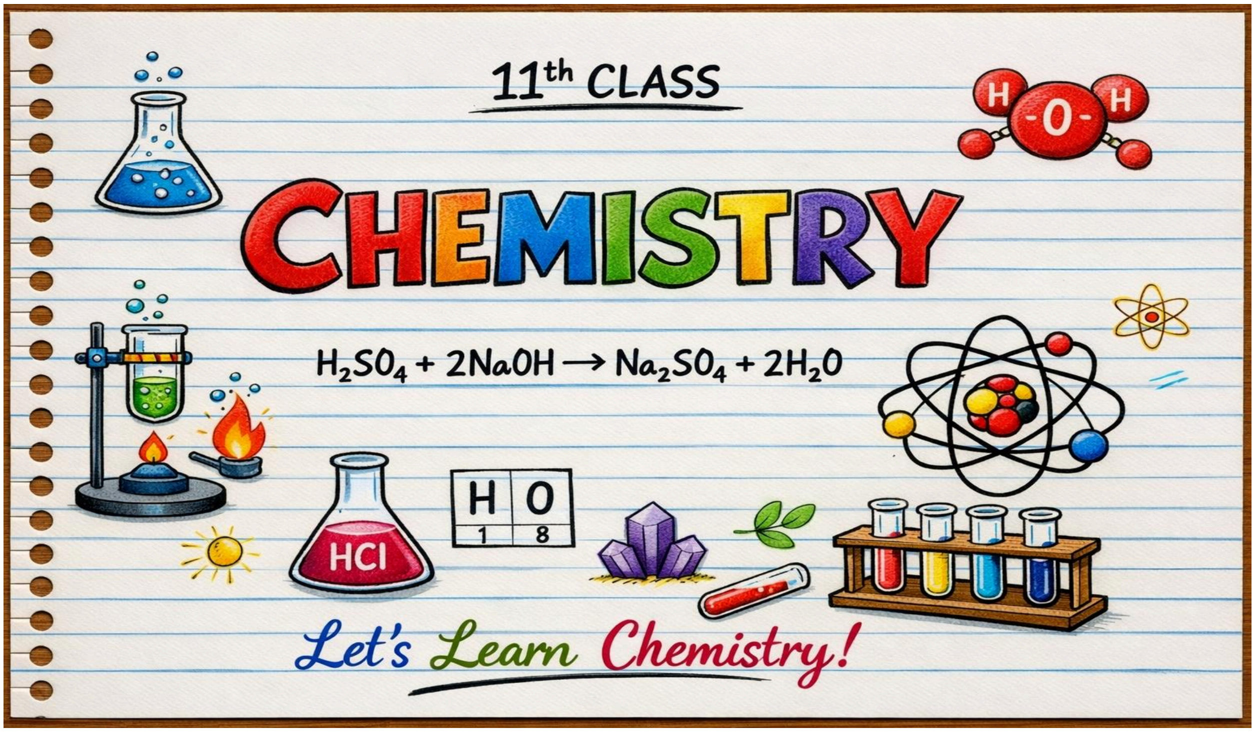

Class: 11th

Subject: Chemistry

Chapter 11: HYDROCARBONS

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❖ Important MCQs:

