Elements are classified as Metals and Non-Metals based on their physical and chemical properties. A comparative study of their physical properties is as follows:

Metals	Non-Metals
Mostly solids Except Hg Ga -30 C , Cs – 28.5 C liquids	Non- Metals are Solid and gaseous, except Br is a liquid
Metals are lustrous, that is, they have a shiny surface. Except Pb which is dull	They are not lustrous, that is, they do not have shiny surface. Except, graphite and Iodine crystal are violet or purple shiny.
They are hard and tough except sodium and potassium that can be cut with a knife. Zn is also soft.	Solid non-metals are brittle and break down into powdery mass on striking with a hammer except diamond which is the hardest non-metal.
Metals can be drawn into wires, that is they are Ductile. Ag and Au are very ductile.	They are non- ductile.
Metals are malleable, that is, they can be beaten into sheets. For eg. Aluminium foil used for packing food.	They are non- malleable.
They are good conductors of electricity and heat. Except Lead and mercury.	They are poor conductors of electricity and heat. Exception-graphite is good conductor of electricity.
They have high density and high melting point, except Sodium and Potassium which have low melting points.	They have low density compared to metals and low melting point. Diamond is an exception which has high melting point.

Chemical Properties of Metals

- Metal reacts with air or oxygen to form metal oxide.
- For example, Copper reacts with oxygen to form Copper Oxide.

$$\text{Metal} + \text{Oxygen} = \text{Metal Oxide}$$

$$2Cu + O_2 \rightarrow CuO$$

$$2Al + 3O_2 \rightarrow Al_2O_3$$

- Metals oxides can react with both acids and bases to produce salt and water. Such oxides are known as Amphoteric Oxides.

$$Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + H_2O$$

$$Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$$

- Metals can also react with water to form metal oxide. Metal oxide can again react with water to form metal hydroxide. For Example

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

$$2Zn + H_2O \rightarrow ZnO + H_2$$

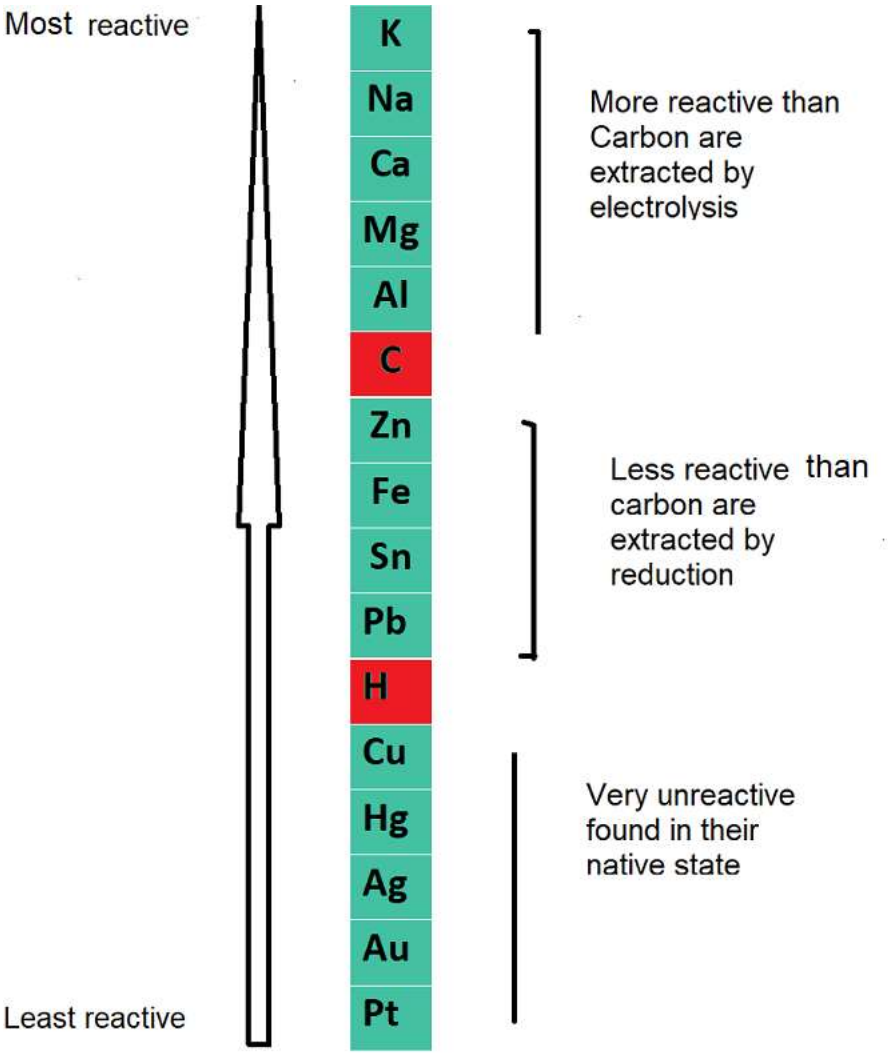
- Metals react with acids to produce hydrogen gas. For example Magnesium reacts with dilute hydrochloric acid to produce magnesium chloride and hydrogen.

