Class: 10th # Metals And Nonmetals **Subject: Chemistry**

What are Metals?

Metals are the elements (except hydrogen) which form positive ions by losing electrons.

Thus, metals are electropositive elements. Gold, Silver, Copper, Tin, Lead, Iron, Mercury are typical metals. These metals were known to the ancient people. All metals except mercury are solid under normal conditions. More than three-forth of the elements known are metals.

What are nonmetals?

The elements which tend to form anions by gaining electrons are termed nonmetals. There are 22 nonmetals. Most of nonmetals are gases. Some nonmetals occur as solid. Bromine is the only nonmetals which occur as liquid under normal conditions.

(a) Solid nonmetals: Carbon, sulphur, Phosphorus, Iodine.

(b) Liquid nonmetal: Bromine

(c) Gaseous nonmetals: Hydrogen, Nitrogen, Oxygen, Fluorine, Chlorine.

Major nonmetals present in the earth's crust are Oxygen, Silicon, Phosphorous and sulphur.

What are metalloids?

The elements which have like metals and nonmetals both are called metalloids. Boron (B), Silicon (Si) and Arsenic (As) are metalloids.

What are physical properties of metals?

All metals show some common physical properties. There is however, some variation in each property from metal to metal.

(i) **Metals are malleable:** This means that metals can be hammered in to very thin sheets. Gold and silver are among the most malleable metals. Both gold and silver can be hammered into foils much thinner than a thinnest paper.

(ii) **Metals are ductile:** This means that metals can be drawn into thin wires. All metals are not equally ductile i.e., some metals are more ductile whereas other are less ductile. Gold, Silver and copper are among the most ductile metals.

(iii) **Metals are good conductors of heat and electricity:** Metals permit heat and electricity to pass through them. Silver, Copper and aluminium are good conductors of heat and electricity. Silver is the best conductor of heat, while lead is the poorest conductor of heat. Copper and aluminium are good conductors of heat.

(iv) **Metals are lustrous:** This means that metals are shiny. The characteristic shine of metals is called metallic luster. Metals can be polished.

(v) **Metals have high tensile strength:** Metals are very strong. They can bear a lot of stress.

(vi) Most metals are hard except sodium and potassium

(vii) Metals except sodium and potassium have high densities.

(viii) Most metals except sodium and potassium have high melting and boiling point.

(ix) **Metals are sonorous:** Metals when hit by a hammer produce a characteristic metallic sound.

(x) **All metals except mercury are solids:** Under normal conditions, all, metals are solids. Mercury is the only metal which is liquid under normal conditions.

(xi) **Metals can form alloys with other metals:** Metals can form homogeneous mixtures with other metals. Such solid homogenous mixtures are called **alloys.**

What are the chemical properties of metals?

Metals are electropositive elements. In chemical reactions, metals lose electrons to form positively charged ions (called cations). The reactivity of a metal depends upon its nature and the reaction conditions. Some typical chemical reactions of metals are described below.

How do metals react with oxygen?

All metals combine with oxygen to form metal oxides. The reactivity of a metal towards oxygen depends upon its nature. For example,

(a) Sodium reacts with oxygen at room temperature to form sodium oxide.

$$4Na + O_2 \longrightarrow 2Na_2O$$

Sodium Oxygen / air Sodium oxide

(b) Magnesium does not react with oxygen at room temperature. On heating in oxygen / air, magnesium burns with a dazzling white light to give magnesium oxide.

$$2\,Mg + O_2 \xrightarrow{Heat} 2\,Mg\,O$$

(Burns with a dazzling white light) magnesium oxide

(c) Zinc reacts with oxygen only on strong heating. Zinc burns with a bluish flame when heated strongly with oxygen.

$$2\,Zn + O_2 \xrightarrow[\text{(Burns with a blue flame)}]{\text{Strong heating}} 2ZnO$$

Zinc Zinc oxide

(d) Iron reacts with oxygen on strong heating without burning.

$$3\,Fe + 2\,O_2 \xrightarrow[\text{(no burning)}]{\text{Strong heating}} Fe_3O_4$$

Iron Oxygen iron (II, III) oxide (Ferroso – ferric oxide)

Fe_3O_4 contains (Fe) in +2 as well as +3 Oxidations states.

How do metals react with water?

