Ch 1 Chemical Reactions and Equations

Introduction

→ Most of the substance around us undergoes various changes. Some of these changes are temporary with no new substance being formed. They are called physical changes.

→ In certain other changes the new substance formed in which the reactant or the parent loses its identity to form new substance called product. These changes are permanent changes as we won't get the reactant back.

Chemical Reaction

→ Chemical reaction is the process by which two or more substance react with each other to form new substance with different properties.

→ These are the following changes to determine that the chemical reaction has taken place:
(i) Change in state
(ii) Change in colour
(iii) Evolution of gas
(iv) Change in temperature

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Chemical Equation

→ A chemical equation is the symbolic representation of a chemical reaction in the form of symbols and formulae, wherein the reactant entities are given on the left-hand side and the product entities on the right-hand side.

Magnesium + oxygen → magnesium oxide

Balanced chemical equation

→ The chemical equation that shows the chemical reaction needs to be balanced. A balanced chemical equation occurs when the number of the atoms involved in the reactants side is equal to the number of atoms in the products side.

$Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$

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

Types of chemical reaction

→ **Combination reaction**: Such a reaction in which a single product is formed from two or more reactants is known as a combination reaction.

$CaO\ (s) + H_2O\ (l) \rightarrow Ca(OH)_2\ (aq)$

Calcium oxide reacts vigorously with water to produce slaked lime (calcium hydroxide) releasing a large amount of heat.

A solution of slaked lime produced by the reaction is used for white washing walls. Calcium hydroxide reacts slowly with the carbon dioxide in air to form a thin layer of calcium carbonate on the walls. Calcium carbonate is formed after two to three days of white washing and gives a shiny finish to the walls. It is interesting to note that the chemical formula for marble is also $CaCO_3$.

$Ca(OH)_2\ (aq) + CO_2\ (g) \rightarrow CaCO_3\ (s) + H_2O\ (l)$

(slaked lime) (calcium carbonate)

Burning of coal: $C\ (s) + O_2\ (g) \rightarrow CO_2\ (aq)$

Formation of water: $H_2\ (g) + O_2\ (g) \rightarrow H_2O\ (aq)$

Burning of natural gas (Methane): $CH_4\ (g) + O_2\ (g) \rightarrow CO_2\ (g) + H_2O\ (l)$

→ **Exothermic reaction**: An exothermic process releases heat, and causes the temperature of the immediate surroundings to rise The rice, potatoes and bread we eat contain carbohydrates. These carbohydrates are broken down to form glucose. This glucose combines with oxygen in the cells of our body and provides energy. The special name of this reaction is respiration is an exothermic reaction.

$C_6H_{12}O_6\ (aq) + 6O_2\ (aq) \rightarrow 6CO_2 + 6H_2O\ (l) + energy$

(glucose)

→ **Endothermic reaction**: An endothermic process absorbs heat and cools the surroundings. The decomposition of vegetable matter into compost is also an example of an endothermic reaction.

→ **Decomposition reaction**: When single reactant breaks down to give simpler products. This is a decomposition reaction.

$$FeSO_{4(s)} \xrightarrow{heat} Fe_2O_{3(g)} + SO_{2(g)} + SO_{3(g)}$$

(Ferrous sulphate) (Ferric oxide)

$$2Pb(NO_2)_{3(s)} \rightarrow 2PbO + 4NO_{2(g)} + O_{2(g)}$$

(lead nitrate) (lead oxide)

White silver chloride turns grey in sunlight. This is due to the decomposition of silver chloride int silver and chlorine by light.

$$2AgCl(s) \xrightarrow{sunlight} 2Ag(s) + Cl_2(g)$$

$$2AgBr(s) \xrightarrow{sunlight} 2Ag(s) + Br_2(g)$$

The above reactions are used in black and white photography.

→ **Displacement reaction**: Displacement reaction is a chemical reaction in which a more reactive element displaces a less reactive element from its compound. Both metals and non-metals take part in displacement reactions. Reaction of iron nails with copper sulphate solution.

Fe (s) + $CuSO_4$ (aq) → $FeSO_4$ (g) + Cu (s)

Pb (s) + $CuCl_2$ (aq) → $PbCl_2$ (aq) + Cu (s)

→ **Double Displacement reaction:** A double displacement reaction, also known as a double replacement reaction or metathesis, is a type of chemical reaction where two compounds react, and the positive ions (cation) and the negative ions (anion) of the two reactants switch places, forming two new compounds or products.

