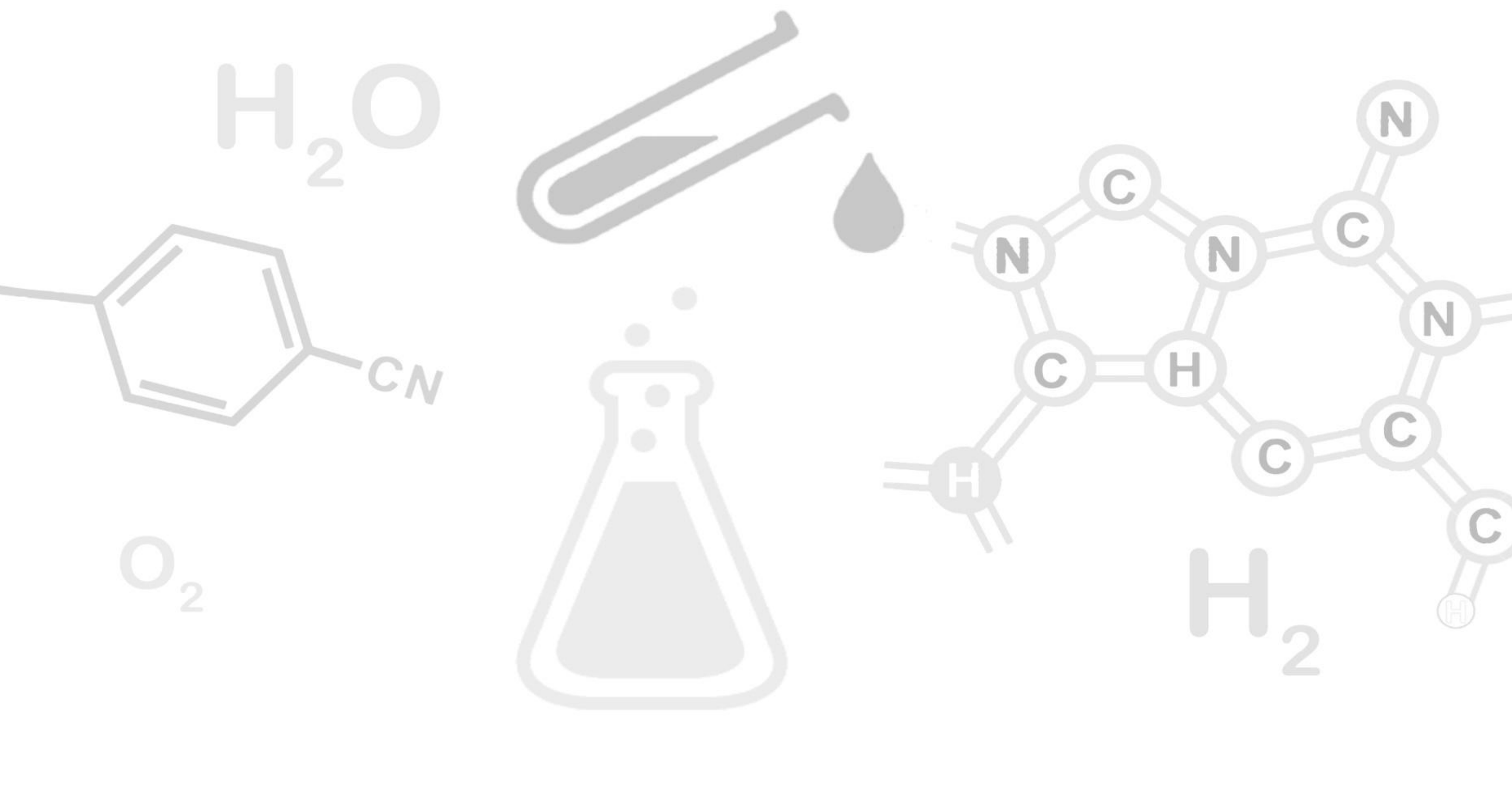
TOPPER LEARNING
Get More Marks

Revision Notes

CHEMISTRY



Metals & Non-Metals

Introduction

- At present there are 115 known elements.
- There are similarities as well as differences in the properties of these elements.
- On the basis of their properties, elements can be divided into metals and non-metals.