Metals react with water to from metal oxide or metal hydroxide along with hydrogen gas. The reactivity of metals towards water depends upon the nature of the metals. Some metals react even with cold water, some react with water only on heating while there some metals which do not react even with steam. For Example.

(i) Sodium metal reacts vigorously with cold water to form sodium hydroxide and hydrogen gas. The reaction is highly vigorous and the hydrogen so product catches fire.

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

Sodium Cold water Sodium **Hydroxide** Hydrogen

(ii) Magnesium reacts very slowly with cold water but reacts rapidly with hot boiling water (steam) forming magnesium oxide and hydrogen gas.

$$Mg + 2H_2O \longrightarrow MgO + H_2$$

Magnesium Boiling Water Magnesium Oxide

(iii) Zinc reacts only with water under ordinary conditions. The reaction occurs only when ste4am is passed over red hot iron and the products are magnetic oxide of iron and hydrogen gas.

$$Zn + H_2O \longrightarrow Fe_3\,O_4 + H_2$$

Zinc Steam Zinc Oxide

(iv) Iron metal does not react with water under ordinary conditions. The reaction occurs only when steam is passed over red hot iron and the products are magnetic oxide of iron and hydrogen gas.

$$3Fe + 4H_2O \longrightarrow Fe_3\,O_4 + H_2$$

Iron Steam Magnetic Oxide of iron

(v) Metals like copper, silver, and gold do not react with water even under drastic conditions. The order of reactivity of above metals with water is :

Na > Mg > Zn > Fe > Cu

How do metals react with dilute acids?

Usually metals displace hydrogen from dilute acids. The less reactive metals such as copper, silver, gold etc., however do not displace hydrogen from dilute acids. Therefore, the order of reactivity of these metals with dilute acid is,

Na > Mg > Zn > Fe > Cu

Reactivity decreases →

Some examples of reactions of metal and dilute acids are given below :

(a) Sodium reacts with hydrochloric acid with explosive violence to form hydrogen gas and sodium chloride.

$2Na + 2HCl \longrightarrow NaCl + H_2$

Sodium sodium chloride

Similar reaction takes place with dilute sulphuric acid.

$Na + H_2SO_4 \longrightarrow Na_2SO_4 + H_2$

Sodium Sulphuric Acid

(b) Magnesium reacts rapidly with hydrochloride acid to form magnesium chloride and hydrogen gas.

$MG + 2HCl \longrightarrow MgCl_2 + H_2$

Magnesium Magnesium Chloride

Similar reaction takes place with dilute sulphuric acid

$Mg + H_2SO_4 \longrightarrow MgSO_4$

Magnesium Magnesium Sulhate

(c) Zinc reacts with dilute hydrochloric acid, but less rapidly than magnesium. This shows zinc is less reactive than magnesium.

$Zn + 2\,HCl \longrightarrow ZnCl_2 + H_2$

Zinc Zinc Chloride

Similar reaction takes place with dilute H_2SO_4.

$Zn + H_2SO_4 \longrightarrow ZnSO_4 + H_2$

Zinc Zinc Sulphate

(d) Iron reacts slowly with dilute hydrochloric acid to form ferrous and hydrogen gas. The rate of evolution of hydrogen shows that it is least reactive among the above mentioned metals.

$Fe + 2HCl \longrightarrow FeCl_2 + H_2$

Iron Ferrous chloride

Similar reaction takes place with dilute H_2SO_4.

$Fe + H_2\,SO_4 \longrightarrow FeSO_4 + H_2$

Iron Ferrous sulphate

(e) Copper does not react with dilute hydrochloric acid or dilute sulphuric acid.

$Cu + HCl \longrightarrow$ No reaction

$Cu + H_2\,SO_4 \longrightarrow$ No reaction

How do metals react with Chlorine?

Most metals react with chlorine to form chlorides. Metal chlorides are mostly ionic (or electrovalent) compounds. The formation of a metal chloride involves the following steps.

(a) Loss of electrons by an atom of the metal (M) to form a cation (M^{n+})

$M \longrightarrow M^{n+} + ne^-$ (where n may be 1, 2, 3)

metal atom Metal ion released electrons

(b) Gain of an electron by a chlorine (Cl) to form chloride (Cl^-) ion.

