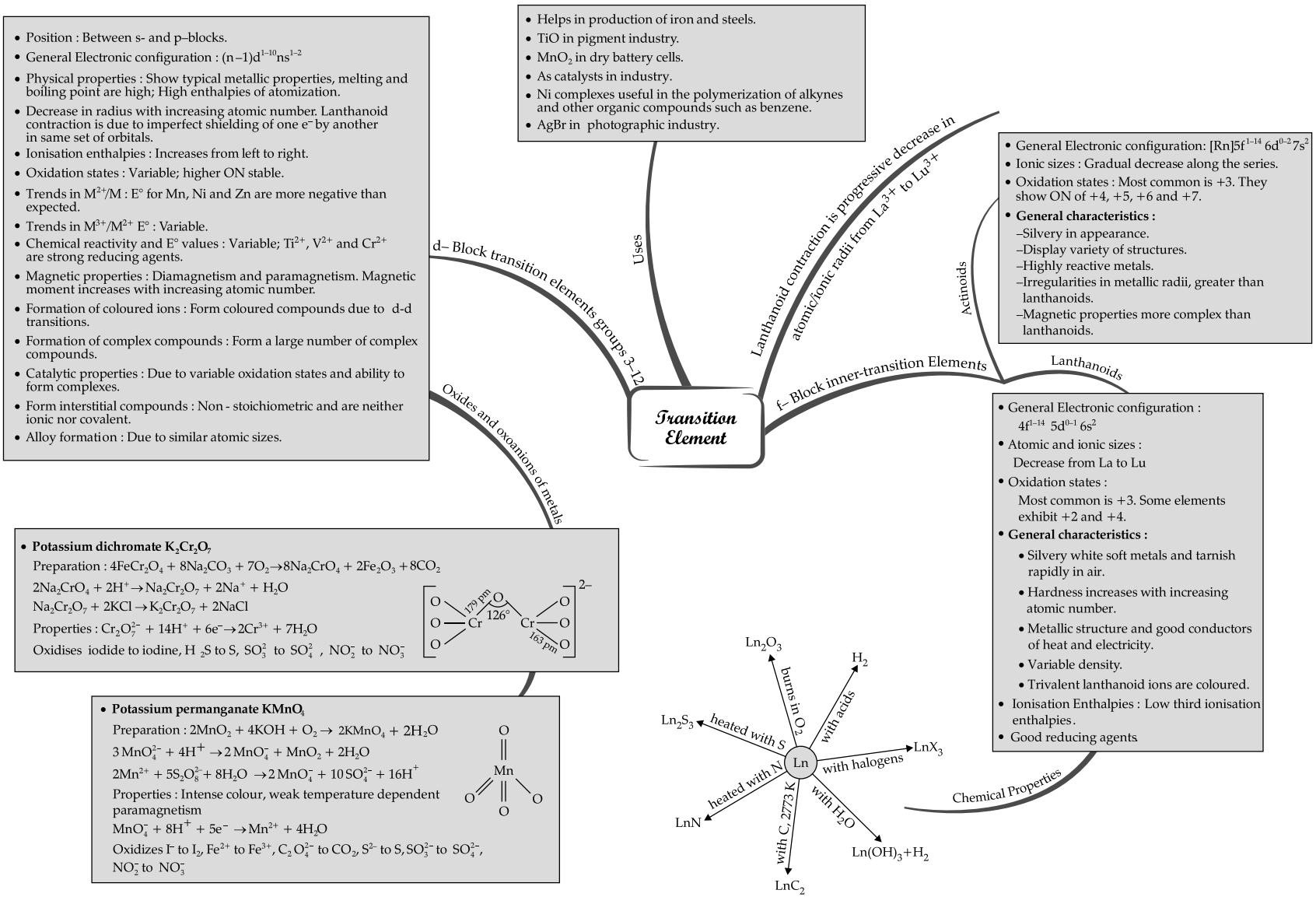
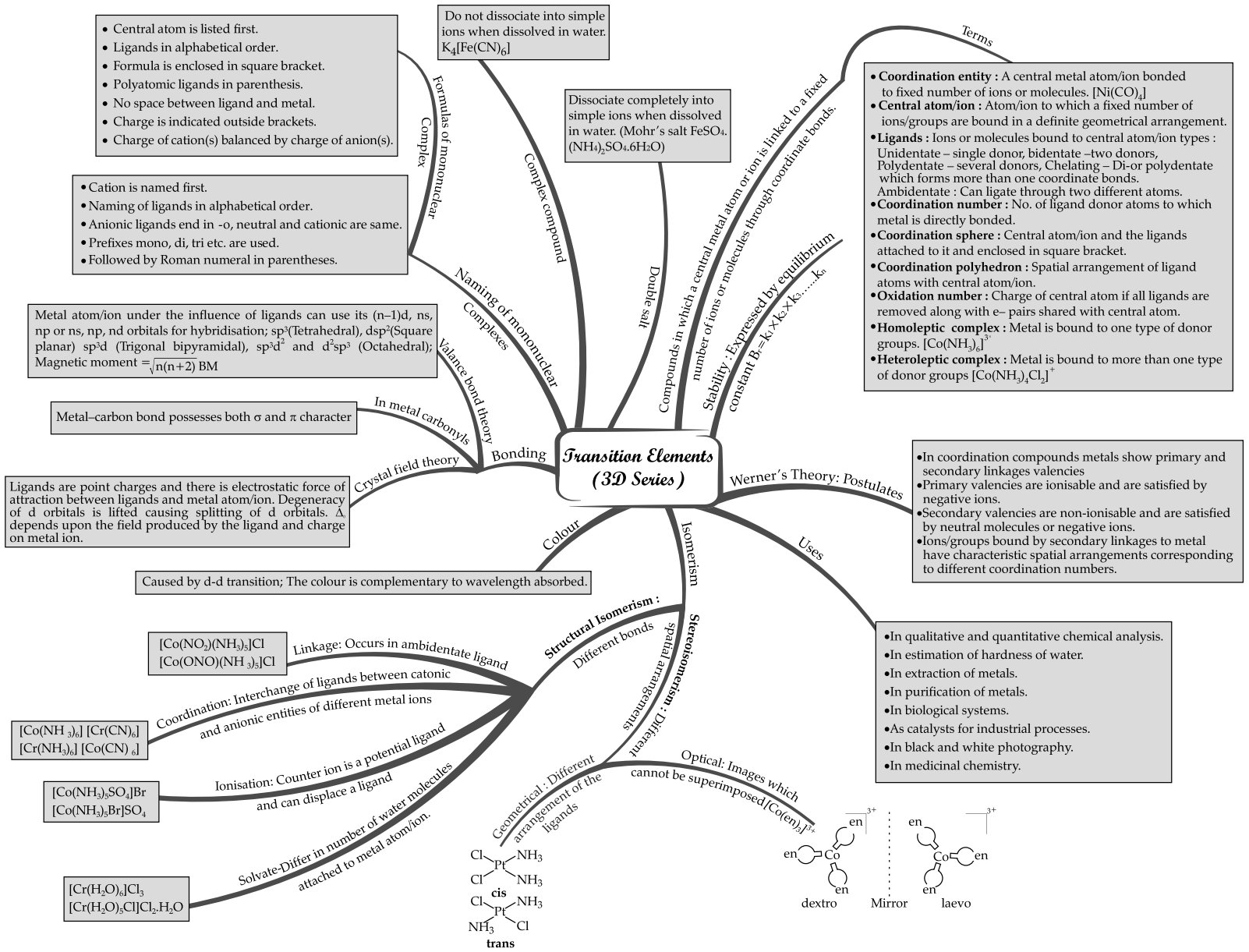
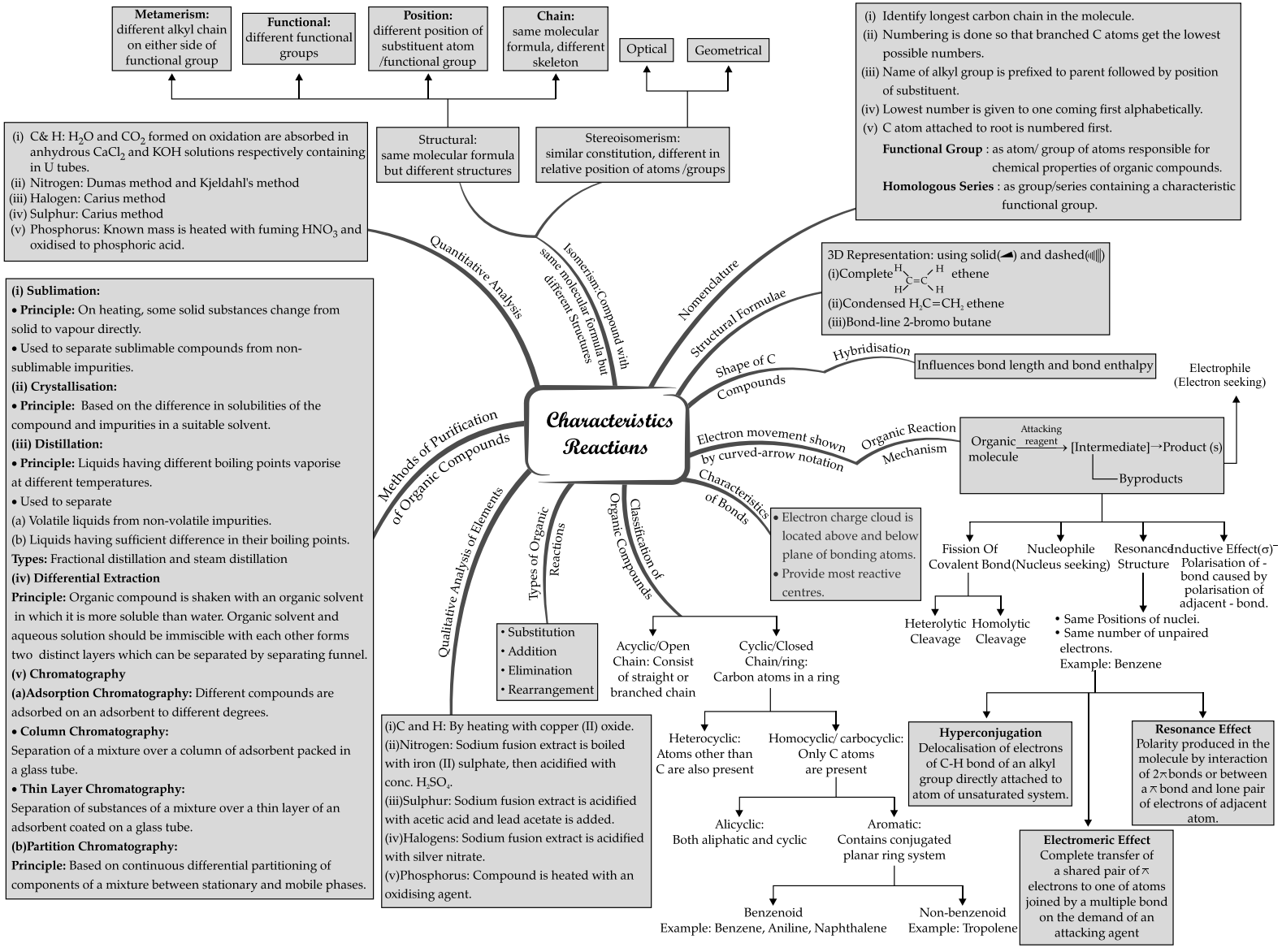

