

FINAL QUESTION PAPER

1. 26. Which of the following is considered a strong nucleophile, favoring SN2 reactions? (a) H₂O (b) CH₃OH (c) I⁻ (d) CH₃COOH
2. 144. Which of the following alkanes will yield only one monobrominated product upon free radical bromination? (a) n-Butane (b) Isobutane (c) Ethane (d) Propane
3. 100. The addition of HBr to ethyne (acetylene) gives mainly: (a) 1,1-dibromoethane (b) 1,2-dibromoethane (c) Bromoethene (d) 2-bromoethene
4. 55. The hydration of propyne in the presence of H₂SO₄ and HgSO₄ produces: (a) Propanal (b) Propan-1-ol (c) Acetone (d) Propanoic acid
5. 131. Which of the following compounds would undergo electrophilic substitution reaction at the slowest rate? (a) Toluene (b) Anisole (c) Nitrobenzene (d) Phenol
6. 30. Which of the following statements is NOT a characteristic of an SN1 reaction? (a) It involves a carbocation intermediate. (b) Its rate depends only on the concentration of the substrate. (c) It is favored by polar aprotic solvents. (d) It can lead to racemization if the carbon is chiral.
7. 89. The intermediate formed during electrophilic aromatic substitution is a resonance-stabilized carbocation. What is this intermediate commonly known as? (a) Carbanion (b) Free radical (c) Arenium ion or sigma complex (d) Enolate ion
8. 97. When bromine water (Br₂/H₂O) is added to ethene, the major product formed is: (a) 1,2-dibromoethane (b) 2-bromoethanol (c) Ethylene glycol (d) Bromoethane
9. 153. Which of the following compounds will exhibit keto-enol tautomerism? (a) 2,2-Dimethylpropanal (b) Benzophenone (c) Cyclohexanone (d) Trimethylacetic acid
10. 54. Identify the statement that is INCORRECT regarding the electrophilic addition of HBr to 1-butyne. (a) The first addition forms a vinyl carbocation. (b) The major product after one equivalent of HBr addition is 2-bromobut-1-ene. (c) Markovnikov's rule is followed for the first addition. (d) After two equivalents of HBr, the final product is 2,2-dibromobutane.
11. 169. The stability of carbocations follows the order: (a) Methyl > Primary > Secondary > Tertiary (b) Tertiary > Secondary > Primary > Methyl (c) Primary > Secondary > Tertiary > Methyl (d) Secondary > Primary > Tertiary > Methyl
12. 7. (R)-3-bromo-3-methylhexane undergoes solvolysis in ethanol. What will be the stereochemical nature of the major product, 3-ethoxy-3-methylhexane? (a) Pure (R) enantiomer (b) Pure (S) enantiomer (c) A racemic mixture (d) An optically active mixture with excess (R) enantiomer
13. 40. Which type of solvent typically favors E1 and SN1 reactions over E2 and SN2 reactions? (a) Aprotic, polar solvent (b) Protic, polar solvent (c) Non-polar solvent (d) Aprotic, non-polar solvent
14. 31. Which of the following statements is true regarding the E2 elimination mechanism? (a) It is a two-step process involving a carbocation intermediate. (b) The rate of reaction depends only on the concentration of the

substrate. (c) It requires an anti-periplanar geometry of the leaving group and the beta-hydrogen. (d) It typically gives Hofmann product as the major product.

15. 81. What is the major product when toluene undergoes monobromination in the presence of FeBr_3 ? (a) Bromobenzene (b) o-Bromotoluene and p-Bromotoluene (c) m-Bromotoluene (d) Benzyl bromide

16. 18. Which of the following carbocations is most stable and thus favors an SN_1 reaction? (a) Primary carbocation (b) Secondary carbocation (c) Tertiary carbocation (d) Methyl carbocation

17. 24. Consider the reaction: $(\text{CH}_3)_3\text{C-Br} + \text{CH}_3\text{OH} \rightarrow (\text{CH}_3)_3\text{C-OCH}_3 + \text{HBr}$. This reaction is likely to proceed via: (a) SN_1 mechanism (b) SN_2 mechanism (c) E_1 mechanism (d) E_2 mechanism

18. 161. Pyridin-2-ol and Pyridin-2(1H)-one are tautomers. This interconversion involves the movement of: (a) An electron pair. (b) A hydroxyl group. (c) A proton and an electron pair. (d) A methyl group.

19. 91. Which of the following species acts as an electrophile in an electrophilic addition reaction? (a) OH^- (b) CN^- (c) H^+ (d) NH_3

20. 152. Consider the keto-enol tautomerism of 2,4-pentanedione (acetylacetone). Which factor primarily contributes to the high percentage of its enol form at equilibrium? (a) Steric hindrance in the keto form. (b) Intramolecular hydrogen bonding in the enol form. (c) Increased resonance stabilization of the keto form. (d) Higher electronegativity of oxygen in the keto form.

21. 125. The correct order of reactivity towards electrophilic substitution for benzene, chlorobenzene, and toluene is: (a) Toluene > Benzene > Chlorobenzene (b) Benzene > Toluene > Chlorobenzene (c) Chlorobenzene > Benzene > Toluene (d) Benzene > Chlorobenzene > Toluene

22. 141. Bromination of alkanes via free radical substitution is generally more selective than chlorination. This is primarily due to: (a) Bromine being a smaller atom than chlorine. (b) The C-H bond breaking in bromination being more endothermic. (c) The bromine radical being less reactive and more stable than the chlorine radical. (d) Higher concentration of bromine used.

23. 105. Hydroboration-oxidation of propene yields: (a) 1-propanol (b) 2-propanol (c) Propanal (d) Propanoic acid

24. 118. Which of the following compounds is most likely to undergo free radical addition polymerization? (a) Benzene (b) Methane (c) Ethene (d) Ethyne

25. 101. Which of the following correctly describes the first step of electrophilic addition of HBr to propene? (a) HBr attacks the carbocation. (b) Br^- attacks the pi bond. (c) H^+ attacks the pi bond to form a carbocation. (d) Br^- attacks the pi bond.