$Cl + e^- \longrightarrow Cl^-$

chlorine atom chloride ion

or $\frac{1}{2}\,Cl_2 + e^- \longrightarrow Cl^-$

(c) The metal cation (M^{n+}) and the chloride ion (cl^-) so formed unite to form the metal chloride.

$M^{n+} + nCl^- \longrightarrow M^{n+}(Cl^-)_n \longrightarrow MCl_n$

metal cation chloride ions metal chloride

How do metals react with hydrogen?

Only highly electropositive metals such as sodium, potassium, calcium etc., react with hydrogen to form solid hydrides. Hydrides of highly electropositive metals are ionic compounds. In hydride, hydrogen exists as hydride (H^-) ion. The reactivity of the metals follow the oder:

Na > Ca > Mg > Cu > Al, Zn, Fe

most reactive reactivity decreases least reactive

Reaction with salt solutions :

When a more reactive metal is brought in contact with the salt solution of less reactive metal. Then the more reactive metal goes into solution and displaces the less reactive metal which appears in the form of precipitate. For example, if we add a piece of zinc (more reactive) in a blue colored solution of copper (II) sulphate. Then zinc slowly dissolves while copper is precipitated.

$$Zn(s) + CuSO_4(aq) \longrightarrow Cu(s) + ZnSO_4(aq)$$

What are minerals and ores?

Minerals and ores are defined as follows: The naturally – occurring compounds of metals with earthly materials are called minerals. A mineral may contain a small or large percentage of metal in it. The metal content of a mineral may also vary from place to place.A mineral from which a metal can be extracted on a commercial scale economically and easily is called an ore The extraction of metal from a mineral containing very small percentage of metal may not be commercially profitable. For extraction, only those minerals are used which have a reasonable amount of metal in them. Therefore, an ore is a mineral but a mineral may not necessarily be an ore.

Ionic Compounds:-

The compounds containing ionic bonds are known as ionic compounds. They are formed by the transfer of electrons from one atom to another the ionic compounds are made up of positively charged ions and negatively charged ions.

Properties of Ionic compounds:-

(I) **Physical nature:** Ionic compounds are solids and are somewhat hard because of the strong force of attraction between the positive and negative ions. These compounds are generally brittle and break into pieces when pressure is applied.

(II) **Melting and Boiling Points**: Ionic compounds have high melting and boiling points .this is because a considerable amount of energy is required to break the strong inter-ionic attraction.

(III) **Solubility:** Electrovalent compounds are generally soluble in water and insoluble in solvents such as kerosene, petrol,etc

(IV) **Conduction of Electricity:** the conduction of electricity through a solution involves the movement of charged particles. a solution of an ionic compound I water contains ions, which move to the opposite. Electrodes when electricity is passed through the solution. Ionic compounds in the solid state do not conduct electricity because movement of Ions in the solid is not possible due to their rigid structural but ionic compounds conduct electricity in the molten state. This is possible in the molten state since the electrostatic forces of attraction between the oppositely charged ions are overcome de to the heat. Thus, the ions move freely and conduct electricity.

(V) Ionic reaction: reaction between two ionic compounds is the reaction between their ions. As oppositely charged ions combine very quickly, therefore, these reactions are very fast.

What is the reactivity series of Metals?

Some metals are more reactive than others. The tendency of a metal to lose electrons is a measure of its reactivity. Thus, a more electropositive metal is more reactive. The arrangement of metals in a vertical column in the order of decreasing reactivity is called reactivity series of metals. In the reactivity series, the most reactive metal is placed at the top whereas the least reactive metal is placed at the bottom. The reactivity series is also called activity series. The more reactive metals have greater tendency to lose electrons. So more reactive metals are more electropositive or more metallic in nature. Therefore, the electropositive (or metallic) character of metals decreases as we go down from top to bottom in the reactivity series of metals. The reactivity series of some common metals is given below:

Reactivity series of metals

Most reactive metal

These metals are more reactive than hydrogen →

Ka	(Potassium)
Ba	(Barium)
Ca	(Calcium)
Na	(sodium)
Mg	(Magnesium)
Al	(Aluminium)
Zn	(Zinc)
Fe	(Iron)
Ni	(Nickel)
Sn	(Tin)
Pb	(Lead)
H	**(Hydrogen)**
Cu	(Copper)
Hg	(Mercury)
Ag	(Silver)
Au	(Gold)
Pt	(Platinum)

These metals are less reactive than hydrogen →

Chemical reactivity of metals decrease in this direction.