Transition Element
d– Block transition elements groups 3–12
Uses
• Helps in production of iron and steels.
• TiO in pigment industry.
• MnO_2 in dry battery cells.
• As catalysts in industry.
• Ni complexes useful in the polymerization of alkynes and other organic compounds such as benzene.
• AgBr in photographic industry.
• Position : Between s- and p–blocks.
• General 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 enthalpies : Increases from left to right.
• Oxidation states : Variable; higher ON stable.
• Trends in M^{2+}/M : 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 coloured compounds due to d-d transitions.
• Formation of complex compounds : Form a large number of complex compounds.
• Catalytic properties : Due to variable oxidation states and ability to form complexes.
• Form interstitial compounds : Non - stoichiometric and are neither ionic nor covalent.
• Alloy formation : Due to similar atomic 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 iodide to iodine, H_2S to S, SO_3^{2-} to SO_4^{2-}, NO_2^- to NO_3^-
179 pm
126°
163 pm
2–
• 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^-
f– Block inner-transition Elements
Lanthanoid contraction is progressive decrease in atomic/ionic radii from La^{3+} to Lu^{3+}
Actinoids
• General Electronic configuration: $[Rn]5f^{1-14}\ 6d^{0-2}7s^2$
• Ionic sizes : Gradual decrease 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 lanthanoids.
–Magnetic properties more complex than lanthanoids.
Lanthanoids
• General Electronic configuration : $4f^{1-14}\ 5d^{0-1}\ 6s^2$
• Atomic and ionic sizes : Decrease 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
Ln
Ln_2O_3
burns in O_2
H_2
with acids
Ln_2S_3
heated with S
LnX_3
with halogens
heated with N
LnN
with C, 2773 K
LnC_2
with H_2O
$Ln(OH)_3 + H_2$

