DINAKRUSHNA COLLEGE, JALESWAR

Department of Chemistry

QUESTION BANK

Paper II — Core II / Major II: Fundamental Organic Chemistry

Unit / Chapter	Fill in Blanks (1 Mark)	Short Qs (2 Marks)	Medium Qs (5 Marks)	Long Qs (8 Marks)	Total
Unit-I: Basics of Organic Chemistry	10	10	10	5	35
Unit-II: Stereochemistry	10	10	10	5	35
Unit-III: Unsaturated Hydrocarbons	10	10	10	5	35
Unit-IV: Aromatic Hydrocarbons	10	10	10	5	35
Total Prepared	40	40	40	20	140

Unit-I: Basics of Organic Chemistry

Learning Outcome: The learners are able to understand electronic displacement phenomena, types of organic reaction intermediates, their stabilities, and basic alkane reactions.
Detailed Syllabus: Electronic Displacements: Inductive, electromeric, resonance and mesomeric effects, hyperconjugation and their applications in dipole moment; organic acids and bases; their relative strength. Homolytic and heterolytic fission with suitable examples. Curly arrow rules; Electrophiles and Nucleophiles; Nucleophilicity and basicity; Types, shape and relative stability of carbocations, carbanions, free radicals and carbenes. Introduction to types of organic reactions: Addition, Elimination, Substitution, Rearrangement and Pericyclic reactions. Carbon-carbon sigma bonds, chemistry of alkanes: Formation of alkanes, Wurtz Reaction, Corey-House Reactions, Free radical substitutions: Halogenation - relative reactivity and selectivity.

I. Fill in the Blanks (1 Mark each)

1. The permanent displacement of electron pairs along a chain of carbon atoms due to the presence of a polar covalent bond is known as the _____ effect.
2. The temporary electronic displacement that occurs in a multi-bond system only in the presence of an attacking reagent is called the _____ effect.
3. Delocalization of sigma electrons of a C-H bond with an adjacent pi-system or unhybridized p-orbital is termed _____.
4. Symmetrical cleavage of a covalent bond where each atom retains one electron is called _____ fission.
5. Homolytic bond fission leads to the generation of highly reactive species containing an unpaired electron called _____.
6. Chemical species that are electron-deficient and seek an electron pair to form a covalent bond are classified as _____.
7. A negatively charged or neutral species possessing a lone pair of electrons available to attack an electron-deficient carbon atom is a _____.

8. The geometric shape of a methyl carbocation, having sp2 hybridization, is _____.
9. The Corey-House synthesis utilizes a lithium dialkylcuirate reagent, also widely referred to as a _____ reagent.
10. During free-radical halogenation of alkanes, bromine exhibits greater _____ than chlorine, which is highly reactive.

II. Short Answer Questions (2 Marks each)

1. Differentiate between inductive effect and electromeric effect.
2. Explain hyperconjugation with reference to the stability of ethyl carbocation.
3. What is homolytic fission? Give one example.
4. Define nucleophilicity and distinguish it briefly from basicity.
5. Arrange the following carbocations in increasing order of stability: methyl, primary, secondary, tertiary.
6. State the 'curly arrow rules' used to represent electron movement in mechanism pathways.
7. What is a carbene? Name the two spin states of carbenes.
8. Briefly define a pericyclic reaction with a suitable example.
9. Write the chemical equation for the Wurtz reaction and state one of its major limitations.
10. Compare the relative strengths of acetic acid and chloroacetic acid based on inductive effect.

III. Medium Answer Questions (5 Marks each)

1. Discuss the mesomeric/resonance effect, explaining its types (+M and -M) with suitable chemical structures.
2. Explain how the inductive effect influences the relative strengths of organic bases like methylamine and ammonia.
3. Describe the generation, geometric shape, and structural factors influencing the stability of carbanions.
4. Outline the steps involved in the free-radical mechanism of the halogenation of alkanes.
5. Explain the Corey-House reaction mechanism for synthesis of unsymmetrical alkanes.
6. Differentiate between electrophiles and nucleophiles, giving two neutral and two charged examples of each.
7. Discuss homolytic versus heterolytic fission, detailing the types of intermediates produced by each.
8. Illustrate the application of resonance and inductive effects in determining the dipole moments of substituted benzenes.
9. Classify major types of organic reactions (Addition, Elimination, Substitution, Rearrangement) with one example equation for each.
10. Analyze why tertiary free radicals are more stable than primary ones using hyperconjugation diagrams.

IV. Long Answer Questions (8 Marks each)

1. Provide a comprehensive account of electronic displacements (Inductive, Resonance, Hyperconjugation) and discuss their direct applications in determining organic acidity and basicity.
2. Elaborate on the types, shapes, orbital hybridization, and relative stabilities of carbocations, carbanions, and free radicals.

