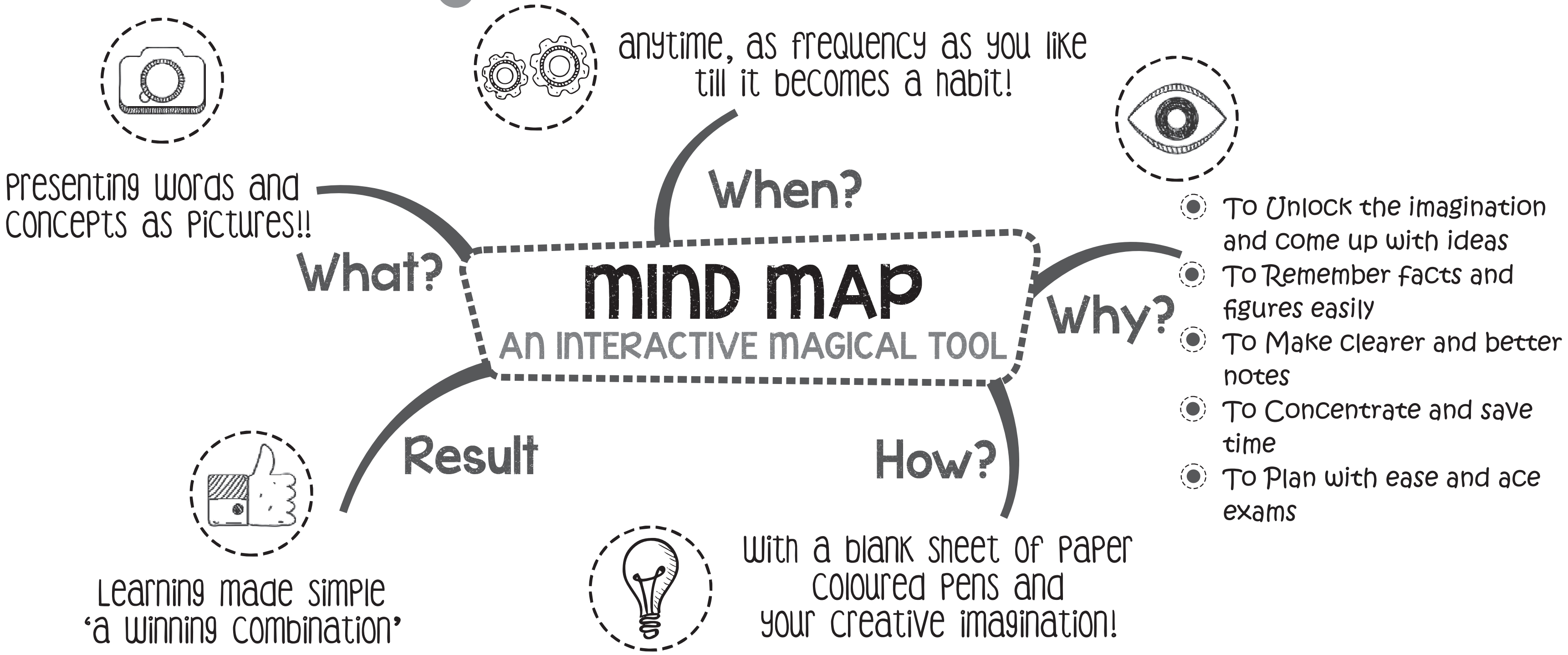
OSWAAL
EXAM
TOOLS

MIND MAPS

Learning MADE Simple



MIND MAP

AN INTERACTIVE MAGICAL TOOL

What?

Presenting words and concepts as pictures!!

When?

anytime, as frequency as you like till it becomes a habit!

Why?

- To Unlock the imagination and come up with ideas
- To Remember facts and figures easily
- To Make clearer and better notes
- To Concentrate and save time
- To Plan with ease and ace exams

How?

With a blank sheet of paper coloured pens and your creative imagination!

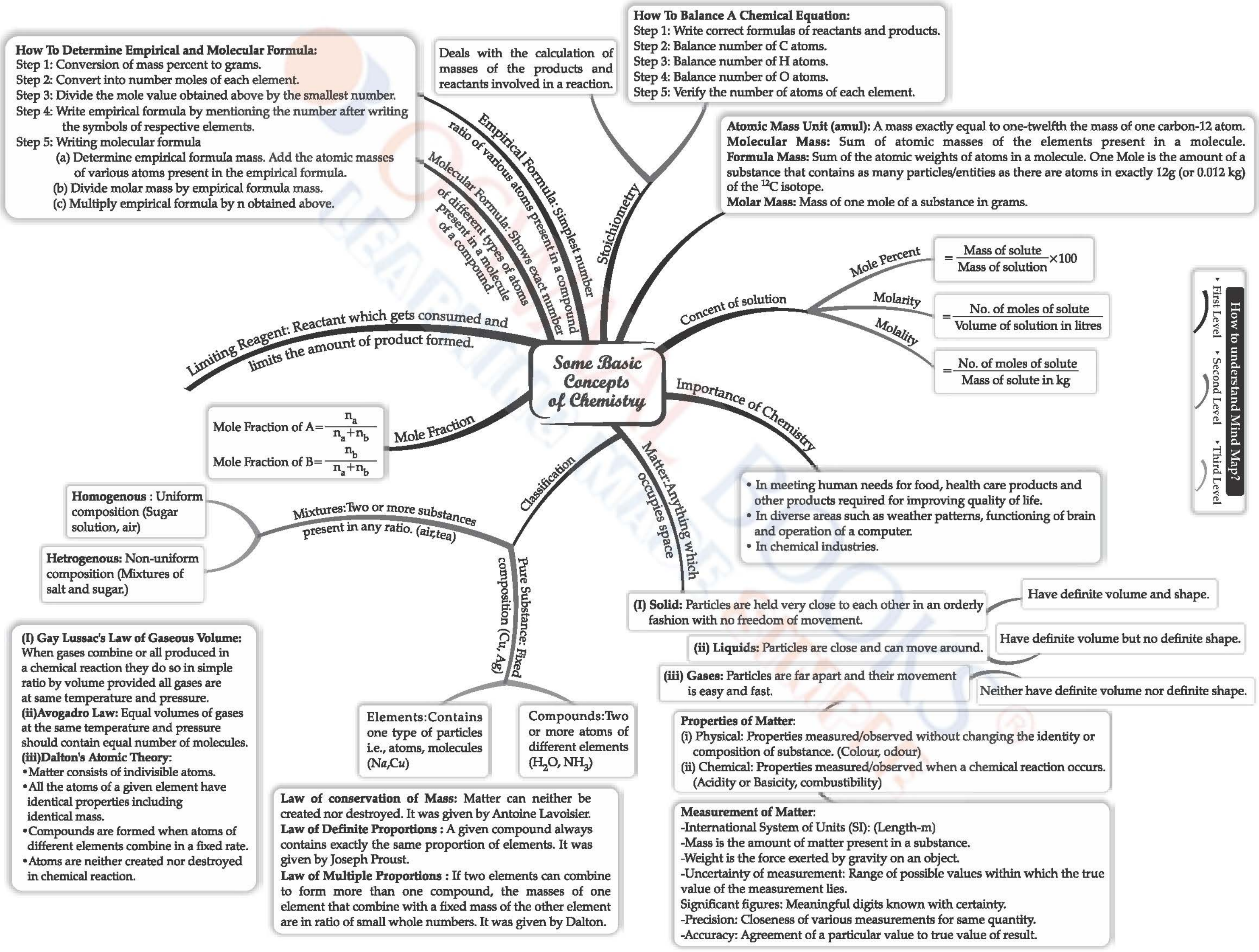
Result

Learning made simple 'a winning combination'

What are Associations?

It's a technique connecting the core concept at the Centre to related concepts or ideas. Associations spreading out straight from the core concept are the First Level of Association. Then we have a Second Level of Association emitting from the first level and the chronology continues. The thickest line is the First Level of Association and the lines keep getting thinner as we move to the subsequent levels of association. This is exactly how the brain functions, therefore these Mind Maps. Associations are one powerful memory aid connecting seemingly unrelated concepts, hence strengthening memory.

CHEMISTRY



Stoichiometry

Deals with the calculation of masses of the products and reactants involved in a reaction.

How To Balance A Chemical Equation:
Step 1: Write correct formulas of reactants and products.
Step 2: Balance number of C atoms.
Step 3: Balance number of H atoms.
Step 4: Balance number of O atoms.
Step 5: Verify the number of atoms of each element.

Atomic Mass Unit (amul): A mass exactly equal to one-twelfth the mass of one carbon-12 atom.
Molecular Mass: Sum of atomic masses of the elements present in a molecule.
Formula Mass: Sum of the atomic weights of atoms in a molecule. One Mole is the amount of a substance that contains as many particles/entities as there are atoms in exactly 12g (or 0.012 kg) of the ^{12}C isotope.
Molar Mass: Mass of one mole of a substance in grams.

Concent of solution

Mole Percent $= \frac{\text{Mass of solute}}{\text{Mass of solution}} \times 100$

Molarity $= \frac{\text{No. of moles of solute}}{\text{Volume of solution in litres}}$

Molality $= \frac{\text{No. of moles of solute}}{\text{Mass of solute in kg}}$

Importance of Chemistry

- In meeting human needs for food, health care products and other products required for improving quality of life.
- In diverse areas such as weather patterns, functioning of brain and operation of a computer.
- In chemical industries.

Matter: Anything which occupies space

(I) Solid: Particles are held very close to each other in an orderly fashion with no freedom of movement. — Have definite volume and shape.

(ii) Liquids: Particles are close and can move around. — Have definite volume but no definite shape.

(iii) Gases: Particles are far apart and their movement is easy and fast. — Neither have definite volume nor definite shape.

Properties of Matter:
(i) Physical: Properties measured/observed without changing the identity or composition of substance. (Colour, odour)
(ii) Chemical: Properties measured/observed when a chemical reaction occurs. (Acidity or Basicity, combustibility)

Measurement of Matter:
-International System of Units (SI): (Length-m)
-Mass is the amount of matter present in a substance.
-Weight is the force exerted by gravity on an object.
-Uncertainty of measurement: Range of possible values within which the true value of the measurement lies.
Significant figures: Meaningful digits known with certainty.
-Precision: Closeness of various measurements for same quantity.
-Accuracy: Agreement of a particular value to true value of result.

Classification

Pure Substance: Fixed composition (Cu, Ag)

Elements: Contains one type of particles i.e., atoms, molecules (Na,Cu)

Compounds: Two or more atoms of different elements (H_2O, NH_3)

Law of conservation of Mass: Matter can neither be created nor destroyed. It was given by Antoine Lavoisier.
Law of Definite Proportions : A given compound always contains exactly the same proportion of elements. It was given by Joseph Proust.
Law of Multiple Proportions : If two elements can combine to form more than one compound, the masses of one element that combine with a fixed mass of the other element are in ratio of small whole numbers. It was given by Dalton.

Mixtures: Two or more substances present in any ratio. (air,tea)

Homogenous : Uniform composition (Sugar solution, air)

Hetrogenous: Non-uniform composition (Mixtures of salt and sugar.)

(I) Gay Lussac's Law of Gaseous Volume: When gases combine or all produced in a chemical reaction they do so in simple ratio by volume provided all gases are at same temperature and pressure.
(ii)Avogadro Law: Equal volumes of gases at the same temperature and pressure should contain equal number of molecules.
(iii)Dalton's Atomic Theory:
- Matter consists of indivisible atoms.
- All the atoms of a given element have identical properties including identical mass.
- Compounds are formed when atoms of different elements combine in a fixed rate.
- Atoms are neither created nor destroyed in chemical reaction.

Mole Fraction

Mole Fraction of A $= \frac{n_a}{n_a+n_b}$

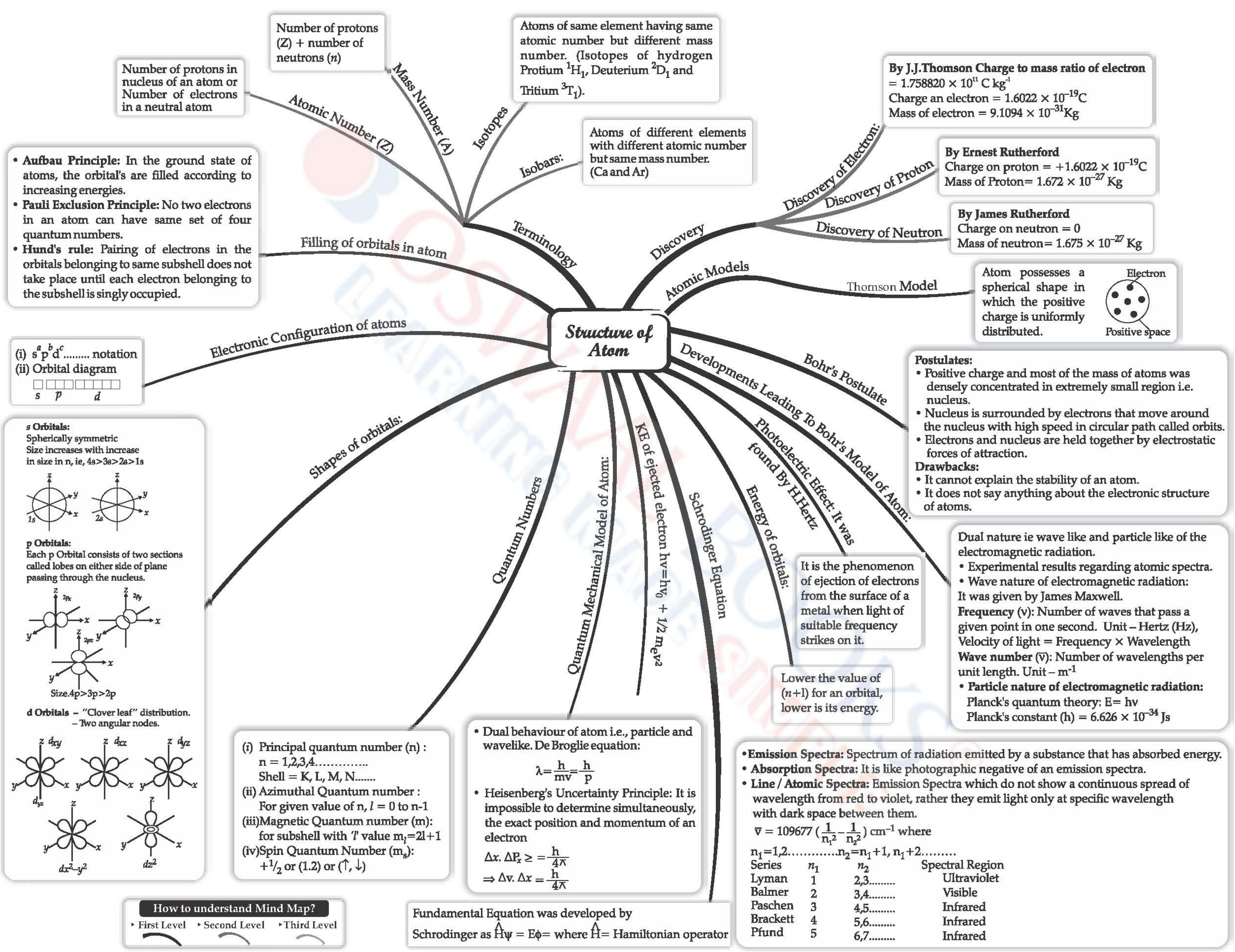
Mole Fraction of B $= \frac{n_b}{n_a+n_b}$

Limiting Reagent: Reactant which gets consumed and limits the amount of product formed.

Molecular Formula: Shows exact number of different types of atoms present in a molecule of a compound.

Empirical Formula: Simplest number ratio of various atoms present in a compound

How To Determine Empirical and Molecular Formula:
Step 1: Conversion of mass percent to grams.
Step 2: Convert into number moles of each element.
Step 3: Divide the mole value obtained above by the smallest number.
Step 4: Write empirical formula by mentioning the number after writing the symbols of respective elements.
Step 5: Writing molecular formula
  (a) Determine empirical formula mass. Add the atomic masses of various atoms present in the empirical formula.
  (b) Divide molar mass by empirical formula mass.
  (c) Multiply empirical formula by n obtained above.



Structure of Atom

Terminology

Atomic Number (Z): Number of protons in nucleus of an atom or Number of electrons in a neutral atom

Mass Number (A): Number of protons (Z) + number of neutrons (*n*)

Isotopes: Atoms of same element having same atomic number but different mass number. (Isotopes of hydrogen Protium $^1H_1$, Deuterium $^2D_1$ and Tritium $^3T_1$).

Isobars: Atoms of different elements with different atomic number but same mass number. (Ca and Ar)

Discovery

Discovery of Electron: By J.J.Thomson Charge to mass ratio of electron $= 1.758820 \times 10^{11}$ C kg^{-1}
Charge an electron $= 1.6022 \times 10^{-19}$C
Mass of electron $= 9.1094 \times 10^{-31}$Kg

Discovery of Proton By Ernest Rutherford
Charge on proton $= +1.6022 \times 10^{-19}$C
Mass of Proton $= 1.672 \times 10^{-27}$ Kg

Discovery of Neutron By James Rutherford
Charge on neutron = 0
Mass of neutron $= 1.675 \times 10^{-27}$ Kg

Atomic Models

Thomson Model: Atom possesses a spherical shape in which the positive charge is uniformly distributed.

Bohr's Postulate

Postulates:
- Positive charge and most of the mass of atoms was densely concentrated in extremely small region i.e. nucleus.
- Nucleus is surrounded by electrons that move around the nucleus with high speed in circular path called orbits.
- Electrons and nucleus are held together by electrostatic forces of attraction.

Drawbacks:
- It cannot explain the stability of an atom.
- It does not say anything about the electronic structure of atoms.

Developments Leading To Bohr's Model of Atom:

Dual nature ie wave like and particle like of the electromagnetic radiation.
- Experimental results regarding atomic spectra.
- Wave nature of electromagnetic radiation:

It was given by James Maxwell.
Frequency (ν): Number of waves that pass a given point in one second. Unit – Hertz (Hz),
Velocity of light = Frequency × Wavelength
Wave number ($\bar{v}$): Number of wavelengths per unit length. Unit – m^{-1}
- **Particle nature of electromagnetic radiation:**
  Planck's quantum theory: E= hν
  Planck's constant (h) $= 6.626 \times 10^{-34}$ Js

- **Emission Spectra:** Spectrum of radiation emitted by a substance that has absorbed energy.
- **Absorption Spectra:** It is like photographic negative of an emission spectra.
- **Line / Atomic Spectra:** Emission Spectra which do not show a continuous spread of wavelength from red to violet, rather they emit light only at specific wavelength with dark space between them.

$\bar{v} = 109677 \left(\frac{1}{n_1^2} - \frac{1}{n_2^2}\right)$ cm^{-1} where

n_1=1,2............n_2=n_1+1, n_1+2.........

Series	n_1	n_2	Spectral Region
Lyman	1	2,3.........	Ultraviolet
Balmer	2	3,4.........	Visible
Paschen	3	4,5.........	Infrared
Brackett	4	5,6.........	Infrared
Pfund	5	6,7.........	Infrared

Photoelectric Effect: It was found By H.Hertz: It is the phenomenon of ejection of electrons from the surface of a metal when light of suitable frequency strikes on it.

Energy of orbitals: Lower the value of (*n*+l) for an orbital, lower is its energy.

Schrodinger Equation: Fundamental Equation was developed by Schrodinger as $\hat{H}\psi = E\phi$= where $\hat{H}$= Hamiltonian operator

KE of ejected electron $h\nu = h\nu_0 + 1/2\ m_e v^2$

Quantum Mechanical Model of Atom:
- Dual behaviour of atom i.e., particle and wavelike. De Broglie equation:

$$\lambda = \frac{h}{mv} = \frac{h}{p}$$

- Heisenberg's Uncertainty Principle: It is impossible to determine simultaneously, the exact position and momentum of an electron

$$\Delta x.\ \Delta P_x \geq = \frac{h}{4\pi}$$

$$\Rightarrow \Delta v.\ \Delta x = \frac{h}{4\pi}$$

Quantum Numbers

(i) Principal quantum number (n) :
n = 1,2,3,4..............
Shell = K, L, M, N.......
(ii) Azimuthal Quantum number :
For given value of n, *l* = 0 to n-1
(iii) Magnetic Quantum number (m):
for subshell with '*l*' value m_l=2l+1
(iv) Spin Quantum Number (m_s):
$+^1/_2$ or (1.2) or (↑, ↓)

Shapes of orbitals:

s Orbitals:
Spherically symmetric
Size increases with increase in size in n, ie, 4s>3s>2s>1s

p Orbitals:
Each p Orbital consists of two sections called lobes on either side of plane passing through the nucleus.
Size.4p>3p>2p

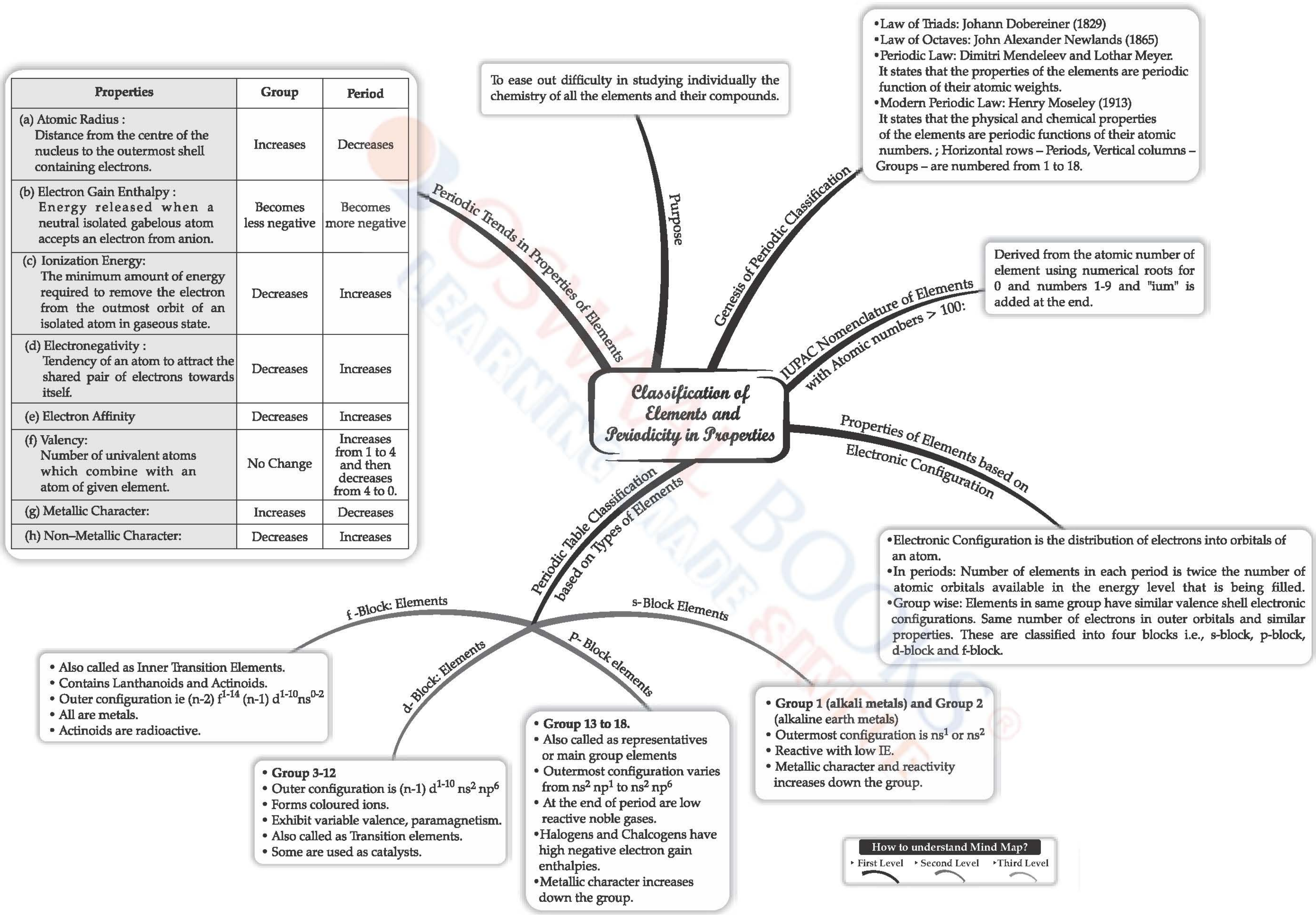
d Orbitals – "Clover leaf" distribution.
– Two angular nodes.

Electronic Configuration of atoms

(i) $s^a p^b d^c$......... notation
(ii) Orbital diagram
☐ ☐☐☐ ☐☐☐☐☐
s p d

Filling of orbitals in atom
- **Aufbau Principle:** In the ground state of atoms, the orbital's are filled according to increasing energies.
- **Pauli Exclusion Principle:** No two electrons in an atom can have same set of four quantum numbers.
- **Hund's rule:** Pairing of electrons in the orbitals belonging to same subshell does not take place until each electron belonging to the subshell is singly occupied.

How to understand Mind Map?
- First Level
- Second Level
- Third Level



Classification of Elements and Periodicity in Properties

Purpose

To ease out difficulty in studying individually the chemistry of all the elements and their compounds.

Genesis of Periodic Classification

- Law of Triads: Johann Dobereiner (1829)
- Law of Octaves: John Alexander Newlands (1865)
- Periodic Law: Dimitri Mendeleev and Lothar Meyer. It states that the properties of the elements are periodic function of their atomic weights.
- Modern Periodic Law: Henry Moseley (1913) It states that the physical and chemical properties of the elements are periodic functions of their atomic numbers. ; Horizontal rows – Periods, Vertical columns – Groups – are numbered from 1 to 18.

IUPAC Nomenclature of Elements with Atomic numbers > 100:

Derived from the atomic number of element using numerical roots for 0 and numbers 1-9 and "ium" is added at the end.

Properties of Elements based on Electronic Configuration

- Electronic Configuration is the distribution of electrons into orbitals of an atom.
- In periods: Number of elements in each period is twice the number of atomic orbitals available in the energy level that is being filled.
- Group wise: Elements in same group have similar valence shell electronic configurations. Same number of electrons in outer orbitals and similar properties. These are classified into four blocks i.e., s-block, p-block, d-block and f-block.

Periodic Table Classification based on Types of Elements

s-Block Elements

- **Group 1 (alkali metals) and Group 2** (alkaline earth metals)
- Outermost configuration is ns^1 or ns^2
- Reactive with low IE.
- Metallic character and reactivity increases down the group.

P- Block elements

- **Group 13 to 18.**
- Also called as representatives or main group elements
- Outermost configuration varies from $ns^2 np^1$ to $ns^2 np^6$
- At the end of period are low reactive noble gases.
- Halogens and Chalcogens have high negative electron gain enthalpies.
- Metallic character increases down the group.

d- Block: Elements

- **Group 3-12**
- Outer configuration is $(n-1) d^{1-10} ns^2 np^6$
- Forms coloured ions.
- Exhibit variable valence, paramagnetism.
- Also called as Transition elements.
- Some are used as catalysts.

f -Block: Elements

- Also called as Inner Transition Elements.
- Contains Lanthanoids and Actinoids.
- Outer configuration ie $(n-2) f^{1-14} (n-1) d^{1-10} ns^{0-2}$
- All are metals.
- Actinoids are radioactive.

Periodic Trends in Properties of Elements

Properties	Group	Period
(a) Atomic Radius : Distance from the centre of the nucleus to the outermost shell containing electrons.	Increases	Decreases
(b) Electron Gain Enthalpy : Energy released when a neutral isolated gabelous atom accepts an electron from anion.	Becomes less negative	Becomes more negative
(c) Ionization Energy: The minimum amount of energy required to remove the electron from the outmost orbit of an isolated atom in gaseous state.	Decreases	Increases
(d) Electronegativity : Tendency of an atom to attract the shared pair of electrons towards itself.	Decreases	Increases
(e) Electron Affinity	Decreases	Increases
(f) Valency: Number of univalent atoms which combine with an atom of given element.	No Change	Increases from 1 to 4 and then decreases from 4 to 0.
(g) Metallic Character:	Increases	Decreases
(h) Non–Metallic Character:	Decreases	Increases

How to understand Mind Map?

How to understand Mind Map?

- First Level
- Second Level
- Third Level

Chemical Bonding and Molecular Structure

Chemical Bonding

Kossel Lewis approach to chemical bonding:

- Lewis pictured the atom as a positively charged 'kernel' and the outer shell accommodates a maximum of eight electrons.
- Lewis postulated that atoms achieve the stable octet when linked by chemical bonds.
- Kossel gave following facts:
- In the periodic table, highly electronegative halogens and highly electropositive alkali separated by noble gases.
- Formation of a negative ion from a halogen atom and a positive ion from an alkali metal atom is associated with gain and loss of electron by respective atoms.
- Negative and positive ions formed attains noble gas electronic configuration.
- Negative and positive ions are stabilized by electrostatic attraction.

Octet Rule: Atoms can combine either by transfer of valence electrons from one atom to another or by sharing of valence electrons to complete octet in their valence shells.

Lewis Dot Structure provides a picture of bonding in molecules and ions in terms of the shared pairs of electrons and the octet rule.

How To Write A Lewis Dot Structure:

Step 1: Add the valence electrons of the combining atoms to obtain total number of electrons.

Step 2: For anions, each negative charge means addition of one electron. For cations, each positive charge means subtraction of one electron from total number of valence electrons.

Step 3: Write chemical symbols of combining atoms.

Step 4: Least electronegative atom occupies central position.

Step 5: After accounting for shared pairs of electrons, remaining are either utilized for multiple bonding or remain as lone pairs.

Formal Charge= (Total number of valence electrons in free atom) – (Total number of non-bonding electrons) – 1/2(Total number of bonding electrons)

Limitations Of Octet Rule:

- Shows three types of exceptions i.e. incomplete octet of central atom, odd-electron molecules and expanded octet.
- Does not account for the shape of molecules.
- Fails to explain stability of molecules.

Hydrogen Bond: Formed when the negative end of one molecule attracts the positive end of other.

Types:

(i) Intermolecular: Between two different molecules of same or different substances.

(ii) Intramolecular : H atom is between two highly electronegative atom.

Molecular orbital theory

Postulates:

- Electrons in a molecule are present in various molecular orbitals as electrons are present in atomic orbitals.
- Atomic orbitals of comparable energies and proper symmetry combine.
- Atomic orbitals is monocentric while a molecular orbital is polycentric.
- Number of molecular orbital formed is equal to number of combining molecular orbitals.
- Bonding molecular orbitals has low energy and high stability Types of MO: σ(Sigma),π (Pi), δ (Delta)

Chemical Bond: Attractive forces which hold the various chemical constituents together in different chemical species.

