METALS AND NON-METALS

- **On the basis of their properties, all the elements can be divided into two main groups: metals and non-metals.**

- **Malleable means which can be beaten with a hammer to form thin sheets(without breaking).**

- **Ductile means which can be stretched (or drawn) to form thin wires.**

- **Brittle means which breaks into pieces on hammering or stretching.**

- **Metals are the elements that conduct heat and electricity, and are malleable and ductile.**
- **Some of the examples of metals are : Iron, Aluminium, Copper, Silver, Gold, Platinum, Zinc, Tin, Lead, Mercury,Sodium, Potassium, Calcium and Magnesium.**

- **Metals are the elements (except hydrogen) which form positive ions by losing electrons (or donating electrons).**
- **metals are known as electropositive elements because they can form positive ions by losing electrons.**
- **The most abundant metal in the earth's crust is aluminium,**

- **Non-metals are the elements that do not conduct heat and electricity, and are neither malleable nor ductile. They are brittle in nature.**
- **Some of the examples of non-metals are : Carbon, Sulphur, Phosphorus, Silicon,Hydrogen, Oxygen, Nitrogen, Chlorine, Bromine, Iodine, Helium, Neon and Argon diamond and graphite, are also non-metals.**

- **Non-metals are the elements which form negative ions by gaining electrons (or accepting electrons).**
- **Non-metals are known as electronegative elements because they can form negative ions by gaining electrons.**
- **Though non-metals are small in number as compared to metals, but they play a very important role in our daily life. Like carbon, oxygen, Nitrogen, Sulphur.**
- **The most abundant non-metal in the earth's crust is oxygen**
- **The properties of non-metals are opposite to those of metals**

- **Malleability is an important characteristic property of metals. Gold and silver metals are some of the best malleable metals.**
- **Aluminium foils are used for packing food items like biscuits, chocolates, medicines, cigarettes.**

- **Ductility is another important characteristic property of metals. Gold is the most ductile metal.**
- **Copper and aluminium metals are also very ductile and can be drawn into thin copper wires and aluminium wires (which are used as electric wires).**
- **Metals allow heat to pass through them easily. Silver metal is the best conductor of heat.**
- **The cooking utensils and water boilers, etc., are usually made of copper or aluminium metals because they are very good conductors of heat.**
- **Heat conductivity (or thermal conductivity) is a characteristic property of metals.**
- **Metals allow electricity (or electric current) to pass through them easily. Silver metal is the best conductor of electricity.**
- **The electric wires are made of copper and aluminium metals because they are very good conductors of electricity.**
- **Electrical conductivity is another characteristic property of metals.**
- **Metals are good conductors of heat and electricity.**
- **Metal have a shining surface that is called lustrous property of metals.**
- **The metals lose their shine or brightness on keeping in air for a long time and acquire a dull appearance due to the formation of a thin layer of oxide, carbonate or sulphide on their surface (by the slow action of the various gases present in air).**
- **Sodium and potassium are soft metals which can be easily cut with a knife.**
- **Metal can hold large weights without snapping (without breaking).**
- **Sonorous is the property of metal because of ringing sound of it.**
- **It is due to the property ofsonorousness (or sonority) that metals are used for making bells, and strings (wires) of musical instruments like violin.**

.

- ❖ **The physical properties of non-metals are just the opposite of the physical properties of metals.**
- ❖ **Solid non-metals can neither be hammered into thin sheets nor drawn into thin wires.**
- ❖ **The property of being brittle (breaking easily) is called brittleness.**
- ❖ **Brittleness is a characteristic property of non-metals.**
- ❖ **Carbon (in the form of graphite) is the only non-metal which is a good conductor of electricity.**
- ❖ **Non-metals do not have a shining surface.**
- ❖ **The solid non-metals have a dull appearance.**
- ❖ **Iodine is a non-metal having lustrous appearance.**
- ❖ **Only one non-metal carbon (in the form of diamond) is very hard.**

1. Electrical Conductivity.

Carbon (in the form of graphite) is a non-metal which conducts electricity.

2. Lustre.

Iodine is a non-metal which is lustrous, having a shining surface

3. Hardness and Softness.

Alkali metals (lithium, sodium and potassium) are soft

Carbon (in the form of diamond) is a non-metal which is extremely hard

4. Physical State.

Mercury metal is a liquid at room temperature.

5. Melting Points and Boiling Points.

Sodium, potassium, cesium and gallium metals have low melting points (just like non-metals). Diamond is a non-metal which has a very high melting point and boiling point

- **we cannot classify the elements as metals or non-metals clearly on the basis of their physical properties alone because there are many exceptions.**

Metals and non-metals show different chemical properties.

