Microorganisms: Friend and Foe

Chemical Properties of Metal and Non-Metal

CHEMICAL PROPERTIES OF METALS

All metals give similar chemical reactions. However, the reactivity of a metal depends upon its nature and reaction conditions. Some typical reactions of metals are described below :

(i) Reaction with oxygen : All metals combine with oxygen to form metal oxides. Different metals react with oxygen under different conditions.

For example,

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

Sodium (Na) : Sodium + Oxygen/air $\xrightarrow{\text{room temp.}}$ Sodium oxide

$$2\,Mg + O_2 \longrightarrow 2\,MgO$$

Magnesium (Mg) : Magnesium + Oxygen $\xrightarrow[\text{(burns with a dazzling white light)}]{\text{Heat}}$ Magnesium oxide

$$2\,Zn + O_2 \longrightarrow 2\,ZnO$$

Zinc (Zn) : Zinc + Oxygen $\xrightarrow[\text{(burns with a blue flame)}]{\text{strong heating}}$ Zinc oxide

$$3\,Fe + 2\,O_2 \longrightarrow Fe_3O_4$$

Iron (Fe) : Iron + Oxygen $\xrightarrow[\text{(no burning)}]{\text{strong heating}}$ Ferroso-ferric oxide

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

Copper (Cu) : Copper + Oxygen $\xrightarrow[\text{(no burning)}]{\text{prolonged strong heating}}$ Copper oxide

From the reaction conditions of the reactions given above, the order of reactivity of metals with oxygen is,

Sodium (Na) > Magnesium (Mg) > Zinc (Zn) > Iron (Fe) > Copper (Cu

(ii) Reaction with Water : Different metals react with water under different conditions.

Reactions of some common metals with water are given below :

$Na + H_2O \longrightarrow NaOH + H_2$

Sodium (Na) : Sodium + Water (cold) $\longrightarrow$ Sodium hydroxide + Hydrogen

$Mg + H_2O \longrightarrow MgO + H_2$

Magnesium(Mg) : Magnesium + Water (boiling) $\longrightarrow$ Magnesium oxide + Hydrogen

$2Fe + 3H_2O \longrightarrow Fe_2O_3 + 3H_2$

Iron (Fe) : Iron (red hot) + Steam $\longrightarrow$ Ferroso-ferric oxide + Hydrogen

$Cu + H_2O \longrightarrow$ No Reaction

Copper (Cu) : Copper + Water $\longrightarrow$ No reaction even at high temperature

From the reaction conditions of the above reactions, the order of reactivity of metals with water is

Sodium (Na) > Magnesium (Mg) > Iron (Fe) > Copper (Cu)

(iii) Reactions with Acids : Most metals react with dilute acids produce salt and hydrogen gas. Reaction of some common metals with dilute hydrochloric acid are given below :

	2Na	**+**	**2HCl**	$\longrightarrow$	**2NaCl**	**+**	**H_2**	
Sodium (Na)	: Sodium	+	Hydrochloric acid(dil)	$\longrightarrow$	Sodium chloride	+	Hydrogen	**Vigorous**
	Mg	**+**	**2HCl**	$\longrightarrow$	**$MgCl_2$**	**+**	**H_2**	
Magnesium (Mg)	: Magnesium	+	Hydrochloric acid(dil)	$\longrightarrow$	Magnesium chloride	+	Hydrogen	**Rapid**
	Zn	**+**	**HCl**	$\longrightarrow$	**$ZnCl_2$**	**+**	**H_2**	
Zinc (Zn)	: Zinc	+	Hydrochloric acid(dil)	$\xrightarrow{\text{room temp.}}$	Zinc chloride	+	Hydrogen	**Moderate**
	Fe	**+**	**2HCl**	$\longrightarrow$	**$FeCl_2$**	**+**	**H_2**	
Iron (Fe)	: Iron	+	Hydrochloric acid(dil)	$\xrightarrow{\text{heating}}$	Iron chloride	+	Hydrogen	**Moderate**
	Cu	**+**	**HCl**	$\longrightarrow$	No Reaction			
Copper (Cu)	: Copper	+	Hydrochloric acid(dil)	$\longrightarrow$	No reaction even on heating			

From the reaction conditions of the reaction given above, the order of reactivity of these metals with dilute acid is

Sodium (Na) > Magnesium (Mg) > Zinc (Zn) > Iron (Fe) > Copper (Cu)

CHEMICAL PROPERTIES OF NONMETALS

Some general chemical properties of nonmetals are described below :

Electronegative Character

Nonmetals are electronegative elements. Nonmetals have a tendency to accept electrons and form negatively charged ions (anions).

For examples.

Chlorine + e $-\longrightarrow$ Chloride ion (an anion)

Oxygen + 2e$-\longrightarrow$ Oxide ion (an anion)

Thus, nonmetals are able to remove electrons from electropositive elements and act as oxidising agents.