3. Write a detailed essay on the chemistry of alkanes, highlighting the synthetic utility and mechanistic pathways of the Wurtz and Corey-House reactions.
4. Discuss free radical substitution reactions in alkanes comprehensively, focusing on the halogenation mechanism, reactivity-selectivity principles, and energy profiles.
5. Explain the fundamental pathways of organic reactions, contrasting ionic mechanisms (involving electrophiles/nucleophiles) with pericyclic and radical pathways.

Unit-II: Stereochemistry

Learning Outcome: The learners are able to comprehend geometric and optical isomerism, determine molecular configurations using standard CIP rules, and carry out conformational analysis of acyclic and cyclic systems.
Detailed Syllabus: Concept of Chirality/Asymmetry, Geometrical isomerism and Optical Isomerism: Optical Activity, Specific Rotation. Determination of Relative and absolute configuration in chiral molecules using D/L, R/S, cis/trans, Syn/Anti and E/Z descriptors using C.I.P rules. Representation by Fischer Projection, Newmann and Sawhorse Projection formulae in molecules containing one and two chiral-centres. Enantiomers, Diastereoisomers, meso-structures, Racemic mixture and their resolution. Stability and Conformational analysis: types of cycloalkanes and their relative stability, Baeyer strain theory, Conformational analysis of alkanes (ethane and n-butane): Relative stability with energy diagrams, Energy diagrams of cyclohexane: Chair, Half chair, boat and twist boat forms.

I. Fill in the Blanks (1 Mark each)

1. Molecules that are non-superimposable on their mirror images are said to be _____.
2. An equimolar mixture of a pair of enantiomers that exhibits zero net optical activity is called a _____ mixture.
3. The configuration notation system based on priority rules established by Cahn, Ingold, and Prelog is the _____ system.
4. Stereoisomers that are not mirror images of one another are classified as _____.
5. A molecule containing two or more chiral centers but possessing an internal plane of symmetry that renders it optically inactive is called a _____ structure.
6. In the conformational analysis of ethane, the conformation with the highest potential energy is the _____ conformation.
7. The angle strain present in small cycloalkanes is classically explained by the _____ strain theory.
8. The most stable conformation of cyclohexane, which minimizes both angle and eclipsing strain, is the _____ conformation.
9. The specific rotation of an optically active substance is measured using an instrument called a _____.
10. When two identical or high-priority groups lie on opposite sides of a double bond, the configuration is labeled as _____ in the E/Z system.

II. Short Answer Questions (2 Marks each)

1. Define specific rotation and state its mathematical expression.
2. What is a meso compound? Why is it optically inactive?
3. State the Cahn-Ingold-Prelog (CIP) priority rules for assigning configurations.

4. Draw the Newman projection formula for the staggered conformation of n-butane.
5. What are enantiomers? State two physical properties in which they are identical.
6. Briefly explain the limitation of Baeyer's strain theory regarding larger cycloalkanes.
7. Draw the chair and boat conformations of cyclohexane.
8. What is meant by the 'resolution' of a racemic mixture?
9. Differentiate between configuration and conformation.
10. Define geometrical isomerism and give an example of cis/trans isomerism in alkenes.

III. Medium Answer Questions (5 Marks each)

1. Explain optical activity and discuss the structural criteria required for a molecule to show optical isomerism.
2. Describe how to assign R and S configurations to a molecule containing a single chiral center, using an example.
3. Convert a given Sawhorse projection into its corresponding Fischer and Newman projections.
4. Discuss the conformational analysis of n-butane, detailing the relative stabilities of anti, gauche, eclipsed, and fully eclipsed forms.
5. Explain Baeyer's strain theory and calculate the angle strain for cyclopropane and cyclobutane.
6. Compare enantiomers and diastereoisomers with respect to their structures and chemical properties.
7. Discuss the structural features and energy profiles of the four conformations of cyclohexane (chair, half-chair, boat, twist-boat).
8. Illustrate the application of E/Z descriptors in assigning configurations to complex tri- and tetra-substituted alkenes.
9. Explain the concept of asymmetry and chirality, highlighting why chiral centers are not always mandatory for molecular asymmetry.
10. Describe any two chemical or biochemical methods used for the resolution of racemic mixtures.

IV. Long Answer Questions (8 Marks each)

1. Provide a comprehensive account of optical isomerism, covering chirality, enantiomers, diastereomers, racemic mixtures, resolution techniques, and meso-structures.
2. Elaborate on the method of determining absolute configurations (R/S and E/Z systems) using the Cahn-Ingold-Prelog rules with diverse examples.
3. Write a detailed essay on the conformational analysis of open-chain alkanes (ethane and n-butane), highlighting their energy profile diagrams and torsional stability factors.
4. Discuss the stereochemistry of cyclohexane comprehensively, illustrating its diverse conformations and analyzing their stability using detailed energy-level diagrams.
5. Critically evaluate Baeyer's strain theory, explaining its structural successes in small rings and its limitations, followed by the strainless ring theory of Sachse and Mohr.