26. 150. If you perform free radical bromination of 2,2,4-trimethylpentane, how many different monobrominated products (structural isomers) could theoretically be formed? (a) 2 (b) 3 (c) 4 (d) 5

27. 159. Which of the following compounds exists predominantly in its enol form due to aromaticity? (a) Phenol (b) Cyclohex-2-en-1-one (c) Acetylacetone (d) Acetaldehyde

28. 132. Halogenation of benzene requires a Lewis acid catalyst because: (a) The Lewis acid makes the benzene ring more reactive. (b) The Lewis acid helps in generating the electrophile (e.g., Br^+). (c) The Lewis acid removes the halogen from the product. (d) The Lewis acid activates the aromatic ring to attack by a nucleophile.

29. 143. Which of the following is NOT a characteristic feature of free radical substitution reactions? (a) Proceed through a chain mechanism. (b) Involve homolytic bond cleavage. (c) Are typically favored by high temperatures or UV light. (d) Involve carbocation intermediates.
30. 120. Which of the following is a key difference between electrophilic addition and free radical addition reactions of alkenes? (a) Electrophilic addition forms free radicals, while free radical addition forms carbocations. (b) Electrophilic addition is always anti-Markovnikov, while free radical addition is always Markovnikov. (c) Electrophilic addition proceeds via carbocations, while free radical addition proceeds via free radicals. (d) Electrophilic addition requires peroxides, while free radical addition does not.
31. 149. To minimize polysubstitution (formation of di-, tri-substituted products) during the free radical halogenation of an alkane, which of the following conditions is generally employed? (a) Use a large excess of alkane. (b) Use a large excess of halogen. (c) Conduct the reaction at very low temperatures. (d) Add an inhibitor.
32. 3. The formation of an equimolar mixture of two enantiomers from an optically active compound is known as: (a) Inversion (b) Retention (c) Racemization (d) Diastereomerization
33. 45. In the E2 elimination of 2-bromo-2,3-dimethylbutane, how many distinct alkene products can be formed? (a) 1 (b) 2 (c) 3 (d) 4
34. 147. In the reaction of methane with chlorine in the presence of UV light, the highly reactive intermediate formed that attacks methane is: (a) Methyl carbocation (b) Chloronium ion (c) Chlorine free radical (d) Methyl carbanion
35. 138. The free radical halogenation of alkanes is typically initiated by: (a) Presence of strong acid (b) High pressure (c) UV light or heat (d) Transition metal catalyst
36. 165. Consider the compound cyclopropanone. Which statement about its keto-enol tautomerism is correct? (a) It readily forms an enol due to angle strain relief. (b) It does not exhibit keto-enol tautomerism due to the absence of alpha-hydrogens. (c) It forms an enol but the equilibrium strongly favors the keto form due to high enol instability. (d) Its enol form is aromatic, making it highly stable.
37. 166. Homolytic bond fission typically results in the formation of: (a) Carbocations (b) Carbanions (c) Free radicals (d) Transition states
38. 77. What is the electrophile generated during the nitration of benzene using concentrated nitric acid and concentrated sulfuric acid? (a) NO^+ (b) NO_2^+ (c) NO_3^- (d) H_3O^+
39. 5. A reaction involving the formation of a carbocation intermediate at a chiral carbon typically leads to which stereochemical outcome? (a) Complete inversion (b) Complete retention (c) Racemization (d) Formation of a single enantiomer
40. 71. Consider the nucleophilic addition of water to a carbonyl compound to form a hydrate. Which carbonyl compound would form the most stable hydrate? (a) Acetone (b) Acetaldehyde (c) Formaldehyde (d) Propanal
41. 12. A racemic mixture is characterized by: (a) Having a zero specific rotation. (b) Being optically active. (c) Containing only one enantiomer. (d) Being composed of diastereomers.
42. 67. What type of product is formed when an aldehyde reacts with a primary amine (R-NH_2) in the presence of a trace amount of acid? (a) Amide (b) Imine (Schiff's base) (c) Nitrile (d) Oxime

43. 76. Which step is generally the rate-determining step in an electrophilic aromatic substitution reaction? (a) Formation of the electrophile. (b) Attack of the electrophile on the aromatic ring to form a sigma complex. (c) Deprotonation of the sigma complex to restore aromaticity. (d) Rearrangement of the electrophile.
44. 51. The addition of bromine (Br_2) to trans-2-butene typically results in: (a) Primarily syn-addition product (b) Primarily anti-addition product (c) Racemic mixture of syn and anti products (d) No reaction due to steric hindrance
45. 137. Which of the following alkyl free radicals is the most stable? (a) Methyl radical (b) Primary alkyl radical (c) Secondary alkyl radical (d) Tertiary alkyl radical
46. 108. Arrange the following free radicals in increasing order of their stability: I. Methyl radical II. Tertiary butyl radical III. Isopropyl radical IV. Ethyl radical (a) $\text{I} < \text{IV} < \text{III} < \text{II}$ (b) $\text{II} < \text{III} < \text{IV} < \text{I}$ (c) $\text{I} < \text{III} < \text{IV} < \text{II}$ (d) $\text{IV} < \text{I} < \text{III} < \text{II}$
47. 157. For a compound to exhibit keto-enol tautomerism, it must possess: (a) A carbonyl group and at least one alpha-hydrogen atom. (b) A double bond and a hydroxyl group. (c) Only a carbonyl group. (d) A carbon atom with four different substituents.
48. 79. For the bromination of benzene, which of the following is the correct set of reagents? (a) Br_2 in CCl_4 (b) Br_2 and H_2O (c) Br_2 and FeBr_3 (d) HBr and FeBr_3
49. 142. What is the correct order of reactivity of hydrogen atoms towards free radical halogenation? (a) Primary H > Secondary H > Tertiary H (b) Tertiary H > Secondary H > Primary H (c) Secondary H > Primary H > Tertiary H (d) Primary H = Secondary H = Tertiary H
50. 70. Which of the following carbonyl compounds will be least reactive towards nucleophilic addition? (a) Ethanal (b) Propanal (c) Butanone (d) 2,2-Dimethylpropanal
51. 107. The primary role of organic peroxides in the anti-Markovnikov addition of HBr to alkenes is to: (a) Stabilize the carbocation intermediate. (b) Act as a Lewis acid to activate the alkene. (c) Undergo homolytic cleavage to produce free radicals. (d) Catalyze the formation of a nucleophile.
52. 44. Increasing the temperature in an elimination reaction (E_1 or E_2) generally: (a) Favors substitution over elimination. (b) Favors elimination over substitution. (c) Has no effect on the product ratio. (d) Favors SN_1 over SN_2 .
53. 93. The major product formed when propene reacts with HBr is: (a) 1-bromopropane (b) 2-bromopropane (c) 1,2-dibromopropane (d) Propyl bromide
54. 27. The energy profile diagram for an SN_1 reaction typically shows: (a) A single transition state (b) One intermediate and one transition state (c) One intermediate and two transition states (d) No intermediates or transition states
55. 106. Which of the following statements is true regarding free radical addition reactions? (a) They involve the initial attack of an electrophile on the pi bond. (b) They proceed via carbocation intermediates. (c) They are initiated by homolytic fission of a covalent bond. (d) They typically follow Markovnikov's rule in the presence of peroxides.
56. 46. Which of the following species acts as an electrophile in the electrophilic addition reaction of propene with HBr ? (a) Propene (b) Bromide ion (Br^-) (c) Hydrogen ion (H^+) (d) Water (H_2O)

