FOSSEE SUMMER FELLOWSHIP 2023 REPORT

On

Creating concept mapping using **Freeplane**

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Acknowledgment

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I am deeply grateful for the auspicious opportunity that was bestowed upon me as a FOSSEE intern, and I would like to express my sincere gratitude for being a part of the prestigious institution known as IIT Bombay. It is an immense honor to have been given the chance to contribute to the remarkable work and legacy of IIT Bombay, and I am truly thankful for the experience and knowledge gained during my time as an intern.

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CHAPTER 1

Introduction

Freeplane is a free and open-source mind mapping software that allows users to visually organize, structure, and present their thoughts, ideas, and information. It is a versatile tool that facilitates brainstorming, planning, note-taking, knowledge management, and collaborative work.

Freeplane provides a user-friendly interface with a wide range of features to create and manipulate mind maps. Users can create nodes representing concepts or ideas and connect them with lines to depict relationships or hierarchies. The software supports various customization options, allowing users to format nodes, add icons, images, and attachments, and apply styles to enhance visual clarity.

One of the notable features of Freeplane is its flexibility and extensibility. It supports the use of keyboard shortcuts, scripting, and plugins, enabling users to tailor the software according to their specific needs and preferences. This flexibility enhances productivity and enables users to create highly customized mind maps.

Freeplane also supports collaboration by allowing multiple users to work on the same mind map simultaneously. It offers features for sharing and publishing mind maps, facilitating teamwork and knowledge sharing among individuals or within organizations.

Overall, Freeplane is a powerful and intuitive software that empowers users to unleash their creativity, organize information effectively, and explore connections and ideas in a visual and structured manner. It is widely used by individuals, students, educators, and professionals in various domains for brainstorming, project management, decision-making, and knowledge representation.

CHAPTER 2

Reflection on the internship

2.i Merits of the concept map

Clear Visualization: Concept maps provide a clear and visual representation of complex information. By organizing concepts and their relationships in a structured manner, learners can easily see the connections and hierarchies between different ideas, enhancing their understanding of the subject.

Promotes Active Learning: Concept maps engage learners in the active construction of knowledge. By creating their own concept maps, individuals actively process and organize information, leading to better retention and comprehension compared to passive learning methods.

Facilitates Meaningful Learning: Concept maps encourage meaningful learning by helping learners connect new information with their prior knowledge. By integrating new concepts into their existing mental frameworks, learners establish meaningful associations, promoting deeper understanding and long-term retention.

Encourages Critical Thinking: Creating concept maps requires learners to think critically, analyze information, and evaluate relationships between concepts. This process enhances critical thinking skills by fostering the ability to identify patterns, make connections, and evaluate the significance of different ideas.

Promotes Conceptual Thinking: Concept maps focus on the relationships between concepts rather than just the isolated facts. This promotes conceptual thinking, allowing learners to grasp the underlying principles and connections that govern a subject, leading to a deeper understanding of the topic.

2.ii Purpose of the concept map

Concept maps serve a profound purpose in the realm of learning and cognition, as they act as dynamic frameworks that facilitate a multitude of essential processes. Their overarching goal is to foster optimal knowledge organization, ignite profound understanding and comprehension, cultivate critical thinking, bolster effective communication and collaboration, stimulate boundless creativity, empower problem-solving and decision-making, and enable personalized learning and reflective practices. Concept maps stand as versatile tools that transcend disciplinary boundaries, enriching learning, teaching, and cognitive processes across diverse domains and contexts.

The purpose of concept maps is to facilitate knowledge organization, promote understanding and comprehension, foster critical thinking, support communication and collaboration, stimulate creativity, aid in problem-solving and decision-making, and enable personalized learning and reflection. Concept maps serve as versatile tools that enhance learning, teaching, and cognitive processes across various domains.

2.iii Outcomes of the concept map

Concept maps yield outcomes that encompass improved understanding, enhanced knowledge retention, critical and creative thinking development, effective communication, improved problem-solving skills, integration of prior knowledge, metacognitive awareness, collaboration and teamwork, and transferable skills. By leveraging the power of concept maps, learners can enhance their learning experiences, deepen their understanding, and develop valuable cognitive skills applicable in various domains.

Concept maps serve as guiding beacons, illuminating the path towards meaningful learning, intellectual growth, and the acquisition of invaluable skills applicable in a myriad of domains.

CHAPTER 3

Abstract

During my summer internship at the Soul Project, I developed mind maps for six chapters from the Chemistry textbook (Part I) of class XII and one chapter from the Physics textbook (Part I) of class XI. The mind maps provided comprehensive overviews of each chapter, highlighting key concepts, their interrelationships, and practical applications. The chapters covered topics such as "Surface Chemistry" explores the nature of surfaces, adsorption, catalysts, and properties of colloids."Solid State" is a chapter that delves into understanding solid materials, their classification, crystal lattice structures, density, imperfections, and the electrical, magnetic, and thermal properties associated with them. Solutions" emphasized the significance of mixtures, distinguishing between solute and solvent, and examining properties such as vapor pressure and colligative properties that depend on the number of solute particles. "Coordination Compounds" mind map focused on chemical bonding, highlighting the significance of compounds like chlorophyll and hemoglobin, explaining the colors of complex compounds, and providing a comprehensive understanding of their role in chemical processes. General Principles and Isolation Processes of Elements" covered the extraction of pure elements from natural sources, explaining techniques such as mining, concentration, smelting, and electrolysis to obtain and separate desired elements from impurities. Lastly ,In the "Mechanical Properties of Solids" chapter, the mind map explained how materials react to external forces and deformations, covering concepts like stress and strain in elastic bodies and introducing the concept of elastic modulus. Accompanied by detailed .docx files and mind map images, these resources serve as valuable study aids for students, promoting better understanding and academic success.

1. Surface chemistry

This gives an overview about the study of nature of surfaces and molecular species present on it. Explanations of adsorption, absorption of substances on the surface and about catalysts are given. Catalysts aid in increasing the rate of chemical reaction. Detailed information about colloids and its classification & properties are also explained.

Description:

The branch of chemistry which deals with the study of nature of the surface and the species present on it is called Surface Chemistry.

Adsorption is the accumulation of molecular species at the surface rather than in the bulk of a solid or liquid. Adsorbate is the molecular species which accumulates at the surface. Adsorbent is the substance on the surface of which the adsorption occurs. Extent of adsorption increases with increase in surface area. It is a exothermic process and here entropy decreases.

There are two types of adsorptions:

Chemisorption and Physisorption. The variation in the amount of gas adsorbed by the adsorbent with pressure at constant temperature can be expressed by means of a curve as adsorption isotherm.

Catalyst is a substance which can change the speed of chemical reaction without itself undergoing any change in mass and chemical composition at the end of reaction. If the rate of the reaction increases, it is a promoter and if the rate of the reaction is decreased by the catalyst it is an inhibitor. There are two types of catalysis – Heterogenous (Catalysts in different phase) and homogenous (catalysts in same phase).

Colloids are heterogeneous mixtures of two substances in which minute particles of one substance are dispersed in another substance. Type of particles of dispersed phase, physical state and nature of interaction are important properties in forming colloids. Fog, mist, rain & blood are examples around us for this. Colloids have colligative properties, Brownian movement and electrophoresis.

Emulsion is a mixture of two or more liquids that are normally immiscible. The term emulsion comes from the Latin word ‘emulate’ which means “to milk out”. Water in oil and oil in water are two types of emulsions which we commonly come across.

Glossary:

- **Langmuir Adsorption Isotherm:**
  $\theta = (K * P) / (1 + K * P)$
  where,
  θ= represents the fractional surface coverage
  K = the adsorption equilibrium constant, and P is the pressure of the adsorbate.
- **BET Adsorption Isotherm:**
  $P / (P_0 * (V\_m - V) = (C - 1) / (C * V)$
  Where,
  P = the equilibrium pressure of the adsorbate gas
  P_0 = the saturation pressure
  V_m = the monolayer capacity
  V = the amount adsorbed
  C = a constant

- **Gibbs Adsorption Equation:**
  $\Delta G = \Delta H - T\Delta S$
  Where,
  ΔG = the change in Gibbs free energy of adsorption
  ΔH = the enthalpy of adsorption
  T = the temperature
  ΔS is the entropy of adsorption

- **Kelvin Equation:**
  $\ln (P / P_0) = (2\gamma M) / (RT * r)$, where P is the vapor pressure, P_0 is the equilibrium vapor pressure, γ is the surface tension of the liquid, M is the molar mass of the adsorbate, R is the ideal gas constant, T is the temperature, and r is the radius of the curved liquid surface.