1. Which of the following best describes hydrocarbons?

(a) Compounds containing carbon, hydrogen and oxygen

(b) Compounds containing only carbon and hydrogen ✅

(c) Compounds containing carbon and nitrogen

(d) Compounds containing hydrogen and oxygen only

2. Which type of hydrocarbons are mainly used as starting materials in industries?

(a) Alkanes

(b) Cycloalkanes

(c) Alkenes ✅

(d) Aromatic hydrocarbons only

3. Which of the following is an aromatic hydrocarbon?

(a) Ethane

(b) Ethene

(c) Benzene ✅

(d) Ethyne

4. Aliphatic hydrocarbons can be classified into:

(a) Only cyclic compounds

(b) Only saturated compounds

(c) Open chain and cyclic compounds ✅

(d) Only aromatic compounds

5. Which hydrocarbons are unsaturated?

(a) Alkanes

(b) Cycloalkanes

(c) Alkenes and Alkynes ✅

(d) Aromatic hydrocarbons

6. Which of the following has the highest carbon to hydrogen ratio?

(a) Alkanes

(b) Alkenes

(c) Alkynes

(d) Aromatic hydrocarbons ✅

7. Cycloalkanes are:

(a) Acyclic hydrocarbons

(b) Aromatic hydrocarbons

(c) Cyclic aliphatic hydrocarbons ✅

(d) Unsaturated hydrocarbons only

8. Which compound is NOT a benzene derivative?

(a) Toluene

(b) Phenol

(c) Ethane ✅

(d) Aniline

9. Hydrocarbons are widely used as fuels because:

(a) They contain oxygen

(b) They are soluble in water

(c) They release large energy on burning ✅

(d) They are non-reactive

10. Aromatic hydrocarbons are characterized by:

(a) Open chain structure

(b) Low stability

(c) Cyclic structure with special stability ✅

(d) Presence of nitrogen

11. The general formula C_nH_{2n+2} represents:

(a) Alkenes

(b) Alkynes

(c) Alkanes ✅

(d) Aromatic hydrocarbons

12. Which statement about methane is correct?

(a) It is unsaturated

(b) It is the simplest alkane ✅

(c) It contains double bond

(d) It is cyclic

13. An alkyl group is formed by:

(a) Addition of hydrogen

(b) Removal of one hydrogen atom from an alkane ✅

(c) Addition of oxygen

(d) Removal of carbon atom

14. The correct name of CH_3– group is:

(a) Methyl ✅

(b) Methane

(c) Methene

(d) Methyne

15. The parent chain in IUPAC naming is:

(a) Shortest chain

(b) Chain with most hydrogens

(c) Longest continuous carbon chain ✅

(d) Most branched chain

16. If longest chain has 7 carbon atoms, parent name will be:

(a) Hexane

(b) Heptane ✅

(c) Octane

(d) Pentane

17. Numbering of chain is done to give substituent:

(a) Highest number

(b) Middle number

(c) Lowest possible number ✅

(d) Random number

18. In naming, substituents are written:

(a) After parent chain

(b) Before parent chain ✅

(c) Without numbers

(d) Ignored

19. In 4-ethyl-2-methylhexane, alphabetical order is based on:

(a) Position number

(b) Molecular mass

(c) Name of substituent (ethyl before methyl) ✅

(d) Chain length

20. Prefix “tri-” indicates:

(a) Two identical groups

(b) Three identical groups ✅

(c) Four groups

(d) One group

21. When two substituents are on same carbon, numbering is:

(a) Single number

(b) Ignored

(c) Repeated twice ✅

(d) Added

22. If two parent chains have same length, priority is given to chain with:

(a) Less substituents

(b) More substituents ✅

(c) Less carbon atoms

(d) More hydrogen atoms

23. When branching occurs at equal distance, correct rule is:

(a) Give highest number

(b) Ignore substituent

(c) Choose lowest number at first point of difference ✅

(d) Choose alphabetically

24. Hybridization of carbon in alkanes is:

(a) sp

(b) sp^2

(c) sp^3 ✅

(d) sp^3d

25. Shape around carbon in alkanes is:

(a) Linear

(b) Trigonal planar

(c) Tetrahedral ✅

(d) Bent

26. Bond angle in alkanes is approximately:

(a) 90°

(b) 120°

(c) 109.5° ✅

(d) 180°

27. Cycloalkanes are:

(a) Unsaturated open chain

(b) Saturated cyclic hydrocarbons ✅

(c) Aromatic only

(d) Double bonded

28. Alkanes up to four carbons are:

(a) Liquids

(b) Solids

(c) Gases ✅

(d) Plasma

29. Solubility of alkanes in water is:

(a) High

(b) Moderate

(c) Insoluble due to non-polar nature ✅

(d) Depends on temperature only

30. Which statement is correct about boiling point?

(a) Branching increases boiling point

(b) Straight chain has lower boiling point

(c) Branching decreases boiling point ✅

(d) No effect of structure

31. Reaction mechanism is defined as:

(a) Final product of reaction

(b) Series of steps in a chemical reaction ✅

(c) Energy released in reaction

(d) Type of catalyst used

32. Homolytic fission produces:

(a) Ions

(b) Free radicals ✅

(c) Molecules

(d) Cations only

33. A free radical is:

(a) Species with paired electrons

(b) Species with unpaired electron ✅

(c) Negatively charged ion

(d) Positively charged ion

34. Heterolytic fission results in formation of:

(a) Free radicals

(b) Neutral molecules

(c) Oppositely charged ions ✅

(d) Only anions

35. In heterolytic bond cleavage, the shared electron pair is:

(a) Equally divided

(b) Lost completely

(c) Taken by one atom only ✅

(d) Shared again

36. Alkanes are generally unreactive towards polar reagents because:

(a) They contain ionic bonds

(b) They are highly reactive

(c) Their bonds are non-polar ✅

(d) They contain double bonds

37. The small electronegativity difference between C and H results in:

(a) Polar bonds

(b) Ionic bonds

(c) Non-polar bonds ✅

(d) Hydrogen bonding

38. Sigma (σ) bonds in alkanes are:

(a) Weak and reactive

(b) Strong and stable ✅

(c) Ionic in nature

(d) Easily broken

39. High energy is required to break sigma bonds because:

(a) Electrons are loosely held

(b) Electrons are tightly held between nuclei ✅

(c) Bonds are ionic

(d) Bonds are polar

40. Under normal conditions, alkanes do NOT react with:

(a) Oxygen