Hydrogen is the only nonmetal which can lose as well as gain an electron.

H	+	e^-	$\longrightarrow$	H^-
Hydrogen	+	from a highly electropositive element	$\longrightarrow$	Hydride ion (an anion)
H	–	e^-	$\longrightarrow$	H^+
Hydrogen	–	from a highly electronegative element	$\longrightarrow$	Hydrogen ion (a cation)

Thus, hydrogen can act both as an oxidising as well as reducing agent.

Reaction with Halogens

Nonmetals react with halogen to give covalent halides. In pure state, the halides of nonmetals do not conduct electricity.

For example with chlorine,

2P	+	**$3Cl_2$**	⟶	**$2PCl_3$**
Phosphorus	+	Chlorine	$\xrightarrow{\text{Heat}}$	Phosphorus trichloride
2P	+	**$5Cl_2$**	⟶	**$2PCl_5$**
Phosphorus	+	Chlorine	$\xrightarrow{\text{Heat}}$	Phosphorus pentachloride
H_2	+	**Cl_2**	⟶	**2HCl**
Hydrogen	+	Chlorine	$\xrightarrow{\text{sunlight}}$	Hydrogen chloride

Sulphur reacts with fluorine at higher temperature to give sulphur hexafluoride.

S	+	**3Fe**	⟶	**SF_6**
Sulphur	+	Fluorine	$\xrightarrow{\text{high temp.}}$	Sulphur hexafluoride

Reaction with Hydrogen

Nonmetals react with hydrogen to form covalent hydrides. Thus in the hydrides of nonmetals, hydrogen is bonded to the nonmetal atom by covalent bonds. The hydrides of nonmetals atom by covalent bonds. The hydrides of nonmetals do not conduct electricity. The hydrides of nonmetals may be acidic, basic or neutral depending upon the nature of the nonmetal. For example,

(i) Sulphur with hydrogen gives hydrogen sulphide (H_2S). H_2S is weakly acidic in nature.

$$\mathbf{H_2} + \mathbf{S} \longrightarrow \mathbf{H_2S}$$

Hydrogen + Sulphur ⟶ Hydrogen sulphide (weakly acidic)

(ii) Nitrogen reacts with hydrogen to give ammonia (NH_3). Ammonia is basic in nature.

$$\mathbf{H_2} + \mathbf{3N_2} \longrightarrow \mathbf{2NH_3}$$

Hydrogen + Nitrogen ⟶ Ammonia (basic)

(iii) Oxygen reacts with hydrogen to given water (H_2O). Water is neutral in nature.

$$\mathbf{H_2} + \mathbf{O_2} \longrightarrow \mathbf{2H_2O}$$

Hydrogen + Oxygen $\xrightarrow{\text{electric spark}}$ Water

Reaction with Acids

Nonmetals do not displace hydrogen from dilute acids. This is because nonmetals are able to give electron(s) for the reduction of H+. Some nonmetals however react with concentrated oxidising acids to form the corresponding oxyacids. For example, sulphur reacts with conc. nitric acid to give sulphuric acid.

Sulphur + Nitric acid (conc.) ⟶ Sulphuric acid + Nitrogen dioxide + Water

Displacement Reactions

Certain more reactive nonmetals displace less reactive nonmetals from their salt solutions. For example, Chlorine displaces bromine from bromides and iodine from iodides.

2KBr	+	**Cl_2**	⟶	**2KCl**	+	**Br_2**
Potassium bromide	+	Chlorine	⟶	Potassium chloride	+	Bromine
2KI	+	**Cl_2**	⟶	**2KCl**	+	**I_2**
Potassium iodide	+	Chlorine	⟶	Potassium chloride	+	Iodine

Oxides of Metals

The oxides of metals are basic in nature. When dissolved in water, metal oxides give alkaline (or basic) solution which turn red litmus blue. For example, magnesium (Mg) burns in air to give magnesium oxide (MgO), which is basic in nature.

2Mg	+	**O_2**	⟶	**2(MgO)**
Magnesium	+	Oxygen (from air)	⟶	Magnesium oxide (basic oxide)
MgO	+	**H_2O**	⟶	**$Mg(OH)_2$**
Magnesium oxide	+	Water	⟶	Magnesium hydroxide (basic in nature) turns red litmus blue

Oxides of Nonmetals

The oxides of nonmetals are acidic in nature. When dissolved in water nonmetal oxides give acidic give solutions which turn blue litmus red.

For example, sulphur on burning in air, gives sulphur dioxide (SO_2) which is acidic in nature.

S	**+**	**O_2**	**⟶**	**SO_2**
		Oxygen		Sulphur dioxide
Sulphur	+	(fromair)	⟶	(acidic oxide)
SO_2	**+**	**H_2O**	**⟶**	**H_2SO_3**
				Sulphurous acid
Sulphur dioxide	+	Water	⟶	turns blue litmus red