8. Metallurgy

Metals

- **Physical properties**
- Shining surface (in pure state) [called metallic lustre]
- Generally hard [varies from metal to metal]
- Malleable [i.e. can be made thin sheets by beating]
- Ductile [i.e. can be drawn into thin wires]
    - [Gold → Highly ductile]
- Good conductors of heat
- High melting point
- Conduct electricity
- Produce sound [some metals; these are called sonorous]

Non-metals

- Non-metals are found in all the three states i.e. solid, liquid and gas, at room temperature.
- Iodine (non-metal) has lustre
- Carbon has allotropes (exists in different forms)
    - Diamond is hard
    - Graphite (Conducts electricity)

Metals	Non-metals
1. Generally, these are hard and lustrous.	These are soft and have no lustre.
2. These are malleable and ductile (Malleable: can be beaten into sheets; Ductile: can be drawn into wires).	These are non-malleable and non-ductile.
3. These are sonorous (produce ringing sound when struck).	These are not sonorous.
4. These are good conductors of heat and electricity.	These are poor conductors of heat and electricity.

- **Chemical properties:**

Metals	Non-metals
These react with oxygen to produce metal oxides, which are basic in nature.	These react with oxygen to form non-metallic oxides, which are acidic in nature.

Chemical properties

- **Reaction with oxygen**
- **Combine with oxygen to form oxides**
- $2Cu + O_2 \rightarrow 2CuO$

- $4Al + 3O_2 \rightarrow 2Al_2O_3$
- Most metal oxides are insoluble in water.
- If soluble, they form alkali.
- $Na_2O + H_2O \rightarrow 2NaOH$
  $K_2O + H_2O \rightarrow 2KOH$

- Sodium, potassium react very easily with O_2. So, they are kept immersed in kerosene.
- Mg, Al, Zn, Pb form thin layers of oxides.
- **Reaction with water**
- Produce metal oxide + H_2
- If oxide is soluble, then metal hydroxide is formed.

$2K + 2H_2O \longrightarrow 2KOH + H_2$ } That's why they are not put in water

$2Na + 2H_2O \longrightarrow 2NaOH + H_2$ } Violent reactions

$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$ (Less violent)

Mg → Doesn't react with cold H_2O

- Al, Zn, Fe do not react with H_2O, but react with steam.

  $2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2$

  $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

- **Chemical properties:**

Metals	Non-metals
These react with acids to produce metal salts and hydrogen gas.	These do not react with acids.
Some metals react with bases to produce hydrogen gas.	Reactions of non-metals with bases are complex.

Reaction with Acids

- Metal + Dilute acid → Metal salt + H_2
- H_2 doesn't evolve in the case of HNO_3 as it is a strong oxidising agent. It oxidises H_2.
- Cu does not react with acids like dilute H_2SO_4 and dilute HCl.
- **Aqua regia**
  - Freshly-prepared concentrated HCl and concentrated HNO_3 in 3:1 ratio
  - It can dissolve gold and platinum.

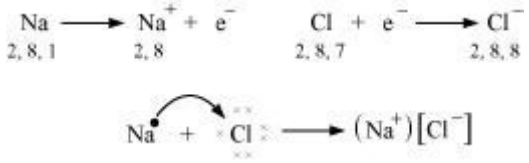
Reaction with Bases

- Metals react with bases to produce hydrogen gas.
- Reactions of non-metals with bases are complex.

- **Reactivity Mg > Al > Zn > Fe > Cu**
- **Reaction with solutions of other metal salts**
- Displacement reactions

- Metal A + Salt solution of B → Salt solution of A + Metal B
- Reactivity series
- **Main Features of Reactivity Series**
  - Metals are arranged in the decreasing order of their electropositive character.
  - Metals at the top have greater reducing power. This power decreases on moving down the series.
  - Metals at the top show greater tendency to get oxidised.
  - Metals above hydrogen in the reactivity series liberate hydrogen gas from mineral acids.
  - Metals at the top displace metals lower in the series from the aqueous solution of their salts.
  - Metal oxides above Al, cannot be reduced by common reducing agents, the reverse is true for metal oxides below Al.
- **K > Na > Ca > Mg > Al > Zn > Fe > Pb > H > Cu > Hg > Ag > Au**

- **Metals + Non-metals**
  - **1)**



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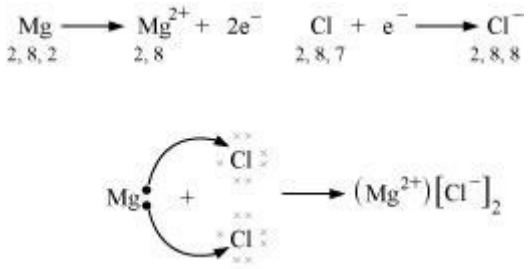
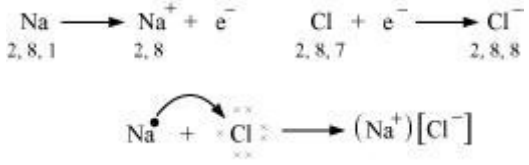


- **Physical Properties of Ionic compounds**

1. Solid
2. Hard [because of strong attraction force]
3. Brittle
4. High melting and boiling points
5. Soluble in H_2O; insoluble in kerosene, petrol
6. Conduct electricity in H_2O solution

- **Metals + Non-metals**
  - **1)**



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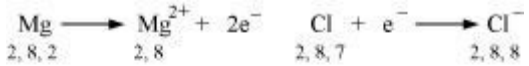

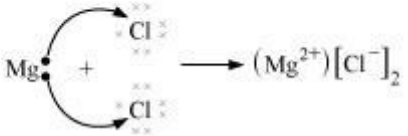

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Elements on earth are found in different parts of earth and are found in different forms. Different parts of earth include lithosphere, hydrosphere and atmosphere.

