

Some Basic Concepts of Chemistry

General Introduction: Importance and scope of chemistry.

Nature of matter, laws of chemical combination, Dalton's atomic theory: concept of elements, atoms and molecules.

Atomic and molecular masses, mole concept and molar mass, percentage composition, empirical and molecular formula, chemical reactions, stoichiometry and calculations based on stoichiometry.

Unit II: Structure of Atom

Discovery of Electron, Proton and Neutron, atomic number, isotopes and isobars. Thomson's model and its limitations. Rutherford's model and its limitations, Bohr's model and its limitations, concept of shells and subshells, dual nature of matter and light, de Broglie's relationship, Heisenberg uncertainty principle, concept of orbitals, quantum numbers, shapes of s, p and d orbitals, rules for filling electrons in orbitals - Aufbau principle, Pauli's exclusion principle and Hund's rule, electronic configuration of atoms, stability of half filled and completely filled orbitals.

Unit III: Classification of Elements and Periodicity in Properties

Significance of classification, brief history of the development of periodic table, modern periodic law and the present form of periodic table, periodic trends in properties of elements - atomic radii, ionic radii, inert gas radii Ionization enthalpy, electron gain enthalpy, electronegativity, valency. Nomenclature of elements with atomic number greater than 100.

Unit IV: Chemical Bonding and Molecular Structure

Valence electrons, ionic bond, covalent bond; bond parameters, Lewis structure, polar character of covalent bond, covalent character of ionic bond, valence bond theory, resonance, geometry of covalent molecules, VSEPR theory, concept of hybridization, involving s,p and d orbitals and shapes of some simple molecules, molecular orbital theory of homonuclear diatomic molecules (qualitative idea only), hydrogen bond.

Unit V: States of Matter: Gases and Liquids

Three states of matter, intermolecular interactions, types of bonding, melting and boiling points, role of gas laws in elucidating the concept of the molecule, Boyle's law, Charles law, Gay Lussac's law, Avogadro's law, ideal behaviour, empirical derivation of gas equation, Avogadro's

number, ideal gas equation. Deviation from ideal behaviour, liquefaction of gases, critical temperature, kinetic energy and molecular speeds (elementary idea) Liquid State- vapour pressure, viscosity and surface tension (qualitative idea only, no mathematical derivations)

Unit VI: Chemical Thermodynamics

Concepts of System and types of systems, surroundings, work, heat, energy, extensive and intensive properties, state functions.

First law of thermodynamics -internal energy and enthalpy, heat capacity and specific heat, measurement of ΔU and ΔH , Hess's law of constant heat summation, enthalpy of bond dissociation, combustion, formation, atomization, sublimation, phase transition, ionization, solution and dilution. Second law of Thermodynamics (brief introduction)

Introduction of entropy as a state function, Gibb's energy change for spontaneous and non-spontaneous processes, criteria for equilibrium.

Third law of thermodynamics (brief introduction).

Unit VII: Equilibrium

Equilibrium in physical and chemical processes, dynamic nature of equilibrium, law of mass action, equilibrium constant, factors affecting equilibrium - Le Chatelier's principle, ionic equilibrium-ionization of acids and bases, strong and weak electrolytes, degree of ionization, ionization of poly basic acids, acid strength, concept of pH, Henderson Equation, hydrolysis of salts (elementary idea), buffer solution, solubility product, common ion effect (with illustrative examples).

Unit VIII: Redox Reaction

Concept of oxidation and reduction, redox reactions, oxidation number, balancing redox reactions, in terms of loss and gain of electrons and change in oxidation number, applications of redox reactions.

Unit IX: Hydrogen

Position of hydrogen in periodic table, occurrence, isotopes, preparation, properties and uses of hydrogen, hydrides-ionic covalent and interstitial; physical and chemical properties of water, heavy water, hydrogen peroxide -preparation, reactions and structure and use; hydrogen as a fuel.

Unit X: s -Block Elements (Alkali and Alkaline Earth Metals)

Group 1 and Group 2 Elements

General introduction, electronic configuration, occurrence, anomalous properties of the first element of each group, diagonal relationship, trends in the variation of properties (such as

ionization enthalpy, atomic and ionic radii), trends in chemical reactivity with oxygen, water, hydrogen and halogens, uses.

Preparation and Properties of Some Important Compounds:

Sodium Carbonate, Sodium Chloride, Sodium Hydroxide and Sodium Hydrogencarbonate, Biological importance of Sodium and Potassium. Calcium Oxide and Calcium Carbonate and their industrial uses, biological importance of Magnesium and Calcium.

Unit XI: Some p -Block Elements

General Introduction to p - Block Elements

Group 13 Elements: General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous properties of first element of the group, Boron - physical and chemical properties, some important compounds, Borax, Boric acid, Boron Hydrides, Aluminium: Reactions with acids and alkalies, uses.

Group 14 Elements: General introduction, electronic configuration, occurrence, variation of properties, oxidation states, trends in chemical reactivity, anomalous behaviour of first elements. Carbon-catenation, allotropic forms, physical and chemical properties; uses of some important compounds: oxides. Important compounds of Silicon and a few uses: Silicon Tetrachloride, Silicones, Silicates and Zeolites, their uses.

Unit XII: Organic Chemistry - Some Basic Principles and Technique

General introduction, methods of purification, qualitative and quantitative analysis, classification and IUPAC nomenclature of organic compounds. Electronic displacements in a covalent bond: inductive effect, electromeric effect, resonance and hyper conjugation. Homolytic and heterolytic fission of a covalent bond: free radicals, carbocations, carbanions, electrophiles and nucleophiles, types of organic reactions.

Unit XIII: Hydrocarbons

Classification of Hydrocarbons

Aliphatic Hydrocarbons:

Alkanes - Nomenclature, isomerism, conformation (ethane only), physical properties, chemical reactions including free radical mechanism of halogenation, combustion and pyrolysis.