- **Hamaker Constant:**
  $A = (3 / 2) * (\pi / 2) * \varepsilon_0 * \varepsilon_1 * \varepsilon_2 * ((n_0^2 - n_1^2) / (n_0^2 + n_1^2)) * ((n_0^2 - n_2^2) / (n_0^2 + n_2^2))$, where A is the Hamaker constant, ε_0, ε_1, and ε_2 are the dielectric constants of the vacuum, medium 1, and medium 2 respectively, and n_0, n_1, and n_2 are the refractive indices of the vacuum, medium 1, and medium 2 respectively.
- **Contact Angle:**
  $\theta = \cos^{-1}[(r\_L - r\_S) / (r\_L + r\_S)]$, where θ is the contact angle, r_L is the radius of the liquid drop, and r_S is the radius of the solid surface.

- **About the links & attachments:**

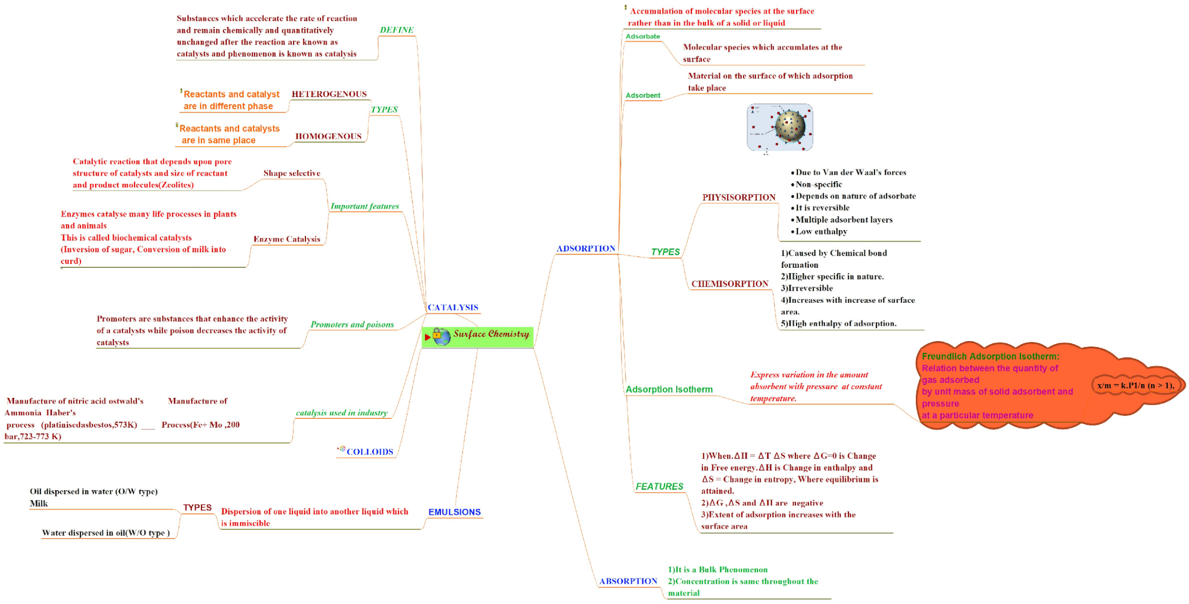
  Brownian movement image link: https://commons.wikimedia.org/wiki/File:Brownian_motion_1.svg

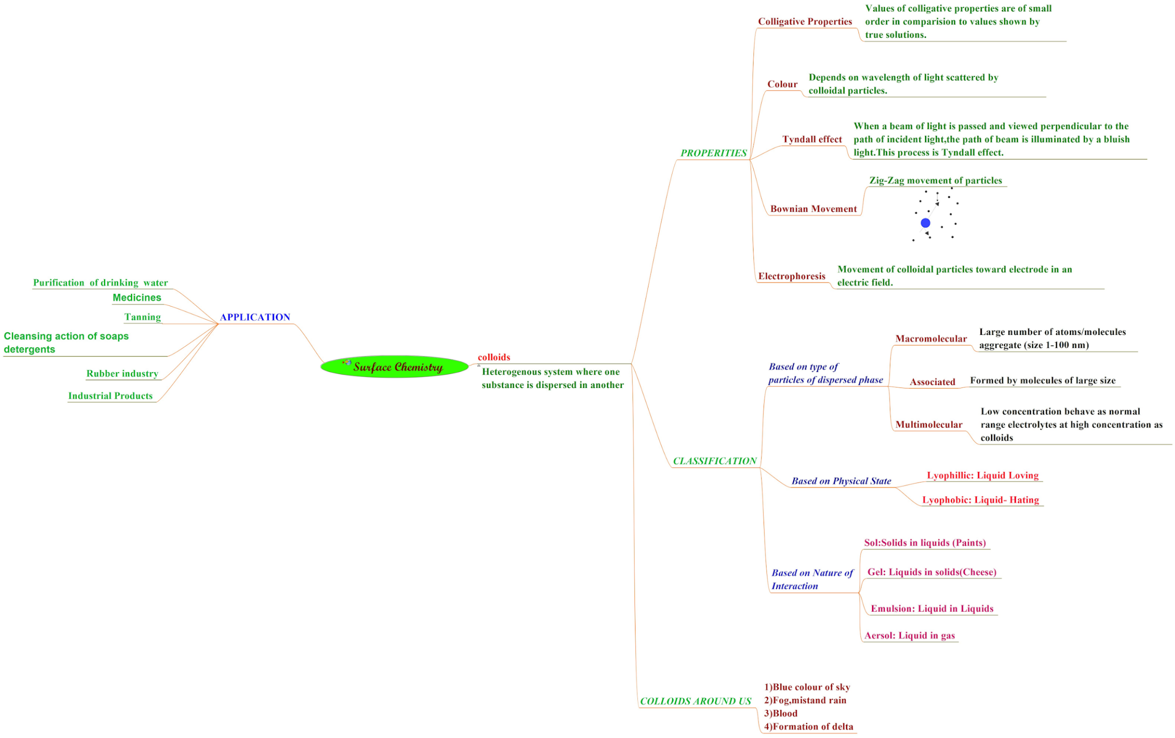
  Adsorption image link :

  https://commons.wikimedia.org/wiki/File:Adsorbent.jpg

  NCERT link for surface chemistry:

  https://ncert.nic.in/ncerts/l/lech105.pdf





- *Surface Chemistry*
  - APPLICATION
    - Purification of drinking water
    - Medicines
    - Tanning
    - Cleansing action of soaps detergents
    - Rubber industry
    - Industrial Products
  - colloids
    - Heterogenous system where one substance is dispersed in another
    - *PROPERITIES*
      - Colligative Properties
        - Values of colligative properties are of small order in comparision to values shown by true solutions.
      - Colour
        - Depends on wavelength of light scattered by colloidal particles.
      - Tyndall effect
        - When a beam of light is passed and viewed perpendicular to the path of incident light,the path of beam is illuminated by a bluish light.This process is Tyndall effect.
      - Bownian Movement
        - Zig-Zag movement of particles
      - Electrophoresis
        - Movement of colloidal particles toward electrode in an electric field.
    - *CLASSIFICATION*
      - *Based on type of particles of dispersed phase*
        - Macromolecular
          - Large number of atoms/molecules aggregate (size 1-100 nm)
        - Associated
          - Formed by molecules of large size
        - Multimolecular
          - Low concentration behave as normal range electrolytes at high concentration as colloids
      - *Based on Physical State*
        - Lyophillic: Liquid Loving
        - Lyophobic: Liquid- Hating
      - *Based on Nature of Interaction*
        - Sol:Solids in liquids (Paints)
        - Gel: Liquids in solids(Cheese)
        - Emulsion: Liquid in Liquids
        - Aersol: Liquid in gas
    - *COLLOIDS AROUND US*
      - 1)Blue colour of sky
      - 2)Fog,mistand rain
      - 3)Blood
      - 4)Formation of delta

2. Solid State

This chapter focuses on the study of solid materials and their properties. It covers topics such as classification of solids based on their arrangement and types of bonding, crystal lattice structures, and unit cells. The chapter discusses concepts like packing efficiency, density, and imperfections in solids. It also explores electrical, magnetic, and thermal properties of solids. Overall, the chapter provides a comprehensive understanding of the structure, properties, and behaviour of solids, highlighting their importance in various fields of science and technology.