Physical Properties of Metals

Physical State

- All metals are solids at room temperature.
- Exceptions: Mercury and gallium are liquids at room temperature.

Lustre

- All metals in their pure state have a shine and can be polished to give a highly reflective surface.

Malleability

- Metals have the ability to withstand high tensile strength and can be made into thin sheets. This property of metals is called malleability.

Ductility

- Metals can also be drawn into thin wires. The ability of metals to be drawn into wires is called ductility.
  Example: Gold and silver are the most ductile metals.

Conduction of Heat

- Metals are good conductors of heat and have high melting points.
  Example: Silver and copper are very good conductors of electricity.
- Exceptions: Lead and mercury are poor conductors of heat.

Conduction of Electricity

- Metals are good conductors of electricity.
- All electric wires are made of copper.

Hardness

- Metals are generally hard, and their hardness varies from metal to metal.
- Alkali metals such as sodium and potassium are soft metals and can be easily cut with a knife.

Melting & Boiling Points

- Metals usually have high melting and boiling points.
- Tungsten has the highest melting point whereas sodium and potassium have low melting points.

Sonorous

- Metals which produce a sound on striking a hard surface are said to be sonorous.

Physical Properties of Non-Metals

- Non-metals are either in the solid or gaseous state.
  Exception: Bromine is an exception which exists in the liquid state.
- Non-metals do not have lustre.
  Exception: Iodine crystals are lustrous.
- They do not possess the property of hardness.
  Exception: Carbon in the form of diamond is the hardest substance, which has a high melting and boiling point.
- Non-metals are poor conductors of heat and electricity.
  Exception: Graphite, an allotrope of carbon conducts electricity.

Chemical Properties of Metals

Reaction of Metals with Oxygen

Almost all metals react with oxygen to form metal oxides.

i. Sodium and potassium are the most reactive and react with oxygen present in the air at room temperature to form the oxides.
   $4Na + O_2 \rightarrow 2Na_2O$
   $4K + O_2 \rightarrow 2K_2O$

ii. Magnesium does not react with oxygen at room temperature, but on heating, it burns in the air with intense light and heat to form magnesium oxide.
   $2Mg + O_2 \rightarrow 2MgO$

Reaction of Metals with Water

Metals react with water to produce metal oxides with the release of hydrogen gas. But all metals do not react with water.

i. Metals such as sodium and potassium react vigorously with cold water to lead to evolution of hydrogen, which immediately catches fire producing a large quantity of heat.
   $2K + 2H_2O \rightarrow 2KOH + H_2 + \text{Heat}$
   $2Na + 2H_2O \rightarrow 2NaOH + H_2 + \text{Heat}$

ii. Metals such as aluminium, zinc and iron do not react with cold or hot water, but they react with steam to form metal oxides and hydrogen.
   $2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2$
   $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

Reactions of Metals with Acids

Metals react with acids to form salt and hydrogen gas.

i. Metals react with dilute hydrochloric acid to give metal chloride and hydrogen gas.

$Mg + 2HCl \rightarrow MgCl_2 + H_2$

$Zn + 2HCl \rightarrow ZnCl_2 + H_2$

ii. Metals react with sulphuric acid to form metal sulphate and hydrogen gas.

$Fe + H_2SO_4 \rightarrow FeSO_4 + H_2$

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

iii. Metals react with nitric acid, but hydrogen gas is not evolved since nitric acid is a strong oxidising agent. So, it oxidises the hydrogen to water and itself gets reduced to a nitrogen oxide.