Least reactive metal

OCCURRENCE OF METALS

How do metals occur in nature?

Metals occur in nature in the free as well as in the combined states. The less reactive metals like silver, gold and platinum are generally found in the Free State. Most of the metals, however, are found in the combined frm as minerals.

Metals in nature

e In free (or native) form

r, (Gold, Platinum, Mercury)

In the combined state

(Sodium, Potassium, Calcium, Magnesium, Iron, Aluminium, Copper etc.)

The less reactive metals like silver, gold and platinum occur in free form because they do not react with air, water etc. Thus, all metals which are not affected by water and by the gasses present in the air occur in free state in nature.

On the other hand, all metals which react with water, carbon dioxide, oxygen, and other chemicals which exist in nature occur in the combined form as compounds. Aluminium (Al) is the most abundant metal in the earth's crust. Iron (Fe) and calcium (Ca) being the second and third most abundant metals in the earth's crust.

What is gangue?

Ores usually containing large quantities of unwanted earthy materials. Such unwanted earthy material present in an ore is called gangue. Gangue may be acidic or basic in nature.

What is a flux?

A substance which during smelting combines with the earthly impurities present in the ore to form a fusible slag is called a flux. There are two types of fluxes.

(a) Acidic flux e.g., silica (SiO_2).

(b) Basic flux e.g., lime (CaO), limestone CaCO3).

What is meant by metallurgy?

The process of extracting metals from their ores is called metallurgy. Various steps involved in the extract action of a metal from its ore are,

(i) Crushing and pulverization of the ore.

(ii) Concentration (or dressing) of the ore.

(iii) Extracting of metal.

(vi) Refining of metal.

The actual metallurgical process and the various steps involved in it depend upon nature of the ore and metal.

How is an ore crushed and pulverized?

Big lumps of the ores are crushed to smaller pieces by hammering It in a hammer mill, and pulverized to a fine power in pulverizers or stamps mills.,

How is an ore concentrated?

Ore usually contain unwanted earthly materials called gangue. The gangue must be removed before the ore is processed further. The removal of unwanted earthly materials from an ore is called concentration of ore. Concentration of an ore is also called dressing of ore. Based on the nature of the gangue and the ore, the Following methods are generally used for the Concentration of ores .

1. **Hydraulic washing method:**

In this method, the crushed ore is washed with a stream of water. The lighter gangue particles are washed away. The heavier mineral particles settle down to the bottom and can be removed. A typical hydraulic classifier is shown in the fig.

2. **Magnetic separation method:**

This method is based on the difference in the magnetic properties of ore and gangue. That is magnetic separation method is used only when either of the two, ore or gangue, is magnetic. The powdered ore is dropped over a conveyor belt moving over two rollers, one of which is magnetic. When the ore passes over the magnetic roller, the magnetic and the nonmagnetic materials fall separately.Some typical ores which can be concentrated by magnetic separation method are,

(a) Tin stone which contains magnetic impurity wolfram.

(b) Pyrolusite (a manganese ore)

(c) Chromite (a chromium ore)

(d) Magnetite (an iron ore)

3. **Froth flotation process:**

Froth flotation process is used for concentrating sulphide ore, particularly of zinc, copper and lead.

Principle: The froth flotation process is based on the difference in the wetting properties of the ore and gangue particles. The sulphide ore particles are preferentially wetted by pine oil whereas the gangue particles are wetted by water.

Process: the powdered ore is mixed with water and a little pine oil. The mixture is vigorously stirred by passing compressed air. Froth produced rises to the surface and can be removed easily. The gangue is left behind. Froth flotation method is shown in the fig.

What is meant by the Calcination of an ore?

The process of heating an ore strongly in the absence of air or in the presence of very limited quantity of air is called Calcination. Calcination of an ore is done to

(i) Convert a carbonate ore into oxide,
(ii) Remove moisture / water from the wet/ hydrated ores.
(iii) Remove volatile impurities from the ore.