Types:

(i) Covalent Bond: A chemical bond formed between two atoms by mutual sharing of electrons between them to complete their octet.

(ii) Ionic Bond: A chemical bond formed by complete transfer of electrons from one atom to another acquire the stable nearest noble gas configuration.

Lattice Enthalpy

Energy required to completely separate one mole of a solid ionic compound into gaseous constituent ions.

Valence Shell Electron Pair Repulsion (VSEPR)

Postulates:

- Shape of molecule depends upon the number of valence shell electron pairs around central atom.
- Pairs of electrons in the valence shell repel one another.
- These pairs of electrons tend to occupy such positions in space that minimize repulsion.
- The valence shell is taken as a sphere with electron pairs localising on spherical surface at maximum distance from one another.
- A multiple bond is treated as if it is a single electron pair and the two or three electron pairs of a multiple bond are treated as a single super pair.
- When one or more resonance structures can represent a molecule, VSEPR model is applicable.
- **Decreasing order of repulsive interaction:**
  lp – lp > lp – bp > bp – bp

Valence Bond Theory: Given by L Pauling. It explains that a covalent bond is formed between two atoms by overlap of their half-filled valance orbitals, each of which contains one unpaired electron.

Orbital Overlap Concept: Formation of a covalent bond results by pairing of electrons in valence shell with opposite spins.

Types of Overlapping: (i) Sigma (σ) bond – end to end.

(ii) Pi (π) bond – axis remain parallel to each other.

Hybridisation: Process of intermixing of orbitals of different energies resulting in formation of new set of orbitals of equivalent energies and shape.

Types of Hybridisation –(I) sp (ii) sp^2 (iii) sp^3

Bonding Molecular Orbitals: Addition of atomic orbitals.

Antibonding Molecular Orbitals: Substraction of atomic orbitals.

Bond Parameters

(I) Bond Length: Equilibrium distance between the nuclei of two bonded atoms in molecule.

(ii) Bond Angle: Angle between the orbitals containing bonding electron pairs around central atom in a molecule complex ion.

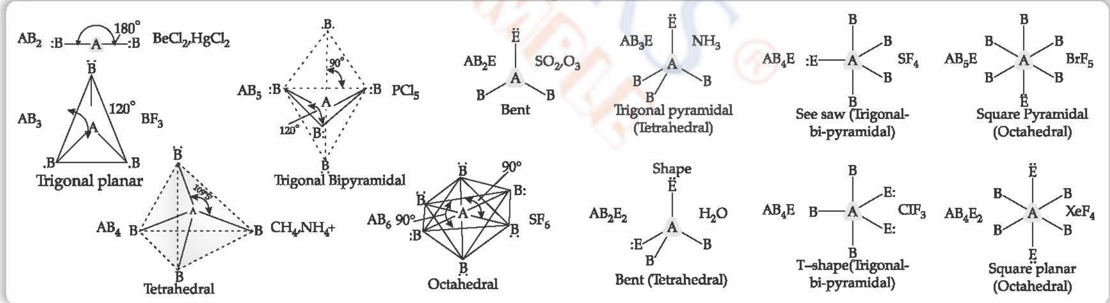
(iii) Bond Enthalpy: Amount of energy required to break one mole of bonds of particular type between 2 atoms.

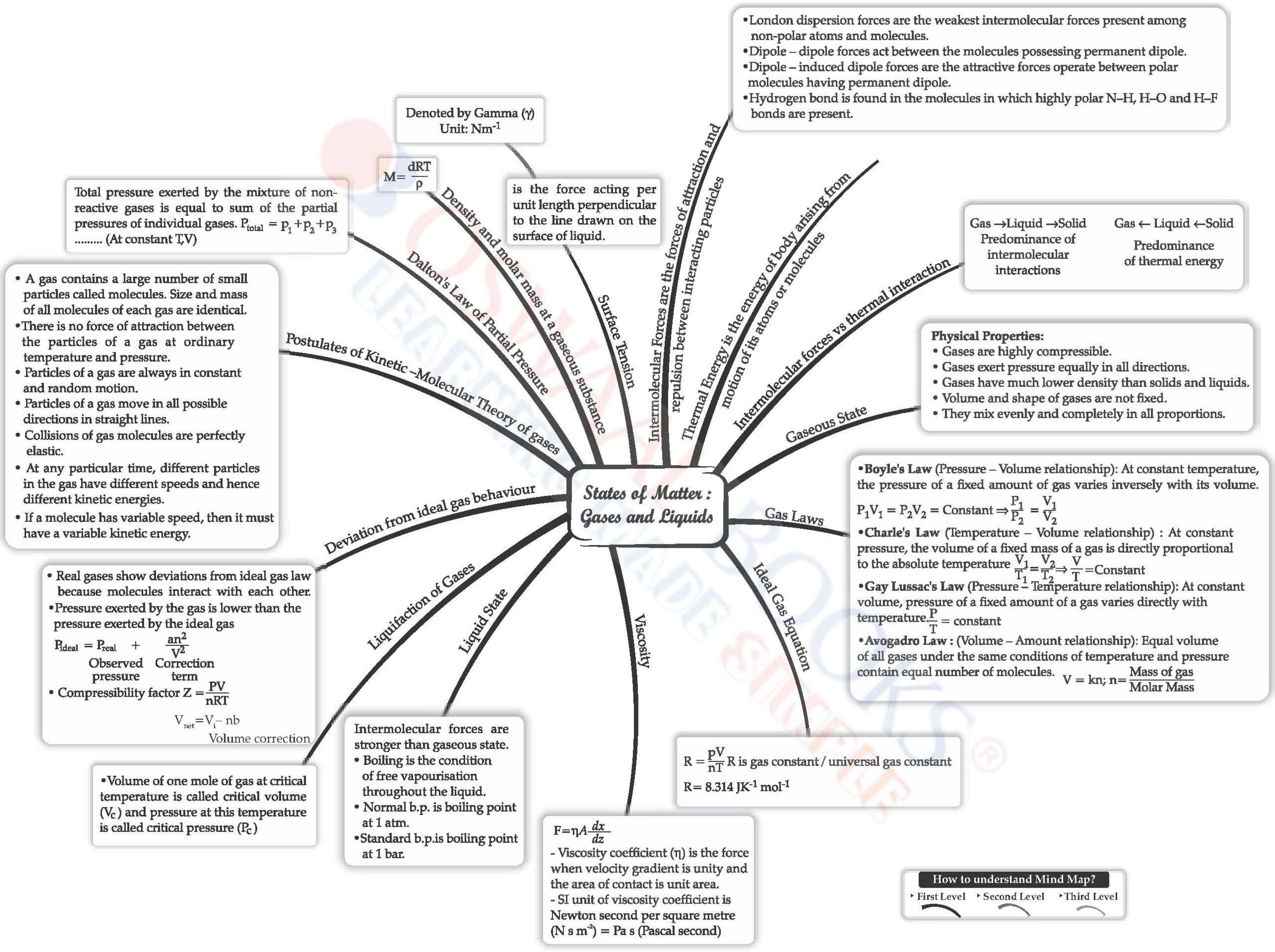
(iv) Bond Order: Number of bonds between the two atoms of a molecule.

(v) Resonance Structures: A set of two or more Lewis structures that collectively describe the electronic bonding a single polyatomic species.

(vi) Dipole Moment: Product of the magnitude of the charge and distance between centres of positive and negative charge. μ= Q x r

Hybridization





States of Matter : Gases and Liquids

Intermolecular Forces are the forces of attraction and repulsion between interacting particles

- London dispersion forces are the weakest intermolecular forces present among non-polar atoms and molecules.
- Dipole – dipole forces act between the molecules possessing permanent dipole.
- Dipole – induced dipole forces are the attractive forces operate between polar molecules having permanent dipole.
- Hydrogen bond is found in the molecules in which highly polar N–H, H–O and H–F bonds are present.

Thermal Energy is the energy of body arising from motion of its atoms or molecules

Intermolecular forces vs thermal interaction

Gas →Liquid →Solid
Predominance of intermolecular interactions

Gas ← Liquid ←Solid
Predominance of thermal energy

Gaseous State

Physical Properties:
- Gases are highly compressible.
- Gases exert pressure equally in all directions.
- Gases have much lower density than solids and liquids.
- Volume and shape of gases are not fixed.
- They mix evenly and completely in all proportions.

Gas Laws

- **Boyle's Law** (Pressure – Volume relationship): At constant temperature, the pressure of a fixed amount of gas varies inversely with its volume.
  $P_1V_1 = P_2V_2 = \text{Constant} \Rightarrow \frac{P_1}{P_2} = \frac{V_1}{V_2}$
- **Charle's Law** (Temperature – Volume relationship) : At constant pressure, the volume of a fixed mass of a gas is directly proportional to the absolute temperature $\frac{V_1}{T_1}=\frac{V_2}{T_2} \Rightarrow \frac{V}{T}$ =Constant
- **Gay Lussac's Law** (Pressure – Temperature relationship): At constant volume, pressure of a fixed amount of a gas varies directly with temperature.$\frac{P}{T}$ = constant
- **Avogadro Law :** (Volume – Amount relationship): Equal volume of all gases under the same conditions of temperature and pressure contain equal number of molecules. $V = kn;\ n=\frac{\text{Mass of gas}}{\text{Molar Mass}}$

Ideal Gas Equation

$R = \frac{pV}{nT}$ R is gas constant / universal gas constant

$R= 8.314\ JK^{-1}\ mol^{-1}$

Viscosity

$F=\eta A\frac{dx}{dz}$
- Viscosity coefficient (η) is the force when velocity gradient is unity and the area of contact is unit area.
- SI unit of viscosity coefficient is Newton second per square metre ($N\ s\ m^{-2}$) = Pa s (Pascal second)

Liquid State

Intermolecular forces are stronger than gaseous state.
- Boiling is the condition of free vapourisation throughout the liquid.
- Normal b.p. is boiling point at 1 atm.
- Standard b.p.is boiling point at 1 bar.

Liquifaction of Gases

- Volume of one mole of gas at critical temperature is called critical volume (V_C) and pressure at this temperature is called critical pressure (P_C)

Deviation from ideal gas behaviour

- Real gases show deviations from ideal gas law because molecules interact with each other.
- Pressure exerted by the gas is lower than the pressure exerted by the ideal gas
  $P_{ideal} = \underset{\text{Observed pressure}}{P_{real}} + \underset{\text{Correction term}}{\frac{an^2}{V^2}}$
- Compressibility factor $Z = \frac{PV}{nRT}$

$\underset{\text{Volume correction}}{V_{net} = V_i - nb}$

Postulates of Kinetic –Molecular Theory of gases

- A gas contains a large number of small particles called molecules. Size and mass of all molecules of each gas are identical.
- There is no force of attraction between the particles of a gas at ordinary temperature and pressure.
- Particles of a gas are always in constant and random motion.
- Particles of a gas move in all possible directions in straight lines.
- Collisions of gas molecules are perfectly elastic.
- At any particular time, different particles in the gas have different speeds and hence different kinetic energies.
- If a molecule has variable speed, then it must have a variable kinetic energy.

Dalton's Law of Partial Pressure

Total pressure exerted by the mixture of non-reactive gases is equal to sum of the partial pressures of individual gases. $P_{total} = p_1+p_2+p_3$ ……… (At constant T,V)

Density and molar mass at a gaseous substance

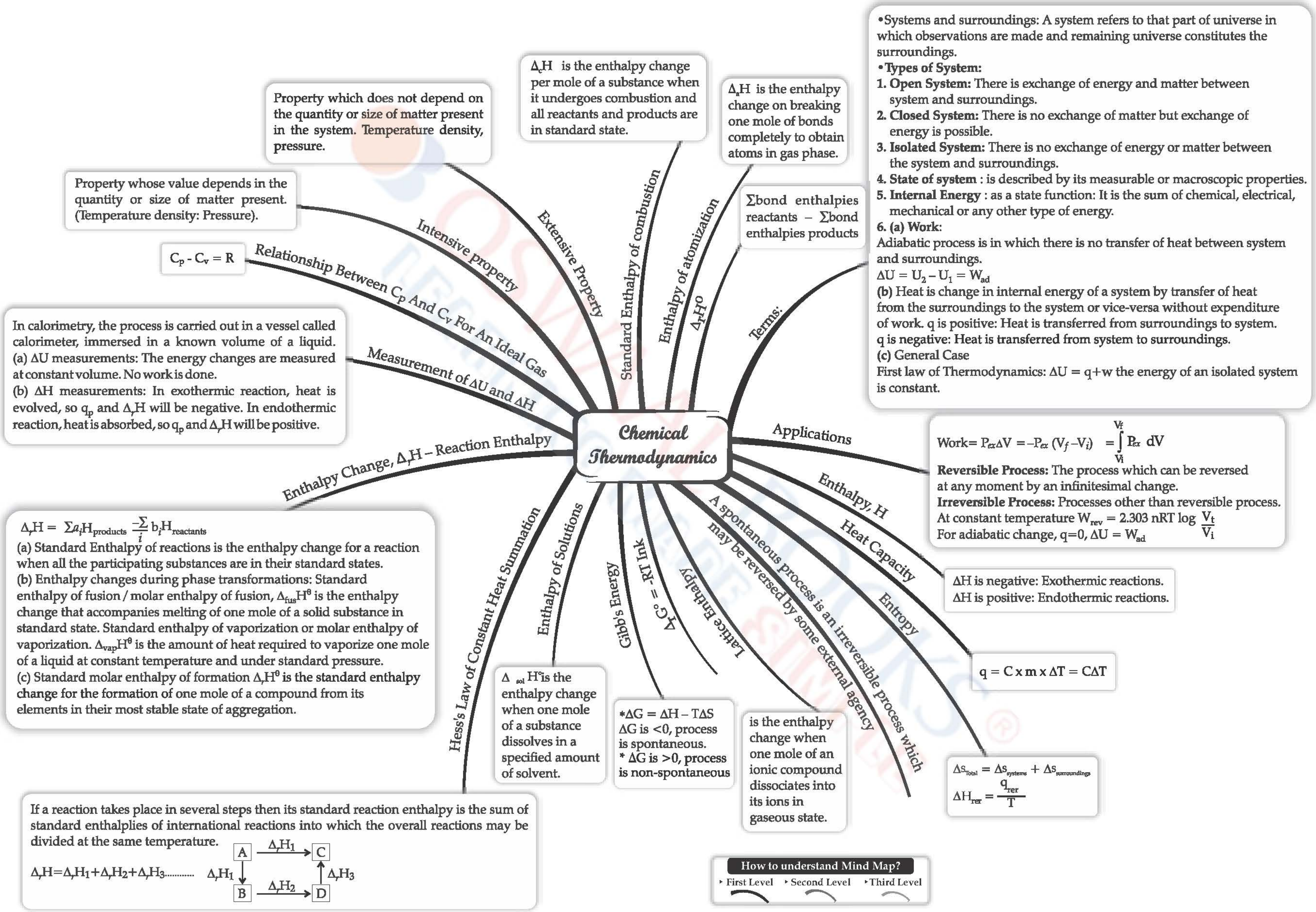
$M= \frac{dRT}{\rho}$

Surface Tension

is the force acting per unit length perpendicular to the line drawn on the surface of liquid.

Denoted by Gamma (γ)
Unit: Nm^{-1}

How to understand Mind Map?



Chemical Thermodynamics

Terms:

- Systems and surroundings: A system refers to that part of universe in which observations are made and remaining universe constitutes the surroundings.
- **Types of System:**

1. **Open System:** There is exchange of energy and matter between system and surroundings.
2. **Closed System:** There is no exchange of matter but exchange of energy is possible.
3. **Isolated System:** There is no exchange of energy or matter between the system and surroundings.
4. **State of system** : is described by its measurable or macroscopic properties.
5. **Internal Energy** : as a state function: It is the sum of chemical, electrical, mechanical or any other type of energy.
6. **(a) Work**:

Adiabatic process is in which there is no transfer of heat between system and surroundings.

$\Delta U = U_2 - U_1 = W_{ad}$

(b) Heat is change in internal energy of a system by transfer of heat from the surroundings to the system or vice-versa without expenditure of work. q is positive: Heat is transferred from surroundings to system. q is negative: Heat is transferred from system to surroundings.

(c) General Case

First law of Thermodynamics: $\Delta U = q+w$ the energy of an isolated system is constant.

Applications

$\text{Work} = P_{ex}\Delta V = -P_{ex}(V_f - V_i) = \int_{V_i}^{V_f} P_{ex}\, dV$

Reversible Process: The process which can be reversed at any moment by an infinitesimal change.

Irreversible Process: Processes other than reversible process.

At constant temperature $W_{rev} = 2.303\ nRT \log \frac{V_t}{V_i}$

For adiabatic change, $q=0, \Delta U = W_{ad}$

Enthalpy, H

ΔH is negative: Exothermic reactions.

ΔH is positive: Endothermic reactions.

Heat Capacity

$q = C \times m \times \Delta T = C\Delta T$

Entropy

$\Delta s_{Total} = \Delta s_{systems} + \Delta s_{surroundings}$

$\Delta H_{rer} = \frac{q_{rer}}{T}$

A spontaneous process is an irreversible process which may be reversed by some external agency

Lattice Enthalpy

is the enthalpy change when one mole of an ionic compound dissociates into its ions in gaseous state.

$\Delta_r G^o = -RT \ln k$

Gibb's Energy

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

ΔG is <0, process is spontaneous.

$* \Delta G$ is >0, process is non-spontaneous

Enthalpy of Solutions

$\Delta_{sol} H^o$ is the enthalpy change when one mole of a substance dissolves in a specified amount of solvent.

Hess's Law of Constant Heat Summation

If a reaction takes place in several steps then its standard reaction enthalpy is the sum of standard enthalpies of international reactions into which the overall reactions may be divided at the same temperature.

$\Delta_r H = \Delta_r H_1 + \Delta_r H_2 + \Delta_r H_3$............

$$\begin{tikzcd}
\boxed{A} \arrow[r, "\Delta_r H_1"] \arrow[d, "\Delta_r H_1"'] & \boxed{C} \\
\boxed{B} \arrow[r, "\Delta_r H_2"] & \boxed{D} \arrow[u, "\Delta_r H_3"']
\end{tikzcd}$$

Enthalpy Change, $\Delta_r H$ – Reaction Enthalpy

$\Delta_r H = \Sigma a_i H_{products} \underset{i}{-\Sigma} b_i H_{reactants}$

(a) Standard Enthalpy of reactions is the enthalpy change for a reaction when all the participating substances are in their standard states.

(b) Enthalpy changes during phase transformations: Standard enthalpy of fusion / molar enthalpy of fusion, $\Delta_{fus}H^\theta$ is the enthalpy change that accompanies melting of one mole of a solid substance in standard state. Standard enthalpy of vaporization or molar enthalpy of vaporization. $\Delta_{vap}H^\theta$ is the amount of heat required to vaporize one mole of a liquid at constant temperature and under standard pressure.

(c) Standard molar enthalpy of formation $\Delta_f H^\theta$ is the standard enthalpy change for the formation of one mole of a compound from its elements in their most stable state of aggregation.

Measurement of ΔU and ΔH

In calorimetry, the process is carried out in a vessel called calorimeter, immersed in a known volume of a liquid.

(a) ΔU measurements: The energy changes are measured at constant volume. No work is done.

(b) ΔH measurements: In exothermic reaction, heat is evolved, so q_p and $\Delta_r H$ will be negative. In endothermic reaction, heat is absorbed, so q_p and $\Delta_r H$ will be positive.

Relationship Between C_p And C_v For An Ideal Gas

$C_p - C_v = R$

Intensive property

Property whose value depends in the quantity or size of matter present. (Temperature density: Pressure).

Extensive Property

Property which does not depend on the quantity or size of matter present in the system. Temperature density, pressure.

Standard Enthalpy of combustion

$\Delta_c H$ is the enthalpy change per mole of a substance when it undergoes combustion and all reactants and products are in standard state.

Enthalpy of atomization

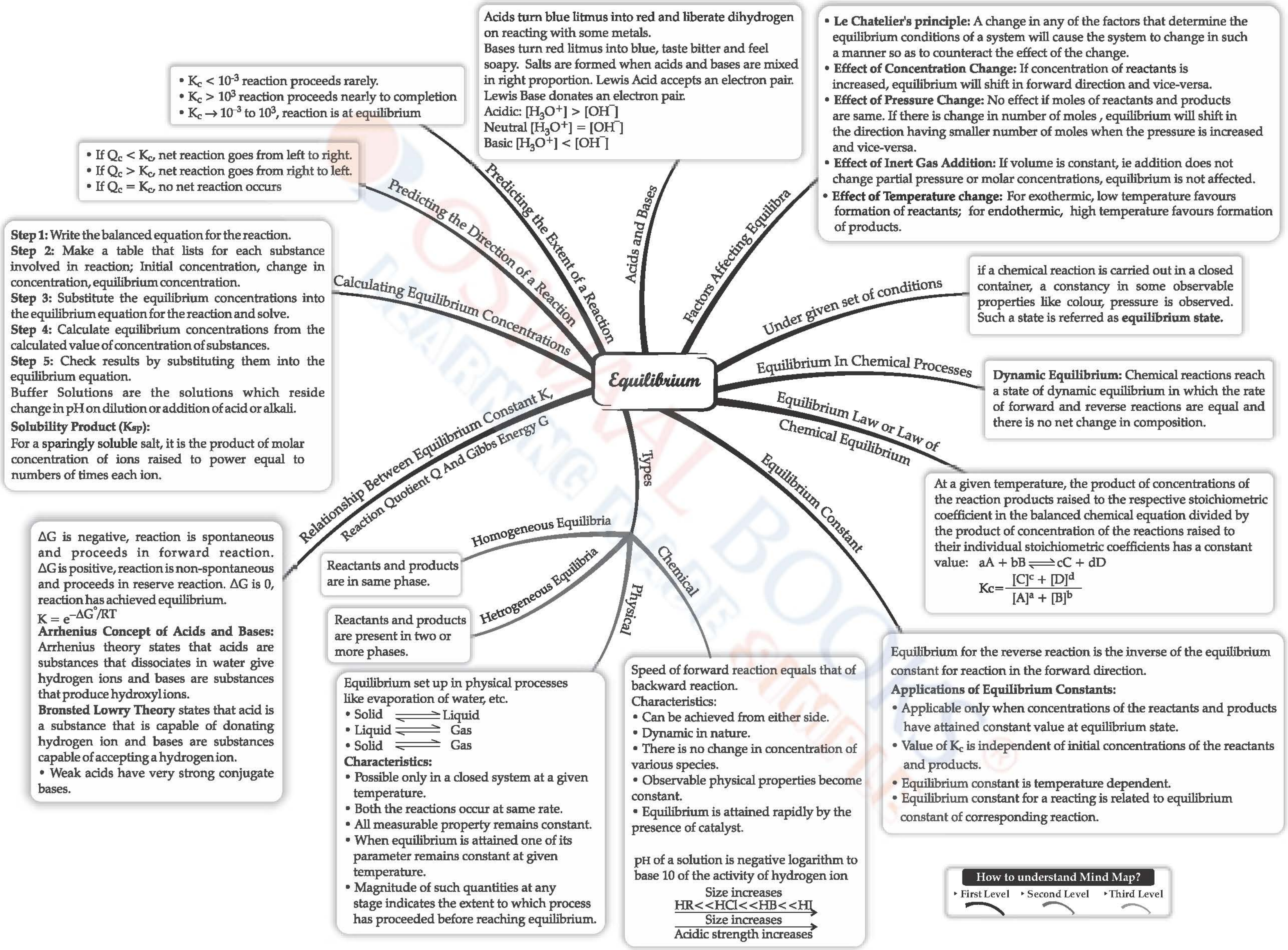
$\Delta_a H$ is the enthalpy change on breaking one mole of bonds completely to obtain atoms in gas phase.

$\Delta_r H^o$

Σbond enthalpies reactants – Σbond enthalpies products

How to understand Mind Map?

- First Level
- Second Level
- Third Level



- **Le Chatelier's principle:** A change in any of the factors that determine the equilibrium conditions of a system will cause the system to change in such a manner so as to counteract the effect of the change.
- **Effect of Concentration Change:** If concentration of reactants is increased, equilibrium will shift in forward direction and vice-versa.
- **Effect of Pressure Change:** No effect if moles of reactants and products are same. If there is change in number of moles , equilibrium will shift in the direction having smaller number of moles when the pressure is increased and vice-versa.
- **Effect of Inert Gas Addition:** If volume is constant, ie addition does not change partial pressure or molar concentrations, equilibrium is not affected.
- **Effect of Temperature change:** For exothermic, low temperature favours formation of reactants; for endothermic, high temperature favours formation of products.

if a chemical reaction is carried out in a closed container, a constancy in some observable properties like colour, pressure is observed. Such a state is referred as **equilibrium state.**

Dynamic Equilibrium: Chemical reactions reach a state of dynamic equilibrium in which the rate of forward and reverse reactions are equal and there is no net change in composition.

At a given temperature, the product of concentrations of the reaction products raised to the respective stoichiometric coefficient in the balanced chemical equation divided by the product of concentration of the reactions raised to their individual stoichiometric coefficients has a constant value: $aA + bB \rightleftharpoons cC + dD$

$$Kc = \frac{[C]^c + [D]^d}{[A]^a + [B]^b}$$

Equilibrium for the reverse reaction is the inverse of the equilibrium constant for reaction in the forward direction.

Applications of Equilibrium Constants:

- Applicable only when concentrations of the reactants and products have attained constant value at equilibrium state.
- Value of K_c is independent of initial concentrations of the reactants and products.
- Equilibrium constant is temperature dependent.
- Equilibrium constant for a reacting is related to equilibrium constant of corresponding reaction.

Speed of forward reaction equals that of backward reaction.
Characteristics:

- Can be achieved from either side.
- Dynamic in nature.
- There is no change in concentration of various species.
- Observable physical properties become constant.
- Equilibrium is attained rapidly by the presence of catalyst.

pH of a solution is negative logarithm to base 10 of the activity of hydrogen ion

$$\xrightarrow[\text{Size increases}]{\text{Size increases}} \quad HR << HCl << HB << HI \quad \xrightarrow{\text{Acidic strength increases}}$$

Equilibrium set up in physical processes like evaporation of water, etc.

- Solid $\rightleftharpoons$ Liquid
- Liquid $\rightleftharpoons$ Gas
- Solid $\rightleftharpoons$ Gas

Characteristics:

- Possible only in a closed system at a given temperature.
- Both the reactions occur at same rate.
- All measurable property remains constant.
- When equilibrium is attained one of its parameter remains constant at given temperature.
- Magnitude of such quantities at any stage indicates the extent to which process has proceeded before reaching equilibrium.

Reactants and products are in same phase.

Reactants and products are present in two or more phases.

ΔG is negative, reaction is spontaneous and proceeds in forward reaction. ΔG is positive, reaction is non-spontaneous and proceeds in reserve reaction. ΔG is 0, reaction has achieved equilibrium.

$K = e^{-\Delta G^\circ/RT}$

Arrhenius Concept of Acids and Bases: Arrhenius theory states that acids are substances that dissociates in water give hydrogen ions and bases are substances that produce hydroxyl ions.

Bronsted Lowry Theory states that acid is a substance that is capable of donating hydrogen ion and bases are substances capable of accepting a hydrogen ion.

- Weak acids have very strong conjugate bases.

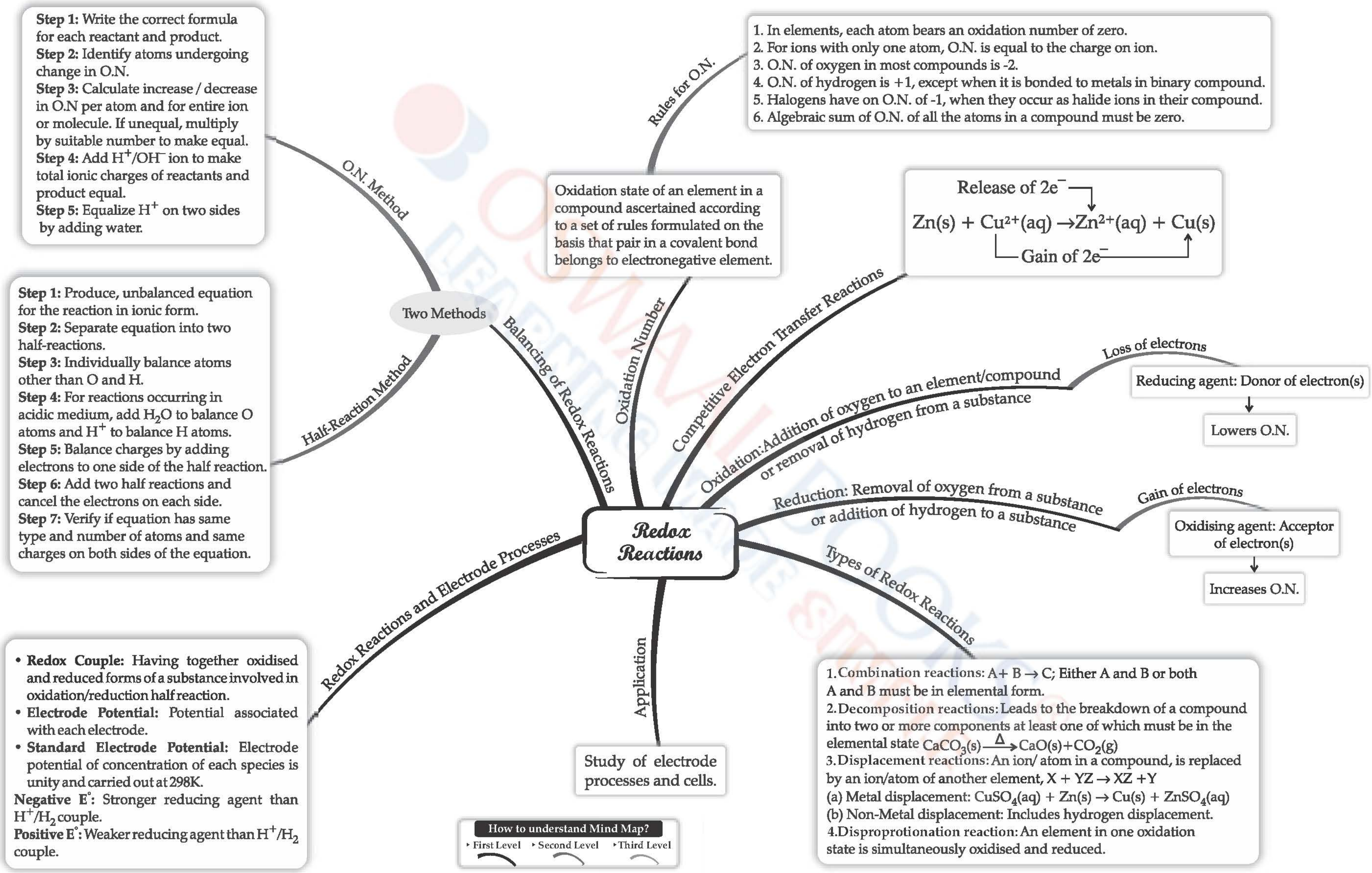
Step 1: Write the balanced equation for the reaction.
Step 2: Make a table that lists for each substance involved in reaction; Initial concentration, change in concentration, equilibrium concentration.
Step 3: Substitute the equilibrium concentrations into the equilibrium equation for the reaction and solve.
Step 4: Calculate equilibrium concentrations from the calculated value of concentration of substances.
Step 5: Check results by substituting them into the equilibrium equation.
Buffer Solutions are the solutions which reside change in pH on dilution or addition of acid or alkali.