(b) Acids and alkalis ✅

(c) Halogens

(d) Heat

41. Alkanes undergo reactions mainly under:

(a) Low temperature

(b) Normal conditions

(c) High temperature or special conditions ✅

(d) Vacuum only

42. Combustion and cracking are examples of:

(a) Substitution reactions

(b) Thermal and catalytic reactions ✅

(c) Addition reactions

(d) Oxidation only

43. Free radical substitution involves:

(a) Addition of atoms

(b) Removal of atoms

(c) Replacement of atom/group ✅

(d) Rearrangement only

44. Halogenation of alkanes occurs in presence of:

(a) Water

(b) Catalyst only

(c) Sunlight or UV light ✅

(d) Acid

45. Which halogen reacts most vigorously with alkanes?

(a) Chlorine

(b) Bromine

(c) Iodine

(d) Fluorine ✅

46. The correct order of reactivity of halogens is:

(a) $I_2 > Br_2 > Cl_2 > F_2$

(b) $F_2 > Cl_2 > Br_2 > I_2$ ✅

(c) $Cl_2 > F_2 > Br_2 > I_2$

(d) $Br_2 > Cl_2 > F_2 > I_2$

47. The initiation step in halogenation involves:

(a) Formation of product

(b) Breaking of bond homolytically using UV light ✅

(c) Combination of radicals

(d) Formation of ions

48. In propagation step:

(a) Reaction stops

(b) Radicals react to form stable product

(c) Radicals attack alkane to form new radicals ✅

(d) No reaction occurs

49. Termination step involves:

(a) Formation of radicals

(b) Breaking of bonds

(c) Combination of free radicals to form stable products ✅

(d) Addition of halogen

50. Iodine does not readily react with alkanes because:

(a) Reaction is too fast

(b) Reaction is violent

(c) Reaction is slow and reversible ✅

(d) It forms ionic bonds

51. Alkenes are classified as:

(a) Saturated hydrocarbons

(b) Unsaturated hydrocarbons ✅

(c) Aromatic hydrocarbons

(d) Aliphatic saturated hydrocarbons

52. The general formula of alkenes is:

(a) C_nH_{2n+2}

(b) C_nH_{2n} ✅

(c) C_nH_{2n-2}

(d) C_nH_n

53. Alkenes contain:

(a) Single bonds only

(b) Double bonds between carbon atoms ✅

(c) Triple bonds

(d) Ionic bonds

54. Compared to alkanes, alkenes have:

(a) Two more hydrogen atoms

(b) Same number of hydrogen atoms

(c) Two fewer hydrogen atoms ✅

(d) No hydrogen atoms

55. In IUPAC naming of alkenes, suffix used is:

(a) -ane

(b) -ene ✅

(c) -yne

(d) -ol

56. The parent chain in alkenes must contain:

(a) Maximum branches

(b) Double bond ✅

(c) Maximum hydrogen

(d) Only single bonds

57. Numbering of alkene chain starts from:

(a) End nearest substituent

(b) Middle carbon

(c) End nearest double bond ✅

(d) Any end

58. The position of double bond is indicated by:

(a) Suffix only

(b) Prefix number ✅

(c) Ignored

(d) Molecular formula

59. Preparation of alkenes generally involves:

(a) Addition reaction

(b) Substitution reaction

(c) Elimination reaction ✅

(d) Neutralization

60. Elimination reaction involves removal of:

(a) Large molecules

(b) Small atoms or groups (H, OH, X) ✅

(c) Only carbon atoms

(d) Only oxygen atoms

61. Dehydration of alcohol produces:

(a) Alkane

(b) Alkene ✅

(c) Alkyne

(d) Alcohol

62. Ethene is prepared from ethanol using:

(a) Dilute acid

(b) Concentrated H_2SO_4 and heat ✅

(c) Water

(d) NaOH

63. Temperature required for dehydration of ethanol is approximately:

(a) 50°C

(b) 100°C

(c) 180°C ✅

(d) 300°C

64. Dehydrohalogenation of alkyl halides requires:

(a) Aqueous KOH

(b) Alcoholic KOH ✅

(c) Water

(d) Acid

65. In dehydrohalogenation, removal occurs from:

(a) Same carbon

(b) Adjacent carbon atoms ✅

(c) Distant carbons

(d) Oxygen atoms

66. First three alkenes at room temperature are:

(a) Solids

(b) Liquids

(c) Gases ✅

(d) Plasma

67. Alkenes are insoluble in water because they are:

(a) Ionic

(b) Highly polar

(c) Non-polar/weakly polar ✅

(d) Acidic

68. Alkenes are soluble in:

(a) Water

(b) Alcohol ✅

(c) Salt solution

(d) Acid

69. Alkenes burn with:

(a) Non-luminous flame

(b) Luminous flame ✅

(c) Blue flame only

(d) No flame

70. Weak polarity in alkenes is due to:

(a) sp hybridization

(b) sp^2 hybridization ✅

(c) sp^3 hybridization

(d) Ionic bonding

71. The simplest alkene is:

(a) Methene

(b) Ethene ✅

(c) Propene

(d) Butene

72. Hybridization of carbon in ethene is:

(a) sp

(b) sp^2 ✅

(c) sp^3

(d) dsp^2

73. In ethene, each carbon forms how many σ bonds?

(a) One

(b) Two

(c) Three ✅

(d) Four

74. The unhybridized p-orbital in ethene lies:

(a) In the same plane

(b) Parallel to σ bonds

(c) Perpendicular to plane of hybrid orbitals ✅

(d) Inside nucleus

75. A π bond is formed by:

(a) End-to-end overlap

(b) Sidewise (lateral) overlap of p-orbitals ✅

(c) Ionic interaction

(d) Hydrogen bonding

76. Which bond is weaker in alkenes?

(a) σ bond

(b) π bond ✅

(c) Ionic bond

(d) Hydrogen bond

77. The geometry around carbon in alkenes is:

(a) Linear

(b) Tetrahedral

(c) Trigonal planar ✅

(d) Bent

78. Bond angle in alkenes is approximately:

(a) 90°

(b) 109.5°

(c) 120° ✅

(d) 180°

79. Alkenes are more reactive than alkanes due to:

(a) Strong σ bonds

(b) Presence of π bond ✅

(c) Presence of hydrogen

(d) Ionic nature

80. π electrons are more reactive because they are:

(a) Strongly held

(b) Close to nucleus

(c) Loosely held and exposed ✅

(d) Absent

81. Alkenes mainly undergo:

(a) Substitution reactions

(b) Elimination reactions

(c) Electrophilic addition reactions ✅

(d) Neutralization

82. Reactions of alkenes proceed through formation of:

(a) Free radicals

(b) Carbocations ✅

(c) Anions

(d) Neutrons

83. A carbocation is:

(a) Negatively charged carbon

(b) Neutral species

(c) Positively charged carbon species ✅

(d) Radical species

84. A carbocation attached to one alkyl group is:

(a) Methyl

(b) Primary (1°) ✅

(c) Secondary (2°)

(d) Tertiary (3°)