During calcination, the ore becomes porous and dry. For example, Calamine (an ore of zinc) when calcined decomposes to give zinc oxide.

$$\underset{\text{calamine ore}}{ZnCO_3} \xrightarrow{\Delta} \underset{\text{zinc oxide}}{ZnO} + CO_2(g)$$

Calcination of malachite (an ore of copper) gives copper oxide.

$$\underset{\text{malachite}}{CuCO_3.Cu(OH)_2} \xrightarrow{\text{heat}} \underset{\text{copper oxide}}{2CuO} \uparrow + CO_2 \uparrow + H_2O$$

During calcination, a carbonate ore gives out carbon dioxide gas.

What is meant by roasting of an ore?

The process of heating an ore (generally, a sulphide ore) strongly below its melting point in the presence of an excess of air is called roasting. Sulphide ores are converted to oxide by roasting. Roasting of an ore is done to

i) convert a sulphide ore to oxide ore
ii) Remove volatile impurities and moisture.

The chemical reactions during roasting of some common ores are given below.

$$\underset{\text{zinc blende (zinc sulphide)}}{ZnS} + 3O_2 \xrightarrow[\text{(in air)}]{\text{heat}} \underset{\text{zinc oxide}}{2ZnO} + 2SO_2(g)$$

REFINING OF METALS:

Metals obtained by reduction process contain small amount of various impurities. The process of removing impurities from the metals extracted from their ores is called refining of metals. There are various methods used for refining impure metals. The choice of the method depends upon nature of the metal to be refined. Some common methods used for refining metals are described below.

What is liquation method?

This method is used for refining low-melting Metals such as tin (Sn), lead(Pb), bismuth(Bi) etc. In this method, impure metal is placed on the Slopping hearth. The temperature of the slopping hearth is raised to slightly above the melting point of the metal. The molten pure metal flows down &the impurities are left behind on the hearth.

What is electrolytic refining method?

It is the method used for refining impure metals. Most metals *viz.,* copper, aluminium, chromium, silver etc., are refined by electrolytic method. This refining is done using the following steps.

(a) A thick block of impure metal is made anode. It is connected to the +ve terminal of the battery.
(b) A thin sheet of pure metal is made cathode. It is connected to the –ve terminal of the battery.
(c) An aqueous solution of a suitable salt of the metal is used as the electrolyte.

Extraction of metals low in the activity series:-

Metals low in the activity series are very uncreative. The oxides of these metals can be reduced to metals by heating alone. For example, cinnabar (HgS) is an ore of mercury. When it is heated in air, it is first converted into mercuric oxide (HgO). Mercuric oxide is then reduced to mercury on further heating.

$$2HgS(s) + 3O_2(g) \xrightarrow{Heat} 2HgO(s) + 2SO_2(g)$$

$$2HgO(s) \xrightarrow{Heat} 2Hg(l) + O_2(g)$$

Similarly, copper which is found as Cu_2s in nature can be obtained from its ore by just heating in air.

$$2Cu_2S + 3O_2 \xrightarrow{Heat} 2Cu_2O(s) + 2SO_2(g)$$

$$2Cu_2O + Cu_2S \xrightarrow{} Heat\ 6Cu(s) + SO_2(g).$$

Extracting Metals in the Middle of the Activity Series :-

The metals in the middle of the activity series such as iron, zinc, lead, copper. Etc,. are moderately reactive. These are usually present as sulphides or carbonated in nature. It is easier to obtain a metal from its oxide, as compared to its sulphides and carbonates. Therefore prior to reduction, the metal sulphides and carbonates must be converted into metal oxides. The sulphide ores are converted into oxides by heating strongly in the presence of excess of air. This process is known as roasting. The carbonate ores are changed into oxides by heating strongly in limited air. This process is known as calcinations. The chemical reaction that takes place during roasting and calcinations of zinc roasting

$$2ZnS(s) + 3O_2 \xrightarrow{Heat} 2ZnO(s) + 2SO_2(g)$$

Calcination

$$ZnCO_3(s) \xrightarrow{Heat} ZnO(s) + CO_2(g)$$

The metal oxides are then reduced to the corresponding metals by using suitable reducing agents such as carbon. For example, when zinc oxide is heated with carbon, it is reduced to metallic zinc.

