L. No. 4

Metals and Non-metals

Some points to Remember:

1. **Metals:-** Theseelements are mostly solids and have bright luster. They have high densities and are hard, good conductors of heat and electricity. They have tendency to lose one or more electrons e.g. Iron, Zinc, Sodium, Calcium, Aluminium.
2. **Non- Metals:-** These elements exist in all the three states (solids, liquids &gases). They have no luster and have generally low densities. They are poor conductors of heat and electricity. They have tendency to gain one or more electrons. e.g. Nitrogen, Oxygen, Sulphur, Iodine, Bromine etc.
3. **Metalloids:-** The elements that show the properties of both metals and nonmetals e.g. Arsenic, Antimony, Silicon, Germanium, Tellurium etc.
4. **Activity Series of Metals:-** It is a series in which the various metals have been arranged in decreasing order of their reactivity. A part of this series is shown as below:-

   K>Na> Ca> Mg>Al>Zn>Fe>Pb>Cu>Hg>Ag> Au>Pt
5. **Mineral:-**The elementary state or the compounds in the form of which the metals occur in nature are called minerals.
6. **Ore:-** The mineral from which the metal, can be extracted conveniently and economically is called an ore.
7. **Gangue Or Matrix:-** These are the earthy impurities like sand, lime stone, rocks etc. associated with minerals or ores.
8. **Metallurgy:-** The process of extracting and refining of metals is known as metallurgy.
9. **Roasting:-** The process of heating of shlphide ore strongly in presence of air to get metal oxide is known as Roasting.
10. **Calcination:-** The process ofheating of carbonate ores to convert them into their corresponding oxides in absence of air, is known as calcination.
11. **Smelting:-** The process of reduction of metal oxides by heating them with coke is called smelting.
12. **Aluminothermy:-** The process of reduction of metal oxides by heating them in presence of Aluminium is called aluminothermy.
13. **Refining of Metals:-** The process of purifying the impure (crude) metals is called refining of the metals.
14. **Corrosion:-** It is the Slow eating up (decay) of metals by the action of air and moisture on their surfaces.
15. **Rusting:-**Corrosion of iron is called rusting. Chemically rust is hydrated ferric oxide ($Fe_2O_3 .x H_2O$)
16. **Alloy:-**It is a homogeneous mixture of two or more metals or metals and non-metals. **17. Amphoteric:-** A chemical species that behaves both as an acid and a base is called amphoteric

Additional Questions

Q. What are metals? Give physical and chemical properties of metals.

Metals:- Metals are defined as those elements which form positive ions (cations) by losing one or more electrons i.e. they are electropositive elements. They have 1,2, or 3 electrons in their valence shell.

Physical Properties of metals:-

1. Metals in the pure state possess lustre i.e. shining surface.

Scanned with CamScanner

2. Metals are generally hard. The hardness varies from metal to metal e.g. Iron, Copper, Aluminium, Lead are hard metals. They can't be cut with a knife. However, Lithium, Sodium and Potassium are soft metals. They can be cut even with a knife.
3. Metals are malleable i.e. they can be beaten into thin sheets .e.g. Iron, Copper, Aluminium etc.
4. Metals are ductile in nature i.e. they can be drawn into wires. e.g. 1gram of gold can be drawn into a wire of about 2km length.
5. Metals are good conductors of heat and possess high melting point. Silver is the best conductor of heat and copper is the second best followed by aluminium. Whereas, lead is the poorest conductor of heat.
6. Metals are good conductors of electricity. Silver is the best conductor of electricity where as mercury is very poor conductor of electricity.
7. Metals are sonorous i.e. they produce sound on striking hard surfaces.
8. Metals generally have high density. Exception is Lithium, Sodium, and Potassium which have low densities.
9. Metals have high tensile strength i.e. they possess load bearing capacity.
10. All metals are solids except mercury which is a liquid.

Chemical properties of Metals:-

Some of the chemical properties of metals are summarized as follows:-

1. **Reaction of metals with oxygen:-**

Metals react with oxygen to form their respective oxides. However, the vigour of reactivity varies from metal to metal, e.g.

a. Sodium reacts with oxygen at room temp.

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

b. Magnesium reacts with oxygen on heating.

$$2Mg + O_2 \xrightarrow{Heat} 2MgO$$

c. Zn reacts with oxygen on strong heating.

$$2Zn + O_2 \xrightarrow[Heating]{Strong} 2ZnO$$

2. Properties of oxides/Nature of oxides:

a. Basic/Amphoteric nature of oxides:- Most of the Metal oxides are basic in nature. e.g. Sodium reacts with oxygen at room temperature to form sodium oxide which is basic in nature.

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

Similarly,Magnesium reacts with oxygen on heating to form magnesium oxide which is also basic in nature.

$$2Mg + O_2 \xrightarrow{Heating} 2MgO$$

However, some metal oxides e.g. aluminium oxide (Al_2O_3) and Zinc oxide (ZnO) show basic as well as acidic character. Such metal oxides are called amphoteric oxides.

$$4\ Al + 3O_2 \longrightarrow 2\ Al_2O_3$$
$$2\ Zn + O_2 \longrightarrow 2\ ZnO$$

b. Solubility in water:- Most of the metal oxides are insoluble in water. But some metal oxides dissolve in water to form alkalies (Bases).

e.g. $Na_2O + H_2O \longrightarrow 2Na\ OH$

$K_2O + H_2O \longrightarrow 2KOH$

3. **Reaction of Metals with water:-**

A number of metals react with water to form a hydroxide or an oxide along with the evolution of hydrogen gas.

However, the rate of reactivity of different metals is different towards water.

Some metals such as sodium and potassium react with water at room temp.

Scanned with CamScanner

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

$2K + 2H_2O \longrightarrow 2KOH + H_2\uparrow$

Some metals such as magnesium reacts with water on heating

$$Mg + 2H_2O \xrightarrow{\text{Heat}} Mg(OH)_2 + H_2$$

Similarly some other metals such as aluminium and iron react with steam.

$$2Al + 3H_2O \xrightarrow{\text{Steam}} Al_2O_3 + 3H_2$$

$$3Fe + 4H_2O \xrightarrow{\text{(Steam)}} Fe_3O_4 + 4H_2$$

4. Reaction of Metals with dilute acids:-

Metals displace H_2 gas from dilute acids. However, less reactive metals like Cu, Ag and Au do not displace Hydrogen gas when they are treated with dilute acids.

e.g. (i) Sodium reacts violently with dil. HCl.

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

ii. Magnesium reacts quite rapidly with dil. HCl.

$Mg + 2HCl \longrightarrow MgCl_2 + H_2$

iii. Zinc reacts less rapidly than that of Mg with HCl

$Zn + 2HCl \longrightarrow ZnCl_2 + H_2$

iv. Iron reacts slowly with dil HCl

$Fe + 2HCl \longrightarrow FeCl_2 + H_2$

v. Copper does not react with dil.HCl or dil. H_2SO_4

$Cu + HCl \longrightarrow$ NO reaction .