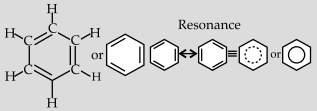

Transition Elements
(3D Series)
Complex compound
Do not dissociate into simple ions when dissolved in water. $K_4[Fe(CN)_6]$
Double salt
Dissociate completely into simple ions when dissolved in water. (Mohr's salt $FeSO_4.(NH_4)_2SO_4.6H_2O$)
Complexes in which a central metal atom or ion is linked to a fixed number of ions or molecules through coordinate bonds.
Stability : Expressed by equilibrium constant $B_n = k_1 \times k_2 \times k_3 \ldots\ldots k_n$
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, bidentate –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 $[Co(NH_3)_4Cl_2]^+$
Naming of mononuclear Complex
Formulas of mononuclear Complex
• 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).
• 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.
Bonding
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 bipyramidal), sp^3d^2 and d^2sp^3 (Octahedral); Magnetic moment $=\sqrt{n(n+2)}$ BM
In metal carbonyls
Metal–carbon bond possesses both σ and π character
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.
Colour
Caused by d-d transition; The colour is complementary to wavelength absorbed.
Isomerism
Structural Isomerism :
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.
$[Cr(H_2O)_6]Cl_3$
$[Cr(H_2O)_5Cl]Cl_2.H_2O$
Stereoisomerism : Different spatial arrangements
Geometrical : Different arrangement of the ligands
Cl Pt NH3 Cl NH3
cis
Cl Pt NH3 NH3 Cl
trans
Optical: Images which cannot be superimposed $[Co(en)_3]^{3+}$
en Co en en en 3+
dextro
Mirror
en Co en en en 3+
laevo
Werner's Theory: Postulates
•In coordination compounds metals show primary and secondary linkages valencies
•Primary valencies are ionisable and are satisfied by negative ions.
•Secondary valencies 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.
•In 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.


Characteristics Reactions
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: 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
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 Formulae
3D Representation: using solid(▬) and dashed(|||)
(i)Complete ethene
(ii)Condensed $H_2C=CH_2$ ethene
(iii)Bond-line 2-bromo butane
Shape of C Compounds
Hybridisation
Influences bond length and bond enthalpy
Electron movement shown by curved-arrow notation
Organic Reaction Mechanism
Organic molecule —Attacking reagent→ [Intermediate]→Product (s)
Byproducts
Electrophile (Electron seeking)
Characteristics of Bonds
• Electron charge cloud is located above and below plane of bonding atoms.
• Provide most reactive centres.
Fission Of Covalent Bond
Heterolytic Cleavage
Homolytic Cleavage
Nucleophile (Nucleus seeking)
Resonance Structure
• Same Positions of nuclei.
• Same number of unpaired electrons.
Example: Benzene
Inductive Effect(σ)
Polarisation of σ-bond caused by polarisation of adjacent σ-bond.
Hyperconjugation
Delocalisation of electrons of C-H bond of an alkyl group directly attached to atom of unsaturated system.
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.
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
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 separating 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.
Qualitative Analysis 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.
Types of Organic Reactions
• Substitution
• Addition
• Elimination
• Rearrangement
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
Benzenoid
Example: Benzene, Aniline, Naphthalene
Non-benzenoid
Example: Tropolene

Hydrocarbons

Aromatic Hydrocarbon

- Types: Benzenoids – contain benzene ring, Non-benzenoids – does not contain benzene ring.
- Isomerism: Ortho (o-), Meat (m-), Para (p-)
- Structure:



- Aromaticity: Planarity, complete delocalisation of the π–electrons 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

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

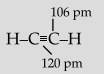
$$C_6H_5OH + Zn \xrightarrow{\Delta} C_6H_6 + ZnO$$

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



- 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:

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

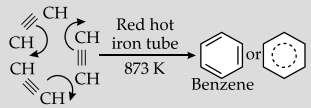
$$HC\equiv CH + H_2 \xrightarrow{Pt/Pd/Ni} [H_2C=CH_2] \xrightarrow{H_2} CH_3-CH_3$$

$$CH_3-C\equiv CH + Br_2 \longrightarrow [CH_3CBr=CHBr] \xrightarrow{Br_2} CH_3-\underset{Br}{\overset{Br}{C}}-\underset{Br}{\overset{Br}{CH}}$$

$$HC\equiv C-H + HBr \longrightarrow [CH_2=CH-Br] \xrightarrow{HBr} \underset{CH_3}{CHBr_2}$$

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

Polymerisation

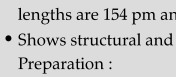


Alkenes (C_2H_{2n})

- Shows structural and geometrical isomerism

Preparation:

$$RC\equiv CR' + H_2 \xrightarrow{Pd/C} \underset{H}{\overset{R}{}}C=C\underset{H}{\overset{R'}{}}$$ cis-Alkene



$$RC\equiv CR' + H_2 \xrightarrow{Na/Liquid\ NH_3} \underset{R'}{\overset{H}{}}C=C\underset{H}{\overset{R}{}}$$ trans-Alkene

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

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

$$CH_3CH_2OH \xrightarrow[\Delta]{conc.H_2SO_4} CH_2=CH_2 + H_2O$$

- Physical Properties :
  - Ethene is a colourless gas with faint sweet smell.
  - All others 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:

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

$$CH_2=CH_2 + HBr \longrightarrow CH_3CH_2Br$$

$$CH_3\text{-}CH=CH_2 + HBr \xrightarrow{Markovnikov\ rule} \begin{cases} CH_3\text{-}\underset{Br}{CH}\text{-}CH_3 \\ CH_3\text{-}CH_2\text{-}CH_2\text{-}Br \end{cases}$$

$$H_3C-\underset{CH_3}{C}=CH_2 + H_2O \xrightarrow{H^+} \underset{CH_3}{\overset{CH_3}{}}\!\!\overset{CH_3}{\underset{CH_3}{C}}\!\!-OH$$

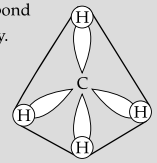
$$CH_3-CH=CH-CH_3 \xrightarrow{KMnO_4/H^+} 2CH_3COOH$$

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

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

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 :

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

Wurtz reaction :

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

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

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

- Physical Properties:

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

  B.P. increases with increases in molecular size.
- Chemical Properties:

$$CH_4 \xrightarrow[hv/-HCl]{+Cl_2} CH_3Cl \xrightarrow[hv/-HCl]{+Cl_2} CH_2Cl_2 \xrightarrow[hv/-HCl]{+Cl_2} CHCl_3 \xrightarrow[hv/-HCl]{+Cl_2} CCl_4$$