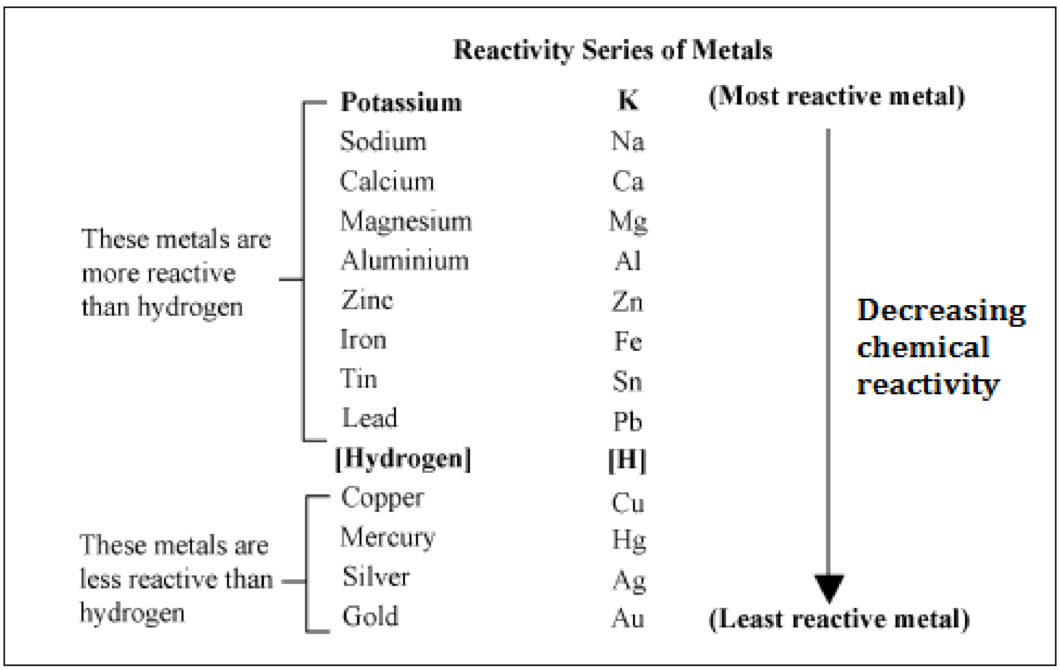
But magnesium and manganese react with dilute nitric acid to evolve hydrogen gas.

$Mg + 2HNO_3 \rightarrow Mg\ (NO_3)_2 + H_2$

$Mn + 6HNO_3 \rightarrow Mn\ (NO_3)_2 + H_2$

Reactivity Series

The arrangement of metals in the order of decreasing reactivities is called the reactivity series of metals.



Reactions of Metals with Solutions of Other Metal Salts

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

For example:

When an iron nail is placed in a copper sulphate solution, the blue colour of $CuSO_4$ fades away slowly and a reddish brown copper metal is formed.

$CuSO_{4(aq)} + Fe_{(s)} \rightarrow FeSO_{4(aq)} + Cu(s)$

Reaction of Metals with Chlorine

Metals react with chlorine to form metal chlorides.

For example:

i. Sodium readily reacts with chlorine to form ionic chloride called sodium chloride.

$$2Na_{(s)} + Cl_{2(g)} \rightarrow 2NaCl_{(s)}$$

ii. Calcium reacts vigorously with chlorine to form calcium chloride.

$$Ca_{(s)} + Cl_{2(g)} \rightarrow 2CaCl_{2(s)}$$

Properties of Ionic Compounds

- Ionic compounds are hard solids, due to the strong force of attraction between the positive and negative ions.
- They are generally brittle and break into pieces when pressure is applied.
- Ionic compounds have high melting and boiling points, since a large amount of energy is required to break the strong intermolecular attractions.
- They are soluble in water, but insoluble in solvents such as kerosene, petrol, etc.
- They do not conduct electricity in a solid state, because electrostatic forces of attraction between ions in the solid state are very strong but conduct electricity in the fused (or in the aqueous state) because these forces weaken in the fused (or in solution) state so that their ions become mobile.

Metallurgy

Minerals: The naturally occurring compounds of metals, along with other impurities are known as minerals.