Description:

- **Simple cube :**

  Spheres can be arranged in a layer such that each metal atom is in touch with four other atoms.

- **Bravis Lattices**

  Combining the shapes of crystals (obtained by repitation of unit cell in 3 dimensions) and the fundamental laws of crystallogram give that there are only 14 basic arrangements known as Bravais lattices.

- **Points**

  The atoms, molecules, or ions making up the crystal are present at the lattice points and are represented by points. There are three types of lattice points.

- **Points at corner:**

  The lattice points at the corner of a unit cell are shared by 8 Vicinal unit cells. Its contribution is 1/8.

- **Points at face center:**

  The lattice point at the face center of a unit cell is shared by 2 adjacent unit cells. Its contribution is 1/2.

- **Points at body center:**

  The lattice point at the body centered of a unit cell belongs entirely to that cell. Its contribution is 1.

- **Voids**

Empty spaces formed by the three-dimensional layers are called voids or holes

- **Octahedral voids**

The vacant space between a group of three spheres in one layer and another set of three spheres in a subsequent layer.

- **Tetrahedral void**

  A hole formed by the three spheres of a layer in contact with each other and a sphere of the next layer. The hole is called a tetrahedral void.

- **Types of defects**

  There are two types of defects if we classify them broadly: point defects and line defects. Line defects are also called dislocations.

- **Stoichiometric defects:**

  These are point defects that do not disturb the stoichiometry (composition) of the solid. They are also called intrinsic or thermodynamic defects.

- **Impurity defects:**

  CaCl2 or SrCl2 is added to molten NaCl, crystallized. Some of the Na+ ions are replaced by Ca2+ ions or Sr2+. Each Ca2+ or Sr2+ ions replaces two Na+ ions. It occupies the site of one of the ions, and the other site remains vacant. The number of cationic vacancies equals the number of bivalent cations added. A similar example of an impurity defect is the addition of CdCl2 to AgCl.

- **Non-stoichiometric defects:**

  Those defects which lead to a change in the composition of solids are called non-stoichiometric defects. They contain constituting particles is a non-stoichiometric ratio, e.g., Fe0.93O1.0, Ni0.94O1.00 are examples of non-stoichiometric compounds.

Glossary:

1. **Number of atoms in different unit cells:**
    - Primitive unit cell: 1 atom
    - Face centred unit cell: 4 atoms
    - Body centred unit cell: 2 atoms

2. **Let the number of close packed spheres = N**
    - Number of octahedral voids generated = N
    - Number of tetrahedral voids generated = 2N

3. Packing efficiency is the percentage of total space occupied by constituent particles (atoms, molecules or ions).
   Volume occupied by spheres in the unit cell /Total volume of unit cell

   - Packing efficiency for face centred cubic unit cell
   - Packing efficiency for body centred cubic unit cell
   - Packing efficiency for simple cubic unit cell

4. **Relationship between radius of constituent particle (r) and edge length(a):**
   - Simple cubic unit cell: $a= 2r$
   - Face centred unit cell: $2r\sqrt{2}$
   - Body centred unit cell: $4r/\sqrt{3}$

5. **Volume of a unit cell = (edge length) = a^3**
   - Simple cubic unit cell: Volume=$(2r)^3$
   - Face centred unit cell: Volume = $(2\sqrt{2}r)$
   - Body centred unit cell: Volume = $(4r/\sqrt{3}$

6. Number of atoms in a unit cell (z):
   - Simple cubic unit cell: $z = 1$
   - Face centred unit cell: $z = 4$
   - Body centred unit cell: $z = 2$

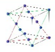
7. Density of unit cell:
   - Density of unit cell= $ZM/a^3.NA$

Detailed link of the attachments :

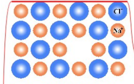
- **NCERT link of solid state chapter:**
  https://ncert.nic.in/ncerts/l/lech101.pdf

- Solid State
  - *Classification based on crystal lattice*
  - *Classification based on Electrical Properties*
    - Conductors or metals
      - **The solids with conductivities ranging between 10^4 ohm^-1m^-1to 10^7 ohm^-1m^-1 are called conductors.**
    - Insulators
      - **These are the solids with very low conductivities ranging between 10^-20 to 10^-10 ohm^-1m^-1**
    - Semiconductor
      - **These are the solids with conductivities in the intermediate range from 10^-6 to 10^-4 ohm^-1 m^-1**
  - *Classification based on Magnetic Properties*
    - **Diamagnetic Substances :**
      Substances ehich are weakly replled by external magnetic field,eg:NaCl,Zn etc
    - **Paramagnetic Substances:**
      Substances which are weakly attracted by external magnetic field.eg:Aluminium, Oxygen etc.
    - **Ferromagnetic Substances:**
      Substances which show permanent magnetism even in the absence of external magnetic field.eg Ni,Fe, Coetc.
    - **Antiferromagnetic Substances:**
      Substances which have zero net dipole moment even though they have large number of unpaired electrons.eg:MnO
    - **Ferrimagnetic Substances:**
      These are the substances which posses very small net magnetic movement even though they have large number of unpaired electrons.eg:Fe3O4

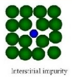
- Solid State
  - *Classification based on Crystal Lattice*
    - **CRYSTALLINE**
      - Define:
        - Definite Shape
        - Anisotropic
        - Long Range Order
        - Sharp Melting Point
      - **CRYSTAL LATTICE AND UNIT CELLS**
        - ***DEFINE:***
          A regular ordered arrangement of consTituent particles in three dimensions is called CRYSTAL LATTICE.
          UNIT CELL is defined as the smallest repeating unit in space lattice which when repeated over and over again generates the complete crystal lattice.The crystal can consist of an infinite no.of unit cells.
        - **PRIMITIVE UNIT CELLS**
          - *Same type of particles are present at corners only*
            - ***SEVEN PRIMITIIVE CELLS***
        - **CENTERED UNIT CELLS**
          - *Same type particles are present besides corners*
            - **FACE CENTERED CELL(FCC)**

              
            - **BODY CENTERED CELL(BCC)**

              
              - **Such a unit cell contains one constituent particle at its body-centre besides the ones that are at its corners.**
            - **END CENTERED CELL (ECC)**
              - **In such aunit cell,one constitutent particle is present at the centre of any two opposite faces besides the ones present at its corners.**
        - **CUBIC SYSTEMS**
          - **VIEW TABLE for FCC & BCC**
          - **VIEW TABLE FOR VOIDS**
      - **TYPES OF DETECTS**
        - **NON-STOICHIOMETRIC DEFECTS**
          - **Metal Excess Defect**
          - **Metal Deficiency Defect**
        - **STOICHIOMETRIC DEFECTS**
          - **Vacancy Defect**

            - **When some of the lattice sites are vacant, the crystal is said to have vacancy defect.**
          - **Interstitial Defect**

            - **When some constituent particles occupy an interstitial site,the crystal is said to have interstitial defect.**
          - **Frenkel Defect**

            - **It creates a vacancy defect at its original site and an interstitial defect at its new location.Frenkel defect is also called as dislocation defect**
          - **Schottky Defect**
            - **It is basically defects in ionic solids**
    - **AMPHOROUS**
      - Define:
        - Irregular Shape
        - Short Range Order
        - Psudeo Solid/Supercooled liquid(Eg:Glass)
        - Irregular edges on cutting
        - Melt over a range of temp

3. Solutions

This chapter underline the utility or importance of pure or mix substances .Solutions are defined as homogenous mixtures of two or more than two components. It explain difference between the solute and solvent. It will make understand about the properties of solutions like vapour and colligative properties in this chapter.

Description:

As homogenous mixture of two or more components is known as Solutions. Solutions contain binary solutions that include two vital components i.e Solute and Solvent.

- The component that is present in large quantity in solution is called Solvent.
- The component that is present in lesser quantity in solution is called Solute.