$_2(SO)_4$ (aq) + $BaCl_2$ (aq) → $BaSO_4$ (s) + NaCl (aq)

→ **Redox reaction**: An oxidation-reduction (Redox) reaction is a type of chemical reaction that involves a transfer of electrons between two species. An oxidation-reduction reaction is any chemical reaction in which the oxidation number of a molecule, atom, or ion changes by gaining or losing an electron.

Oxidation: This process involves gain of oxygen or loss of hydrogen.
Reduction: This process involves gain of hydrogen or loss of oxygen.

$$CuO + H_2 \xrightarrow{\Delta} Cu + H_2O$$

→ **Oxidizing Agent**

It is the substance which gives oxygen or gains hydrogen.
Or it the substance which is reduced itself and oxidizes other.

→ **Reducing Agent**

It is the substance which gives hydrogen or gains oxygen.
Or it the substance which is oxidized itself and reduces other.
Oxidation is the process which involves loss of electrons but reduction is the process which involves gain of electrons.

Corrosion

The process of slow conversion of metals into their undesirable compounds due to their reaction with oxygen, water, acids, gases etc. present in the atmosphere is called corrosion.
Rusting – Iron when reacts with oxygen and moisture forms red substance called rust.

Rancidity

→ The taste and odour of food materials containing fat and oil changes when they are left exposed to air for long time. This is called rancidity. It is caused due to oxidation of fat and oil present in food material.
→ It can be prevented by using various methods such as by adding antioxidants to the food materials,

Ch 2 Acids, Bases and Salts

→ Litmus solution is a purple dye, which is extracted from lichen. When the litmus solution is neither acidic nor basic, its colour is purple.

→ Other natural materials like red cabbage leaves, turmeric, coloured petals of some flowers such as Hydrangea, Petunia and Geranium, which indicate the presence of acid or base in a solution.

Properties of Acids

- The term 'acid' has been derived from the Latin word, 'acidus' which means sour.
- Acids have sour taste.
- They turn blue litmus solution red.
- They give H^+ ions in aqueous solution.

Strong Acids: HCl, H_2SO_4 , HNO_3

Weak Acids: CH_3COOH, Oxalic acid, Lactic acid

Concentrated Acids: More amount of acid + Less amount of water

Dilute Acids: More amount of water + Less amount of acid

Properties of Bases

- These are the substances which are bitter in taste and soapy in touch.
- They turn red litmus solution blue.
- They give OH^- ions in aqueous solution.

Strong Bases: NaOH, KOH, $Ca(OH)_2$

Weak Bases: NH_4OH

Alkalis: These are bases which are soluble in water. Examples: NaOH, KOH, $Ca(OH)_2$.

Types of Indicators and its properties

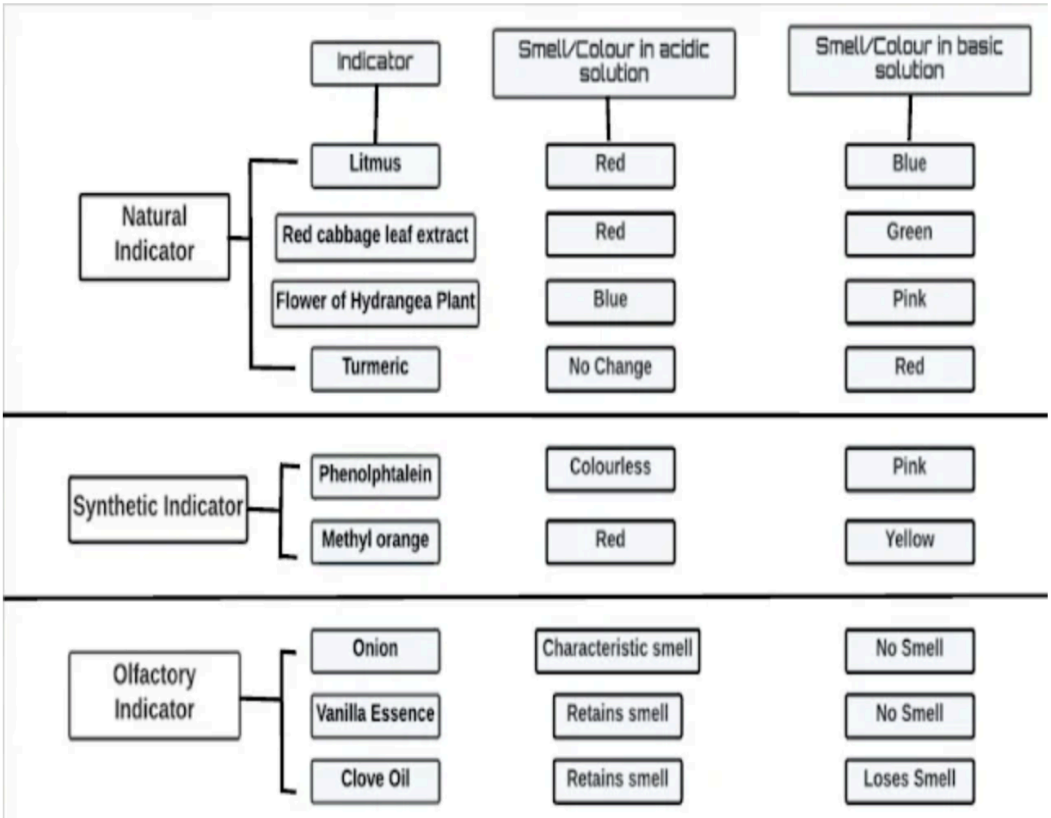
Indicators: Substances which change their colour/smell in different types of substances (like acids and bases).