5. Reaction of metals with chlorine:-

Metals react with chlorine to form metal chlorides. Reactive metals like sodium, potassium, calcium and magnesium combine with chlorine even at room temp.

$2Na + Cl_2 \longrightarrow 2NaCl$

$Ca + Cl_2 \longrightarrow CaCl_2$

However, less reactive metals like zinc, iron, aluminium and copper react with chlorine on heating. e.g.

$$Zn + Cl_2 \xrightarrow{\text{Heat}} ZnCl_2$$

$$2Fe + 3Cl_2 \xrightarrow{\text{Heat}} 2FeCl_3$$

$$2Al + 3Cl_2 \xrightarrow{\text{Heat}} 2AlCl_3$$

6. Reaction of metals with hydrogen:-

Metals generally do not react with hydrogen. Only highly reactive metals like Na, K Ca and Mg combine with hydrogen to from compounds called metal hydrides. e.g.

$$2Na + H_2 \xrightarrow{\text{Heat}} 2NaH$$

$$Ca + H_2 \xrightarrow{\text{Heat}} CaH_2$$

7. Reaction of metals with solutions of other metal salts:-

All metals are not equally reactive. The more reactive metals can displace less reactive metals from their compounds in solution. e.g. Iron can displace copper from copper sulphate solution.

$Fe + CuSO_4 \longrightarrow FeSO_4 + Cu.$

Similarly, copper can displace silver from silver nitrate solutions

$Cu + 2AgNO_3 \longrightarrow Cu(NO_3)_2 + 2Ag.$

8. Reducing behaviour:-

As metals can lose electrons, therefore, they act as reducing agents. e.g. sodium metal reduces chloride ion as follows:-

$2Na + Cl_2 \longrightarrow 2NaCl$

$(Na \xrightarrow{\text{Oxidation}} Na^+ + e^-$

$(Cl + e^- \xrightarrow{\text{Reduction}} Cl^-$

$Na^+ + Cl^- \longrightarrow NaCl$

Scanned with CamScanner

Q.2 What are non-metals? Give their general physical and chemical properties.

Ans. Non metals are defined as the element which have the tendency to gain (accept) electrons i.e. they are electronegative in nature. Because of their electronegative nature they form negative ions (anions). Non metals have 4 to 7 electrons in their outer shells.

Physical properties of non-metals:-

(1) Non-metals do not possess any lustre except iodine which is non-metallic solid but has lustre.

(2) They are soft and brittle i.e. they break into pieces when hammered. The only exception is diamond, an allotropic form of carbon which is the hardest substance known.

(3) They are neither malleable nor ductile.

(4) They are generally bad conductors of heat and electricity, except graphite which is an allotropic form of carbon and is a good conductor of electricity.

(5) They are non-sonorous i.e. they do not produce any sound when hit with any hard object.

(6) They have generally low melting and boiling point except boron, diamond and graphite which have high melting point.

(7) They have low densities i.e. they are light elements.

(8) They have low tensile strength i.e. they are easily broken.

(9) They may be solids, liquids or gases at room temperature. e.g. Carbon, Sulphur, phosphorus are solids and bromine is a liquid,while as hydrogen, oxygen, nitrogen and chlorine are gaseous non-metals.

Chemical properties of non-metals:-

(1) **Reaction with oxygen :-** Non-metals when heated with oxygen form their respective oxides. These oxides may be either acidic or neutral. They never form basic oxides. e.g.

$C + O_2 \rightarrow CO_2$ (Acidic oxide)

$CO_2 + H_2O \rightarrow H_2CO_3$ (Carbonic acid)

$S + O_2 \rightarrow SO_2$ (Acidic oxide)

$SO_2 + H_2O \rightarrow H_2SO_3$ (Sulphurous acid)

$2C + O_2 \rightarrow 2CO$ (Neutral oxide)

$N_2 + O_2 \rightarrow 2NO$ (Neutral oxide)

(2) **Reaction with water:-** Non-metals generally do not react with water. This is because non-metals can't reduce the hydrogen (H^+) ions of water to H_2 gas.

(3) **Reaction with dilute acids:-** Non-metals do not react with dilute acids. It is because non-metals them selves are acceptors of electrons and therefore do not give electrons to reduce the hydrogen (H^+) ions of an acid to hydrogen gas.

(4) **Reaction with chlorine:-** Non-metals react with chlorine to form chlorides. These non-metal chlorides are covalent chlorides and non-electrolytes. e.g.

$H_2 + Cl_2 \rightarrow 2HCl$ (Covalent Chloride)

$P_4 + 6Cl_2 \rightarrow 4PCl_3$ (Covalent Chloride)

(5) **Reaction with hydrogen:-**

Non-metals combine with hydrogen to form covalent hydrides. These hydrides are generally gases or liquids e.g.

$8H_2 + S_8 \xrightarrow{Heat} 8H_2S$

$N_2 + 3H_2 \xrightarrow{Heat} 2NH_3$

Scanned with CamScanner

6. **Reaction with Salts:-**
A More reactive non-metal displaces a less reactive non-metal from its salt solution. e.g.

$2NaBr + Cl_2 \longrightarrow 2NaCl + Br_2$

$2KI + Cl_2 \longrightarrow 2KCl + I_2$

7. **Oxidizing Behavior:-**
Non-metals have a strong tendency to accept electrons to form negative ions. Therefore, non-metals behave as oxidizing agents. e.g. the non-metal fluorine (F_2) is the strongest oxidizing agent. It oxidizes water (H_2O) to oxygen, sulphur to sulphurhexa fluoride etc.

$2H_2O + 2F_2 \longrightarrow 4HF + O_2$

$S_8 + 24F_2 \longrightarrow 8SF_6$

Q.3 State some uses of metals:-

Ans. Metals are used for a large number of purposes. Some of the uses of metals are given below-

1. Copper and aluminium metals are used to make wires to carry electric current.
2. Iron, Copper and Aluminium metals are used to make house-hold utensils and factory equipments.
3. Iron is used as a catalyst in the preparation of ammonia gas by Haber's process.
4. Zinc is used for galvanizing iron to protect it from rusting.
5. Chromium and nicked metals are used for electroplating and in the manufacture of stainless steel.
6. The aluminium foils are used in packaging the medicines, cigarettes and food materials.
7. silver and gold are used to make jewelery.
8. The liquid metal, mercury is used in thermometers.
9. Zirconium metal is used in making bullet proof alloy steels.

Q.4 State some important uses of non-metals.

Ans. The important uses of non-metals are summarized as follows.