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

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

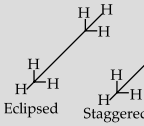
$$CH_4 + O_2 \xrightarrow[\Delta]{Mn_2O_3} HCHO + H_2O$$

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

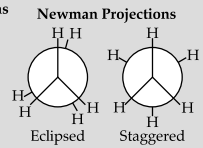
$$CH_4 + H_2O \xrightarrow[\Delta]{Ni} CO + 3H_2$$

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

Sawhorse Projections



Newman Projections



Compounds of Carbon and Hydrogen

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

$$\bigcirc + \text{conc. } HNO_3 + \text{conc. } H_2SO_4 \xrightarrow{323\text{-}333K} \bigcirc\!\!-NO_2 + H_2O$$

$$\bigcirc + Cl_2 \xrightarrow{Anhyd.\ AlCl_3} \bigcirc\!\!-Cl + HCl\ ;\ \bigcirc + H_2SO_4 \xrightarrow{\Delta} \bigcirc\!\!-SO_3H + H_2O$$

$$\bigcirc + CH_3Cl \xrightarrow{Anhyd.\ AlCl_3} \bigcirc\!\!-CH_3 + HCl$$

$$\bigcirc + CH_3COCl \xrightarrow{Anhyd.\ AlCl_3} \bigcirc\!\!-COCH_3 + HCl$$

Classification

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

Haloalkanes and Haloarenes

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.

Racemisation S_N1

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

S_N2 Stereochemical inversion

- (a) Dextro (+/d)
- (b) Laevo (–/l)

Haloalkanes

=>Preparation

- From alcohol :

$$R\text{–}OH + HCl \xrightarrow{ZnCl_2} R\text{–}Cl + H_2O$$

$$3R\text{–}OH + PX_3 \longrightarrow 3R\text{–}X + H_3PO_3$$

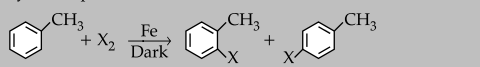
$$ROH + PCl_5 \longrightarrow R\text{–}Cl + POCl_3 + HCl$$

- From hydrocarbons :

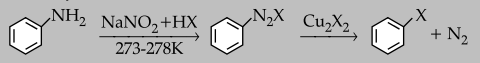
(a) By free radical halogenation

$$CH_3CH_2CH_2CH_3 \xrightarrow{Cl_2/UV} CH_3CH_2CH_2CH_2Cl + CH_3CH_2CHClCH_3$$

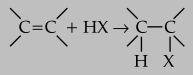
(b) By electrophilic substitution



(c) Sandmeyer's reaction



(d) From alkenes



$$H_2C{=}CH_2 + Br_2 \xrightarrow{CCl_4} BrCH_2\text{–}CH_2Br$$

- Halogen exchange :

$$R\text{–}X + NaI \rightarrow R\text{–}I + NaX$$

=>Properties

- Physical : Colourless, volatile, sweet smell.

Lower members are gases at room temperature while higher are solids.

B.P : RI > RBr > RCl > RF.

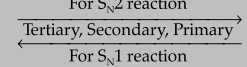
M.P : Para isomers have high m.p. than ortho and meta – isomers.

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

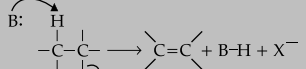


For S_N2 reaction

Tertiary, Secondary, Primary

For S_N1 reaction

(b) Elimination reaction



B = Base; X = Leaving group

(c) Reaction with metals

$$CH_3CH_2Br + Mg \longrightarrow CH_3CH_2MgBr$$

Wurtz reaction :

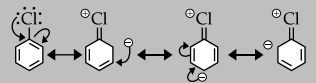
$$2RX + 2Na \xrightarrow{\text{Dry ether}} RR + 2NaX$$

Haloarenes

- Reactions :

(a) Nucleophilic substitution

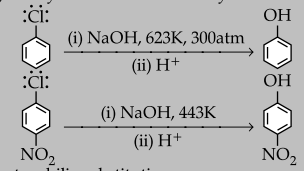
(i) Resonance effect



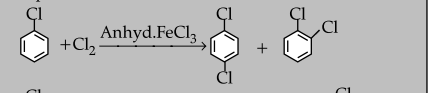
(ii) Hybridization of C – X bond in :

Haloalkane –sp^3; Haloarene –sp^2

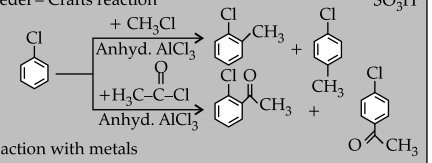
(iii) Phenyl cation unstabilised by resonance



(b) Electrophilic substitution

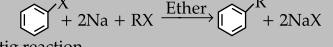


Friedel – Crafts reaction

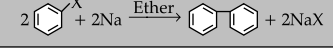


(c) Reaction with metals

Wurtz – Fitting reaction

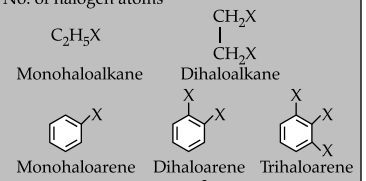


Fittig reaction



Classification

- No. of halogen atoms

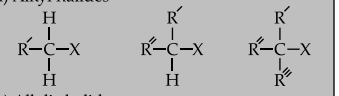


Monohaloalkane Dihaloalkane

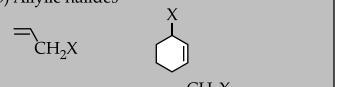
Monohaloarene Dihaloarene Trihaloarene

- Compounds containing sp^3 C–X bond

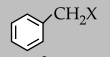
(a) Alkyl halides



(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.

Organic Compounds Containing Oxygen, Alcohols, Phenols And Ethers

Classification

Alcohols

- Mono, Di, Tri, or polyhydric :
  - (i) Containing C_{sp^3} – OH bond
    $-CH_2OH$ (1°) $>CHOH$ (2°) $\geqslant COH$ (3°)
  - (ii) Containing C_{sp^2} –OH bond
    Vinylic alcohol : $CH_2 = CH - OH$ Phenols

Ethers

- (i) Simple/symmetrical : Alkyl or aryl attached to O_2 are same.
- (ii) Mixed/unsymmetrical : Two groups are different.

Nomenclature

- **Alcohols** : Common name : Alkyl group + ol; IUPAC name : substituting 'e' of alkane with suffix 'ol'
- **Phenols** : Common name : Terms ortho, meta and para are used. IUPAC name : Dihydroxy derivatives as 1,2–, 1,3– and 1,4 –benzenediol
- **Ethers** : 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.

Structures of functional groups

- •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.