Solubility Product (K_{sp}):
For a **sparingly soluble** salt, it is the product of molar concentration of ions raised to power equal to numbers of times each ion.

- If $Q_c < K_c$, net reaction goes from left to right.
- If $Q_c > K_c$, net reaction goes from right to left.
- If $Q_c = K_c$, no net reaction occurs

- $K_c < 10^{-3}$ reaction proceeds rarely.
- $K_c > 10^3$ reaction proceeds nearly to completion
- $K_c \rightarrow 10^{-3}$ to 10^3, reaction is at equilibrium

Acids turn blue litmus into red and liberate dihydrogen on reacting with some metals.
Bases turn red litmus into blue, taste bitter and feel soapy. Salts are formed when acids and bases are mixed in right proportion. Lewis Acid accepts an electron pair.
Lewis Base donates an electron pair.
Acidic: $[H_3O^+] > [OH^-]$
Neutral $[H_3O^+] = [OH^-]$
Basic $[H_3O^+] < [OH^-]$



Redox Reactions

Oxidation Number

Oxidation state of an element in a compound ascertained according to a set of rules formulated on the basis that pair in a covalent bond belongs to electronegative element.

Rules for O.N.

1. In elements, each atom bears an oxidation number of zero.
2. For ions with only one atom, O.N. is equal to the charge on ion.
3. O.N. of oxygen in most compounds is -2.
4. O.N. of hydrogen is +1, except when it is bonded to metals in binary compound.
5. Halogens have on O.N. of -1, when they occur as halide ions in their compound.
6. Algebraic sum of O.N. of all the atoms in a compound must be zero.

Competitive Electron Transfer Reactions

Release of $2e^-$

$$Zn(s) + Cu^{2+}(aq) \rightarrow Zn^{2+}(aq) + Cu(s)$$

Gain of $2e^-$

Oxidation: Addition of oxygen to an element/compound or removal of hydrogen from a substance

Loss of electrons

Reducing agent: Donor of electron(s)

Lowers O.N.

Reduction: Removal of oxygen from a substance or addition of hydrogen to a substance

Gain of electrons

Oxidising agent: Acceptor of electron(s)

Increases O.N.

Types of Redox Reactions

1. Combination reactions: A+ B → C; Either A and B or both A and B must be in elemental form.
2. Decomposition reactions: Leads to the breakdown of a compound into two or more components at least one of which must be in the elemental state $CaCO_3(s) \xrightarrow{\Delta} CaO(s)+CO_2(g)$
3. Displacement reactions: An ion/ atom in a compound, is replaced by an ion/atom of another element, $X + YZ \rightarrow XZ + Y$
(a) Metal displacement: $CuSO_4(aq) + Zn(s) \rightarrow Cu(s) + ZnSO_4(aq)$
(b) Non-Metal displacement: Includes hydrogen displacement.
4. Disproportionation reaction: An element in one oxidation state is simultaneously oxidised and reduced.

Application

Study of electrode processes and cells.

Redox Reactions and Electrode Processes

- **Redox Couple:** Having together oxidised and reduced forms of a substance involved in oxidation/reduction half reaction.
- **Electrode Potential:** Potential associated with each electrode.
- **Standard Electrode Potential:** Electrode potential of concentration of each species is unity and carried out at 298K.

Negative E°: Stronger reducing agent than H^+/H_2 couple.
Positive E°: Weaker reducing agent than H^+/H_2 couple.

Balancing of Redox Reactions

Two Methods

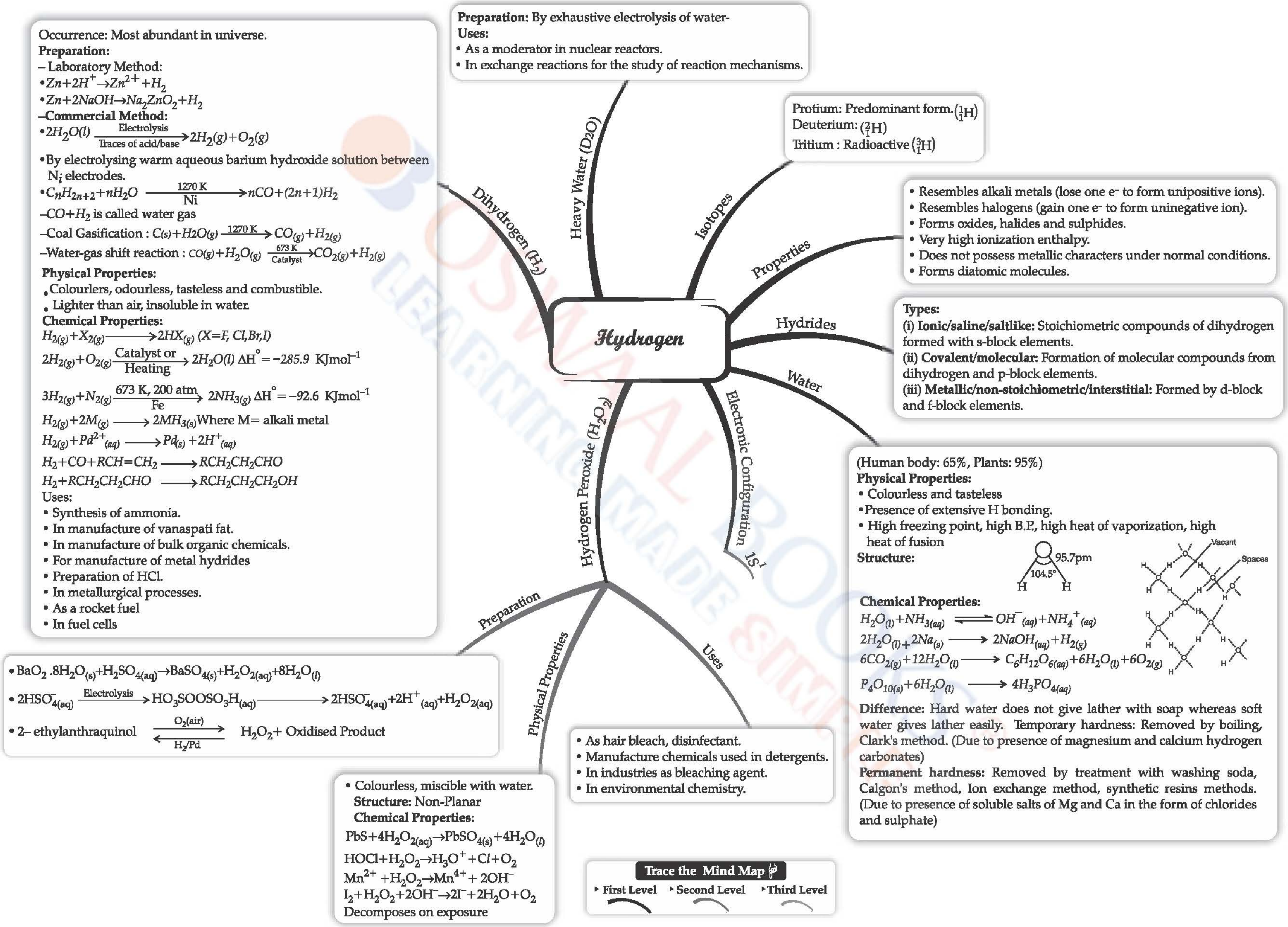
O.N. Method

Step 1: Write the correct formula for each reactant and product.
Step 2: Identify atoms undergoing change in O.N.
Step 3: Calculate increase / decrease in O.N per atom and for entire ion or molecule. If unequal, multiply by suitable number to make equal.
Step 4: Add H^+/OH^- ion to make total ionic charges of reactants and product equal.
Step 5: Equalize H^+ on two sides by adding water.

Half-Reaction Method

Step 1: Produce, unbalanced equation for the reaction in ionic form.
Step 2: Separate equation into two half-reactions.
Step 3: Individually balance atoms other than O and H.
Step 4: For reactions occurring in acidic medium, add H_2O to balance O atoms and H^+ to balance H atoms.
Step 5: Balance charges by adding electrons to one side of the half reaction.
Step 6: Add two half reactions and cancel the electrons on each side.
Step 7: Verify if equation has same type and number of atoms and same charges on both sides of the equation.

How to understand Mind Map?
- First Level
- Second Level
- Third Level



Dihydrogen (H_2)

Occurrence: Most abundant in universe.
Preparation:
– Laboratory Method:
- $Zn+2H^+ \rightarrow Zn^{2+}+H_2$
- $Zn+2NaOH \rightarrow Na_2ZnO_2+H_2$

–**Commercial Method:**
- $2H_2O(l) \xrightarrow[\text{Traces of acid/base}]{\text{Electrolysis}} 2H_2(g)+O_2(g)$
- By electrolysing warm aqueous barium hydroxide solution between N_i electrodes.
- $C_nH_{2n+2}+nH_2O \xrightarrow[\text{Ni}]{1270\text{ K}} nCO+(2n+1)H_2$

–$CO+H_2$ is called water gas
–Coal Gasification : $C(s)+H2O(g) \xrightarrow{1270\text{ K}} CO_{(g)}+H_{2(g)}$
–Water-gas shift reaction : $CO(g)+H_2O_{(g)} \xrightarrow[\text{Catalyst}]{673\text{ K}} CO_{2(g)}+H_{2(g)}$

Physical Properties:
- Colourlers, odourless, tasteless and combustible.
- Lighter than air, insoluble in water.

Chemical Properties:
$H_{2(g)}+X_{2(g)} \longrightarrow 2HX_{(g)}$ (X=F, Cl,Br,I)
$2H_{2(g)}+O_{2(g)} \xrightarrow[\text{Heating}]{\text{Catalyst or}} 2H_2O(l)$ $\Delta H^\circ = -285.9$ KJmol^{-1}
$3H_{2(g)}+N_{2(g)} \xrightarrow[\text{Fe}]{673\text{ K, 200 atm}} 2NH_{3(g)}$ $\Delta H^\circ = -92.6$ KJmol^{-1}
$H_{2(g)}+2M_{(g)} \longrightarrow 2MH_{3(s)}$Where M= alkali metal
$H_{2(g)}+Pd^{2+}{}_{(aq)} \longrightarrow Pd_{(s)}+2H^+{}_{(aq)}$
$H_2+CO+RCH=CH_2 \longrightarrow RCH_2CH_2CHO$
$H_2+RCH_2CH_2CHO \longrightarrow RCH_2CH_2CH_2OH$

Uses:
- Synthesis of ammonia.
- In manufacture of vanaspati fat.
- In manufacture of bulk organic chemicals.
- For manufacture of metal hydrides
- Preparation of HCl.
- In metallurgical processes.
- As a rocket fuel
- In fuel cells

Heavy Water (D2O)

Preparation: By exhaustive electrolysis of water-
Uses:
- As a moderator in nuclear reactors.
- In exchange reactions for the study of reaction mechanisms.

Isotopes

Protium: Predominant form.($^1_1$H)
Deuterium: ($^2_1$H)
Tritium : Radioactive ($^3_1$H)

Properties

- Resembles alkali metals (lose one e⁻ to form unipositive ions).
- Resembles halogens (gain one e⁻ to form uninegative ion).
- Forms oxides, halides and sulphides.
- Very high ionization enthalpy.
- Does not possess metallic characters under normal conditions.
- Forms diatomic molecules.

Hydrides

Types:
(i) **Ionic/saline/saltlike:** Stoichiometric compounds of dihydrogen formed with s-block elements.
(ii) **Covalent/molecular:** Formation of molecular compounds from dihydrogen and p-block elements.
(iii) **Metallic/non-stoichiometric/interstitial:** Formed by d-block and f-block elements.

Water

(Human body: 65%, Plants: 95%)
Physical Properties:
- Colourless and tasteless
- Presence of extensive H bonding.
- High freezing point, high B.P., high heat of vaporization, high heat of fusion

Structure:

Chemical Properties:
$H_2O_{(l)}+NH_{3(aq)} \rightleftharpoons OH^-{}_{(aq)}+NH_4^+{}_{(aq)}$
$2H_2O_{(l)}+2Na_{(s)} \longrightarrow 2NaOH_{(aq)}+H_{2(g)}$
$6CO_{2(g)}+12H_2O_{(l)} \longrightarrow C_6H_{12}O_{6(aq)}+6H_2O_{(l)}+6O_{2(g)}$
$P_4O_{10(s)}+6H_2O_{(l)} \longrightarrow 4H_3PO_{4(aq)}$

Difference: Hard water does not give lather with soap whereas soft water gives lather easily. Temporary hardness: Removed by boiling, Clark's method. (Due to presence of magnesium and calcium hydrogen carbonates)
Permanent hardness: Removed by treatment with washing soda, Calgon's method, Ion exchange method, synthetic resins methods. (Due to presence of soluble salts of Mg and Ca in the form of chlorides and sulphate)

Electronic Configuration $1S^1$

Hydrogen Peroxide (H_2O_2)

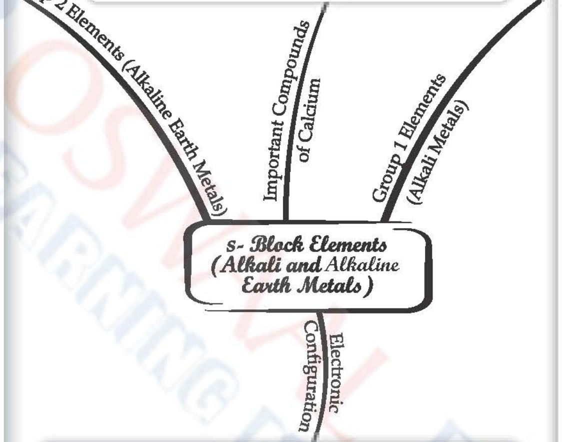
Preparation
- $BaO_2.8H_2O_{(s)}+H_2SO_{4(aq)} \rightarrow BaSO_{4(s)}+H_2O_{2(aq)}+8H_2O_{(l)}$
- $2HSO_{4(aq)}^- \xrightarrow{\text{Electrolysis}} HO_3SOOSO_3H_{(aq)} \longrightarrow 2HSO_{4(aq)}^-+2H^+{}_{(aq)}+H_2O_{2(aq)}$
- 2– ethylanthraquinol $\underset{H_2/Pd}{\overset{O_2(air)}{\rightleftarrows}}$ H_2O_2+ Oxidised Product

Physical Properties
- Colourless, miscible with water.

Structure: Non-Planar
Chemical Properties:
$PbS+4H_2O_{2(aq)} \rightarrow PbSO_{4(s)}+4H_2O_{(l)}$
$HOCl+H_2O_2 \rightarrow H_3O^++Cl+O_2$
$Mn^{2+}+H_2O_2 \rightarrow Mn^{4+}+2OH^-$
$I_2+H_2O_2+2OH^- \rightarrow 2I^-+2H_2O+O_2$
Decomposes on exposure

Uses
- As hair bleach, disinfectant.
- Manufacture chemicals used in detergents.
- In industries as bleaching agent.
- In environmental chemistry.

Trace the Mind Map
- First Level
- Second Level
- Third Level



- **Atomic and Ionic Radii:** Smaller than corresponding alkali in group, increases with increase in atomic number.
- I.E:IE_1 higher than corresponding Group 1 metals. IE_2 smaller than corresponding alkali metals.
- **Hydration Enthalpies:** Decreases with increase in ionic size down the group.

Physical properties:

- Slivery white, lustrous and relatively soft but harder than alkali metals.
- **M.p. and b.p.** higher than corresponding alkali metals.
- Electropositive character increases down the group.

Chemical properties:

- Be and Mg are kinetically inert to O and H_2O
- Mg is more electropositive and burns in air.
- Ca, Sr and Ba with air forms oxide and nitride.

$M + X_2 \longrightarrow MX_2 (X = F, Cl, Br, I)$

$2BeCl_2 + LiAlH_4 \longrightarrow 2BeH_2 + LiCl + AlCl_3$

$M + 2HCl \longrightarrow MCl_2 + H_2$

$M + (x+y)NH_3 \longrightarrow [M(NH_3)_x]^{2+} + 2[e(NH_3)_y]^-$

Uses:

- Be is used in the manufacture of alloys.
- Metallic Be is used for making windows of X–rays tubes.
- Mg-Al alloys are used in air craft construction.
- Ca in extraction of metals.
- Ra is used in radiotherapy.

Characteristics of Compounds of Alkaline Earth Metals:

- **Oxides and Hydroxides**
- Alkaline earth metals burn oxygen to form MO.
- All oxides except BeO are basic in nature

$MO + H_2O \longrightarrow M(OH)_2$

$Be(OH)_2$ is amphoteric in nature

Halides:

- Except for Be halides, all other halides are ionic.
- Tendency to form halide hydrates decreases gradually.
- Salts of oxoacids: Forms carbonates, sulphates and nitrates.
- Anomalous behavior of Be: Small atomic and ionic sizes, does not exhibit C.N. more than four, its oxide and hydroxide are amphoteric.
- Be shows diagonal relationship with Al.

Biological Importance Of Mg And Ca:

- All enzymes that utilise ATP in PO_4 transfer requires Mg as cofactor. Chlorophyll contains Mg. Ca is present in bones and teeth. Important in neuromuscular function, intraneuronal transmission and blood coagulation.

(i) CaO, Quick Lime

Preparations: $CaCO_3 \overset{heat}{\rightleftarrows} CaO + CO_2$

Properties : White amorphous solid with m.p. 2870 K

$CaO + H_2O \longrightarrow Ca(OH)_2$, $CaO + CO_2 \longrightarrow CaCO_3$

(ii)$Ca(OH)_2$ Calcium hydroxide : Preparations: Addition of water to CaO. $CaO + H_2O \longrightarrow Ca(OH)_2$

Properties: White amorphous powder.

$Ca(OH_2) + CO_2 \longrightarrow CaCO_3 + H_2O$

(iii)$CaSO_4$. ½H_2O(Plaster of Paris)

$2(CaSO_4.2H_2O) \longrightarrow 2(CaSO_4).H_2O + 3H_2O$

ns^1 : Alkaline metals; ns^2 : Alkaline earth metals

Important Compounds of Sodium:

(i)Sodium Carbonate (Washing Soda): Preparation: By Solvay process $2NH_3 + H_2O + CO_2 \rightarrow (NH_4)_2CO_3$

$(NH_4)_2CO_3 + H_2O + CO_2 \rightarrow 2NH_4HCO_3$

$NH_4HCO_3 + NaCl \rightarrow NH_4Cl + NaHCO_3$

$2NaHCO_3 \rightarrow Na_2CO_3 + CO_2 + H_2O$

$2NH_4Cl + Ca(OH)_2 \rightarrow 2NH_3 + CaCl_2 + H_2O$

Properties: (a)White, crystalline solid. (b)Readily soluble in water

$Na_2CO_3 \cdot 10H_2O \xrightarrow{375K} Na_2CO_3 \times H_2O + 9H_2O$

$Na_2CO_3 \cdot H_2O \xrightarrow{>373K} Na_2CO_3 + H_2O$

Uses: Water softening, laundering, cleaning, manufacture, as laboratory reagent.

(*i*)Sodium Chloride (NaCl)

Preparation: Crude NaCl by crystallization of brine solution.

-Pure NaCl is obtained by dissolving crude salt in minimum water and filtered to remove insoluble impurities. Solution is saturated with HCl gas. Uses: As common salt.

(ii)Sodium Hydroxide (NaOH)

Preparation: By electrolysis of NaCl in Castner-Kellner cell.

Uses: In manufacture of soap, paper, petroleum refining.

(iii)Sodium Hydrogencarbonate ($NaHCO_3$)

Preparation: $Na_2CO_3 + H_2O + CO_2 \rightarrow 2NaHCO_3$

- **Atomic and Ionic Radii:** Increases with increase in atomic number.
- **I.E.:** Decreases down the group.
- **Hydration Enthalpy:** Decreases with increase in ionic sizes.
- **Physical properties:**
- Silvery white, soft and light metals.
- Low m.p. and b.p.
- Alkali metals and their salts impart colour to an oxidizing flame.

Chemical Properties:

$4Li + O_2 \rightarrow 2Li_2O$; $2Na + O_2 \rightarrow Na_2O_2$; $M + O_2 \rightarrow MO_2$ (M=K, Rb, Cs)

$2M + 2H_2O \rightarrow 2M^+ + 2OH^- + H_2$

$2M + H_2 \rightarrow 2M^+H^-$

React vigorously with halogens to form ionic halides

$M + (x + y)NH_3 \rightarrow [M(NH_3)_x]^+ + [e(NH_3)_y]^-$

Uses:

- Li is used to make useful alloys.
- Li is used in thermonuclear reactions and making electrochemical cells.
- Na is used to make Na/Pb alloy.
- Liquid Na metal is used as coolant in nuclear reactors.
- KCl is used as fertilizer.
- Cs is used in devising photoelectric cells.

Characteristics Of Compounds Of Alkali Metals:

– Oxide and Hydroxides

Combustion in excess of air

$\xrightarrow{+Li} Li_2O$

$\xrightarrow{+Na} Na_2O_2$

$\xrightarrow{+K/Rb/Cs} MO_2$

– Halides

- Alkali metal halides (MX) have high melting, colourless crystalline solids.
- Preparation: Reaction of oxide, hydroxide or carbonate with aq HX.
- High negative enthalpies of formation.
- Melting and boiling points: F >Cl> Br > I
- Soluble in water.

Salts of Oxo-Acids:

- Alkali metals form salts with all oxo-acids.
- Soluble in water and thermally stable.
- Stability of carbonates and hydrogencarbonates increases

Anomalies properties of Li: Due to

(i) exceptionally small size of its atom and ion.

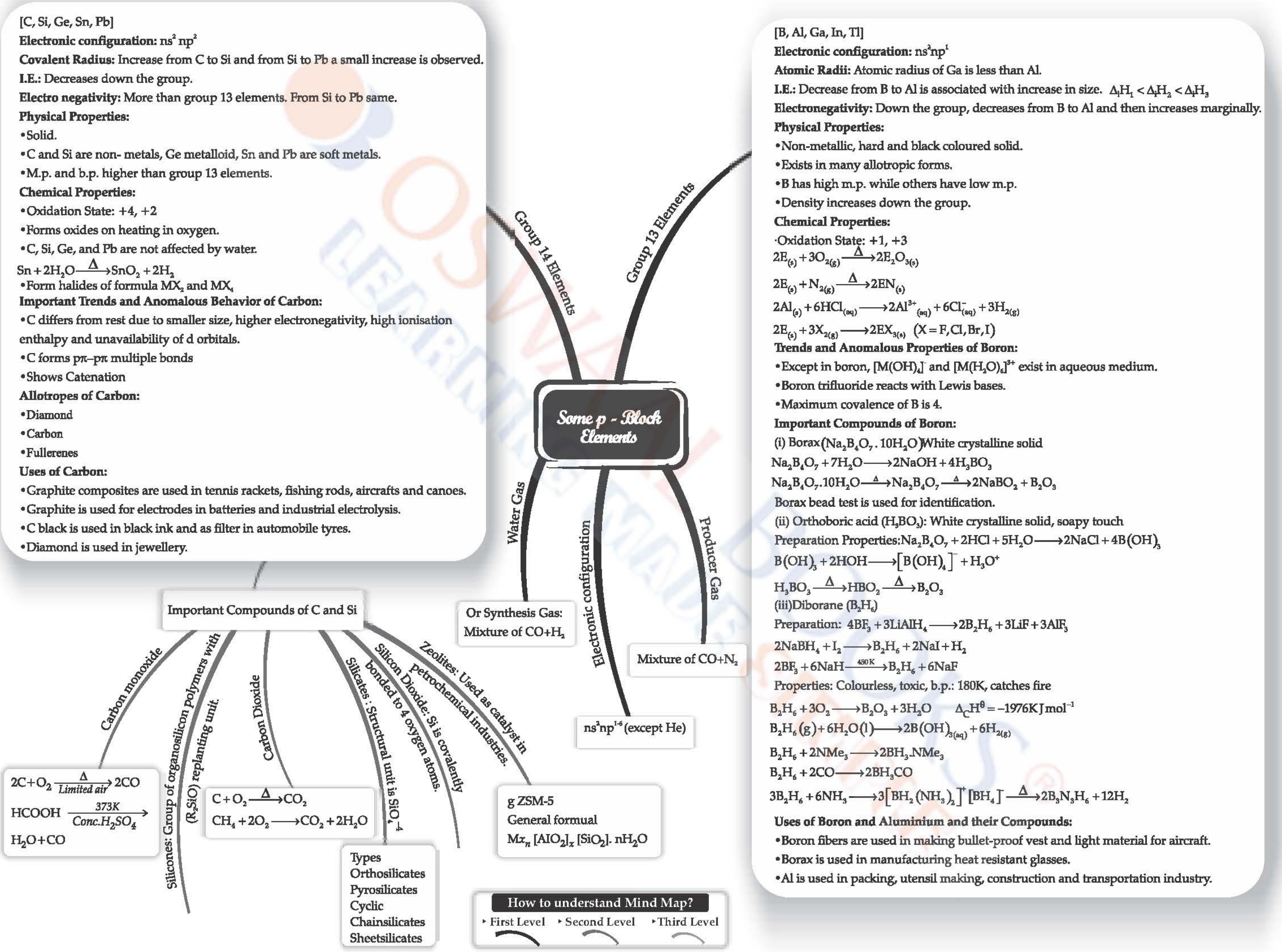
(ii) High polarising power.

Biological Importance of Na and K:

Na ions participate in nuclear signals transmission, regulator of flow of water across cell membranes. K ions activate many enzymes and oxidation of glucose to produce ATP.

How to understand Mind Map?

First Level Second Level Third Level



Some p - Block Elements

Group 13 Elements

[B, Al, Ga, In, Tl]

Electronic configuration: ns^2np^1

Atomic Radii: Atomic radius of Ga is less than Al.

I.E.: Decrease from B to Al is associated with increase in size. $\Delta_iH_1 < \Delta_iH_2 < \Delta_iH_3$

Electronegativity: Down the group, decreases from B to Al and then increases marginally.

Physical Properties:

- Non-metallic, hard and black coloured solid.
- Exists in many allotropic forms.
- B has high m.p. while others have low m.p.
- Density increases down the group.

Chemical Properties:

·Oxidation State: +1, +3

$2E_{(s)} + 3O_{2(g)} \xrightarrow{\Delta} 2E_2O_{3(s)}$

$2E_{(s)} + N_{2(g)} \xrightarrow{\Delta} 2EN_{(s)}$

$2Al_{(s)} + 6HCl_{(aq)} \longrightarrow 2Al^{3+}{}_{(aq)} + 6Cl^-_{(aq)} + 3H_{2(g)}$

$2E_{(s)} + 3X_{2(g)} \longrightarrow 2EX_{3(s)}$ $(X = F, Cl, Br, I)$

Trends and Anomalous Properties of Boron:

- Except in boron, $[M(OH)_4]^-$ and $[M(H_2O)_6]^{3+}$ exist in aqueous medium.
- Boron trifluoride reacts with Lewis bases.
- Maximum covalence of B is 4.

Important Compounds of Boron:

(i) Borax$(Na_2B_4O_7 . 10H_2O)$White crystalline solid

$Na_2B_4O_7 + 7H_2O \longrightarrow 2NaOH + 4H_3BO_3$

$Na_2B_4O_7.10H_2O \xrightarrow{\Delta} Na_2B_4O_7 \xrightarrow{\Delta} 2NaBO_2 + B_2O_3$

Borax bead test is used for identification.

(ii) Orthoboric acid (H_3BO_3): White crystalline solid, soapy touch

Preparation Properties:$Na_2B_4O_7 + 2HCl + 5H_2O \longrightarrow 2NaCl + 4B(OH)_3$

$B(OH)_3 + 2HOH \longrightarrow [B(OH)_4]^- + H_3O^+$

$H_3BO_3 \xrightarrow{\Delta} HBO_2 \xrightarrow{\Delta} B_2O_3$

(iii)Diborane (B_2H_6)

Preparation: $4BF_3 + 3LiAlH_4 \longrightarrow 2B_2H_6 + 3LiF + 3AlF_3$

$2NaBH_4 + I_2 \longrightarrow B_2H_6 + 2NaI + H_2$

$2BF_3 + 6NaH \xrightarrow{450K} B_2H_6 + 6NaF$

Properties: Colourless, toxic, b.p.: 180K, catches fire

$B_2H_6 + 3O_2 \longrightarrow B_2O_3 + 3H_2O$ $\quad \Delta_CH^\theta = -1976 KJ mol^{-1}$

$B_2H_6(g) + 6H_2O(l) \longrightarrow 2B(OH)_{3(aq)} + 6H_{2(g)}$

$B_2H_6 + 2NMe_3 \longrightarrow 2BH_3.NMe_3$

$B_2H_6 + 2CO \longrightarrow 2BH_3CO$

$3B_2H_6 + 6NH_3 \longrightarrow 3[BH_2(NH_3)_2]^+[BH_4]^- \xrightarrow{\Delta} 2B_3N_3H_6 + 12H_2$

Uses of Boron and Aluminium and their Compounds:

- Boron fibers are used in making bullet-proof vest and light material for aircraft.
- Borax is used in manufacturing heat resistant glasses.
- Al is used in packing, utensil making, construction and transportation industry.

Group 14 Elements

[C, Si, Ge, Sn, Pb]

Electronic configuration: $ns^2 np^2$

Covalent Radius: Increase from C to Si and from Si to Pb a small increase is observed.

I.E.: Decreases down the group.

Electro negativity: More than group 13 elements. From Si to Pb same.

Physical Properties:

- Solid.
- C and Si are non- metals, Ge metalloid, Sn and Pb are soft metals.
- M.p. and b.p. higher than group 13 elements.

Chemical Properties:

- Oxidation State: +4, +2
- Forms oxides on heating in oxygen.
- C, Si, Ge, and Pb are not affected by water.