1. Hydrogen is used in the hydrogenation of vegetable oils to make vegetable ghee (or venaspati ghee.) Hydrogen is also used in the manufacture of ammonia which in turn is used for the manufacture of fertilizers.
2. Carbon is one of the most important non-metal because life is based up on it. For example carbohydrates, proteins, oils and fats, vitamins, enzymes etc. which are all made up of carbon compounds are the basic units of life supporting substance. Carbon in form of graphite, is also used as electrodes in electrolytic cells and dry cells.
3. Oxygen gas in air imparts its use in different life processes and combustion processes.
4. Nitrogen is used in the manufacture of ammonia, nitric acid and fertilizers. Some of the compounds of nitrogen, such as trinitrotoluene (TNT), nitroglycerine etc. are used as explosives.
5. Sulphur is present in many of the substances found in plants and animals. It is present in proteins, hair, Onion, garlic, wool etc. it is used in as a fungicide and in making gunpowder.

Q. What is the cause of chemical combination? "OR" Why do metals and non-metals react?

Ans. Two theories or concepts are used to explain the cause of chemical combination these are:-

i. **Electronic theory or octet rule**:- Tendency of the atoms to acquire the stable nearest noble gas electronic configuration. This theory was given by Kossel and Lewis. The noble gases have eight electrons (octet) in their valence shells except helium which has two electrons (duplet) and are chemically less reactive. This configuration was regarded as extra stable electronic configuration.The atoms of all other elements have less than eight electrons in their valence shells and are reactive in nature. The atoms of these elements combine with each other with the redistribution of electrons in the valence shells so that they acquire the stable nearest noble gas configuration (duplet or octet).

ii. **Tendency to acquire a state of minimum energy (modern concept)**:-According to modern concept, the atoms of various elements combine with each other only if the chemical

Scanned with CamScanner

combination leads to the decrease in the energy of the system. If on chemical combination the energy of the system increases, no bond is said to be formed between them.

Q. What are the different modes of chemical combination? OR How do atoms combine?

Ans. To acquire stability, all atoms tend to complete their octets (i.e. outer most shell with eight electrons) or duplet (i.e. outer most shell with two electrons, if K-shell is the outer most shell) in order to acquire the nearest noble gas configuration.

To acquire the nearest noble gas configuration. the atoms combine, by any one of the following methods.

1. **By transfer of electrons**:- By transfer of one or more electrons from valance shell of one atom to the other forming an electrovalent (or ionic) bond.
2. **By mutual sharing of electron** :- By mutual sharing of one, two or three pairs of electrons between two atoms forming covalent bond.
3. **By one sideds sharing of electron:-**By sharing one electron pair in which the shared electron pair is contributed by only one of the combining atoms resulting in the formation of a co-ordinate or dative bond.

Q. What is electron dot structure? Give electron dot structure of some elements.

Ans. In the formation of a chemical bond between two atoms, only the electrons of outer most shell are involved. These electrons present in the outer most shell are called valence electrons.

G.N. Lewis introduced a simple method of representing the valence electrons by dots or small crosses around the symbol of the atom. These symbols are known as electron dot symbols or Lewis symbols. A few examples of given below:

Element	symbol	At. No.	Valence electrons	Lewis symbol
Hydrogen	H	1	1	H or H ×
Helium	He	2	2	He or He
Lithium	Li	3	1	Li or Li ×
Beryllium	Be	4	2	Be or Be
Boron	B	5	3	B or B
Carbon	C	6	4	C or C
Nitrogen	N	7	5	N or N
Oxygen	O	8	6	O or O
Flourine	F	9	7	F or F
Neon	Ne	10	8	Ne or Ne

Q. What is ionic or electrovalent bond?

Ans. It is the chemical bond formed between the two atoms by the transfer of one or more electrons from the valence shell of one atom to the other atom. This bond is formed between metal atoms and non-metal atoms. One of the combining atoms (metal atom) loses one or more electrons and becomes cation. The other atom (non-metallic atom) gains one or more electrons and becomes an anion. The cation and anion attract each other and are held together by strong electrostatic forces of attraction. This electrostatic force of attraction that binds cations and anions together is known as ionic bond or electrovalent bond. The compounds formed as a result ofionic bond or electrovalent bond

Scanned with CamScanner

are called ionic or electrovalent compounds e.g. NaCl, $MgCl_2$ KCl etc. To illustrate the formation of ionic compounds, a few examples are given below:-

II **Formation of sodium chloride (NaCl).**

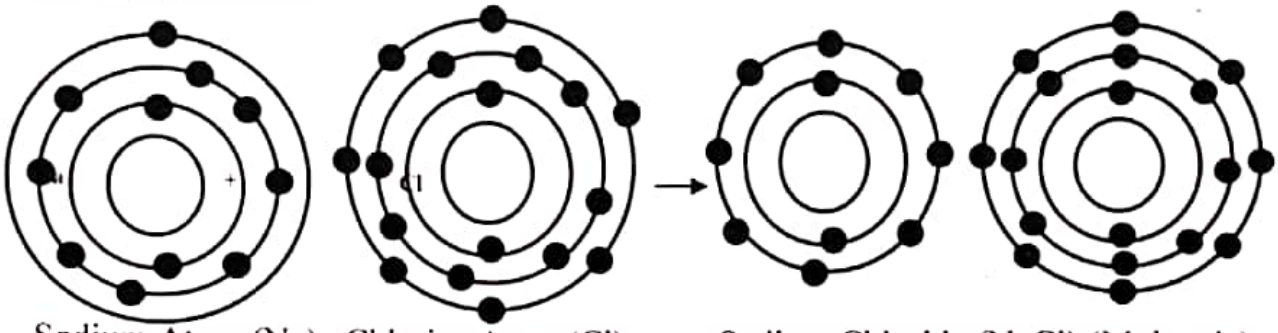
Atomic member of sodium, Na = 11 its electronic configuration, = 2, 8, 1

Atomic number of chlorine, Cl = 17 its electronic configuration = 2, 8, 7.

During the formation of sodium chloride, one electron is transferred from valence shell of sodium to valence shell of chlorine atom. The transfer of electron from sodium to chlorine may be represented as follows:-

$$Na \longrightarrow Na^+ + e^-$$
$$Cl_2 \longrightarrow 2Cl$$
$$Cl + e^- \longrightarrow Cl^-$$
$$Na^+ + Cl^- \longrightarrow Na^+ Cl^- \text{ or } NaCl$$

This can be represented by writing complete structure of the atoms involved in the bond formation as under

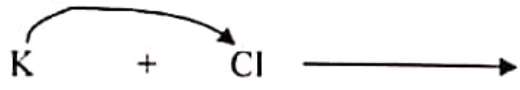


Sodium Atom (Na) Chlorine Atom (Cl) Sodium Chloride (NaCl) (Molecule)

ii. **Formation of potassium chloride (KCl)**

Atomic number of potassium, K=19 electronic configuration of K= 2, 8, 8, 1. it loses the valance electron to form K^+ ion and attains the nearest noble gas configuration as that of argon (2, 8, 8).