Types of Indicators:
(i) Natural indicators
(ii) Synthetic indicators
(iii) Olfactory indicators

(i) Natural indicators: Found in nature in plants. Examples: Litmus, red cabbage leaves extract, flowers of hydrangea plant, turmeric.

(ii) Synthetic indicators: These are chemical substances. Examples: Methyl orange, phenolphthalein.

(iii) Olfactory indicators: These substances have different odour in acid and bases.



Reaction of Acids and Bases with Metals

→ Reaction of Acids with Metals

• Acids react with metal to form metal salt and releases Hydrogen Gas.
Acid + Metal → Salt + Hydrogen Gas

• Example: Zinc granules react with dilute Hydrochloric acid in a test tube.
$2HCl + Zn \rightarrow ZnCl_2 + H_2$

→ Reaction of Bases with Metals

• Bases react with metal to evolve hydrogen Gas. Also, note that all metals do not react with bases. The metal must be more reactive than the metals present in the base for the reaction to take place.
Base + Metal → Salt + Hydrogen gas

• Example: Zinc granules react with NaOH solution to form sodium zincate and evolve hydrogen gas.
$2NaOH + Zn \rightarrow Na_2ZnO_2 + H_2$

• Hydrogen gas released can be tested by bringing burning candle near gas bubbles, it burst with pop sound.

Reaction of Acids with Metal Carbonates and Metal Hydrogencarbonates

• Acids reacts with Metal Carbonates and Metal Hydrogencarbonates to form Salt, Carbon dioxide and water.
Metal carbonate/Metal hydrogen carbonate + Acid → Salt + Carbon dioxide + Water

• Examples: (i) $2HCl + Na_2CO_3 \rightarrow 2NaCl + CO_2 + H_2O$
(ii) $HCl + NaHCO_3 \rightarrow NaCl + CO_2 + H_2O$

• CO_2 can be tested by passing it through lime water. It turns lime water milky.
$Ca(OH)_2 + CO_2 \rightarrow CaCO_3 + H_2O$

• When excess CO2 is passed, milkiness disappears.
$CaCO_3 + CO_2 + H_2O \rightarrow Ca(HCO)_3$

• Bases do not react with Metal Carbonates and Metal Hydrogencarbonates.
Base + Metal Carbonate/Metal Hydrogen Carbonate → No Reaction

Reaction of Acids and Bases with each other

• Acids and Bases react to form salt and water.
Acid + Base → Salt + H_2O

• **Neutralisation Reaction:** Reaction of acid with a base is called as neutralization reaction.
Example: HCl + NaOH → NaCl + H_2O

• Strong Acid + Weak Base → Acidic salt + H_2O

• Weak Acid + Strong Base → Basic salt + H_2O

• Strong Acid + Strong Base → Neutral salt + H_2O

• Weak Acid + Weak Base → Neutral salt + H_2O

Reaction of Metallic Oxides with Acids

→ Metallic oxides are basic in nature.

Example: CaO, MgO are basic oxides.
Metallic Oxide + Acid → Salt + H_2O
$CaO + 2HCl \rightarrow CaCl_2 + H_2O$

Reaction of Non-metallic Oxides with Bases

→ Non-metallic oxides are acidic in nature.

