3 Metal and Non-Metal

Introduction:

Metals and non-metals are the two primary categories of elements. Metals are generally hard, have high melting points, and are good conductors of heat and electricity. Non-metals, in contrast, have varied physical properties, are poor conductors of heat and electricity.

Metals are typically found on the left side and center of the periodic table.

Non-metals are found on the right side of the periodic table.

Examples of Metals: Na, Mg, Ca, Zn, Al, Au, Ag etc.

Examples of Non-metals: C, O, N, S etc.

3.1 Physical Properties of Metals and Non-metals:

Property	Metals	Non-Metals
1. Lustre	Metals have shining surface.	They do not have shining surface. • Except Iodine.
2. Hardness	They are generally hard. • Except Sodium, Lithium and Potassium which are soft and can be easily cut with knife.	Generally soft. • Except Diamond, a form of carbon which is the hardest natural substance.
3. State	Exist as solids. • Except Mercury that exists as liquid.	Exist as solids or gases • Except Bromine that exists as liquid.
4. Malleability	Metals can be beaten into thin sheets. • Gold, Silver and Aluminium are the most malleable metals.	Non-metals are non-malleable. • They are brittle.
5. Ductility	Metals can be drawn into thin wires.	They are non-ductile.
6. Conductor of heat & electricity	Metals are good conductors of heat and electricity.	Non-metals are poor conductors of heat and electricity. • Except Graphite.
7. Density and Melting point	Generally metals have high density and high melting point. • Except Sodium and Potassium	Non metals have low density and low melting point.
8. Sonorous	Metals produce a sound on striking a hard surface.	They are not sonorous.
9. Oxides	Metallic oxides are basic in nature.	Non-metallic oxides are acidic in nature.

3.2 Chemical Properties of Metals:

a) Reaction with Oxygen: Metals react with oxygen to form metal oxides. They are in basic nature.

$$\text{Metals} + O_2 \rightarrow \text{Metal oxide}$$

Examples: (i) $2Mg + O_2 \rightarrow 2MgO$

Magnesium oxide

(i) $2Cu + O2 \rightarrow 2CuO$

Copper oxide

Amphoteric Oxides: Metal oxides which react with both acids as well as bases to produce salt and water are called amphoteric oxides.

Examples: $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + 3H_2O$

Aluminium chloride

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

Sodium aluminate

b) Reaction with Water: Some metals react with water, releasing hydrogen gas.

Metal + Water → Metal oxide + Hydrogen

Examples: Metal oxide + Water → Metal hydroxide

$$2Mg + 2H_2O \rightarrow 2MgO + 2H_2 \uparrow$$

Magnesium oxide

$$MgO + H_2O \rightarrow Mg(OH)_2$$

Magnesium hydroxide

Sodium and Potassium react vigorously with water.

Magnesium metal reacts with hot water to produce magnesium hydroxide and hydrogen gas.

Aluminium and zinc react with steam to produce metal oxide and hydrogen gas.

Metals like silver, gold, copper and lead do not react with water.

c) Reaction with Acids: Metals react with acids to produce hydrogen gas.

Example: Metal + Dil. Acid → Salt + Hydrogen gas

$$Mg + H_2SO_4 \rightarrow MgSO_4 + H_2$$

Hydrogen gas

Copper, mercury and silver don't react with dilute acids.

d) Reaction with solutions of other Metal Salts:

Metal A + Salt solution of B → Salt solution of A + Metal B

If metal A displaces metal B from its solution, it is more reactive than B.

A more reactive metal displaces a less reactive metal from its salt solution.

e) Formation of Ionic Compounds: Metals generally form cations (positive ions) by losing electrons in chemical reactions.

Example: The formation of Na? ions in sodium chloride (NaCl).

3.3 Chemical Properties of Non-metals:

a) Reaction with oxygen: Non- metals react with oxygen to form acidic oxides.

Example: $C + O_2 \rightarrow CO_2$

b) Reaction with water: Non-metals do not react with water because they do not release any electrons.

c) Reaction with dil. acids: Non-metals typically do not react with acids.

d) Reaction with salt solutions: A more reactive non-metals will displace less reactive non-metal from its salt solution.

e) Reaction with chlorine: Non-metals react with chlorine to form their respective Chlorides.

Example: $H_2 + Cl_2 \rightarrow 2HCl$

f) Reaction with hydrogen: Non-metals react with hydrogen to form their respective hydrides.

Example: $H_2 + S \rightarrow H2_S$

g) Formation of Covalent Compounds: Non-metals tend to form covalent bonds by sharing electrons, such as in H_2O (water) and CO_2 (carbon dioxide).

3.4 Reactivity or activity series of metals:

All the metals do not react with the same rate. Some react very fast, some react moderately whereas others react very slowly. The series of metals in decreasing order of reactivity is called reactivity or activity series of metals. The metals at the top (K at the top most) are most reactive whereas metals at the bottom (Pt at the extreme bottom) are least reactive.

K	Potassium	Most reactive
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
Zn	Zinc	Reactivity decreases
Fe	Iron	
Pb	Lead	
[H]	[Hydrogen]	
Cu	Copper	
Hg	Mercury	
Ag	Silver	
Au	Gold	Least reactive

3.5 Reaction between metal and non-metals:

Reactivity of an element is the tendency to attain completely filled valence shells. Atoms of metals can lose electrons from valence shells to form cations while atoms of non-metals can gain electrons in valence shell to form anions. Opposite charged ions attract each other and held by strong electrostatic forces of attraction.