Preparation

Alcohols

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

(ii) By hydroboration – oxidation

$CH_3-CH=CH_2 + (H-BH_2)_2 \longrightarrow CH_3-\underset{H}{CH}-\underset{BH_2}{CH_2} \xrightarrow{CH_3-CH=CH_2} (CH_3-CH_2-CH_2)_2BH$

$3CH_3-CH_2-CH_2-OH + B(OH)_3 \xleftarrow[3H_2O_2,OH]{H_2O} CH_3-CH_2-CH_2)_3B \xleftarrow{(CH_3-CH=CH_2)}$

2. From carbonyl compounds :

(i) By reduction of aldehydes and ketones

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

(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

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

Phenols

1. From haloarenes

$\xrightarrow[300atm]{623K, +NaOH}$ (Cl → ONa) $\xrightarrow{HCl}$ (OH)

2. From benzene sulphonic acid

(SO$_3$H) $\xrightarrow{Oleum}$ $\xrightarrow[(ii)\ H^+]{(i)\ NaOH}$ (OH)

3. From diazonium salts

(NH$_2$) $\xrightarrow[HCl]{NaNO_2}$ (N$_2$Cl) $\xrightarrow[Warm]{H_2O}$ (OH) $+N_2+HCl$

4. From Cumene

$CH_3-CH-CH_3$ $\xrightarrow{O_2}$ $CH_3-\underset{CH_3}{C}-O-OH$ $\xrightarrow[H_2O]{H^+}$ (OH) $+CH_3COCH_3$

Ethers

1. By dehydration of alcohols

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

2. Williamson synthesis

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

(OH) $+ NaOH \longrightarrow$ (ONa) $\xrightarrow{R-X}$ (OR)

Properties

Alcohols

(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 : $2-R-O-H + 2Na \longrightarrow 2R-O-Na + H_2$;Acidity – primary > secondary > tertiary

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

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

Phenol

(i) Physical :
- Generally colourless liquids and solids
- Slightly solute in water

(ii) Chemical :

Phenol (OH) →
- $\xrightarrow{Dil.\ HNO_3}$ (OH, NO$_2$) + (OH, NO$_2$)
- $\xrightarrow{Conc.\ HNO_3}$ (OH, O$_2$N, NO$_2$, NO$_2$)
- $\xrightarrow[273K]{Br_2\ in\ CS_2}$ (OH, Br) + (OH, Br)
- $\xrightarrow{3Br_2}$ (OH, Br, Br, Br)
- $\xrightarrow{Zn}$ $+ZnO$
- $\xrightarrow[H_2SO_4]{Na_2Cr_2O_7}$ (O, O)

Kolbe's reaction : (OH) $\xrightarrow{NaOH}$ (ONa) $\xrightarrow[(ii)\ H^+]{(i)\ CO_2}$ (OH, COOH)

Reimer Tiemann reaction : (OH) $\xrightarrow[aqNaOH]{CHCl_3}$ (ONa, $CHCl_2$) $\xrightarrow{NaOH}$ (ONa, CHO) $\xrightarrow{H^+}$ (OH, CHO)

Commercially important alcohols

- **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.

Ethers

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

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

(OCH_3) $\xrightarrow[Ethanoic\ acid]{Br_2\ in}$ (OCH_3, Br) + (OCH_3, Br)

(OCH_3) $\xrightarrow[HNO_3]{H_2SO_4}$ (OCH_3, NO_2) + (OCH_3, NO_2)

Friedel-Crafts reaction :

(OCH_3) $+ CH_3Cl \xrightarrow[CS_2]{Anhyd.AlCl_3}$ (OCH_3, CH_3) + (OCH_3, CH_3)

(OCH_3) $+ CH_3COCl \xrightarrow{Anhyd.AlCl_3}$ (OCH_3, $COCH_3$) + (OCH_3, $COCH_3$)

Aldehydes, Ketones and Carboxylic Acids

Properties

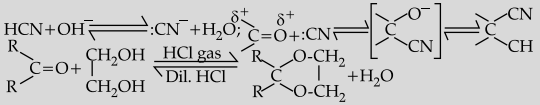
Aldehydes and Ketones:

(i) Physical:

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

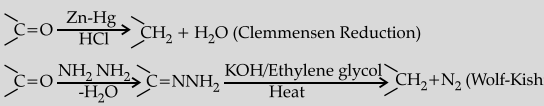
(ii)Chemical :Nucleophilic addition reactions :

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



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

(b) To hydrocarbons –

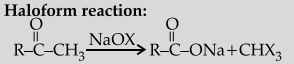


Oxidation: $RCHO \xrightarrow{[O]} R\text{–}COOH$

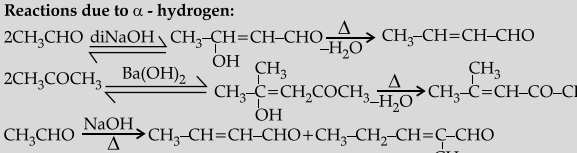
Tollen's test : $RCHO + 2[Ag(NH_3)_2]^+ + 3OH^- \longrightarrow RCOO^- + 2Ag + 2H_2O + 4NH_3$

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

Haloform reaction:

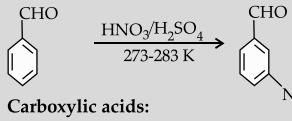


Reactions due to α - hydrogen:



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

Electrophilic substitution reaction:

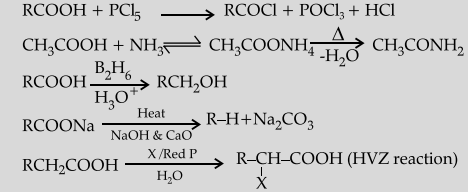


Carboxylic acids:

(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



Nomenclature and uses

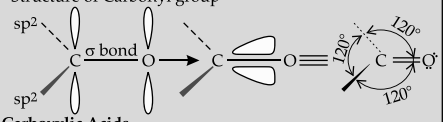
1. Aldehydes and Ketones

Common names :

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

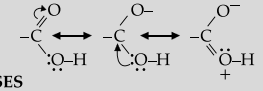
IUPAC names :

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



2. Carboxylic Acids

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



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.