$$Mg + 2HCl \rightarrow MgCl_2 + H_2$$
$$2Na + HCl \rightarrow 2NaCl + H_2$$

Reaction of metals with solutions of other metal salts

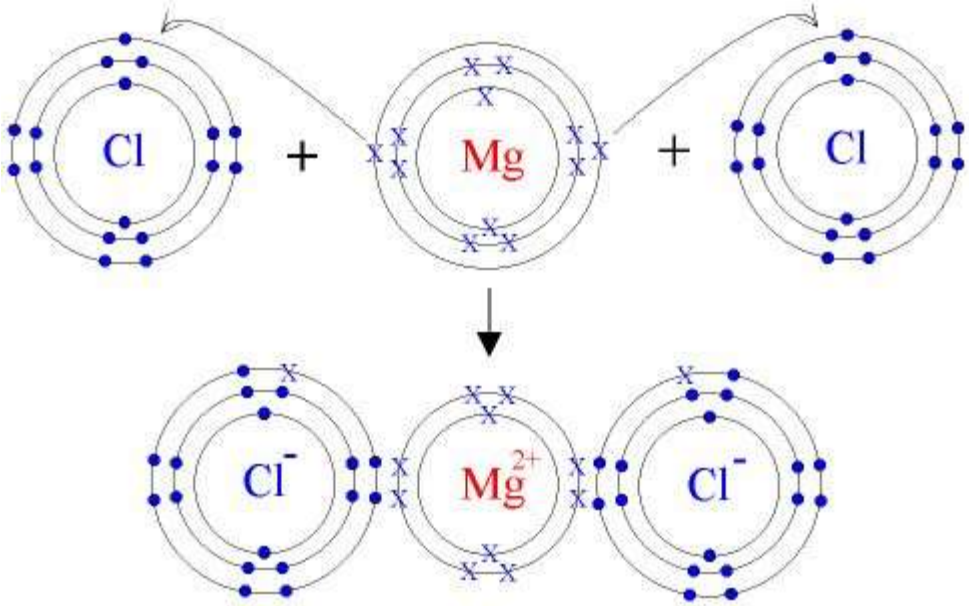
- Reactive metals have a tendency of displacing less reactive metals from solutions of their compounds. This kind of reactions are known as displacement reactions.
- The list of metals arranged in the order of their decreasing activities is known as Reactivity Series.

Reactivity Series

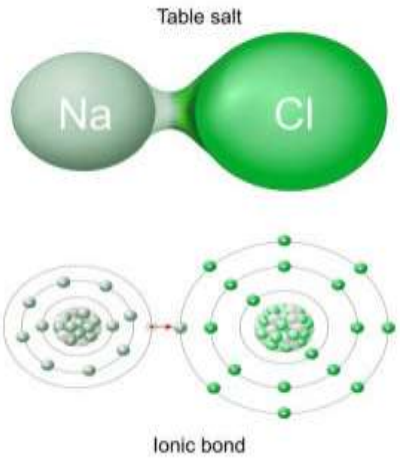


How do metals and non- metals react?