Alkenes - Nomenclature, structure of double bond (ethene), geometrical isomerism, physical properties, methods of preparation, chemical reactions: addition of hydrogen, halogen, water, hydrogen halides (Markownikov's addition and peroxide effect), ozonolysis, oxidation, mechanism of electrophilic addition.

Alkynes - Nomenclature, structure of triple bond (ethyne), physical properties, methods of preparation, chemical reactions: acidic character of alkynes, addition reaction of - hydrogen, halogens, hydrogen halides and water.

Aromatic Hydrocarbons: Introduction, IUPAC nomenclature, benzene: resonance, aromaticity, chemical properties: mechanism of electrophilic substitution. nitration, sulphonation, halogenation, Friedel Craft's alkylation and acylation, directive influence of functional group in monosubstituted benzene. Carcinogenicity and toxicity.

Unit XIV: Environmental Chemistry

Environmental pollution - air, water and soil pollution, chemical reactions in atmosphere, smog, major atmospheric pollutants, acid rain, ozone and its reactions, effects of depletion of ozone layer, greenhouse effect and global warming- pollution due to industrial wastes, green chemistry as an alternative tool for reducing pollution, strategies for control of environmental pollution.

- **Adsorption:**
 - (i) The accumulation of molecular species at the surface rather than in the bulk of a solid or liquid is termed as adsorption.
 - (ii) It is a surface phenomenon.
 - (iii) The concentration of adsorbate increases only at the surface of the adsorbent.
- **Adsorbate:** It is the substance which is being adsorbed on the surface of another substance.
- **Adsorbent:** It is the substance present in bulk, on the surface of which adsorption is taking place.
- **Desorption:** It is the process of removing an adsorbed substance from a surface on which it is adsorbed.
- **Absorption:**
 - (i) It is the phenomenon in which a substance is uniformly distributed throughout the bulk of the solid.
 - (ii) It is a bulk phenomenon.
 - (iii) The concentration is uniform throughout the bulk of solid.
- **Sorption:** When adsorption and absorption take place simultaneously, it is called sorption.
- **Enthalpy or heat of adsorption:** Since, adsorption occurs with release in energy, i.e., it is exothermic in nature. The enthalpy change for the adsorption of one mole of an adsorbate on the surface of adsorbent is called enthalpy or heat of adsorption.
- **Types of adsorption:** There are different types of adsorption namely,

1. Physical adsorption
2. Chemical adsorption

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- **Physical adsorption**

- (i) If the adsorbate is held on a surface of adsorbent by weak van der Waals' forces, the adsorption is called physical adsorption or physisorption.

- (ii) It is non-specific.

- (iii) It is reversible.

- (iv) The amount of gas depends upon nature of gas, i.e., easily liquefiable gases like NH_3 , CO_2 , gas adsorbed to greater extent than H_2 and He. Higher the critical temperature of gas, more will be the extent of adsorption.

- (v) The extent of adsorption increases with increase in surface area, e.g. porous and finely divided metals are good adsorbents.

- (vi) There are weak van der Waals' forces of attraction between adsorbate and adsorbent.

- (vii) It has low enthalpy of adsorption ($20 - 40 \text{ kJ mol}^{-1}$).

- (viii) Low temperature is favourable.

- (ix) No appreciable activation energy is needed.

- (x) It forms multimolecular layers.

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- **Chemical adsorption or chemisorption:**

- (i) If the forces holding the adsorbate are as strong as in chemical bonds, the adsorption process is known as chemical adsorption or chemisorption.

- (ii) It is highly specific.

- (iii) It is irreversible.

- (iv) The amount of gas adsorbed is not related to critical temperature of the gas.

- (v) It also increases with increase in surface area.

- (vi) There is strong force of attraction similar to chemical bond.

- (vii) It has enthalpy heat of adsorption ($180 - 240 \text{ kJ mol}^{-1}$).

- (viii) High temperature is favourable.

- (ix) High activation energy is sometimes needed.

- (x) It forms unimolecular layers.

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- **Factors affecting adsorption of gases on solids:**

- a. Nature of adsorbate:**

- b. Physical adsorption is non-specific in nature and therefore every gas gets adsorbed on the surface of any solid to a lesser or greater extent. However, easily liquefiable gases like NH_3 , HCl , CO_2 , etc. which have higher critical temperatures are adsorbed to greater extent whereas H_2 , O_2 , N_2 etc. are adsorbed to lesser

extent. The chemical adsorption being highly specific, therefore, a gas gets adsorbed on specific solid only if it enters into chemical combination with it.

b. Nature of adsorbent: Activated carbon, metal oxides like aluminum oxide, silica gel and clay are commonly used adsorbents. They have their specific adsorption properties depending upon pores.

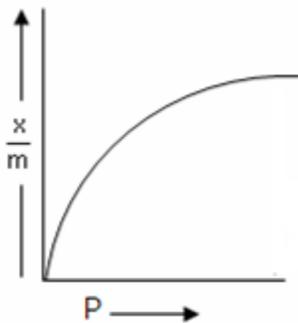
c. Specific area of the adsorbent: The greater the specific area, more will be the extent of adsorption. That is why porous or finely divided forms of adsorbents adsorb larger quantities of adsorbate. The pores should be large enough to allow the gas molecules to enter.

d. Pressure of the gas: Physical adsorption increases with increase in pressure.

- Adsorption isotherm:
- The variation in the amount of gas adsorbed by the adsorbent with pressure at constant temperature can be expressed by means of a curve is termed as adsorption isotherm.
- Freundlich Adsorption isotherm: The relationship between and pressure of the gas at constant temperature is called adsorption isotherm and is given by

Where x - mass of the gas adsorbed on mass m of the adsorbent and the gas at a particular temperature k and n depends upon the nature of gas

- The solid first increases with increase in pressure at low pressure but becomes independent of pressure at high pressure.