Atomic number of chlorine =17 electronic configuration of Cl = 2, 8. 7 it gains one electron in valence shell to form Cl^- and attains nearest noble gas configuration of argon thus, formation of KCl, by transfer of electron from K to Cl may be represented as follows:-

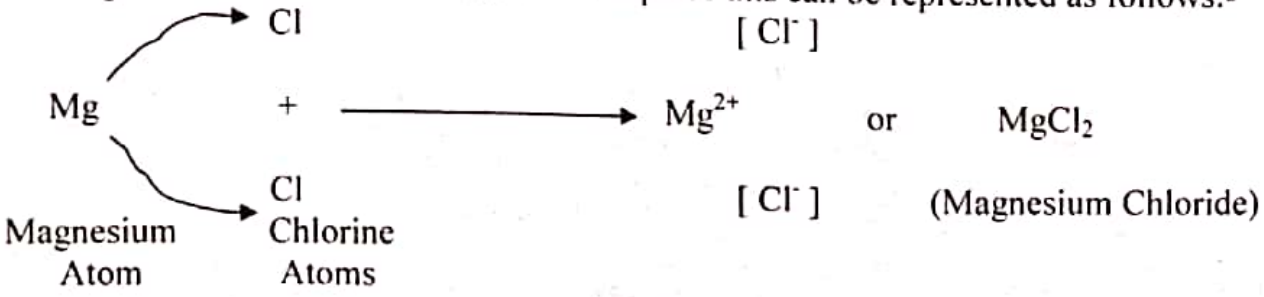


$$K + Cl \longrightarrow K^+ Cl^- \quad \text{or} \quad KCl$$

Potassium atom chlorine atom Potassium Chloride

3. **Formation of magnesium chloride ($MgCl_2$).**

Atomic number of magnesium (Mg) =12 its electronic configuration = 2,8,2. it loses two electrons from the valence shell to acquire the nearest noble gas configuration. of neon (2,8) and form Mg^{2+} ion. Atomic no of Chlorine (Cl) = 17. it needs only one electron in the valence shell to acquire the nearest noble gas configuration of argon (2,8,8) and form chloride ion (Cl^-) therefore, the transference of two electrons from one magnesium to two chlorine atoms takes place this can be represented as follows:-



Cl [Cl^-]

Mg + $\longrightarrow$ Mg^{2+} or $MgCl_2$

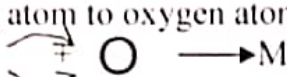
Cl [Cl^-] (Magnesium Chloride)

Magnesium Atom Chlorine Atoms

Scanned with CamScanner

4. **Formation of Magnesium oxide (MgO):-**

Atomic number of magnesium (Mg) = 12 its electronic configuration = 2, 8, 2.
It loses two electrons to acquire stable configuration of neon (2,8) and form Mg^{2+} ion.
Atomic No. of oxygen (O) = 8 Its electronic configuration = 2, 6 . it gains two electrons in the valence shell to acquire the stable configuration of neon (2,8) and form O^{2-} ion.
Thus, in the formation of magnesium oxide, two electrons are transferred from magnesium atom to oxygen atom as represented below:-



Mg: $\rightarrow Mg^{+}\ O^{2-}$ or MgO

Magnesium atom — Oxygen atom — Magnesium oxide.

Q. Give some important properties of ionic compounds.

Ans. Some of the important properties of ionic compounds are as follows:-

1. **Physical state:-** Most of the ionic compounds are crystalline solids. They are relatively hard because of strong electrostatic forces of attraction between the oppositely charged ions. They are britle and break into pieces on applying force.
2. **Solubility:-** They are soluble in water but insoluble in organic solvents such as alcohol, petrol, kerosene oil etc.
3. **Melting points and boiling points:-** They have high melting and boiling points.
4. **Ionic compounds impart characteristic colours to the flame:-** Most of the ionic salts when brought into the flame, impart characteristic colours to the flame. e.g. sodium chloride imparts golden yellow colour, potassium salts impart violet colour and barium salts impart green colour to the flame.
5. **Electrical conductivity:-** Upon dissolving in water ionic compounds dissociate into free ions. As these ions can conduct electricity Therefore ionic compounds conduct electricity in the aqueous solution.

Q. How do metals occur in nature?

Ans. Metals are found to occur in the nature either in free state (also called native state) i.e. free elements or in the combined state i.e. in the form of their compounds. This is because of the fact that different metals possess different chemical reactivities.

1. **Free or Native State:-** The metals at the bottom of the activity series are least reactive therefore, these are not attacked by moisture, oxygen and carbon dioxide in the air. Thus they occur in the native state. e.g. Gold and Platinum.
2. **Combined state:-**The metals at the top of the activity series (K, Na, Ca, Mg etc.) are highly reactive. Therefore, these are easily attacked by moisture, oxygen and carbon dioxide of the air. They occur in the combined state in the form of their compounds called minerals.

The metals in the middle of the activity series (Al, Zn, Fe, Pb, etc.) are found in the earth's crust mainly as oxides, sulphides or carbonates.

Q. Where from the metals are obtained in nature? Give their relative abundance in nature?

Ans. The major source of metals (whether in free state or combined state) is the earth's crust. Some metals (Na, K etc) which form soluble salts (like NaCl, $MgCl_2$) are also found to occur in the sea water in the form of their soluble salts.

The most abundant metal on the earth's crust is aluminum (about 7%) followed by iron (about 4%)calcium (3%) sodium (2.7%) potassium (2.5%) magnesium (2%) and titanium (about 0.6%). The remaining metals are present on the earth's crust in very small amounts.

Q. Write note on:-

1. **Mineral:-** The elementary state or the compounds in the form of which the metals occur in nature are called minerals. Minerals are the compounds of metals which occur in nature.

Scanned with CamScanner

2. **Ore:-** The mineral from which the metal can be extracted conveniently and economically is called ore. All minerals are not ores.
3. **Gangue:-** When the minerals are mined from the earth's crust, they are always contaminated with earthy, sandy and rocky impurities. These earthy, sandy and rocky impurities associated with the mineral are called gangue or matrix.