85. Which carbocation is most stable?

(a) Methyl

(b) Primary

(c) Secondary

(d) Tertiary ✅

86. Stability of carbocation increases due to:

(a) Electron withdrawing effect

(b) +I effect of alkyl groups ✅

(c) π bond

(d) Lone pairs

87. Inductive effect is defined as:

(a) Breaking of bond

(b) Transfer of proton

(c) Polarization of σ bond due to substituents ✅

(d) Formation of radicals

88. Alkyl groups show:

(a) Negative inductive effect

(b) Positive inductive effect (+I) ✅

(c) No effect

(d) Ionic effect

89. Halogens generally show:

(a) Positive inductive effect

(b) Neutral effect

(c) Negative inductive effect (–I) ✅

(d) No polarity

90. Electron withdrawing groups cause:

(a) Increase electron density on carbon

(b) Decrease positive charge

(c) Pull electrons away creating partial positive carbon ✅

(d) Formation of radicals

91. Alkenes mainly undergo which type of reaction?

(a) Substitution

(b) Electrophilic addition ✅

(c) Elimination

(d) Neutralization

92. Alkenes are more reactive due to presence of:

(a) σ bond only

(b) π bond in double bond ✅

(c) Ionic bond

(d) Hydrogen bond

93. In electrophilic addition, first step is attack by:

(a) Nucleophile

(b) Electrophile on double bond region ✅

(c) Free radical

(d) Anion only

94. Bromine water test is used to detect:

(a) Saturation

(b) Unsaturation in compounds ✅

(c) Acidity

(d) Basicity

95. Decolourization of bromine water indicates:

(a) Alkane presence

(b) Alkene presence (C=C bond) ✅

(c) Alcohol presence

(d) Ketone presence

96. In halogenation of alkenes, intermediate formed is:

(a) Free radical

(b) Carbocation ✅

(c) Anion

(d) Ester

97. Hydrogen halides add to alkenes by:

(a) Free radical substitution

(b) Electrophilic addition mechanism ✅

(c) Oxidation

(d) Combustion

98. Rate of addition of hydrogen halides increases in order:

(a) HI > HBr > HCl > HF

(b) HF > HCl > HBr > HI

(c) HF < HCl < HBr < HI ✅

(d) HCl > HF > HI > HBr

99. According to Markovnikov's rule:

(a) H attaches to carbon with fewer hydrogens

(b) Negative part attaches to carbon with more hydrogens

(c) Negative part goes to carbon with fewer hydrogens (more substituted carbon gets positive part) ✅

(d) Reaction is random

100. Major product in addition of HBr to propene is:

(a) 1-bromopropane

(b) 2-bromopropane ✅

(c) 1,2-dibromopropane

(d) No reaction

101. Hydrogenation of alkenes is best described as:

(a) Addition of oxygen

(b) Addition of hydrogen to double bond to form alkane ✅

(c) Removal of hydrogen

(d) Substitution reaction

102. Catalyst used in hydrogenation is:

(a) Fe / Cu

(b) Ni / Pt ✅

(c) NaOH

(d) H_2SO_4

103. Industrial hydrogenation is mainly used for:

(a) Polymer formation

(b) Margarine (banaspati ghee) production ✅

(c) Alcohol formation

(d) Acid formation

104. Hydration of alkenes gives:

(a) Alkanes

(b) Alcohols ✅

(c) Ketones

(d) Alkenes

105. Hydration reaction requires:

(a) Dry HCl

(b) Steam + H_2SO_4 catalyst + heat/pressure ✅

(c) Br_2 water

(d) NaOH

106. Key intermediate in hydration mechanism is:

(a) Radical

(b) Carbocation ✅

(c) Anion

(d) Neutral atom

107. Halohydration produces:

(a) Alkane

(b) Halohydrin (–OH and halogen) ✅

(c) Ether

(d) Alkene

108. In halohydration, addition occurs in presence of:

(a) Only halogen

(b) Water + halogen (Br_2/Cl_2) ✅

(c) Only acid

(d) Only base

109. Epoxidation of alkenes results in formation of:

(a) Alcohol

(b) Epoxide (3-membered cyclic ether) ✅

(c) Alkane

(d) Acid

110. Epoxidation generally uses:

(a) Reducing agent

(b) Oxidizing agent / metal catalyst + O_2 ✅

(c) Base

(d) Halogen only

111. Ozonolysis is a reaction involving:

(a) Addition

(b) Oxidative cleavage of C=C bond using O_3 ✅

(c) Substitution

(d) Polymerization

112. Main purpose of ozonolysis is:

(a) Make polymers

(b) Identify structure of alkenes by breaking double bond ✅

(c) Reduce alkenes

(d) Hydrogenate alkenes

113. Ozonolysis ultimately produces:

(a) Alcohols only

(b) Carbonyl compounds (aldehydes/ketones) ✅

(c) Alkanes

(d) Salts

114. Polymerization of alkenes is:

(a) Breaking monomers

(b) Joining many monomers to form long chain polymer ✅

(c) Removal of oxygen

(d) Formation of ions

115. In addition polymerization, the key bond that breaks is:

(a) σ bond

(b) π bond of C=C double bond ✅

(c) Ionic bond

(d) Hydrogen bond

116. A diene is a compound that contains:

(a) One C=C bond

(b) Two C=C bonds ✅

(c) Three C=C bonds

(d) No double bond

117. In conjugated dienes, double bonds are separated by:

(a) Two single bonds

(b) One single bond ✅

(c) No bond

(d) Triple bond

118. Conjugation leads to:

(a) Electron localization

(b) Electron delocalization over π system ✅

(c) Ionic bonding

(d) Hydrogen bonding

119. Stability of conjugated dienes is due to:

(a) σ bond strength

(b) π electron delocalization ✅

(c) Ionic attraction

(d) Steric hindrance

120. Which is a conjugated diene?

(a) Ethene

(b) Propane

(c) 1,3-butadiene ✅

(d) Ethyne

121. Conjugated dienes are important in production of:

(a) Glass

(b) Synthetic rubber ✅

(c) Fertilizers

(d) Acids

122. Isomers are compounds having same:

(a) Structural formula

(b) Molecular formula but different structure/properties ✅

(c) Physical state

(d) Functional group always

123. First alkane showing structural isomerism is:

(a) Ethane

(b) Propane

(c) Butane (C_4H_{10}) ✅

(d) Methane

124. Structural isomerism arises due to difference in:

(a) Molecular formula

(b) Arrangement of atoms in molecule ✅

(c) Atomic number

(d) Electrons

125. 1-chlorobutane and 2-chlorobutane are examples of:

(a) Chain isomers

(b) Position isomers ✅

(c) Functional isomers

(d) Optical isomers

126. Chain isomerism is due to difference in:

(a) Functional group

(b) Carbon skeleton arrangement ✅

(c) Hybridization

(d) Bond angle

127. Functional group isomerism involves:

(a) Same functional group

(b) Different functional groups with same formula ✅

(c) Same structure

(d) Same chain length only

128. Metamerism arises due to difference in:

(a) Functional group

(b) Distribution of alkyl groups around functional group ✅

(c) Molecular formula

(d) Bond type

129. Tautomerism involves:

(a) Structural rearrangement of atoms

(b) Proton shift within molecule forming isomers in equilibrium ✅

(c) Addition reaction

(d) Elimination reaction

130. Stereoisomers have same:

(a) Molecular formula and connectivity but differ in space arrangement ✅

(b) Functional group

(c) Physical state

(d) Reaction type

131. Types of stereoisomerism are:

(a) Chain and position

(b) Geometrical and optical isomerism ✅

(c) Functional and chain

(d) Metamerism only

132. Geometrical isomerism is also called:

(a) Optical isomerism

(b) cis-trans isomerism ✅

(c) chain isomerism

(d) structural isomerism

133. Organic oxidation generally means:

(a) Gain of hydrogen

(b) Loss of oxygen

(c) Gain of oxygen or loss of hydrogen ✅

(d) Gain of electrons only

134. Organic reduction means:

(a) Gain of oxygen

(b) Gain of hydrogen or loss of oxygen ✅

(c) Loss of electrons

(d) Combustion only

135. Ozonolysis is:

(a) Reduction reaction

(b) Oxidative cleavage of double bond using O_3 ✅

(c) Substitution reaction

(d) Addition reaction only

136. Epoxidation of alkenes is an example of:

(a) Reduction

(b) Oxidation reaction ✅

(c) Elimination

(d) Substitution

137. Hydrogenation of alkenes is:

(a) Oxidation

(b) Reduction reaction (addition of H_2) ✅

(c) Substitution

(d) Hydrolysis

138. Common reducing agents include:

(a) $KMnO_4$

(b) $K_2Cr_2O_7$

(c) $LiAlH_4$ / $NaBH_4$ ✅

(d) O_3

139. Reduction of nitriles produces:

(a) Alcohols

(b) Amines ✅

(c) Ketones

(d) Alkanes

140. Nitrobenzene on reduction gives:

(a) Phenol

(b) Aniline (phenylamine) ✅

(c) Benzene

(d) Toluene

❖ Important Short Questions

1. What are hydrocarbons?

Answer:

Hydrocarbons are organic compounds that contain only carbon and hydrogen atoms.

Example: Methane (CH_4), Ethane (C_2H_6)

2. Differentiate between aliphatic and aromatic hydrocarbons.

Answer:

Aliphatic hydrocarbons: Non-aromatic compounds which may be open chain or cyclic.

Example: Ethane (C_2H_6), Propene (C_3H_6)

Aromatic hydrocarbons: Cyclic compounds containing benzene ring or similar stable structure.

Example: Benzene (C_6H_6), Toluene ($C_6H_5CH_3$)

3. What are aromatic hydrocarbons?

Answer:

Aromatic hydrocarbons are cyclic compounds based on benzene ring with delocalized π-electrons.

Example: Benzene (C_6H_6), Phenol (C_6H_5OH)

4. Write the general formula of alkanes.

Answer:

The general formula of alkanes is CnH_2n_{+2}.

Example:

- Methane = CH_4
- Ethane = C_2H_6

5. What is an alkyl group?

Answer:

An alkyl group is formed when one hydrogen atom is removed from an alkane. It is represented by R–.

Example:

Methane (CH_4) ⟶ Methyl group (CH_3–)

6. State the rules of IUPAC naming of alkanes.

Answer:

1. Select the longest continuous carbon chain as parent.
2. Number chain from nearest substituent.
3. Name substituents with their positions.
4. Use alphabetical order for substituents.
5. Use prefixes like di-, tri- for identical groups.

Example: 4-ethyl-2-methylhexane

7. What is meant by the longest chain rule?

Answer:

The longest continuous carbon chain in a molecule is selected as the parent chain for naming.

Example: In heptane structure, a 7-carbon chain is chosen as parent.

8. What type of bonding is present in alkanes?

Answer:

Alkanes contain only single covalent (sigma) bonds between carbon and hydrogen atoms.

Example: Ethane (C_2H_6) has C–C and C–H sigma bonds.

9. Why are alkanes considered unreactive?

Answer:

Alkanes are unreactive because they contain non-polar C–C and C–H sigma bonds which are very stable and require high energy to break.

Example: Methane does not react with acids or bases under normal conditions.

10. Define homolytic fission.

Answer:

Homolytic fission is the equal breaking of a covalent bond where each atom gets one electron, forming free radicals.

Example:

$Cl{-}Cl \longrightarrow Cl^{\bullet} + Cl^{\bullet}$

11. Define heterolytic fission.

Answer:

Heterolytic fission is the unequal breaking of a covalent bond in which both electrons go to one atom, forming ions.

Example:

$H{-}Cl \longrightarrow H^+ + Cl^-$

12. What is a free radical?

Answer:

A free radical is a neutral species that contains an unpaired electron and is highly reactive.

Example:

Cl• (chlorine free radical)

13. Write the general formula of alkenes.

Answer:

The general formula of alkenes is CnH_2n.

Example:

Ethene = C_2H_4, Propene = C_3H_6

14. What is a π (pi) bond?

Answer:

A π bond is a weak bond formed by sideways (lateral) overlap of p-orbitals in a double bond.

Example:

C=C bond in ethene contains one π bond.

15. Why are alkenes more reactive than alkanes?

Answer:

Alkenes are more reactive due to the presence of a weak π bond which breaks easily and exposes electrons to attack.

Example:

Ethene reacts easily with bromine water, but ethane does not.

16. What is electrophilic addition reaction?

Answer:

It is a reaction in which an electrophile adds to the carbon-carbon double bond of an alkene.

Example:

$CH_2{=}CH_2 + HBr \longrightarrow CH_3{-}CH_2Br$

17. State Markovnikov's rule.

Answer:

In addition of HX to an unsymmetrical alkene, hydrogen attaches to the carbon having more hydrogen atoms already.

Example:

Propene + HBr ⟶ 2-bromopropane (major product)

18. What is hydrogenation of alkenes?

Answer:

Hydrogenation is the addition of hydrogen (H_2) to an alkene in the presence of Ni/Pt catalyst to form alkane.