METALS

1. Reaction of Metals with Oxygen (of Air)

Metal + Oxygen ----------→ Metal oxide

- **metals react with oxygen to form metal oxides. Metal oxides are basic in nature. Metal oxides, being basic, turn red litmus solution blue.**
- **The vigour of reaction with oxygen depends on the chemical reactivity of metal.**

$$\underset{\text{Sodium (Metal)}}{4Na\,(s)} + \underset{\text{Oxygen (From air)}}{O_2\,(g)} \longrightarrow \underset{\text{Sodium oxide (Basic oxide)}}{2Na_2O\,(s)}$$

- **potassium metal and sodium metal are stored under kerosene oil to prevent their reaction with the oxygen, moisture and carbon dioxide of air (so as to protect them).**

- **Most of the metal oxides are insoluble in water. But some of the metal oxides dissolve in water to form alkalis.**

$$\underset{\text{Sodium oxide (Basic oxide)}}{Na_2O\,(s)} + \underset{\text{Water}}{H_2O\,(l)} \longrightarrow \underset{\text{Sodium hydroxide (An alkali)}}{2NaOH\,(aq)}$$

- **Those metal oxides which show basic as well as acidic behaviour are known as amphoteric oxides. aluminium oxide and zinc oxide are amphoteric in nature .**
- **Amphoteric oxides react with both, acids as well as bases to form salts and water.**

- **Reaction of aluminium to form oxide.**

$$\underset{\text{Aluminium (Metal)}}{4Al\ (s)} + \underset{\text{Oxygen (From air)}}{3O_2\ (g)} \longrightarrow \underset{\text{Aluminium oxide (Amphoteric oxide)}}{2Al_2O_3\ (s)}$$

- **In this reaction, aluminium oxide behaves as a basic oxide**

$$\underset{\text{Aluminium oxide}}{Al_2O_3\ (s)} + \underset{\text{Hydrochloric acid (Acid)}}{6HCl\ (aq)} \longrightarrow \underset{\text{Aluminium chloride (Salt)}}{2AlCl_3\ (aq)} + \underset{\text{Water}}{3H_2O\ (l)}$$

- **In this reaction, aluminium oxide behaves as an acidic oxide**

$$\underset{\text{Aluminium oxide}}{Al_2O_3\ (s)} + \underset{\text{Sodium hydroxide (Base)}}{2NaOH\ (aq)} \longrightarrow \underset{\text{Sodium aluminate (Salt)}}{2NaAlO_2\ (aq)} + \underset{\text{Water}}{H_2O\ (l)}$$

- **Similarly Zinc metal reacts with oxygen to form zinc oxide.**
- **zinc oxide behaves as a basic oxide.**
- **zinc oxide behaves as an acidic oxide**

2. Reaction of Metals with Water

Metals react with water to form a metal hydroxide (or metal oxide) and hydrogen gas.

- **metal + water ----------→ metal hydroxide + hydrogen gas**

- **Metal + steam ----------→ Metal oxide + Hydrogen gas**

$$\underset{\text{Potassium}}{2K\ (s)} + \underset{\text{Water (Cold)}}{2H_2O\ (l)} \longrightarrow \underset{\text{Potassium hydroxide}}{2KOH\ (aq)} + \underset{\text{Hydrogen}}{H_2\ (g)} + \text{Heat}$$

$$\underset{\text{Magnesium}}{Mg\ (s)} + \underset{\text{Water (Hot)}}{2H_2O\ (l)} \longrightarrow \underset{\text{Magnesium hydroxide}}{Mg(OH)_2\ (aq)} + \underset{\text{Hydrogen}}{H_2\ (g)}$$

- **Metals like aluminium, zinc and iron do not react with either cold water or hot water. They reactwith steam to form a metal oxide and hydrogen.**

$$\underset{\text{Aluminium}}{2Al\ (s)} + \underset{\text{Steam}}{3H_2O\ (g)} \longrightarrow \underset{\text{Aluminium oxide}}{Al_2O_3\ (s)} + \underset{\text{Hydrogen}}{3H_2\ (g)}$$

$$\underset{\text{Zinc}}{Zn\ (s)} + \underset{\text{Steam}}{H_2O\ (g)} \longrightarrow \underset{\text{Zinc oxide}}{ZnO\ (s)} + \underset{\text{Hydrogen}}{H_2\ (g)}$$

$$\underset{\text{Iron}}{3Fe\ (s)} + \underset{\text{Steam}}{4H_2O\ (g)} \longrightarrow \underset{\text{Iron (II, III) oxide}}{Fe_3O_4\ (s)} + \underset{\text{Hydrogen}}{4H_2\ (g)}$$