The ores of some common metals are given below:-

Metal	Name of ore	Name of compound present in the ore	Formula of the ore
1. Sodium (Na)	Rock Salt	Sodium Chloride	NaCl
2. Calcium (Ca)	Dolomite	Calcium Magnesium carbonate	$CaCO_3$ $MgCO_3$
3. Aluminium(Al)	Bauxite	Aluminium Oxide	Al_2O_3 $2H_2O$
4. Copper (Cu)	i. Cuprite ii. Copper glance iii. Copper Pyrite	Copper (i) Oxide Copper (i) sulphide Copper Iron sulphide	Cu_2O Cu_2S Cu Fe S_2
5. Iron (Fe)	i. Iron Pyrite ii. Hamatite	Iron sulphide Iron (iii) oxide	Fe S_2 Fe_2 O_3
6. Zinc (Zn)	i. Zinc Blend ii. Calamine	Zinc Sulphide Zinc Carbonte	ZnS $ZnCO_3$
7. Mercury (Hg)	Cinabar	Mercury (ii) Sulphide	HgS
8. Silver (Ag)	Argentite	Silver sulphide	Ag_2S
9. Lead (Pb)	Galena	Lead Sulphide	PbS

Q. What is metallurgy? Describe in detail the various process involved in metallurgy.

Ans. The various steps involved in the extraction of the metal from its ores followed by refining of the metal is called metallurgy.

The actual process employed for the extraction of a particular metal from its ore depends upon a number of factors e.g.

i. Nature of the ore.
ii. Nature of the impurities present.
iii. Nature of the metal to be extracted.

The three main steps involved in the extraction of any metal are:-

1. Enrichment of the ore or Concentration of the ore
2. Extraction of the metal from the concentrated ore.
3. Refining of the impure metal.

1 **concentration of the ore or enrichment of the ore:-** The process of removal of gangue from the powdered ore is called concentration of the ore or enrichment of the ore or ore dressing. The method used for the concentration of the ore depends upon the nature of ore and nature of impurities present in the ore.

The two main methods employed are:

i. Physical method
ii. Chemical method

i. **Physical method:-** Physical method of concentration of ore is of following types:-

a. **Gravity separation or hydraulic washing:-** This method is used for the concentration of oxide ores of heavy metals such as lead, tin, iron etc. the method is based upon the difference in the densities of the ore and the gangue. The powdered ore is spread on

Scanned with CamScanner

special type of table having grooves on the top. A stream of water is thrown from one side of the table. The gangue particles being lighter are washed away with the stream of water leaving behind heavy ore particles on the table.

b. **Froth floatation process:-** This method is based upon the principle that the ore particles are preferentially wetted by oil where as gangue particles are preferentially wetted by water. This method is used for concentration of sulphide ores of copper, Zinc and lead.

In this method the powdered ore is mixed with water in a large tank. Then some pine oil or ethyl xanthate is added to it. The mixture is agitated with air. The lighter ore particles are wetted by the oil and form a froth. The froth being lighter floats on the surface. Then the froth formed is transferred to another tank. However, the gangue particles being heavier settle at the bottom of the tank.

c. **Magnetic separation:-** This method is based upon the principle that the magnetic particles are attracted by a magnet where as non-magnetic particles are not attracted by a magnet and get separated.In this method the powdered ore is placed on a leather belt which passes over two rollers, one of which is magnetic and other is non magnetic. When the magnetic particles come over the roller they are attracted to the magnetic roller and fall apart from the non-magnetic particles.

ii. **Chemical separation or by leaching:-** It is based upon the principle that gangue and ore have different properties and behave differently towards a chemical reagent. In this case, the powdered ore is treated with a suitable reagent (like acid, base etc.) which dissolves the ore particles where as gangue is left behind and are removed by filtration. This process is called leaching. For example, bauxite ore

($Al_2 O_3\ 2H_2O$) can be concentrated by this method. The powdered bauxite ore is heated with concentrated (45%) sodium hydroxide. As a result, aluminium oxide present in the ore reacts with NaOH solution to form water soluble sodium aluminate.

$$Al_2 O_3 + 2Na\ OH \longrightarrow 2Na\ AlO_2 + H_2O$$

Silica present in the ore also reacts with NaOH to form water soluble sodium silicate.

$$SiO_2 + 2Na\ OH \longrightarrow Na_2\ SiO_3 + H_2O$$

Iron oxide present in the ore does not dissolve in NaOH and thus remains as insoluble. It is separated out by filtration.The filtrate containing sodium aluminate and sodium silicate is diluted with water and stirred. Sodium aluminate reacts with water to form a precipitate of aluminium hydroxide where as sodium silicate does not react and remains in the solution.

$$Na\ AlO_2 + 2H_2O \longrightarrow Al\ (OH)_3 + NaOH$$

The precipitate is washed, dried and then heated strongly. It decomposes to give pure alumina.

$$2Al\ (OH)_3 \xrightarrow[\text{Heating}]{\text{Strong}} Al_2O_3 + 3\ H_2O$$

2. **Extraction of the metal from the concentrated ore:-** The method used for the extraction of the metal from the concentrated ore depends upon the nature of the metal. Based on their reactivity, the metals have been grouped into the following three categories.

a. Metals of low reactivity (low in the activity series)
b. Metals of medium reactivity (in the middle of the activity series)
c. Metals of high reactivity (At top of the activity series)

a. **Extraction of metals low in the activity series (Cu, Hg, Ag, Au, Pt)**

Among these metals gold and platinum are found in their native states. For other metals like Cu and Hg, the basic principles of their extraction from the concentrated ore are explained below:-

Scanned with CamScanner

Roasting:- As most common ores of above mentioned metals are sulphides therefore, the method required for extraction is **roasting**. In roasting metal sulphides are converted into metal oxides, the oxides formed on further heating are reduced to metals. For example:-

$$2HgS + 3O_2 \xrightarrow{Heating} 2HgO + 2SO_2$$

(Cinnabar ore of Hg)

$$2HgO \xrightarrow{Heat} 2Hg + O_2$$

Similarly,

$$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$$
$$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$$

b. **Extraction of metals in the middle of the activity series (Fe, Zn, Pb etc.)**

These metals are found in nature in the form of their oxides, sulphides and carbonate ores. Further, as it is easier to reduce oxides than sulphides and carbonates, therefore, the sulphide and carbonate ores are first converted into the corresponding metal oxides, which in turn are converted into metals. The different steps involved are as follows:-

i. **Calcination (For carbonate ores):-** It is the process of heating the carbonate ore strongly in the absence of air, so as to form metal oxide e.g.

$$ZnCO_3 \xrightarrow{Heating} ZnO + CO_2$$

(Calamine ore of Zinc)

ii. **Roasting (for sulphide ores):** It is the process of heating the sulphide ore strongly in presence of air.

$$2ZnS + 3O_2 \xrightarrow[Presence\ of\ air]{Heating} 2ZnO + 2SO_2$$

The metal oxides obtained above can not be reduced directly into their corresponding metals. Therefore, a suitable reducing agent such as carbon (Coke) is used. e.g.

iii. **Smelting**:-The reduction of metal oxides by heating with coke is called smelting.

$$Fe_2O_3 + 3C \xrightarrow{\Delta} 2Fe + 3CO$$
$$ZnO + C \longrightarrow Zn + CO$$

The active metals can't be obtained by reduction of their oxides with coke because these metal oxides are very stable.The oxides of metals like copper and manganese can not be reduced by using coke. Therefore, such metal oxides are reduced by strongly heating the mixture with aluminium e.g.

$$Cu_2O_3 + 2Al \longrightarrow 2Cu + Al_2O_3$$
$$3MnO_2 + 4Al \longrightarrow 3Mn + 2Al_2O_3$$

The reduction of metals oxides to metal using aluminium as reducing agent is called as aluminothermy.

b. **Extraction of metals High up in the activity series (K, Ca, Mg, and Al) (Electrometallurgy):-** The process of extraction of the metal from the concentrated ore using electric current or by electrolysis is called electro metallurgy.

