CHAPTER- METALS AND NON METALS

Metals are the elements that conduct heat and electricity and are malleable and ductile. Examples are Iron (Fe), Aluminium (Al), Silver (Ag), Copper (Cu), Gold (Au), Platinum (Pt), Lead (Pb), Potassium (K), Sodium (Na), Calcium (Ca) and Magnesium (Mg) etc.
Metals are the elements which form positive ions by losing electrons. Thus, metals are known as Electropositive Elements.

Physical Properties of Metals

Hardness: Most of the metals are hard, except alkali metals, such as sodium, potassium, lithium, etc. are very soft metals. These can be cut by using a knife.
Strength: Most of the metals are strong and have high tensile strength. Because of this, big structures are made using metals, such as copper (Cu) and iron (Fe). (Except Sodium (Na) and potassium (K) which are soft metals).
State: Metals are solid at room temperature except for mercury (Hg).
Sound: Metals produce ringing sound, so, metals are called Sonorous. Sound of metals is also known as Metallic sound. This is the cause that metal wires are used in making musical instruments.
Conduction: Metals are a good conductor of heat and electricity. This is the cause that electric wires are made of metals like copper and aluminium.
Malleability: Metals are malleable. This means metals can be beaten into a thin sheet. Because of this property, iron is used in making big ships.
Ductility: Metals are ductile. This means metals can be drawn into thin wire. Because of this property, a wire is made of metals.
Melting and Boiling Point: Metals have generally high melting and boiling points. (Except sodium and potassium metals which have low melting and boiling point.)
Density: Most of the metals have a high density.
Colour: Most of the metals are grey in colour. But gold and copper are exceptions.

Chemical Properties of Metals

1. Reaction with oxygen: Most of the metals form respective metal oxides when reacting with oxygen.
Metal + Oxygen → Metal Oxide
Examples:
Reaction of Potassium with Oxygen: Potassium metal forms potassium oxide when reacts with oxygen.

$$4K + O_2 \longrightarrow 2K_2O$$

Potassium Oxygen → Potassium oxide

Reaction of Sodium with Oxygen: Sodium metal forms sodium oxide when reacts with oxygen.

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

Sodium Oxygen → Sodium oxide

Lithium, potassium, sodium, etc. are known as Alkali-metals. Alkali metals react vigorously with oxygen.
Reaction of Copper metal with Oxygen: Copper does not react with oxygen at room temperature but when burnt in air, it gives oxide.

$$2Cu + O_2 \longrightarrow 2CuO$$

Copper Oxygen → Copper(II) oxide

Silver, gold and platinum do not combine with the oxygen of air even at high temperature. They are the least reactive.

Reaction of metals with water: Metals form respective hydroxide and hydrogen gas when reacting with water.

Metal + Water → Metal hydroxide + Hydrogen

Most of the metals do not react with water. However, alkali metals react vigorously with water.

Reaction of Sodium metal with Water: Sodium metal forms sodium hydroxide and liberates hydrogen gas along with lot of heat when reacting with water.

$$\underset{\text{Sodium}}{Na} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Sodium hydroxide}}{NaOH} + \underset{\text{Hydrogen}}{H_2}$$

Reaction of Calcium metal with Water: Calcium forms calcium hydroxide along with hydrogen gas and heat when react with water.

$$\underset{\text{Calcium}}{Ca} + \underset{\text{Water}}{2H_2O} \longrightarrow \underset{\text{Calcium hydroxide}}{Ca(OH)_2} + \underset{\text{Hydrogen}}{H_2}$$

Reaction of Magnesium metal with Water: Magnesium metal reacts with water slowly and forms magnesium hydroxide and hydrogen gas.

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Magnesium hydroxide}}{Mg(OH)_2} + \underset{\text{Hydrogen}}{H_2}$$

When steam is passed over magnesium metal, magnesium oxide and hydrogen gas are formed.

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Magnesium oxide}}{MgO} + \underset{\text{Hydrogen}}{H_2}$$

Reaction of Aluminium metal with Water: Reaction of aluminium metal with cold water is too slow to come into notice. But when steam is passed over aluminium metal, aluminium oxide and hydrogen gas are produced.