- **Metals like lead, copper, silver and gold do not react with water (or even steam).**
- **We will now explain how metals displace hydrogen from water. only those metals displace hydrogen from water (or steam) which are above hydrogen in the reactivity series.**

3. Reaction of Metals with Dilute Acids

- **Metals usually displace hydrogen from dilute acids.**
- **Metal + Dilute acid ----------→ Metal salt + Hydrogen**
- **Metals react with dilute hydrochloric acid to give metal chlorides and hydrogen gas.**

$$\underset{\text{Sodium}}{2Na\ (s)} + \underset{\text{Hydrochloric acid}}{2HCl\ (aq)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl\ (aq)} + \underset{\text{Hydrogen}}{H_2\ (g)}$$

- **Copper, Silver and gold metals also do not react with dilute acids.**

$$\underset{\text{Copper}}{Cu\ (s)} + \underset{\text{Hydrochloric acid (Dilute)}}{HCl\ (aq)} \longrightarrow \text{No reaction}$$

- **The metals like copper and silver which are less reactive than hydrogen, do not displace hydrogen from dilute acids. all the metals which are above hydrogen in the activity series, displace hydrogen from dilute acids**

- **Aqua-regia is a freshly prepared mixture of 1 part of concentrated nitric acid and 3 parts of concentrated hydrochloric acid.**
- **Aqua-regia can dissolve all metals.**
- **aqua-regia can dissolve even gold and platinum metals**

- **The arrangement of metals in a vertical column in the order of decreasing reactivities is called reactivity series of metals (or activity series of metals).**
- **the metals which are more reactive than hydrogen are: Potassium, Sodium, Calcium, Magnesium, Aluminium, Zinc, Iron, Tin and Lead.**
- **the metals which are less reactive than hydrogen are: Copper, Mercury, Silver and Gold.**
- **We should remember the reactivity series of metals to decide whether a particular displacement reaction will take place or not.**

4. Reaction of Metals with Salt Solutions

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

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

- **The Reaction of Zinc with Copper Sulphate Solution.**

$$\underset{\text{Copper sulphate (Blue solution)}}{CuSO_4\,(aq)} + \underset{\text{Zinc (Silvery-white)}}{Zn\,(s)} \longrightarrow \underset{\text{Zinc sulphate (Colourless solution)}}{ZnSO_4\,(aq)} + \underset{\text{Copper (Red-brown)}}{Cu\,(s)}$$

- **Reaction of Iron with Copper Sulphate Solution.**

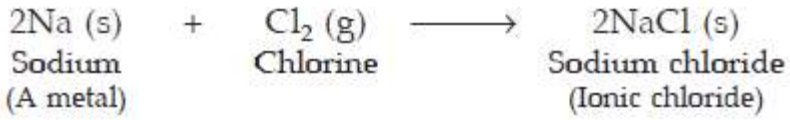
$$\underset{\text{Copper (II) sulphate (Blue solution)}}{CuSO_4\,(aq)} + \underset{\text{Iron (Grey)}}{Fe\,(s)} \longrightarrow \underset{\text{Iron (II) sulphate (Greenish solution)}}{FeSO_4\,(aq)} + \underset{\text{Copper (Red-brown)}}{Cu\,(s)}$$

- **Reaction of Copper with Silver Nitrate Solution.**

$$\underset{\text{Silver nitrate (Colourless solution)}}{2AgNO_3\,(aq)} + \underset{\text{Copper (Red-brown)}}{Cu\,(s)} \longrightarrow \underset{\text{Copper nitrate (Blue solution)}}{Cu(NO_3)_2\,(aq)} + \underset{\text{Silver (Greyish-white)}}{2Ag\,(s)}$$

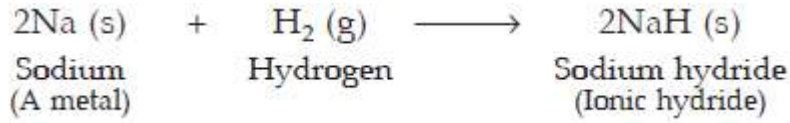
5. Reaction of Metals with Chlorine

Metals react with chlorine to form ionic chlorides



6. Reaction of Metals with Hydrogen

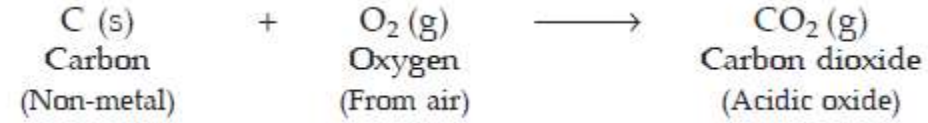
most of the metals do not combine with hydrogen. Only a few reactive metals like sodium, potassium, calcium and magnesium react with hydrogen to form metal hydrides.