57. 68. Which of the following factors contributes to the lower reactivity of ketones compared to aldehydes towards nucleophilic addition? I. Steric hindrance II. +I effect of alkyl groups III. -I effect of alkyl groups (a) I only (b) II only (c) I and II (d) I and III

58. 167. Which of the following species can act as a nucleophile? (a) CH_3^+ (b) H_3O^+ (c) NH_3 (d) BF_3

59. 114. Free radical addition reactions typically require which of the following conditions? (a) Presence of a strong acid catalyst. (b) High pressure and low temperature. (c) UV light or peroxides for initiation. (d) Polar solvent to stabilize carbocations.

60. 29. The stability of a carbocation is primarily enhanced by: (a) Electron-withdrawing inductive effect (b) Electron-donating inductive effect and hyperconjugation (c) Resonance effect in all cases (d) Steric hindrance

61. 56. The stability of carbocations is primarily explained by: (a) Inductive effect and resonance effect (b) Hyperconjugation and inductive effect (c) Resonance effect and hyperconjugation (d) All of the above

62. 84. A deactivating group for electrophilic aromatic substitution will generally: (a) Increase the electron density in the ring. (b) Decrease the electron density in the ring. (c) Have no effect on electron density. (d) Only direct the incoming electrophile to ortho/para positions.

63. 122. In the nitration of benzene, the electrophile involved is: (a) NO_2^+ (b) NO^+ (c) N_2O_4 (d) HNO_3

64. 33. For the reaction of 2-bromopropane with a strong base like sodium ethoxide in ethanol, what is the order of the elimination reaction? (a) First order (b) Second order (c) Zero order (d) Depends on the concentration of 2-bromopropane only

65. 53. Which of the following reagents is used in oxymercuration-demercuration, a reaction that follows Markovnikov's rule without carbocation rearrangement? (a) BH_3 , THF followed by H_2O_2 , NaOH (b) H_2SO_4 , H_2O (c) $\text{Hg}(\text{OAc})_2$, H_2O followed by NaBH_4 (d) Br_2 in CCl_4

66. 17. Which of the following alkyl halides is most reactive towards $\text{S}_\text{N}2$ reaction? (a) $(\text{CH}_3)_3\text{C-Br}$ (b) $\text{CH}_3\text{CH}_2\text{-Br}$ (c) $(\text{CH}_3)_2\text{CH-Br}$ (d) $\text{CH}_3\text{-Br}$

67. 58. Which of the following alkenes would react fastest with HBr ? (a) Ethene (b) Propene (c) 2-Methylpropene (d) 1-Butene

68. 130. Considering the stability of carbocations, which intermediate is formed in the electrophilic attack on an aromatic ring? (a) A benzylic carbocation. (b) A sigma complex (arenium ion). (c) A pi complex. (d) A primary carbocation.

69. 123. Which of the following groups is an ortho-para directing and activating group in electrophilic aromatic substitution? (a) $-\text{NO}_2$ (b) $-\text{COOH}$ (c) $-\text{OH}$ (d) $-\text{CN}$

70. 10. For a nucleophilic substitution reaction to show observable inversion, retention, or racemization, the reactant must possess: (a) A tertiary carbon atom (b) A chiral carbon atom (c) A double bond (d) An aromatic ring

71. 85. The $-\text{NH}_2$ group is a strong activating group and an ortho/para director. Which of the following best explains its directing effect? (a) It is electron-withdrawing by induction. (b) It can donate electrons to the ring by resonance. (c) It is a bulky group that prefers ortho/para. (d) It forms a hydrogen bond with the incoming

electrophile.

72. 35. Which of the following factors does NOT favor an E1 reaction? (a) Weak nucleophile/base (b) Protic solvent (c) Tertiary alkyl halide (d) High concentration of a strong base

73. 36. The E2 reaction of 2-bromobutane with potassium tert-butoxide (a bulky strong base) would primarily yield: (a) But-1-ene (Hofmann product) (b) But-2-ene (Zaitsev product) (c) 2-butanol (d) 2-ethoxybutane

74. 78. Which of the following reagent combinations is used for the nitration of benzene? (a) Conc. HNO₃ and Conc. HCl (b) Conc. H₂SO₄ and Conc. HCl (c) Conc. HNO₃ and Conc. H₂SO₄ (d) Dil. HNO₃ and Dil. H₂SO₄

75. 61. What is the primary characteristic of the carbonyl carbon atom in an aldehyde or ketone that makes it susceptible to nucleophilic attack? (a) It is electron-rich due to the oxygen atom. (b) It is sp² hybridized and planar. (c) It is electron-deficient due to the electronegativity of the oxygen atom. (d) It has a partial negative charge.

