🧪 Chapter 3: Metals and Non-metals

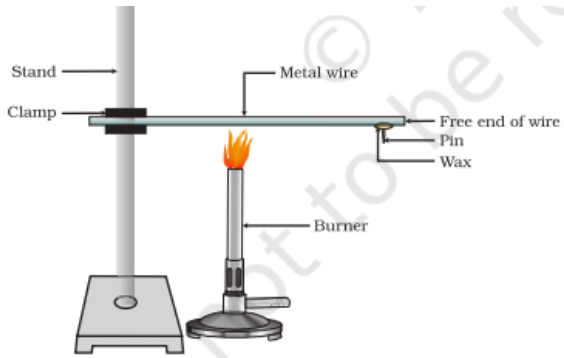
This chapter explores the physical and chemical properties of metals and non-metals, how they react, how they are extracted, and how they are refined.

🔹 3.1 Physical Properties

🔸 Metals

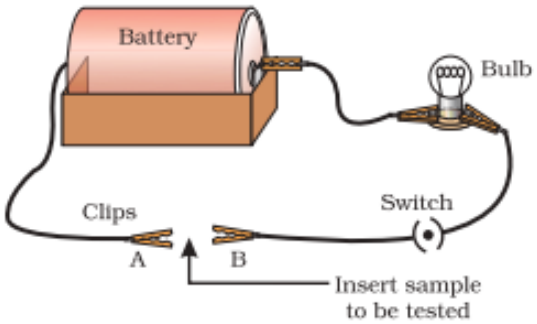
🟦 Definition:
Metals are elements that are generally hard, shiny, malleable, ductile, good conductors of heat and electricity, and have high melting and boiling points.

- **Lustre:** Shiny appearance (e.g., iron, copper)



📷 Fig. 3.1 – Metallic Lustre (Activity 3.1)

- **Malleability:** Can be hammered into thin sheets (e.g., gold, silver)
- **Ductility:** Can be drawn into wires (e.g., copper, gold)
- **Conductivity:** Good conductors of heat and electricity (e.g., copper, aluminium)



📷 Fig. 3.2 and 3.3

- **Sonorous:** Produce ringing sound when struck
- High melting/boiling points (e.g., silver, copper)

🧪 Exceptions:

- Mercury is liquid at room temp.

- Alkali metals (Na, K) are soft and can be cut with a knife.
- Lead and mercury are poor conductors of heat.

🔸 Non-Metals

🟦 Definition:

Non-metals are elements that lack metallic properties. They are brittle, non-lustrous, non-ductile and bad conductors (except graphite).

📌 Key Features:

- Exist as solids, gases (except bromine – liquid)
- Non-sonorous, dull, and poor conductors
- Cannot be drawn into wires or beaten into sheets
  📷 Activity 3.6 and 3.7

🧪 Exceptions:

- Iodine is lustrous.
- Graphite (carbon) conducts electricity.
- Diamond is a hard non-metal (allotrope of carbon).

🔷 3.2 Chemical Properties of Metals

3.2.1 Reaction with Oxygen

🟦 Reaction:

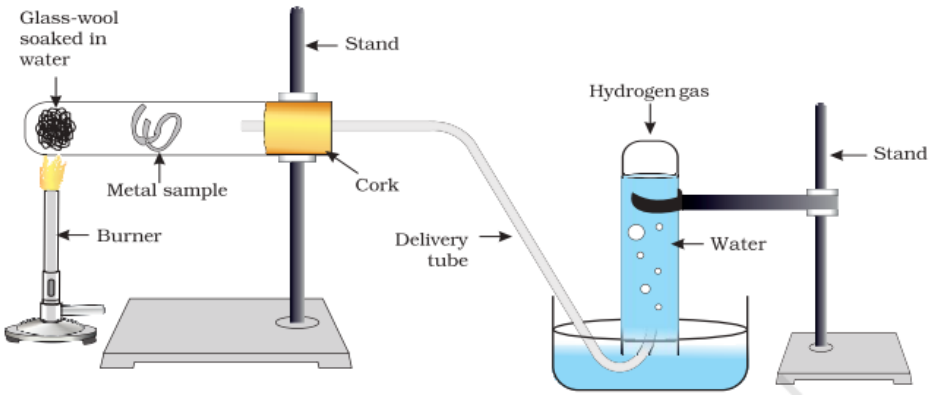
Metal + Oxygen → Metal Oxide

Example:

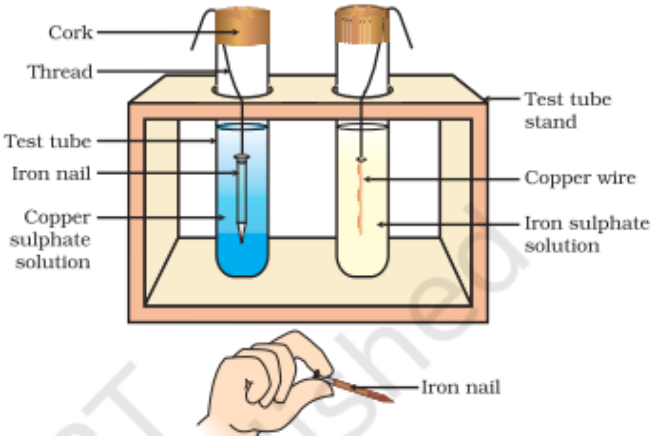
$2Mg + O_2 \rightarrow 2MgO$

📌 Properties:

- Metal oxides are basic.
- Some (like Al_2O_3, ZnO) are amphoteric – react with both acids and bases.



📷 *Fig. 3.3 – Reaction with Steam*



📷 *Fig. 3.4 – Activity: Reactivity of metals with oxygen*

—

3.2.2 Reaction with Water

🟦 **General Reaction:**

Metal + Water → Metal Hydroxide + Hydrogen

Examples:

- $2Na + 2H_2O \rightarrow 2NaOH + H_2$ (vigorous)
- $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
- Mg reacts only with hot water
- Al, Fe, Zn react with steam
- Cu, Ag, Au – No reaction

—

3.2.3 Reaction with Acids

🟦 **General Reaction:**

Metal + Dilute Acid → Salt + Hydrogen

Example: $Zn + HCl \rightarrow ZnCl_2 + H_2$

🧪 **Notes:**

- HNO_3 is a strong oxidizing agent, so H_2 is not liberated (except for Mg, Mn with dilute HNO_3)
  📷 Activity 3.11

—

3.2.4 Reaction with Metal Salt Solutions

🟦 **Displacement Reaction:**

More reactive metal displaces a less reactive metal from its salt solution.

Example: $Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

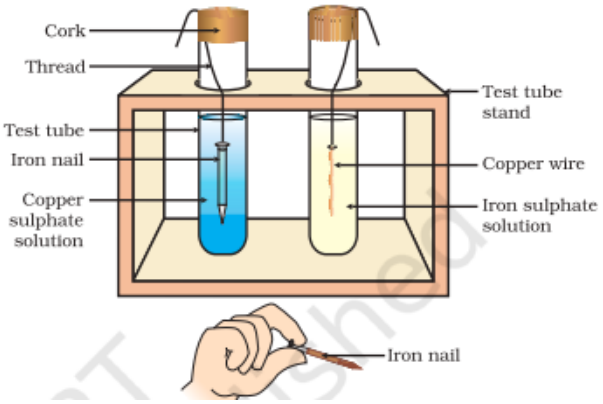


Fig. 3.4 – Activity 3.12

—

3.2.5 Reactivity Series

Definition:
A list of metals in decreasing order of their reactivity.

Reactivity Series:

K > Na > Ca > Mg > Al > Zn > Fe > Pb > (H) > Cu > Hg > Ag > Au

—

3.3 How Do Metals and Non-Metals React?

Ionic Bond Formation

Definition:
A bond formed by complete transfer of electrons from a metal to a non-metal.

Example:
Na (2,8,1) → Na^+ (2,8) + e^-
Cl (2,8,7) + e^- → Cl^- (2,8,8)

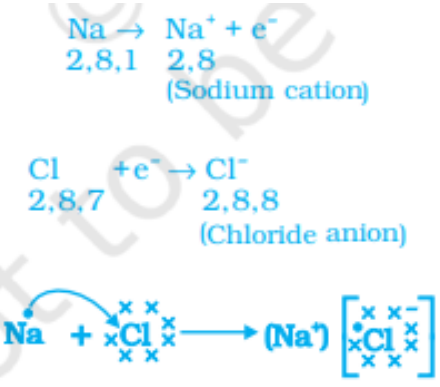
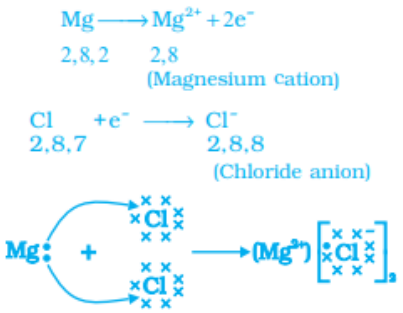


Fig. 3.5 – Formation of NaCl



📷 Fig. 3.6 – Formation of $MgCl_2$

—

🔹 3.3.1 Properties of Ionic Compounds

🟦 **Definition:**
Compounds formed through ionic bonding (e.g., NaCl, $CaCl_2$).