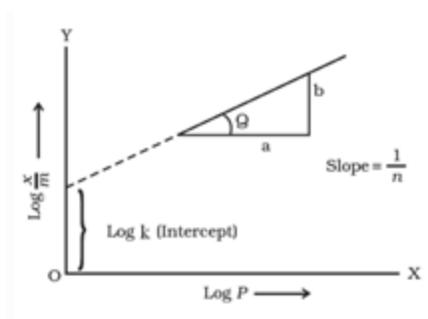


Taking logarithm on both sides, we get,

$$\log \frac{x}{m} = \log k + \frac{1}{n} \log p$$

Taking logarithm on both sides, we get,

- If we plot a graph between $\log d \log P$, we get a straight line.



Unit	Title	Marks
I	Solid State	23
II	Solutions	
III	Electrochemistry	
IV	Chemical Kinetics	
V	Surface Chemistry	
VI	Isolation of Elements	19
VII	p-Block Elements	
VIII	d- and f-Block Elements	
IX	Coordination Compounds	
X	Haloalkanes and Haloarenes	28
XI	Alcohols, Phenols and Ethers	
XII	Aldehydes, Ketones and Carboxylic Acids	
XIII	Organic Compounds containing Nitrogen	
XIV	Biomolecules	
XV	Polymers	
XVI	Chemistry in Everyday Life	
	Total	70

Unit 1: Solid State

Classification of solids based on different binding forces: molecular, ionic, covalent and metallic solids, amorphous and crystalline solids (elementary idea), Crystal Lattices and

unit cells, calculation of density of unit cell, packing in solids, voids, number of atoms per unit cell in a cubic unit cell, point defects, electrical and magnetic properties.

Unit 2: Solutions

Types of solutions, expression of concentration of solutions of solids in liquids, solubility of gases in liquids, solid solutions, colligative properties - relative lowering of vapour pressure, elevation of boiling point, depression of freezing point, osmotic pressure, determination of molecular masses using colligative properties, abnormal molecular mass.

Earth crust is the source of many elements. Out of these elements, 70% are metals. Aluminium is the most abundant metal of earth crust and iron comes second. The percentage of different elements in earth crust are

O-49%, Si-26%, Al-7.5%, Fe-4.2%, Ca-3.2%, Na-2.4%, K-2.3%, Mg-2.3%, H-1%

Metals occur in two forms in nature (i) in native state (ii) in combined state, depending upon their chemical reactivities.

Native State

Elements which have low chemical reactivity or noble metals having least electropositive character are not attacked by oxygen, moisture and CO₂ of the air. These elements, therefore, occur in the free state or in the native state, e.g., Au, Ag, Pt, S, O, N, noble gases, etc.

Combined State

Highly reactive elements such as F, Cl, Na, K, etc., occur in nature combined form as their compounds such as oxides, carbonates sulphides, halides, etc.

Hydrogen is the only non-metal which exists in oxidised form only.

Minerals and Ores

The naturally occurring substances in the form of which the metals occur in the earth crust are called minerals.

Every mineral is not suitable for the extraction of the metal. The mineral from which the metal is economically and conveniently extracted is called an ore.

Thus, all ores are minerals but all minerals are not ores.

polymer is a large molecule or a macromolecule which essentially is a combination of many subunits. The term polymer in Greek means 'many parts'. Polymers can be found all around us. From the strand of our DNA which is a naturally occurring biopolymer to polypropylene which is used throughout the world as plastic.

Polymers may be naturally found in plants and animals (**natural polymers**) or may be man-made (**synthetic polymers**). Different polymers have a number of unique physical and chemical properties due to which they find usage in everyday life.

Combined state	Element	Ore/mineral
Oxides	Fe	Haematite (Fe_2O_3), Magnetite (Fe_3O_4), Limonite ($\text{Fe}_2\text{O}_3 \cdot 3\text{H}_2\text{O}$), Chromite ($\text{FeO} \cdot \text{Cr}_2\text{O}_3$)
	Al	Bauxite ($\text{Al}_2\text{O}_3 \cdot 2\text{H}_2\text{O}$), Diaspore ($\text{Al}_2\text{O}_3 \cdot \text{H}_2\text{O}$), Corundum (Al_2O_3)
	Mn	Pyrolusite (MnO_2)
	Zn	Zincite (ZnO)
	Ti	Rutile (TiO_2)
	Cu	Cuprite (Cu_2O)
	Sn	Cassiterite or tin stone (SnO_2)
	Carbonates	Ca
Mg		Magnesite (MgCO_3)
Ca, Mg		Dolomite ($\text{CaCO}_3 \cdot \text{MgCO}_3$)
Cu		Malachite [$\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$]
Zn		Calamine (ZnCO_3)
Fe		Siderite or spathic ore (FeCO_3)
Pb		Cerussite (PbCO_3)
Au	Azurite [$2\text{CuCO}_3 \cdot \text{Cu}(\text{OH})_2$]	
Sulphides	Fe	Iron pyrite (FeS_2)
	Cu	Copper glance (CuS_2)
	Cu, Fe	Copper pyrite or chalcopyrite (CuFeS_2)
	Hg	Cinnabar (HgS)
	Zn	Zinc blende (ZnS)
	Pb	Galena (PbS)
	Ag	Argentite or silver glance (Ag_2S)
Halides	Na	Common salt or Rock salt (NaCl)
	Al	Cryolite (Na_3AlF_6)
	K, Mg	Carnallite ($\text{KCl} \cdot \text{MgCl}_2 \cdot 6\text{H}_2\text{O}$)
	Ag	Horn silver (AgCl)

Gangue or Matrix

Impurities associated with ores are called gangue or matrix.