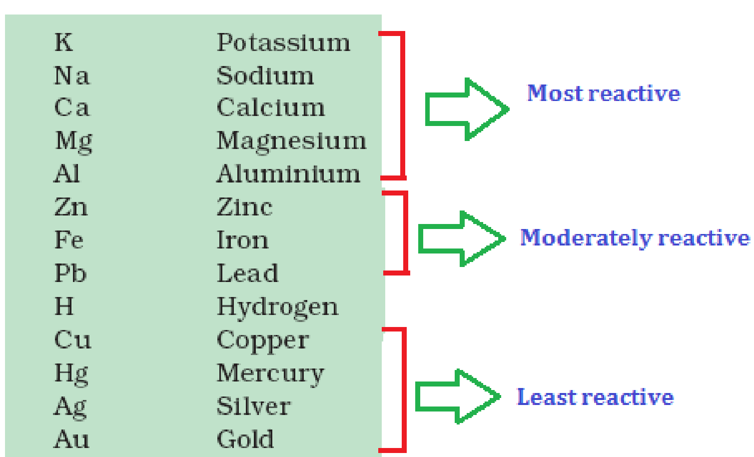
Ores: The minerals from which metals are extracted profitably and conveniently are called ores.

Gangue: Earthly impurities including silica, mud, etc. associated with the ore are called gangue.

Metallurgy: The process used for the extraction of metals in their pure form from their ores is referred to as metallurgy.

Extraction of Metals

- The reactivity of elements differs for different metals.



- Three major steps involved in the extraction of metals from their ores are:

Enrichment of Ores

- The ores of metals are usually contaminated with a large amount of impurities such as sand, soil, etc. called gangue.
- Before extracting the metal from an ore, it is necessary to remove these impurities.
- The method used for removing gangue from the ore depends on the differences between the physical and chemical properties of the gangue and the ore.

Conversion of Concentrated Ore into Metal

- The extraction of a metal from its concentrated ore is essentially a process of reduction of the metal compound present in the ore.
- The method of reduction to be used depends on the reactivity of the metal to be extracted.

Metal		Method of extraction
K	Potassium	Electrolysis of molten chloride or oxide
Na	Sodium	
Ca	Calcium	
Mg	Magnesium	
Al	Aluminium	
Zn	Zinc	Reduction of oxide with carbon
Fe	Iron	
Pb	Lead	
Cu	Copper	
Cu	Copper	Heating sulphide in air (Reduction by heat alone)
Hg	Mercury	
Ag	Silver	Found in native state(as metals)
Au	Gold	

- **Extraction of Less Reactive Metals**
  Metals at the bottom of the reactivity series are not very reactive and the oxides of these metals can be reduced by heating the ore itself.
  Extraction of Mercury
  Cinnabar, an ore of mercury is first heated in the air and is converted into mercuric oxide.

  $$2HgS_{(s)} + 3O_{2(g)} \xrightarrow{Heat} 2HgO_{(s)} + 2SO_{2(g)}$$

  Mercuric oxide is then reduced to mercury on further heating.

  $$2HgO_{(s)} \xrightarrow{Heat} 2Hg_{(s)} + O_{2(g)}$$

- **Extraction of Moderately Reactive Metals**
  - The moderately reactive metals in the middle of the reactivity series are extracted by the reduction of their oxides with carbon, aluminium, sodium or calcium.
  - It is easier to obtain metals from their oxides (by reduction) than from carbonates or sulphides. So, before reduction can be done, the ore is converted into a metal oxide.
  - The concentrated ores can be converted into metal oxides by the process of calcination or roasting.

Calcination is the process in which a carbonate ore is heated strongly in the absence of air to convert it into a metal oxide.

For example:

When zinc carbonate is heated strongly in the absence of air, it decomposes to form zinc oxide and carbon dioxide.

$ZnCO_{3(s)} \xrightarrow{\text{Calcination}} ZnO_{(s)} + CO_{2(g)}$

Roasting is the process in which a sulphide ore is strongly heated in the presence of air to convert it into a metal oxide.

$2ZnS_{(s)} + 3O_{2(g)} \xrightarrow{\text{Roasting}} 2ZnO_{(s)} + 2SO_{2(g)}$

The metal oxides are converted to free metal by using reducing agents such as carbon, aluminium, sodium or calcium.