$Sn + 2H_2O \xrightarrow{\Delta} SnO_2 + 2H_2$

- Form halides of formula MX_2 and MX_4

Important Trends and Anomalous Behavior of Carbon:

- C differs from rest due to smaller size, higher electronegativity, high ionisation enthalpy and unavailability of d orbitals.
- C forms pπ–pπ multiple bonds
- Shows Catenation

Allotropes of Carbon:

- Diamond
- Carbon
- Fullerenes

Uses of Carbon:

- Graphite composites are used in tennis rackets, fishing rods, aircrafts and canoes.
- Graphite is used for electrodes in batteries and industrial electrolysis.
- C black is used in black ink and as filter in automobile tyres.
- Diamond is used in jewellery.

Important Compounds of C and Si

Carbon monoxide

$2C + O_2 \xrightarrow[\text{Limited air}]{\Delta} 2CO$

$HCOOH \xrightarrow[Conc.H_2SO_4]{373K}$

$H_2O + CO$

Silicones: Group of organosilicon polymers with (R_2SiO) replanting unit.

Carbon Dioxide

$C + O_2 \xrightarrow{\Delta} CO_2$

$CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$

Silicates : Structural unit is SiO_4^{-4}

Types
Orthosilicates
Pyrosilicates
Cyclic
Chainsilicates
Sheetsilicates

Silicon Dioxide: Si is covalently bonded to 4 oxygen atoms.

Zeolites: Used as catalyst in petrochemical industries.

g ZSM-5
General formual
$Mx_n [AlO_2]_x [SiO_2]. nH_2O$

Water Gas

Or Synthesis Gas: Mixture of $CO+H_2$

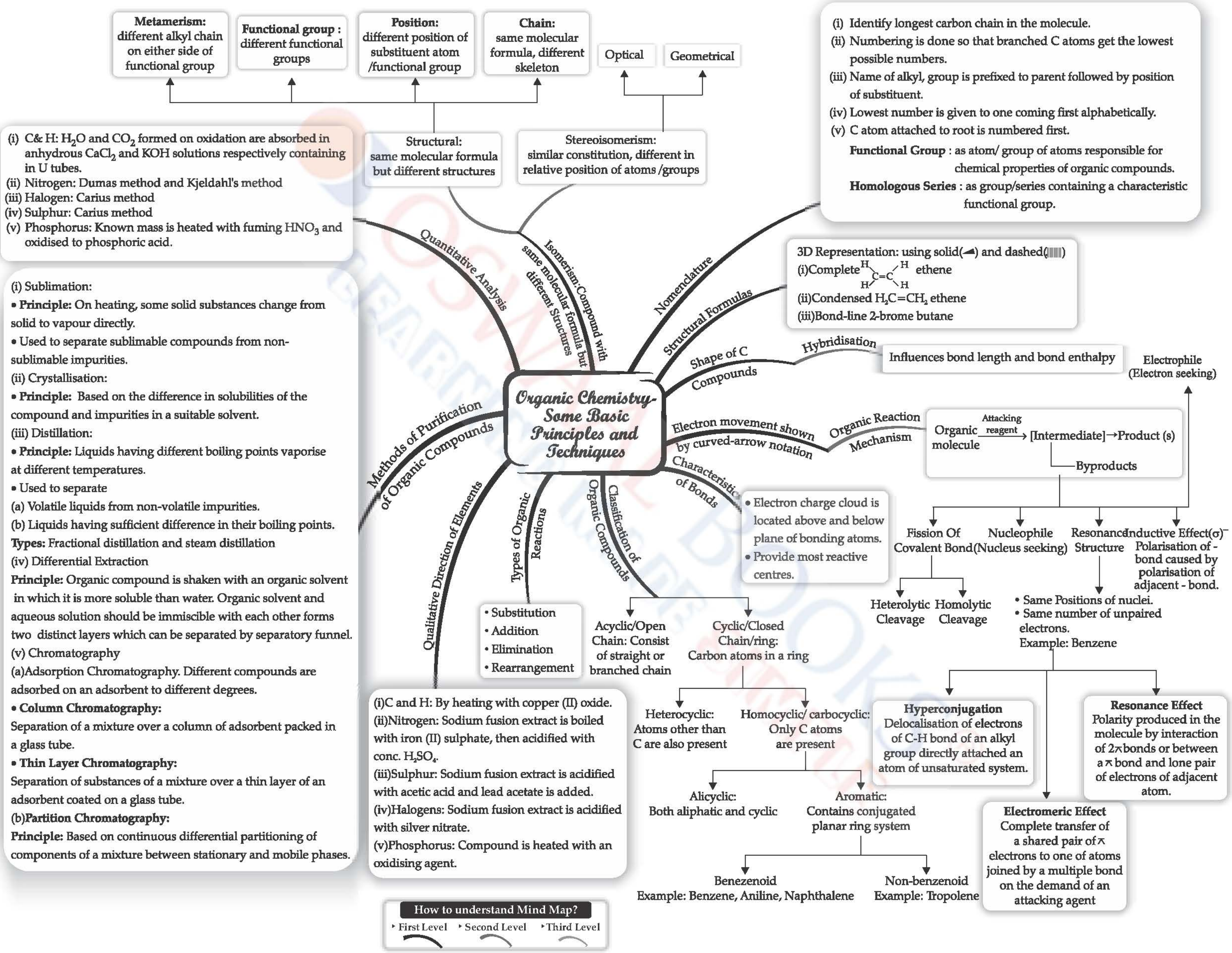
Electronic configuration

ns^2np^{1-6} (except He)

Producer Gas

Mixture of $CO+N_2$

How to understand Mind Map?



Organic Chemistry- Some Basic Principles and Techniques

Nomenclature

(i) Identify longest carbon chain in the molecule.
(ii) Numbering is done so that branched C atoms get the lowest possible numbers.
(iii) Name of alkyl, group is prefixed to parent followed by position of substituent.
(iv) Lowest number is given to one coming first alphabetically.
(v) C atom attached to root is numbered first.

Functional Group : as atom/ group of atoms responsible for chemical properties of organic compounds.

Homologous Series : as group/series containing a characteristic functional group.

Structural Formulas

3D Representation: using solid(◄) and dashed(||||)
(i)Complete ethene
(ii)Condensed $H_2C=CH_2$ ethene
(iii)Bond-line 2-brome butane

Shape of C Compounds

Hybridisation — Influences bond length and bond enthalpy

Electron movement shown by curved-arrow notation

Organic Reaction Mechanism

Organic molecule $\xrightarrow{\text{Attacking reagent}}$ [Intermediate]→Product (s)

Byproducts

- Fission Of Covalent Bond
  - Heterolytic Cleavage
  - Homolytic Cleavage
- Nucleophile (Nucleus seeking)
- Resonance Structure
  - Same Positions of nuclei.
  - Same number of unpaired electrons.
  - Example: Benzene
    - Hyperconjugation: Delocalisation of electrons of C-H bond of an alkyl group directly attached an atom of unsaturated system.
    - Electromeric Effect: Complete transfer of a shared pair of π electrons to one of atoms joined by a multiple bond on the demand of an attacking agent
    - Resonance Effect: Polarity produced in the molecule by interaction of 2π bonds or between a π bond and lone pair of electrons of adjacent atom.
- Inductive Effect(σ)⁻ Polarisation of - bond caused by polarisation of adjacent - bond.
- Electrophile (Electron seeking)

Characteristic of Bonds

- Electron charge cloud is located above and below plane of bonding atoms.
- Provide most reactive centres.

Classification of Organic Compounds

- Acyclic/Open Chain: Consist of straight or branched chain
- Cyclic/Closed Chain/ring: Carbon atoms in a ring
  - Heterocyclic: Atoms other than C are also present
  - Homocyclic/ carbocyclic: Only C atoms are present
    - Alicyclic: Both aliphatic and cyclic
    - Aromatic: Contains conjugated planar ring system
      - Benezenoid Example: Benzene, Aniline, Naphthalene
      - Non-benzenoid Example: Tropolene

Types of Organic Reactions

- Substitution
- Addition
- Elimination
- Rearrangement

Qualitative Direction of Elements

(i)C and H: By heating with copper (II) oxide.
(ii)Nitrogen: Sodium fusion extract is boiled with iron (II) sulphate, then acidified with conc. H_2SO_4.
(iii)Sulphur: Sodium fusion extract is acidified with acetic acid and lead acetate is added.
(iv)Halogens: Sodium fusion extract is acidified with silver nitrate.
(v)Phosphorus: Compound is heated with an oxidising agent.

Methods of Purification of Organic Compounds

(i) Sublimation:
- **Principle:** On heating, some solid substances change from solid to vapour directly.
- Used to separate sublimable compounds from non-sublimable impurities.

(ii) Crystallisation:
- **Principle:** Based on the difference in solubilities of the compound and impurities in a suitable solvent.

(iii) Distillation:
- **Principle:** Liquids having different boiling points vaporise at different temperatures.
- Used to separate
(a) Volatile liquids from non-volatile impurities.
(b) Liquids having sufficient difference in their boiling points.

Types: Fractional distillation and steam distillation

(iv) Differential Extraction

Principle: Organic compound is shaken with an organic solvent in which it is more soluble than water. Organic solvent and aqueous solution should be immiscible with each other forms two distinct layers which can be separated by separatory funnel.

(v) Chromatography

(a)Adsorption Chromatography. Different compounds are adsorbed on an adsorbent to different degrees.
- **Column Chromatography:**
Separation of a mixture over a column of adsorbent packed in a glass tube.
- **Thin Layer Chromatography:**
Separation of substances of a mixture over a thin layer of an adsorbent coated on a glass tube.

(b)**Partition Chromatography:**

Principle: Based on continuous differential partitioning of components of a mixture between stationary and mobile phases.

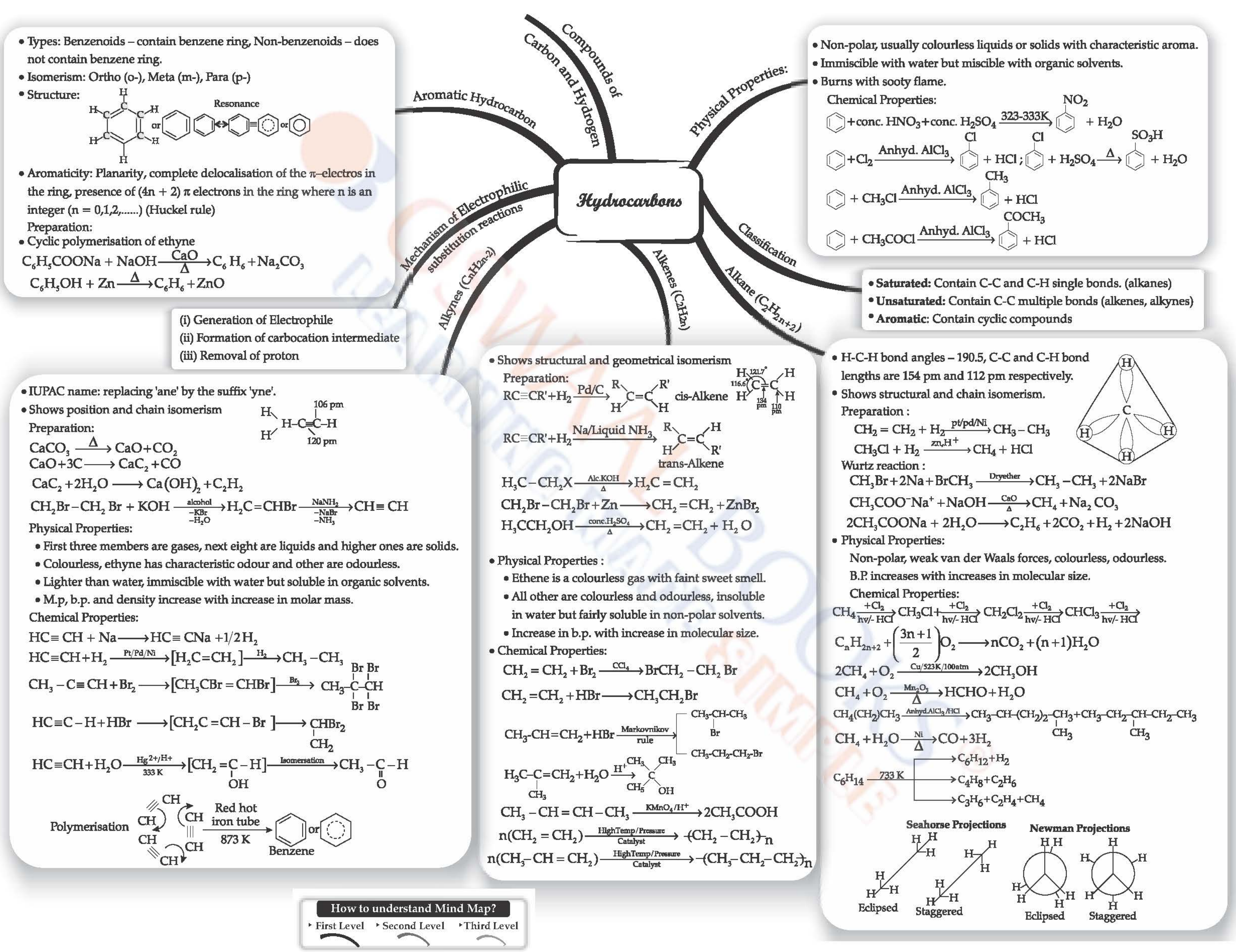
Quantitative Analysis

(i) C& H: H_2O and CO_2 formed on oxidation are absorbed in anhydrous $CaCl_2$ and KOH solutions respectively containing in U tubes.
(ii) Nitrogen: Dumas method and Kjeldahl's method
(iii) Halogen: Carius method
(iv) Sulphur: Carius method
(v) Phosphorus: Known mass is heated with fuming HNO_3 and oxidised to phosphoric acid.

Isomerism:Compound with same molecular formula but different Structures

- Structural: same molecular formula but different structures
  - **Metamerism:** different alkyl chain on either side of functional group
  - **Functional group :** different functional groups
  - **Position:** different position of substituent atom /functional group
  - **Chain:** same molecular formula, different skeleton
- Stereoisomerism: similar constitution, different in relative position of atoms /groups
  - Optical
  - Geometrical

How to understand Mind Map?
- First Level
- Second Level
- Third Level



Aromatic Hydrocarbon

- Types: Benzenoids – contain benzene ring, Non-benzenoids – does not contain benzene ring.
- Isomerism: Ortho (o-), Meta (m-), Para (p-)
- Structure:
- Aromaticity: Planarity, complete delocalisation of the π–electros in the ring, presence of (4n + 2) π electrons in the ring where n is an integer (n = 0,1,2,......) (Huckel rule)

Preparation:

- Cyclic polymerisation of ethyne

$C_6H_5COONa + NaOH \xrightarrow[\Delta]{CaO} C_6H_6 + Na_2CO_3$

$C_6H_5OH + Zn \xrightarrow{\Delta} C_6H_6 + ZnO$

Mechanism of Electrophilic substitution reactions

(i) Generation of Electrophile
(ii) Formation of carbocation intermediate
(iii) Removal of proton

Alkynes (C_nH_{2n-2})

- IUPAC name: replacing 'ane' by the suffix 'yne'.
- Shows position and chain isomerism

106 pm, 120 pm

Preparation:

$CaCO_3 \xrightarrow{\Delta} CaO + CO_2$

$CaO + 3C \longrightarrow CaC_2 + CO$

$CaC_2 + 2H_2O \longrightarrow Ca(OH)_2 + C_2H_2$

$CH_2Br-CH_2Br + KOH \xrightarrow[-KBr, -H_2O]{alcohol} H_2C=CHBr \xrightarrow[-NaBr, -NH_3]{NaNH_2} CH \equiv CH$

Physical Properties:

- First three members are gases, next eight are liquids and higher ones are solids.
- Colourless, ethyne has characteristic odour and other are odourless.
- Lighter than water, immiscible with water but soluble in organic solvents.
- M.p, b.p. and density increase with increase in molar mass.

Chemical Properties:

$HC\equiv CH + Na \longrightarrow HC\equiv CNa + 1/2H_2$

$HC\equiv CH + H_2 \xrightarrow{Pt/Pd/Ni} [H_2C=CH_2] \xrightarrow{H_2} CH_3-CH_3$

$CH_3-C\equiv CH + Br_2 \longrightarrow [CH_3CBr=CHBr] \xrightarrow{Br_2} CH_3-CBr_2-CHBr_2$

$HC\equiv C-H + HBr \longrightarrow [CH_2C=CH-Br] \longrightarrow CHBr_2-CH_2$

$HC\equiv CH + H_2O \xrightarrow[333\ K]{Hg^{2+}/H^+} [CH_2=C(OH)-H] \xrightarrow{Isomersation} CH_3-C(=O)-H$

Polymerisation: $3\ CH\equiv CH \xrightarrow[873\ K]{\text{Red hot iron tube}}$ Benzene

Alkenes (C2H2n)

- Shows structural and geometrical isomerism

Preparation:

$RC\equiv CR' + H_2 \xrightarrow{Pd/C}$ cis-Alkene

H 121.7° H, 116.6°, 134 pm, 110 pm

$RC\equiv CR' + H_2 \xrightarrow{Na/Liquid\ NH_3}$ trans-Alkene

$H_3C-CH_2X \xrightarrow[\Delta]{Alc.KOH} H_2C=CH_2$

$CH_2Br-CH_2Br + Zn \longrightarrow CH_2=CH_2 + ZnBr_2$

$H_3CCH_2OH \xrightarrow[\Delta]{conc.H_2SO_4} CH_2=CH_2 + H_2O$

- Physical Properties :
  - Ethene is a colourless gas with faint sweet smell.
  - All other are colourless and odourless, insoluble in water but fairly soluble in non-polar solvents.
  - Increase in b.p. with increase in molecular size.
- Chemical Properties:

$CH_2=CH_2 + Br_2 \xrightarrow{CCl_4} BrCH_2-CH_2Br$

$CH_2=CH_2 + HBr \longrightarrow CH_3CH_2Br$

$CH_3-CH=CH_2 + HBr \xrightarrow{Markovnikov\ rule} CH_3-CH(Br)-CH_3$; $CH_3-CH_2-CH_2-Br$

$H_3C-C(CH_3)=CH_2 + H_2O \xrightarrow{H^+} (CH_3)(CH_3)(CH_5)C-OH$

$CH_3-CH=CH-CH_3 \xrightarrow{KMnO_4/H^+} 2CH_3COOH$

$n(CH_2=CH_2) \xrightarrow[Catalyst]{HighTemp/Pressure} -(CH_2-CH_2)-_n$

$n(CH_3-CH=CH_2) \xrightarrow[Catalyst]{HighTemp/Pressure} -(CH_3-CH_2-CH_2)-_n$

Physical Properties:

- Non-polar, usually colourless liquids or solids with characteristic aroma.
- Immiscible with water but miscible with organic solvents.
- Burns with sooty flame.

Chemical Properties:

$C_6H_6 + conc.\ HNO_3 + conc.\ H_2SO_4 \xrightarrow{323\text{-}333K} C_6H_5NO_2 + H_2O$

$C_6H_6 + Cl_2 \xrightarrow{Anhyd.\ AlCl_3} C_6H_5Cl + HCl$; $C_6H_6 + H_2SO_4 \xrightarrow{\Delta} C_6H_5SO_3H + H_2O$

$C_6H_6 + CH_3Cl \xrightarrow{Anhyd.\ AlCl_3} C_6H_5CH_3 + HCl$

$C_6H_6 + CH_3COCl \xrightarrow{Anhyd.\ AlCl_3} C_6H_5COCH_3 + HCl$

Classification

- **Saturated:** Contain C-C and C-H single bonds. (alkanes)
- **Unsaturated:** Contain C-C multiple bonds (alkenes, alkynes)
- **Aromatic**: Contain cyclic compounds

Alkane (C_nH_{2n+2})

- H-C-H bond angles – 190.5, C-C and C-H bond lengths are 154 pm and 112 pm respectively.
- Shows structural and chain isomerism.

Preparation :

$CH_2=CH_2 + H_2 \xrightarrow{pt/pd/Ni} CH_3-CH_3$

$CH_3Cl + H_2 \xrightarrow{zn,H^+} CH_4 + HCl$

Wurtz reaction :

$CH_3Br + 2Na + BrCH_3 \xrightarrow{Dryether} CH_3-CH_3 + 2NaBr$

$CH_3COO^-Na^+ + NaOH \xrightarrow[\Delta]{CaO} CH_4 + Na_2CO_3$

$2CH_3COONa + 2H_2O \longrightarrow C_2H_6 + 2CO_2 + H_2 + 2NaOH$

- Physical Properties:

Non-polar, weak van der Waals forces, colourless, odourless.

B.P. increases with increases in molecular size.

Chemical Properties:

$CH_4 \xrightarrow[hv/-HCl]{+Cl_2} CH_3Cl + \xrightarrow[hv/-HCl]{+Cl_2} CH_2Cl_2 \xrightarrow[hv/-HCl]{+Cl_2} CHCl_3 \xrightarrow[hv/-HCl]{+Cl_2}$

$C_nH_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \longrightarrow nCO_2 + (n+1)H_2O$

$2CH_4 + O_2 \xrightarrow{Cu/523K/100atm} 2CH_3OH$

$CH_4 + O_2 \xrightarrow[\Delta]{Mn_2O_3} HCHO + H_2O$

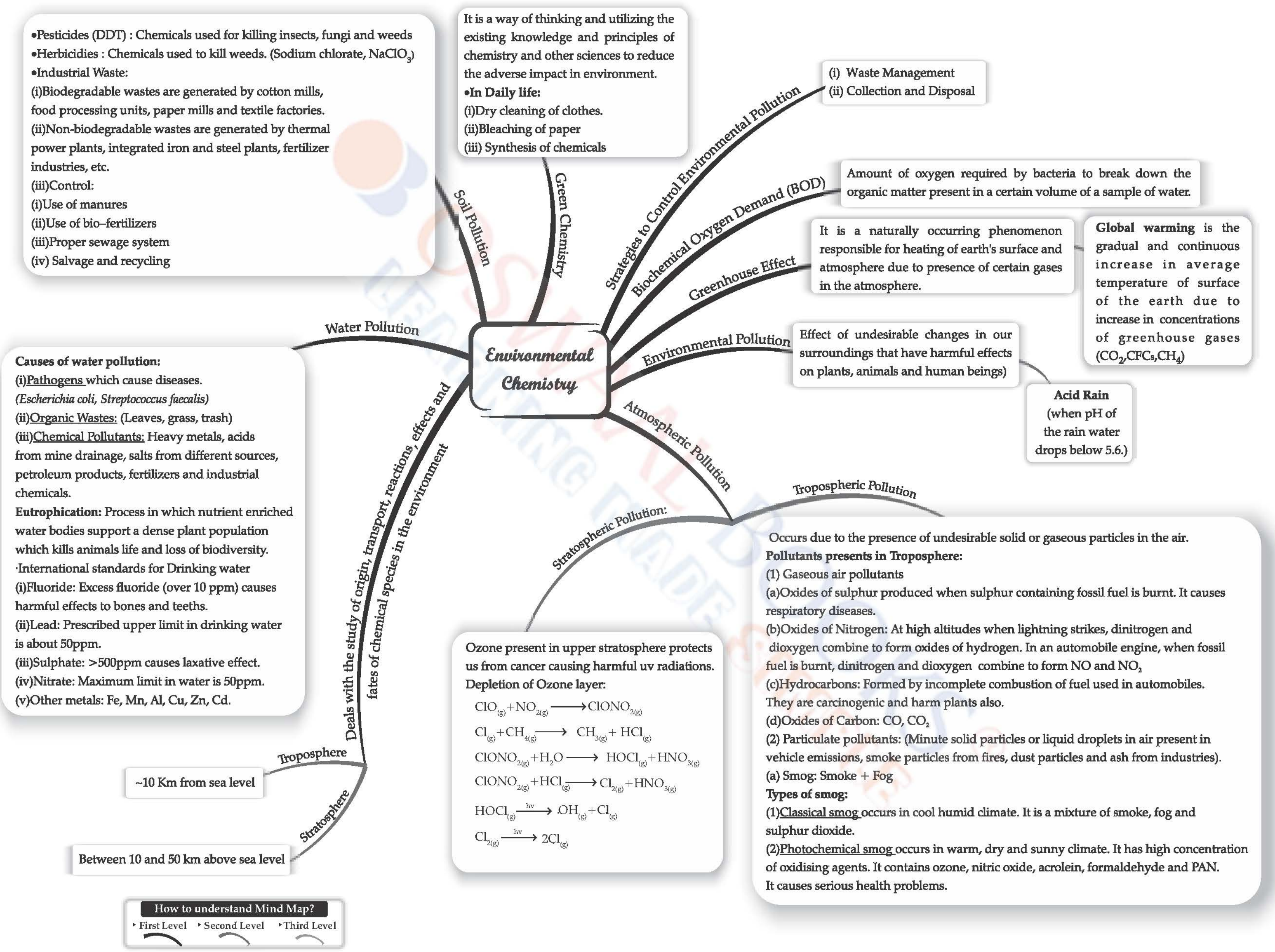
$CH_4(CH_2)CH_3 \xrightarrow{Anhyd.AlCl_3/HCl} CH_3-CH(CH_3)-(CH_2)_2-CH_3 + CH_3-CH_2-CH(CH_3)-CH_2-CH_3$

$CH_4 + H_2O \xrightarrow[\Delta]{Ni} CO + 3H_2$

$C_6H_{14} \xrightarrow{733\ K} C_6H_{12} + H_2$; $C_4H_8 + C_2H_6$; $C_3H_6 + C_2H_4 + CH_4$

Seahorse Projections

Newman Projections



Environmental Chemistry

Deals with the study of origin, transport, reactions, effects and fates of chemical species in the environment

- Troposphere
  - ~10 Km from sea level
- Stratosphere
  - Between 10 and 50 km above sea level

Soil Pollution

- •Pesticides (DDT) : Chemicals used for killing insects, fungi and weeds
- •Herbicidies : Chemicals used to kill weeds. (Sodium chlorate, $NaClO_3$)
- •Industrial Waste:
  - (i)Biodegradable wastes are generated by cotton mills, food processing units, paper mills and textile factories.
  - (ii)Non-biodegradable wastes are generated by thermal power plants, integrated iron and steel plants, fertilizer industries, etc.
  - (iii)Control:
    - (i)Use of manures
    - (ii)Use of bio–fertilizers
    - (iii)Proper sewage system
    - (iv) Salvage and recycling

Green Chemistry

It is a way of thinking and utilizing the existing knowledge and principles of chemistry and other sciences to reduce the adverse impact in environment.

•In Daily life:
- (i)Dry cleaning of clothes.
- (ii)Bleaching of paper
- (iii) Synthesis of chemicals

Strategies to Control Environmental Pollution

- (i) Waste Management
- (ii) Collection and Disposal

Biochemical Oxygen Demand (BOD)

Amount of oxygen required by bacteria to break down the organic matter present in a certain volume of a sample of water.

Greenhouse Effect

It is a naturally occurring phenomenon responsible for heating of earth's surface and atmosphere due to presence of certain gases in the atmosphere.

Global warming is the gradual and continuous increase in average temperature of surface of the earth due to increase in concentrations of greenhouse gases (CO_2,CFCs,CH_4)

Environmental Pollution

Effect of undesirable changes in our surroundings that have harmful effects on plants, animals and human beings)

Acid Rain (when pH of the rain water drops below 5.6.)

Atmospheric Pollution

Tropospheric Pollution

Occurs due to the presence of undesirable solid or gaseous particles in the air.

Pollutants presents in Troposphere:

(1) Gaseous air pollutants

(a)Oxides of sulphur produced when sulphur containing fossil fuel is burnt. It causes respiratory diseases.

(b)Oxides of Nitrogen: At high altitudes when lightning strikes, dinitrogen and dioxygen combine to form oxides of hydrogen. In an automobile engine, when fossil fuel is burnt, dinitrogen and dioxygen combine to form NO and NO_2

(c)Hydrocarbons: Formed by incomplete combustion of fuel used in automobiles. They are carcinogenic and harm plants also.

(d)Oxides of Carbon: CO, CO_2

(2) Particulate pollutants: (Minute solid particles or liquid droplets in air present in vehicle emissions, smoke particles from fires, dust particles and ash from industries).

(a) Smog: Smoke + Fog

Types of smog:

(1)<u>Classical smog</u> occurs in cool humid climate. It is a mixture of smoke, fog and sulphur dioxide.

(2)<u>Photochemical smog</u> occurs in warm, dry and sunny climate. It has high concentration of oxidising agents. It contains ozone, nitric oxide, acrolein, formaldehyde and PAN. It causes serious health problems.

Stratospheric Pollution:

Ozone present in upper stratosphere protects us from cancer causing harmful uv radiations.

Depletion of Ozone layer:

$$ClO_{(g)} + NO_{2(g)} \longrightarrow ClONO_{2(g)}$$

$$Cl_{(g)} + CH_{4(g)} \longrightarrow CH_{3(g)} + HCl_{(g)}$$

$$ClONO_{2(g)} + H_2O \longrightarrow HOCl_{(g)} + HNO_{3(g)}$$

$$ClONO_{2(g)} + HCl_{(g)} \longrightarrow Cl_{2(g)} + HNO_{3(g)}$$

$$HOCl_{(g)} \xrightarrow{hv} \cdot OH_{(g)} + Cl_{(g)}$$

$$Cl_{2(g)} \xrightarrow{hv} 2Cl_{(g)}$$

Water Pollution

Causes of water pollution:

(i)<u>Pathogens</u> which cause diseases.
(Escherichia coli, Streptococcus faecalis)

(ii)<u>Organic Wastes:</u> (Leaves, grass, trash)

(iii)<u>Chemical Pollutants:</u> Heavy metals, acids from mine drainage, salts from different sources, petroleum products, fertilizers and industrial chemicals.

Eutrophication: Process in which nutrient enriched water bodies support a dense plant population which kills animals life and loss of biodiversity.

·International standards for Drinking water

(i)Fluoride: Excess fluoride (over 10 ppm) causes harmful effects to bones and teeths.