$2Al + 3H_2O \rightarrow Al_2O_3 + 2H_2$

Reaction of Zinc metal with Water: Zinc metal produces zinc oxide and hydrogen gas when steam is passed over it. Zinc does not react with cold water.

$$\underset{\text{Zinc}}{Zn} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Zinc oxide}}{ZnO} + \underset{\text{Hydrogen}}{H_2}$$

Reaction of Iron with Water: Reaction of iron with cold water is very slow and comes into notice after a long time. Iron forms rust (iron oxide) when reacts with moisture present in the atmosphere. Iron oxide and hydrogen gas are formed by passing of steam over iron metal.

$$\underset{\text{Iron}}{3Fe} + \underset{\text{Water}}{4H_2O} \longrightarrow \underset{\text{Iron(III) oxide}}{Fe_3O_4} + \underset{\text{Hydrogen}}{4H_2}$$

Both calcium (Ca) and magnesium (Mg) are heavier than water but still float over it: Both calcium and magnesium float over water surface because hydrogen gas is evolved when these metals react with water. It is in the form of bubbles which stick on the metal surface. Therefore,

they float over it.

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

Other metals usually do not react with water or react very slowly. Lead, copper, silver and gold do not react with steam. Thus, the order of reactivity of different metals towards water may be written as :

K > Na > Ca > Mg > Zn > Fe > Pb > Cu > Ag > Au

Reaction of metals with dilute acid: Metals form respective salts when reacting with dilute acid.

Metal + dil. acid → Metal salt + Hydrogen

Reaction of Sodium metal with dilute hydrochloric acid: Sodium metal gives sodium chloride and hydrogen gas when react with dilute hydrochloric acid.

$$\underset{\text{Sodium}}{2Na} + \underset{\text{Hydrochloric Acid}}{2HCl} \longrightarrow \underset{\text{Sodium Chloride}}{2NaCl} + \underset{\text{Hydrogen}}{H_2}$$

Reaction of Magnesium metal with dilute hydrochloric acid: Magnesium chloride and hydrogen gas are formed when magnesium reacts with dilute hydrochloric acid.

$$\underset{\text{Magnesium}}{Mg} + \underset{\text{Hydrochloric Acid}}{2HCl} \longrightarrow \underset{\text{Magnesium Chloride}}{MgCl_2} + \underset{\text{Hydrogen}}{H_2}$$

Reaction of Zinc with dilute sulphuric acid: Zinc sulphate and hydrogen gas are formed when zinc reacts with dilute sulphuric acid. This method is used in the laboratory to produce hydrogen gas.

$$\underset{\text{Zinc}}{Zn} + \underset{\text{Sulphuric acid}}{H_2SO_4} \longrightarrow \underset{\text{Zinc Sulphate}}{ZnSO_4} + \underset{\text{Hydrogen}}{H_2}$$

Hydrogen (H_2) gas is not evolved when metal is treated with nitric acid (HNO_3):

Nitric acid is strong oxidising agent and it oxidises the hydrogen gas (H_2) liberated into water (H_2O) and itself get reduced to some oxide of nitrogen like nitrous oxide $(N_2O)_3$ nitric oxide (NO) and nitrogen dioxide (NO_2).

Copper, gold, silver are known as noble metals. These do not react with water or dilute acids.

The order of reactivity of metal towards dilute hydrochloric acid or sulphuric acid is in the order;

K > Na > Ca > Mg > Al > Zn > Fe > Cu > Hg > Ag

Metal Oxides

Chemical Properties: Metal oxides are basic in nature. The aqueous solution of metal oxides turns red litmus blue.

Reaction of Metal oxides with Water: Most of the metal oxides are insoluble in water. Alkali metal oxides are soluble in water. Alkali metal oxides give strong base when dissolved in water.