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

Extracting Metals towards the Top of the Activity Series:-

The metals high up in the reactivity series are very reactive. They cannot be obtained from their compounds by heating with carbon. For example, carbon cannot reduce the oxides of sodium, magnesium, calcium, aluminium, etc., to the respective metals. This is because these metals have more affinity for oxygen than carbon. These metals are obtained by electrolytic reduction. For example; sodium, magnesium and calcium are obtained by the electrolysis of their molten chlorides .the metals are deposited at the cathode (the negatively charged electrode), whereas, chlorine is liberated at the anode (the positively charged electrode). The reactions are :

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

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

Similarly Almunium is obtained by the electrolytic reaction of aluminium oxide.

USES OF METALS.

What are the uses of pure metals?

The uses of some metals are described below.

i) Copper and aluminium are very good conductors of electricity. So, copper and aluminium are used for making electrical wires and cables. Aluminium is also used for making cooking utensils. Aluminium foils are used for packaging of medicines, food materials etc.

ii) Iron is the most widely used metal. Its uses, however mainly depend upon its carbon content. For example,

Cast iron is used for manufacturing wrought iron and steel. It is generally used for making stove burners,gutter pipes, railway sleepers etc.

Steels are used for the manufacturing of permanent magnets, engine parts, utensils, surgical equipments, springs, gears: drive shafts, Armour plates etc.

Wrought iron is used for making anchors, wire ropes, bolts, chains and agricultural appliances.

iii) Zinc is used for the galvanization of iron. Tin is used for tinning of iron plates / sheets and copper / brass utensils. Thus, Zinc and tin are used for protecting iron from rusting.

iv) Nickel and chromium are mainly used for electroplating and for the manufacture of stainless steel. Nickel is also used as a catalyst in many industrial processes.

i) Gold and silver are used for making jewellery and for decorative purposes.

ii) Sodium, titanium and zirconium are used in atomic energy and space science projects. Zirconium is used for making Bullet – proof alloy steels.

iii) Mercury is used in thermometers and barometers.

iv) Titanium is used in, (i) aerospace, (ii) aircraft frames and engines,(iii) military hardware,(iv) marine equipment,(v) chemical reactors,(vi) chemical industries, and(vii) atomic energy and space science projects. Titanium due to its special applications is considered as a strategic metal. These applications of titanium are due to its

(a) High tensile strength, lightness, resistance to corrosion

(b) High melting and high boiling points.

What is an alloy?

A homogeneous mixture of a metal with other metals or with a nonmetal is called an alloy. Alloys are also called Solid solutions. Alloys are commonly prepared by melting the component metals in the required ratio and allowing the molten mass to solidify.

NONMETALS :-

The elements which have a tendency to gain electrons to form anions are nonmetals. Thus nonmetals are electronegative elements. There are 22 nonmetals: eleven nonmetals are gases, one is liquid and the rest ten are solids. Some common nonmetals are, Gaseous nonmetals: Nitrogen (N), Oxygen (O), Chlorine (Cl) **Liquid nonmetals:** Bromine (Br) **Solid nonmetals:** Carbon (C), Phosphorous (P), Sulphur (s) Oxygen is the most abundant nonmetal in the earth's crust. Nonmetals are located in the upper right hand side of the periodic table.

What are the general Physical properties of nonmetals?

Some important general physical properties of nonmetals are given below.

1.**Nonmetals are brittle** i.e., nonmetals break up into pieces when pressed hard or hammered. For example, sulphur and red phosphorous are brittle.

2. **Nonmetals are neither ductile nor malleable.** Nonmetals cannot be drawn into wires, and beaten into leaves/sheets because they are brittle.

3.**Nonmetals are Insulators i.e.,** nonmetals do not conduct heat and electricity. This is because they do not have free electrons. However, graphite is a good conductor of heat and electricity.

4. **Nonmetals do not have luster** i.e., nonmetals are not shiny. However, graphite and Iodine are the only nonmetals which have luster. As a result, nonmetals cannot be polished.

5. **Nonmetals usually have low densities and are soft.** Diamond (an allotrope of carbon) however is an exception. Diamond is the hardest natural substance Known.

6.**Nonmetals have low melting and boiling points.** However, graphite has a high melting point (3700^0 C). Sulphur and phosphorous have low melting points: White phosphorous melts at 44^0C, whereas sulphur melts at 119^0C.

7.**Nonmetals are non sonorous** i.e., nonmetals do not produce sound when hit with an object.