1. **Expressing the strength of solutions:**
    1. **Mass percentage(w/w):**

The mass percentage of a component of a solution is defined

$$= \frac{\text{Mass of the component in the solution} * 100}{\text{Total mass of the solution}}$$

2. **Volume percentage(V/V):**

The volume percentage is defined as:

$$= \frac{\text{Volume of the component} * 100}{\text{Total Volume of Solution}}$$

3. **Mass by volume percentage(w/V):**

It is defined as mass of solute in grams present in 100 ml of solution.

$$= \frac{\text{Mass of solute in grams}}{\text{Volume of solution in ml}} * 100$$

- **Parts per million:**

Mass of solute in one million (10^6) parts by mass of solution.

$$= \frac{\text{No.of parts of the component}}{\text{Total no. of all the components of solutions}} * 10^6$$

- **Molarity:** Moles of Solute in 1 L of Solution.
- **Molality:** Moles of Solute in 1kg of Solvent.

- **Solubility:**

Maximum amount that can be dissolved in a specific amount of solvent at a specific temperature.

Solubility of solid in liquid

- **Factors affecting :**

  a) Effect of temperature

  b) Effect of pressure

Solubility of gas in liquid

- **Henry's law:**
  The partial pressure of the gas in vapour phase is proportional to the mole fraction of gas in solution.

  P= KHX, KH is a henry's constant

  Value of KH increases with increase in temperature.

  Solubility decrease with increase in KH.

- **Azeotropes:**

  The mixture of liquids at particular composition which constant boiling point and behaves like a pure liquid and cannot be separated by simple distillation.

- **Azeotropes are of two types :**

  Minimum boiling Azeotrope (mixture which shows positive deviations) example: alcohol and water.

  Maximum boiling Azeotrope (which shows negative deviations) example: acetone and chloroform.

  Vapour pressure: Vapour pressure is the maximum pressure exerted by a vapour in equilibrium with the liquid.

- **Factors affecting vapour pressure:**

  Nature of liquid:

  When the vapour phase is in equilibrium with the liquid is for a given temperature then the pressure forced by the vapours is known as vapour pressure of a liquid. Nature of the liquid and temperature are the two dependent properties for it.

- **Raoult's Law:** According to Raoult's law, for a solution of volatile liquids, the relative lowering of vapour pressure of solution is directly proportional to its mole fraction of dissolved solvent in solute.

  Ideal Solutions

  The solution which obeys Raoult's law over the entire range of concentration is called an ideal solutions.

  Non-ideal Solutions

  When solution which doesn't obey Raoult's law over the entire range of concentration is called non-ideal Solutions.

- **Colligative properties:**

  It depends upon no. of moles of solute.

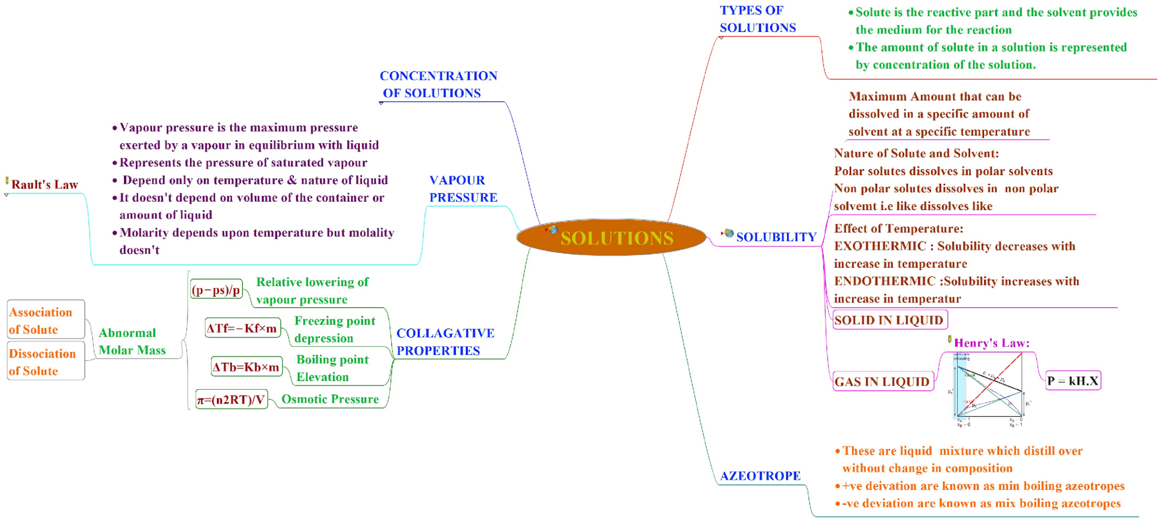
  1. Relative lowering of vapour pressure
  2. Elevation of boiling point
  3. Depression in freezing point
  4. Osmotic pressure

Glossary:

- **Concentration (C):**
  C = (Amount of solute / Volume of solution), where the amount of solute is typically measured in moles or grams, and the volume of the solution is measured in litres or millilitres.
- **Molarity (M):**
  M = (Number of moles of solute / Volume of solution in liters), which represents the number of moles of solute per litre of solution.
- **Molality (m):**
  m = (Number of moles of solute / Mass of the solvent in kilograms), which represents the number of moles of solute per kilogram of solvent.
- **Mass Percent (% m/m):**
  % m/m = (Mass of solute / Mass of solution) × 100, which represents the mass of the solute as a percentage of the total mass of the solution.
- **Volume Percent (% v/v):**

% v/v = (Volume of solute / Volume of solution) × 100, which represents the volume of the solute as a percentage of the total volume of the solution.

Links: https://ncert.nic.in/ncerts/l/lech102.pdf



- Solute is the reactive part and the solvent provides the medium for the reaction
- The amount of solute in a solution is represented by concentration of the solution.

- Vapour pressure is the maximum pressure exerted by a vapour in equilibrium with liquid
- Represents the pressure of saturated vapour
- Depend only on temperature & nature of liquid
- It doesn't depend on volume of the container or amount of liquid
- Molarity depends upon temperature but molality doesn't

Maximum Amount that can be dissolved in a specific amount of solvent at a specific temperature

Nature of Solute and Solvent:
Polar solutes dissolves in polar solvents
Non polar solutes dissolves in non polar solvemt i.e like dissolves like

Effect of Temperature:
EXOTHERMIC : Solubility decreases with increase in temperature
ENDOTHERMIC :Solubility increases with increase in temperatur

- These are liquid mixture which distill over without change in composition
- +ve deivation are known as min boiling azeotropes
- -ve deviation are known as mix boiling azeotropes

4. Co-ordination Compounds

The study of chemical bonding in this chapter will help you to determine the importance of chlorophyll and haemoglobin in blood. This chapter highlight colours of the complex compounds and its formations.

DESCRIPTION:

The transition metal atoms form a large number of complex compounds in which metal atoms are bound to a number of anions or neutral molecules, such compounds are called co-ordination compounds.

DIFFERENCE BETWEEN A DOUBLE SALT AND A COMPLEX:

The key distinction between double salts and complexes lies in the nature of their bonding, stability, and the resulting properties. Double salts involve physical bonding between ions, while complexes involve chemical bonding between a central metal ion and ligands, resulting in a more stable and distinct entity.

SOME IMPORTANT TERMS OF CO-ORDINATION COMPOUNDS:

- **Coordination entity:**

A central metal atom/ion bonded to fixed number of ions or molecules.It exists as a single entity and usually indicated with square bracket

- **Central atom/ion:**

The atom /ion to which a fixed no. of ions/groups are bound in a definite geometrical arrangements around it.

It act as a Lewis acids.

- **Ligands:**

These are molecules,ions or groups which donate electron pairs to the central metal atom through coordinate bond.

It act as Lewis Bases.

- **Coordination Number:** No. of ligand donor atoms to which metal is directly bonded.
- **Coordination Sphere:** Central atom/ion and the ligands attached to it and enclosed in square bracket
- **Coordination polyhedron:** Spatial arrangement of ligand atoms with central atom/ion

- **Oxidation number of central atom:** Charge of central atom if all ligands are removed along with e-pairs shared with central atom
- **Homoleptic:** Metal is bound to one type of donor groups. Heteroleptic complexes: Metal is bound to more than one type of donor groups.

IUPAC NOMENCLATURE OF MONONUCLEAR:

- **Naming of ions:**

  If the complex compound is ionic,positive cation whether simple or complex, is named first followed by the negative ion.

- **Naming of Ligands:**

The no. of each kind of ligand is specified using the Greek prefixes di, tri, tetra and penta etc.

If the name of ligand itself is complex i.e it includes a numerical prefix (terms like bis(two),pentakis(for five)etc)are used followed by name of ligand placed without brackets.