Example:

$CH_2=CH_2 + H_2 \longrightarrow CH_3–CH_3$

19. What is hydration of alkenes?

Answer:

Hydration is the addition of water (H_2O) to an alkene in presence of acid to form alcohol.

Example:

$CH_2=CH_2 + H_2O \longrightarrow C_2H_5OH$

20. What is halogenation of alkenes?

Answer:

Halogenation is the addition of halogens (Cl_2 or Br_2) to alkenes to form dihalogen compounds.

Example:

$CH_2=CH_2 + Br_2 \longrightarrow CH_2Br–CH_2Br$

21. Define ozonolysis.

Answer:

Ozonolysis is the oxidative cleavage of alkenes using ozone (O_3) to form carbonyl compounds.

Example:

Ethene ⟶ formaldehyde (CH_2O)

22. What is polymerization?

Answer:

Polymerization is the process in which many small monomers join to form a long-chain polymer.

Example:

Ethene ⟶ Polyethene (plastic)

23. What is a conjugated diene?

Answer:

A conjugated diene is a compound where two double bonds are separated by a single bond.

Example:

1,3-butadiene ($CH_2=CH–CH=CH_2$)

24. Define isomerism.

Answer:

Isomerism is the phenomenon in which compounds have the same molecular formula but different structures.

Example:

C_4H_{10} ⟶ butane and isobutane

25. What is a carbocation?

Answer:

A carbocation is a positively charged carbon species formed during organic reactions.

Example:

$CH_3–CH^+–CH_3$ (secondary carbocation)

❖ Important Long Questions:

🌟 Q1. Explain the classification of hydrocarbons in detail.

❖ Answer:

1. Classification of Hydrocarbons

Hydrocarbons are organic compounds made up of only carbon (C) and hydrogen (H) atoms. They are widely found in natural gas and petroleum and are an important source of fuels and industrial chemicals.

Hydrocarbons are mainly classified into two major groups:

A. Aliphatic Hydrocarbons

Aliphatic hydrocarbons are those hydrocarbons which are non-aromatic in nature. They may be open chain (straight or branched) or cyclic, but they do not contain a benzene ring.

Aliphatic hydrocarbons are further divided into three main types:

1. Alkanes (Saturated Hydrocarbons)

Alkanes are hydrocarbons in which all carbon atoms are connected by single covalent bonds (sigma bonds) only.

General formula: CnH_2n_{+2}

They are called saturated hydrocarbons because they contain maximum number of hydrogen atoms.

Examples:

- Methane ⟶ CH_4
- Ethane ⟶ $CH_3–CH_3$
- Propane ⟶ $CH_3–CH_2–CH_3$

2. Alkenes (Unsaturated Hydrocarbons)

Alkenes are hydrocarbons that contain at least one carbon-carbon double bond ($C=C$).

General formula: CnH_2n

They are more reactive due to the presence of a weak π bond.

Examples:

- Ethene ⟶ $CH_2=CH_2$
- Propene ⟶ $CH_3–CH=CH_2$

3. Alkynes (Unsaturated Hydrocarbons)

Alkynes are hydrocarbons that contain at least one carbon-carbon triple bond ($C≡C$).

General formula: CnH_2n_{-2}

They are highly reactive due to the presence of two π bonds.

Examples:

- Ethyne ⟶ $HC≡CH$
- Propyne ⟶ $CH_3–C≡CH$

B. Aromatic Hydrocarbons

Aromatic hydrocarbons are a special class of cyclic hydrocarbons that contain a benzene ring structure or similar stable ring systems.

They are characterized by:

- Delocalized π-electrons
- High stability
- Distinct chemical behavior compared to aliphatic compounds

Examples:

- Benzene ⟶ C_6H_6 (basic aromatic compound)

- Toluene ⟶ $C_6H_5CH_3$
- Phenol ⟶ C_6H_5OH

Summary:

Hydrocarbons are broadly divided into aliphatic and aromatic types based on structure. Aliphatic hydrocarbons are further classified into alkanes, alkenes, and alkynes depending on the type of carbon-carbon bonds present. Aromatic hydrocarbons contain benzene-like stable ring structures and show special chemical properties.

🌟 Q2. Explain IUPAC nomenclature of alkanes with rules and examples.

❖ **Answer:**

IUPAC (International Union of Pure and Applied Chemistry) nomenclature is a systematic method used to name organic compounds so that each compound has a unique and clear name. Alkanes are named according to a set of specific rules, especially when they are branched chain compounds.

Important Rules for Naming Branched Chain Alkanes

1. Longest Chain Rule

The first step is to identify the longest continuous chain of carbon atoms in the molecule.

This longest chain is called the parent chain, and its name forms the base of the compound.

Example:

If the longest chain contains 6 carbon atoms, the parent name will be hexane.

2. Numbering the Carbon Chain

The longest chain is numbered from the end nearest to the substituent (branch) so that substituents get the lowest possible numbers.

This helps in giving correct and systematic position numbers.

3. Naming of Substituents

Groups attached to the main chain are called substituents (alkyl groups).

They are named by replacing “-ane” with “-yl”.

Examples:

- $CH_3–$ ⟶ Methyl
- $C_2H_5–$ ⟶ Ethyl

4. Position of Substituents

The position of each substituent is indicated by the carbon number of the parent chain to which it is attached.

The format is:

Number – Substituent – Parent name

5. Alphabetical Order Rule

If more than one different substituent is present, they are written in alphabetical order in the name.

Important Note:

Prefixes like di-, tri-, tetra- are ignored while deciding alphabetical order.

6. Use of Prefixes (di-, tri-, tetra-)

If the same type of substituent appears more than once, we use prefixes:

- 2 = di
- 3 = tri
- 4 = tetra

Each substituent must still have its own position number.

7. Same Carbon Substitution Rule

If two substituents are attached to the same carbon atom, the same number is written twice.

8. Equal Chain Rule (Tie Rule)

If two chains of equal length are present, choose the one with:

- greater number of substituents

9. First Point of Difference Rule

If numbering is possible from both ends, choose the direction that gives the lowest number at the first point of difference.