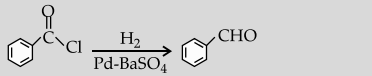
(b) Aldehydes of ketones

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

Preparations

Aldehydes :

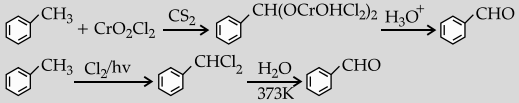
1. From acyl chloride



2. From nitriles and esters : Stephen reaction

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

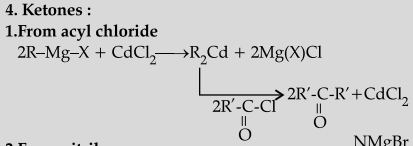
3. From hydrocarbons : Etard reaction



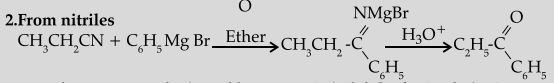
4.Gratterman – Koch reaction

4. Ketones :

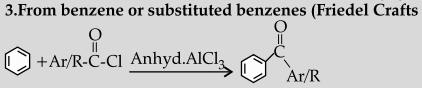
1.From acyl chloride



2.From nitriles



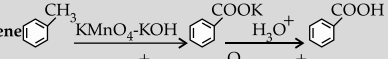
3.From benzene or substituted benzenes (Friedel Crafts Acylation)



Carboxylic Acids:

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

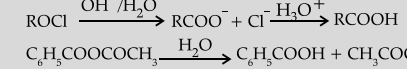
2.From alkylbenzene



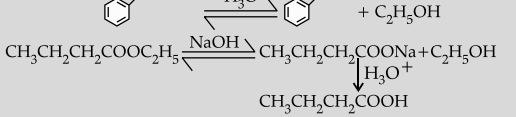
3.From nitriles and amides $R\text{–}CN \xrightarrow[H_2O]{H^+ \text{or } OH^-} R\text{-}C(=O)\text{-}NH_2 \xrightarrow[\Delta]{H^+ \text{or } OH^-} RCOOH$

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

5.From acyl halides and anhydrides



6.From esters



Organic Compounds Containing nitrogen

Chemical reactions

(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 : $1^\circ > 2^\circ > 3^\circ$

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

(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) $C_6H_5-SO_2-Cl + H_2N-C_2H_5 \longrightarrow C_6H_5-SO_2-HNC_2H_5 + HCl$

(vi) Electrophilic substitution

$C_6H_5NH_2 + 3Br_2 \xrightarrow{Br_2/H_2O} 2,4,6\text{-}Tribromoaniline + 3HBr$

$C_6H_5NH_2 \xrightarrow[288K]{HNO_3,\ H_2SO_4}$ *p*-nitroaniline (51%) + *m*-nitroaniline (47%) + 2,4-dinitroaniline (2%)

$C_6H_5NH_2 \xrightarrow{H_2SO_4} C_6H_5NH_3HSO_4 \xrightarrow{453\text{-}473K} C_6H_5(NH_2)(SO_3H) \rightleftharpoons C_6H_5(NH_3^+)(SO_3^-)$

Preparation

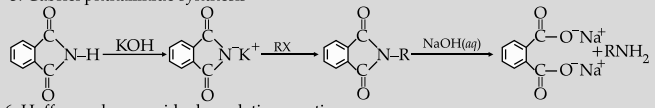
1. Reduction of nitro compounds: $C_6H_5NO_2 \xrightarrow[\text{Ethanol}]{H_2/Pd} C_6H_5NH_2$; $C_6H_5NO_2 \xrightarrow[\text{or Fe+HCl}]{Sn+HCl} C_6H_5NH_2$

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

3. Reduction of nitriles: $R-C\equiv N \xrightarrow[Na(Hg)/C_2H_5OH]{H_2/Ni} R-CH_2NH_2$

4. Reduction of amides: $R-C(=O)-NH_2 \xrightarrow[H_2O]{LiAlH_4} R-CH_2-NH_2$

5. Gabriel phthalimide synthesis



6. Hoffmann bromamide degradation reaction

$R-C(=O)-NH_2 + Br_2 + 4NaOH \longrightarrow R-NH_2 + Na_2CO_3 + 2NaBr + 2H_2O$

Alkyl Isocyanides

Preparation :

$RI + AgCN \longrightarrow RNC + AGI$

Physical Properties :

Colourless, extremely poisonous unpleasant liquid insoluble in water

Chemical Properties :

$R-N\equiv C \xrightarrow{H_3O^+} RNH_2 + HCOOH$

$R-N\equiv C \xrightarrow[C_2H_3O_4]{Na} RNHCH_3$

$R-N\equiv C \xrightarrow{HgO} R-N=C=O$

Physical properties

- 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

Importance of diazonium salts in synthesis of aromatic compounds

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

Diazonium Salts (RN_2X)

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: $ArN_2X \xrightarrow[Cu_2Br_2/HBr]{Cu_2Cl_2/HCl} ArCl + N_2$; $\xrightarrow{} ArBr + N_2$; $\xrightarrow[CuCN/KCN]{} ArCN + N_2$

(ii) Gattermann reaction :

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

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

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

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

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

(vii) **Coupling reaction :**

$ArN_2Cl + H-C_6H_4-OH \xrightarrow{OH^-} ArN=N-C_6H_3(OH) + Cl^- + H_2O$ (Orange dye)

$ArN_2Cl + H-C_6H_4-NH_2 \xrightarrow{H^+} ArN=N-C_6H_3(NH_2) + Cl^- + H_2O$ (Yellow dye)

Alkyl Cyanides

Preparation :

$RI + KCN \xrightarrow{\Delta} RCN + KI$

Physical Properties :

Neutral with unpleasant smell moderately soluble in water

Chemical Properties :

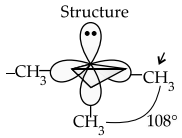
$R-C\equiv N \xrightarrow[NaOH]{H_2O} RCOOH + NH_3$

$R-C\equiv N \xrightarrow[Na/C_2H_5OH]{(H)} RCH_2NH_2$

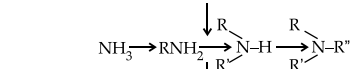
$R-C\equiv N \xrightarrow{R'MgX} R-C(=NMgX)-R' \xrightarrow[-NH_3]{H_2O} R-C(=O)-R'$

Derivatives of ammonia, obtained by replacement of one, two or all the three H-atoms by alkyl and/or aryl groups

Structure



Classification

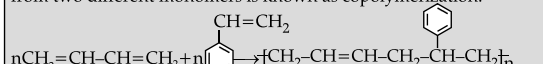


Nomenclature:

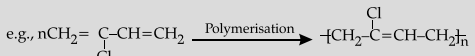
Common name : Aliphatic amine is named by prefixing alkyl group to amine. In secondary and tertiary amines prefix di or tri is put before name of alkyl group. IUPAC name : replacement of 'e' of alkane by the word amine. Suffix 'e' of arene is replaced by amine.

Properties and uses of Some Important Polymers

Copolymerization : The process by which polymers are made by addition polymerisation from two different monomers is known as copolymerization.