The highly electro positive metals such as Li, Na, K, Ca, Mg etc are extracted by this method. These metals are extracted by the electrolysis of their molten halide or oxides. The metal is produced at cathode. e.g. sodium is obtained by the electrolysis of molten Na Cl.

$$2NaCl \longrightarrow 2Na^+ + 2Cl^-$$

At Anode

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

At cathode

$$2Na^+ + 2e^- \longrightarrow 2Na$$

Scanned with CamScanner

Similarly electrolysis of Al_2O_3 can be represented as follows:

$$Al_2O_3 \longrightarrow 2Al^{3+} + 3O^{2-}$$

At anode

$$3O^{2-} \longrightarrow 3O + 6e^-$$
$$O + O \longrightarrow O_2$$

At Cathode.

$$2Al^{3+} + 6e^- \longrightarrow 2Al$$

3. **Refining of impure metals:-** The process of purifying the impure (crude) metal is called refining of the metal.

The most commonly employed method for the purification of metals is electrolytic refining. A large number of metals such as copper, silver, gold, nickel, chromium, zinc, aluminium, tin, lead etc are purified by this method.

let us take the example of electrolytic refining of copper. In this method a container called electrolytic tank is taken. In this tank a solution of copper sulphate is taken as an electrolyte. The impure copper is taken as anode. A thin plate of pure copper acts as cathode. On passing electric current, pure copper from the anode passes into the solution as Cu^{2+} ions. An equivalent amount of Cu^{2+} ions from the solution are deposited on the cathode as pure copper. The reactions that take place at cathode and anode are shown as follows:-

At Anode

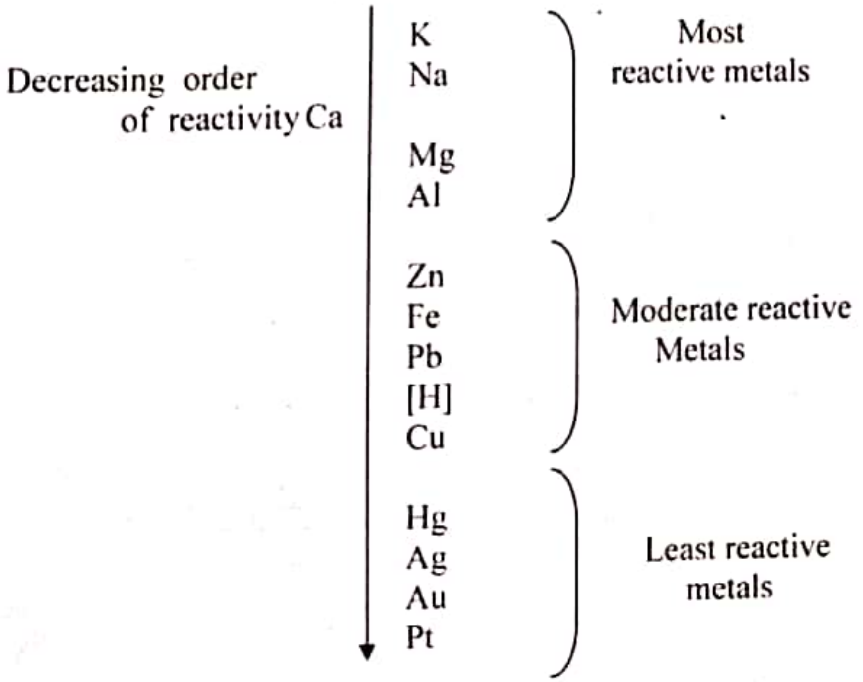
$$\underset{\text{Copper atom}}{Cu} \longrightarrow \underset{\text{Copper ions}}{Cu^{2+}} + 2e^-$$

At Cathode

$$\underset{\text{Copper ions}}{Cu^{2+}} + 2e^- \longrightarrow \underset{\text{Copper atom}}{Cu}$$

Q. What is activity series?

Ans. The arrangement of metals in a vertical column in order of their decreasing reactivity with respect to each other is called activity series of metals. In activity series, the most active metal is placed at the top, where as the least reactive metal is placed at the bottom.



Scanned with CamScanner

Q. What is corrosion? Explain by suitable examples.

Ans. The process of slow eating up (decay) of metals due to their conversion into oxides, carbonates, sulphides, sulphates etc. by the action of atmospheric gases and moisture is called corrosion. A few examples of corrosion are given below:

i. When iron is exposed to moist air for a long time, its surface gets covered with a coating of a brown, flaky (or non-sticky) substance called rust. This is due to the reaction of oxygen and moisture (present in the air) on the surface of iron. Rust is mainly hydrated ferric oxide.

$$\underset{\text{Iron}}{2Fe} + \underset{\text{(air)}}{^3/_2\, O_2} + \underset{\text{moisture}}{X\, H_2O} \longrightarrow \underset{\text{(Rust)}}{Fe_2O_3\ X\, H_2O}$$

ii. Similarly copper objects when remain exposed to air, their surface reacts with CO_2 and moisture present in the air forming a green coating of basic copper carbonate.

$$\underset{\text{Copper}}{2Cu} + \underset{\text{From moist air}}{CO_2 + O_2 + H_2O} \longrightarrow \underset{\text{(Basic copper carbonate green)}}{CuCO_3 \cdot Cu(OH)_2}$$

iii. The surface of silver metal gets tarnished on exposure to air. This is due to the formation of a coating of black silver sulphide (Ag_2S) on its surface by the action H_2S gas present in air.

$$\underset{\text{Silver}}{2Ag} + H_2S \longrightarrow \underset{\text{Silver Sulphide (Black)}}{Ag_2S} + H_2$$

Q. What is Rusting? State the conditions necessary for rusting.

Ans. Corrosion of iron is called rusting i.e. when iron is exposed to moist air for a long time, its surface acquires a coating of a red brown flaky substance called rust. Rust is mainly hydrated iron oxide. ($Fe_2O_3\ X\, H_2O$)

During rusting of iron, iron metal combines with oxygen of air in presence of moisture to form hydrated iron oxide. The number of molecules of water varies in it, but is not fixed.

$$\underset{\text{Iron}}{2Fe} + \underset{\text{(air)}}{^3/_2\, O_2} + \underset{\text{moisture}}{X\, H_2O} \longrightarrow \underset{\text{(Rust)}}{Fe_2O_3\ X\, H_2O}$$

Rust can be commonly observed in the form of red brown flaky substance on screws, nails, pipes and railings. It is not only the iron which rusts, even the steel rusts on being exposed to damp air or on being kept in water but steel rusts less readily than iron. The conditions necessary for rusting are:-

a. Presence of air

b. Presence of moisture.