Reaction of Sodium oxide with Water: Sodium oxide gives sodium hydroxide when reacts with water.

$$\underset{\text{Sodium oxide}}{Na_2O} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Sodium hydroxide}}{2NaOH}$$

Reaction of Potassium oxide with Water: Potassium oxide gives potassium hydroxide when reacts with water.

$$\underset{\text{Potassium oxide}}{K_2O} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Potassium hydroxide}}{2KOH}$$

Reaction of Zinc oxide and Aluminium oxide: Aluminium oxide and zinc oxide are insoluble in water. Aluminium oxide and zinc oxide are amphoteric in nature. An amphoteric substance shows both acidic and basic characters. It reacts with base like acid and reacts with an acid like a base.

When zinc oxide reacts with sodium hydroxide, it behaves like an acid. In this reaction, sodium zincate and water are formed.

$$\underset{\text{Zinc oxide}}{ZnO} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{Sodium zincate}}{Na_2ZnO_2} + \underset{\text{Water}}{H_2O}$$

Zinc oxide behaves like a base when reacts with acid. Zinc oxide gives zinc chloride and water on reaction with hydrochloric acid.

$$\underset{\text{Zinc oxide}}{ZnO} + \underset{\text{Hydrochloric acid}}{2HCl} \longrightarrow \underset{\text{Zinc chloride}}{ZnCl_2} + \underset{\text{Water}}{H_2O}$$

In a similar way, aluminium oxide behaves like a base when reacts with acid and behaves like acid when reacts with a base.

Aluminium oxide gives sodium aluminate along with water when reacts with sodium hydroxide.

$$\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Sodium hydroxide}}{2NaOH} \longrightarrow \underset{\text{Sodium aluminate}}{2NaAlO_2} + \underset{\text{Water}}{H_2O}$$

Aluminium oxide gives aluminium chloride along with water when it reacts with hydrochloric acid.

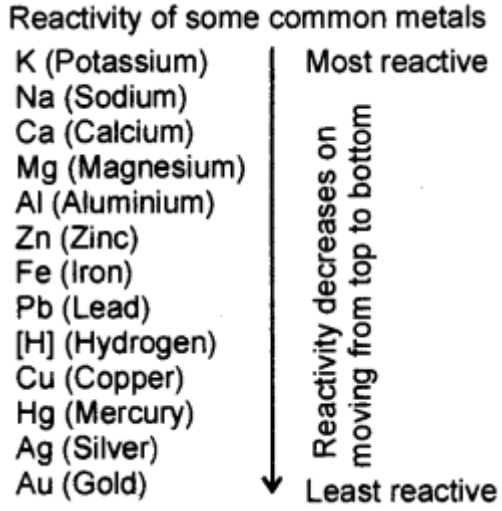
$$\underset{\text{Aluminium oxide}}{Al_2O_3} + \underset{\text{Hydrochloric acid}}{6HCl} \longrightarrow \underset{\text{Aluminium chloride}}{2AlCl_3} + \underset{\text{Water}}{3H_2O}$$

Reactivity Series of Metals: The order of intensity or reactivity of metal is known as Reactivity Series. Reactivity of elements decreases on moving from top to bottom in the given reactivity series.

In the reactivity series, copper, gold, and silver are at the bottom and hence, least reactive. These metals are known as Noble metals. Potassium is at the top of the series and hence, most reactive.

Reactivity of some metals are given in descending order :

K > Na > Ca > Mg > Al > Zn > Fe > Pb > Cu

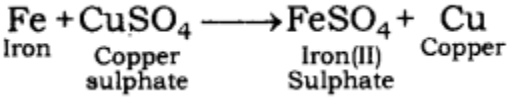


Reaction of metals with solution of other metal salts: Reaction of metals with the solution of other metal salt is displacement reaction. In this reaction, more reactive metal displaces the less reactive metal from its salt.

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

Examples :

Iron displaces copper from copper sulphate solution.