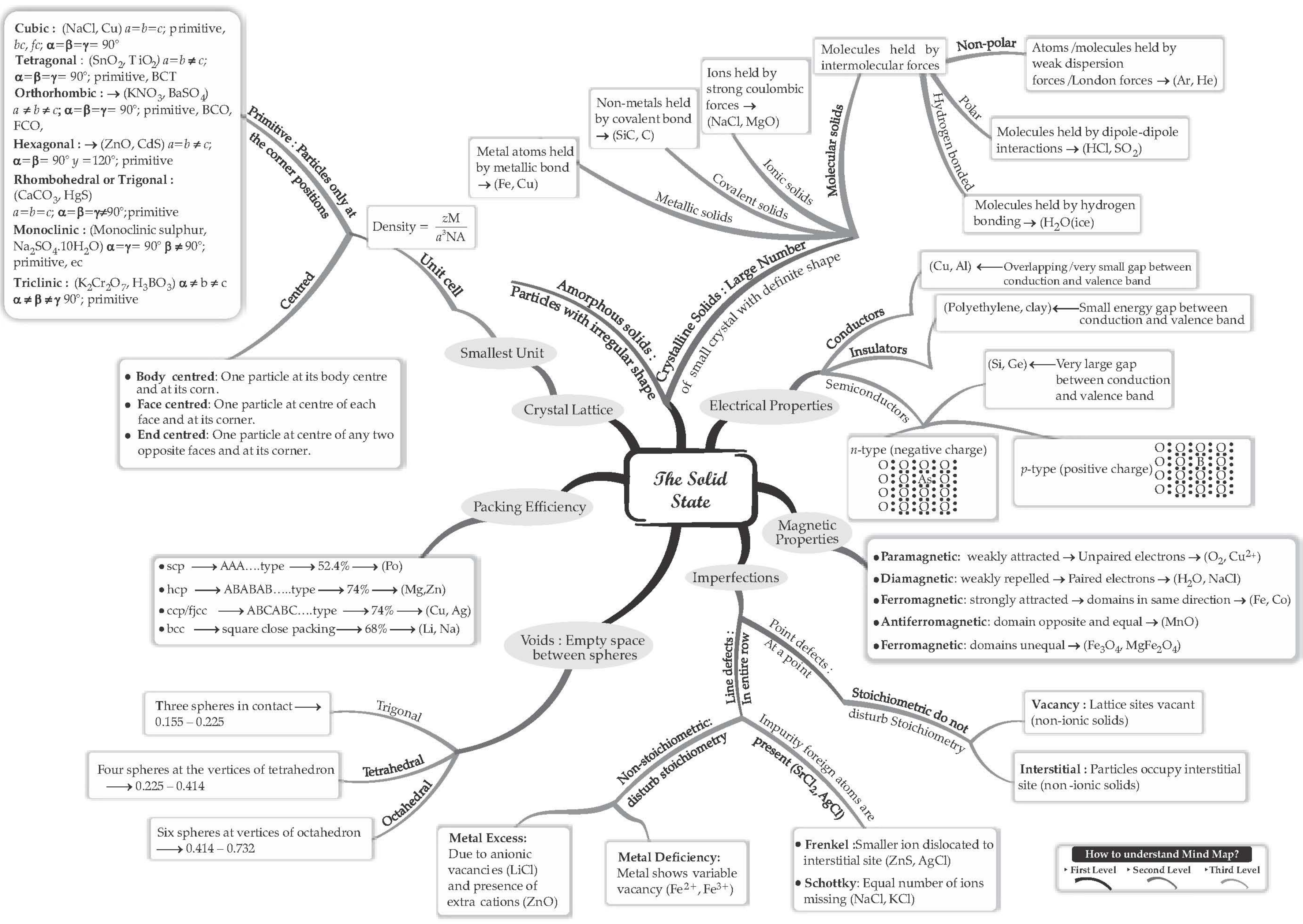
(ii)Lead: Prescribed upper limit in drinking water is about 50ppm.

(iii)Sulphate: >500ppm causes laxative effect.

(iv)Nitrate: Maximum limit in water is 50ppm.

(v)Other metals: Fe, Mn, Al, Cu, Zn, Cd.

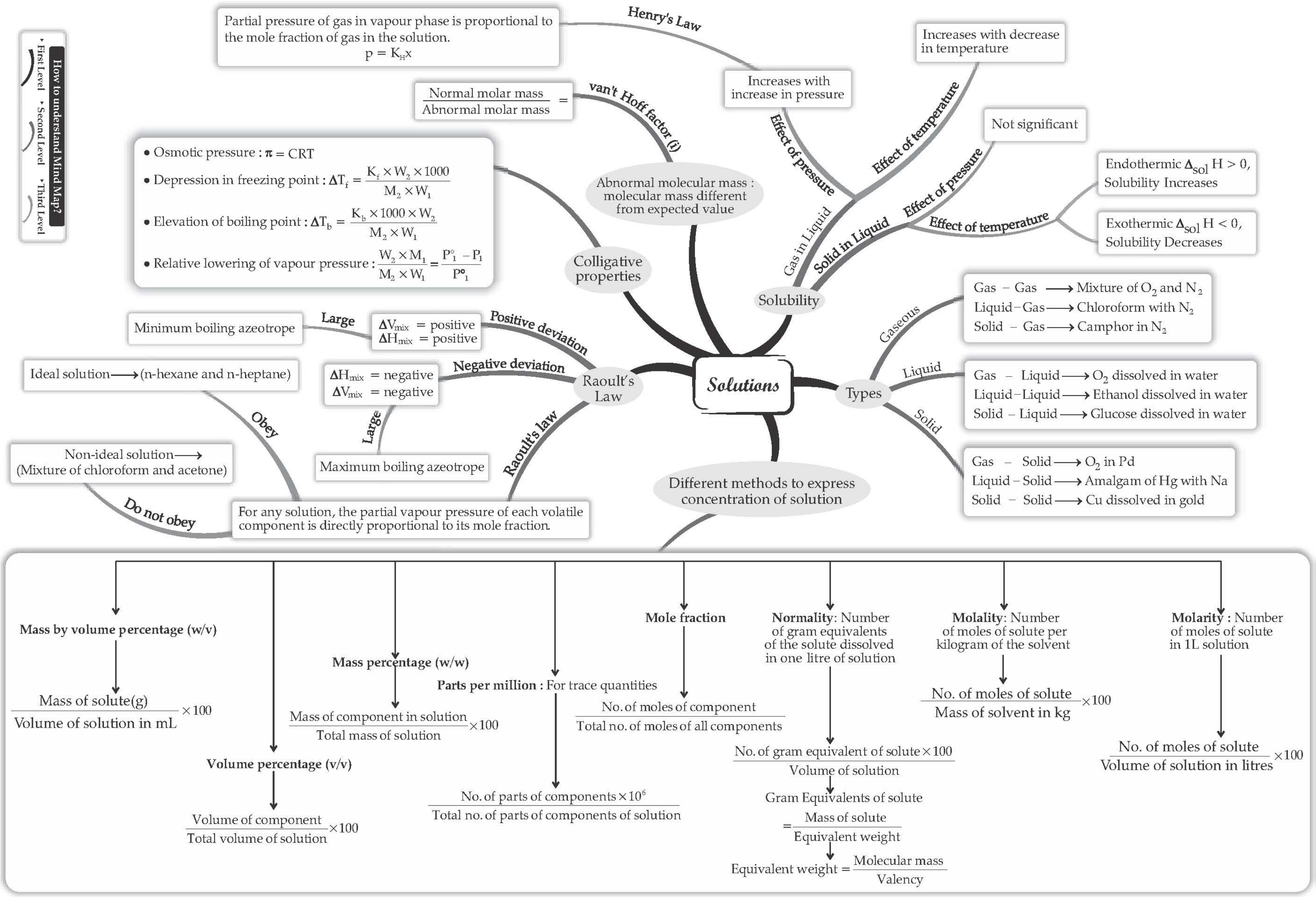
How to understand Mind Map?



The Solid State

- **Amorphous solids : Particles with irregular shape**
- **Crystalline Solids : Large Number** of small crystal with definite shape
  - **Molecular solids**
    - Molecules held by intermolecular forces
      - **Non-polar**: Atoms /molecules held by weak dispersion forces /London forces → (Ar, He)
      - Polar: Molecules held by dipole-dipole interactions → (HCl, SO_2)
      - Hydrogen bonded: Molecules held by hydrogen bonding → (H_2O(ice))
  - Ionic solids: Ions held by strong coulombic forces → (NaCl, MgO)
  - Covalent solids: Non-metals held by covalent bond → (SiC, C)
  - Metallic solids: Metal atoms held by metallic bond → (Fe, Cu)
- Crystal Lattice
  - Smallest Unit
    - **Unit cell**
      - Density = $\frac{zM}{a^3 NA}$
      - **Primitive : Particles only at the corner positions**
        - **Cubic :** (NaCl, Cu) $a=b=c$; primitive, bc, fc; $\alpha=\beta=\gamma=90°$
        - **Tetragonal** : (SnO_2, TiO_2) $a=b\neq c$; $\alpha=\beta=\gamma=90°$; primitive, BCT
        - **Orthorhombic :** → (KNO_3, $BaSO_4$) $a\neq b\neq c$; $\alpha=\beta=\gamma=90°$; primitive, BCO, FCO,
        - **Hexagonal :** → (ZnO, CdS) $a=b\neq c$; $\alpha=\beta=90°$ $y=120°$; primitive
        - **Rhombohedral or Trigonal :** ($CaCO_3$, HgS) $a=b=c$; $\alpha=\beta=\gamma\neq 90°$;primitive
        - **Monoclinic :** (Monoclinic sulphur, $Na_2SO_4.10H_2O$) $\alpha=\gamma=90°$ $\beta\neq 90°$; primitive, ec
        - **Triclinic :** ($K_2Cr_2O_7$, H_3BO_3) $\alpha\neq b\neq c$ $\alpha\neq\beta\neq\gamma$ 90°; primitive
      - **Centred**
        - **Body centred**: One particle at its body centre and at its corn.
        - **Face centred**: One particle at centre of each face and at its corner.
        - **End centred**: One particle at centre of any two opposite faces and at its corner.
- Packing Efficiency
  - scp ⟶ AAA….type ⟶ 52.4% ⟶ (Po)
  - hcp ⟶ ABABAB…..type ⟶ 74% ⟶ (Mg,Zn)
  - ccp/fjcc ⟶ ABCABC….type ⟶ 74% ⟶ (Cu, Ag)
  - bcc ⟶ square close packing ⟶ 68% ⟶ (Li, Na)
- Voids : Empty space between spheres
  - Trigonal: Three spheres in contact ⟶ 0.155 – 0.225
  - **Tetrahedral**: Four spheres at the vertices of tetrahedron ⟶ 0.225 – 0.414
  - **Octahedral**: Six spheres at vertices of octahedron ⟶ 0.414 – 0.732
- Electrical Properties
  - **Conductors**: (Cu, Al) ⟵ Overlapping /very small gap between conduction and valence band
  - **Insulators**: (Polyethylene, clay) ⟵ Small energy gap between conduction and valence band
  - Semiconductors: (Si, Ge) ⟵ Very large gap between conduction and valence band
    - *n*-type (negative charge)
    - *p*-type (positive charge)
- Magnetic Properties
  - **Paramagnetic**: weakly attracted → Unpaired electrons → (O_2, Cu^{2+})
  - **Diamagnetic**: weakly repelled → Paired electrons → (H_2O, NaCl)
  - **Ferromagnetic**: strongly attracted → domains in same direction → (Fe, Co)
  - **Antiferromagnetic**: domain opposite and equal → (MnO)
  - **Ferromagnetic**: domains unequal → (Fe_3O_4, $MgFe_2O_4$)
- Imperfections
  - Point defects : At a point
    - **Stoichiometric do not** disturb Stoichiometry
      - **Vacancy :** Lattice sites vacant (non-ionic solids)
      - **Interstitial :** Particles occupy interstitial site (non -ionic solids)
    - Impurity foreign atoms are **present ($SrCl_2$, AgCl)**
      - **Frenkel** :Smaller ion dislocated to interstitial site (ZnS, AgCl)
      - **Schottky**: Equal number of ions missing (NaCl, KCl)
    - **Non-stoichiometric: disturb stoichiometry**
      - **Metal Deficiency:** Metal shows variable vacancy (Fe^{2+}, Fe^{3+})
      - **Metal Excess:** Due to anionic vacancies (LiCl) and presence of extra cations (ZnO)
  - **Line defects : In entire row**

How to understand Mind Map?
‣ First Level ‣ Second Level ‣ Third Level



Solutions

Solubility

- Gas in Liquid
  - Henry's Law: Partial pressure of gas in vapour phase is proportional to the mole fraction of gas in the solution. $p = K_H x$
  - Effect of pressure: Increases with increase in pressure
  - Effect of temperature: Increases with decrease in temperature
- Solid in Liquid
  - Effect of pressure: Not significant
  - Effect of temperature
    - Endothermic $\Delta_{sol}H > 0$, Solubility Increases
    - Exothermic $\Delta_{sol}H < 0$, Solubility Decreases

Types

- Gaseous
  - Gas – Gas ⟶ Mixture of O_2 and N_2
  - Liquid – Gas ⟶ Chloroform with N_2
  - Solid – Gas ⟶ Camphor in N_2
- Liquid
  - Gas – Liquid ⟶ O_2 dissolved in water
  - Liquid – Liquid ⟶ Ethanol dissolved in water
  - Solid – Liquid ⟶ Glucose dissolved in water
- Solid
  - Gas – Solid ⟶ O_2 in Pd
  - Liquid – Solid ⟶ Amalgam of Hg with Na
  - Solid – Solid ⟶ Cu dissolved in gold

Abnormal molecular mass : molecular mass different from expected value

- van't Hoff factor (i) $= \frac{\text{Normal molar mass}}{\text{Abnormal molar mass}}$

Colligative properties

- Osmotic pressure : $\pi = CRT$
- Depression in freezing point : $\Delta T_f = \frac{K_f \times W_2 \times 1000}{M_2 \times W_1}$
- Elevation of boiling point : $\Delta T_b = \frac{K_b \times 1000 \times W_2}{M_2 \times W_1}$
- Relative lowering of vapour pressure : $\frac{W_2 \times M_1}{M_2 \times W_1} = \frac{P_1^\circ - P_1}{P^\circ_1}$

Raoult's Law

- Positive deviation: ΔV_{mix} = positive, ΔH_{mix} = positive
  - Large: Minimum boiling azeotrope
- Negative deviation: ΔH_{mix} = negative, ΔV_{mix} = negative
  - Large: Maximum boiling azeotrope
- Raoult's law: For any solution, the partial vapour pressure of each volatile component is directly proportional to its mole fraction.
  - Obey: Ideal solution ⟶ (n-hexane and n-heptane)
  - Do not obey: Non-ideal solution ⟶ (Mixture of chloroform and acetone)

Different methods to express concentration of solution

- **Mass by volume percentage (w/v)** ⟶ $\frac{\text{Mass of solute(g)}}{\text{Volume of solution in mL}} \times 100$
- **Volume percentage (v/v)** ⟶ $\frac{\text{Volume of component}}{\text{Total volume of solution}} \times 100$
- **Mass percentage (w/w)** ⟶ $\frac{\text{Mass of component in solution}}{\text{Total mass of solution}} \times 100$
- **Parts per million** : For trace quantities ⟶ $\frac{\text{No. of parts of components} \times 10^6}{\text{Total no. of parts of components of solution}}$
- **Mole fraction** ⟶ $\frac{\text{No. of moles of component}}{\text{Total no. of moles of all components}}$
- **Normality**: Number of gram equivalents of the solute dissolved in one litre of solution ⟶ $\frac{\text{No. of gram equivalent of solute} \times 100}{\text{Volume of solution}}$
  - ⟶ Gram Equivalents of solute $= \frac{\text{Mass of solute}}{\text{Equivalent weight}}$
  - ⟶ Equivalent weight $= \frac{\text{Molecular mass}}{\text{Valency}}$
- **Molality**: Number of moles of solute per kilogram of the solvent ⟶ $\frac{\text{No. of moles of solute}}{\text{Mass of solvent in kg}} \times 100$
- **Molarity** : Number of moles of solute in 1L solution ⟶ $\frac{\text{No. of moles of solute}}{\text{Volume of solution in litres}} \times 100$

How to understand Mind Map?

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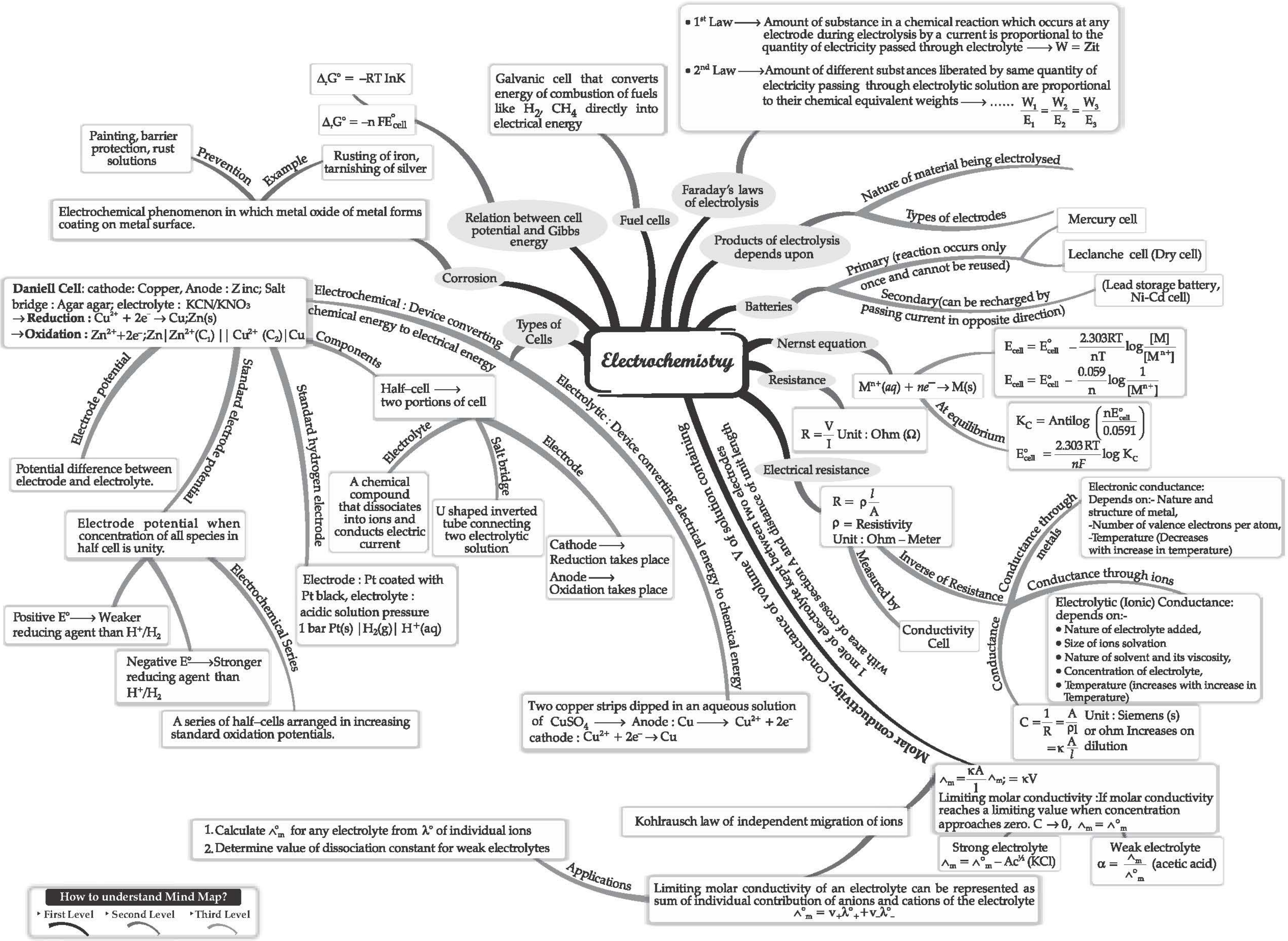
Electrochemistry
Faraday's laws of electrolysis
1st Law ⟶ Amount of substance in a chemical reaction which occurs at any electrode during electrolysis by a current is proportional to the quantity of electricity passed through electrolyte ⟶ W = Zit
2nd Law ⟶ Amount of different substances liberated by same quantity of electricity passing through electrolytic solution are proportional to their chemical equivalent weights ⟶ …… $\frac{W_1}{E_1} = \frac{W_2}{E_2} = \frac{W_3}{E_3}$
Fuel cells
Galvanic cell that converts energy of combustion of fuels like H_2, CH_4 directly into electrical energy
Relation between cell potential and Gibbs energy
$\Delta_r G^\circ = -RT \ln K$
$\Delta_r G^\circ = -nFE^\circ_{cell}$
Corrosion
Electrochemical phenomenon in which metal oxide of metal forms coating on metal surface.
Example
Rusting of iron, tarnishing of silver
Prevention
Painting, barrier protection, rust solutions
Products of electrolysis depends upon
Nature of material being electrolysed
Types of electrodes
Batteries
Primary (reaction occurs only once and cannot be reused)
Mercury cell
Leclanche cell (Dry cell)
Secondary(can be recharged by passing current in opposite direction)
(Lead storage battery, Ni-Cd cell)
Nernst equation
$M^{n+}(aq) + ne^- \rightarrow M(s)$
$E_{cell} = E^\circ_{cell} - \frac{2.303RT}{nT}\log\frac{[M]}{[M^{n+}]}$
$E_{cell} = E^\circ_{cell} - \frac{0.059}{n}\log\frac{1}{[M^{n+}]}$
At equilibrium
$K_C = \text{Antilog}\left(\frac{nE^\circ_{cell}}{0.0591}\right)$
$E^\circ_{cell} = \frac{2.303\,RT}{nF}\log K_C$
Resistance
$R = \frac{V}{I}$ Unit : Ohm (Ω)
Electrical resistance
$R = \rho\frac{l}{A}$
ρ = Resistivity
Unit : Ohm – Meter
Measured by
Conductivity Cell
Inverse of Resistance
Conductance
Conductance through metals
Electronic conductance: Depends on:- Nature and structure of metal, -Number of valence electrons per atom, -Temperature (Decreases with increase in temperature)
Conductance through ions
Electrolytic (Ionic) Conductance: depends on:-
• Nature of electrolyte added,
• Size of ions solvation
• Nature of solvent and its viscosity,
• Concentration of electrolyte,
• Temperature (increases with increase in Temperature)
$C = \frac{1}{R} = \frac{A}{\rho l} = \kappa\frac{A}{l}$ Unit : Siemens (s) or ohm Increases on dilution
Molar conductivity: Conductance of volume V of solution containing 1 mole of electrolyte kept between two electrodes with area of cross section A and distance of unit length
$\wedge_m = \frac{\kappa A}{1}\wedge_m; = \kappa V$
Limiting molar conductivity :If molar conductivity reaches a limiting value when concentration approaches zero. $C \rightarrow 0$, $\wedge_m = \wedge^\circ_m$
Strong electrolyte $\wedge_m = \wedge^\circ_m - Ac^{½}$ (KCl)
Weak electrolyte $\alpha = \frac{\wedge_m}{\wedge^\circ_m}$ (acetic acid)
Kohlrausch law of independent migration of ions
Limiting molar conductivity of an electrolyte can be represented as sum of individual contribution of anions and cations of the electrolyte $\wedge^\circ_m = v_+\lambda^\circ_+ + v_-\lambda^\circ_-$
Applications
1. Calculate $\wedge^\circ_m$ for any electrolyte from λ° of individual ions
2. Determine value of dissociation constant for weak electrolytes
Electrolytic : Device converting electrical energy to chemical energy
Two copper strips dipped in an aqueous solution of $CuSO_4$ ⟶ Anode : Cu ⟶ $Cu^{2+} + 2e^-$ cathode : $Cu^{2+} + 2e^- \rightarrow Cu$
Types of Cells
Electrochemical : Device converting chemical energy to electrical energy
Daniell Cell: cathode: Copper, Anode : Z inc; Salt bridge : Agar agar; electrolyte : KCN/KNO₃
→Reduction : $Cu^{2+} + 2e^- \rightarrow Cu;Zn(s)$
→Oxidation : $Zn^{2+}+2e^-;Zn|Zn^{2+}(C_1) || Cu^{2+}(C_2)|Cu$
Components
Half–cell ⟶ two portions of cell
Electrolyte
A chemical compound that dissociates into ions and conducts electric current
Salt bridge
U shaped inverted tube connecting two electrolytic solution
Electrode
Cathode ⟶ Reduction takes place
Anode ⟶ Oxidation takes place
Standard hydrogen electrode
Electrode : Pt coated with Pt black, electrolyte : acidic solution pressure 1 bar Pt(s) $|H_2(g)|$ $H^+(aq)$
Standard electrode potential
Electrode potential when concentration of all species in half cell is unity.
Positive E° ⟶ Weaker reducing agent than H^+/H_2
Negative E° ⟶ Stronger reducing agent than H^+/H_2
Electrochemical Series
A series of half–cells arranged in increasing standard oxidation potentials.
Electrode potential
Potential difference between electrode and electrolyte.
How to understand Mind Map?
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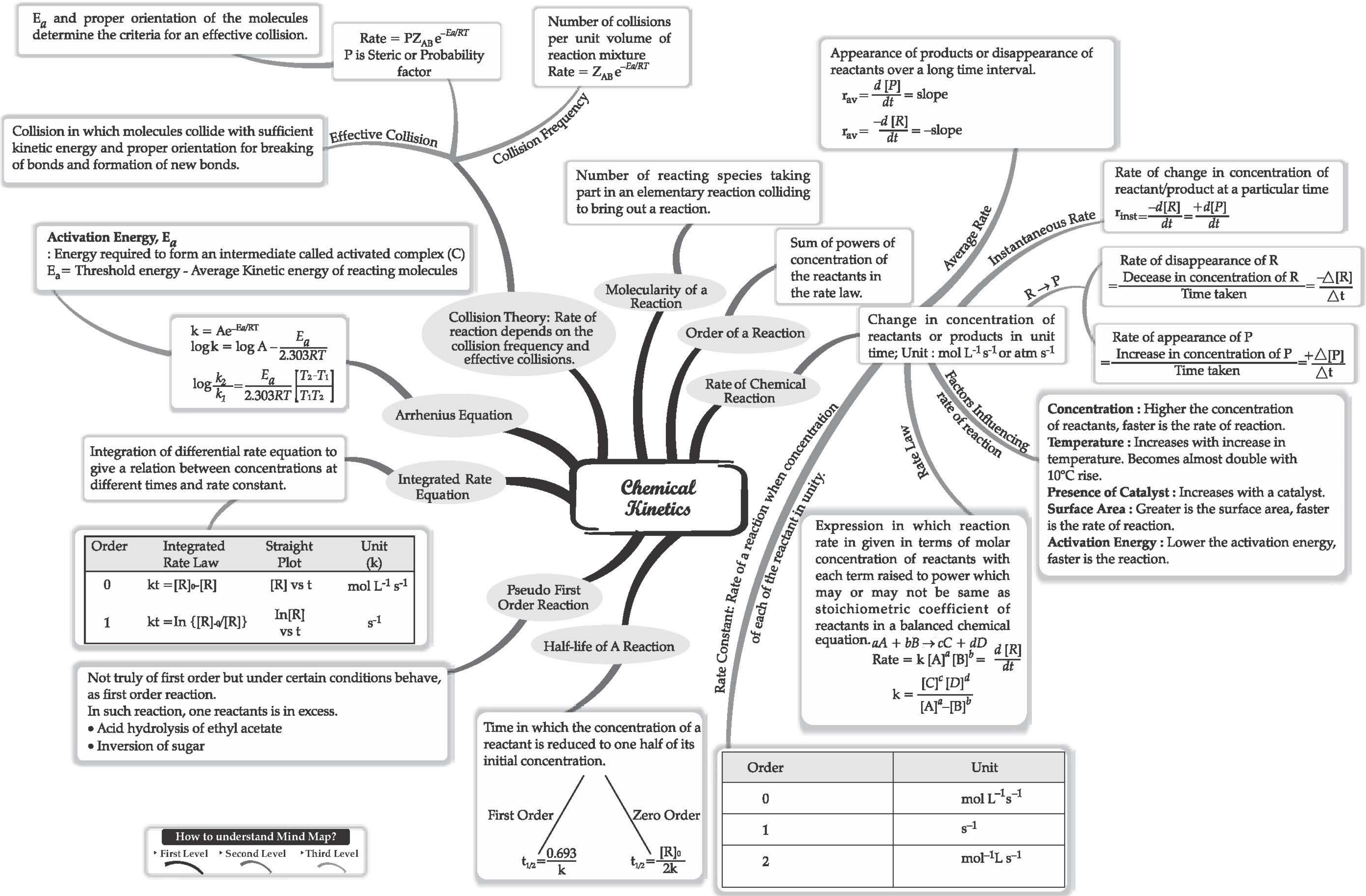

Chemical Kinetics

Rate of Chemical Reaction

Change in concentration of reactants or products in unit time; Unit : mol $L^{-1}s^{-1}$ or atm s^{-1}

Average Rate

Appearance of products or disappearance of reactants over a long time interval.

$r_{av} = \frac{d[P]}{dt}$ = slope

$r_{av} = \frac{-d[R]}{dt}$ = –slope

Instantaneous Rate

Rate of change in concentration of reactant/product at a particular time

$r_{inst} = \frac{-d[R]}{dt} = \frac{+d[P]}{dt}$

R → P

Rate of disappearance of R

$= \frac{\text{Decease in concentration of R}}{\text{Time taken}} = \frac{-\triangle[R]}{\triangle t}$

Rate of appearance of P

$= \frac{\text{Increase in concentration of P}}{\text{Time taken}} = \frac{+\triangle[P]}{\triangle t}$

Factors Influencing rate of reaction

Concentration : Higher the concentration of reactants, faster is the rate of reaction.
Temperature : Increases with increase in temperature. Becomes almost double with 10°C rise.
Presence of Catalyst : Increases with a catalyst.
Surface Area : Greater is the surface area, faster is the rate of reaction.
Activation Energy : Lower the activation energy, faster is the reaction.

Rate Law

Expression in which reaction rate in given in terms of molar concentration of reactants with each term raised to power which may or may not be same as stoichiometric coefficient of reactants in a balanced chemical equation. $aA + bB \rightarrow cC + dD$

Rate = $k[A]^a[B]^b = \frac{d[R]}{dt}$

$k = \frac{[C]^c[D]^d}{[A]^a–[B]^b}$

Rate Constant: Rate of a reaction when concentration of each of the reactant in unity.

Order	Unit
0	mol $L^{-1}s^{-1}$
1	s^{-1}
2	$mol^{-1}L\ s^{-1}$

Order of a Reaction

Sum of powers of concentration of the reactants in the rate law.

Molecularity of a Reaction

Number of reacting species taking part in an elementary reaction colliding to bring out a reaction.

Collision Theory: Rate of reaction depends on the collision frequency and effective collisions.

Collision Frequency

Number of collisions per unit volume of reaction mixture
Rate = $Z_{AB}e^{-Ea/RT}$

Effective Collision

Collision in which molecules collide with sufficient kinetic energy and proper orientation for breaking of bonds and formation of new bonds.