Types :
- **(i) Natural rubber :** Natural and obtained from rubber latex. It is polymer of isoprene.
- **(ii) Synthetic rubber :** Any vulcanizable rubber or elastomer



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 consist 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.

Classification on the basis of

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

Structure
- (i) Linear polymers : Polythene
- (ii) Branched polymers : PVC
- (iii) Cross-linked polymers : Bakelite

Heating Behavior
- (i) Thermoplastics : regain their original propenties on cooling e.g., Nylon-6, 6
- (ii) Thermosetting Polymeres : Do not regain their original properties in cooling e.g., Bakelite

Synthesis
- (i) Addition polymers : formed by intermolecular combination by repeating units without elimination of small molecules. e.g., PVC, PAN etc.
- (ii) Condensation polymers : formed by intermolecular combination of repeating units with the elimination of small molecules e.g., Nylon–6, 6 etc.

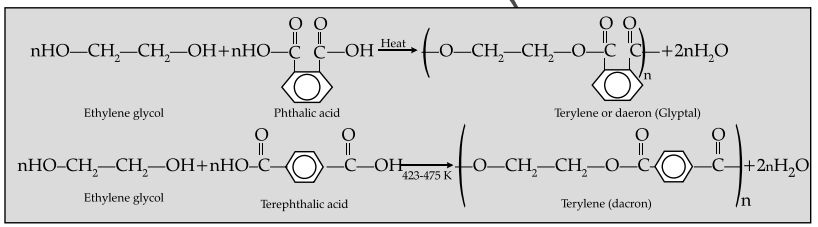
Configuration
- (i) Isotactic polymers : Substituents are arranged on same side.
- (ii) Synditactic polymers : substituents are arranged in alternate manner.
- (iii) Atactic polymers : Substituents are arranged in random manner.

Monomer Units
- (i) Homopolymer : formed by same repeating units –A–A–A–A–
- (ii) Copolymers : formed by different repeating units –A–B–A–B–A–B

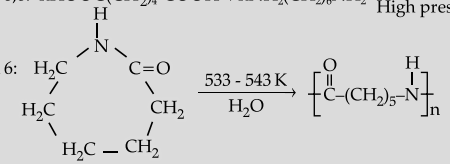
Very large molecules having high molecular mass

Examples

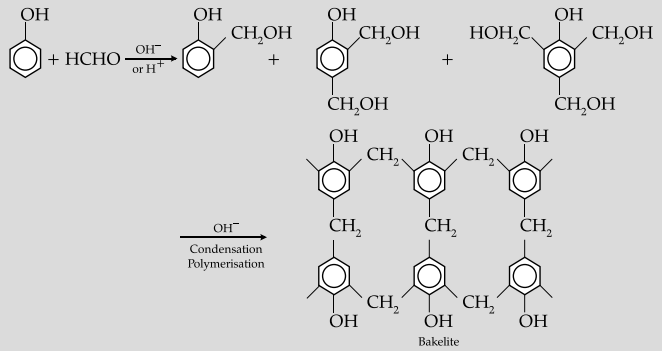
Polyesters — Polymers having large number of ester linkages



Preparations
- Polythene
  Low density : Polymerization of ethene under 1000–2000 atm at 350–570 K + catalyst.
  High 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: $nCH_2=CHCN \xrightarrow[\text{Peroxide}]{\text{Polymerisation}} -[CH_2-CH(CN)]_n-$
- Nylon 6,6: $nHOOC(CH_2)_4COOH + nNH_2(CH_2)_6NH_2 \xrightarrow[\text{High pressure}]{533K} -[NH-(CH_2)_6-NH-CO-(CH_2)_4-CO]_n-$
- Nylon 6:



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



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 : $H_2N – CH_2 –$ [CO–NH] (Peptide linkage) $– CH(CH_3) –$ 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.

Carbohydrates

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

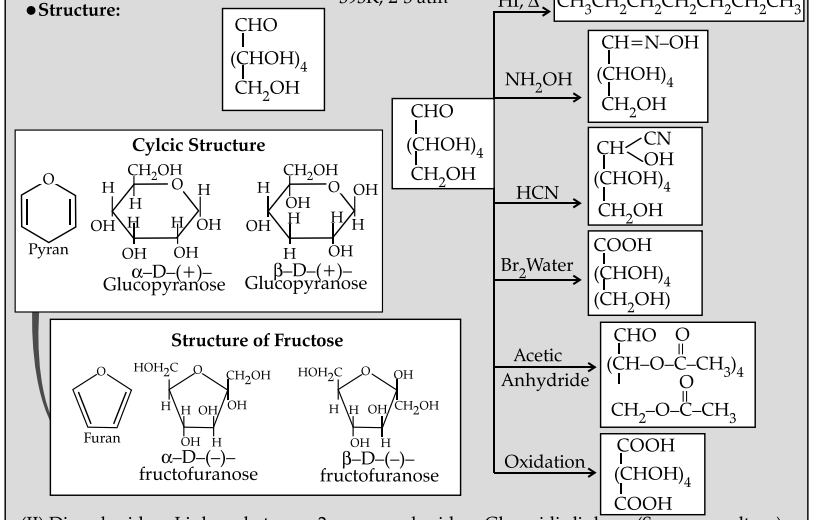
- **Classification:**

(I) Monosaccharides : (Aldehyde group – aldose, Keto group –ketose)
Glucose : Preparation :

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

(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 amylose 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.

Hormones

Chemical substances prodwed by ductless gland called endocrine glanh. e.g., Adrenalin, thyroxine etc.

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.