- Metal loses electron from the valence shell (valence electron) and forms a cation.
- Non- metals gain those electrons and forms an anion.
- The cation and anion get attracted to each other due to strong electrostatic force of attraction thus forming an ionic bond.
- For example, in magnesium chloride the ionic bond is formed between oppositely charged magnesium and chloride ions.



- In sodium chloride, sodium exists as the cation and chloride as anion. Therefore, it is an ionic compound.



Properties of Ionic Compounds

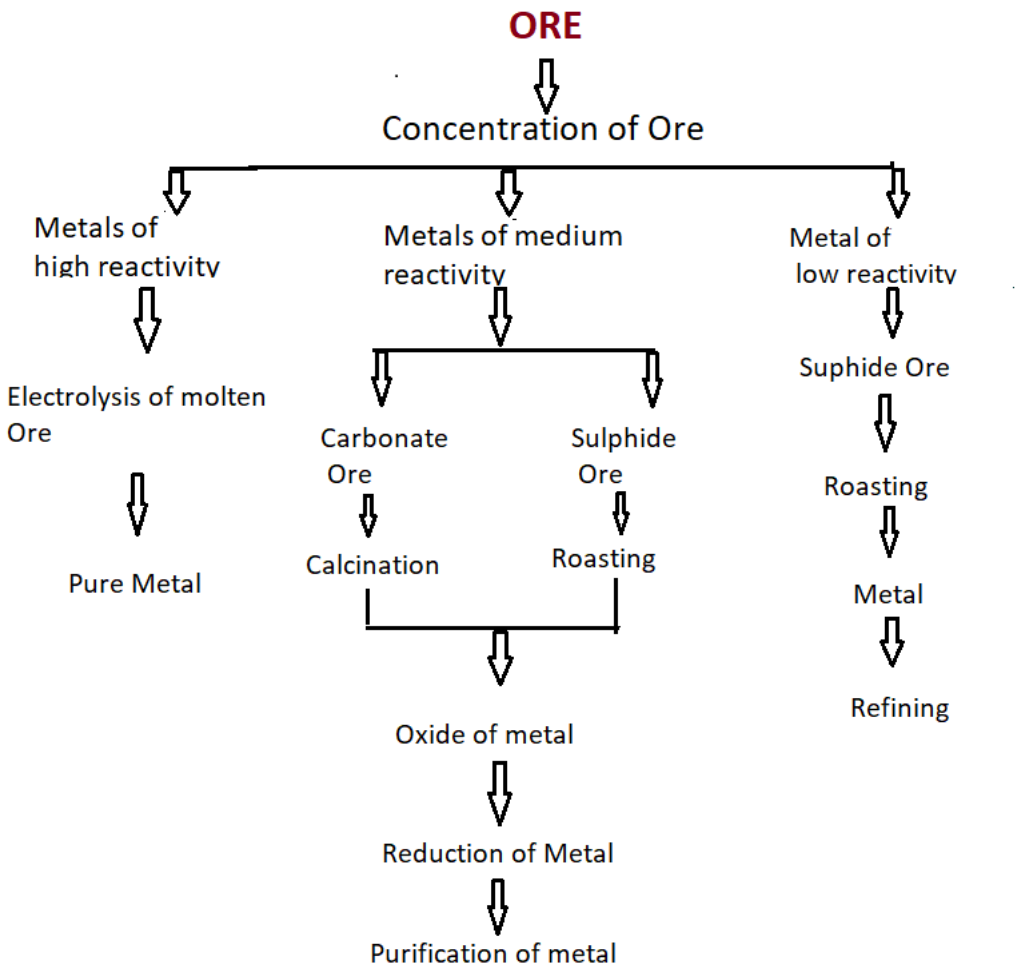
- **Physical nature:** Ionic compound are solids and are quite hard because of presence of strong force of attraction between the positive and negative ions. These are generally brittle and break into pieces when pressure is applied.
- **Melting and Boiling points:** Ionic compounds have high melting and boiling points because considerable amount of energy is required to break the strong inter-ionic association.
- **Solubility:** These are generally soluble in water and are insoluble in organic solvents like kerosene, petrol etc.
- **Conduction of electricity:** Ionic compounds conduct electricity either in the form of aqueous solution or in molten state. This is because their ions are free to move from place to place. Ionic compounds cannot conduct electricity in solid state because ions have fixed positions and movement is not possible.