Metallurgy

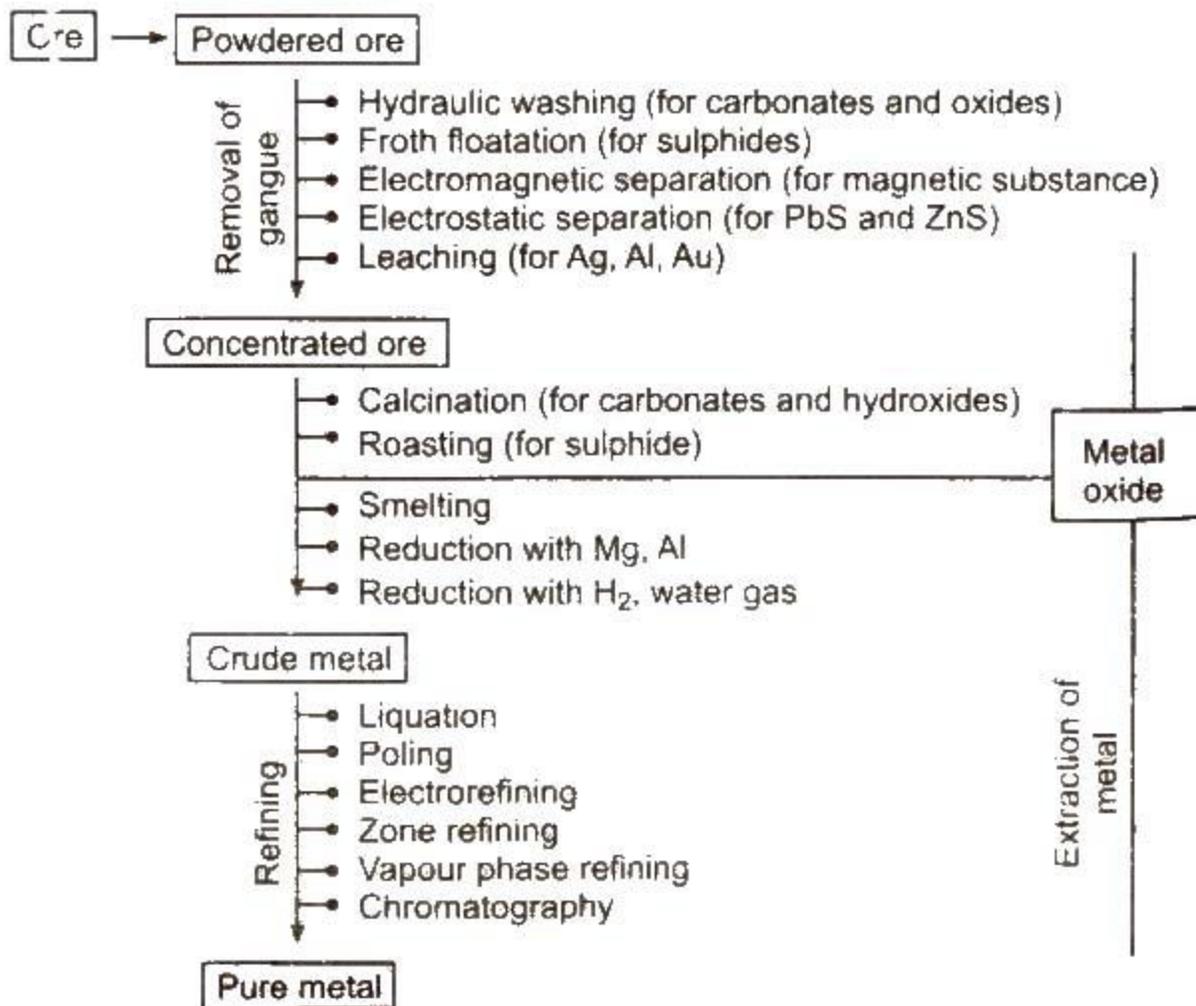
The entire scientific and technological process used for isolation of the metal from its ores is known as metallurgy.

Types of Metallurgical Processes

1. Pyrometallurgy Extraction of metals takes place at very high temperature. Cu, Fe, Zn, Sn, etc .. are extracted by this method.
2. Hydrometallurgical process In this method, metals are extracted by the use of their aqueous solution. Ag and Au are extracted by this method.
3. Electrometallurgical process Na, K, Li, Ca, etc., are extracted from their molten salt solution through electrolytic method.

Steps Involved in Metallurgy

Following steps are involved in the metallurgy :



Crushing of the Ore

The big lumps of ore are crushed into smaller pieces with the help of jaw-crushers. The process of grinding the crushed ore into fine powder with the help of the stamp mills is called pulverisation.

Concentration of Ores

Removal of unwanted materials (e.g., sand, clays, etc.) from the ore is known as ore concentration, ore dressing or ore benefaction. It can be carried out by various ways depending upon the nature of the ore.

Hydraulic Washing/Gravity Separation/Levigation

The process by which lighter earthy impurities are removed from the heavier ore particles by washing with water is called levigation. The lighter impurities

are washed away. Thus, this method is based on the difference in the densities (specific gravities) of ore and gangue.

This method is commonly used for oxide ores such as haematite, tin stone and native ores of Au, Ag, etc.

Froth Floatation

This method is used for the concentration of sulphide ores. This method is based on the preferential wetting of ore particles by oil and that of gangue by water .. As a result, the ore particles become light and rise to the top in the form of froth while the gangue particles become heavy and settle down. Thus, adsorption is involved in this method.

The froth can be stabilised by the addition of stabilisers (aniline or cresols).

Activator They activate the floating property of one of the component of the ore and help in the separation of different minerals present in the same ore (CuSO₄ is used as activator).

Depressants These are used to prevent certain types of particles from forming the froth with air bubbled, e.g., NaCN can be used as a depressant in the separation of ZnS and PbS ores. KCN is another depressant.