Rate = $PZ_{AB}e^{-Ea/RT}$
P is Steric or Probability factor

E_a and proper orientation of the molecules determine the criteria for an effective collision.

Arrhenius Equation

$k = Ae^{-Ea/RT}$

$\log k = \log A - \frac{E_a}{2.303RT}$

$\log\frac{k_2}{k_1} = \frac{E_a}{2.303RT}\left[\frac{T_2-T_1}{T_1T_2}\right]$

Activation Energy, E_a
: Energy required to form an intermediate called activated complex (C)
E_a = Threshold energy - Average Kinetic energy of reacting molecules

Integrated Rate Equation

Integration of differential rate equation to give a relation between concentrations at different times and rate constant.

Order	Integrated Rate Law	Straight Plot	Unit (k)
0	kt =$[R]_0$-[R]	[R] vs t	mol $L^{-1}s^{-1}$
1	kt =In {$[R]_0$/[R]}	In[R] vs t	s^{-1}

Pseudo First Order Reaction

Not truly of first order but under certain conditions behave, as first order reaction.
In such reaction, one reactants is in excess.
- Acid hydrolysis of ethyl acetate
- Inversion of sugar

Half-life of A Reaction

Time in which the concentration of a reactant is reduced to one half of its initial concentration.

First Order: $t_{1/2} = \frac{0.693}{k}$

Zero Order: $t_{1/2} = \frac{[R]_0}{2k}$

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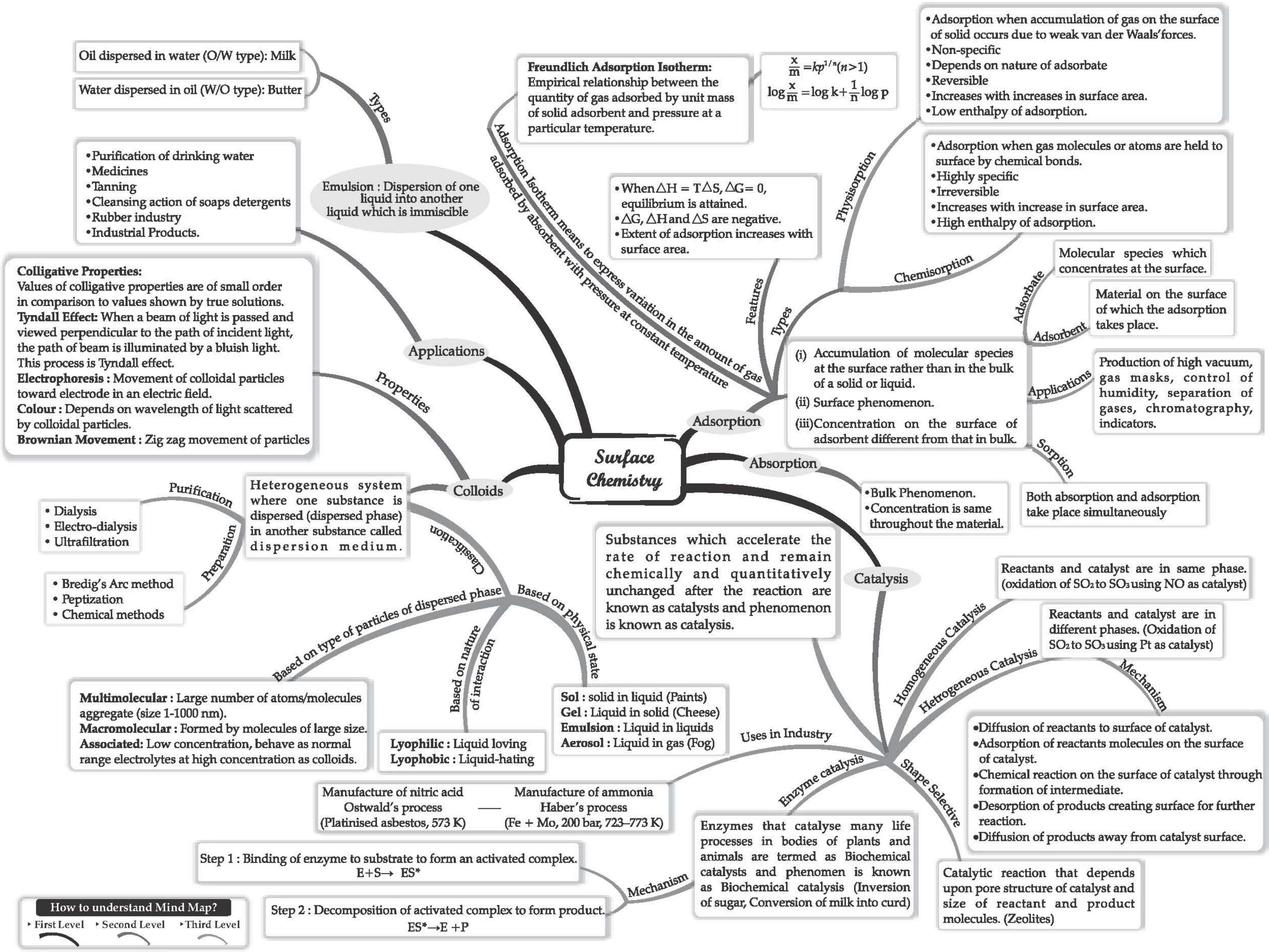


- Adsorption when accumulation of gas on the surface of solid occurs due to weak van der Waals' forces.
- Non-specific
- Depends on nature of adsorbate
- Reversible
- Increases with increases in surface area.
- Low enthalpy of adsorption.

- Adsorption when gas molecules or atoms are held to surface by chemical bonds.
- Highly specific
- Irreversible
- Increases with increase in surface area.
- High enthalpy of adsorption.

$\frac{x}{m} = kp^{1/n}(n>1)$

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

Freundlich Adsorption Isotherm: Empirical relationship between the quantity of gas adsorbed by unit mass of solid adsorbent and pressure at a particular temperature.

Adsorption Isotherm means to express variation in the amount of gas adsorbed by absorbent with pressure at constant temperature

- When $\Delta H = T\Delta S$, $\Delta G = 0$, equilibrium is attained.
- ΔG, ΔH and ΔS are negative.
- Extent of adsorption increases with surface area.

(i) Accumulation of molecular species at the surface rather than in the bulk of a solid or liquid.
(ii) Surface phenomenon.
(iii) Concentration on the surface of adsorbent different from that in bulk.

Molecular species which concentrates at the surface.

Material on the surface of which the adsorption takes place.

Production of high vacuum, gas masks, control of humidity, separation of gases, chromatography, indicators.

Both absorption and adsorption take place simultaneously

- Bulk Phenomenon.
- Concentration is same throughout the material.

Substances which accelerate the rate of reaction and remain chemically and quantitatively unchanged after the reaction are known as catalysts and phenomenon is known as catalysis.

Reactants and catalyst are in same phase. (oxidation of SO_2 to SO_3 using NO as catalyst)

Reactants and catalyst are in different phases. (Oxidation of SO_2 to SO_3 using Pt as catalyst)

- Diffusion of reactants to surface of catalyst.
- Adsorption of reactants molecules on the surface of catalyst.
- Chemical reaction on the surface of catalyst through formation of intermediate.
- Desorption of products creating surface for further reaction.
- Diffusion of products away from catalyst surface.

Catalytic reaction that depends upon pore structure of catalyst and size of reactant and product molecules. (Zeolites)

Enzymes that catalyse many life processes in bodies of plants and animals are termed as Biochemical catalysts and phenomen is known as Biochemical catalysis (Inversion of sugar, Conversion of milk into curd)

Manufacture of nitric acid — Manufacture of ammonia
Ostwald's process — Haber's process
(Platinised asbestos, 573 K) — (Fe + Mo, 200 bar, 723–773 K)

Step 1 : Binding of enzyme to substrate to form an activated complex.
$E+S \rightarrow ES^*$

Step 2 : Decomposition of activated complex to form product.
$ES^* \rightarrow E + P$

Heterogeneous system where one substance is dispersed (dispersed phase) in another substance called dispersion medium.

Sol : solid in liquid (Paints)
Gel : Liquid in solid (Cheese)
Emulsion : Liquid in liquids
Aerosol : Liquid in gas (Fog)

Lyophilic : Liquid loving
Lyophobic : Liquid-hating

Multimolecular : Large number of atoms/molecules aggregate (size 1-1000 nm).
Macromolecular : Formed by molecules of large size.
Associated: Low concentration, behave as normal range electrolytes at high concentration as colloids.

- Dialysis
- Electro-dialysis
- Ultrafiltration

- Bredig's Arc method
- Peptization
- Chemical methods

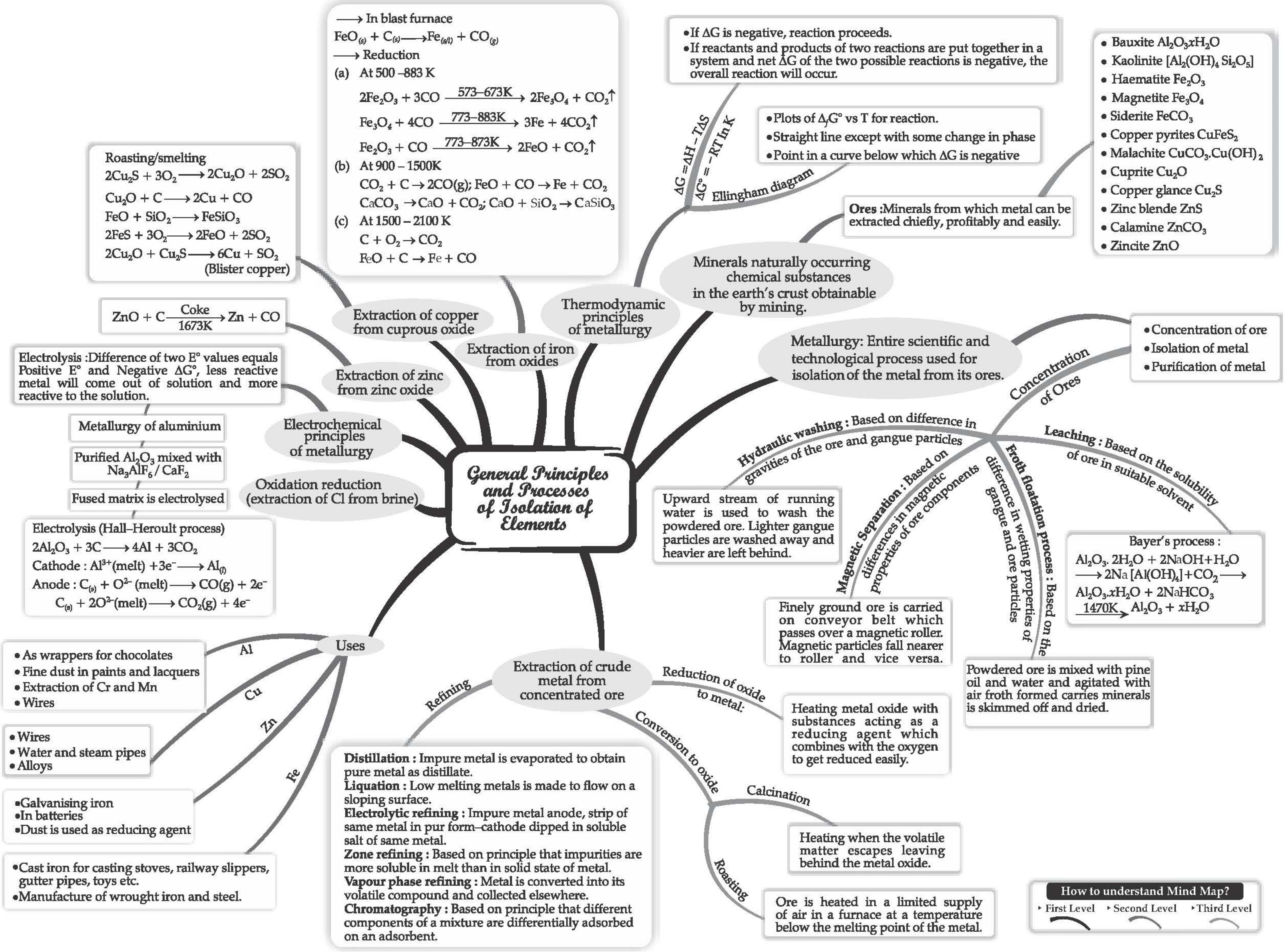
Colligative Properties:
Values of colligative properties are of small order in comparison to values shown by true solutions.
Tyndall Effect: When a beam of light is passed and viewed perpendicular to the path of incident light, the path of beam is illuminated by a bluish light. This process is Tyndall effect.
Electrophoresis : Movement of colloidal particles toward electrode in an electric field.
Colour : Depends on wavelength of light scattered by colloidal particles.
Brownian Movement : Zig zag movement of particles

- Purification of drinking water
- Medicines
- Tanning
- Cleansing action of soaps detergents
- Rubber industry
- Industrial Products.

Emulsion : Dispersion of one liquid into another liquid which is immiscible

Oil dispersed in water (O/W type): Milk

Water dispersed in oil (W/O type): Butter



General Principles and Processes of Isolation of Elements

Metallurgy: Entire scientific and technological process used for isolation of the metal from its ores.

- Concentration of ore
- Isolation of metal
- Purification of metal

Minerals naturally occurring chemical substances in the earth's crust obtainable by mining.

Ores : Minerals from which metal can be extracted chiefly, profitably and easily.

- Bauxite $Al_2O_3.xH_2O$
- Kaolinite $[Al_2(OH)_4 Si_2O_5]$
- Haematite Fe_2O_3
- Magnetite Fe_3O_4
- Siderite $FeCO_3$
- Copper pyrites $CuFeS_2$
- Malachite $CuCO_3.Cu(OH)_2$
- Cuprite Cu_2O
- Copper glance Cu_2S
- Zinc blende ZnS
- Calamine $ZnCO_3$
- Zincite ZnO

Concentration of Ores

Hydraulic washing : Based on difference in gravities of the ore and gangue particles

Upward stream of running water is used to wash the powdered ore. Lighter gangue particles are washed away and heavier are left behind.

Magnetic Separation : Based on differences in magnetic properties of ore components

Finely ground ore is carried on conveyor belt which passes over a magnetic roller. Magnetic particles fall nearer to roller and vice versa.

Froth floatation process : Based on the difference in wetting properties of gangue and ore particles

Powdered ore is mixed with pine oil and water and agitated with air froth formed carries minerals is skimmed off and dried.

Leaching : Based on the solubility of ore in suitable solvent

Bayer's process :

$Al_2O_3.\ 2H_2O + 2NaOH + H_2O \longrightarrow 2Na[Al(OH)_4] + CO_2 \longrightarrow$

$Al_2O_3.xH_2O + 2NaHCO_3 \xrightarrow{1470K} Al_2O_3 + xH_2O$

Thermodynamic principles of metallurgy

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

$\Delta G^\circ = -RT \ln K$

- If ΔG is negative, reaction proceeds.
- If reactants and products of two reactions are put together in a system and net ΔG of the two possible reactions is negative, the overall reaction will occur.

Ellingham diagram

- Plots of $\Delta_f G^\circ$ vs T for reaction.
- Straight line except with some change in phase
- Point in a curve below which ΔG is negative

Extraction of iron from oxides

$\longrightarrow$ In blast furnace

$FeO_{(s)} + C_{(s)} \longrightarrow Fe_{(s/l)} + CO_{(g)}$

$\longrightarrow$ Reduction

(a) At 500 –883 K

$2Fe_2O_3 + 3CO \xrightarrow{573–673K} 2Fe_3O_4 + CO_2\uparrow$

$Fe_3O_4 + 4CO \xrightarrow{773–883K} 3Fe + 4CO_2\uparrow$

$Fe_2O_3 + CO \xrightarrow{773–873K} 2FeO + CO_2\uparrow$

(b) At 900 – 1500K

$CO_2 + C \rightarrow 2CO(g)$; $FeO + CO \rightarrow Fe + CO_2$

$CaCO_3 \rightarrow CaO + CO_2$; $CaO + SiO_2 \rightarrow CaSiO_3$

(c) At 1500 – 2100 K

$C + O_2 \rightarrow CO_2$

$FeO + C \rightarrow Fe + CO$

Extraction of copper from cuprous oxide

Roasting/smelting

$2Cu_2S + 3O_2 \longrightarrow 2Cu_2O + 2SO_2$

$Cu_2O + C \longrightarrow 2Cu + CO$

$FeO + SiO_2 \longrightarrow FeSiO_3$

$2FeS + 3O_2 \longrightarrow 2FeO + 2SO_2$

$2Cu_2O + Cu_2S \longrightarrow 6Cu + SO_2$ (Blister copper)

Extraction of zinc from zinc oxide

$ZnO + C \xrightarrow[1673K]{Coke} Zn + CO$

Electrochemical principles of metallurgy

Electrolysis :Difference of two E° values equals Positive E° and Negative ΔG°, 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 / CaF_2

Fused matrix is electrolysed

Electrolysis (Hall–Heroult process)

$2Al_2O_3 + 3C \longrightarrow 4Al + 3CO_2$

Cathode : $Al^{3+}(melt) + 3e^- \longrightarrow Al_{(l)}$

Anode : $C_{(s)} + O^{2-}(melt) \longrightarrow CO(g) + 2e^-$

$C_{(s)} + 2O^{2-}(melt) \longrightarrow CO_2(g) + 4e^-$

Oxidation reduction (extraction of Cl from brine)

Uses

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

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, toys etc.
- Manufacture of wrought iron and steel.

Extraction of crude metal from concentrated ore

Conversion to oxide

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

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

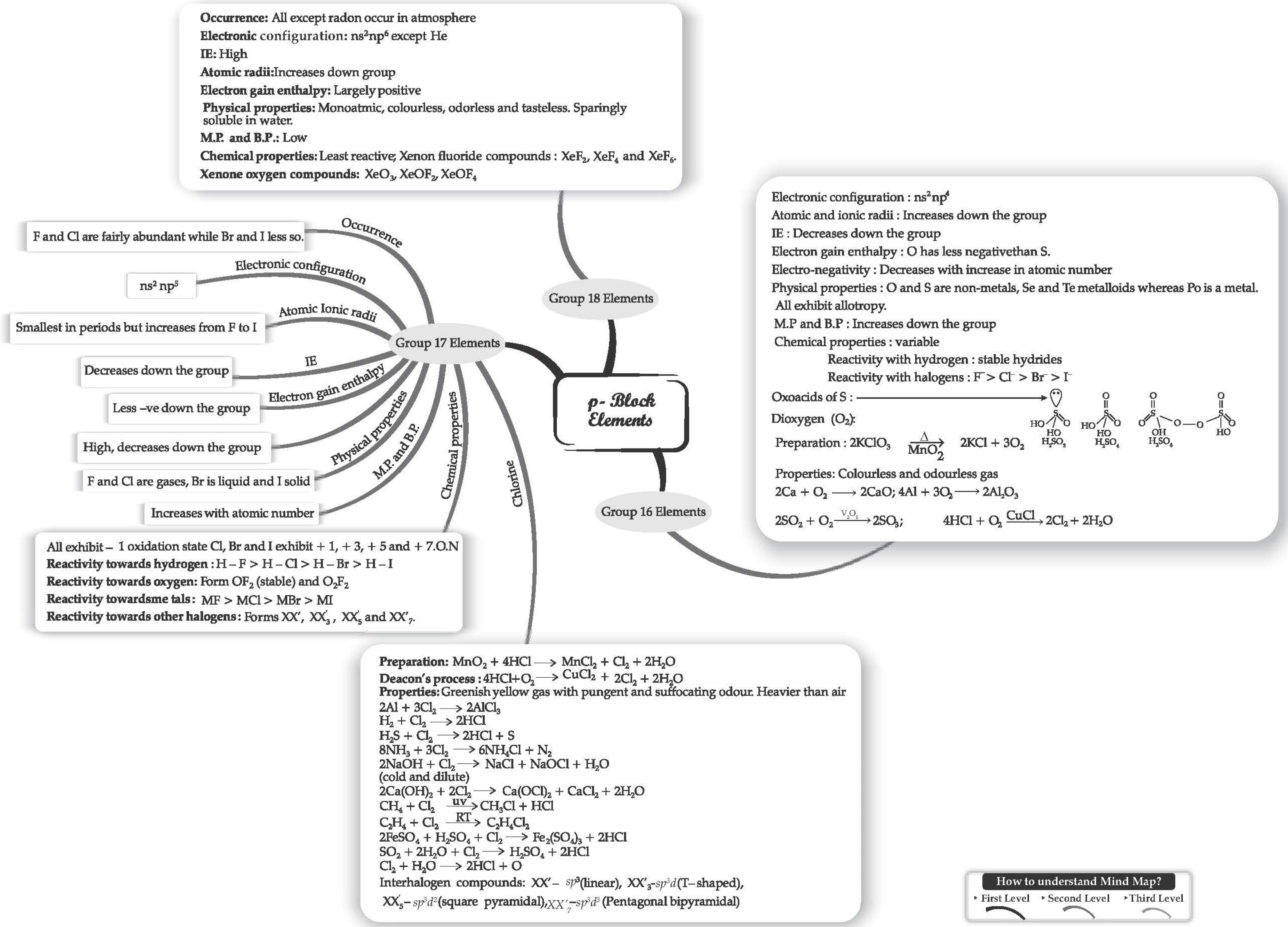
Reduction of oxide to metal: Heating metal oxide with substances acting as a reducing agent which combines with the oxygen to get reduced easily.

Refining

Distillation : Impure metal is evaporated to obtain pure metal as distillate.
Liquation : Low melting metals is made to flow on a sloping surface.
Electrolytic refining : Impure metal anode, strip of same metal in pur form–cathode dipped in soluble salt of same metal.
Zone refining : Based on principle that impurities are more soluble in melt than in solid state of metal.
Vapour phase refining : Metal is converted into its volatile compound and collected elsewhere.
Chromatography : Based on principle that different components of a mixture are differentially adsorbed on an adsorbent.

How to understand Mind Map?

First Level · Second Level · Third Level



p- Block Elements

Group 18 Elements

Occurrence: All except radon occur in atmosphere
Electronic configuration: ns^2np^6 except He
IE: High
Atomic radii: Increases down group
Electron gain enthalpy: Largely positive
Physical properties: Monoatmic, colourless, odorless and tasteless. Sparingly soluble in water.
M.P. and B.P.: Low
Chemical properties: Least reactive; Xenon fluoride compounds : XeF_2, XeF_4 and XeF_6.
Xenone oxygen compounds: XeO_3, $XeOF_2$, $XeOF_4$

Group 17 Elements

- Occurrence: F and Cl are fairly abundant while Br and I less so.
- Electronic configuration: $ns^2 np^5$
- Atomic Ionic radii: Smallest in periods but increases from F to I
- IE: Decreases down the group
- Electron gain enthalpy: Less –ve down the group
- Physical properties: High, decreases down the group
- M.P and B.P: F and Cl are gases, Br is liquid and I solid
- Increases with atomic number
- Chemical properties:

All exhibit – 1 oxidation state Cl, Br and I exhibit + 1, + 3, + 5 and + 7.O.N
Reactivity towards hydrogen : H – F > H – Cl > H – Br > H – I
Reactivity towards oxygen: Form OF_2 (stable) and O_2F_2
Reactivity towardsme tals: MF > MCl > MBr > MI
Reactivity towards other halogens : Forms XX′, XX'_3 , XX'_5 and XX'_7.

- Chlorine:

Preparation: $MnO_2 + 4HCl \longrightarrow MnCl_2 + Cl_2 + 2H_2O$
Deacon's process : $4HCl+O_2 \longrightarrow CuCl_2 + 2Cl_2 + 2H_2O$
Properties: Greenish yellow gas with pungent and suffocating odour. Heavier than air
$2Al + 3Cl_2 \longrightarrow 2AlCl_3$
$H_2 + Cl_2 \longrightarrow 2HCl$
$H_2S + Cl_2 \longrightarrow 2HCl + S$
$8NH_3 + 3Cl_2 \longrightarrow 6NH_4Cl + N_2$
$2NaOH + Cl_2 \longrightarrow NaCl + NaOCl + H_2O$
(cold and dilute)
$2Ca(OH)_2 + 2Cl_2 \longrightarrow Ca(OCl)_2 + CaCl_2 + 2H_2O$
$CH_4 + Cl_2 \xrightarrow{uv} CH_3Cl + HCl$
$C_2H_4 + Cl_2 \xrightarrow{RT} C_2H_4Cl_2$
$2FeSO_4 + H_2SO_4 + Cl_2 \longrightarrow Fe_2(SO_4)_3 + 2HCl$
$SO_2 + 2H_2O + Cl_2 \longrightarrow H_2SO_4 + 2HCl$
$Cl_2 + H_2O \longrightarrow 2HCl + O$
Interhalogen compounds: XX′– sp^3(linear), XX'_3-sp^3d(T–shaped),
XX'_5– sp^3d^2(square pyramidal),XX'_7–sp^3d^3 (Pentagonal bipyramidal)

Group 16 Elements

Electronic configuration : ns^2np^4
Atomic and ionic radii : Increases down the group
IE : Decreases down the group
Electron gain enthalpy : O has less negativethan S.
Electro-negativity : Decreases with increase in atomic number
Physical properties : O and S are non-metals, Se and Te metalloids whereas Po is a metal.
All exhibit allotropy.
M.P and B.P : Increases down the group
Chemical properties : variable
Reactivity with hydrogen : stable hydrides
Reactivity with halogens : $F^- > Cl^- > Br^- > I^-$
Oxoacids of S : $\longrightarrow$
Dioxygen (O_2):
Preparation : $2KClO_3 \xrightarrow[MnO_2]{\Delta} 2KCl + 3O_2$
Properties: Colourless and odourless gas
$2Ca + O_2 \longrightarrow 2CaO; 4Al + 3O_2 \longrightarrow 2Al_2O_3$
$2SO_2 + O_2 \xrightarrow{V_2O_5} 2SO_3$; $4HCl + O_2 \xrightarrow{CuCl} 2Cl_2 + 2H_2O$

How to understand Mind Map?
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d-and f-Block Elements

d– Block transition elements groups 3–12

Position: Between s- and p–blocks.

Electronic configuration: $(n-1)d^{1-10}ns^{1-2}$

Physical properties : Show typical metallic properties, melting and boiling point are high; High enthalpies of atomization.

Decrease in radius with increasing atomic number. Lanthanoid contraction is due to imperfect shielding of one e^- by another in same set of orbitals.

Ionisation enthaplies: Increases from leftto right.

Oxidation states: Variable; higher ON stable.

Trends in M^{2+}/M E° : E° for Mn, Ni and Zn are more negative than expected.

Trends in M^{3+}/M^{2+} E° : Variable.

Chemical reactivity and E° values : Variable; Ti^{2+}, V^{2+} and Cr^{2+} are strong reducing agents.

Magnetic properties : Diamagnetism and paramagnetism. Magnetic moment increases with increasing atomic number.

Formation of coloured ions : Form colouredco mpounds due to d-d transitions.

Formation of complex compounds : Form a large number of complex compounds.

Catalytic properties: Due to variable oxidation states andabil ity to form complexes.

Forms interstitial compounds : Non-stoichiometric and are neither ionic nor covalent.

Alloy formation: Due to similarat omic sizes.

Oxides and oxoanions of metals

Potassium dichromate $K_2Cr_2O_7$

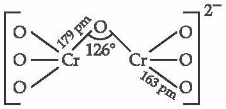
Preparation : $4FeCr_2O_4 + 8Na_2CO_3 + 7O_2 \rightarrow 8Na_2CrO_4 + 2Fe_2O_3 + 8CO_2$

$2Na_2CrO_4 + 2H^+ \rightarrow Na_2Cr_2O_7 + 2Na^+ + H_2O$

$Na_2Cr_2O_7 + 2KCl \rightarrow K_2Cr_2O_7 + 2NaCl$

Properties : $Cr_2O_7^2 + 14H^+ + 6e^- \rightarrow 2Cr^{3+} + 7H_2O$

Oxidises iodides to iodine, H_2S to S, SO_3^2 to SO_4^2 , NO_2 to NO_3



Potassium permanganate $KMnO_4$

Preparation : $2MnO_2 + 4KOH + O_2 \rightarrow 2KMnO_4 + 2H_2O$

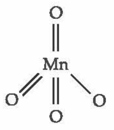
$3MnO_4^2 + 4H^+ \rightarrow 2MnO_4 + MnO_2 + 2H_2O$

$2Mn^{2+} + 5S_2O_8^2 + 8H_2O \rightarrow 2MnO_4 + 10SO_4^2 + 16H^+$

Properties : Intense colour, weak temperature dependent paramagnetism

$MnO_4 + 8H^+ + 5e^- \rightarrow Mn^{2+} + 4H_2O$

Oxidizes I^- to I_2, Fe^{2+} to Fe^{3+}, $C_2O_4^2$ to CO_2, S^{2-} to S, SO_3^2 to SO_4^2 , NO_2 to NO_3



Uses

Helps in production of iron and steels.

TiO in pigment industry.

MnO_2 in dry battery cells.

As catalysts in industry.

Ni complexes useful in the polymerization of alkynes and other organic compounds such as benzene.

AgBr in photographic industry.

Lanthanoid contraction is progressive decrease in atomic/ionic radii from La^{3+} to Lu^{3+}

f– Block Transition Elements

Actinoids

Electronic : configuration $[Rn]5f^{1-14}6d^{0-2}7s^2$

Ionic sizes : Gradualde crease along the series.

Oxidation states : Most common is +3. They show ON of+4 , +5,+6 and +7.

General characteristics:

–Silvery in appearance.

–Display variety of structures.

–Highly reactive metals.

–Irregularities in metallic radii, greater than in lanthanoids.

–Magnetic properties more complex than lanthanoids.

Lanthanoids

Electronic configuration :
$4f^{1-14}$ $5d^{0-1}$ $6s^2$

Atomic and ionic sizes :
Decreases from La to Lu

Oxidation states :
Most common is +3. Some elements exhibit +2 and +4.

General characteristics:

Silvery white soft metals and tarnish rapidly in air.

Hardness increases with increasing atomic number.

Metallic structure and good conductors of heat and electricity.

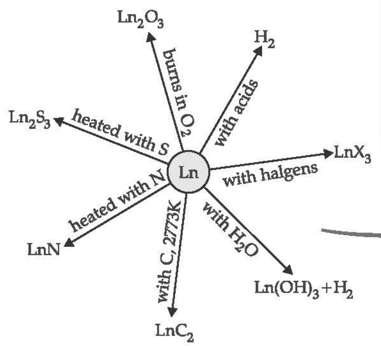
Variable density.

Trivalent lanthanoid ions are coloured.