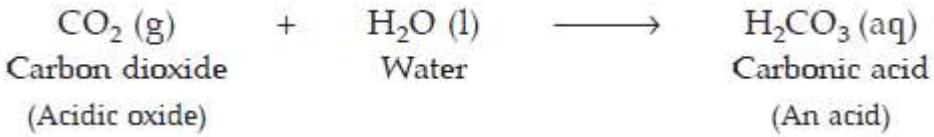
NON-METALS

1. Reaction of Non-Metals with Oxygen

- **Non-metals react with oxygen to form acidic oxides or neutral oxides.**
- **The acidic oxides of non-metals dissolve in water to form acids.**



- **On dissolving it in water**



- **We will now discuss some of the non-metal oxides which are neutral, being neither acidic nor basic. The neutral non-metal oxides are carbon monoxide, CO; water, H_2O;**

2. Reaction of Non-Metals with Water

Non-metals do not react with water (or steam) to evolve hydrogen gas.

3. Reaction of Non-Metals with Dilute Acids

Non-metals do not react with dilute acids. if non-metals like carbon, sulphur or phosphorus are put into a test-tube containing dilute sulphuric acid (or dilute hydrochloric acid), then no hydrogen gas is evolved.

4. Reaction of Non-Metals with Salt Solutions

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

$$\underset{\text{Sodium bromide}}{2NaBr\,(aq)} + \underset{\text{Chlorine}}{Cl_2\,(g)} \longrightarrow \underset{\text{Sodium chloride}}{2NaCl\,(aq)} + \underset{\text{Bromine}}{Br_2\,(aq)}$$

5. Reaction of Non-Metals with Chlorine

Non-metals react with chlorine to form covalent chlorides which are non-electrolytes (do not conduct electricity).

$$\underset{\substack{\text{Hydrogen}\\\text{(Non-metal)}}}{H_2\,(g)} + \underset{\text{Chlorine}}{Cl_2\,(g)} \longrightarrow \underset{\substack{\text{Hydrogen chloride}\\\text{(Covalent chloride)}}}{2HCl\,(g)}$$

Non-metals form covalent chlorides because they cannot give electrons to chlorine atoms to form chloride ions.

6. Reaction of Non-Metals with Hydrogen

Non-metals react with hydrogen to form covalent hydrides.

$$\underset{\text{Hydrogen}}{H_2\,(g)} + \underset{\substack{\text{Sulphur}\\\text{(Non-metal)}}}{S\,(l)} \longrightarrow \underset{\substack{\text{Hydrogen sulphide}\\\text{(Covalent hydride)}}}{H_2S\,(g)}$$

Non-metals form covalent hydrides because non-metal atoms cannot give electrons to hydrogen

HOW DO METALS AND NON-METALS REACT

- **When metals react with non-metals, they form ionic compounds**
- **when non-metals react with other non-metals, they form covalent compounds**
- **The force which links the atoms (or ions) in a molecule is called a chemical bond (or just 'bond')**
- **Only one inert gas helium has 2 electrons in its outermost shell, all other inert gases have 8 electrons in the outermost shells of their atoms. though 8 electrons in the outermost shell always impart stability to an atom, but 2 electrons in the outermost shell impart stability only when the outermost shell is the first shell (K shell), and no other shells are present in the atom.**
- **The usual number of electrons in the outermost shell of the atom of a noble gas is 8. Only in the case of one noble gas helium, the number of outermost electrons is 2. the noble gas atoms have completely filled outermost shells (or valence shells)**
- **we can explain the reactivity of elements as a tendency of their atoms to achieve a completely filled outermost shell or valence shell (just like those of noble gases) and become stable. The atoms combine with one another to achieve the inert gas electron arrangement and become more stable.**
- **Atoms form chemical bonds to achieve stability by acquiring the inert gas electron configuration.**
- **An atom can achieve the inert gas electron arrangement (or noble gas electron arrangement) in three ways :**

1. **by losing one or more electrons (to another atom)**
2. **by gaining one or more electrons (from another atom)**
3. **by sharing one or more electrons (with another atom)**

IONS

- **An ion is an electrically charged atom (or group of atoms).**
- **An ion is formed by the loss or gain of electrons by an atom, so it contains an unequal number of electrons and protons.**

cations and anions.

1. A positively charged ion is known as cation. A cation is formed by the loss of one or more electrons by an atom. a cation contains less electrons than a normal atom. a cation contains less electrons than protons.

2. A negatively charged ion is known as anion. An anion is formed by the gain of one or more electrons by an atom. an anion contains more electrons than a normal atom. an anion contains more electrons than protons.