76. 156. In the acid-catalyzed enolization of a ketone, which step involves the protonation of the carbonyl oxygen? (a) Loss of alpha-hydrogen from the carbon. (b) Attack of a nucleophile on the carbonyl carbon. (c) Formation of an enolate ion. (d) Activation of the carbonyl group for subsequent deprotonation.

77. 180. Which of the following factors generally stabilizes a carbanion? (a) Presence of electron-donating groups (+I or +M effect) (b) Presence of electron-withdrawing groups (-I or -M effect) (c) Increase in steric hindrance (d) Formation of an sp hybridized carbon center

78. 96. Anti-Markovnikov addition of HBr to an alkene occurs in the presence of: (a) Peroxides (b) UV light (c) Anhydrous AlCl₃ (d) H₂SO₄

79. 174. In an E1 elimination reaction, the rate-determining step involves: (a) Abstraction of a proton by a base (b) Formation of a carbanion (c) Formation of a carbocation (d) Attack by a nucleophile

80. 66. Nucleophilic addition of sodium bisulfite (NaHSO₃) to carbonyl compounds typically forms a crystalline adduct. This reaction is most characteristic for: (a) All ketones and aldehydes. (b) Aldehydes and methyl ketones. (c) Only aldehydes. (d) Only methyl ketones.

81. 23. Which type of solvent is generally preferred for S_N2 reactions? (a) Polar protic (b) Non-polar (c) Polar aprotic (d) Highly acidic

82. 111. A propagation step in a free radical addition reaction involves: (a) Formation of two free radicals from a non-radical species. (b) Reaction of two free radicals to form a non-radical species. (c) Reaction of a free radical with a non-radical species to form a new free radical and a new non-radical species. (d) Reaction of a free radical with a non-radical species to form two new non-radical species.

83. 63. Which of the following statements is true regarding the role of an acid catalyst in the nucleophilic addition to carbonyl compounds? (a) It deprotonates the nucleophile, making it stronger. (b) It increases the steric hindrance around the carbonyl carbon. (c) It protonates the carbonyl oxygen, increasing the electrophilicity of the carbonyl carbon. (d) It converts the carbonyl group into an enol.

84. 16. The rate of an S_N1 reaction depends on the concentration of: (a) only the substrate (b) only the nucleophile (c) both the substrate and the nucleophile (d) neither the substrate nor the nucleophile

85. 135. The attacking species in an electrophilic substitution reaction is always: (a) Electron-rich (b) Electron-deficient (c) Neutral (d) A free radical

86. 176. The addition of HBr to propene in the absence of peroxides follows: (a) Free radical addition mechanism (b) Electrophilic addition mechanism (c) Nucleophilic addition mechanism (d) Elimination mechanism

87. 170. Which electronic effect involves the delocalization of pi electrons through conjugation, where electron-donating groups stabilize carbocations and destabilize carbanions? (a) Inductive effect (b) Hyperconjugation (c) Mesomeric effect (+M) (d) Electromeric effect

88. 41. The major product obtained when 1-bromo-1-methylcyclohexane is treated with a strong base like sodium methoxide in methanol at high temperature is: (a) 1-methoxy-1-methylcyclohexane (b) 1-methylcyclohexene (c) Methylene cyclohexane (d) 1-methylcyclohexanol

89. 173. An SN2 reaction primarily involves: (a) Racemization (b) A carbocation intermediate (c) A single, concerted step (d) A polar protic solvent

90. 6. When (S)-2-chlorobutane reacts with a strong nucleophile like OH⁻ in the presence of a polar aprotic solvent, the major product will predominantly have which configuration? (a) (S) configuration (b) (R) configuration (c) A racemic mixture of (S) and (R) configurations (d) An achiral product

91. 52. The acid-catalyzed hydration of 2-methylpropene yields predominantly: (a) 2-methyl-1-propanol (b) 2-methyl-2-propanol (c) 1-butanol (d) 2-butanol

92. 8. Which statement is correct regarding Walden inversion? (a) It exclusively occurs in SN1 reactions. (b) It involves the breaking and formation of bonds simultaneously in a concerted manner. (c) It results in a racemic mixture. (d) It refers to the preservation of configuration.

93. 140. When propane undergoes free radical monochlorination, how many possible structural isomers of monochloropropane can be formed? (a) 1 (b) 2 (c) 3 (d) 4

94. 1. Which of the following terms describes the complete change in the spatial arrangement of bonds around a chiral center during a chemical reaction? (a) Racemization (b) Inversion (c) Retention (d) Epimerization

95. 39. Consider the reaction of 2-bromo-2-methylpropane with ethanol (weak base/nucleophile) at elevated temperature. The major organic product will be formed via: (a) SN1 mechanism (b) SN2 mechanism (c) E1 mechanism (d) E2 mechanism

96. 99. Which of the following alkenes would react fastest with HBr? (a) Ethene (b) Propene (c) 2-methylpropene (d) 1-butene

97. 87. Which of the following aromatic compounds is most reactive towards nitration? (a) Nitrobenzene (b) Benzoic acid (c) Toluene (d) Chlorobenzene

98. 127. Aniline does not undergo Friedel-Crafts reactions due to: (a) The amino group being an ortho-para director. (b) The amino group being a strong activator. (c) Formation of a complex with the Lewis acid catalyst (AlCl₃). (d) Steric hindrance from the amino group.