- Elements or compounds, which occur naturally in the Earth's crust, are known as minerals.

- **Extraction of metals**

K Na Ca Mg Al	Zn Fe Pb Cu	Ag An
Highly reactive metals	Medium reactive metals	Foundin native form
–	–	
Electrolysis	Carbon reduction	

- **Low active metals**

$$\left.\begin{aligned} &2HgS+3O_2 \rightarrow 2HgO+2SO_2 \\ &2HgO(s) \rightarrow 2Hg(I)+O_2(g) \\ &2Cu_2S+3O_2 \rightarrow 2Cu_2O(s)+2SO_2(g) \\ &2Cu_2O+Cu_2S \rightarrow 6Cu(s)+SO_2(g) \end{aligned}\right\} \text{Heated in air}$$

- **Middle active metals**

- **Roasting** – Heating of sulphide ore in **excess air**

$$2ZnS+3O_2 \rightarrow 2ZnO+2SO_2$$

- **Calcination –** Heating of carbonate ores in **limited air**

$$ZnCO_3 \rightarrow ZnO + CO_2$$

- **Thermite reaction**

$$Fe_2O_3 + 2AI \rightarrow 2Fe + AI_2O_3 + Heat$$

- **Electrolytic Reduction**

Reaction at cathode (negative electrode): $Na^+ + e^- \rightarrow Na$

Reaction at anode (positive electrode): $2Cl^- \rightarrow Cl_2 + 2e^-$

$$\text{Net reaction: } 2NaCl(l) \xrightarrow{\text{Electrolytic reduction}} 2Na(s) + Cl_2(g)$$

Sodium chloride (Molten) — Sodium — chlorine

- **Electrolytic refining of metals**
  - Impure metal is made the anode and thin strip of pure metal is made cathode.
  - A solution of metal salt is used as an electrolyte

Extraction of Aluminium from Alumina

- Aluminium is generally extracted from the bauxite ore. The bauxite ore can be concentrated by the process of leaching by digesting it with concentrated sodium hydroxide solution at 473-523 K and 35-36 bar pressure.
- In Electrolytic Reduction of Alumina, Na_3AlF_6 or CaF_2 is added to pure alumina to lower the melting point and to increase the conductivity of the electrolyte.
- This electrolytic process is known as the Hall-Heroult process. The oxygen liberated at the anode reacts with the carbon of the anode to produce CO and CO_2. Therefore, the carbon anode has to be replaced periodically as the oxygen released oxidises it.
- The obtained aluminium metal is purified by Hoope's process.

Properties of Aluminium

- It is a silvery white light metal.
- It is malleable, ductile and a good conductor of electricity.
- It reacts with oxygen and nitrogen present in the air to form a protective layer over its surface.
- It reacts with acids as well as bases.
- It is affected by steam and a layer of oxide is formed on exposure to steam.
- It reacts with non-metals.
- It has reducing property and is used in aluminothermy.

Uses of Aluminium

- As wrappers for foods in the form of foils
- In paints and lacquers
- In the extraction of chromium and manganese from their oxides
- In conduction of electricity in the form of wire

Alloys of Aluminium

- **Duralumin** (95 % Al, 4 % Cu, 0.5 % Mg, 0.5 % Mn) which is used in the manufacture of aeroplanes as it is very light, strong, ductile, and resistant to corrosion

- **Magnelium** (90 % Al, 10 % Mg) which is used in the manufacture of light tools and machine parts as it is very light, strong, and resistant to corrosion

Corrosion:

The process of breaking down of metals because of their reactions with moisture and gases present in the air is known as corrosion. Rusting of iron is the most common example of corrosion.

Factors Affecting Corrosion

- Reactive nature of metal: Highly reactive metals corrode easily.
- Presence of dissolved salts: They act as electrolyte and increase the rate of corrosion.
- Presence of pollutants: They increase the rate of corrosion.
- Presence of less reactive metal: If a less reactive metal is present, it will make the more reactive metal susceptible to corrosion.

Methods to prevent corrosion:

- Rusting can be prevented by painting, oiling, and greasing of iron articles. In fact, paints and grease should be applied regularly to prevent rusting.
- Rusting can also be prevented by applying a layer of a metal such as chromium or zinc on the surface of iron articles. **The process of depositing zinc on iron is called galvanization.**
- Rusting can also be prevented by connecting the iron object with a more reactive metal like zinc with the help of a wire. **The process of connecting iron with a more reactive metal through a wire is called cathode protection.**
- Alloying can also be used to prevent rusting or corrosion.

Alloys
An alloy is a homogeneous mixture of two or more elements, at least one of which is a metal. Some common alloys are stainless steel (iron+nickel+chromium), brass (copper+zinc) and bronze (copper+tin).