Non-Metals: Physical Properties of non-metals, chemical properties of non-metals, non¬metal oxides, Reaction of metal and Non-metal, Ionic bonds and formation of an ionic bond. Non-metals are the elements that do not conduct electricity and are neither malleable nor ductile. Examples: Carbon (C), Sulphur (S), Phosphorous (P), Silicon (Si), Hydrogen (H), Oxygen (O), Nitrogen (N), Chlorine (Cl), Bromine (Br), Neon (Ne) and Argon (Ar) etc.

Non-metals are the elements which form negative ions by gaining an electron. Thus, non¬metals are also known as Electronegative Elements.

Physical properties of non-metals

Hardness: Non-metals are not hard rather they are generally soft. But the diamond is an exception; it is the hardest naturally occurring substance.

State: Non-metals may be solid, liquid or gas.

Lustre: Non-metals have a dull appearance. Diamond and iodine are exceptions.

Sonority: Non-metals are not sonorous, i.e., they do not produce a typical sound on being hit.

Conduction: Non-metals are a bad conductor of heat and electricity. Graphite which is allotrope of carbon is a good conductor of electricity and is an exception.

Malleability and ductility: Non-metals are brittle.

Melting and boiling point: Non-metals have generally low melting and boiling points.

Density: Most of the non-metals have low density.

Colour: Non-metals are in many colours.

Carbon in the form of graphite is non-metal which conduct electricity.

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

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

Diamond is a non-metal which has a very high melting point and boiling point

Chemical properties of Non-metals

1. Reaction of Non-metals with Oxygen: Non-metals form respective oxide when reacting with oxygen.

Non-metal + Oxygen → Non-metallic oxide

When carbon reacts with oxygen, carbon dioxide is formed along with the production of heat.

$$\underset{\text{Carbon}}{C} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Carbon dioxide}}{CO_2} + \text{Heat}$$

Sulphur gives sulphur dioxide when reacting with oxygen. Sulphur catches fire when exposed to air.

$$\underset{\text{Sulphur}}{S} + \underset{\text{Oxygen}}{O_2} \longrightarrow \underset{\text{Sulphur dioxide}}{SO_2}$$

Non-metallic Oxide: Non-metallic oxides are acidic in nature. The solution of non-metal oxides turns blue litmus red.

Carbon dioxide gives carbonic acid when dissolved in water.

$$\underset{\text{Carbon dioxide}}{CO_2} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Carbonic acid}}{H_2CO_3}$$

Sulphur dioxide gives sulphurous acid when dissolved in water.

$$\underset{\text{Sulphur dioxide}}{SO_2} + \underset{\text{Water}}{H_2O} \longrightarrow \underset{\text{Sulphurous acid}}{H_2SO_3}$$

Reaction of Non-metal with Chlorine: Non-metal gives respective chloride when they react with chlorine gas.

Non-metal + Chlorine → Non-metal chloride

Hydrogen gives hydrogen chloride and phosphorous gives phosphorous trichloride when reacting with chlorine.

$$\underset{\text{Hydrogen}}{H_2} + \underset{\text{Chlorine}}{Cl_2} \longrightarrow \underset{\text{Hydrochloric acid}}{2HCl}$$

$$\underset{\text{Phosphorous}}{P_4} + \underset{\text{Chlorine}}{6Cl_2} \longrightarrow \underset{\text{Phosphorous tri chloride}}{4PCl_3}$$

Reaction of Non-metals with Hydrogen: Non-metals reactive with hydrogen to form covalent hydrides.

Non-metal + Hydrogen → Covalent Hydride

Sulphur combines with hydrogen to form a covalent hydride is called Hydrogen sulphide.

$$\underset{\text{Hydrogen}}{H_2} + \underset{\text{Sulphur}}{S} \longrightarrow \underset{\text{Hydrogen sulphide}}{H_2S}$$

Nitrogen combines with hydrogen in presence of an iron catalyst to form covalent hydride ammonia.

$$\underset{\text{Nitrogen}}{N_2} + \underset{\text{Hydrogen}}{3H_2} \longrightarrow \underset{\text{Ammonis}}{2NH_3}$$

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

Non-metals do not react with dilute acids

Reaction of Metal and Non-metal: Many metals form ionic bonds when they react with non-metals. Compounds so formed are known as Ionic Compounds.