- **Naming of Complex ion:**

While naming the complex ion,name the ligands first & then metal. The names of anionic ligands end with o(eg:br-,Bromo) Neutral ligands are specified by their usual names, except for water, amines & carbon monooxide which are called aqua,ammine and carbonyl respectively

ISOMERISM IN CO-ORDINATION COMPUNDS:

It consists of :

Structural isomerism: It is consists of

1. Ionisation isomerism
2. Hydrate isomerism
3. Linkage isomerism
4. Ligand isomerism
5. Co-ordiantion isomerism
6. Coordination Position isomerism

Steroisomerism isomerism:

1. Geometrical
2. Optical
3. No. of steroisomerism

BONDING IN CO-ORDINATION COMPOUNDS:

- **Valence Bond Theory:**

  The central metal atom provides a no. of empty orbitals equal to its coordination no. for the formation of coordinate bonds with the ligands

  The empty orbitals of metal ion hybridise to give equal number of hybrid orbitals of equivalent energy

  The metal atom or ion can use(n-1)d,ns,np and nd orbitals for hybridisation to yield square planar, tetrahedral or octahedral geometry

  These hybridised orbitals overlap with ligand orbitals. Ligand orbitals donate electron pair to the hybridised orbitals for bonding

  The overlapping may result in a sigma-bond or a coordinate bond

  When complex has unpaired electrons,it behave as paramagnetic and otherwise diamagnetic.

- **Limitations of VBT:**

1. It involves a no. of assumptions.
2. It doesn't give quantitative interpretation of magnetic data.
3. It doesn't explain the colour exhibited by coordination compounds
4. It does not differentiate between the weak and strong bonds.
5. It does not provide quantitative interpretation of the thermodynamic or kinetic stabilities of coordination compounds.

- **Crystal field theory:**

  The valence bond theory is less widely accepted than the Crystal Field Theory. It is assumed that the attraction between a complex's central metal and its ligands is purely electrostatic. The following assumptions are made in the crystal field.

  Ligands are considered point charges.

  Metal orbitals and ligand orbitals have no interaction.

  In the free atom, all of the d orbitals on the metal have the same energy (that is, they are degenerate). However, when a complex is formed, the ligands destroy the degeneracy of these orbitals, resulting in different energies for the orbitals. Limitations of Cryatal field theory:

This theory only takes the core atom’s d-orbitals into account. There is no investigation of the s and p orbitals.

This theory falls short of explaining why some metals split significantly while others split much less.

This theory falls short of explaining how it is possible to have p bonding, which is observed in many complexes.

- **IMPORTANCE AND APPLICATIONS OF CO-ORDINATION COMPOUNDS:**

  EDTA is another complex compound we use for the determination of hardness of water. Uses of coordination compounds also involve their application as catalysts. These days, they are becoming increasingly popular in the polymer industry as well.

  We apply the concept of coordination compounds in the

  extraction of metals from their ores too frequently these days. Extraction of nickel and cobalt involves uses a major use of these compounds. These metals are extracted by hydro-metallurgical processes requiring a lot of complex ions.

  Solutions of the complexes like [Ag(CN)2]– and [Au(CN)2]– can be used for the smooth and even electroplating of metals by gold or silver.

  Chlorophyll, a pigment responsible for photosynthesis, is a coordination compound of magnesium. Also, haemoglobin, the red pigment of blood which acts as oxygen carrier is a coordination compound of iron.

Glossary:

1. **Complex Ion Formula:**

   $[ML_x]^{n+}$, where M represents the central metal ion, L represents the ligands, and $_x$ represents the number of ligands coordinated to the metal ion. The charge on the complex ion is represented by $^{n+}$.

2. **Coordination Complex Formula:**

   $[M(L_1)(L_2)(L_3)...(L_□)]^{n+}$, where M represents the central metal ion, and $L_1, L_2, L_3, ... L_□$ represent the ligands coordinated to the metal ion. The charge on the coordination complex is represented by $^{n+}$.

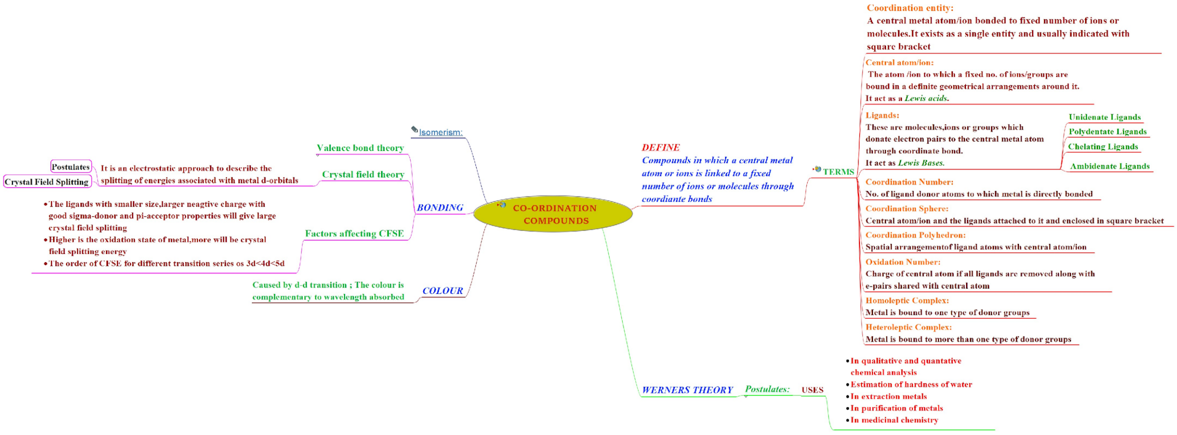
3. **Structural Isomerism Formula:**

Different structural isomers of coordination compounds can be represented by adding prefixes such as cis-, trans-, fac-, mer-, or iso- to the complex ion or coordination complex formula.

4. **Chelate Complex Formula:**

$[M(L)_x]^{n+}$, where M represents the central metal ion, L represents a polydentate ligand (chelating ligand) that forms multiple bonds with the metal, and $_x$ represents the number of ligating groups in the polydentate ligand.

Links: https://ncert.nic.in/textbook/pdf/lech109.pdf



It is an electrostatic approach to describe the splitting of energies associated with metal d-orbitals

- The ligands with smaller size,larger neagtive charge with good sigma-donor and pi-acceptor properties will give large crystal field splitting
- Higher is the oxidation state of metal,more will be crystal field splitting energy
- The order of CFSE for different transition series os 3d<4d<5d

Caused by d-d transition ; The colour is complementary to wavelength absorbed

Compounds in which a central metal atom or ions is linked to a fixed number of ions or molecules through coordiante bonds

Coordination entity:
A central metal atom/ion bonded to fixed number of ions or molecules.It exists as a single entity and usually indicated with square bracket

Central atom/ion:
The atom /ion to which a fixed no. of ions/groups are bound in a definite geometrical arrangements around it. It act as a *Lewis acids.*

Ligands:
These are molecules,ions or groups which donate electron pairs to the central metal atom through coordinate bond. It act as *Lewis Bases.*

Coordination Number:
No. of ligand donor atoms to which metal is directly bonded

Coordination Sphere:
Central atom/ion and the ligands attached to it and enclosed in square bracket

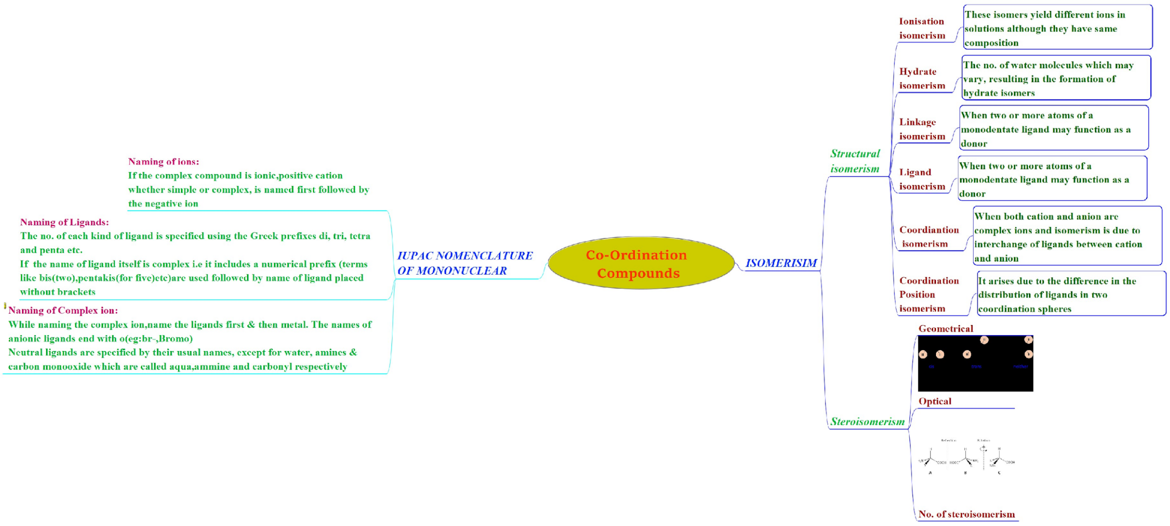
Coordination Polyhedron:
Spatial arrangementof ligand atoms with central atom/ion