Base / Base / Base
–Sugar–Phosphate–[Sugar–Phosphate]–Sugar–

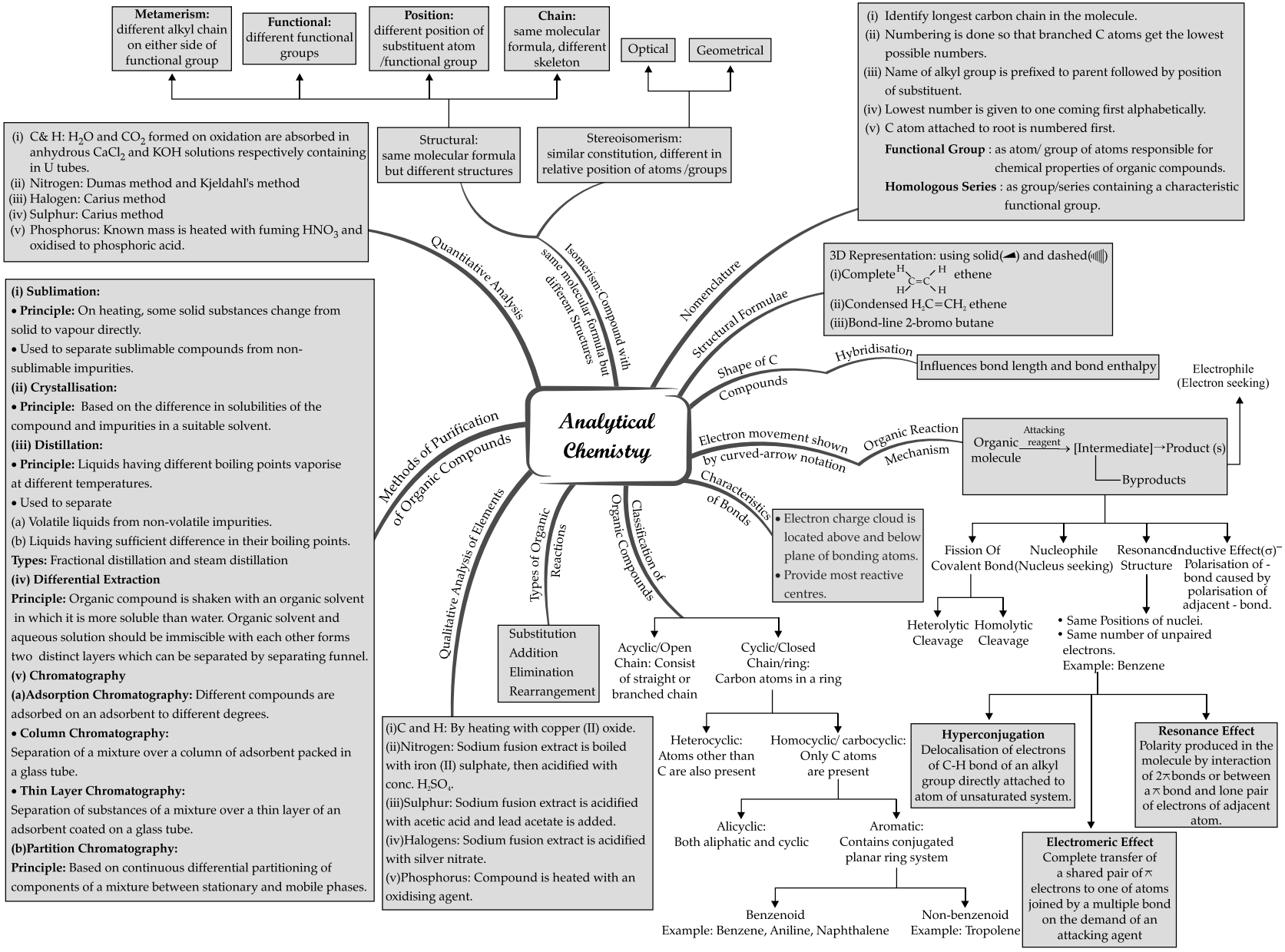
Types of RNA : m–RNA, r–RNA, t–RNA

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


Analytical Chemistry
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
Stereoisomerism: similar constitution, different in relative position of atoms /groups
Metamerism: different alkyl chain on either side of functional group
Functional: different functional groups
Position: different position of substituent atom /functional group
Chain: same molecular formula, different skeleton
Optical
Geometrical
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 Formulae
3D Representation: using solid(◢) and dashed(|||)
(i)Complete ethene
(ii)Condensed $H_2C=CH_2$ ethene
(iii)Bond-line 2-bromo butane
Shape of C Compounds
Hybridisation
Influences bond length and bond enthalpy
Electron movement shown by curved-arrow notation
Organic Reaction Mechanism
Organic molecule —Attacking reagent→ [Intermediate]→Product (s)
Byproducts
Electrophile (Electron seeking)
Nucleophile (Nucleus seeking)
Characteristics of Bonds
• Electron charge cloud is located above and below plane of bonding atoms.
• Provide most reactive centres.
Fission Of Covalent Bond
Heterolytic Cleavage
Homolytic Cleavage
Resonance Structure
• Same Positions of nuclei.
• Same number of unpaired electrons.
Example: Benzene
Inductive Effect(σ)
Polarisation of - bond caused by polarisation of adjacent - bond.
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 separating 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.
Qualitative Analysis 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.
Types of Organic Reactions
Substitution
Addition
Elimination
Rearrangement
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
Benzenoid
Example: Benzene, Aniline, Naphthalene
Non-benzenoid
Example: Tropolene
Hyperconjugation
Delocalisation of electrons of C-H bond of an alkyl group directly attached to atom of unsaturated system.
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.
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

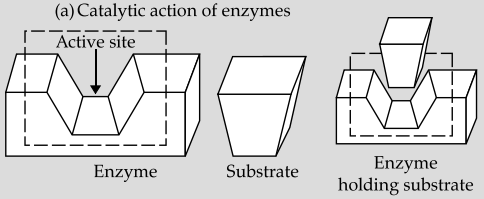
Chemistry in Everyday Life

Therapeutic Action of Different Classes of Drugs

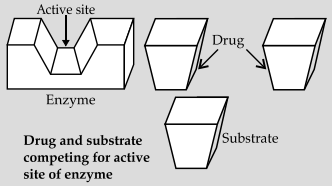
- **Antacids :** Substances that neutralize the excess HCl and raise pH in stomach (Ranitidine, Cimetidine).
- **Antihistamines :** Interfere with natural action of histamine by competing with histamine for binding sites of receptor where histamine exerts its effect.
- **Neurologically Active Drugs**
  - (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)

Medicines:Chemicals which generate therapeutic and useful biological response

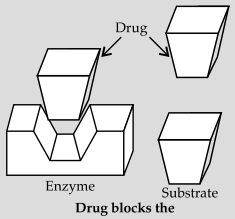
- Drugs are chemicals of low molecular masses. Interact with macromolecular targets to produce a biological response.
- **Classification of drugs:**
  - (a) On the basis of pharmalogical effect : Provides range of drugs available for a particular type of problem. (Analgesics, Antiseptics).
  - (b) On 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



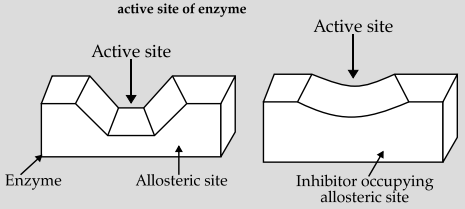
  - (b) Drug–enzyme interaction



Drug and substrate competing for active site of enzyme



Drug blocks the active site of enzyme



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

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

Types

Detergents

(i) **Soap (Saponification)**

Glyceryl ester of stearic acid (fat) + Sodium hydroxide ⟶ Sodium stearate + 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.