Ions: Positive or negative charged atoms are known as ions. Ions are formed because of loss or gain of electrons. Atoms form ions obtain by the electronic configuration of the nearest noble gas.

Positive ion: A positive ion is formed because of the loss of electrons by an atom.

Following are some examples of positive ions:

Sodium forms sodium ion because of the loss of one electron. Because of the loss of one electron, one positive charge comes over sodium.

$$\underset{\text{Sodium}}{Na} \longrightarrow \underset{\text{Sodium ion}}{Na^+} + e^-$$

Magnesium forms positive ion because of the loss of two electrons. Two positive charges come over magnesium because of loss of two electrons.

$$\underset{\text{Magnesium}}{Mg} \longrightarrow \underset{\text{Magnesium ion}}{Mg^{2+}} + 2e^-$$

Negative ion: A negative ion is formed because of the gain of an electron.

Some examples are given below :

Chlorine gains one electron in order to achieve a stable configuration. After the loss of one electron, chlorine gets one negative charge over it forming chlorine ion.

$$\underset{\text{Chlorine}}{Cl} + e^- \longrightarrow \underset{\text{Chloride ion}}{Cl^-}$$

Ionic Bonds: Ionic bonds are formed because of transfer of electrons from metal to non¬metal. In this course, metals get positive charge because of transfer of electrons and non-metal gets negative charge because of acceptance of electrons. In other words, bond formed between positive and negative ion is called Ionic Bond.

Since, a compound is electrically neutral, so to form an ionic compound, negative and positive both ions must be combined.

examples are given below:

Formation of Sodium Chloride (NaCl): In sodium chloride, sodium is a metal (alkali metal) and chlorine is a non-metal.

Atomic number of sodium = 11

Electronic configuration of sodium : 2, 8, 1

Number of electrons in outermost orbit = 1

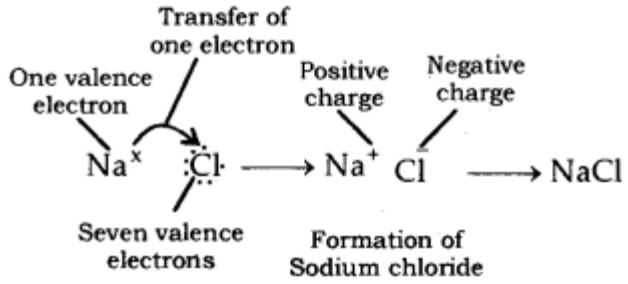
Valence electrons = Electrons in outermost orbit = 1

Atomic number of chlorine = 17

Electronic configuration of chlorine : 2, 8, 7

Electrons in outermost orbit = 7

Therefore, valence electrons = ?



Sodium has one valence electron and chlorine has seven valence electrons. Sodium requires losing one electron to obtain stable configuration and chlorine requires gaining one electron in

order to obtain stable electronic configuration. Thus, in order to obtain stable configuration, sodium transfers one electron to chlorine. After loss of one electron, sodium gets one positive charge (+) and chlorine gets one negative charge after gain of one electron. Sodium chloride is formed because of transfer of electrons. Thus, ionic bond is formed between sodium and chlorine. Since, sodium chloride is formed because of ionic bond, thus, it is called Ionic compound. In similar way, potassium chloride (KCl) is formed.

Properties of Ionic compound

- Ionic compounds are solid. Ionic bond has a greater force of attraction because of which ions attract each other strongly. This makes ionic compounds solid.
- Ionic compounds are brittle.
- Ionic compounds have high melting and boiling points because force of attraction between ions of ionic compounds is very strong.
- Ionic compounds generally dissolve in water.
- Ionic compounds are generally insoluble in organic solvents; like kerosene, petrol, etc.
- Ionic compounds do not conduct electricity in the solid state.

The solution of ionic compounds in water conduct electricity. This happens because ions present in the solution of ionic compound facilitate the passage of electricity by moving towards opposite electrodes.

Ionic compounds conduct electricity in the molten state.