99. 48. What is the major product when propene reacts with HBr in the absence of peroxides? (a) 1-Bromopropane (b) 2-Bromopropane (c) 1,2-Dibromopropane (d) Propane

100. 69. The reaction of propanone with methanol in the presence of dry HCl gas forms: (a) Hemiacetal (b) Acetal (c) Ketal (d) Enol

101. 83. Which of the following groups is an activating group for electrophilic aromatic substitution? (a) $-\text{NO}_2$ (b) $-\text{COOH}$ (c) $-\text{OCH}_3$ (d) $-\text{CN}$

102. 20. The $\text{S}_\text{N}1$ reaction of an optically active alkyl halide typically results in: (a) Inversion of configuration (b) Retention of configuration (c) Complete racemization (d) Partial racemization or complete racemization depending on conditions

103. 80. In Friedel-Crafts alkylation of benzene, what is the primary role of a Lewis acid like anhydrous AlCl_3 ? (a) To act as a nucleophile. (b) To generate the carbocation electrophile. (c) To protonate the aromatic ring. (d) To abstract a proton from the sigma complex.

104. 95. In the addition of HCl to 3,3-dimethyl-1-butene, the major product will involve: (a) Formation of a primary carbocation (b) Hydride shift rearrangement (c) Methyl shift rearrangement (d) Elimination reaction

105. 102. Electron-donating groups attached to the double bond of an alkene generally: (a) Decrease the rate of electrophilic addition. (b) Increase the rate of electrophilic addition. (c) Have no effect on the rate. (d) Convert the reaction into a substitution reaction.

106. 124. The product formed when toluene undergoes nitration is primarily: (a) m-nitrotoluene (b) o-nitrotoluene and p-nitrotoluene (c) a mixture of all three isomers (d) p-nitrotoluene only

107. 117. Identify the major product of the reaction: $\text{CH}_3\text{-CH=CH}_2 + \text{HBr} \xrightarrow{(\text{ROOR}, \text{heat/light})}$ Product (a) $\text{CH}_3\text{-CH(Br)-CH}_3$ (b) $\text{CH}_3\text{-CH}_2\text{-CH}_2\text{Br}$ (c) $\text{CH}_2\text{(Br)-CH=CH}_2$ (d) $\text{CH}_3\text{-CH=CH-Br}$

108. 38. An anti-periplanar arrangement is essential for which of the following elimination reactions? (a) E_1 reaction (b) E_2 reaction (c) Both E_1 and E_2 reactions (d) Neither E_1 nor E_2 reactions

109. 22. Which type of solvent is generally preferred for $\text{S}_\text{N}1$ reactions? (a) Polar aprotic (b) Non-polar (c) Polar protic (d) Aprotic non-polar

110. 21. Which of the following is the best leaving group in a nucleophilic substitution reaction? (a) $-\text{OH}$ (b) $-\text{Cl}$ (c) $-\text{F}$ (d) $-\text{I}$

111. 25. Carbocation rearrangements are most likely to occur during which type of nucleophilic substitution reaction? (a) $\text{S}_\text{N}1$ reactions (b) $\text{S}_\text{N}2$ reactions (c) Both $\text{S}_\text{N}1$ and $\text{S}_\text{N}2$ reactions (d) Neither $\text{S}_\text{N}1$ nor $\text{S}_\text{N}2$ reactions

112. 109. What is the major product formed when propene reacts with HBr in the presence of benzoyl peroxide? (a) 2-Bromopropane (b) 1-Bromopropane (c) 1,2-Dibromopropane (d) 2,2-Dibromopropane

113. 104. Which of the following carbocations is most stable? (a) CH_3^+ (b) CH_3CH_2^+ (c) $(\text{CH}_3)_2\text{CH}^+$ (d) $(\text{CH}_3)_3\text{C}^+$

114. 47. The reactive intermediate formed during the hydrohalogenation of an unsymmetrical alkene following Markovnikov's rule is a: (a) Carbocation (b) Carbanion (c) Free radical (d) Alkyl halide

115. 14. If a chiral reactant undergoes a reaction where the new chiral center is formed, and the reaction proceeds via a planar intermediate (e.g., carbocation), what will be the stereochemical outcome if no chiral auxiliary is

used? (a) Complete retention (b) Complete inversion (c) A racemic mixture (d) Formation of only one enantiomer

116. 98. The intermediate formed during the acid-catalyzed hydration of an alkene is a: (a) Carbanion (b) Free radical (c) Carbocation (d) Alkoxide ion

117. 9. A nucleophilic substitution reaction of a chiral alkyl halide produces a product with the same configuration as the reactant. This implies the reaction proceeded with: (a) Complete inversion (b) Racemization (c) Retention of configuration (d) Formation of an achiral intermediate

118. 178. The formation of an equimolar mixture of enantiomers from a single enantiomer or an achiral starting material is known as: (a) Inversion (b) Retention (c) Racemization (d) Diastereomerization

119. 175. Which statement is true for an E2 elimination reaction? (a) It is a two-step process involving a carbocation intermediate. (b) The rate depends only on the concentration of the substrate. (c) It requires a strong base. (d) It is favored by polar protic solvents.

120. 43. Which of the following conditions would favor an E2 elimination over an SN2 reaction for a secondary alkyl halide? (a) A weak base in a protic solvent (b) A strong, bulky base in an aprotic solvent (c) A strong nucleophile in a polar protic solvent (d) Low temperature

121. 86. Which of the following substituents is a meta-director for electrophilic aromatic substitution? (a) -CH₃ (b) -OH (c) -SO₃H (d) -NH₂

122. 2. A reaction is said to involve 'retention of configuration' if: (a) The product formed is an enantiomer of the reactant. (b) The spatial arrangement of groups around the chiral center in the product is the same as in the reactant. (c) A mixture of enantiomers is formed in equal proportions. (d) The reactant is converted into a non-chiral product.

123. 133. Sulfonation of benzene is a reversible reaction. Which of the following conditions would favor desulfonation (removal of -SO₃H group)? (a) Heating with fuming H₂SO₄. (b) Heating with dilute H₂SO₄ or steam. (c) Reaction with SOCl₂. (d) Reaction with NaOH.