Unit-III: Chemistry of Unsaturated Hydrocarbons

Learning Outcome: The learners understand the synthesis, stability, and typical addition and elimination mechanisms of alkenes, alkynes, and conjugated dienes.
Detailed Syllabus: Carbon-Carbon Pi Bonds: Formation of alkenes and alkynes by elimination reactions, Mechanism of E1, E2, E1cb reactions. Saytzeff and Hofmann eliminations. Reactions of

alkenes: Electrophilic additions their mechanisms (Markownikoff/AntiMarkownikoff addition), mechanism of oxymercuration-demercuration, hydroboration-oxidation, ozonolysis, syn and anti-hydroxylation (oxidation).1,2- and 1,4-addition reactions in conjugated dienes and Diels-Alder reaction; Reactions of alkynes: Acidity, Electrophilic and Nucleophilic additions. Hydration to form carbonyl compounds, Alkylation of terminal alkynes.

I. Fill in the Blanks (1 Mark each)

1. The elimination reaction that proceeds via a unimolecular pathway involving a carbocation intermediate is the _____ mechanism.
2. According to the _____ rule, the major alkene product in an elimination reaction is the more highly substituted, stable alkene.
3. Electrophilic addition of hydrogen halides to unsymmetrical alkenes follows _____ rule to yield the more stable regioisomer.
4. Hydroboration-oxidation of alkenes results in an overall net addition of water that formally mimics _____ regioselectivity.
5. Ozonolysis of alkenes followed by reductive cleavage with zinc and water yields aldehydes or _____.
6. The reaction of a conjugated diene with an alkene (dienophile) to form a cyclohexene ring is known as the _____ reaction.
7. Syn-hydroxylation of alkenes can be achieved using cold, dilute, alkaline solution of _____.
8. Terminal alkynes are unusually acidic because their C-H bond involves a carbon atom with _____ hybridization.
9. Oxymercuration-demercuration of an alkene avoids structural rearrangements because it does not form a free _____ intermediate.
10. Alkylation of terminal alkynes is initiated by treating the alkyne with a strong base like sodium amide to form an _____ ion.

II. Short Answer Questions (2 Marks each)

1. State Saytzeff's rule and give an example reaction.
2. What is the major difference between E1 and E2 elimination mechanisms?
3. Explain why terminal alkynes are more acidic than alkenes and alkanes.
4. What is the Diels-Alder reaction? Write a basic chemical equation for it.
5. Predict the product when propene undergoes hydroboration-oxidation.
6. What is an E1cb reaction? Under what conditions does it occur?
7. Define 1,2- and 1,4-addition in the context of conjugated dienes.
8. What reagents are used to carry out anti-hydroxylation of alkenes?
9. Show the ozonolysis products of 2-butene.
10. How can you convert ethyne into propyne?

III. Medium Answer Questions (5 Marks each)

1. Describe the step-by-step mechanism of the E2 elimination reaction, highlighting its stereoelectronic requirements.
2. Explain Markownikoff's rule on the basis of carbocation stability using the addition of HBr to propene.

3. Detail the mechanism of oxymercuration-demercuration of alkenes and state its primary advantages over direct hydration.
4. Discuss the mechanism and synthetic applications of the hydroboration-oxidation reaction of alkenes.
5. Examine Hofmann elimination, highlighting the structural factors that favor the formation of the less substituted alkene.
6. Explain the mechanistic details of 1,2- versus 1,4-addition to 1,3-butadiene, outlining kinetic vs. thermodynamic control.
7. Describe the addition of water to alkynes (hydration) catalyzed by mercuric sulfate and sulfuric acid, showing the keto-enol tautomerism step.
8. Discuss the mechanisms of syn-hydroxylation using $KMnO_4$ and anti-hydroxylation using peracids.
9. Illustrate the process of alkylation of terminal alkynes to synthesize higher alkynes.
10. Explain the mechanism of electrophilic addition of halogens (Cl_2 or Br_2) to alkenes via a cyclic halonium ion.

IV. Long Answer Questions (8 Marks each)

1. Provide a comparative analysis of E1, E2, and E1cb elimination mechanisms, focusing on kinetics, intermediates, transition states, and factors influencing product distribution.
2. Elaborate on the electrophilic addition reactions of alkenes, contrasting the mechanisms and stereochemical outcomes of oxymercuration-demercuration, hydroboration-oxidation, and addition of halogen/water.
3. Write a detailed essay on the chemistry of conjugated dienes, explaining their stability, 1,2- and 1,4-addition mechanisms under different temperatures, and the theory of the Diels-Alder reaction.
4. Discuss the chemical properties of alkynes, focusing on their acidic nature, electrophilic addition reactions, nucleophilic addition reactions, and terminal alkylation methods.
5. Explain ozonolysis and hydroxylation of unsaturated hydrocarbons comprehensively, detailing mechanisms, reagents, and practical applications in structure elucidation and synthesis.