8.**Nonmetals have low tensile strength,** i.e., nonmetals can be easily broken.

9.**Nonmetals may be solid, liquid or gaseous at room temperature.** For example under room temperature conditions, sulphur, phosphorous are solids, bromine in liquid, whereas hydrogen, oxygen and nitrogen are gases.

10. **Nonmetals show allotropy.** Some nonmetals can exist in more than one forms, i.e., they exist in more than one allotropic forms. For example, Phosphorous exists in five different forms viz,

How do metals and nonmetals differ in their physical properties.

The main points between the physical properties of metals and nonmetals are given below.

Metals	Non-metals
1.Metals arte good conductors of heat and electricity	Nonmetals are nonconductor of heat and electricity. Graphite however is a good conductor of heat and electricity.
2.Metals are malleable and ductile.	Nonmetals are brittle, i.e., nonmetals are neither malleable nor ductile.
3.Metals are lustrous and can be polished.	Nonmetals are nonlustrous. Graphite and iodine however have metallic lustrous.
4.Metals except mercury are solids and hard.	Nonmetals are soft solids, liquids or gases.
5.Metals have high melting and boiling points.	Nonmetals have low melting and boiling points.
6.Metals have high densities.	Nonmetals have low densities.
7.Metals are sonorous.	Nonmetals are nonsonorous.
8.Metals posses high tensile strength.	Nonmetals posses low tensile strength.

How do metals and nonmetals differ in their chemical properties?

Metals	Non-metals
1. Metals form basic oxides, some are amphoteric also.	1. Non-Metals form acidic or neutral oxides.
2. Metals displace hydrogen from acids and form salts.	2. Non-Metals do not displace hydrogen from acids.
3. Metals react with Cl_2 to form electrovalent chlorides.	3. Non-Metals react with Cl_2 to form covalent chlorides.
4. With hydrogen, only a few metals combine to form electrovalent hydrides.	4. With hydrogen, non-metals form many stable hydrides which are covalent.
5. Metals are electropositive in character.	5. Non-metals are electronegative.
6. Metals act as reducing agents.	6. Non-metals act as oxidizing agents.

ALLOY :

An alloy is a homogeneous mixture of two or more metals or a metal and a non-metal.

For example, iron is the most widely used metal. But it is never used in the pure form. This is because pure iron is very soft and stretches easily when hot. But when it is mixed with a small amount of carbon (about 0.05%), it becomes hard and strong. The new form of iron is called steel.

OBJECTS OF ALLOYS MAKING :

Alloys ate generally prepared to have certain specific properties which are not possessed by the constituent metals. The main objects of alloy making are :

(i) To increase resistance to corrosion. For example, stainless steel is prepared which is more resistant to corrosion than iron.

(ii) To modify chemical reactivity. The chemical reactivity of sodium is decreased by making an alloy with mercury which is known as sodium amalgam.

(iii) To increase the hardness. Steel, an alloy of iron and carbon is harder than iron.

(iv) To increase tensile strength. Magnalium is an alloy of magnesium and aluminum. It has grater tensile strength as compared to magnesium and aluminium.

(v) To produce good casting. Type metal is an alloy of lead, tin and mercury.

(vi) To lower the melting point.

AMALGAM :

These are special class of alloys in which one of the constituent metals is mercury.
These are formed by treating metals such as sodium, zinc, tin, gold, etc. with mercury. Different amalgams are prepared depending upon their uses. For example,

(i) Sodium amalgam is used to decrease the chemical reactivity of sodium metal. It is also caused as a good reducing agent.

(ii) Tin amalgam is used for silvering cheap mirrors.

(iii) The process of amalgamation is used for the extraction of metals like gold or silver from their native ores.

CORROSION OF METALS :

One of the most destructive and annoying processes that occur in nature is the corrosion of metals. This process takes place on the surface of metals when they are exposed to air. Due to corrosion, small holes appear on the surface of the metal and the strength of the metal goes on decreasing. The process of corrosion is caused by the reaction of the metal with oxygen of air or with oxygen dissolved in water. In many cases, an oxide of the metal is formed on the surface of the metal. Besides oxygen, carbon dioxide, sulphur dioxide or hydrogen sulphide present in atmosphere are responsible for corrosion of metals. Thus, corrosion brings about slow destruction of the metal.