Example

Consider the structure:

$CH_3–CH(CH_3)–CH_2–CH_2–CH_3$

Step 1: Longest chain

5 carbon atoms ⟶ Pentane

Step 2: Numbering

Number from the side nearest substituent:

$CH_3–CH(CH_3)–CH_2–CH_2–CH_3$

⟶ substituent at carbon 2

Step 3: Identify substituent

CH_3 group = methyl

Final Name:

👉 2-Methylpentane

Summary:

IUPAC naming of alkanes is a systematic process based on longest chain selection, correct numbering, identification of substituents, and proper arrangement using alphabetical order and prefix rules. These rules ensure that every compound has a unique and universally accepted name.

🌟Q3. Describe the structure, bonding and shape of alkenes (ethene).

❖ **Answer:**

Ethene (C_2H_4) is the simplest alkene and a very important unsaturated hydrocarbon. It contains a carbon-carbon double bond (C=C) and shows special structural and bonding features due to sp^2 hybridization.

1. Hybridization of Carbon in Ethene (sp^2 Hybridization)

In ethene, each carbon atom undergoes sp^2 hybridization.

- One 2s orbital and two 2p orbitals of carbon mix together to form three equivalent sp^2 hybrid orbitals.
- One p orbital remains unhybridized.

These three sp^2 orbitals lie in the same plane and are arranged at equal angles.

2. Formation of Sigma (σ) Bonds

Sigma bonds are strong covalent bonds formed by head-on overlap of orbitals.

In ethene:

- One sp^2 orbital of each carbon overlaps to form a C–C sigma bond
- Remaining sp^2 orbitals form C–H sigma bonds with hydrogen atoms

So, ethene contains:

- 1 C–C sigma bond
- 4 C–H sigma bonds

3. Formation of Pi (π) Bond

The unhybridized p orbitals on each carbon are:

- Parallel to each other
- Perpendicular to the plane of sp^2 orbitals

These p orbitals overlap sidewise (lateral overlap) to form a π bond.

- The π bond is weaker than a sigma bond
- It is responsible for the reactivity of alkenes

4. Shape and Geometry of Ethene

Because of sp^2 hybridization:

- Each carbon has three regions of electron density
- These arrange themselves in a trigonal planar shape
- All atoms attached to the double bond lie in the same plane

5. Bond Angle

- The bond angles in ethene are approximately 120°
- This is due to maximum separation of electron pairs in a planar arrangement

6. Overall Structure of Ethene

Planar molecule

C=C double bond consists of:

- 1 sigma bond (strong)
- 1 pi bond (weak)

High electron density above and below the plane of molecule

Summary:

Ethene has a trigonal planar structure due to sp^2 hybridization. It forms strong sigma bonds through head-on overlap and a weaker pi bond through sidewise overlap of p orbitals. The bond angle is 120°, and all atoms lie in the same plane, making ethene a reactive unsaturated hydrocarbon.

🌟 Q4. Explain electrophilic addition reactions of alkenes with mechanism.

❖ Answer:

Alkenes are unsaturated hydrocarbons containing a carbon–carbon double bond (C=C). The double bond contains a π bond, which is weak and electron-rich. Because of this high electron density, alkenes easily react with electrophiles. Such reactions are called electrophilic addition reactions.

1. General Mechanism of Electrophilic Addition

Electrophilic addition reactions usually occur in two main steps:

Step 1: Formation of Carbocation

- The π electrons of the double bond attack the electrophile (E^+).
- The double bond breaks and a carbocation (positively charged carbon intermediate) is formed.

Step 2: Nucleophilic Attack

- A nucleophile (X^- or Br^- etc.) attacks the carbocation.
- This forms the final addition product.

👉 Carbocation formation is the key intermediate step in this mechanism.

2. Halogenation of Alkenes

Halogenation is the addition of halogens such as Br_2 or Cl_2 to alkenes.

Example: Ethene + Bromine

Reaction: $CH_2{=}CH_2 + Br_2 \longrightarrow CH_2Br{-}CH_2Br$

Mechanism:

Step 1: Polarisation of Br_2

When Br_2 approaches the double bond, it becomes polar:

$Br^{\delta+} – Br^{\delta-}$

Step 2: Formation of Carbocation

π electrons attack $Br^{\delta+}$

Br–Br bond breaks and a carbocation intermediate is formed

Step 3: Nucleophilic Attack

Br^- attacks the carbocation

Final product: 1,2-dibromoethane

3. Hydrohalogenation of Alkenes

Hydrohalogenation is the addition of hydrogen halides (HCl, HBr, HI) to alkenes.

Example: Ethene + HBr

Reaction: $CH_2=CH_2 + HBr \longrightarrow CH_3–CH_2Br$

Mechanism:

Step 1: Protonation of Alkene

- π bond attacks H^+ from HBr
- H–Br bond breaks heterolytically
- A carbocation ($CH_3–CH_2^+$) is formed

Step 2: Nucleophilic Attack

- Br^- attacks the carbocation

- Product formed: Bromoethane

4. Reaction with Unsymmetrical Alkenes (Markovnikov Rule)

When HBr adds to an unsymmetrical alkene (e.g., propene):

$CH_3–CH=CH_2 + HBr \longrightarrow$ Two products possible

But major product follows:

👉 **Markovnikov’s Rule:**

Hydrogen attaches to the carbon having more hydrogen atoms, and halogen attaches to the more substituted carbon.

- Major product: 2-bromopropane
- Minor product: 1-bromopropane

5. Importance of Carbocation Stability

Carbocation formation determines product distribution:

- 3° carbocation > 2° carbocation > 1° carbocation
- More stable carbocation ⟶ major product

Summary:

Electrophilic addition reactions of alkenes occur due to the presence of a reactive π bond. The mechanism involves formation of a carbocation intermediate followed by nucleophilic attack. Halogenation and hydrohalogenation are important examples, and in unsymmetrical alkenes, product formation follows Markovnikov’s rule.