Unit-IV: Chemistry of Aromatic Hydrocarbons

Learning Outcome: The students are able to evaluate aromaticity in varied rings, understand electrophilic aromatic substitution mechanisms, and interpret the directing and activating effects of groups.
Detailed Syllabus: Aromaticity: Hückel's rule, aromaticity in benzenoid and non-benzenoid compounds, cyclic carbocations/carbanions and heterocyclic compounds with suitable examples. Electrophilic aromatic substitution with mechanism: halogenation, nitration, sulphonation and Friedel-Craft's alkylation/acylation with their mechanism. Directing effects of the functional groups.

I. Fill in the Blanks (1 Mark each)

1. According to Hückel's rule, a planar, monocyclic, conjugated system is aromatic if it contains _____ pi electrons.
2. A non-benzenoid aromatic hydrocarbon containing a fused five-membered and seven-membered ring system is _____.

3. The cyclopentadienyl anion is aromatic because it possesses a fully delocalized ring system containing _____ pi electrons.
4. During the nitration of benzene, the active attacking electrophile generated in situ is the _____ ion.
5. The active electrophilic species responsible for the sulphonation of benzene is _____.
6. Friedel-Crafts alkylation involves the reaction of an alkyl halide with benzene in the presence of a Lewis acid catalyst like anhydrous _____.
7. Functional groups like -OH and -NH2 activate the benzene ring towards substitution and guide the incoming electrophile to the _____ positions.
8. The -NO2 group is highly deactivating and acts as a _____ director during electrophilic substitution.
9. Pyridine and pyrrole are classic examples of _____ aromatic compounds.
10. A major limitation of Friedel-Crafts alkylation is that the intermediate carbocation can undergo _____ to yield a more stable product.

II. Short Answer Questions (2 Marks each)

1. State Hückel's rule of aromaticity with its conditions.
2. Why is the cyclopropenyl cation stable and considered aromatic?
3. Write the chemical equation for the nitration of benzene, specifying the required reagents.
4. Classify the following as activating or deactivating groups: -OCH3, -COOH, -CH3, -SO3H.
5. What is a non-benzenoid aromatic compound? Give one example.
6. Why does Friedel-Crafts acylation not suffer from rearrangement issues like alkylation?
7. Explain why the cyclopentadienyl cation is anti-aromatic.
8. What is the active electrophile in the bromination of benzene, and how is it generated?
9. Define heterocyclic aromatic compounds and give two examples.
10. What are ortho/para-directing deactivators? Name one such group.

III. Medium Answer Questions (5 Marks each)

1. Explain the concept of aromaticity, anti-aromaticity, and non-aromaticity with one illustrative example for each.
2. Describe the complete step-by-step mechanism for the nitration of benzene, drawing all resonance structures of the sigma complex.
3. Discuss Friedel-Crafts alkylation, its mechanism, and outline three major limitations associated with this reaction.
4. Explain why the amino group (-NH2) is highly activating and ortho/para-directing, using resonance structural arguments.
5. Analyze the mechanism of the sulphonation of benzene, highlighting why it is a reversible reaction.
6. Explain the aromatic character of heterocyclic systems like pyrrole, furan, and pyridine.
7. Discuss the directing and deactivating effect of halogens (-Cl, -Br) on electrophilic aromatic substitution.
8. Describe Friedel-Crafts acylation, its mechanism via the acylium ion, and its advantages over alkylation.
9. Evaluate the aromaticity of the cycloheptatrienyl cation (tropylium ion) and cyclooctatetraene.
10. Explain the meta-directing mechanism of the nitro group (-NO2) by drawing the resonance structures of its intermediate complexes.

IV. Long Answer Questions (8 Marks each)

1. Provide a comprehensive account of aromaticity, establishing Hückel's criteria and analyzing benzenoid, non-benzenoid, cyclic ionic, and heterocyclic aromatic systems.
2. Elaborate on the general mechanism of electrophilic aromatic substitution (SEAr) and detail the specific mechanisms of nitration, halogenation, and sulphonation.
3. Write a comprehensive essay on Friedel-Crafts reactions, contrasting alkylation and acylation with respect to mechanisms, catalysts, scopes, limitations, and synthetic modifications.
4. Discuss orientation and reactivity in electrophilic aromatic substitution, classifying functional groups into distinct categories and explaining their pathways via intermediate stability fields.
5. Write a detailed report on the structures, properties, resonance energies, and typical chemical reactions of benzene, pyrole, and pyridine, highlighting their differences in reactivity profiles.