124. 57. When ethene reacts with HBr, the bond broken in ethene is: (a) Sigma bond (b) Pi bond (c) Both sigma and pi bonds (d) C-H bond

125. 179. Carbocation rearrangements, such as hydride or alkyl shifts, typically occur to: (a) Form a less stable carbocation (b) Form a more stable carbocation (c) Facilitate nucleophilic attack (d) Achieve steric hindrance

126. 34. What is the most stable carbocation intermediate that can be formed during an E1 reaction? (a) Primary carbocation (b) Secondary carbocation (c) Tertiary carbocation (d) Methyl carbocation

127. 155. The tautomerism observed in nitromethane (CH₃-NO₂) is an example of: (a) Keto-enol tautomerism (b) Lactam-lactim tautomerism (c) Nitro-aci-nitro tautomerism (d) Amide-iminol tautomerism

128. 4. Which type of nucleophilic substitution reaction typically proceeds with inversion of configuration at the chiral center? (a) SN1 reaction (b) SN2 reaction (c) Both SN1 and SN2 reactions (d) Neither SN1 nor SN2 reactions

129. 163. A system where the mobile proton moves between two atoms linked by a single intervening atom is classified as a: (a) Dyad system (b) Triad system (c) Pentad system (d) Hexad system

130. 88. Friedel-Crafts alkylation or acylation reactions generally do not occur on strongly deactivated aromatic rings. Which of the following rings would be least reactive towards Friedel-Crafts reactions? (a) Anisole (b) Chlorobenzene (c) Toluene (d) Nitrobenzene

131. 50. Which of the following reactions is most likely to involve a carbocation rearrangement? (a) Addition of HBr to ethene (b) Addition of Br₂ to cyclopentene (c) Addition of H₂O/H⁺ to 3,3-dimethyl-1-butene (d) Hydroboration-oxidation of 1-butene

132. 110. Which of the following represents an initiation step in the free radical addition of HBr to an alkene? (a) $R-O\cdot + CH_2=CH-R' \rightarrow R-O-CH_2-\dot{C}H-R'$ (b) $R-O-O-R \rightarrow 2 R-O\cdot$ (c) $R-O-CH_2-\dot{C}H-R' + H-Br \rightarrow R-O-CH_2-CH_2-R' + Br\cdot$ (d) $Br\cdot + CH_2=CH-R' \rightarrow Br-CH_2-\dot{C}H-R'$

133. 121. Which of the following best describes an electrophilic substitution reaction? (a) A nucleophile replaces an atom or group from the substrate. (b) An electrophile replaces an atom or group from the substrate. (c) A free radical replaces an atom or group from the substrate. (d) Two molecules combine to form a single product.

134. 73. Which of the following nucleophiles is generally considered to be a strong nucleophile for addition to carbonyl compounds under neutral or basic conditions? (a) H₂O (b) CH₃OH (c) CN⁻ (d) H⁺

135. 94. Arrange the following carbocations in increasing order of stability: I. Methyl carbocation II. Primary carbocation III. Secondary carbocation IV. Tertiary carbocation (a) I < II < III < IV (b) IV < III < II < I (c) II < I < III < IV (d) I < II < IV < III

136. 65. When a Grignard reagent (RMgX) adds to a ketone followed by hydrolysis, what type of alcohol is formed? (a) Primary alcohol (b) Secondary alcohol (c) Tertiary alcohol (d) Both primary and secondary alcohol

137. 103. The addition of Br₂ to an alkene proceeds via a cyclic intermediate and results in: (a) Syn addition (b) Anti addition (c) Rearrangement (d) Elimination

138. 154. Which of the following compounds is least likely to exhibit keto-enol tautomerism? (a) Acetaldehyde (b) Acetone (c) Benzaldehyde (d) Ethyl acetoacetate

139. 160. Tautomerism is a specific type of isomerism where two isomers are in dynamic equilibrium. How does it fundamentally differ from resonance? (a) Tautomers involve movement of electrons only, while resonance involves movement of atoms. (b) Tautomers are real, distinct molecules in equilibrium, while resonance structures are hypothetical contributors to a single hybrid. (c) Tautomers have the same functional groups, while resonance structures have different functional groups. (d) Tautomerism involves delocalization of charge, while resonance involves only delocalization of pi electrons.

140. 151. Which of the following statements best describes tautomerism? (a) It involves the interconversion of isomers that differ in the arrangement of atoms in space. (b) It involves the interconversion of isomers that differ in the position of a proton and a double bond. (c) It involves the interconversion of isomers that differ in their connectivity of atoms, leading to different functional groups. (d) It involves the delocalization of pi electrons within a molecule without changes in atomic positions.

141. 126. Which of the following is NOT a limitation of Friedel-Crafts alkylation? (a) Rearrangement of carbocations can occur. (b) Polyalkylation can occur. (c) The reaction requires a Lewis acid catalyst. (d) It cannot be performed on strongly deactivated aromatic rings.

142. 148. The stability of alkyl free radicals is explained by: (a) Inductive effect only (b) Resonance effect only (c) Hyperconjugation and inductive effect (d) Steric hindrance

143. 90. When benzene reacts with 1-chloropropane in the presence of anhydrous AlCl_3 , the major alkylated product is often isopropylbenzene (cumene) instead of n-propylbenzene. This is an example of: (a) Aromatic halogenation (b) Carbocation rearrangement (c) Free radical substitution (d) Nucleophilic attack on benzene

144. 139. In the free radical chlorination of methane, which of the following represents a propagation step? (a) $\text{Cl}_2 \rightarrow 2\text{Cl}\cdot$ (b) $\text{CH}_3\cdot + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl} + \text{Cl}\cdot$ (c) $\text{CH}_4 + \text{Cl}\cdot \rightarrow \text{CH}_3\cdot + \text{HCl}$ (d) $\text{CH}_3\cdot + \text{CH}_3\cdot \rightarrow \text{CH}_3\text{-CH}_3$

145. 82. Which position will be preferentially substituted during the mononitration of nitrobenzene? (a) Ortho position (b) Meta position (c) Para position (d) Both ortho and para positions equally

146. 59. The electrophilic addition of X_2 (halogen) to an alkene in an inert solvent proceeds via which type of intermediate? (a) Carbocation (b) Carbanion (c) Halonium ion (d) Free radical

147. 158. The tautomeric forms of DNA bases, particularly guanine and thymine, are crucial because their minor tautomeric forms can lead to: (a) Increased solubility in water. (b) Changes in the DNA backbone structure. (c) Mismatching during DNA replication and transcription. (d) Enhanced stability of the double helix.