Slow destruction of metals due to chemical reactions on their surface by oxygen, carbon dioxide moisture, sulphur dioxide, hydrogen sulphide, etc., of the atmosphere, is known as corrosion of metals.

In corrosion, the metal atoms give up electrons (i.e., they are oxidized) and are converted into ions.

$$M \longrightarrow M^+ + e$$

The ions move from one part of the metal to another more easily in the presence of moisture. This is because moisture provides the medium through which ions can flow.

Factors Determining the rate of Corrosion :

The process of corrosion is speeded up in the following circumstances.

1.Two metals are in contact with each other :

The corrosion of a more electropositive metal is speeded up when it is in contact with a less electropositive metal. Two metals form an electrochemical (galvanic) cell in the presence of moisture. Electrons begin to flow from the more electropositive (or more reactive) to the less electropositive (or less reactive) metal. Thus, the more electropositive metal is lost as ions.

2.Polluting materials in air :

The air near industrial units is generally polluted with CO_2, SO_2, H_2S, etc. Gases coming out of chimneys contain these gases in abundance. We know that these gases are also responsible for the corrosion of metals. Therefore, the process of corrosion is speeded up in presence of these pollutants.

Prevention of Corrosion :

1. **By painting :**

The corrosion of a metal can be prevented simply by painting the metal surface by grease or varnish that forms a protective layer on the surface of the metal. The metal is, thus, protected from moisture and air.

2. **Self prevention :**

Some metals form their own layer of protection. For example, when zinc is left exposed to the atmosphere, it combines with the oxygen of air to form a layer of zinc oxide over its surface. This oxide layer does not allow air to go into the interior of the metal. Thus, zinc is protected from corrosion by its own protective layer.

3. **By coating iron with zinc :**

Rusting of iron can be effectively prevented by coating iron with zinc. The layer of zinc does not allow iron to come in contact with air and moisture. If the coating gets scratched at a place the two metals form an electrochemical (galvanic) cell in the presence of moisture. Since zinc is more electropositive or more reactive. Zinc forms zinc ions and hence protects iron from rusting.

4. **Cathodic protection :**

The more reactive metals are more corrosion-prone. A corrosion-prone metal is connected to a bar of another metal that is even more prone to corrosion. In other words, the metal to be protected from the more reactive metal, electrons flow from the more reactive metal to the less reactive metal (metal to be protected). Thus the metal to be protected becomes the cathode and the more reactive metal becomes the anode. In this way, the two metals form an electrochemical (galvanic) cell. Thus, the oxidation of the metal is prevented.

RUSTING OF IRON :

When ordinary iron objects are exposed to moist air, they get corroded slowly and are covered with a thin brown scale commonly known as rust. Rusting is thus, a process of corrosion of iron in moist air. Chemically; rust is a mixture of ferric oxide and ferric hydroxide. Thus chemical reaction of rusting can be represented as,

$$4Fe + \underbrace{3O_2 + 3H_2O}_{\text{Moist air}} \longrightarrow \underbrace{Fe_2O_3.2Fe(OH)_3}_{\text{Rust}}$$

<u>CONDITIONS NECESSARY FOR RUSTING</u> :

The two conditions necessary for the rusting of iron are :

(i) Presence of moisture, and
(ii) Presence of air.

<u>PREVENTION OF RUSTING</u> :

There are several ways of preventing rusting of iron. Some of these are discussed below :

1. **Barrier protection.**

In this method, a barrier film is introduced between iron and atmospheric oxygen and moisture. Barrier protection can be achieved by any of the following ways :

- By painting the surface.
- By coating the surface with a thin film of oil or grease.
- By electroplating iron with some non-corrosive metal such as nickel, chromium, copper, etc.

2. **Surfacial protection.**

In this method, surface of iron is covered with a layer of more active metal like zinc. The active metal undergoes oxidation in preference to iron and hence, prevents the rusting of iron. Zinc metal is generally used for protecting iron and the process is called galvanization.

3. **Use of anti-rust solutions.**

The alkaline phosphate and alkaline chromate solutions act as anti-rust solutions, when iron articles are dipped into a boiling alkaline solution of sodium phosphate, a protective insoluble film of iron phosphate is formed on them. This film protects the article from rusting.