Collectors It increases the non-wettability of ore particles by water, e.g., pine oils, xanthates and fatty acids.

Electromagnetic Separation

This method of concentration is employed when either the ore or the impurities associated with it are magnetic in nature. e.g., chromite, FeCr₂O₄, containing magnetic Silicious gangue and wolframite FeWO₄, containing cassiterite, SnO₂ (non-magnetic impurities) can be separated by this method.

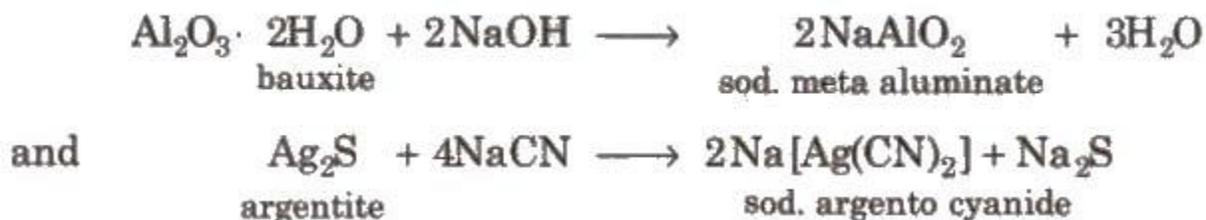
Electrostatic Separation

This method is used for the separation of lead sulphide (good conductor) which is charged immediately in an electrostatic field and is thrown away from the roller from zinc sulphide (poor conductor) which is not charged and hence, drops vertically from the roller.

Chemical Method-Leaching

Leaching is the process in which the ore is concentrated by chemical reaction with a suitable reagent which dissolves the ore but not the impurities, e.g., bauxite is leached with a hot concentrated solution of NaOH which dissolves aluminium while other oxides (Fe₂O₃, TiO₂, SiO₂), remain undissolved and

noble metals (Ag and Au) are leached with a dilute aqueous solution of NaCN or KCN in the presence of air.



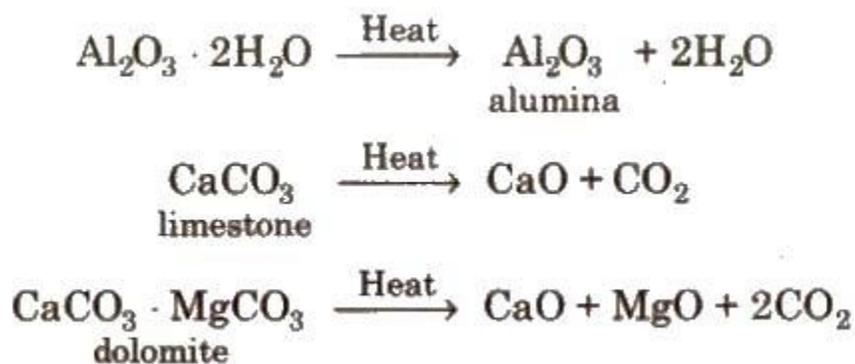
Extraction of Crude Metals from Concentrated Ore

The concentrated ore is usually converted to oxide before reduction, as oxides are easier to reduce. Thus, isolation of crude metal from concentrated ore involves two major steps:

1. Conversion to oxide.
2. Reduction of the oxides to metal.

Conversion to Oxides

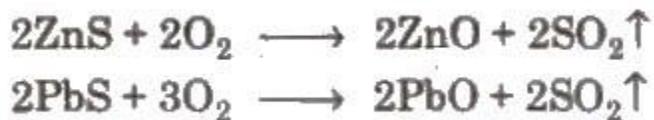
(i) Calcination It is the process of converting an ore into its oxides by heating it strongly, below its melting point in a limited supply of air or in absence of air. During calcination, volatile impurities as well as organic matter and moisture are removed.



Calcination is used for metal carbonates and hydroxides and is carried out in reverberatory furnace.

(ii) Roasting It is the process of converting an ore into its metallic oxide by heating it strongly, below its melting point in excess of air. This process is commonly used for sulphide ores and is carried out in blast furnace or

reverberatory furnace. Roasting helps to remove the non-metallic impurities and moisture.



The furnaces used in calcination and roasting employ refractory materials which resist high temperature and do not become soft.

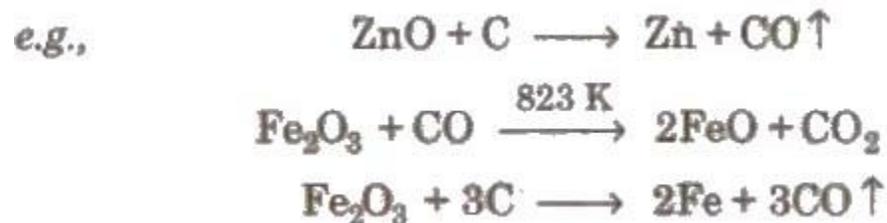
- Acidic refractories : SiO_2 and $\text{SiO}_2 + \text{Al}_2\text{O}_3$
 - Basic refractories : CaO and MgO
 - Neutral refractories : Graphite, chromites. etc.
- Heavy metals like Cu, Zn, Fe, Sn, etc., are obtained by roasting and smelting.

Reduction of the Oxides to Metal

The roasted or the calcined ore is then converted to the free metal by reduction. Reduction method depends upon the activity of metal.

Metals which are low in the activity series (like Cu, Hg, Au) are obtained by heating their compounds in air; metals which are in the middle of the activity series (like Fe, Zn, Ni, Sn) are obtained by heating their oxides with carbon while metals which are very high in the activity series (e.g., Na, K, Ca, Mg, Al) are obtained by electrolytic reduction method.

(i) Smelting (reduction with carbon) The process of extracting the metal by fusion of its oxide ore with carbon (C) or CO is called smelting. It is carried out in a reverberatory furnace.



