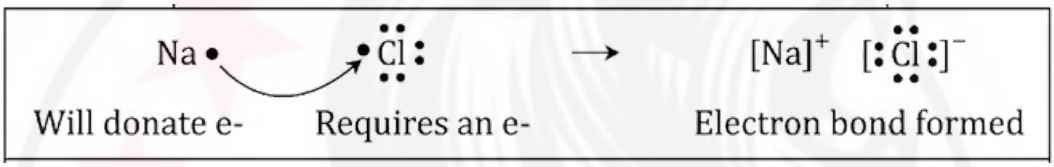
- Non-metals do not react with water, steam or dilute acid.
- The reason is that they act as an electron acceptor and cannot accept $H^+$ ions of acids to reduce them to hydrogen gas.
- But on heating, they readily form oxides or salts with concentrated acids.

$$S\ (s) + 2H_2SO_4\ (conc.)\ \Delta \rightarrow 3SO_2\ (g) + 2H_2O\ (l)$$

$$S\ (s) + 6HNO_3\ (conc.)\ \Delta \rightarrow H_2SO_4\ (aq) + 6NO_2\ (g) + 2H_2O\ (aq)$$

## Reaction between Metals and Non-metals Ionic Bond formation

### Ionic Bond Formation of NaCl




Na configuration: 2, 8, 1
Cl configuration: 2, 8, 7

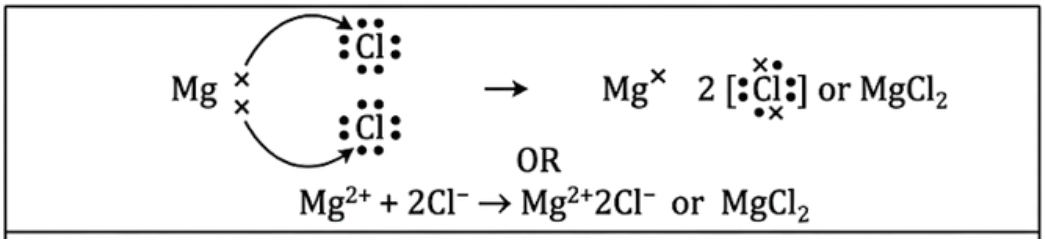
- When Na transfers an electron to Cl, it results in NaCl. Na atom with 11 electrons and 11 proton transfers its single valence electron to Cl atom. Na becomes positively charged and Cl atom becomes negatively charged.

### Electrovalent Bond

- An electrovalent bond, also known as an ionic bond, is a chemical bond formed by the complete transfer of electrons from one atom (usually a metal) to another atom (usually a nonmetal), resulting in the formation of oppositely charged ions held together by electrostatic attraction.

Ionic compounds show anisotropic properties.

### Ionic Bond Formation of $MgCl_2$



# Properties of Ionic Compounds

## Physical Nature

- Ionic compounds are hard crystalline solids because of strong force of attraction between the positive and negative ions. These compounds are generally brittle and break into pieces when pressure is applied.

## Melting and boiling points

- These compounds have high melting and boiling points as large amount of energy is required to break strong inter-ionic attraction.

## Solubility

- These compounds are soluble in water (polar solvent) and insoluble in organic solvents (non-polar solvent) like kerosene, benzene, ether, petrol, etc.

## Conduction of electricity

- The conduction of electricity through a solution involves movement of charged particle. Ionic and electrovalent compounds are good conductors of electricity, but they conduct electricity either in molten form or in their aqueous solution, as the ions are free to move and carry charge.

# Occurrence of Metals in the Form of Their Ore

- Ore = Metal + Impurities (Gangue)

1. **Aluminium:** Bauxite, Cryolite
2. **Iron:** Magnetite, Hematite, Limonite, Siderite
3. **Zinc:** Zinc Blende/Sphalerite; Calamine; Zincite (Zinc)
4. **Mercury:** Cinnabar (Hgs)
5. **Thorium:** Monazite
6. **Sodium:** Borax; Chile saltpeter ($NaNO_3$) and Indian saltpeter ($KNO_3$) ← Use as Explosive
7. **Lead:** Galena
8. **Magnesium:** Epsom salt ($MgSO_4 \cdot 7H_2O$)
9. **Tin:** Cassiterite
10. **Uranium:** Pitchblende (it is made up of Uranium Oxide ($UO_2$) and variable proportions of $UO_3$)

# Corrosion

- **Silver:** Black coating is formed due to silver sulphide by the reaction of silver with sulphur in air and is also known as "Tarnishing of Silver".
- **Copper:** Green coating due to basic copper carbonate formed by reaction of copper with carbon dioxide in air.
- **Iron:** Reddish brown coating called Rust; iron corrode rapidly in air and water.

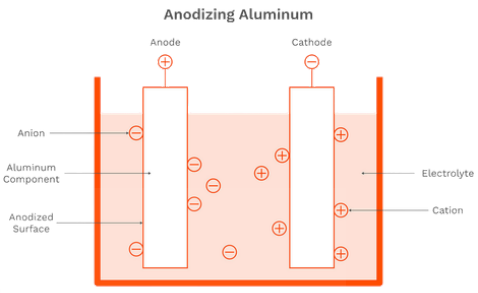




Titanium is used for making Boat because it does not corrode in sea water.

## Prevention of Corrosion

- **Galvanisation:** Galvanisation is protecting steel and iron from rusting by coating them with a thin layer of zinc.
- **Anodizing:** It is an electrochemical process that creates a thick, protective oxide layer on aluminium (and its alloys) to enhance corrosion resistance and improve its appearance.
- Metals like aluminium, magnesium, titanium can undergo anodization to form a protective oxide layer.
- Anodizing process is used in aircraft industry.