Let us understand formation of NaCl with the help of an example:

Step1: Atomic number of sodium (Na) is 1. Atoms in last shell are 1.

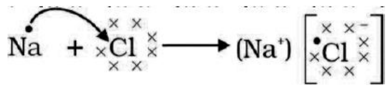
Step2: Atomic number of chlorine (Cl) is 17. Atoms in last shell are 7.

Step3: So, Na gives 1 atom to chlorine

Step4: This is complete transfer of electrons. So, it is ionic compound.

$$\underset{2,8,1}{Na} \rightarrow \underset{2,8}{Na^+} + e^-$$
(Sodium cation)

$$\underset{2,8,7}{Cl} + e^- \rightarrow \underset{2,8,8}{Cl^-}$$
(Chloride anion)



3.6 Ionic Compounds:

The compounds formed by the transfer of electrons from a metal to a non-metal are called ionic compounds or electrovalent compounds. Ex: NaCl, KOH, CaCl2 etc.

Properties of Ionic Compounds:

(i) Physical nature: They are solid and hard, generally brittle.

(ii) Melting and Boiling Point: They have high melting and boiling points.

(iii) Solubility: Generally soluble in water and insoluble in solvents such as kerosene, petrol, etc.

(iv) Conduction of electricity: Ionic compounds conduct electricity in molten and solution form but not in solid state.

3.7 Occurrence of metals:

The earth's crust is the major source of metals.

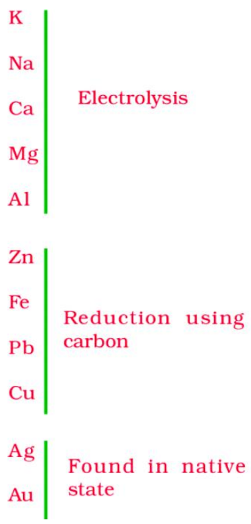
Metallurgy: The extraction of metals from their ores and then refining them for use is known as metallurgy.

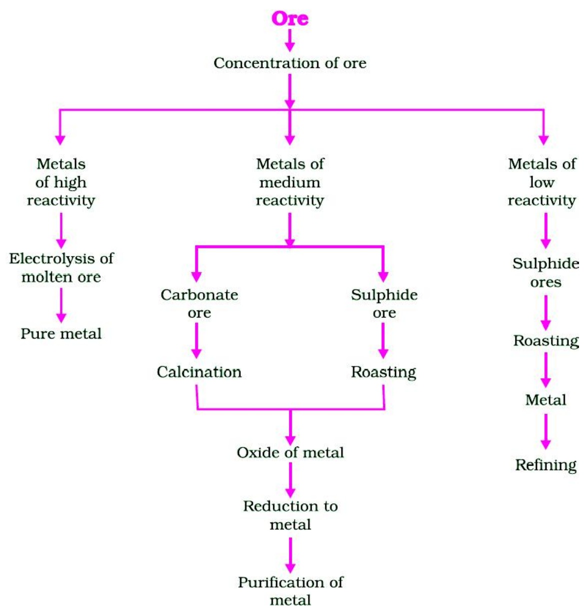
Minerals: The elements or compounds which occur naturally in the earth's crust are called minerals.

Ores: Minerals that contain very high percentage of particular metal and the metal can be profitably extracted from it, such minerals are called ores.

Gangue: Ores mined from the earth are usually contaminated with large amounts of impurities called gangue.

(a) Extraction of metals: Group the metals into 3





categories.

i) Metals of low reactivity ii) Metals of medium reactivity iii) Metals of high reactivity

(b) Enrichment of ores: The processes used for removing the gangue from the ore are based on the differences between the physical or chemical properties of the gangue and the ore.

(c) Extracting metals low in the activity series: Metals low in the activity series are very unreactive. The oxides of these metals can be reduced to metals by heating alone.

(d) Extracting metals in the middle of the activity series: The metals in the middle of the activity series such as iron, zinc, lead, copper, are moderately reactive. These are usually present as sulphides or carbonates in nature.

(e) Extracting metals towards the top of the activity series: The metals high up in the reactivity series are very reactive. These metals are obtained by electrolytic reduction.

(f) Refining of metals: The most widely used method for refining impure metals is electrolytic refining.

3.8 Correction:

The surface of some metals, such as iron, is corroded when they are exposed to moist air for a long period of time. This phenomenon is known as corrosion

Example: i) Silver reacts with sulphur in air to form silver sulphide and articles become black.

ii) Copper reacts with moist carbon dioxide in air and forms green coat of copper carbonate.

iii) Iron acquires a coating of brown flaky substance called rust.

Prevention of corrosion: By painting, oiling, greasing, galvanizing and by making alloys.

Galvanization: It is the process which involves coating of iron with zinc. The oxide thus formed is impervious to air and moisture thus protects further layers from getting corroded.

3.9 Alloys:

These are homogeneous mixture of metals with metals and non-metals. For example,

Stainless steel: Alloy of iron, nickel, chromium

Brass: Alloy of copper and zinc

Bronze: Alloy of copper and tin

Solder: Alloy of lead and tin

Amalgam: If one of the metals is mercury, then the alloy is known as amalgam. E.g, Sodium amalgam and silver amalgam.