CLASS 10- SCIENCE

CHAPTER 3- METALS AND NON-METALS

PART 3- CHEMICAL PROPERTIES OF METALS

1- REACTION OF METALS WITH OXYGEN

✦ Most of the metals react with oxygen to form respective metal oxides.

Metal + Oxygen ⟶ Metal oxide

✦ The metal oxides so formed are basic in nature i.e. they turn red litmus solution blue.

✦The reactivity of different metals with oxygen is different because the vigour or intensity of reaction depends upon the chemical reactivity of the metal.

✦ Alkali metals like lithium, sodium, potassium etc. react vigorously with oxygen.

✦ Sodium and potassium metals are so reactive that they catch fire and start burning if kept open in the air. That is why, they are kept immersed in kerosene oil.

✦ Examples-

i) Sodium and potassium react with oxygen to form their basic oxides.

$$4\,Na\,(s) + O_2\,(g) \longrightarrow 2\,Na_2O\,(s)$$

Sodium (metal) Oxygen Sodium oxide (Basic oxide)

$$4\,K\,(s) + O_2\,(g) \longrightarrow 2\,K_2O\,(s)$$

Potassium (metal) Oxygen Potassium oxide (Basic oxide)

ii) Magnesium metal does not react with oxygen at room temperature. On heating, magnesium metal burns in air giving intense heat and bright flame to form its basic oxide.

$$2\,Mg(s) + O_2\,(g) \longrightarrow 2\,MgO\,(s)$$

Magnesium (metal) Oxygen Magnesium oxide (Basic oxide)

✦ Examples (cont) -

iii) Copper metal does not burn in air even on heating, but forms a black coating of copper (II) oxide.

$$2\,Cu\,(s) + O_2\,(g) \longrightarrow 2\,CuO\,(s)$$

Copper (metal) Oxygen Copper (II) oxide

iv) Iron does not burn on heating, but iron fillings burn vigorously when sprinkled on the flame of a burner. Iron reacts with oxygen (present in air) on heating to form iron (II, III) oxide.

$$3Fe\,(s) + 2\,O_2\,(g) \longrightarrow Fe_3O_4\,(s)$$

Iron(metal) Oxygen Iron(II, III)oxide

v) Silver and gold do not react with oxygen even at high temperature.

✦ Self protecting metals- The metals that react with air to form a thin layer of their oxide over them to get protected from further oxidation, and to avoid getting corroded or tarnished are called self protecting metals.

Eg- Magnesium, aluminium, zinc, lead, etc.

✦ Amphoteric Oxides-

Some metal oxides show both acidic as well as basic properties i.e. they react with both acid as well as base to form salt and water. Such metal oxides are known as amphoteric oxides.

✦ Examples-

a) Aluminium- It burns in air, on heating, to form aluminium oxide, which is an amphoteric oxide.

$$4\,Al\,(s) + 3\,O_2\,(g) \longrightarrow 2\,Al_2O_3\,(s)$$

Aluminium (metal) — Oxygen — Aluminium oxide (Amphoteric oxide)

$$Al_2O_3\,(s) + 6\,HCl\,(aq) \longrightarrow 2\,AlCl_3\,(aq) + 3\,H_2O\,(l)$$

Aluminium oxide — Hydrochloric acid (acid) — Aluminium chloride (salt) — Water

Here, aluminium oxide is a basic oxide because it reacts with an acid to form salt and water.

$$Al_2O_3\,(s) + 2\,NaOH\,(aq) \longrightarrow 2\,NaAlO_2\,(aq) + H_2O\,(l)$$

Aluminium oxide — Sodium hydroxide (base) — Sodium aluminate (salt) — Water

Here, aluminium oxide is an acidic oxide because it reacts with a base to form salt and water.

✦ Amphoteric Oxides Examples (cont)-

b) Zinc- It burns in air, on strong heating, to form zinc oxide.

$$2\,Zn\,(s) + O_2\,(g) \longrightarrow 2\,ZnO\,(s)$$

Zinc (metal) Oxygen Zinc oxide (Amphoteric oxide)

The so formed zinc oxide is an amphoteric oxide.

$$ZnO\,(s) + 2\,HCl\,(aq) \longrightarrow ZnCl_2\,(aq) + H_2O\,(l)$$

Zinc oxide Hydrochloric acid (acid) Zinc chloride (salt) Water

Here, zinc oxide behaves as a basic oxide because it reacts with an acid to form salt and water.

$$ZnO\,(s) + 2\,NaOH\,(aq) \longrightarrow Na_2ZnO_2\,(aq) + H_2O\,(l)$$

Zinc oxide Sodium hydroxide (base) Sodium zincate (salt) Water

Here, zinc oxide behaves as an acidic oxide because it reacts with a base to form salt and water.

2- REACTION OF METALS WITH WATER-

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

Metal + Water ⟶ Metal hydroxide/Metal oxide + Hydrogen

✦ The reactivity of different metals with water is different as the intensity of the reaction depends upon the chemical reactivity of the metal.

✦ Examples-

i) Metals which react with cold water-

Metals like sodium and potassium react violently with cold water to form their respective hydroxides and hydrogen gas.