## Formation of Alloy

- Alloys generally have lower electrical conductivity and lower melting points than their constituent metals.

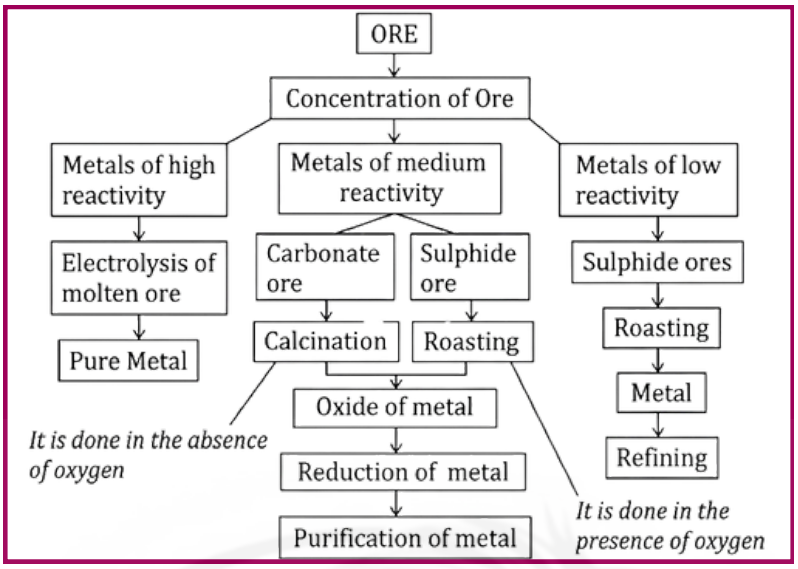
| Alloy | Composition |
|---|---|
| Brass | Cu (80%) + Zn (20%) |
| Bronze | Cu (88%) + Sn (12%) |
| Solder | Sn + Pb |
| Bell Metal | Cu + Sn |
| Gun Metal | Cu + Sn + Zn |
| Amalgam | Hg + other metals |
| Stainless Steel | Fe + Ni + Cr + Carbon |
| Constantin | Cu + Ni |
| Manganin | Cu + Ni + Mn |
| Nichrome | Ni + Cr + Mn + Fe |
| German Silver | Cu + Ni + Zn |
| White Gold | Au (75%) + Ni + Pd |
| Magnalium | Al (95%) + Mg |
| Duralumin | Al (95%) + Mg + Mn + Cu |

## Steps Involved in Extraction of Metals from Ores

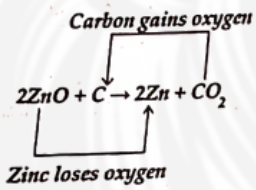
### Metallurgy

- Metallurgy is the science of extracting metals from their ores and refining them into pure metals and alloys.

- White gold was originally developed to imitate platinum (a naturally white metal).
- Jewellery made of gold is an alloy. Pure gold has (22 parts of Au + 2 parts of Cu/Ag).
- **Amalgam:** An amalgam is a metal alloy of mercury with one or more metal.

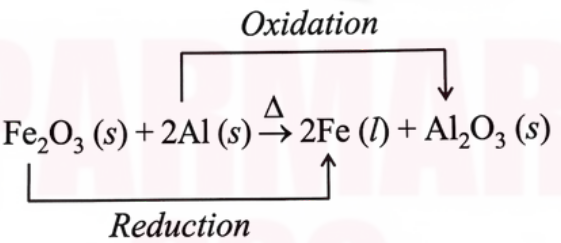



## Reduction of Metal




## Thermite Reaction

- It is a type of reaction in which a metal oxide is reduced by using aluminium as the reducing agent. It is generally exothermic in nature.

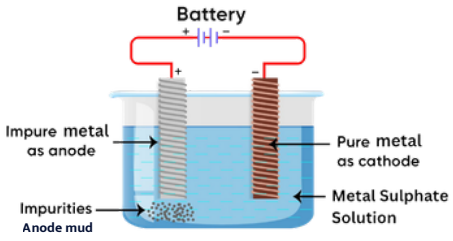



Iron oxide (III) Aluminium Iron Aluminium oxide


Thermit Welding on Railway Track

## Electrolytic Refining

- It is a process that uses electricity to purify impure metals. An impure metal is used as anode and a pure metal is used as cathode.
- A solution of a metal salt is used as electrolyte.
- When an electric current is passed through the cell, the impure metal dissolves into the electrolyte and is replaced by an equal amount of pure metal from the cathode.




**The pure metal is deposited at the cathode, while the insoluble impurities from the impure metal settle down beneath the anode as anode mud.**





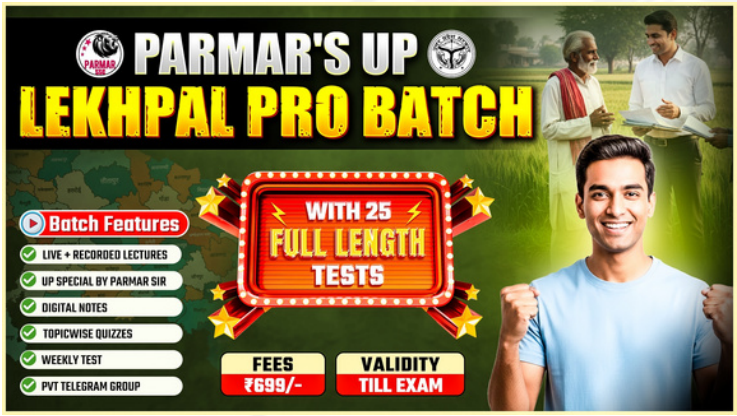


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