- **If an element has 1, 2 or 3 electrons in the outermost shell of its atoms, then it loses these electrons to achieve the inert gas electron arrangement of eight valence electrons and forms positively charged ion or cation.**

- **the metal atoms lose electrons to form positively charged ions or cations.**

- **The electronic configuration of a sodium ion is the same as that of the nearest inert gas neon.Since the number of protons and electrons in a sodium atom is equal, therefore, it is electrically neutral having no overall charge. Due to 1 more proton than electrons, a sodium ion has 1 unit positive charge.**

- **If an element has 5, 6 or 7 electrons in the outermost shell of its atom, then it gains (accepts) electrons to achieve the stable, inert gas electron configuration of 8 valence electrons, and forms negatively charged ion called anion**

- **the nonmetal atoms accept electrons to form negative ions or anions. The electronic configuration of a chloride ion is the same as that of its nearest inert gas argon. Since the number of protons and electrons in a chlorine atom is equal, therefore, it is electrically neutral, having no overall charge. Due to 1 more electron than protons, a chloride ion has 1 unit negative charge.**

IONIC BOND

- **ionic bond is also called electrovalent bond.**
- **The chemical bond formed by the transfer of electrons from one atom to another is known as an ionic bond.**

- **An ionic bond is formed when one of the atoms can donate electrons to achieve the inert gas electron configuration, and the other atom needs electrons to achieve the inert gas electron configuration. when a metal reacts with a non-metal, transfer of**

electrons takes place from metal atoms to the non-metal atoms, and an ionic bond is formed.

- **the ionic bonds are formed between metals and non-metals.The strong force of attraction developedbetween the oppositely charged ions is known as an ionic bond.**
- **Ionic compounds are made up of ions.**
- **Sodium metal reacts with chlorine to form an ionic compound, sodium chloride.**

COVALENT BOND

- **The chemical bond formed by the sharing of electrons between two atoms is known as a covalent bond.**
- **A covalent bond is formed when both the reacting atoms need electrons to achieve the inert gas electron arrangement. whenever a non-metal combines with another non metal, sharing of electrons takes place between their atoms and a covalent bond is formed.**
- **a covalent bond can also be formed between two atoms of the same non-metal.**
- **The bond formed between the atoms of the same element is a covalent bond.**
- **The shared electrons are counted with both the atoms due to which each atom in the resulting molecule gets an inert gas electron arrangement of 8 electrons (or 2 electrons) in the outermost shell.**

Covalent bonds are of three types :

1. **Single covalent bond**
2. **Double covalent bond**
3. **Triple covalent bond**

- **A single bond is formed by the sharing of one pair of electrons between two atoms. a single covalent bond is formed by the sharing of 2 electrons between the atoms, each atom contributing one electron for sharing.**

- **A double bond is formed by the sharing of two pairs of electrons between two atoms. a double covalent bond is formed by the sharing of four electrons between two atoms, each atom contributing two electrons for sharing.**

- **A triple bond is formed by the sharing of three pairs of electrons between two atoms. a triple bond is formed by the sharing of six electrons between two atoms, each atom contributing three electrons for sharing.**

PROPERTIES OF IONIC COMPOUND

1. Ionic compounds are usually crystalline solids. The ionic compounds are solids because their oppositely charged ions attract one another strongly and form a regular crystal structure.

2. Ionic compounds have high melting points and high boiling points.

3. Ionic compounds are usually soluble in water but insoluble in organic solvents (like ether, acetone, alcohol, benzene, kerosene, carbon disulphide and carbon tetrachloride).

4. Ionic compounds conduct electricity when dissolved in water or when melted.
Ionic compounds conduct electricity because they contain charged particles called ions.

- **When we dissolve the ionic solid in water or melt it, the crystal structure is broken down and ions become free to move and conduct electricity. Thus, an aqueous solution of an ionic compound (or a molten ionic compound) conducts electricity because there are plenty of free ions in the solution which are able to conduct electric**

PROPERTIES OF COVALENT COMPOUND

1. Covalent compounds are usually liquids or gases. Only some of them are solids.

2. Covalent compounds have usually low melting points and low boiling points.

3. Covalent compounds are usually insoluble in water but they are soluble in organic solvents.

4. Covalent compounds do not conduct electricity. Covalent compounds do not conduct electricity because they do not contain ions.