Oxidation Number:
Charge of central atom if all ligands are removed along with e-pairs shared with central atom

Homoleptic Complex:
Metal is bound to one type of donor groups

Heteroleptic Complex:
Metal is bound to more than one type of donor groups

- In qualitative and quantative chemical analysis
- Estimation of hardness of water
- In extraction metals
- In purification of metals
- In medicinal chemistry



Naming of ions:
If the complex compound is ionic,positive cation whether simple or complex, is named first followed by the negative ion

Naming of Ligands:
The no. of each kind of ligand is specified using the Greek prefixes di, tri, tetra and penta etc.
If the name of ligand itself is complex i.e it includes a numerical prefix (terms like bis(two),pentakis(for five)etc)are used followed by name of ligand placed without brackets

Naming of Complex ion:
While naming the complex ion,name the ligands first & then metal. The names of anionic ligands end with o(eg:br-,Bromo)
Neutral ligands are specified by their usual names, except for water, amines & carbon monooxide which are called aqua,ammine and carbonyl respectively

Ionisation isomerism: These isomers yield different ions in solutions although they have same composition

Hydrate isomerism: The no. of water molecules which may vary, resulting in the formation of hydrate isomers

Linkage isomerism: When two or more atoms of a monodentate ligand may function as a donor

Ligand isomerism: When two or more atoms of a monodentate ligand may function as a donor

Coordiantion isomerism: When both cation and anion are complex ions and isomerism is due to interchange of ligands between cation and anion

Coordination Position isomerism: It arises due to the difference in the distribution of ligands in two coordination spheres

6. General principle and isolation of elements

The general principles and isolation processes of elements involve techniques such as mining, crushing, and concentration to obtain ores. These ores undergo further processing, including roasting, calcination, or reduction, to convert them into a suitable form for extraction. Extraction methods like smelting, leaching, or electrolysis are employed to separate the desired element from impurities and obtain it in its pure form. The reactivity and properties of the elements determine the complexity of the isolation process. The ultimate objective is to obtain pure elements from their naturally occurring sources for various applications

Description:

For getting acknowledge about particular metals ,we would get a notion about minerals, ores, gangue:

Minerals: There are naturally occurring chemical substances containing metal in the earth's crust and are obtain through mining.

Ores: Minerals which are visible to be used as source of the metal are called ores.

Gangue: The undesired impurities such as sand , clay associated with the ore are called gangue or metals.

The extraction and isolation of metals from ores involve the following major steps:

- Concentration of the ore,
- Isolation of the metal from its concentrated ore, and
- Purification of the metal.

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

Concentration of ores:

Removal of the unwanted materials (e.g., sand, clays, etc.) from the ore

is known as concentration, dressing or benefaction.

Some of the important procedures are described below:

- Hydraulic Washing: The process of removing of lighter particles of sand,clay etc.by washing with water using hydraulic classifier. Separation is based on difference between specific gravity of the ore and gangue particles. It is type of a gravity separation.

- **Magnetic Washing:**

This is used when either the ore or the gangue is attracted towards magnetic field. It is used for Iron Ores.

- **Froth Floatation method:** This method is used for the concentration oof sulphides ore. This process is based on the erential wetting of ore particles by pine oil and gangue particles by water.

- **Leaching:** It involves the treatment of the ore with a suitable reagent to make it soluble while impurities remain insoluble.The ore or the metal is recovered from the solution by a suitable chemical method.

Occurrence of metals:

Metal	Ore	Composition
Aluminium	Bauxite	$Al_2O_3.2H_2O$
	Corundum	Al_2O_3
	Cryolite	Na_3AlF_6
Iron	Magnetite	Fe_3O_4
	Haematite	Fe_2O_3
	Siderite	$FeCO_3$
Copper	Cuprite	Cu_2O
	Chalcopyrite	$CuFeS_2$
	Copper glance	Cu_2S
Zinc	Zincite	ZnO
	Calamine	$ZnCO_3$
	Zinc blende	ZnS
Magnesium	Dolomite	$MgCO_3.CaCO_3$
	Magnesite	$MgCO_3$
	Carnalite	$KCl.MgCl_2.6$

Extraction of crude metal from Concentrated Ore:

It is subdivided as:

1. Conversion of ore into metallic oxide
2. Reduction of metallic oxide
3. Refining

Conversion of ore into metallic oxide:

1. Calcination:

Heating when the volatile matter escapes leaving behind the metal oxide.

2. Roasting:

Ore is heated is a limited supply of air in a furnance at a temperature below the melting point of the metal.

Reduction of metallic oxide:

Smelting:

Heating metal oxide with substances acting as a reducing agent which combines with the oxygen to get reduced easily.

Refining:

Distillation:

Impure metal is evaporated to obtain pure metal as distillate.

Liquation: Low melting metals made to flow on a sloping surface.

Electrolyte refining:

Impure metal anode, strip of same metal in pure form -cathode dipped in soluble salt of same metal.

Zone refining:

Based on principle that impurities are more soluble in melt than in solid of metal.

Vapour Phase refining:

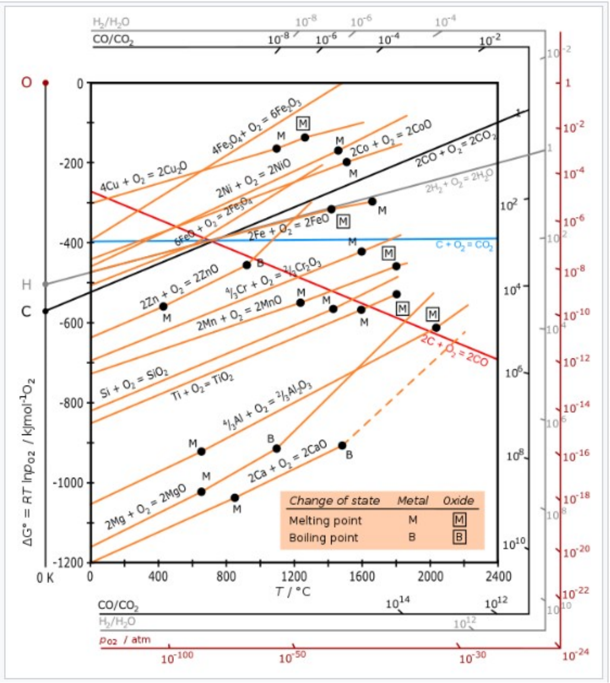
Metal is converted into its volatile compound and collected elsewhere.

Chromatographic method:

Based on principle that different components of a mixture are differentially adsorbed on an adsorbent.

Thermodynamic Principles of Metallurgy :

ΔG =ΔH-TS Or ΔG^0 =-RT ln K



These diagrams are plots of the change in Gibbs free energy in forming oxides of elements vs. temperature. It gives a good concept for choosing a reducing agent for oxide reduction. These diagrams help determine whether a thermal reduction of ores is feasible. Gibbs free energy change must be negative at a particular temperature for a reaction to be possible. These diagrams have the drawback of not taking the kinetics of reduction into account, which means the reduction rate cannot be predicted.