Occurrence of Metals

- Some metals are found in the earth crust in their free state or as compounds.
- The metals at the top of the reactivity series (Na, K, Ca, Al, Mg) are highly reactive. Hence, they are never found in nature as free elements
- The metals in the middle (Zn, Fe, Pb etc) are moderately reactive. They are found as oxides, sulphides or carbonates.
- The metals at the bottom (Au, Ag, Pt and Co) are least reactive. Therefore, found in free state. Copper and silver are found as sulphides and oxide ores.
- Ores obtained from the earth crust are generally contaminated with large amounts of impurities like sand, soil etc, called gangue. These impurities should be removed before the extraction of metal. The processes used for this purpose are based on the differences between the physical or chemical properties of the gangue and the ore.

Extraction of a metal from its ore takes places in the following steps:

- Enrichment of the ore
- Extraction of metal
- Refining of the metal



Flowchart of extraction of metals.

Extraction of metals low in the activity series

- Metals low in the series are least reactive. The oxides of these metals can be reduced to metals by heating alone.
- For example, Cinnabar HgS

$$2HgS(s) + 3O_2(g) \rightarrow 2HgO(s) + 2SO_2(g)$$

$$2HgO(s) \rightarrow 2Hg(l) + O_2(g)$$

Extraction of metals in the middle in the activity series

- These metals are moderately reactive. These are generally present as sulphides and carbonates in nature.
- Before reduction, these sulphides and carbonates must be converted into their oxides.
- Sulphide ores are converted into oxide ore by heating strongly in the presence of excess air, this is called as Roasting.
- Carbonate ores are converted to oxide ore by heating in limited air. This is called as Calcination.

Roasting

$$ZnS(s) + 3O_2 \rightarrow 2ZnO(s) + SO_2(g)$$

Calcination

$$ZnCO_3(s) \rightarrow ZnO(s) + CO_2(g)$$

- The oxides ores are then reduced to the metal by using suitable reducing agent like Carbon. For example, when Zinc Oxide is heated with carbon, it gets reduced to metallic Zinc.

$$ZnO(s) + C(s) \rightarrow Zn(s) + CO\ (g)$$

Extraction of metals towards the top of the activity series

- The metals at the top of the series are highly reactive.
- They cannot be obtained from their compound just by heating with carbon.
- They have more affinity towards oxygen. Hence metals are obtained by electrolytic reduction.
- For example, Sodium, Calcium and Magnesium are obtained by electrolysis of their molten chlorides. The metals get deposited at the cathode, whereas, Chlorine is liberated at the anode.

At cathode $Na^+ + e^- \rightarrow Na$

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

Refining of Metals

- It is the last step in metallurgy, in which crude metal is refined by removing the impurities or gangue from the metal.
- Metals like copper, nickel, silver, gold, zinc, tin etc are refined electrolytically.
- The impure metal is made as anode and thin strip of pure metal is made as cathode.
- When electric current is passed through this, pure metal from the anode dissolves in the electrolyte and equal amount of pure metal from the electrolyte deposits on the cathode.
- The insoluble impurities settle down at the bottom of the anode and is called as anode mud.

Corrosion

- Gradual deterioration of any material generally, a metal by the action of air, moisture or chemicals present in the surroundings is known as Corrosion.
- Example:
    - silver articles turn black when exposed to air because it reacts with sulphur in the air to form a coating of silver sulphide.
    - Copper reacts with moist CO_2 in the air loses its shine and gains a green coat. This is because of basic copper carbonate.

Prevention of Corrosion

- Coating of paint or oil or grease on metal surface prevents contact with moisture or air.
- Making alloy of metals also prevents corrosion. An alloy is a homogenous mixture of two or more metals or a metal and a non- metal. When iron is mixed with chromium and nickel, we get stainless steel. It is hard and does not rust.
- Galvanisation: coating iron articles with zinc prevents corrosion.
- Electroplating: coating of one metal with another metal using electric current. This process not only prevents corrosion but also enhances the metallic appearance.