$2\,Na\,(s) + 2\,H_2O\,(l) \longrightarrow 2\,NaOH\,(aq) + H_2\,(g) + Heat$

Sodium — Water (cold) — Sodium hydroxide — Hydrogen

$2\,K\,(s) + 2\,H_2O\,(l) \longrightarrow 2\,KOH\,(aq) + H_2\,(g) + Heat$

Potassium — Water (cold) — Potassium hydroxide — Hydrogen

The reaction of sodium and potassium metals with water is highly exothermic (heat producing) due to which the hydrogen gas so formed during the reaction catches fire easily and can burn causing little explosions.

Calcium metal also reacts with cold water to form calcium hydroxide and hydrogen.

$$Ca\,(s) + 2\,H_2O\,(l) \longrightarrow Ca(OH)_2\,(aq) + H_2\,(g)$$

Calcium — Water(cold) — Calcium hydroxide — Hydrogen

In this reaction, the heat produced is very less which cannot burn hydrogen gas and hence cannot cause explosions.

ii) <u>Metals which react with hot water-</u>

Magnesium metal reacts with hot water to form magnesium hydroxide and hydrogen.

$$Mg\,(s) + 2\,H_2O\,(l) \longrightarrow Mg(OH)_2\,(aq) + H_2\,(g)$$

Magnesium — Water (hot) — Magnesium hydroxide — Hydrogen

<u>Note-</u> The pieces of calcium and magnesium metals start floating in water due to the bubbles of hydrogen gas sticking to their surfaces.

iii) Metals which react with steam-

Aluminium, zinc and iron react only with steam to form the metal oxide and hydrogen. Magnesium can react with steam also, to form magnesium oxide and hydrogen.

$$2\,Al\,(s) + 3\,H_2O\,(g) \longrightarrow Al_2O_3\,(s) + 3\,H_2\,(g)$$

Aluminium + Steam → Aluminium oxide + Hydrogen

$$Zn\,(s) + H_2O\,(g) \longrightarrow ZnO\,(s) + H_2\,(g)$$

Zinc + Steam → Zinc oxide + Hydrogen

$$3\,Fe\,(s) + 4\,H_2O\,(g) \longrightarrow Fe_3O_4\,(s) + 4\,H_2\,(g)$$

Iron + Steam → Iron (II, III) oxide + Hydrogen

$$Mg\,(s) + H_2O\,(g) \longrightarrow MgO\,(s) + H_2\,(g)$$

Magnesium + Steam → Magnesium oxide + Hydrogen

iv) Metals which do not react with water-

Metals like lead, copper, silver and gold do not react with water or steam.

v) Reaction of metal oxide with water-

Most of the metal oxides are insoluble in water. But sodium oxide and potassium oxide dissolve in water to form alkalis. Magnesium oxide also dissolves partially to form its hydroxide. These alkalis or hydroxides so formed are bases and can turn red litmus blue.

$Na_2O\ (s) + H_2O\ (l) \longrightarrow 2\ NaOH\ (aq)$

Sodium oxide (Basic oxide) + Water → Sodium hydroxide (Alkali)

$K_2O\ (s) + H_2O\ (l) \longrightarrow 2\ KOH\ (aq)$

Potassium oxide (Basic oxide) + Water → Potassium hydroxide (Alkali)

$MgO\ (s) + H_2O\ (l) \longrightarrow Mg(OH)_2\ (aq)$

Magnesium oxide (Basic oxide) + Water → Magnesium hydroxide (Base)

3- REACTION OF METALS WITH DILUTE ACIDS-

✦ When metals react with acids they give metal salt and hydrogen gas.

Metal + Dilute acid ⟶ Metal salt + Hydrogen

✦ The intensity of the reaction of a metal with dilute acid depends upon its chemical reactivity. Some metals react very rapidly, some react less rapidly, some react on heating and some do not react at all.

✦ Metals react with dilute hydrochloric acid or dilute sulphuric acid to give their metal chlorides or metal sulphates respectively along with hydrogen gas.

