Chapter-3 Metals and Non-Metals

Notes:

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.

Chemical Properties of Metals:

(A) Reaction of Metals with Air:
Metals combine with oxygen to form metal oxide.
Metals + O2 → Metal oxide

Examples:

(i) $2Cu + O_2 \rightarrow 2CuO$
Copper (II) oxide (black)

(ii) $4Al + 3O_2 \rightarrow 2Al_2O_3$
Aluminium oxide

(iii) $2Mg + O_2 \rightarrow 2MgO$
Magnesium oxide

Different metals show different reactivity towards O2 .

- Na and K react so vigorously with oxygen that they catch fire if kept in open. So, they are kept immersed in kerosene.
- Surfaces of Mg, Al, Zn and Pb are covered with a thin layer of oxide which prevent them from further oxidation. λ Fe does not burn on heating but iron fillings burn vigorously.
- Cu does not burn but is coated with black copper (II) oxide.
- Au and Ag do not react with oxygen.

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 of Metals with Water:

Metals react with water to produce metal hydroxide and 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.

Mg + 2H2 O → Mg (OH)2 + H2

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

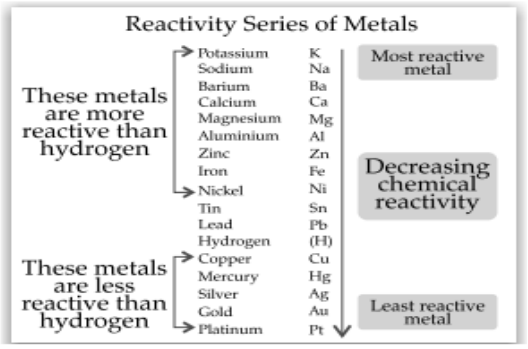
Metals like silver, gold, copper and lead do not react with water.

(C) Reactions of Metals with Acid:
Metal + Dil. Acid → Salt + Hydrogen gas
e.g., Mg + H2 SO4 → MgSO4 + H2
Copper, mercury and silver don't react with dilute acids.

(D) Reaction of Metals with solutions of other Metal Salts:
Metal A + Salt solution B → Salt solution A + Metal B
Reactive metals can displace less reactive metals from their compounds in solution form.
Fe + CuSO4 → FeSO4 + Cu

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.



Reaction of Non-Metals:

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

e.g., $C + O_2 \rightarrow CO_2$

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

Reaction with dil. acids: No reaction.

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

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

e.g., $H_2 + Cl_2 \rightarrow 2HCl$

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

e.g., $H_2 + S \rightarrow H_2S$

Aqua Regia is a mixture of conc. HCl and conc. HNO3 in the ratio of 3: 1. It can dissolve gold and platinum. Aqua Regia is a strong oxidizing agent due to the formation of NaCl (Nitrosyl chloride) and chlorine produced by reaction of two acids.

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.

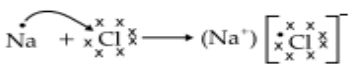
Let us understand formation of NaCl with the help of an example:

Example

Formation of ionic compound NaCl.
Step 1: Atomic number of sodium (Na) is 1. Atoms in last shell are 1.
Step 2: Atomic number of chlorine (Cl) is 17. Atoms in last shell are 7.
Step 3: So, Na gives 1 atom to chlorine.
Step 4: This is complete transfer of electrons. So, it is ionic compound.

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

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



Ionic Compounds:

The compounds formed by the transfer of electrons from a metal to a non-metal are called ionic compounds or electrovalent compounds.

Properties of Ionic Compounds:

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

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

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

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

Occurrence of Metals

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.

Metals on the basis of reactivity, can be grouped into three categories:

Metals at the bottom of the activity series are least reactive and are often found in free state. For e.g., Gold, silver, platinum and copper.

These metals are very unreactive. The oxides of these metals can be reduced to metals by heating alone. For example, cinnabar (HgS) (an ore of mercury). When it is heated in air, it is first converted into mercuric oxide which is further reduced to mercury on heating.

$2HgS(s) + 3O2\ (g)\ \Delta \rightarrow 2HgO(s) + 2SO2\ (g)$

$2HgO(s)\ \Delta \rightarrow 2Hg(l) + O2\ (g)$

Metals at the top of the activity series are so reactive that they are not found in nature as free state. e.g., K, Na, Ca, Mg and Al.

Metals in the middle of the activity series are moderately reactive. They are found in the earth's crust as oxides, sulphides and carbonates. e.g., Zn, Fe, Pb, etc.

The highly reactive metals are used as reducing agents because they can displace metals of lower reactivity from their compounds

For example:

$3MnO2\ (s) + 4Al(s) \rightarrow 3Mn(l) + 2Al2\ O3\ (s) + Heat$

Thermit reaction: $Fe2\ O3\ (s) + 2Al(s) \rightarrow 2Fe(l) + Al2\ O3\ (s) + Heat$

The amount of heat evolved is so large that the metals are produced in the molten state. This reaction is used to join railway tracks or cracked machine parts.

Extraction of metals:

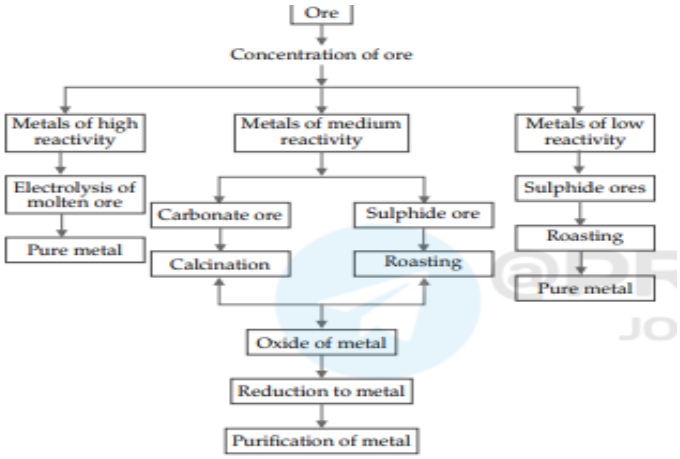
It is the process of obtaining pure metal from its ore.

Extraction of metal can be classified into three steps:

(1) Enrichment of ores or concentration of ores.

(2) Extraction of metal from the concentrated ores.

(3) Refining of metal



Steps involved in extraction of metals from ores are as follows:

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

Corrosion: It is the deterioration of a metal as a result of chemical reactions between it and surrounding environment. For example,

Silver reacts with sulphur in air to form silver sulphide and articles become black.

Copper reacts with moist carbon dioxide in air and forms green coat of copper carbonate. l Iron acquires a coating of brown flaky substance called rust.

Rust is hydrated Iron (III) oxide, i.e., Fe2 O3. xH2O

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.

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.