Q. What are alloys? How alloys are prepared? Discuss various types of alloys with suitable examples.

Ans. An alloy is a homogeneous mixture of two or more metals, or a metal and a non-metal e.g. brass, bronze, alnico etc.

An alloy is usually prepared by first melting the main metal and then dissolving the other elements in it in definite proportions. It is then cooled to room temperature.

Alloys have been divided in to following three types.:-

1. **Ferrous Alloys:-** An alloy in which iron is present as one of the constituents is called as ferrous alloy. e.g. manganese steel (Fe = 86 %, Mn = 13% C= 1%) and nickel steel (iron = 96 – 98% Ni = 4- 2 %)

Scanned with CamScanner

2. **Non- Ferrous alloys:-**An alloy which does not contain iron as a one of the constituents is called non-ferrous alloy. e.g.
Brass (Cu = 80% Zn = 20 %)
Bronze (Cu = 90% Sn = 10%)

3. **Amalgam:-** An alloy containing mercury as one of the constituent metals is known as amalgam e.g. sodium amalgam, zinc amalgam etc.

Q. What are the objectives/ advantages/ merits of alloy making?

Ans. Alloys are prepared to develop certain specific properties which are not possessed by constituent elements. The main objectives of alloy making are:-

1. **To increase hardness**. when carbon is added to iron, its hardness increases. This hardened iron is called steel.
2. **To increase tensile strength.** Chrome steel prepared by mixing iron and chromium has high tensile strength.
3. **To increase resistance to corrosion.** Stain less steel which is an alloy of iron, chromium and nickel resist corrosion.
4. **To lower melting point** Solder an alloy of tin and lead has a lower melting point than either of its constituents. It is therefore, used for joining electrical wires together.
5. **To modify chemical reactivity**. Sodium is highly reactive metal. Its reactivity can be reduced by making its alloy with mercury i.e. amalgam.
6. **To reduce electrical conductivity**. Conductivity of copper decreases when it is alloyed with other metals.
7. **To modify colour**. Aluminium is silvery white while copper is brown but aluminium bronze, an alloy of aluminium and copper has beautiful yellow colour and is used for making coins, picture frames and cheap jewelry.

Text Book Questions

Page No 145

Q.1 Give an example of a metal which

a. is a liquid at room temp?

Ans. Metal which is liquid at room temp. is mercury

bcan be easily cut with a knife.

Ans.

c. is the best conductor of heat.

d. is the poorest conductor of heat.

Ans. a. .

b. Metals such as Lithium, Sodium, Potassium etc ca be cut with a knife.

c. Silver is the best conductor of heat.

d. Lead is the poorest conductor of heat.

Q. Explain the meaning of malleable and ductile.

Ans. **Malleability:** The property which allows the metals to be hammered into thin sheets is called malleability. Malleability is an important characteristic property of metals. Most of the metals are malleable. Gold and silver are the most malleable metals

Ductility:- The property which allows the metals to be drawn into thin wires is called ductility. Ductility is another characteristic property of metals. Most of the metals are ductile. Gold and silver are the most ductile metals. Gold is so ductile that 1 gram of gold can be drawn in to a wire of about 2 kilo meter.

Q. Why is sodium kept immersed in kerosene oil?

Ans. Sodium is a very reactive metal. It reacts with oxygen of the air to form sodium oxide. It also reacts with moisture present in air to form sodium hydroxide and hydrogen. The hydrogen thus produced some times catches fire & results in explosive type of reaction.

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

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

Scanned with CamScanner

Therefore, to protect the metal and also to prevent accidental fires sodium is kept immersed in kerosene oil.

Q. Write equations for the reactions of:-

a. Iron with steam.

b. Calcium and potassium with water.

Ans. a. Iron reacts with steam to form magnetic oxide and hydrogen gas

$$3Fe + 4H_2O \longrightarrow Fe_3O_4 + 4H_2$$

(iron) (steam) (Magnetic oxide of iron)

b. Potassium reacts violently with cold water producing potassium hydroxide and hydrogen gas.

$$2K + 2H_2O \longrightarrow 2KOH + H_2 + Heat$$

Calcium reacts less violently with cold water as compared with that of potassium.

$$Ca + 2H_2O \longrightarrow Ca(OH)_2 + H_2$$

Q. Question in tabulated form available on book :

Ans. a. A can displace Cu, B can displace Fe, C can displace Ag. As order of reactivity of Cu, Fe and Ag is Fe > Cu> Ag. Hence B is the most reactive metal.

b. As B is more reactive than copper, it will displace copper from Cu (II) sulphate solution. Hence blue colour of $CuSO_4$ will fade.

c. B can displace Fe, A can displace Cu, C can displace Ag and D can displace none. Hence order of decreasing reactivity will be B>A>C>D.

Q. Which gas is produced when dilute hydrochloric acid is added to a reactive metal? Write the chemical reaction when iron reacts with dilute H_2SO_4.

Ans. When dilute hydrochloric acid is added to active metals like Zn, H_2 gas is produced.

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

Iron reacts with dilute sulphuric acid to produce hydrogen gas.

$$Fe + H_2SO_4 \longrightarrow FeSO_4 + H_2$$

Q. What would you observe when Zinc is added to a solution of Iron (II) sulphate? Write the chemical equation that takes place.

Ans. From the activity series, it is evident that Zinc is more reactive than iron. Therefore, when Zinc is added to $FeSO_4$, iron gets displaced by Zinc as shown.

$$Zn + FeSO_4 \longrightarrow ZnSO_4 + Fe$$

Q. a. Write the electron dot structures of sodium, oxygen and magnesium.

Ans. The electronic configuration of Na is:-

K	L	M
2	8	1

∴ Electron dot structure of sodium is $Na^{\bullet}$

The electric configuration of oxygen is.

K	L
2	6

∴ Electron dot structure of oxygen is $:\overset{\bullet\bullet}{O}:$

Electronic Configuration of Magnesium is

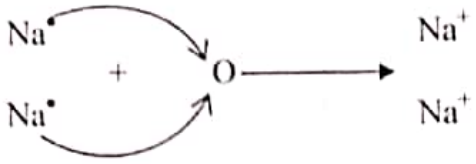
K	L	M
2	8	2

∴ Electron dot structure of Mg is. $Mg:$

Scanned with CamScanner

b. Show the formation of Na_2O and MgO by transfer of electrons.