- **The best test to distinguish between ionic compounds and covalent compounds is the electrical conductivity test.**

- **The earth's crust is the major source of metals. Most of the metals are quite reactive and hence they do not occur as free elements in nature.**

- **Only a few less reactive metals (like copper, silver, gold and platinum) are found in the 'free state' as metals copper and silver metals occur in free state (native state) as well as in the combined state (in the form of compounds).**

- **all the metals which are placed above copper in the reactivity series are found in nature only in the form of their compounds.**

- **The natural materials in which the metals or their compounds are found in earth are called minerals.**

- **Those minerals from which the metals can be extracted conveniently and profitably are called ores.**

- **All the ores are minerals, but all the minerals are not ores.**

- **To obtain a metal from its ore is called the extraction of metal.**

- **The various processes involved in the extraction of metals from their ores, and refining are known as metallurgy.**

ORES AND THEIR NAMES

Metal (to be extracted)	*Name of ore*	*Name of compound in ore*	*Formula of ore*
1. Sodium	Rock salt	Sodium chloride	NaCl
2. Aluminium	Bauxite	Aluminium oxide	$Al_2O_3.2H_2O$
3. Manganese	Pyrolusite	Manganese dioxide	MnO_2
4. Zinc	(*i*) Calamine	Zinc carbonate	$ZnCO_3$
	(*ii*) Zinc blende	Zinc sulphide	ZnS
5. Iron	Haematite	Iron (III) oxide	Fe_2O_3
6. Copper	(*i*) Cuprite	Copper (I) oxide	Cu_2O
	(*ii*) Copper glance	Copper (I) sulphide	Cu_2S
7. Mercury	Cinnabar	Mercury (II) sulphide	HgS

EXTRACTION OF METALS

The three major steps involved in the extraction of a metal from its ore are :
(*i*) Concentration of ore (or Enrichment of ore),

(*ii*) Conversion of concentrated ore into metal,

(*iii*) Refining (purification) of impure metal.

1. Concentration of Ore (or Enrichment of Ore)

- **The unwanted impurities like sand, rocky material, earthy particles, limestone, mica, etc., present in an ore are called gangue.**

2. 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.

- **Extraction of Highly Reactive Metals**

  - **The highly reactive metals such as potassium, sodium, calcium, magnesium and aluminium are placed high up in the reactivity series in its upper part.**

  - **The highly reactive metals are extracted by the of their molten chlorides or oxides.**

  - **The highly reactive metals (which are placed high up in the reactivity series) are extracted by the electrolysis of their molten chlorides or oxides.**

.

  - **The highly reactive metals potassium, sodium, calcium, and magnesium are extracted by the electrolysis of their molten chlorides**

Extraction of Sodium Metal. **Sodium metal is extracted by the electrolytic reduction (or electrolysis) of molten sodium chloride. When electric current is passed through molten sodium chloride, it decomposes to form sodium metal and chlorine gas.**

$$\underset{\text{Sodium chloride (Molten)}}{2NaCl\ (l)} \xrightarrow{\text{Electrolysis}} \underset{\text{Sodium metal}}{2Na\ (s)} + \underset{\text{Chlorine gas}}{Cl_2\ (g)}$$

At cathode : $2Na^+$ + $2e^-$ ⟶ $2Na$

Sodium ions (From molten NaCl) | Electrons (From cathode) | Sodium atoms (Sodium metal)

At anode : $2Cl^-$ − $2e^-$ ⟶ Cl_2

Chloride ions (From molten NaCl) | Electrons (Given to anode) | Chlorine gas

Extraction of Aluminium Metal. **Aluminium metal is extracted by the electrolytic reduction (or electrolysis) of molten aluminium oxide. When electric current is passed through molten aluminium oxide, it decomposes to form aluminium metal and oxygen gas.**

$2Al_2O_3$ (l) $\xrightarrow{\text{Electrolysis}}$ 4Al (l) + $3O_2$ (g)

Aluminium oxide (Molten) | Aluminium metal | Oxygen

At cathode : Al^{3+} + $3e^-$ ⟶ Al

Aluminium ion (From molten Al_2O_3) | Electrons (From cathode) | Aluminium atom (Aluminium metal)

At anode : $2O^{2-}$ − $4e^-$ ⟶ O_2

Oxide ions (From molten Al_2O_3) | Electrons (Given to anode) | Oxygen gas

- **Aluminium metal is extracted by the electrolysis of its molten oxide.**

Extraction of Moderately Reactive Metals

The moderately reactive metals which are in the middle of 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.

- **The concentrated ores can be converted into metal oxide 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 metal oxide.**

$$\underset{\text{Zinc carbonate (Calamine ore)}}{ZnCO_3\ (s)} \xrightarrow{\text{Calcination}} \underset{\text{Zinc oxide}}{ZnO\ (s)} + \underset{\text{Carbon dioxide}}{CO_2\ (g)}$$

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

$$\underset{\text{Zinc sulphide (Zinc blende ore)}}{2ZnS\ (s)} + \underset{\text{Oxygen (From air)}}{3O_2\ (g)} \xrightarrow{\text{Roasting}} \underset{\text{Zinc oxide}}{2ZnO\ (s)} + \underset{\text{Sulphur dioxide}}{2SO_2\ (g)}$$