148. 136. Which type of bond fission primarily occurs during the initiation step of a free radical substitution reaction? (a) Heterolytic fission (b) Homolytic fission (c) Ionic fission (d) Electrostatic fission

149. 92. The pi (π) bond in alkenes acts as a: (a) Nucleophile (b) Electrophile (c) Free radical (d) Leaving group

150. 13. Consider the reaction: (R)-1-bromo-1-phenylethane + $\text{H}_2\text{O} \rightarrow$ 1-phenylethanol. What is the most likely stereochemical outcome for the 1-phenylethanol product? (a) Predominantly (R)-1-phenylethanol (b) Predominantly (S)-1-phenylethanol (c) A racemic mixture of (R) and (S)-1-phenylethanol (d) An achiral product

151. 11. Which of the following conditions would generally favor racemization over inversion in a nucleophilic substitution reaction? (a) Primary alkyl halide (b) Strong nucleophile (c) Polar protic solvent (d) Polar aprotic solvent

152. 129. Which set of reagents is used for Friedel-Crafts acylation? (a) $\text{R-Cl} / \text{AlCl}_3$ (b) $\text{R-CO-Cl} / \text{AlCl}_3$ (c) $\text{HNO}_3 / \text{H}_2\text{SO}_4$ (d) $\text{Br}_2 / \text{FeBr}_3$

153. 37. Which of the following statements is INCORRECT regarding E_1 elimination? (a) It is a unimolecular reaction. (b) Carbocation rearrangements are possible. (c) The rate of reaction depends on the concentration of both the substrate and the base. (d) It generally forms the more substituted alkene (Zaitsev's product).

154. 171. Hyperconjugation is also known as: (a) No-bond resonance (b) Pi-bond resonance (c) Inductive resonance (d) Sigma-bond induction

155. 134. Which of the following groups is a meta-directing and deactivating group? (a) $-\text{CH}_3$ (b) $-\text{OCH}_3$ (c) $-\text{Cl}$ (d) $-\text{COOH}$

156. 162. Which of the following represents a prototropic tautomerism? (a) Allylic rearrangement (b) Keto-enol tautomerism (c) Ring-chain tautomerism (d) Valence tautomerism

157. 15. The stereochemical outcome of an S_N2 reaction is solely dependent on: (a) The stability of the carbocation intermediate. (b) The strength of the leaving group. (c) The attack of the nucleophile from the backside of the leaving group. (d) The polarity of the solvent.

158. 116. The anti-Markovnikov regioselectivity observed in the peroxide-catalyzed addition of HBr to unsymmetrical alkenes is primarily due to the formation of a more stable: (a) Carbocation intermediate. (b) Free radical intermediate. (c) Carbanion intermediate. (d) Electrophilic species.

159. 177. The bond fission that generates two species, each with an unpaired electron, is called: (a) Heterolytic cleavage (b) Homolytic cleavage (c) Ionic dissociation (d) Electron transfer

160. 112. Which of the following is most likely to be a termination step in the free radical addition of HBr to an alkene? (a) $R-O\cdot + HBr \rightarrow ROH + Br\cdot$ (b) $Br\cdot + Br\cdot \rightarrow Br_2$ (c) $Br\cdot + CH_2=CH_2 \rightarrow BrCH_2-CH_2\cdot$ (d) $CH_3-CH_2\cdot + HBr \rightarrow CH_3-CH_3 + Br\cdot$

161. 19. An S_N2 reaction proceeds with: (a) Racemization (b) Retention of configuration (c) Inversion of configuration (d) Partial racemization

162. 128. In electrophilic aromatic substitution, the rate-determining step involves the formation of: (a) a free radical (b) a carbocation (c) a carbanion (d) an alkoxide ion

163. 164. In keto-enol tautomerism, the equilibrium is generally shifted towards the keto form in: (a) Highly polar, protic solvents. (b) Non-polar solvents. (c) Solutions with strong bases. (d) Solutions with strong acids.

164. 28. The energy profile diagram for an S_N2 reaction typically shows: (a) A single transition state (b) One intermediate and two transition states (c) Two intermediates (d) No transition states

165. 60. Which of the following statements is true regarding electrophilic addition reactions? (a) They involve the attack of a nucleophile on an electron-rich center. (b) They typically involve the breaking of a sigma bond and the formation of two pi bonds. (c) They are characteristic reactions of compounds with pi bonds, such as alkenes and alkynes. (d) They always result in the formation of a racemic mixture.

166. 168. An electrophile is an electron-deficient species that typically accepts electrons. Which of the following is an electrophile? (a) OH^- (b) CN^- (c) H_2O (d) NO_2^+

167. 72. A compound X reacts with hydrazine (NH_2NH_2) to form a hydrazone, which upon heating with KOH/ethylene glycol undergoes reduction. This series of reactions is known as: (a) Clemmensen reduction (b) Wolff-Kishner reduction (c) Rosenmund reduction (d) Aldol condensation

168. 115. What type of reactive intermediate is formed during the propagation steps of a free radical addition reaction? (a) Carbocation (b) Carbanion (c) Free radical (d) Transition state

169. 49. Arrange the following carbocations in increasing order of stability: I. Methyl carbocation II. Primary carbocation III. Secondary carbocation IV. Tertiary carbocation (a) $IV < III < II < I$ (b) $I < II < III < IV$ (c) $II < I < IV < III$ (d) $III < IV < I < II$

170. 42. Which carbocation intermediate is formed initially and undergoes a rearrangement during the $E1$ elimination of 3-bromo-2,2-dimethylbutane? (a) $CH_3-C(CH_3)_2-CH_2-CH_2^+$ (b) $CH_3-CH(CH_3)-C^+(CH_3)_2$ (c) $CH_3-C(CH_3)_2-C^+(H)-CH_3$ (d) $(CH_3)_3C-C^+(H)-CH_3$

171. 75. In the mechanism of nucleophilic addition to a carbonyl group, which step occurs first when the reaction is base-catalyzed? (a) Protonation of the carbonyl oxygen. (b) Nucleophilic attack on the carbonyl carbon. (c) Removal of a proton from the alpha-carbon. (d) Formation of an enolate ion.