Ans. Formation of Na_2O.



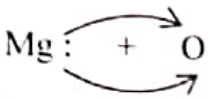
O^{2-} Or $[Na^+]_2\ [O^{2-}]$ or Na_2O

$2Na \longrightarrow 2Na^+ + 2e^-$

$O + 2e^- \longrightarrow O^{2-}$

$2Na + O^{2-} \longrightarrow Na_2O$

Formation of MgO



$\longrightarrow Mg^{2+}\ [O]^{2-}$ or MgO

$Mg \longrightarrow Mg^{2+} + 2e^-$

$O + 2e^- \longrightarrow O^{2-}$

$Mg + O^{2-} \longrightarrow MgO$

c. What are the ions present in these compounds.

Ans. a. In Na_2O, ions present are sodium Cation (Na^+) and oxide anion (O^{2-})

b. In MgO, ions present are magnesium cation (Mg^{2+}) and oxide anion (O^{2-})

Q. Why do ionic compounds have high melting point?

Ans. the compounds formedby the transfer of electrons from one atom to another are known as ionic compounds. These compounds are composed of cations and anions. These constituents (cations and anions) of ionic compounds are held together by very strong electrostatic forces of attraction. To break down these forces, a large amount of energy is needed. As a result, the melting points of ionic compounds are quite high.

Q. Name two metals which are found in nature in the free state.

Ans. Gold and Platinum.

Q. What chemical process is used for obtaining a metal from its oxide?

Ans. Metal are obtained from its oxides by reduction .The reduction of metal oxide is carried by **,Smelting orby heating with highly reactive metals such as sodium, calcium, aluminium**

(i) Smelting: In this method metal is obtained from its oxide by reduction usingcarbon (coke) as reducing agent. This reduction done by heating metal oxides with carbon (coke)

$ZnO + C \longrightarrow Zn + CO$

(ii) **By heating with highly reactive metals such as sodium, calcium, aluminium :** In this method metal is obtained from its oxide by reduction usinghighly reactive metals such as sodium, calcium, aluminium as as reducing agent.This reduction done by strongly heating metal oxides with highly reactive metals such as sodium, calcium, aluminium.

$3\ MnO_2 + 4\ Al \longrightarrow 2Al_2O_3 + 3Mn$

The reduction of metals oxides to metal using aluminium as reducing agent is called as **aluminothermy.**

Q. Metallic oxides of Zinc, Magnesium and copper were heated with the following metals. Zinc Magnesium Copper

Ans. The position of the above given metals in the activity series is as follows:-

K> Na >**Mg** > Ca> Al>**Zn** > Fe >**Cu**> Ag > Au > Pt.

Scanned with CamScanner

It is evident from the activity series that magnesium is more reactive than zinc followed by copper. Therefore, magnesium can displace both zinc and copper from their respective oxides as follows

$Mg + ZnO \longrightarrow MgO + Zn$

$Mg + CuO \longrightarrow MgO + Cu$

Also zinc can displace copper from copper oxide but can not displace magnesium from magnesium oxide

$Zn + CuO \longrightarrow ZnO + Cu$

$Zn + MgO \longrightarrow$ No reaction

Copper being least reactive among the given series of metals can neither displace magnesium nor zinc from their respective oxides.

$Cu + MgO \longrightarrow$ No reaction

$Cu + ZnO \longrightarrow$ No reaction

Q. Which metals do not corrode?

Ans. Metals such as Au, Ag and Pt which lie low in the activity series are highly un reactive. Therefore they are not attacked by atmospheric gases and moisture and hence do not corrode.

Q. What are amphoteric oxides? Give examples of two amphoferic oxides.

Ans. Oxides which react with both acids and bases to form salts and water are called amphoteric oxides. The well known examples of amphoferic oxides are Zinc oxide (ZnO) and aluminium oxide (Al_2O_3). They react with acids and bases as shown below:-

$ZnO + 2HCl \longrightarrow Zn Cl_2 + H_2O$ (Acid)

$ZnO + 2NaOH \longrightarrow Na_2 ZnO_2 + H_2O$ (Base)

$Al_2O_3 + 6HCl \longrightarrow 2Al Cl_3 + 3H_2O$ (Acid)

$Al_2O_3 + 2NaOH \longrightarrow 2Na AlO_2 + H_2O$ (Basic)

Q. Difference between metals and non-metals on the basis of their physical properties.

Ans. The main features that distinguish metals from non-metals are given below:

Metals	Non –metals
1. Metals are generally solid in nature at room temp. (except Hg which is a liquid)	1. Non- metals exist in all the three states i.e. solid, liquid and gaseous state.
2.Metals possess bright luster.	2. Non-metals have dull appearance.
3. Metals have high density (except Na and K which are lighter than H_2O)	3. Non –metals have low densities (except diamond which has a high density.)
4. Metals are usually malleable (except zinc and Hg)	4. Non-metals are non-malleable.
5. Metals are usually ductile (except Zn and Hg)	5. Non-metals are not ductile.
6. Metals are hard and have high tensile strength	6. Non-metals are soft in nature (except diamond which is hardest substance known)
7. Metals are hard but not brittle	7. Non-metals are brittle in nature
8. Metals are good conductors of heat and electricity	8. Non metals are non-conductors of heat and electricity except carbon (graphite).

Scanned with CamScanner

9. Generally metals have high melting and boiling points	9. Non-metals have low melting and boiling points (except carbon, boron and silicon).

Scanned with CamScanner

Q. Compare metals with non-metals on the basis of their chemical properties.

Metals	Non-metals
1. Atoms of metals usually have 1,2, or 3 electrons in their outer most shells.	1. Atoms of non-metals usually have 4 to 7 electrons in their outer most shells.
2. Metals form positive cations by losing electrons i.e. they are electropositive	2. Non metals form negative anions by gaining electrons i.e. they are electronegative in nature.
3. Metals above hydrogen in the activity series usually replace hydrogen from dilute acids.	3. Non- metals do not react with acids.
4. Almost all metals react with oxygen to form oxides. The oxides of metals are generally basic in nature.	4. Non-metals react with oxygen to form oxides, which are generally acidic in nature.
5. Metals have a tendency to lose electrons and hence act as reducing agents. $Na - e^- \longrightarrow Na^+$	5. Non –metals have a tendency to gain electrons and act as oxidizing agents. $Cl + e^- \longrightarrow Cl^-$
6. Metallic chlorides are ionic in nature. They act as electrolytes	6. Non-metal chlorides are covalent in nature and ct as not-electrolytes. A

Scanned with CamScanner