Ionisation Enthalpies : Low third ionisation enthalpies.

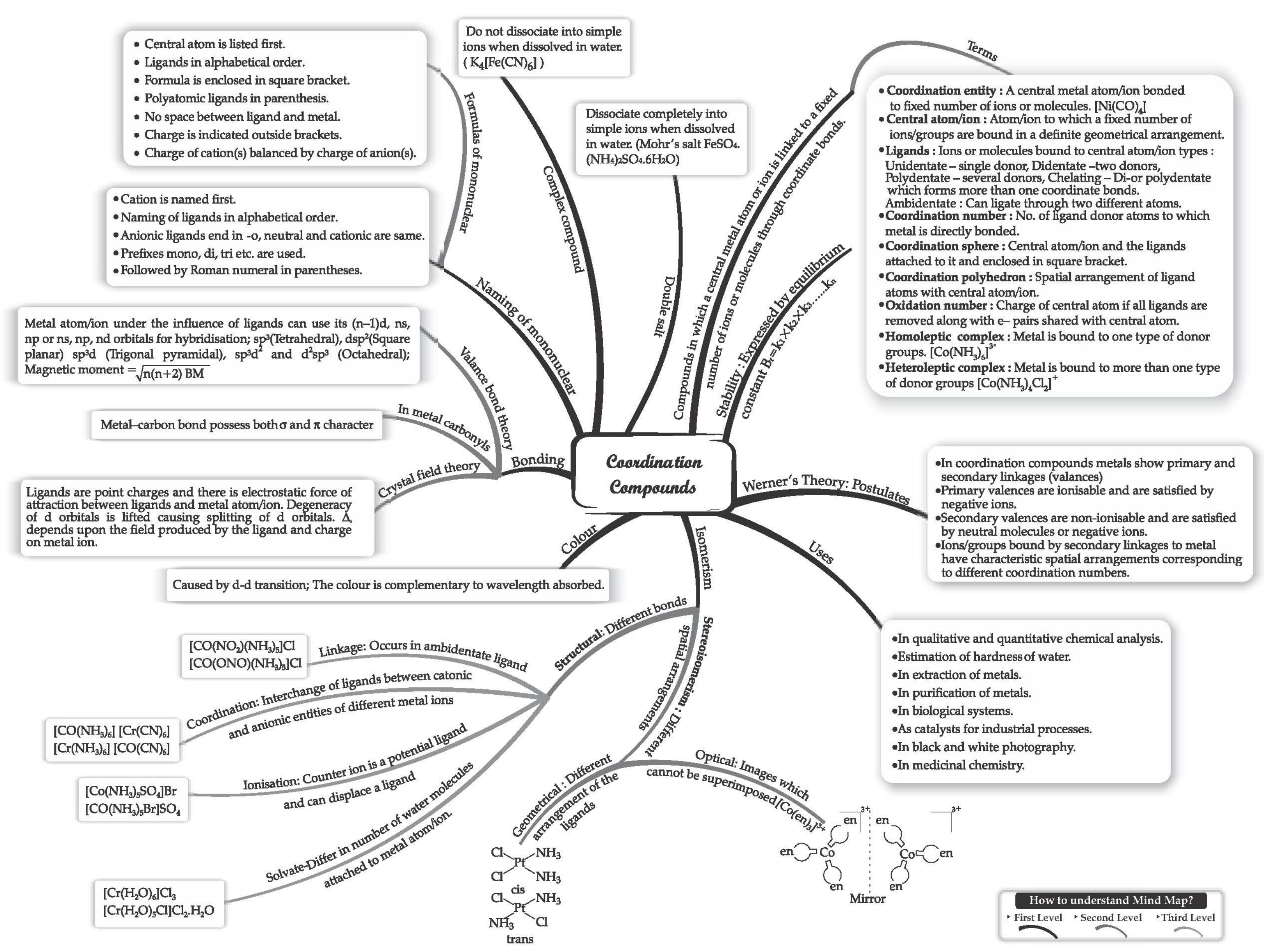
Good reducing agents.

Chemical Properties



How to understand Mind Map?

‣ First Level ‣ Second Level ‣ Third Level



Coordination Compounds

Terms

- **Coordination entity :** A central metal atom/ion bonded to fixed number of ions or molecules. $[Ni(CO)_4]$
- **Central atom/ion :** Atom/ion to which a fixed number of ions/groups are bound in a definite geometrical arrangement.
- **Ligands :** Ions or molecules bound to central atom/ion types : Unidentate – single donor, Didentate –two donors, Polydentate – several donors, Chelating – Di-or polydentate which forms more than one coordinate bonds. Ambidentate : Can ligate through two different atoms.
- **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 :** 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. $[Co(NH_3)_6]^{3+}$
- **Heteroleptic complex :** Metal is bound to more than one type of donor groups $[Co(NH_3)_4Cl_2]^+$

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

Stability : Expressed by equilibrium constant $B_n = k_1 \times k_2 \times k_3 \ldots\ldots k_n$

Werner's Theory: Postulates

- In coordination compounds metals show primary and secondary linkages (valances)
- Primary valences are ionisable and are satisfied by negative ions.
- Secondary valences are non-ionisable and are satisfied by neutral molecules or negative ions.
- Ions/groups bound by secondary linkages to metal have characteristic spatial arrangements corresponding to different coordination numbers.

Uses

- In qualitative and quantitative chemical analysis.
- Estimation of hardness of water.
- In extraction of metals.
- In purification of metals.
- In biological systems.
- As catalysts for industrial processes.
- In black and white photography.
- In medicinal chemistry.

Isomerism

Stereoisomerism : Different spatial arrangements

Optical: Images which cannot be superimposed $[Co(en)_3]^{3+}$

Geometrical : Different arrangement of the ligands

Structural: Different bonds

Linkage: Occurs in ambidentate ligand

$[CO(NO_2)(NH_3)_5]Cl$
$[CO(ONO)(NH_3)_5]Cl$

Coordination: Interchange of ligands between catonic and anionic entities of different metal ions

$[CO(NH_3)_6]\ [Cr(CN)_6]$
$[Cr(NH_3)_6]\ [CO(CN)_6]$

Ionisation: Counter ion is a potential ligand and can displace a ligand

$[Co(NH_3)_5SO_4]Br$
$[CO(NH_3)_5Br]SO_4$

Solvate-Differ in number of water molecules attached to metal atom/ion.

$[Cr(H_2O)_6]Cl_3$
$[Cr(H_2O)_5Cl]Cl_2.H_2O$

Colour

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

Bonding

Crystal field theory

Ligands are point charges and there is electrostatic force of attraction between ligands and metal atom/ion. Degeneracy of d orbitals is lifted causing splitting of d orbitals. Δ, depends upon the field produced by the ligand and charge on metal ion.

In metal carbonyls

Metal–carbon bond possess both σ and π character

Valance bond theory

Metal atom/ion under the influence of ligands can use its (n–1)d, ns, np or ns, np, nd orbitals for hybridisation; sp^3(Tetrahedral), dsp^2(Square planar) sp^3d (Trigonal pyramidal), sp^3d^2 and d^2sp^3 (Octahedral); Magnetic moment $= \sqrt{n(n+2)}$ BM

Naming of mononuclear

- Cation is named first.
- Naming of ligands in alphabetical order.
- Anionic ligands end in -o, neutral and cationic are same.
- Prefixes mono, di, tri etc. are used.
- Followed by Roman numeral in parentheses.

Formulas of mononuclear

- Central atom is listed first.
- Ligands in alphabetical order.
- Formula is enclosed in square bracket.
- Polyatomic ligands in parenthesis.
- No space between ligand and metal.
- Charge is indicated outside brackets.
- Charge of cation(s) balanced by charge of anion(s).

Complex compound

Do not dissociate into simple ions when dissolved in water. ($K_4[Fe(CN)_6]$)

Double salt

Dissociate completely into simple ions when dissolved in water. (Mohr's salt $FeSO_4.(NH_4)_2SO_4.6H_2O$)

How to understand Mind Map?

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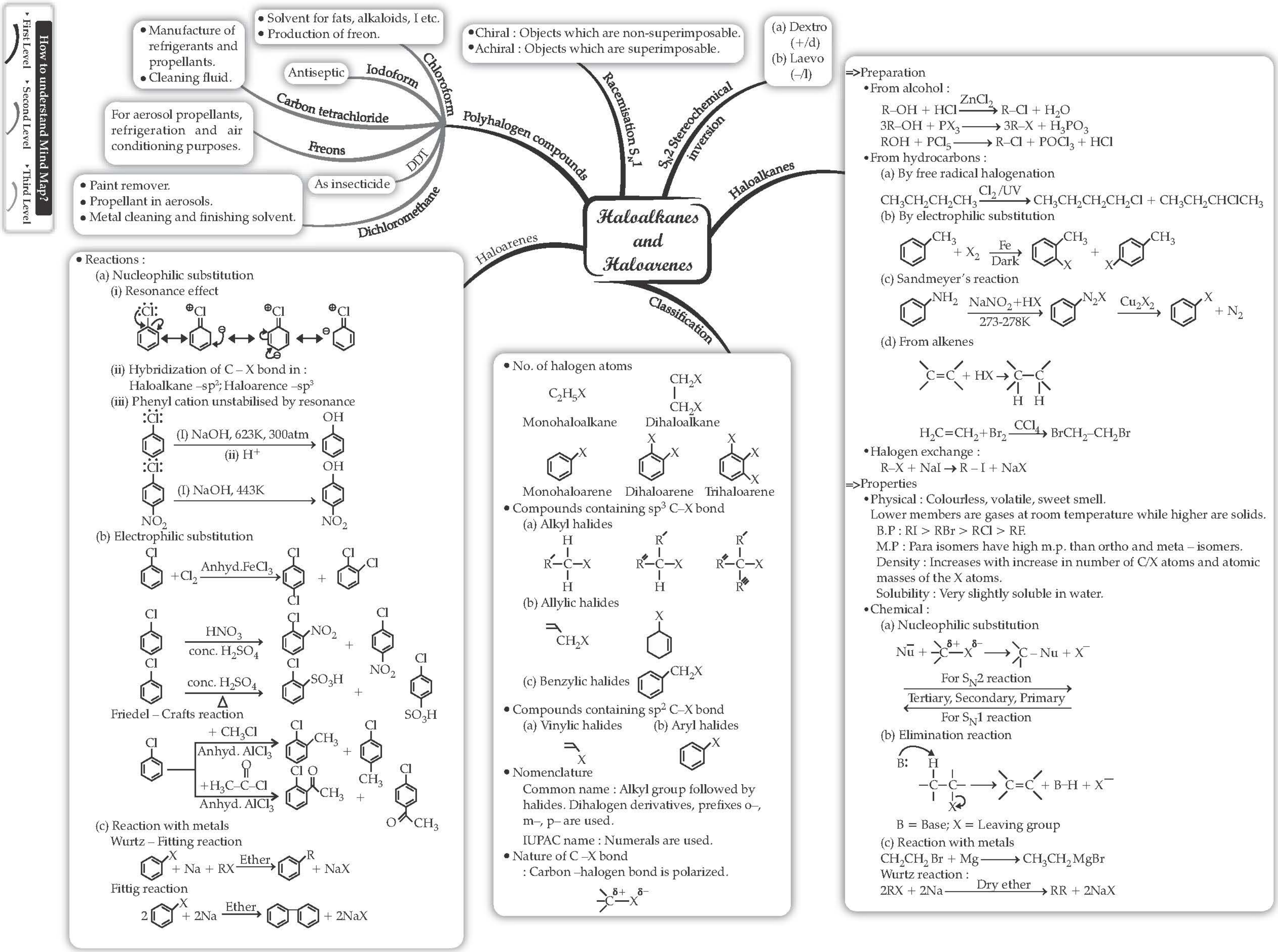


Haloalkanes and Haloarenes

Haloalkanes

=>Preparation

- From alcohol :
  - $R–OH + HCl \xrightarrow{ZnCl_2} R–Cl + H_2O$
  - $3R–OH + PX_3 \longrightarrow 3R–X + H_3PO_3$
  - $ROH + PCl_5 \longrightarrow R–Cl + POCl_3 + HCl$
- From hydrocarbons :
  - (a) By free radical halogenation
    $CH_3CH_2CH_2CH_3 \xrightarrow{Cl_2/UV} CH_3CH_2CH_2CH_2Cl + CH_3CH_2CHClCH_3$
  - (b) By electrophilic substitution
  - (c) Sandmeyer's reaction
  - (d) From alkenes
    $H_2C{=}CH_2 + Br_2 \xrightarrow{CCl_4} BrCH_2–CH_2Br$
- Halogen exchange :
  $R–X + NaI \rightarrow R – I + NaX$

=>Properties

- Physical : Colourless, volatile, sweet smell.
  Lower members are gases at room temperature while higher are solids.
  B.P : RI > RBr > RCl > RF.
  M.P : Para isomers have high m.p. than ortho and meta – isomers.
  Density : Increases with increase in number of C/X atoms and atomic masses of the X atoms.
  Solubility : Very slightly soluble in water.
- Chemical :
  - (a) Nucleophilic substitution
    For S_N2 reaction
    Tertiary, Secondary, Primary
    For S_N1 reaction
  - (b) Elimination reaction
    B = Base; X = Leaving group
  - (c) Reaction with metals
    $CH_2CH_2\,Br + Mg \longrightarrow CH_3CH_2MgBr$
    Wurtz reaction :
    $2RX + 2Na \xrightarrow{\text{Dry ether}} RR + 2NaX$

Classification

- No. of halogen atoms
  C_2H_5X Monohaloalkane; $CH_2X–CH_2X$ Dihaloalkane
  Monohaloarene, Dihaloarene, Trihaloarene
- Compounds containing sp^3 C–X bond
  - (a) Alkyl halides
  - (b) Allylic halides
  - (c) Benzylic halides
- Compounds containing sp^2 C–X bond
  - (a) Vinylic halides
  - (b) Aryl halides
- Nomenclature
  Common name : Alkyl group followed by halides. Dihalogen derivatives, prefixes o–, m–, p– are used.
  IUPAC name : Numerals are used.
- Nature of C –X bond
  : Carbon –halogen bond is polarized.

Haloarenes

- Reactions :
  - (a) Nucleophilic substitution
    - (i) Resonance effect
    - (ii) Hybridization of C – X bond in :
      Haloalkane $–sp^2$; Haloarence $–sp^3$
    - (iii) Phenyl cation unstabilised by resonance
      (I) NaOH, 623K, 300atm; (ii) H^+
      (I) NaOH, 443K
  - (b) Electrophilic substitution
    $+Cl_2$, Anhyd.$FeCl_3$
    HNO_3, conc. H_2SO_4
    conc. H_2SO_4, Δ
    Friedel – Crafts reaction
    $+ CH_3Cl$, Anhyd. $AlCl_3$
    $+H_3C–C(=O)–Cl$, Anhyd. $AlCl_3$
  - (c) Reaction with metals
    Wurtz – Fitting reaction
    Fittig reaction

S_N2 Stereochemical inversion

(a) Dextro (+/d)
(b) Laevo (–/l)

Racemisation S_N1

- Chiral : Objects which are non-superimposable.
- Achiral : Objects which are superimposable.

Polyhalogen compounds

Chloroform
- Solvent for fats, alkaloids, I etc.
- Production of freon.

Iodoform
Antiseptic

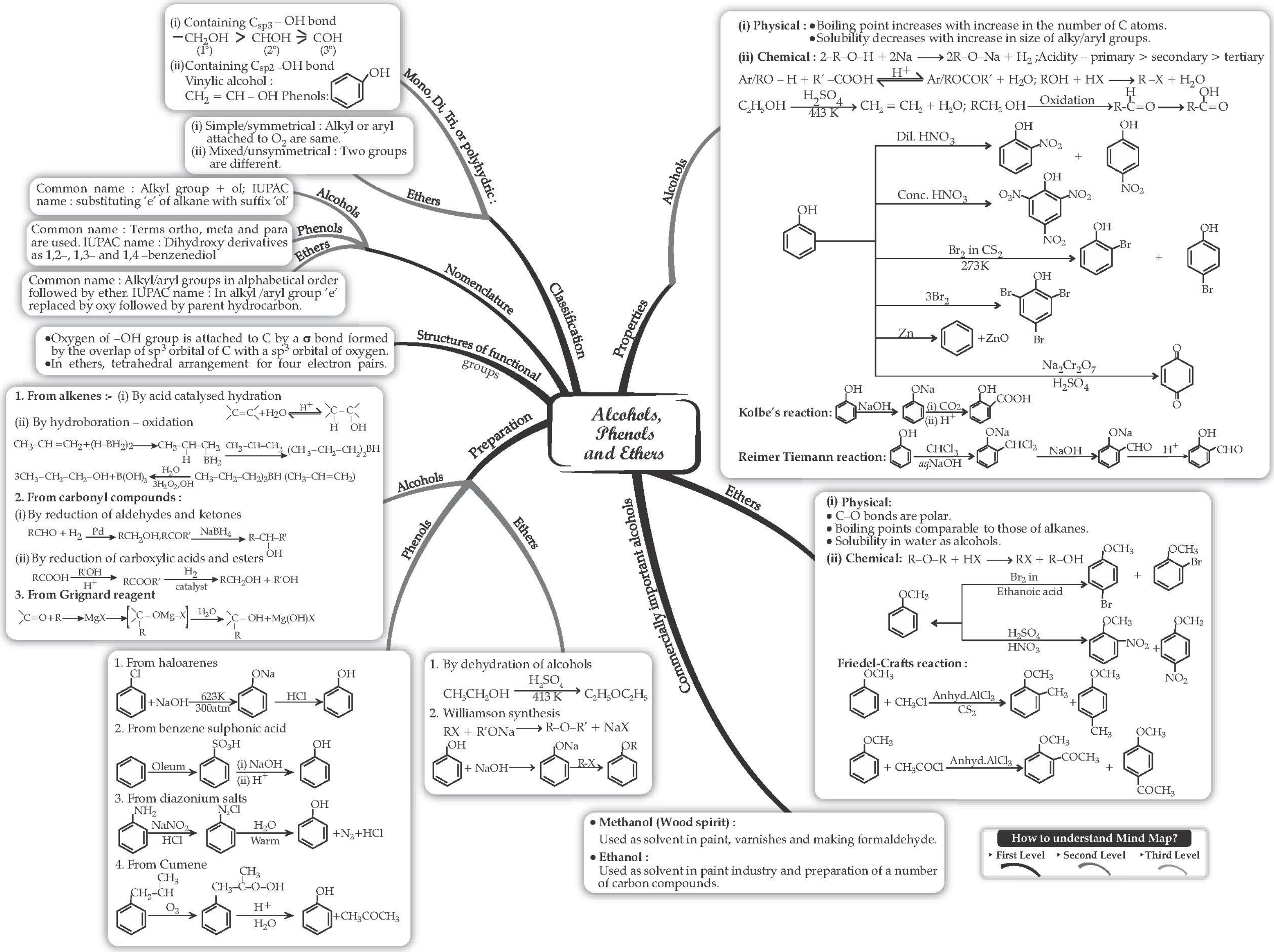
Carbon tetrachloride
- Manufacture of refrigerants and propellants.
- Cleaning fluid.

Freons
For aerosol propellants, refrigeration and air conditioning purposes.

DDT
As insecticide

Dichloromethane
- Paint remover.
- Propellant in aerosols.
- Metal cleaning and finishing solvent.

How to understand Mind Map?
First Level
Second Level
Third Level



(i) Containing C_{sp3} – OH bond

$-CH_2OH > CHOH \geqslant COH$ (1°) (2°) (3°)

(ii) Containing C_{sp2} -OH bond

Vinylic alcohol :

$CH_2 = CH - OH$ Phenols:

(i) Simple/symmetrical : Alkyl or aryl attached to O_2 are same.

(ii) Mixed/unsymmetrical : Two groups are different.

Common name : Alkyl group + ol; IUPAC name : substituting 'e' of alkane with suffix 'ol'

Common name : Terms ortho, meta and para are used. IUPAC name : Dihydroxy derivatives as 1,2–, 1,3– and 1,4 –benzenediol

Common name : Alkyl/aryl groups in alphabetical order followed by ether. IUPAC name : In alkyl /aryl group 'e' replaced by oxy followed by parent hydrocarbon.

- Oxygen of –OH group is attached to C by a σ bond formed by the overlap of sp^3 orbital of C with a sp^3 orbital of oxygen.
- In ethers, tetrahedral arrangement for four electron pairs.

1. From alkenes :- (i) By acid catalysed hydration

$$>C=C< + H_2O \overset{H^+}{\rightleftharpoons} >C(H)-C(OH)<$$

(ii) By hydroboration – oxidation

$$CH_3-CH=CH_2+(H-BH_2)2 \longrightarrow CH_3-CH(H)-CH_2(BH_2) \xrightarrow{CH_3-CH=CH_2} (CH_3-CH_2-CH_2)_2BH$$

$$3CH_3-CH_2-CH_2-OH+B(OH)_3 \xleftarrow[3H_2O_2,OH]{H_2O} CH_3-CH_2-CH_2)_3BH\ (CH_3-CH=CH_2)$$

2. From carbonyl compounds :

(i) By reduction of aldehydes and ketones

$$RCHO + H_2 \xrightarrow{Pd} RCH_2OH, RCOR' \xrightarrow{NaBH_4} R-CH(OH)-R'$$

(ii) By reduction of carboxylic acids and esters

$$RCOOH \xrightarrow[H^+]{R'OH} RCOOR' \xrightarrow[catalyst]{H_2} RCH_2OH + R'OH$$

3. From Grignard reagent

$$>C=O+R \longrightarrow MgX \longrightarrow \left[>C(R)-OMg-X\right] \xrightarrow{H_2O} >C(R)-OH+Mg(OH)X$$

1. From haloarenes
2. From benzene sulphonic acid
3. From diazonium salts
4. From Cumene

1. By dehydration of alcohols

$$CH_3CH_2OH \xrightarrow[413\ K]{H_2SO_4} C_2H_5OC_2H_5$$

2. Williamson synthesis

$$RX + R'ONa \longrightarrow R-O-R' + NaX$$

(i) Physical : • Boiling point increases with increase in the number of C atoms.
• Solubility decreases with increase in size of alky/aryl groups.

(ii) Chemical : $2\text{–R–O–H} + 2Na \longrightarrow 2R\text{–O–}Na + H_2$;Acidity – primary > secondary > tertiary

$$Ar/RO-H + R'-COOH \overset{H^+}{\rightleftharpoons} Ar/ROCOR' + H_2O;\ ROH + HX \longrightarrow R-X + H_2O$$

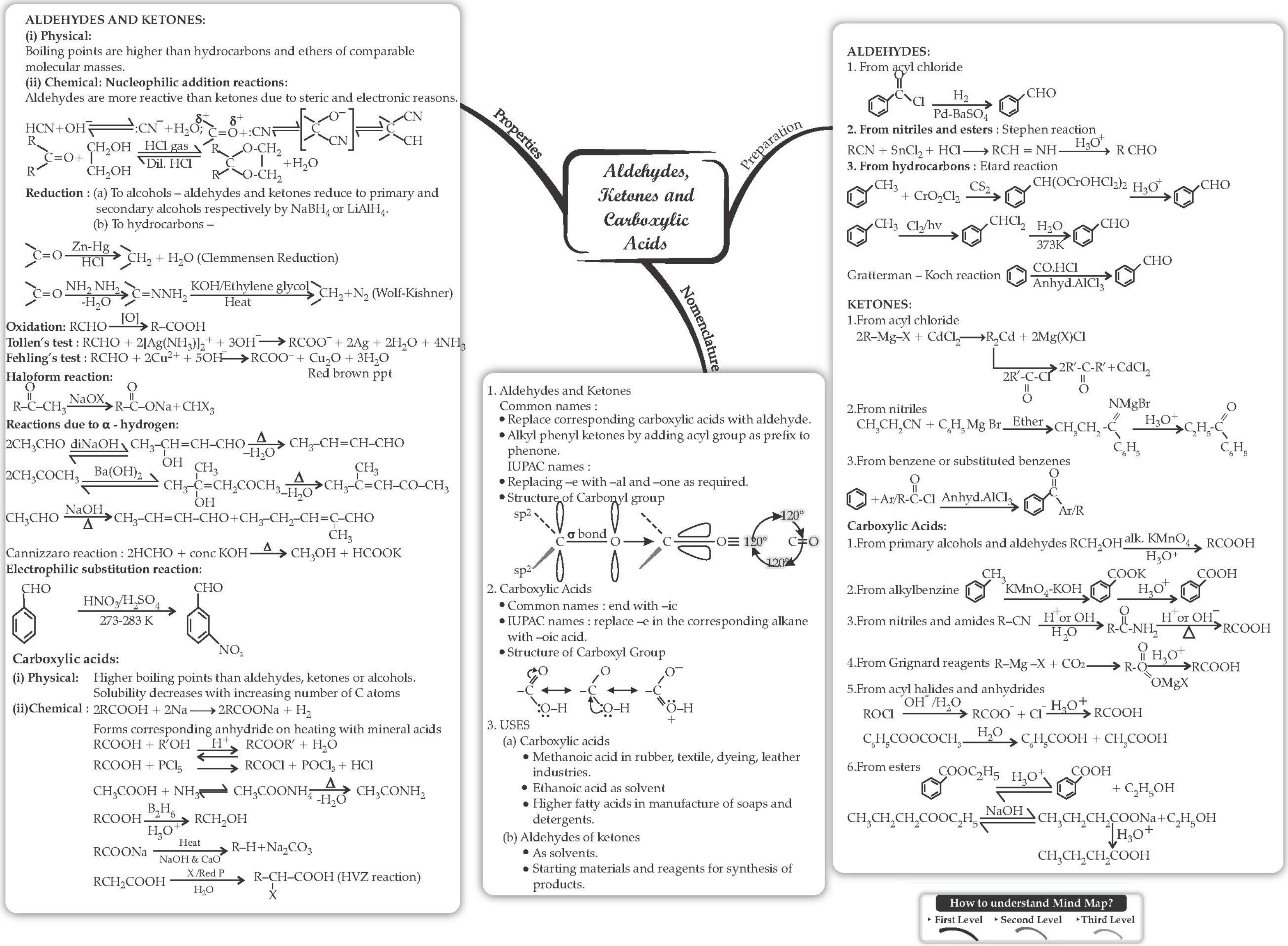
$$C_2H_5OH \xrightarrow[443\ K]{H_2SO_4} CH_2 = CH_2 + H_2O;\ RCH_2OH \xrightarrow{Oxidation} R\text{-}C(H)\text{=}O \longrightarrow R\text{-}C(OH)\text{=}O$$

(i) Physical:
- C–O bonds are polar.
- Boiling points comparable to those of alkanes.
- Solubility in water as alcohols.

(ii) Chemical: $R–O–R + HX \longrightarrow RX + R–OH$

Friedel-Crafts reaction :

- **Methanol (Wood spirit) :**
  Used as solvent in paint, varnishes and making formaldehyde.
- **Ethanol :**
  Used as solvent in paint industry and preparation of a number of carbon compounds.



Aldehydes, Ketones and Carboxylic Acids

ALDEHYDES AND KETONES:

(i) Physical:

Boiling points are higher than hydrocarbons and ethers of comparable molecular masses.

(ii) Chemical: Nucleophilic addition reactions:

Aldehydes are more reactive than ketones due to steric and electronic reasons.

$HCN+OH^- \rightleftharpoons :CN^- + H_2O; \overset{\delta^+}{>C}=\overset{\delta^+}{O}+:CN \rightleftharpoons \left[>C<^{O^-}_{CN}\right] \rightleftharpoons >C<^{CN}_{CH}$

$R_2C=O + \begin{matrix} CH_2OH \\ | \\ CH_2OH \end{matrix} \underset{\text{Dil. HCl}}{\overset{\text{HCl gas}}{\rightleftharpoons}} R_2C<^{O-CH_2}_{O-CH_2} + H_2O$

Reduction : (a) To alcohols – aldehydes and ketones reduce to primary and secondary alcohols respectively by $NaBH_4$ or $LiAlH_4$.

(b) To hydrocarbons –

$>C=O \xrightarrow[\text{HCl}]{\text{Zn-Hg}} >CH_2 + H_2O$ (Clemmensen Reduction)

$>C=O \xrightarrow[-H_2O]{NH_2NH_2} >C=NNH_2 \xrightarrow[\text{Heat}]{\text{KOH/Ethylene glycol}} >CH_2+N_2$ (Wolf-Kishner)

Oxidation: $RCHO \xrightarrow{[O]} R\text{–}COOH$

Tollen's test : $RCHO + 2[Ag(NH_3)]_2{}^+ + 3OH^- \longrightarrow RCOO^- + 2Ag + 2H_2O + 4NH_3$

Fehling's test : $RCHO + 2Cu^{2+} + 5OH^- \longrightarrow RCOO^- + \underset{\text{Red brown ppt}}{Cu_2O} + 3H_2O$

Haloform reaction:

$R\text{–}\overset{O}{\overset{\|}{C}}\text{–}CH_3 \xrightarrow{NaOX} R\text{–}\overset{O}{\overset{\|}{C}}\text{–}ONa + CHX_3$

Reactions due to α - hydrogen:

$2CH_3CHO \underset{}{\overset{\text{diNaOH}}{\rightleftharpoons}} CH_3\text{–}\underset{OH}{\underset{|}{C}}H\text{=CH–CHO} \xrightarrow[-H_2O]{\Delta} CH_3\text{–CH=CH–CHO}$

$2CH_3COCH_3 \overset{Ba(OH)_2}{\rightleftharpoons} CH_3\text{–}\overset{CH_3}{\overset{|}{\underset{OH}{\underset{|}{C}}}}\text{=}CH_2COCH_3 \xrightarrow[-H_2O]{\Delta} CH_3\text{–}\overset{CH_3}{\overset{|}{C}}\text{=CH–CO–}CH_3$

$CH_3CHO \xrightarrow[\Delta]{NaOH} CH_3\text{–CH=CH–CHO}+CH_3\text{–}CH_2\text{–CH=}\underset{CH_3}{\underset{|}{C}}\text{–CHO}$

Cannizzaro reaction : $2HCHO + \text{conc } KOH \xrightarrow{\Delta} CH_3OH + HCOOK$

Electrophilic substitution reaction:

CHO $\xrightarrow[\text{273-283 K}]{HNO_3/H_2SO_4}$ CHO, NO_2

Carboxylic acids:

(i) Physical: Higher boiling points than aldehydes, ketones or alcohols.
Solubility decreases with increasing number of C atoms

(ii)Chemical : $2RCOOH + 2Na \longrightarrow 2RCOONa + H_2$

Forms corresponding anhydride on heating with mineral acids

$RCOOH + R'OH \overset{H^+}{\rightleftharpoons} RCOOR' + H_2O$

$RCOOH + PCl_5 \longrightarrow RCOCl + POCl_3 + HCl$

$CH_3COOH + NH_3 \rightleftharpoons CH_3COONH_4 \xrightarrow[-H_2O]{\Delta} CH_3CONH_2$

$RCOOH \xrightarrow[H_3O^+]{B_2H_6} RCH_2OH$

$RCOONa \xrightarrow[\text{NaOH \& CaO}]{\text{Heat}} R\text{–}H+Na_2CO_3$

$RCH_2COOH \xrightarrow[H_2O]{\text{X /Red P}} R\text{–}\underset{X}{\underset{|}{C}}H\text{–COOH}$ (HVZ reaction)

1. Aldehydes and Ketones

Common names :

- Replace corresponding carboxylic acids with aldehyde.
- Alkyl phenyl ketones by adding acyl group as prefix to phenone.