During smelting a substance, called flux is added which removes the non-fusible impurities as fusible slag. This slag is insoluble in the molten metal and is lighter than the molten metal. So, it floats over the molten metal and is skimmed off.

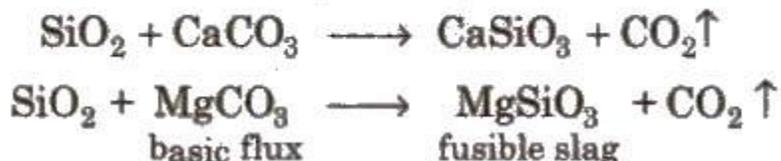
Acidic flux For basic impurities, acidic flux is added.

e.g., $\text{CaO} + \text{SiO}_2 \rightarrow \text{CaSiO}_3$



Basic flux For acidic impurities, basic flux is added.

e.g.,



In the extraction of Cu and Fe, the slag obtained are respectively FeSiO_3 and CaSiO_3 .

The obtained slag is used in road making as well as in the manufacturing of cement and fertilizers.

(ii) Reduction by hydrogen It is done for W or Mo oxide.

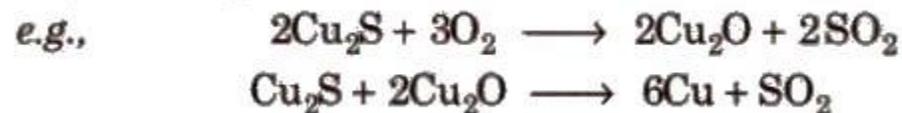


iii) Reduction by aluminium It is known as aluminothermic reduction or Goldschmidt thermite process. Aluminium powder is used for this purpose.

e.g., $\text{Cr}_2\text{O}_3 + 2\text{Al} \rightarrow \text{Al}_2\text{O}_3 + 2\text{Cr}$

Mixture of the oxide and Al in the ratio of 3 : 1 is known as thermite and mixture of $\text{BaO}_2 + \text{Mg}$ powder acts as ignition powder.

(iv) Auto reduction This is used for reduction of sulphide ores of Pb, Hg, Cu, etc. The sulphide ore is heated in a supply of air at 770-970 K when the metal sulphide is partially oxidised to form its oxide or sulphate which then reacts with the remaining sulphide to give the metal.



(v) Reduction by Mg

$\text{TiCl}_4 + 2\text{Mg} \rightarrow 2\text{MgCl}_2 + \text{Ti}$ (Kroll's process)

vi) Electrolytic reduction or electrometallurgy It is the process of extracting highly electropositive (active) metals such as Na, K, Ca, Mg, Al, etc by

electrolysis of their oxides, hydroxides or chlorides in fused state, e.g., Mg is prepared by the electrolysis of fused salt of MgCl_2 (Dow's process).

Thermodynamic Principle in Extraction of Metals

The free energy change (ΔG) occurring during the reduction processes help in deciding the suitable method for reduction.

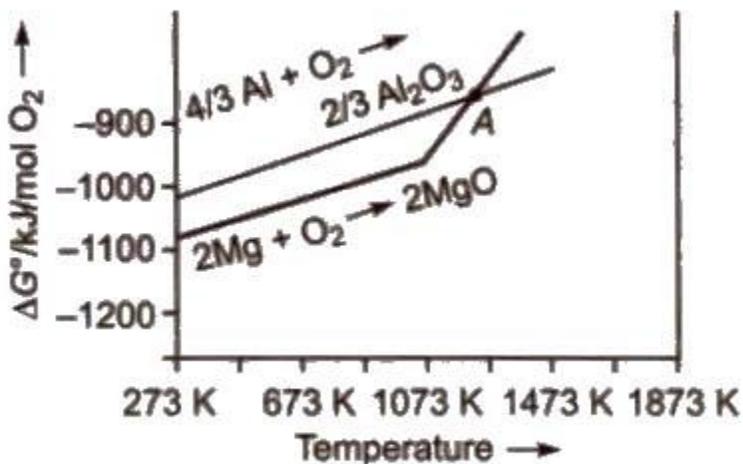
For the spontaneous reduction of an oxide, halide or sulphide by an element, the essential condition is that there is a decrease in the free energy of the system (-ve ΔG).

More the negative value of ΔG , the higher is the reducing power of an element. ΔG can be given as

$$\Delta G = \Delta H - T\Delta S$$

- where, ΔH = enthalpy change;
- ΔG = Gibbs free energy
- T = temperature;
- ΔS = entropy change

For the reduction of a metal oxide with a reducing agent, the plot of ΔG° against temperature is studied, which is called **Ellingham diagram**.



Gibbs energy (ΔG°) vs T plots
(Ellingham diagram)

Characteristics of Ellingham Diagram

1. All the plots slope upwards since ΔG° becomes more positive when temperature increases, i.e., stability of oxides decreases.

2. A metal will reduce the oxide of other metals which lie above it in Ellingham diagram, i.e., the metals for which the free energy of formation (ΔG°_f) of their oxides is more negative can reduce those metal oxides which has less negative ΔG°_f

3. The decreasing order of the negative values of ΔG°_f of metal oxides is Ca > Mg (below 1773 K) > Al > Ti > Cr > C > Fe > Ni > Hg > Ag

Thus, Al reduces FeO, CrO and NiO in thermite reduction but it will not reduce MgO at temperature below 1773 K.

Mg can reduce Al_2O_3 below 162 K but above 1023 K, Al can reduce MgO.

4. CO is more effective reducing agent below 1073 K and above 1073 K. coke is more effective reducing agent, e.g., CO reduces F_2O_3 below 1073 K but above it, coke reduces Fe_2O_3 .

Coke reduces ZnO above 1270 K.