→ Non-metallic Oxide + Base → Salt + H_2O
$CO_2 + Ca(OH)_2 \rightarrow CaCO_3 + H_2O$

Reaction of Acid

(i) Acid + Metal Carbonate → Salt + CO_2 + Water

(ii) Acid + Metal → Salt + H_2

(iii) Acid + Metal Hydrogen Carbonate → Salt + CO_2 + H2O

(iv) Acid + Metallic oxide → Salt +H_2O

(v) Acid + Base → Salt + H_2O

Reaction Of Base

(i) Base + Metal → Salt + H_2

(ii) Base + Metal Carbonate → No Reaction

(iii) Base + Metal Hydrogen Carbonate → No Reaction

(iv) Base + Acid → Salt + H_2O

(v) Base + Non Metallic oxide → Salt + H_2O

Similarities between all Acids and all Bases

→ All acids have H^+ ions in common. All acids produce H^+ ions

→ Acids produce H^+ ions in solution which are responsible for their acidic properties.

→ All bases have OH^- (hydroxyl ions) in common. All bases produce OH^- ions

Acid or Base in Water Solution

→ Acids produce H^+ ions in presence of water.

→ H^+ ions cannot exist alone, they exist as H_3O^+ (hydronium ions).

$H^+ + H_2O \rightarrow H_3O^+$

$HCl + H_2O \rightarrow H_3O^+ + Cl^-$

→ Bases when dissolved in water gives OH – ions.

$NaOH \xrightarrow{H_2O} Na^+ + OH^-$

$Mg(OH) \xrightarrow{H_2O} Mg^{2+} + 2OH^-$

→ Bases soluble in water are called alkali.

→ While diluting acids, it is recommended that the acid should be added to water and not water to acid because the process of dissolving a acid or a base in water is highly exothermic.

Strength of Acids and Base solutions

→ Strength of acid or base can be estimated using universal indicator.

→ Universal indicator: It is a mixture of several indicators. It shows different colours at different concentrations of H^+ ions in the solution.

→ pH Scale: A scale for measuring H^+ ion concentration in a solution. p in pH stands for 'potenz' a German word which means power.

- If value of ph is equal to 7 → neutral solution
- If value of pH is less than 7 → acidic solution
- If value of pH more than 7 → basic solution

Ch 3 Metals and Non-metals

Introduction

→ Elements can be classified as metals and non-metals on the basis of their properties.

- Examples of some metals are: Iron (Fe), Aluminium (Al), Silver (Ag), Copper (Cu)
- Examples of some non-metals are: Hydrogen (H), Nitrogen (N), Sulphur (S), Oxygen (O)

Physical Properties

Property	Metals	Non-Metals
1. Lustre	Metals have shining surface.	They do not have shining surface. • Except Iodine.

2. Hardness	They are generally hard. • Except Sodium, Lithium and Potassium which are soft and can be cut with knife.	Generally soft. • Except Diamond, a form of carbon which is the hardest natural substance.
3. State	Exist as solids. • Except Mercury.	Exist as solids or gaseous. • Except Bromine.
4. Malleability	Metals can be beaten into thin sheets. • Gold and Silver are the most malleable metals.	Non-metals are non-malleable.
5. Ductility	Metals can be drawn into thin wires.	They are non-ductile.
6. Conductor of heat & electricity	Metals are good conductors of heat and electricity. • Silver (Ag) and Copper (Cu): Best conductors of heat. • Lead (Pb), Mercury (Hg) poor conductor of heat.	Non-metals are poor conductor of heat and electricity. • Except Graphite.
7. Density	Generally have high density and high melting point. • Except Sodium and Potassium.	Have low density and low melting point.
8. Sonorous	Metals produce a sound on striking a hard surface.	They are not sonorous.
9. Oxides	Metallic oxides are basic in nature.	Non-metallic oxides are acidic in nature.

Chemical Properties of Metals

• Reaction of metals with air

→ Metals combine with oxygen to form metal oxide.
Metal + O_2 → Metal oxide

Examples:
(i) $2Cu + O_2 \rightarrow 2CuO$
Copper oxide (black)
(ii) $4Al + 3O_2 \rightarrow 2Al_2O_3$
Aluminium oxide
(iii) $2Mg + O\ 2 \rightarrow 2MgO$

The reactivity of different metals are different with O_2.