- **The metal oxides (obtained by calcination or roasting of ores) are converted to the free metal by using reducing agents like carbon, aluminium, sodium or calcium.**

$$\underset{\text{Zinc oxide}}{ZnO\ (s)} + \underset{\text{Carbon (Reducing agent)}}{C\ (s)} \longrightarrow \underset{\text{Zinc metal}}{Zn\ (s)} + \underset{\text{Carbon monoxide}}{CO\ (g)}$$

$$\underset{\text{Manganese dioxide}}{3MnO_2\ (s)} + \underset{\text{Aluminium powder (Reducing agent)}}{4Al\ (s)} \longrightarrow \underset{\text{Manganese metal}}{3Mn\ (l)} + \underset{\text{Aluminium oxide}}{2Al_2O_3\ (s)} + \text{Heat}$$

Extraction of Less Reactive Metals

(i) Extraction of Mercury. **Mercury is a less reactive metal which is quite low in the activity series. Mercury metal can be extracted just by heating its sulphide ore in air.**

$$\underset{\text{Mercury (II) sulphide (Cinnabar ore)}}{2HgS\ (s)} + \underset{\text{Oxygen (From air)}}{3O_2\ (g)} \xrightarrow{\text{Roasting}} \underset{\text{Mercury (II) oxide}}{2HgO\ (s)} + \underset{\text{Sulphur dioxide}}{2SO_2\ (g)}$$

$$\underset{\text{Mercury (II) oxide (Formed above)}}{2HgO\ (s)} \xrightarrow[\text{(Reduction)}]{\text{Heat}} \underset{\text{Mercury metal}}{2Hg\ (l)} + \underset{\text{Oxygen}}{O_2\ (g)}$$

(ii) Extraction of Copper. **Copper is a less reactive metal which is quite low in the reactivity series. Copper metal can be extracted just by heating its sulphide ore in air.**

$$\underset{\text{Copper (I) sulphide (Copper glance ore)}}{2Cu_2S\ (s)} + \underset{\text{Oxygen (From air)}}{3O_2\ (g)} \xrightarrow{\text{Roasting}} \underset{\text{Copper (I) oxide}}{2Cu_2O\ (s)} + \underset{\text{Sulphur dioxide}}{2SO_2\ (g)}$$

$$\underset{\text{Copper (I) oxide (Formed above)}}{2Cu_2O\ (s)} + \underset{\text{Copper (I) sulphide (From unoxidised ore)}}{Cu_2S\ (s)} \xrightarrow{\text{Heat}} \underset{\text{Copper metal}}{6Cu\ (s)} + \underset{\text{Sulphur dioxide}}{SO_2\ (g)}$$

4. Refining of Metals

- **The process of purifying impure metals is called refining of metals.**
- **The most important and most widely used method for refining impure metals is electrolytic refining.**

1. **A thick block of the impure metal is made anode**
2. **A thin strip of the pure metal is made cathode**
3. **A water soluble salt (of the metal to be refined) is taken as electrolyte.**

- *Electrolytic Refining of Copper.*

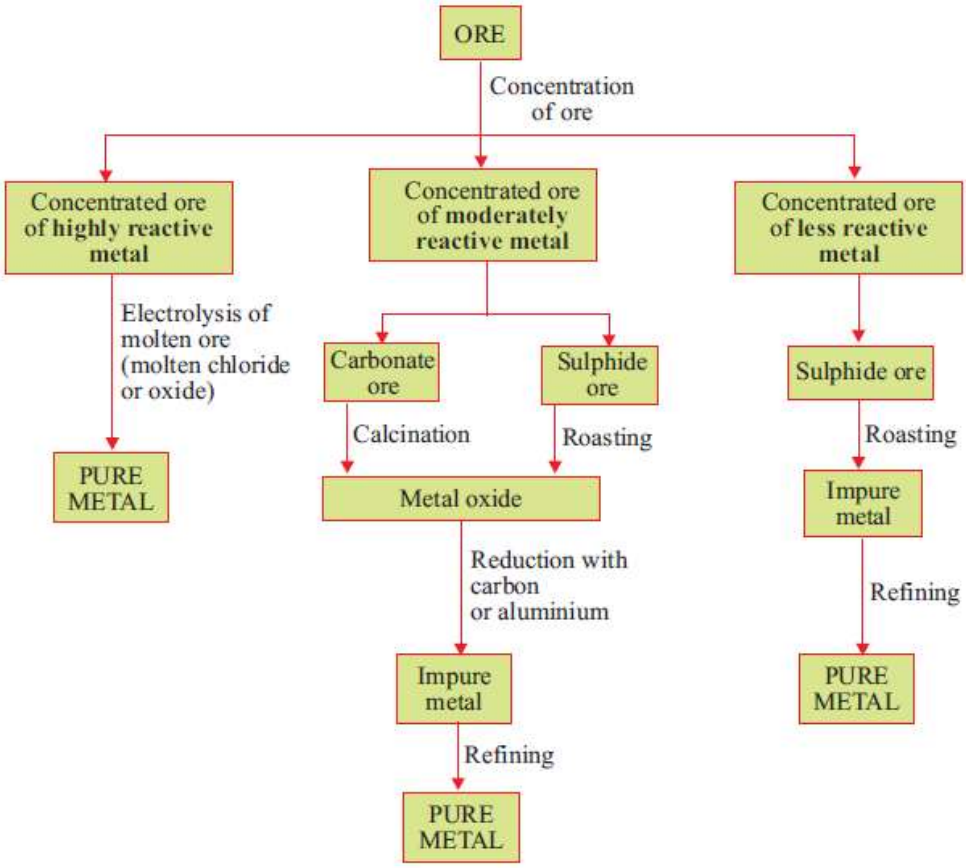
➢ **acidified copper sulphate solution as electrolyte**