Refining or Purification of Crude Metals

Physical Methods

(i) Liquation This method is used for refining the metals having low melting points (such as Sn, Pb, Hg, Bi) than the impurities, The impure metal is placed on the sloping hearth and is gently heated. The metal melts and flows down leaving behind the non-fusible impurities.

(ii) Distillation This is useful for low boiling metals such as Zn, Hg. The impure liquid metal is evaporated to obtain the pure metal as distillate.

(iii) Cupellation

This method is used when impure metal contains impurities of other metals which form volatile oxides.

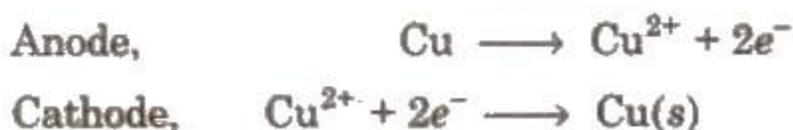
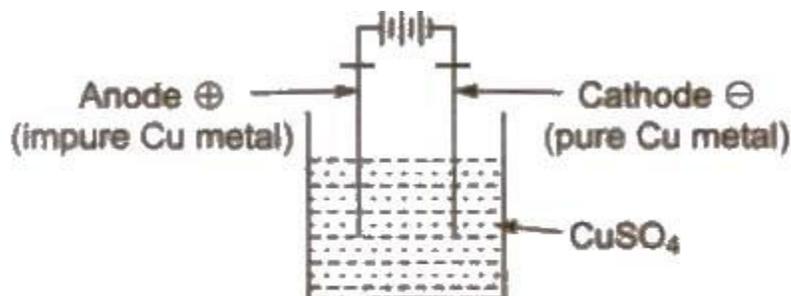
e.g., traces of lead ore removed from silver (as volatile PbO) by this process.

Chemical Methods

(i) Poling This method is used when the impure metal contains impurities of its own oxide, e.g., Cu_2O in blister copper and SnO_2 in impure Sn. The molten impure metal is stirred with green wood poles. At this high temperature, wood liberates gases such as CH_4 which reduces any oxides present in the metal.

(ii) Electro-refining

In this method, impure metal forms the anode while the cathode is a rod or sheet of pure metal. The electrolytic solution consists of a soluble salt of the metal.

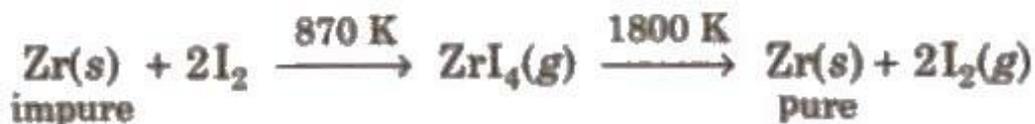


On passing electricity, the pure metal gets deposited on the cathode while the insoluble impurities settle down below the anode as anode mud or anode sludge. Metals like Cu, Ag, Au, Cr, Zn, Ni, etc are purified by this method.

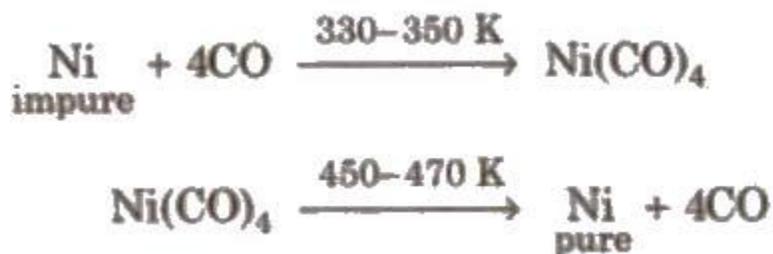
(iii) Zone-refining This method is based upon the principle of fractional crystallisation, i.e., difference in solubilities of impurities in molten and solid state of metal. Semiconductors like silicon, germanium, gallium arsenide and indium antimonide are purified by this method. Elements of very high purity are obtained by this method.

(iv) Vapour phase refining In this method, crude metal is made free from impurities by first converting it into its volatile compound by heating with a chemical reagent at low temperature. After this, the volatile compound is decomposed by heating to some higher temperature to give pure metal.

(a) van Arkel method This method is used for preparing ultra-pure metal used in space technology (e.g., Ti, Zr, etc.)



(b) **Mond's process** It is used for refining of nickel.



(v) **Chromatographic method** Adsorption chromatography is generally used. The impure metal is dissolved in a suitable solvent and the solution is allowed to run slowly into an adsorbent column packed with alumina (Al_2O_3). The metal and the impurities present are adsorbed at different rates. These are then eluted with suitable eluent (solvent). In this method, weakly adsorbed component is eluted first and the strongly adsorbed component is eluted afterwards.

Occurrence and Extraction of Some Metals

1. Metal Aluminium (Al)

Occurrence

1. Bauxite – $\text{Al}_2\text{O}_3 \cdot x\text{H}_2\text{O}$
2. Cryolite – Na_3AlF_6

Common method of extraction Electrolysis of Al_2O_3 dissolved in molten Na_3AlF_6 (neutral flux).

Neutral flux is the neutral compound added to the ore to decrease its melting point and to make it conducting, e.g., CaF_2 , cryolite (Na_3AlF_6) etc.

2. Metal Iron (Fe)

Occurrence

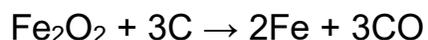
1. Haematite – Fe_2O_3
2. Magnetite – Fe_3O_4

Common method of extraction Reduction of the oxide with CO and coke in blast furnace.

The iron obtained from blast furnace contains about 4% carbon and many impurities in smaller amount (e.g., S, P, Si, Mn) and is known as **pig iron**.

Cast iron is different from pig iron and is made by melting pig iron with scrap iron and coke using hot air blast. It has slightly lower carbon content (about 3%) and is extremely hard and brittle.