→ Na and K react so vigorously that they catch fire if kept in open so they are kept immersed in kerosene.

→ Surfaces of Mg, Al, Zn, Pb are covered with a thin layer of oxide which prevent them from further oxidation.
→ Fe does not burn on heating but iron fillings burn vigorously.
→ Cu does not burn but is coated with black copper oxide.
→ Au and Ag does not react with oxygen.

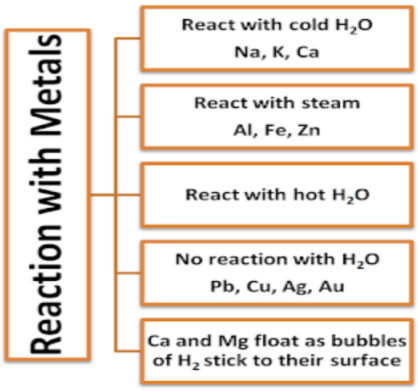
→ **Amphoteric Oxides**: Metal oxides which react with both acids as well as bases to produce salts and water are called amphoteric oxides.

Examples:
(i) $Al_2O_3 + 6HCl \rightarrow 2AlCl_3 + H_2O$

(ii) $Al_2O_3 + 2NaOH \rightarrow 2NaAlO_2 + H_2O$
Sodium Aluminate

• Reaction of metals with water

→ Metal + Water → Metal oxide + Hydrogen



Examples:

(i) $2Na + 2H_2O \rightarrow 2NaOH + H_2 + Heat$
(ii) $Ca + 2H_2O \rightarrow Ca(OH)_2 + H_2$
(iii) $Mg + 2H_2O \rightarrow Mg(OH)_2 + H_2$
(iv) $2Al + 3H_2O \rightarrow Al_2O_3 + 3H_2$
(v) $3Fe + 4H_2O \rightarrow Fe_3O_4 + 4H_2$

• Reaction of metals with acids (Dilute)

→ Metal + Dilute acid → Salt + H_2

→ Cu, Ag, Hg do not react with dil. acids.

Examples:

(i) $Fe + 2HCl \rightarrow FeCl_2 + H_2$

(ii) $Mg + 2HCl \rightarrow MgCl_2 + H_2$

(iii) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$

(iv) $2Al + 6HCl \rightarrow 2AlCl_3 + 3H_2$

• Reaction of Metals with Solutions of other Metal Salts

→ Metal A + Salt solution B → Salt solution A + Metal B

→ Reactive metals can displace less reactive metals from their compounds in solution form.

$Fe + CuSO_4 \rightarrow FeSO_4 + Cu$

Reactivity Series

The reactivity series is a list of metals arranged in the order of their decreasing activities.

K	Most reactive
Na	
Ca	
Mg	
Al	
Zn	Reactivity decreases
Fe	
Pb	
H	
Cu	
Hg	
Ag	
Au	Least reactive

• Reaction of Metals with Non-metals

→ Reactivity of elements is the tendency to attain a completely filled valence shell.
→ Atoms of the metals lose electrons from their valence shell to form cation. Atom of the non-metals gain electrons in the valence shell to form anion.

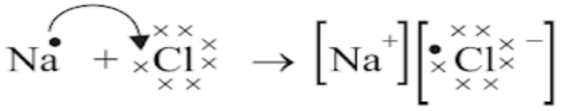
E.g.: Formation of NaCl

$Na \rightarrow Na^+ + e^-$
2, 8, 1 2, 8

Sodium cation

$Cl + e^- \rightarrow Cl^-$
2, 8, 7 2, 8, 8

Chloride anion



Ionic compounds

The compounds formed by the transfer of electrons from a metal to a non-metal are called ionic compounds or electrovalent compounds.

• Properties of Ionic Compounds

(i) Physical nature: They are solid and hard, generally brittle.

(ii) Melting and Boiling Point: They have high melting and boiling point.

(iii) Solubility : Generally soluble in water and insoluble in solvents such as kerosene, petrol etc.

(iv) Conduction of electricity : Ionic compounds conduct electricity in molten and solution form but not in solid state.