Electrochemical Principles of Metallurgy:

- Electrolysis is done in the reduction of molten metal salts.
- Suppose the below equation:
- ΔG(0) = – nE(-)F
- n= no of electrons and E(-) = electrode potential of redox couple formed in the system.
- More reactive metals have large -ve electrode potential values.
- This implies that their reduction is complicated if the variety of two E(-) values corresponds to a positive E(-) and consequently a negative ΔG(0) in the equation.
- As a result, the less reactive metal will come out of the solution, and the more reactive metal will go into the solution.
- For Example: $Cu^{2+} (aq) + Fe(s) \rightarrow Cu(s) + Fe^{2+} (aq)$

- In general electrolysis, the Mn+ ions are discharged at negative electrodes (cathodes) and deposited there. Rarely is a flux added to make the molten mass more conductive.

Glossary:

Importance of aluminium ,copper, zinc and iron:

Al

- As wrappers for chocolates
- Fine dust in paints and lacquers
- Extraction of Cr and Mn

Cu

- Wires
- Water and steam pipes
- Alloys

Zn

- Galvanising iron
- In batteries
- Dust is used as reducing agent

Fe

- Cast iron for casting stoves, railway slippers,gutter pipes etc.
- Manufacture of wrought iron and steel.

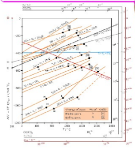
Links:

https://ncert.nic.in/ncerts/l/lech106.pdf

https://www.youtube.com/watch?v=dQQ-1-Ckh7A&t=4316s

General Principles and processes of isolation of elements

- **Occurrence of metals**
  - The most abundant metal in the earth's crust is aluminium
  - Gem 'ruby'(impure Al_2O_3) has Cr impurity.
  - Gem'sapphire'(impure Al_2O_3) has Co impurity
  - The Second most abundant metal on earth crust is iron .
  - *Minerals: There are naturally occuring chemical substances containing metal in the earth's crust and are obtain through mining*
  - *Ores:* Minerals which are visible to be used as source of the metal are called ores.
  - *Gangue:* The undesired impurities such as sand , clay associated with the ore are called gangue or metals.
- **Concentration of ores**
- **Oxidation Reduction**
  - EXAMPLE : Extraction based onoxidation is the extraction of chlorine from brine (chlorine is abundantin sea water as common salt) $2Cl^-(aq) + 2H_2O(l) \rightarrow 2OH^-(aq) + H_2(g) + Cl_2(g)$
- **Thermodynamic Principles of Metallurgy**
  - For considering the choice of reducing agent in reduction of oxide, Elligham diagram is used
  - Elligham diagram consists of plots of ΔG^0 vs T for the formation of oxides of metals and reducing agents.
  - The difference in the two ΔG values determines whether reduction of the oxide of the element of the upper line is feasible by the element of which oxide formation is represented by the lower line.If the difference is large, the reduction is easier.
  - $\Delta G = \Delta H - TS$ or $G^0 = -RT \ln K$



- **Extraction of crude metal from Concentrated Ore**
- **Uses of Aluminium Copper,Zinc and Iron**
  - Aluminium:
    - As wrappers for chocolates
    - Fine dust in paints and lacquers
    - Extraction of Cr and Mn
  - Copper:
    - Wires
    - Water and steam pipes
    - Alloys
  - Zinc:
    - Galvanising iron
    - In batteries
    - Dust is used as reducing agent
  - Iron:
    - Cast iron for casting stoves, railway slippers,gutter pipes etc.
    - Manufacture of wrought iron and steel.
- **Electrochemical Principles of metallurgy**

General Principles and processes of isolation of elements

- **Concentration Of Ores**
  - **Hydraullic Washing**: The process of removing of lighter particles of sand,clay etc.by washing with water using hydraullic classifier.Separation is based on difference between specific gravity of the ore and gangue particles. It is type of a gravity separation.
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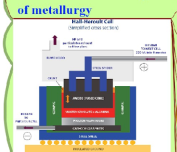
  - **Leaching**: It involves the treatment of the ore with a suitable reagent to make it soluble while impurities remain insoluble.The ore or the metal is recovered from the solution by a suitable chemical method .
- **Electrochemical Principles of metallurgy**
  - Electrolysis difference of two E^0 values equal +ve E^0 and -ve G^0 , less reactive metal will come out of solution and more reactive to the solution.
  - **Metallurgy of aluminium**
  - Purified Al_2O_3 mixed with Na_3AlF_6
  - **Fused matrix is electrolysed**
  - Electrolysis (Hall-Heroult process) $2Al_2O_3 + 3C \rightarrow 4Al + 3CO_2$
  - Cathode : $Al^3 + (melt) + 3e^- \longrightarrow Al(L)$
  - Anode : $C(s) + O^{2-}(melt) \longrightarrow CO(g) + 2e^-$
  - $2O^{2-} + C \rightarrow CO_2 + 4e^-$



- **Extraction of crude metal from Concentrated Ore**
  - **Conversion of ore into metallic oxide**
    - **Calcination:** Heating when the volatile matter escapes leaving behind the metal oxide
    - **Roasting:** Ore is heated is a limited supply of air in a furnance at a temperature below the melting point of the metal.
  - **Reduction of metallic oxide**
    - **Smelting:** Heating metal oxide with substances acting as a reducing agent which combines with the oxygen to get reduced easily.
  - **Refining**
    - **Distillation**: Impure metal is evaporated to obtain pure metal as distillate.
    - **Liquation**: Low melting metals made to flow on a sloping surface
    - **Electrolyte refining**: Impure metal anode, strip of same metal in pure form -cathode dipped in soluble salt of same metal
    - **Zone refining**: Based on principle that impurities are more soluble in melt than in solid of metal
    - **Vapour Phase refining**: Metal is converted into its volatile compound and collected elsewhere
    - **Chromatographic method**: Based on principle that different components of a mixture are differentially adsorbed on an adsorbent

5.

6. Mechanical properties of solid

This chapter showcase how materials respond to external forces and its deformations. It gives precise information about stress and strain present in elastic bodies. This chapter briefly explains about elastic modulus and its characteristics found.

Description:

- **Deforming forces:** Any force that can change shape and size of object is called deforming forces.

  Consists of

- **Elastic Forces:**

  Any body that regains its original shape and size after the removal of deforming force. Eg: Quartz fiber.

  The phenomenon of regaining the shape is called Elasticity.

- **Plastic Forces:**

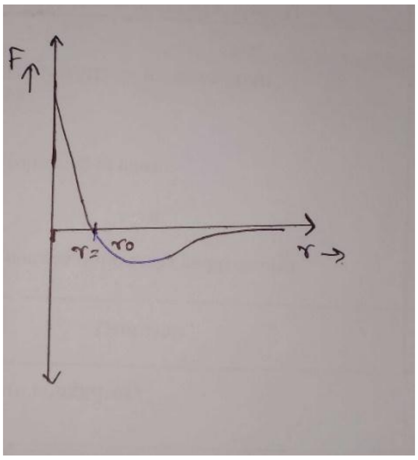
  The body which don't regain shape and size after the removal of deforming forces. Eg:Plastic.

- **Elastic Behaviour in terms of interatomic forces:**

  The atoms in solid are held together by interatomic forces.

  When interatomic separation r is large, the potential energy the atom is negative and interatomic force is attractive.

  When interatomic separation r is small, the potential energy the atom is positive and interatomic force is repulsive.



- **Stress :**
  The internal restoring force per unit area of cross section is called stress.

  $$\text{Stress} = \frac{\text{Force applied}}{\text{Area}}$$

  In SI system, stress is measured in N / m² (pascal) and in CGS system in dyne/cm². The

  dimensional formula for stress is [M L–1T–2]

- **Tensile Stress:**
  If the stress increases the length of the body in the direction of deforming forces , then it is called tensile stress.

- **Shear Stress:**
  When a deforming force acts on tangentially to the surface of the body, it produces a change in body the

- **Compressional Stress:**
  If the stress decreases the length of the body in direction of deforming force, then it is called compressional stress.

- **Hydrostatic Stress:**
  Stress when a body is subjected to uniform forces from the direction and which results in change in volume is said to be hydrostatic stress.

- **Strain:** When deforming force is applied on a body, if undergoes change in its shape and sizes. The ratio of change in dimension to the original dimension is called strain.

- **TYPES OF STRAIN:**

  Longitudinal strain: The change in the length ΔL to the original length L of the body is known as longitudinal strain.

  Shearing strain: The ratio of the displacement of a layer to its distance from the fixed layer.

  Volume strain: The ratio of change in volume to the original volume.