IUPAC names :

- Replacing –e with –al and –one as required.
- Structure of Carbonyl group

2. Carboxylic Acids

- Common names : end with –ic
- IUPAC names : replace –e in the corresponding alkane with –oic acid.
- Structure of Carboxyl Group

3. USES

(a) Carboxylic acids

- Methanoic acid in rubber, textile, dyeing, leather industries.
- Ethanoic acid as solvent
- Higher fatty acids in manufacture of soaps and detergents.

(b) Aldehydes of ketones

- As solvents.
- Starting materials and reagents for synthesis of products.

ALDEHYDES:

1. From acyl chloride

$\xrightarrow[\text{Pd-BaSO}_4]{H_2}$ CHO

2. From nitriles and esters : Stephen reaction

$RCN + SnCl_2 + HCl \longrightarrow RCH = NH \xrightarrow{H_3O^+} R\,CHO$

3. From hydrocarbons : Etard reaction

$CH_3 + CrO_2Cl_2 \xrightarrow{CS_2} CH(OCrOHCl_2)_2 \xrightarrow{H_3O^+} CHO$

$CH_3 \xrightarrow{Cl_2/hv} CHCl_2 \xrightarrow[373K]{H_2O} CHO$

Gratterman – Koch reaction $\xrightarrow[\text{Anhyd.AlCl}_3]{\text{CO.HCl}}$ CHO

KETONES:

1.From acyl chloride

$2R\text{–Mg–X} + CdCl_2 \longrightarrow R_2Cd + 2Mg(X)Cl$

$\xrightarrow{2R'\text{-}\underset{O}{\underset{\|}{C}}\text{-Cl}} 2R'\text{-}\underset{O}{\underset{\|}{C}}\text{-}R' + CdCl_2$

2.From nitriles

$CH_3CH_2CN + C_6H_5MgBr \xrightarrow{\text{Ether}} CH_3CH_2\text{-}C(=NMgBr)\text{–}C_6H_5 \xrightarrow{H_3O^+} C_2H_5\text{-}C(=O)\text{–}C_6H_5$

3.From benzene or substituted benzenes

$+Ar/R\text{-}\overset{O}{\overset{\|}{C}}\text{-Cl} \xrightarrow{\text{Anhyd.AlCl}_3}$ $\overset{O}{\overset{\|}{C}}$ Ar/R

Carboxylic Acids:

1.From primary alcohols and aldehydes $RCH_2OH \xrightarrow[H_3O^+]{\text{alk. }KMnO_4} RCOOH$

2.From alkylbenzine $CH_3 \xrightarrow{KMnO_4\text{-}KOH} COOK \xrightarrow{H_3O^+} COOH$

3.From nitriles and amides $R\text{–CN} \xrightarrow[H_2O]{H^+ \text{or } OH} R\text{-}\overset{O}{\overset{\|}{C}}\text{-}NH_2 \xrightarrow[\Delta]{H^+ \text{or } OH^-} RCOOH$

4.From Grignard reagents $R\text{–Mg –X} + CO_2 \longrightarrow R\text{-}\overset{O}{\overset{\|}{C}}\text{–OMgX} \xrightarrow{H_3O^+} RCOOH$

5.From acyl halides and anhydrides

$ROCl \xrightarrow{OH^-/H_2O} RCOO^- + Cl^- \xrightarrow{H_3O^+} RCOOH$

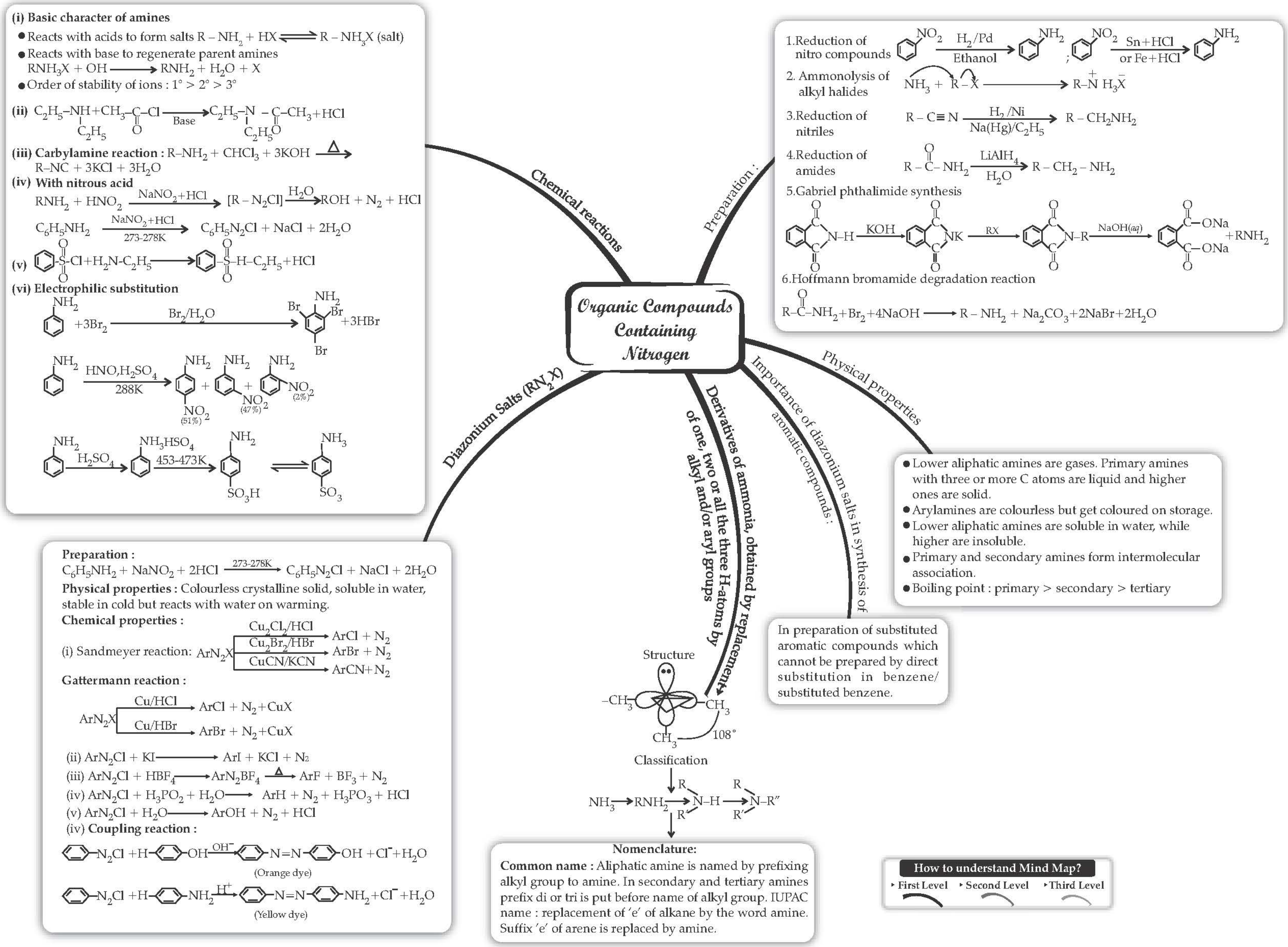
$C_6H_5COOCOCH_3 \xrightarrow{H_2O} C_6H_5COOH + CH_3COOH$

6.From esters

$COOC_2H_5 \overset{H_3O^+}{\rightleftharpoons} COOH + C_2H_5OH$

$CH_3CH_2CH_2COOC_2H_5 \overset{NaOH}{\rightleftharpoons} CH_3CH_2CH_2COONa+C_2H_5OH \xrightarrow{H_3O^+} CH_3CH_2CH_2COOH$

How to understand Mind Map?



1.Reduction of nitro compounds $\xrightarrow[\text{Ethanol}]{H_2/Pd}$; $\xrightarrow[\text{or Fe+HCl}]{\text{Sn+HCl}}$

2. Ammonolysis of alkyl halides $NH_3 + R-X \longrightarrow R-\overset{+}{N}H_3\overset{-}{X}$

3.Reduction of nitriles $R-C\equiv N \xrightarrow[Na(Hg)/C_2H_5]{H_2/Ni} R-CH_2NH_2$

4.Reduction of amides $R-\overset{O}{\overset{\|}{C}}-NH_2 \xrightarrow[H_2O]{LiAlH_4} R-CH_2-NH_2$

5.Gabriel phthalimide synthesis

6.Hoffmann bromamide degradation reaction

$R-\overset{O}{\overset{\|}{C}}-NH_2+Br_2+4NaOH \longrightarrow R-NH_2+Na_2CO_3+2NaBr+2H_2O$

(i) Basic character of amines

- Reacts with acids to form salts $R-NH_2+HX \rightleftharpoons R-NH_3X$ (salt)
- Reacts with base to regenerate parent amines $RNH_3X+OH \longrightarrow RNH_2+H_2O+X$
- Order of stability of ions : 1° > 2° > 3°

(ii) $C_2H_5-\underset{C_2H_5}{NH}+CH_3-\underset{O}{\overset{}{C}}-Cl \xrightarrow[\text{Base}]{} C_2H_5-\underset{C_2H_5}{N}-\underset{O}{C}-CH_3+HCl$

(iii) Carbylamine reaction : $R-NH_2+CHCl_3+3KOH \xrightarrow{\Delta} R-NC+3KCl+3H_2O$

(iv) With nitrous acid

$RNH_2+HNO_2 \xrightarrow{NaNO_2+HCl} [R-N_2Cl] \xrightarrow{H_2O} ROH+N_2+HCl$

$C_6H_5NH_2 \xrightarrow[273\text{-}278K]{NaNO_2+HCl} C_6H_5N_2Cl+NaCl+2H_2O$

(v) $C_6H_5-SO_2-Cl+H_2N-C_2H_5 \longrightarrow C_6H_5-SO_2-H-C_2H_5+HCl$

(vi) Electrophilic substitution

$+3Br_2 \xrightarrow{Br_2/H_2O}$ $+3HBr$

$\xrightarrow[288K]{HNO_3H_2SO_4}$ (51%) + (47%) + (2%)

$\xrightarrow{H_2SO_4}$ NH_3HSO_4 $\xrightarrow{453\text{-}473K}$ $SO_3H \rightleftharpoons SO_3$

- Lower aliphatic amines are gases. Primary amines with three or more C atoms are liquid and higher ones are solid.
- Arylamines are colourless but get coloured on storage.
- Lower aliphatic amines are soluble in water, while higher are insoluble.
- Primary and secondary amines form intermolecular association.
- Boiling point : primary > secondary > tertiary

In preparation of substituted aromatic compounds which cannot be prepared by direct substitution in benzene/ substituted benzene.

$NH_3 \rightarrow RNH_2 \rightarrow R_2NH \rightarrow R_3N$

Nomenclature:

Common name : Aliphatic amine is named by prefixing alkyl group to amine. In secondary and tertiary amines prefix di or tri is put before name of alkyl group. IUPAC name : replacement of 'e' of alkane by the word amine. Suffix 'e' of arene is replaced by amine.

Preparation :

$C_6H_5NH_2+NaNO_2+2HCl \xrightarrow{273\text{-}278K} C_6H_5N_2Cl+NaCl+2H_2O$

Physical properties : Colourless crystalline solid, soluble in water, stable in cold but reacts with water on warming.

Chemical properties :

(i) Sandmeyer reaction: $ArN_2X \xrightarrow{Cu_2Cl_2/HCl} ArCl+N_2$; $\xrightarrow{Cu_2Br_2/HBr} ArBr+N_2$; $\xrightarrow{CuCN/KCN} ArCN+N_2$

Gattermann reaction :

$ArN_2X \xrightarrow{Cu/HCl} ArCl+N_2+CuX$; $\xrightarrow{Cu/HBr} ArBr+N_2+CuX$

(ii) $ArN_2Cl+KI \longrightarrow ArI+KCl+N_2$

(iii) $ArN_2Cl+HBF_4 \longrightarrow ArN_2BF_4 \xrightarrow{\Delta} ArF+BF_3+N_2$

(iv) $ArN_2Cl+H_3PO_2+H_2O \longrightarrow ArH+N_2+H_3PO_3+HCl$

(v) $ArN_2Cl+H_2O \longrightarrow ArOH+N_2+HCl$

(iv) **Coupling reaction :**

$C_6H_5N_2Cl + H-C_6H_4-OH \xrightarrow{OH^-} C_6H_5-N=N-C_6H_4-OH+Cl^-+H_2O$

(Orange dye)

$C_6H_5N_2Cl + H-C_6H_4-NH_2 \xrightarrow{H^+} C_6H_5-N=N-C_6H_4-NH_2+Cl^-+H_2O$

(Yellow dye)

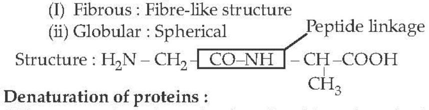
Biomolecules

Proteins

-(Polymers of α–amino acids)
-Amino acids contain $-NH_2$ and $-COOH$ group.

Classification:

- On the basis of relative number of $-NH_2$ and $-COOH$ group:
  - (i) Neutral : Equal number of $-NH_2$ and $-COOH$ group.
  - (ii) Basic : More number of $-NH_2$ than $-COOH$ group.
  - (iii) Acidic : More number of $-COOH$ than $-NH_2$ group.
- On the basis of place of synthesis:
  - (i) Essential – cannot be synthesized in the body.
  - (ii) Non-essential – synthesized in the body.
- On the basis of shape :
  - (I) Fibrous : Fibre-like structure
  - (ii) Globular : Spherical



Structure : $H_2N-CH_2-\boxed{CO-NH}-\underset{CH_3}{\underset{|}{CH}}-COOH$

Denaturation of proteins :
When a protein in its native form is subjected to physical change, globules unfold, helix get uncoiled and protein loses its biological activity.

Vitamins

Organic compounds required in diet in small amounts to perform specific biological functions for maintenance and growth.

Classification:
(i) Fat soluble : Soluble in fats and oils but insoluble in water. (Vitamins A,D,E and K)
(ii) Water soluble : B group and vitamin C are soluble in water.

Nucleic Acids

Chromosomes : Particles in nucleus responsible for heredity. Chromosomes are made up of proteins and nucleic acid.

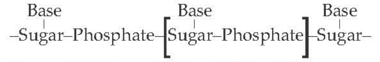
Two types : Deoxyribonucleic acid (DNA), ribonucleic acid (RNA)

Composition : In DNA, sugar is β–D–2–deoxyribose whereas in RNA is β–D–ribose. DNA contains A,G,C,T whereas RNA has A,G,C,U.

Structure : –

Nucleoside : Formed by attachment of a base to 1′ of sugar′

Nucleotide : Formed by link to phosphoric acid at 5′ of sugar.



$-\overset{Base}{\overset{|}{Sugar}}-Phosphate-\left[\overset{Base}{\overset{|}{Sugar}}-Phosphate\right]-\overset{Base}{\overset{|}{Sugar}}-$

Types of RNA : m–RNA, r–RNA, t–RNA

Biological Functions :

- Chemical basis of heredity.
- Responsible for identity of different species of organisms.
- Nucleic acids are responsible for protein synthesis in cell.

DNA Fingerprinting:Unique sequence of bases on DNA.

Enzymes

Globular proteins specific for particular reaction and for particular substrate. Mechanism : Reduces the magnitude of activation energy

Carbohydrates

Optically active polyhydroxy aldehydes or ketones or compounds which produce such units on hydrolysis.

- **Classification:**

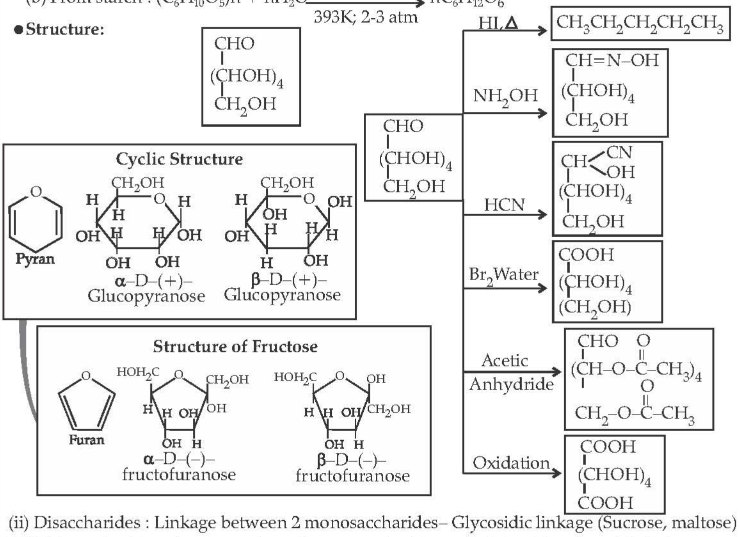
(I) Monosaccharides : (Aldehyde group – aldose, keto group –ketose)

Glucose : Preparation :

(a) From sucrose : $\underset{Sucrose}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{H^+} \underset{Glucose}{C_6H_{12}O_6} + \underset{Fructose}{C_6H_{12}O_6}$

(b) From starch : $(C_6H_{10}O_5)n + nH_2O \xrightarrow[393K;\ 2\text{-}3\ atm]{H^+} nC_6H_{12}O_6$

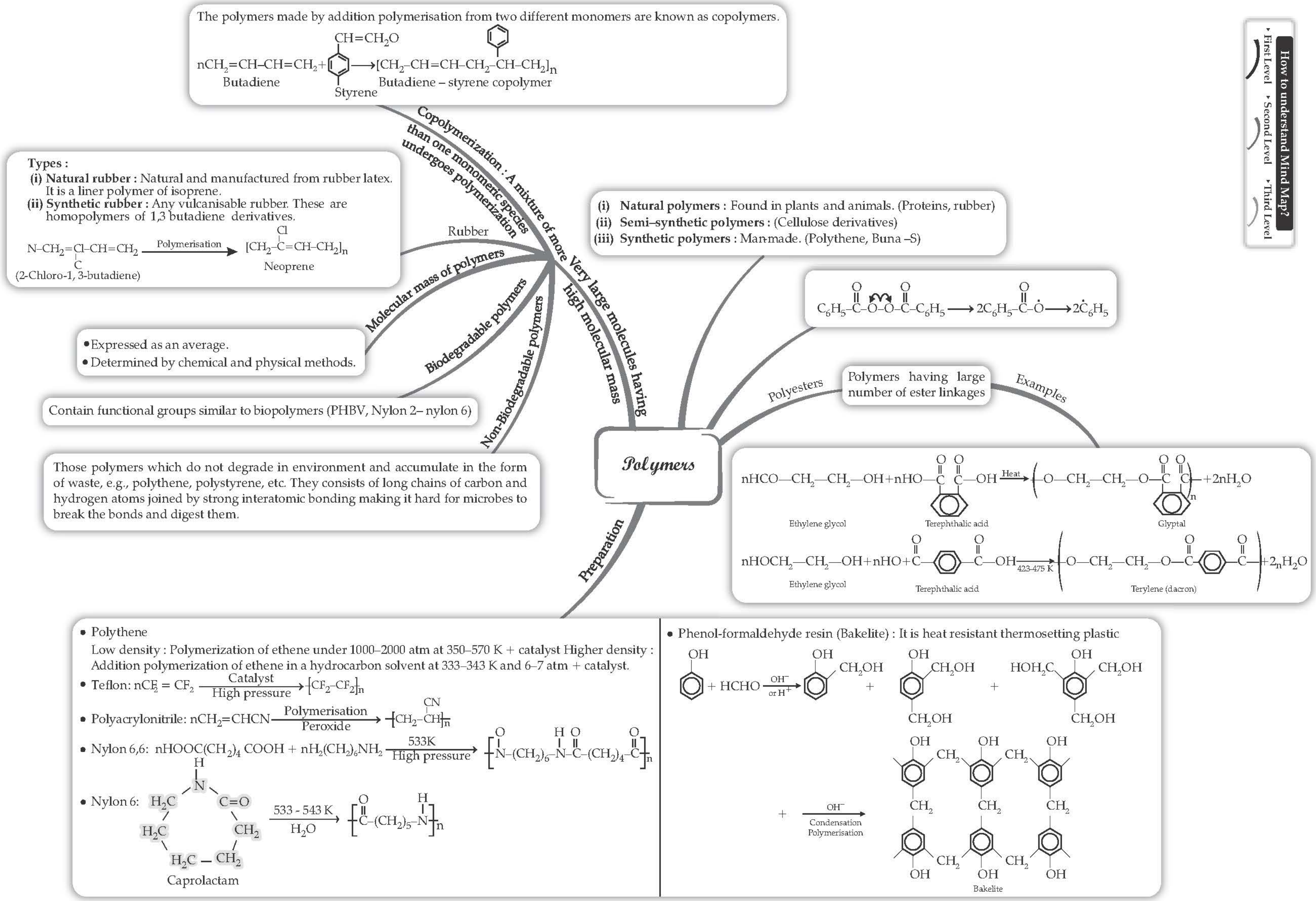
- **Structure:**



(ii) Disaccharides : Linkage between 2 monosaccharides– Glycosidic linkage (Sucrose, maltose)
(iii) Polysaccharides : Large number of monosaccharides units joined by glycosidic linkages.
(a) Starch : Polymer of α–glucose with two components amylase and amylopectin
(b) Cellulose
(c) Glycogen

Importance:

- Form a major portion of food.
- As storage molecules.
- Cellulose forms cell wall of bacteria and plants.
- Raw materials for industries like textiles, paper, lacquers and breweries.



How to understand Mind Map?
- First Level
- Second Level
- Third Level

Polymers

Very large molecules having high molecular mass

Copolymerization : A mixture of more than one monomeric species undergoes polymerization

The polymers made by addition polymerisation from two different monomers are known as copolymers.

$nCH_2{=}CH{-}CH{=}CH_2$ + $CH{=}CH_2O$ (Styrene) $\longrightarrow [CH_2{-}CH{=}CH{-}CH_2{-}CH{-}CH_2]_n$

Butadiene — Styrene — Butadiene – styrene copolymer

Rubber

Types :
(i) **Natural rubber :** Natural and manufactured from rubber latex. It is a liner polymer of isoprene.
(ii) **Synthetic rubber :** Any vulcanisable rubber. These are homopolymers of 1,3 butadiene derivatives.

$N{-}CH_2{=}\underset{|}{\overset{}{Cl}}{-}CH{=}CH_2 \xrightarrow{\text{Polymerisation}} [CH_2{-}\overset{Cl}{\overset{|}{C}}{=}CH{-}CH_2]_n$

(2-Chloro-1, 3-butadiene) — Neoprene

Molecular mass of polymers

- Expressed as an average.
- Determined by chemical and physical methods.

Biodegradable polymers

Contain functional groups similar to biopolymers (PHBV, Nylon 2– nylon 6)

Non-Biodegradable polymers

Those polymers which do not degrade in environment and accumulate in the form of waste, e.g., polythene, polystyrene, etc. They consists of long chains of carbon and hydrogen atoms joined by strong interatomic bonding making it hard for microbes to break the bonds and digest them.

(i) **Natural polymers :** Found in plants and animals. (Proteins, rubber)
(ii) **Semi-synthetic polymers :** (Cellulose derivatives)
(iii) **Synthetic polymers :** Man-made. (Polythene, Buna –S)

$C_6H_5{-}\overset{O}{\overset{||}{C}}{-}O{-}O{-}\overset{O}{\overset{||}{C}}{-}C_6H_5 \longrightarrow 2C_6H_5{-}\overset{O}{\overset{||}{C}}{-}\dot{O} \longrightarrow 2\dot{C}_6H_5$

Polyesters

Polymers having large number of ester linkages

Examples

nHCO—CH$_2$—CH$_2$—OH + nHO—C(O) C(O)—OH $\xrightarrow{\text{Heat}}$ (—O—CH$_2$—CH$_2$—O—C(O) C(O)—)$_n$ + 2nH$_2$O

Ethylene glycol — Terephthalic acid — Glyptal

nHOCH$_2$—CH$_2$—OH + nHO + C(O)—C$_6$H$_4$—C(O)—OH $\xrightarrow{423\text{-}475\text{ K}}$ (—O—CH$_2$—CH$_2$—O—C(O)—C$_6$H$_4$—C(O)—) + 2_nH_2O

Ethylene glycol — Terephthalic acid — Terylene (dacron)

Preparation

- Polythene
  Low density : Polymerization of ethene under 1000–2000 atm at 350–570 K + catalyst Higher density : Addition polymerization of ethene in a hydrocarbon solvent at 333–343 K and 6–7 atm + catalyst.
- Teflon: $nCF_2 = CF_2 \xrightarrow[\text{High pressure}]{\text{Catalyst}} [CF_2{-}CF_2]_n$
- Polyacrylonitrile: $nCH_2{=}CHCN \xrightarrow[\text{Peroxide}]{\text{Polymerisation}} [CH_2{-}\overset{CN}{\overset{|}{CH}}]_n$
- Nylon 6,6: $nHOOC(CH_2)_4\,COOH + nH_2(CH_2)_6NH_2 \xrightarrow[\text{High pressure}]{533K} [\overset{O}{\overset{|}{N}}{-}(CH_2)_6{-}\overset{H}{\overset{|}{N}}{-}\overset{O}{\overset{||}{C}}{-}(CH_2)_4{-}\overset{O}{\overset{||}{C}}]_n$
- Nylon 6: Caprolactam $\xrightarrow[H_2O]{533-543\text{ K}} [\overset{O}{\overset{||}{C}}{-}(CH_2)_5{-}\overset{H}{\overset{|}{N}}]_n$

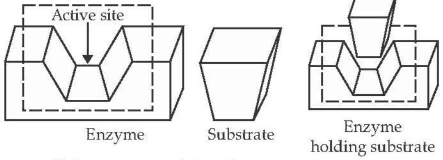
- Phenol-formaldehyde resin (Bakelite) : It is heat resistant thermosetting plastic

Phenol + HCHO $\xrightarrow[\text{or } H^+]{OH^-}$ o-hydroxymethylphenol + p-hydroxymethylphenol + 2,4-bis(hydroxymethyl)phenol... $\xrightarrow[\text{Condensation Polymerisation}]{OH^-}$ Bakelite

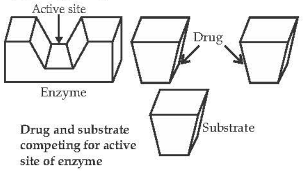
Chemistry in Everyday Life

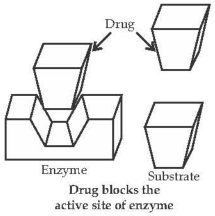
Medicines: Chemicals which generate therapeutic and useful biological response

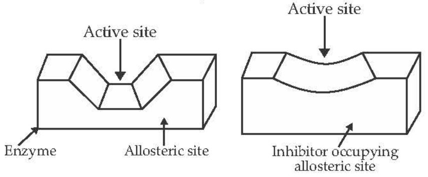
- Drugs are chemicals of low molecular masses. Interact with macromolecular targets to produce a biological response.
- **Classification of drugs:**
  - (a) On the basis of pharmalogical effect : Provides range of drugs available for a particular type of problem. (Analgesics, Antiseptics).
  - (b) On the basis of drug action : (Antihistamines inhibit action of histamine responsible for causing inflammation in the body.
  - (c) On the basis of chemical structure : Common structural features. (Sulphonamides)
  - (d) On the basis of molecular targets : Most useful.
- **Drugs-Target Interaction:**
  - (i) Enzymes as Drug Targets
    - (a) Catalytic action of enzymes



    - (b) Drug–enzyme interaction







  - (ii) **Receptors as Drug Targets**: Receptors are proteins crucial for body's communication and are embedded in cell membrane.

Therapeutic Action of Different Classes of Drugs

- **Antacids :** Substances that neutralize the excess HCl and raise pH in stomach (Ranitidine, Cimetidine).
- **Antihistamines :** Interfere with natural action of histamine by competing with histamine for binding sites of receptor where histamine exerts its effect.
- **Neurologically Active Drugs**
  - (a) **Tranquilizers :** Class of chemical compounds used for the treatment of stress and mild or even severe mental diseases. (Iproniazid, Phenelzine)
  - (b) **Analgesics :** Reduce/abolish pain without causing impairment of consciousness, mental confusion, incoordination or paralysis or other disturbances of nervous system. These are classified as:
    - (i) Non-narcotic (non-addictive) : (Aspirin, Paracetamol)
    - (ii) Narcotic : (Morphine)
- **Antimicrobials**
  - (a) **Antibiotics :** Drugs to treat infections because of their low toxicity for humans and animals. (Prontosil)
  - (b) **Antiseptics and Disinfectants :** Chemicals which either kill or prevent the growth of microorganisms. Antiseptics are applied to living tissues whereas disinfectants are applied to inanimate objects.
- **Antifertility Drugs :** Birth control pills. (Norethindrone, ethynylestradiol)

Chemicals In Food

Purpose:

- For their preservation.
- Enhancing their appeal.
- Adding nutritive value.
  - (a) Artificial Sweetening Agents : Natural sweeteners (sucrose), artificial sweeteners (Aspartame, Saccharin)
  - (b) Food Preservatives : Prevent spoilage of food due to microbial growth. (Table salt, sugar)

Cleansing Agents

Detergents

Types

(i) **Soap (Saponification)**

$$\underset{\text{of stearic acid (fat)}}{\text{Glyceryl ester}} + \underset{\text{hydroxide}}{\text{Sodium}} \longrightarrow \underset{\text{stearate}}{\text{Sodium}} + \text{Glycerol}$$

(ii) **Synthetic Detergents :**

- Anionic detergents : Sodium salts of sulphonated long chain alcohols or hydrocarbons. (Sodium salts of alkyl benzene sulphonates)
- Cationic detergents : Quaternary ammonium salts of amines with acetates, chlorides or bromides as anions. (Cetyltrimethylammonium bromide)
- Non-ionic Detergents : Non-ionic type.

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