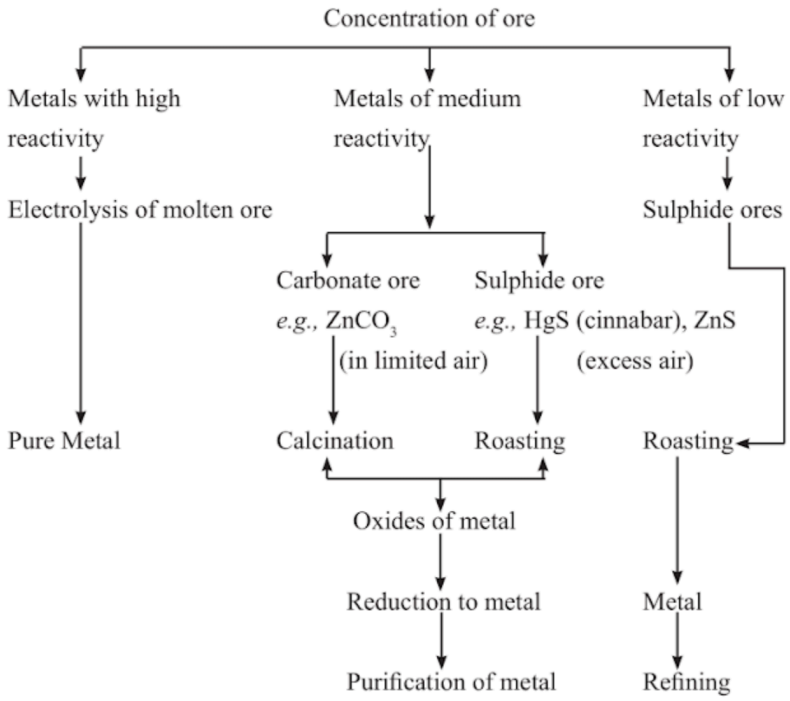
• **Occurrence of Metals**

(i) Minerals: The elements or compounds which occur naturally in the earth's crust are called minerals.

(ii) Ores: Minerals that contain very high percentage of particular metal and the metal can be profitably extracted from it, such minerals are called ores.

Extraction of Metals from Ores

Step 1. Enrichment of ores.
Step 2. Extraction of metals.
Step 3. Refining of metals.



Steps Involved in Extraction of Metals from Ores

Gangue → Roasting → Calcination → Reduction

• Important terms

(a) Gangue : Ores are usually contaminated with large amount of impurities such as soil, sand etc. called gangue.

(b) Roasting : The sulphide ores are converted into oxides by heating strongly in the presence of excess air. This process is called roasting.

$2ZnS + 3O_2 \rightarrow$ (Heast) $2ZnO + 2SO_2$

(c) Calcination : The carbonate ores are changed into oxides by heating strongly in limited air. This process is called calcination.

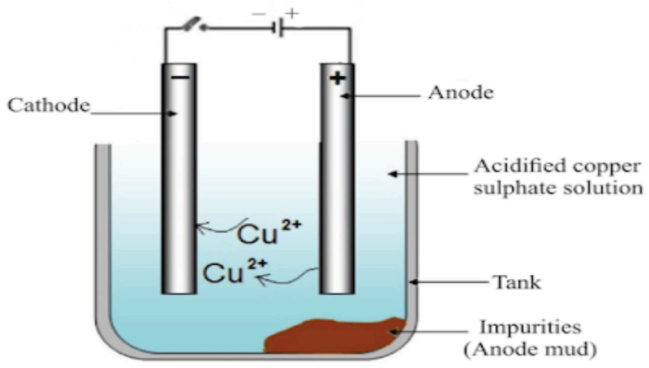
$ZnCO_3 \rightarrow$ (Heat) $ZnO + CO_2$

(d) Reduction : Metal oxides are reduced to corresponding metals by using reducing agent like carbon.

$ZnO + C \rightarrow Zn + CO$

• Refining of metals

The most widely used method for refining impure metal is electrolytic refining.



(i) Anode : Impure copper

(ii) Cathode : Strip of pure copper

(iii) Electrolyte : Solution of acidified copper sulphate

→ On passing the current through electrolyte, the impure metal from anode dissolves into the

→ An equivalent amount of pure metal from the electrolyte is deposited at the cathode.

→ The insoluble impurities settle down at the bottom of the anode and is called anode mud.

Corrosion

The surface of some metals get corroded when they are exposed to moist air for a long period of time. This is called corrosion.

Examples:

(i) Silver becomes black when exposed to air as it reacts with air to form a coating of silver sulphide.

(ii) Copper reacts with moist carbon dioxide in the air and gains a green coat of copper carbonate.