📌 **Properties**:

1. Solid, brittle, and hard
2. High melting and boiling points
3. Soluble in water but not in petrol/kerosene
4. Conduct electricity in molten or aqueous state
   📷 Fig. 3.7 and Fig. 3.8 – Conductivity test

—

🔹 3.4 Occurrence and Extraction of Metals

3.4.1 Minerals and Ores

🟦 **Definitions:**

- Mineral: Naturally occurring compound of a metal.
- Ore: Mineral from which metal can be extracted profitably.
- Gangue: Impurities in the ore

—

3.4.2 Extraction Process

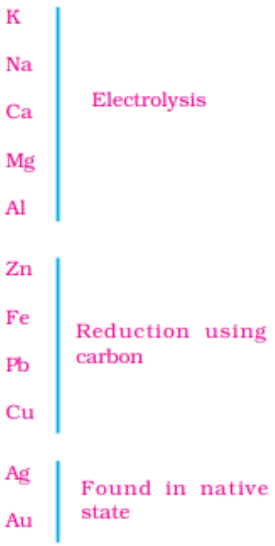


Fig. 3.9 – Activity Series vs Extraction Technique

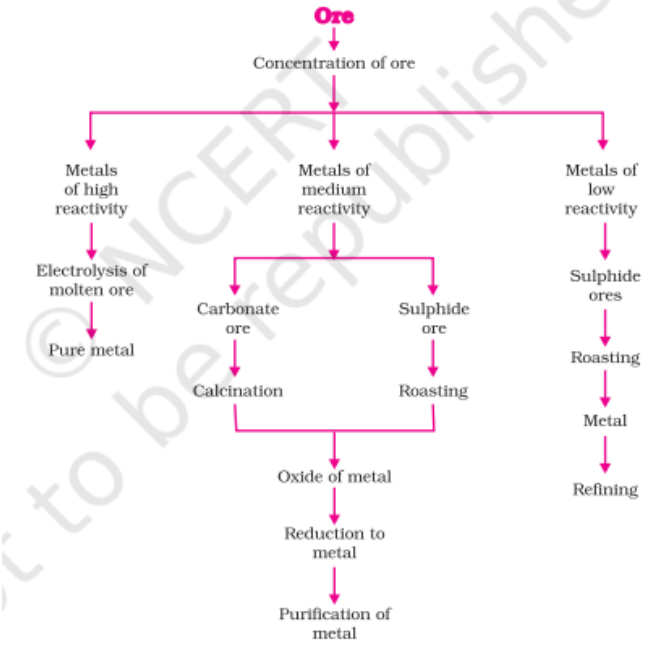


Fig. 3.10 – Steps of Metallurgy

Steps:

1. Enrichment of ore
2. Conversion to oxide (by roasting or calcination)
3. Reduction to metal
4. Refining

—

3.4.3 Extraction Based on Reactivity

- Low Reactive Metals (e.g., Hg, Cu): Heated directly
- Medium Reactive Metals (e.g., Zn, Fe): Roasting/Calcination → Reduction
- High Reactive Metals (e.g., Na, Al): **Electrolysis**

🟦 **Thermit Reaction:**

$Fe_2O_3 + 2Al \rightarrow 2Fe + Al_2O_3 + heat$

📷 Fig. 3.11

—

3.4.6 Electrolytic Refining

📷 Fig. 3.12 – Electrolytic refining setup

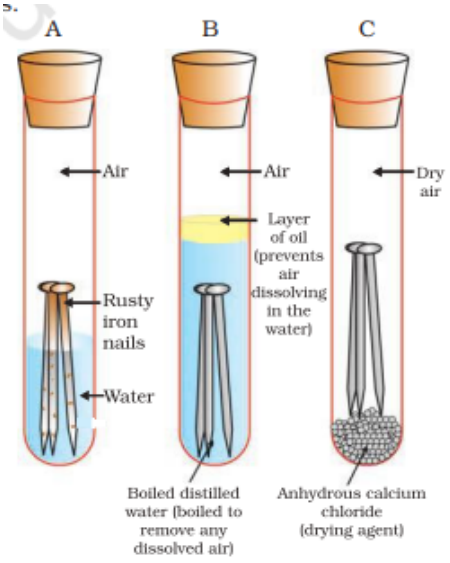
- **Anode:** Impure metal
- **Cathode:** Pure metal
- **Electrolyte:** Salt solution of metal

—

🔹 3.5 Corrosion and Its Prevention

🟦 **Definition:**

Corrosion is the gradual destruction of metal due to environmental conditions (e.g., rusting of iron).



📷 *Fig. 3.13 – Rusting experiment*

🛡️ **Prevention Methods:**

- Painting, greasing, galvanising (zinc coating), anodising
- Alloying

—

🔹 3.6 Alloys

🟦 **Definition:**

An alloy is a homogeneous mixture of two or more metals or a metal and non-metal.

Examples:

- **Brass:** Cu + Zn

- **Bronze:** Cu + Sn
- **Solder:** Pb + Sn
- **Steel:** Fe + C
- **Stainless steel:** Fe + Cr + Ni