➢ **A thick block of impure copper metal is made anode (it is connected to the +ve terminal of the battery)**

➢ **A thin strip of pure copper metal is made cathode (it is connected to the –ve terminal of the battery).**

➢ **pure copper metal is produced on the cathode.**

Flow chart of the refining



- **The eating up of metals by the action of air, moisture or a chemical (such as an acid) on their surface is called corrosion.**

- **corrosion of iron is a continuous process which ultimately eats up the whole iron object. The corrosion of iron is called rusting.**

- **When an iron object is left in damp air (or water) for a considerable time, it gets covered with a red brown flaky substance called rust. This is called rusting of iron.**

1. Presence of air
2. Presence of water

damp air alone supplies both the things, air and water, required for the rusting of iron. Ordinary water alone also supplies both the things, air and water, needed for rusting.

- **Ways to prevent rusting**

1. Rusting of iron can be prevented by painting.

2. Rusting of iron can be prevented by applying grease or oil.

3. Rusting of iron can be prevented by galvanisation.

- **how a more reactive metal zinc is able to protect iron from rusting. the galvanised iron object remains protected against rusting even if a break occurs in the zinc layer.**

4. Rusting of iron can be prevented by tin-plating and chromium-plating.

5. Rusting of iron can be prevented by alloying it to make stainless steel.

- **Due to the formation of a dull layer of aluminium oxide on exposure to moist air, the aluminium vessel loses its shine very soon after use. a thin aluminium oxide layer formed on the surface of aluminium objects protects them from further corrosion.**

- **a common metal which is highly resistant to corrosion is aluminium.**

- **The layer of aluminium oxide on the surface of aluminium objects can be made thicker by electrolysis (to give them even more protection from corrosion). This process is called anodising.**

- **anodising is a process of forming a thick layer of aluminium .**

- **silver ornaments (and other silver articles) gradually turn black due to the formation of a thin silver sulphide layer on their surface by the action of hydrogen sulphide gas present in air .**

- **Silver metal is used to make silver coins, jewellery and silverware (such as silver utensils and decorative articles) because of its bright shiny surface and resistance to corrosion.**

- **Since gold does not corrode, therefore, gold ornaments look new even after several years of use. Gold is used to make jewellery because of its bright shiny surface and high resistance to corrosion.**

- **Platinum is another metal which is highly resistant to corrosion. Platinum is used to make jewellery because of its bright shiny surface and high resistance to corrosion.**

- **aluminium metal is light but not strong, but an alloy of aluminium with copper, magnesium and manganese (called duralumin) is light as well as strong.**

- **aluminium metal is light but not hard, but an alloy of aluminium with magnesium (called magnalium) is light as well as hard.**

- **when a small amount of carbon (varying from about 0.1 per cent to 1.5 per cent) is mixed with iron, we get an alloy called steel. This alloy of iron called steel is hard and strong. It also rusts less readily than pure iron.**

- **when iron metal is alloyed with other metals such as chromium and nickel, we get an alloy called stainless steel which is strong, tough and does not rust at all.**

- **An alloy is a homogeneous mixture of two or more metals (or a metal and small amounts of nonmetals). An alloy is prepared by mixing the various metals in molten state in required proportions, and then cooling their mixture to the room temperature.**

- **The properties of an alloy are different from the properties of the constituent metals (from which it is made).**

- **Some of the common alloys are : Duralumin or Duralium, Magnalium, Steel, Stainless steel, Brass, Bronze, Solder and Amalgams.**

- **The iron pillar at Delhi is a wonder of ancient Indian metallurgy.**