✦ Examples-

i) $2\,Na\,(s) + 2\,HCl\,(aq) \longrightarrow 2\,NaCl\,(aq) + H_2\,(g)$

Sodium — Hydrochloric acid — Sodium chloride — Hydrogen

$2\,Na\,(s) + H_2SO_4\,(aq) \longrightarrow Na_2SO_4\,(aq) + H_2\,(g)$

Sodium — Sulphuric acid — Sodium sulphate — Hydrogen

ii) $Mg\ (s) + 2\ HCl\ (aq) \longrightarrow MgCl_2\ (aq) + H_2\ (g)$

Magnesium — Hydrochloric acid — Magnesium chloride — Hydrogen

$Mg\ (s) + H_2SO_4\ (aq) \longrightarrow MgSO_4\ (aq) + H_2\ (g)$

Magnesium — Sulphuric acid — Magnesium sulphate — Hydrogen

iii) $Zn\ (s) + 2\ HCl\ (aq) \longrightarrow ZnCl_2\ (aq) + H_2\ (g)$

Zinc — Hydrochloric acid — Zinc chloride — Hydrogen

$Zn\ (s) + H_2SO_4\ (aq) \longrightarrow ZnSO_4\ (aq) + H_2\ (g)$

Zinc — Sulphuric acid — Zinc sulphate — Hydrogen

iv) $Fe\ (s) + 2\ HCl\ (aq) \longrightarrow FeCl_2\ (aq) + H_2\ (g)$

Iron — Hydrochloric acid — Iron (II) chloride — Hydrogen

$Fe\ (s) + H_2SO_4\ (aq) \longrightarrow FeSO_4\ (aq) + H_2\ (g)$

Iron — Sulphuric acid — Iron (II) sulphate — Hydrogen

v) $Cu\ (s) + HCl\ (aq) \longrightarrow$ No reaction

Copper — Hydrochloric acid

$Cu\ (s) + H_2SO_4\ (aq) \longrightarrow$ No reaction

Copper — Sulphuric acid

✦ Note-

→ Hydrogen gas is not evolved when a metal reacts with nitric acid. This is so because the nitric acid is a strong oxidising agent and it oxidises hydrogen to water and itself gets reduced to any of the nitrogen oxides like N_2O, NO, NO_2.

→ Magnesium and manganese react with very dilute nitric acid to evolve hydrogen gas as it is a very weak oxidising agent and cannot oxidise hydrogen to water.

→ Reaction of magnesium with very dilute nitric acid-

$$Mg\,(s) + 2HNO_3\,(aq) \longrightarrow Mg(NO_3)_2\,(aq) + H_2\,(g)$$

Magnesium — Nitric acid (very dilute) — Magnesium nitrate — Hydrogen

→ Reaction of manganese with very dilute nitric acid-

$$Mn\,(s) + 2HNO_3\,(aq) \longrightarrow Mn(NO_3)_2\,(aq) + H_2\,(g)$$

Manganese — Nitric acid (very dilute) — Manganese nitrate — Hydrogen

✦ Define and explain Aqua Regia-

→ Aqua regia is a freshly prepared mixture of concentrated hydrochloric acid and concentrated nitric acid in the ratio of 3:1.

→ It is a highly corrosive and fuming liquid.

→ It can dissolve even gold and platinum metals which cannot be dissolved by either of them alone.

✦ The Reactivity Series of Metals-

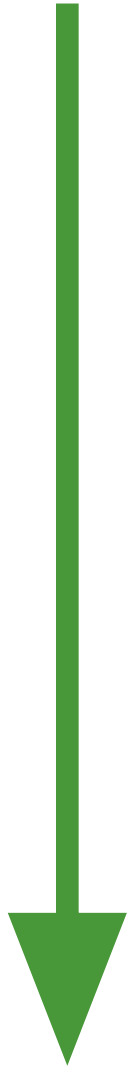
→ The arrangement of metals in a vertical column in the order of decreasing reactivities is called the reactivity series of metals.

→ Reactivity of elements decreases on moving from top to bottom in the reactivity series.

→ Potassium being the most reactive element is at the top of the series, whereas platinum is at the bottom of the series as it is the least reactive element.

Potassium	K
Sodium	Na
Calcium	Ca
Magnesium	Mg
Aluminium	Al
Carbon	C
Zinc	Zn
Iron	Fe
Tin	Sn
Lead	Pb
Hydrogen	H
Copper	Cu
Mercury	Hg
Silver	Ag
Gold	Au
Platinum	Pt

Most reactive metal



Decreasing chemical reactivity

Least reactive metal

4- REACTION OF METALS WITH SOLUTIONS OF OTHER METAL SALTS-

✦ A more reactive metal displaces a less reactive metal from its salt solution. This is a displacement reaction.

✦ All metals are not equally reactive. The reactivity series tells us about the reactivity of different metals as the most reactive metal is placed at the top and the least reactive metal is placed at the bottom of the series.

✦ If metal A is more reactive than metal B, then it can displace metal B from its salt solution to form salt solution of metal A and metal B will be free.

Metal A + Salt solution of Metal B ⟶ Salt solution of Metal A + Metal B

✦ Examples-

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

Zinc — Copper sulphate — Zinc sulphate — Copper

ii) $Fe\ (s) + CuSO_4\ (aq) \longrightarrow FeSO_4\ (aq) + Cu\ (s)$

Iron — Copper (II) sulphate — Iron (II) sulphate — Copper

iii) $Zn\ (s) + FeSO_4\ (aq) \longrightarrow ZnSO_4\ (aq) + Fe\ (s)$

Zinc — Iron (II) sulphate — Zinc sulphate — Iron

iv) $Cu\ (s) + 2\ AgNO_3\ (aq) \longrightarrow Cu(NO_3)_2\ (aq) + 2\ Ag\ (s)$

Copper — Silver nitrate — Copper (II) nitrate — Silver

v) $Mg\ (s) + CuSO_4\ (aq) \longrightarrow MgSO_4\ (aq) + Cu\ (s)$

Magnesium — Copper sulphate — Magnesium sulphate — Copper

THANK YOU