Wrought iron or **malleable iron** is the purest form of commercial iron and is prepared from cast iron by oxidising impurities in a reverberatory furnace lined with haematite. This haematite oxidises carbon to carbon monoxide.



3. Metal Copper (Cu)

Occurrence

1. Copper pyrites – CuFeS_2
2. Copper glance – Cu_2S

Common method of extraction Roasting of sulphide partially and reduction. $\text{Cu}_2\text{S} + \text{FeS}$ is called matte. Blister copper contains 96-98% copper with small amounts of Ag and Au as impurity.

4. Metal Zinc (Zn)

Occurrence

1. Zinc blende or sphalerite- ZnS
2. Calamine – ZnCO_3
3. Zincite – ZnO

Common method of extraction Roasting followed by reduction with coke. The metal may be purified by fractional distillation.

97-98% pure zinc is called spelter.

5. Metal Nickel (Ni)

Occurrence

1. Pentlandite – $(\text{Ni}, \text{Cu}, \text{Fe})\text{S}$
2. Kupfernickel – NiAs
3. Smaltite – $(\text{Fe}, \text{Co}, \text{Ni})\text{As}$

Common method of extraction Roasting followed by Refining is done by Mond's Process.

Water gas is used as a reducing agent for nickel oxide.



[ALL CBSE NOTES FOR CLASS 12 CHEMISTRY MATHS NOTES](#)

Unit 3: Solutions

Redox reactions, conductance in electrolytic solutions, specific and molar conductivity, variations of conductivity with concentration, Kohlrausch's Law, electrolysis and law of electrolysis (elementary idea), dry cell -electrolytic cells and Galvanic cells, lead

accumulator, EMF of a cell, standard electrode potential, Nernst equation and its application to chemical cells, fuel cells.

Unit 4: Electro-Chemistry

Rate of a reaction (Average and instantaneous), factors affecting rate of reaction: concentration, temperature, catalyst order and molecularity of a reaction, rate law and specific rate constant, integrated rate equation and half life (only for zero and first order reactions), collision theory (elementary idea, no mathematical treatment).

Unit 5: Surface Chemistry

Adsorption - physisorption and chemisorption, factors affecting adsorption of gases on solids, colloids distinction between true solutions, colloids and suspension; lyophilic, lyophobic multimolecular and macromolecular colloids; properties of colloids; Tyndall effect, Brownian movement, electrophoresis, coagulation, emulsion - types of emulsions.

Unit 6: General Principles and Processes of Isolation of Elements

Principles and methods of extracting - concentration, oxidation, reduction - electrolytic method and refining; occurrence and principles of extraction of aluminium, copper, zinc and iron.

Unit 7: P -Block Elements

Group -15 Elements: General introduction, electronic configuration, occurrence, oxidation states, trends in physical and chemical properties; compounds of nitrogen: preparation and properties of ammonia and nitric acid, Phosphorous - allotropic forms, compounds of phosphorous: preparation and properties of phosphine, halides (PCl_3 , PCl_5) and oxoacids (elementary idea only).

Group 16 Elements: General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties, simple oxides, Ozone, Sulphure - allotropic forms; compounds of sulphure: sulphuric acid: industrial process of manufacture, properties and uses, oxoacids of sulphure (Structures only).

Group 17 Elements: General introduction, electronic configuration, oxidation states, occurrence, trends in physical and chemical properties; compounds of halogens, hydrochloric acid, interhalogen compounds, oxoacids of halogens (structures only).

Group 18 Elements: General introduction, electronic configuration, occurrence, trends in physical and chemical properties, uses.

Unit 8: D -and F -Block Elements

General introduction, electronic configuration, occurrence and characteristics of transition metals, general trends in properties of the first row transition metals - metallic

character, ionization enthalpy, oxidation states, ionic radii, colour, catalytic property, magnetic properties, interstitial compounds, alloy formation, preparation and properties of $K_2Cr_2O_7$ and $KMnO_4$.

Lanthanoids - Electronic configuration, oxidation states and lanthanoid contraction.

Actinoids - Electronic configuration, oxidation states.

Unit 9: Coordination Compounds

Coordination compounds - Introduction, ligands, coordination number, colour, magnetic properties and shapes, IUPAC nomenclature of mononuclear coordination compounds. Bonding, isomerism, importance of coordination compounds (in qualitative analysis, extraction of metals and biological system).

Unit 10: Haloalkanes and Haloarenes

Haloalkanes: Nomenclature, nature of C-X bond, physical and chemical properties, mechanism of substitution reactions.

Haloarenes: Nature of C-X bond, substitution reactions (Directive influence of halogen in mono-substituted compounds only)

Uses and environmental effects of - trichloromethane, tetrachloromethane, iodoform.

Unit 11: Alcohols, Phenols and Ethers

Alcohols: Nomenclature, methods of preparation, physical and chemical properties (of primary alcohols only), identification of primary, secondary and tertiary alcohols, mechanism of dehydration, uses of methanol and ethanol.

Phenols: Nomenclature, methods of preparation, physical and chemical properties, acidic nature of phenol, electrophilic substitution reactions, uses of phenols.

Ethers: Nomenclature, methods of preparation, physical and chemical properties, uses.

Unit 12: Aldehydes, Ketones and Carboxylic Acids

Aldehydes and Ketones: Nomenclature, nature of carbonyl group, methods of preparation, physical and chemical properties, mechanism of nucleophilic addition, reactivity of alpha hydrogen aldehydes: uses.

Carboxylic Acids: Nomenclature, acidic nature, methods of preparation, physical and chemical properties; uses.

Unit 13: Organic Compounds containing Nitrogen

Amines: Nomenclature, classification, structure, methods of preparation, physical and chemical properties, uses, identification of primary, secondary and tertiary amines.

Cyanides and Isocyanides - will be mentioned at relevant places in context. Diazonium salts: Preparation, chemical reactions and importance in synthetic organic chemistry.