For example:

- The metal zinc is extracted by the reduction of zinc oxide with carbon. Thus, when zinc oxide is heated with carbon, zinc is produced.
  $ZnO_{(s)} + C_{(s)} \rightarrow Zn_{(s)} + CO_{(g)}$
- Aluminium reduces iron oxide to produce the metal iron with the evolution of heat. Due to this heat, the iron is produced in the molten state.
  $Fe_2O_{3(s)} + 2Al_{(s)} \rightarrow 2Fe_{(l)} + Al_2O_{3(s)} + \text{Heat}$
  The reaction of iron (III) oxide with aluminium is used to join railway tracks or cracked machine parts. This reaction is known as the thermite reaction.

- **Extraction of Highly Reactive Metals**

  Metals high up in the reactivity series are very reactive.

  These metals have a strong affinity for oxygen. So, oxides of sodium, magnesium, calcium and aluminium cannot be reduced by carbon.

  These metals are obtained by electrolytic reduction.

  Sodium, magnesium and calcium are obtained by the electrolysis of their molten chlorides.

  For example:

  Sodium metal is extracted by the electrolytic reduction of molten sodium chloride.

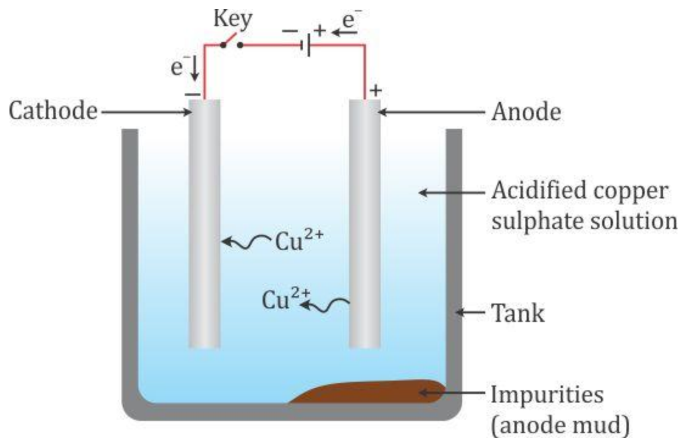
  $2NaCl_{(l)} \xrightarrow{\text{Electrolysis}} 2Na_{(s)} + Cl_{2(g)}$

  At Cathode: $Na^{+} + e^{-} \rightarrow Na$

  At Anode: $2Cl^{-} \rightarrow Cl_2 + 2e^{-}$

Refining of Metals

- The most widely used method for refining impure metals is electrolytic refining.
- Electrolytic refining means refining by electrolysis. Metals such as copper, zinc, tin, lead, chromium, nickel, silver and gold are refined electrolytically.
- For refining an impure metal by electrolysis:
  - A thick block of impure metal is made the anode.
  - A thin strip of pure metal is taken as the cathode.
  - A water soluble salt is taken as the electrolyte.
  - On passing current through the electrolyte, the impure metal from the anode dissolves into the electrolyte.
  - An equivalent amount of pure metal from the electrolyte is deposited on the cathode.
  - The soluble impurities go into the solution, whereas the insoluble impurities settle down at the bottom of the anode and are known as the ‘anode mud’.



Corrosion

- When the surface of a metal is attacked by air, moisture or any other substance around it, the metal is said to corrode and the phenomenon is known as corrosion.
- Copper forms a green deposit on its surface when exposed to moist air. This green substance is nothing but copper carbonate.
- Iron reacts with moist air to acquire a coating of brown flaky substance called rust which is hydrated iron (III) oxide ($Fe_2O_3.xH_2O$).
- Conditions necessary for rusting of iron
  i. Presence of air (or oxygen)
  ii. Presence of water (or moisture)

Prevention of Corrosion

Corrosion of metals can be prevented if the contact between the metal and air is cut off.

This can be done by the following methods:

i. **Galvanising**: It is the process of giving coating a thin layer of zinc on iron or steel to protect them from corrosion. Example: shiny nails, pins. etc.

ii. **Tinning:** It is a process of coating tin over other metals.

iii. **Electroplating:** In this method, a metal is coated with another metal using electrolysis. Example: silver plated spoons, gold plated jewellery etc.

iv. **Alloying:** An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal in a definite proportion. The resultant metals, called alloys do not corrode easily.

For example:
- Brass (copper and zinc)
- Bronze (copper and tin)
- Stainless steel (iron, nickel, chromium and carbon)