- **HOOKE’S LAW:**

Within the elastic limit, the stress is directly proportional to the strain is known as Hooke's law. Hooke's law was named after the scientist Robert Hooke's .Hooke's law is applied to the elastic object only.

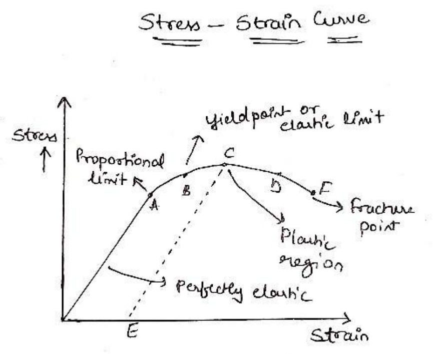
Stress $\propto$ Strain

Stress = k * Strain

Where k is the modulus of elasticity

- **STRESS -STRAIN CURVE:**

Upto point A Hooke's law is valid ,the point A is called proportional limit .The point B upto which a body regain its shape is called Elastic limit & yield point.



- **ElASTIC MODULI:**

The ratio of stress and strain is called modulus of elasticity.

It cosnsists of ;

- **Young's Modulus:**
The ratio of Longitudinal (tensile or compressive) stress (σ) to the longitudinal strain (ϵ) is known as young's modulus (Y).

- **Shear Modulus:**
The ratio of tangential stress to the shearing strain θ is known as modulus of rigidity or shear modulus of elasticity(η).

- **Bulk Modulus:**

The ratio of Hydraulic (compressive) stress (p) to the volumetric strain (ΔV/V) that is known as Bulk modulus (K).

- **POISSON RATIO:**

  Within the elastic limit, lateral strain is directly proportional to the longitudinal strain. The ratio of the lateral strain to the longitudinal strain in a stretched wire is called Poisson's ratio.

- **Lateral strain:**
  The strain is perpendicular to the applied force is called lateral strain

- **Longitudinal strain:**
  The strain in the direction of the applied force is called longitudinal strain.
- **ELASTIC POTENTIAL ENERGY:**

  Elastic potential energy is the potential energy stored by stretching or compressing an elastic object by an external force such as the stretching of a spring. It is equal to the work done to stretch the spring which depends on the spring constant k and the distance stretched.

- **Properties of Solids**

  Solids showcase the following properties:

  1. Plasticity
  2. Ductility
  3. Strength of Solids

<u>Glossary</u>:

- **Young's modulus (E):**

  E = (Stress / Strain)
  Where,
  stress = the applied force per unit area
  strain = the resulting deformation or elongation.

- **Shear modulus (G):**

  G = (Shear stress / Shear strain)
  Where,
  shear stress = the applied force parallel to the material's surface per unit area

shear strain = the resulting angular deformation.

- **Bulk modulus (K):**

  K = -(Change in volume / Applied pressure)
  Where,
  the change in volume = the relative change in the material's volume due to an applied pressure.

- **Tensile strength (TS):**

  TS = (Maximum load / Original cross-sectional area)
  Where,
  the maximum load = the force applied to the material before it fractures.

- **Compressive strength (CS):**

  CS = (Maximum load / Original cross-sectional area) similar to tensile strength, but for compressive forces.

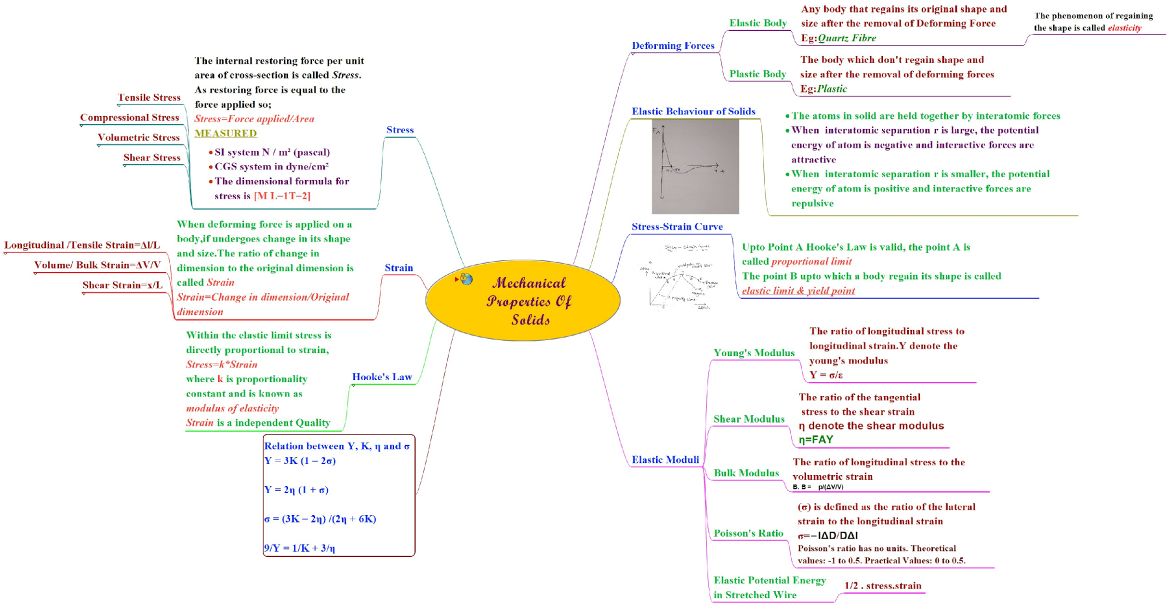
- **Shear strength (SS):**

  SS = (Maximum shear stress)
  Where,
  the maximum shear stress = the force applied parallel to the material's surface per unit area at the point of failure

Detailed links of attachments:

NCERT link:

https://ncert.nic.in/textbook/pdf/keph201.pdf



The internal restoring force per unit area of cross-section is called *Stress*. As restoring force is equal to the force applied so;
Stress=Force applied/Area
MEASURED
- SI system N / m² (pascal)
- CGS system in dyne/cm²
- The dimensional formula for stress is [M L–1T–2]

When deforming force is applied on a body,if undergoes change in its shape and size.The ratio of change in dimension to the original dimension is called *Strain*
Strain=Change in dimension/Original dimension

Within the elastic limit stress is directly proportional to strain,
*Stress=k*Strain*
where k is proportionality constant and is known as *modulus of elasticity*
Strain is a independent Quality

Relation between Y, K, η and σ
$Y = 3K (1 – 2\sigma)$

$Y = 2\eta (1 + \sigma)$

$\sigma = (3K – 2\eta) /(2\eta + 6K)$

$9/Y = 1/K + 3/\eta$

Any body that regains its original shape and size after the removal of Deforming Force
Eg:*Quartz Fibre*

The phenomenon of regaining the shape is called *elasticity*

The body which don't regain shape and size after the removal of deforming forces
Eg:*Plastic*

- The atoms in solid are held together by interatomic forces
- When interatomic separation r is large, the potential energy of atom is negative and interactive forces are attractive
- When interatomic separation r is smaller, the potential energy of atom is positive and interactive forces are repulsive

Upto Point A Hooke's Law is valid, the point A is called *proportional limit*
The point B upto which a body regain its shape is called *elastic limit & yield point*

The ratio of longitudinal stress to longitudinal strain.Y denote the young's modulus
$Y = \sigma/\varepsilon$

The ratio of the tangential stress to the shear strain
η denote the shear modulus
η=FAY

The ratio of longitudinal stress to the volumetric strain
B. B = p/(ΔV/V)

(σ) is defined as the ratio of the lateral strain to the longitudinal strain
σ=−IΔD/DΔI
Poisson's ratio has no units. Theoretical values: -1 to 0.5. Practical Values: 0 to 0.5.

1/2 . stress.strain

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Freeplane software: https://docs.freeplane.org/

Epathshala NCERT book: https://epathshala.nic.in/wp-content/doc/book/flipbook/flipbook.htm?lech1=1-1

CHAPTER 4

Conclusion

This internship has been a life-changing experience for me. It has given me valuable insights, skills, and experiences that will have a lasting impact on my personal and professional life. I am grateful for the opportunities to apply what I learned in a practical way, contribute to meaningful projects, and work with amazing people.

I want to express my heartfelt appreciation to everyone who made this internship possible. Your support, belief in my abilities, and the knowledge I gained through this internship at FOSSEE, IIT Bombay mean a lot to me. I will always remember this time as a special and influential part of my academic and professional journey.