172. 74. The nucleophilic addition of hydrogen cyanide to carbonyl compounds is an example of: (a) A reversible reaction (b) An irreversible reaction (c) An acid-catalyzed reaction only (d) A reaction that always forms a racemic mixture

173. 146. Consider the free radical mechanism for the reaction: $R-H + X_2 \rightarrow R-X + HX$ Which of the following sequence correctly represents the three main steps? (a) Propagation, Initiation, Termination (b) Termination, Propagation, Initiation (c) Initiation, Propagation, Termination (d) Initiation, Termination, Propagation

174. 172. Which of the following is a characteristic feature of an S_N1 reaction? (a) Involves a single transition state (b) Rate is dependent on the concentration of both alkyl halide and nucleophile (c) Proceeds via a carbocation intermediate (d) Leads to inversion of configuration

175. 145. The free radical monochlorination of methane produces chloromethane. What is the main byproduct during the propagation steps? (a) HCl (b) H_2 (c) CH_3-CH_3 (d) Cl_2

176. 113. Why does HCl not undergo anti-Markovnikov addition to alkenes in the presence of peroxides, unlike HBr? (a) The H-Cl bond is too strong, making the first propagation step endothermic. (b) Chlorine radical is too stable to react with the alkene. (c) The C-Cl bond formation is highly exothermic, hindering the reaction. (d) HCl is a strong acid and reacts differently with peroxides.

177. 32. The rate-determining step in an $E1$ elimination reaction involves: (a) Abstraction of a beta-hydrogen by a strong base. (b) Formation of a carbocation by the departure of the leaving group. (c) Attack of a nucleophile on the carbon bearing the leaving group. (d) Formation of a transition state where all bonds are simultaneously broken and formed.

178. 119. What effect does the presence of light or heat have on the initiation step of a free radical reaction? (a) It promotes heterolytic cleavage of the initiator. (b) It provides the energy for homolytic cleavage of the initiator. (c) It stabilizes the free radicals formed. (d) It acts as a catalyst for the overall reaction.

179. 64. The reaction of acetaldehyde with HCN followed by hydrolysis yields a product containing which two functional groups attached to the same carbon atom? (a) Carboxylic acid and hydroxyl (b) Nitrile and hydroxyl (c) Carboxylic acid and aldehyde (d) Ketone and hydroxyl

180. 62. Arrange the following carbonyl compounds in decreasing order of reactivity towards nucleophilic addition: I. Acetaldehyde (CH_3CHO) II. Acetone (CH_3COCH_3) III. Formaldehyde ($HCHO$) (a) $III > I > II$ (b) $I > II > III$ (c) $II > I > III$ (d) $III > II > I$

ANSWER KEY

1. (c)
2. (c)
3. (a)
4. (c)
5. (c)
6. (c)
7. (c)
8. (b)
9. (c)
10. (b)
11. (b)
12. (c)
13. (b)
14. (c)
15. (b)
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17. (a)
18. (c)
19. (c)
20. (b)
21. (a)
22. (c)
23. (a)
24. (c)
25. (c)
26. (d)
27. (a)

28. (b)

29. (d)

30. (c)

31. (a)

32. (c)

33. (b)

34. (c)

35. (c)

36. (c)

37. (c)

38. (b)

39. (c)

40. (c)

41. (a)

42. (b)

43. (b)

44. (b)

45. (d)

46. (a)

47. (a)

48. (c)

49. (b)

50. (d)

51. (c)

52. (b)

53. (b)

54. (c)

55. (c)

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- 57. (c)
- 58. (c)
- 59. (c)
- 60. (b)
- 61. (d)
- 62. (b)
- 63. (a)
- 64. (b)
- 65. (c)
- 66. (d)
- 67. (c)
- 68. (b)
- 69. (c)
- 70. (b)
- 71. (b)
- 72. (d)
- 73. (a)
- 74. (c)
- 75. (c)
- 76. (d)
- 77. (b)
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- 79. (c)
- 80. (b)
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- 82. (c)
- 83. (c)
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- 87. (c)
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- 89. (c)
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- 95. (c)
- 96. (c)
- 97. (c)
- 98. (c)
- 99. (b)
- 100. (c)
- 101. (c)
- 102. (d)
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- 104. (c)
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- 108. (b)
- 109. (c)
- 110. (d)
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- 112. (b)
- 113. (d)

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- 115. (c)
- 116. (c)
- 117. (c)
- 118. (c)
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- 138. (c)
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- 140. (b)
- 141. (c)
- 142. (c)

- 143. (b)
- 144. (c)
- 145. (b)
- 146. (c)
- 147. (c)
- 148. (b)
- 149. (a)
- 150. (c)
- 151. (c)
- 152. (b)
- 153. (c)
- 154. (a)
- 155. (d)
- 156. (b)
- 157. (c)
- 158. (b)
- 159. (b)
- 160. (b)
- 161. (c)
- 162. (b)
- 163. (a)
- 164. (a)
- 165. (c)
- 166. (d)
- 167. (b)
- 168. (c)
- 169. (b)
- 170. (c)
- 171. (b)

172. (a)

173. (c)

174. (c)

175. (a)

176. (a)

177. (b)

178. (b)

179. (b)

180. (a)