🌟 Q5. Explain isomerism and its types in organic compounds.

❖ **Answer:**

Isomerism is a very important concept in organic chemistry because it explains how compounds with the same molecular formula can behave differently due to differences in structure.

1. Definition of Isomerism

Isomerism is the phenomenon in which two or more compounds have the same molecular formula but different structural arrangement of atoms, resulting in different physical and chemical properties. Such compounds are called isomers.

Example:

C_4H_{10} (butane) has two isomers:

n-butane: $CH_3–CH_2–CH_2–CH_3$

isobutane: $(CH_3)_3CH$

2. Structural Isomerism

Structural isomerism occurs when compounds have the same molecular formula but differ in the connectivity (arrangement) of atoms within the molecule.

It has five main types:

(i) Chain Isomerism

In chain isomerism, compounds differ in the arrangement of carbon skeleton (straight or branched chain).

Example (C_5H_{12}):

- n-pentane: $CH_3–CH_2–CH_2–CH_2–CH_3$
- isopentane: $(CH_3)_2CH–CH_2–CH_3$

👉 Both have same formula but different carbon chain arrangement.

(ii) Position Isomerism

Position isomerism occurs when the position of a functional group or double bond changes on the same carbon chain.

Example (C_3H_7Cl):

- 1-chloropropane: $CH_3–CH_2–CH_2Cl$
- 2-chloropropane: $CH_3–CHCl–CH_3$

👉 The carbon chain is same, but chlorine position changes.

(iii) Functional Group Isomerism

In functional group isomerism, compounds have the same molecular formula but different functional groups.

Example (C_2H_6O):

- Ethanol (alcohol): $CH_3–CH_2–OH$
- Dimethyl ether (ether): $CH_3–O–CH_3$

👉 One behaves like alcohol, other like ether.

(iv) Metamerism

Metamerism occurs when compounds have the same molecular formula and same functional group, but different alkyl groups on either side of a polyvalent functional group (like –O–, –NH–, –S–).

Example ($C_4H_{10}O$):

- Diethyl ether: $C_2H_5–O–C_2H_5$
- Methyl propyl ether: $CH_3–O–C_3H_7$

👉 Functional group is same (ether), but alkyl groups differ.

(v) Tautomerism

Tautomerism is a dynamic isomerism in which two isomers exist in rapid equilibrium due to migration of a hydrogen atom (proton) along with a shift of a double bond.

The most common type is keto–enol tautomerism.

Example: $CH_3–CO–CH_3 \rightleftharpoons CH_2=C(OH)–CH_3$

👉 Keto form and enol form continuously interconvert.

3. Stereoisomerism

Stereoisomerism occurs when compounds have the same structural formula but differ in the three-dimensional arrangement of atoms in space.

It is divided into two main types:

(i) Geometrical (cis–trans) Isomerism

This occurs due to restricted rotation around a double bond (C=C).

Example (2-butene):

- **cis-2-butene:** similar groups on same side
- **trans-2-butene:** similar groups on opposite sides

👉 These isomers have different boiling points and stability.

(ii) Optical Isomerism

Optical isomerism occurs when a molecule contains a chiral carbon atom (carbon attached to four different groups).

These isomers are mirror images and cannot be superimposed.

They are called:

- Dextro (+) ⟶ rotates plane-polarized light to right
- Levo (–) ⟶ rotates light to left

Example: Lactic acid: $CH_3–CH(OH)–COOH$

Summary:

Isomerism explains why compounds with the same molecular formula can show different structures and properties. Structural isomerism is based on different connectivity of atoms, while stereoisomerism depends on spatial arrangement. This concept is very important in understanding the behavior of organic compounds in chemistry and biology.

📘 Exercise

Q.1 Four choices are given for each question. Select the correct choice.

i. An alkene undergoes ozonolysis followed by reduction to yield propanone and methanal. The alkene is:

(a) 1-Butene

(b) 2-Butene

(c) 2-Methylpropene

(d) 2-Methyl-2-butene

Answer: (c) 2-Methylpropene ✅

II. Which reagent is used for acid-catalyzed hydration of alkenes?

(a) H_2 / Ni

(b) O_3 / Zn, H_2O

(c) Dilute H_2SO_4

(d) Br_2 in CCl_4

Answer: (c) Dilute H_2SO_4 ✅

III. Halogenation of alkanes is an example of:

(a) Electrophilic substitution

(b) Nucleophilic substitution

(c) Free radical substitution

(d) Oxidation

Answer: (c) Free radical substitution ✅

IV. Which reaction can alkanes undergo?

(a) Addition

(b) Substitution

(c) Polymerization

(d) Nitration

Answer: (d) Nitration ✅

V. First step in electrophilic addition reaction is:

(a) Formation of carbocation

(b) Attack by nucleophile

(c) Attack by electrophile on double bond

(d) Formation of radical

Answer: (c) Attack by electrophile on double bond ✅

VI. Addition of unsymmetrical reagent follows:

(a) Markovnikov's rule

(b) Hand's rule

(c) Le Chatelier’s principle

(d) Aufbau principle

Answer: (a) Markovnikov's rule ✅

VII. Most stable carbocation is:

(a) CH_3^+

(b) $CH_3CH_2^+$

(c) $(CH_3)_2CH^+$

(d) $(CH_3)_3C^+$

Answer: (d) $(CH_3)_3C^+$ ✅

VIII. Markovnikov’s rule is applicable to:

(a) $CH_2=CH_2$

(b) $CH_3–CH_2–CH_3$

(c) $CH_3–CH=CH–CH_3$

(d) $(CH_3)_2C=CH_2$

Answer: (d) $(CH_3)_2C=CH_2$ ✅

IX. Intermediate in electrophilic addition of HBr is:

(a) Carbocation

(b) Carbanion

(c) Radical

(d) Epoxide

Answer: (a) Carbocation ✅

X. Stability of conjugated dienes is due to:

(a) Inductive effect

(b) s-character

(c) Delocalisation of π electrons

(d) Steric hindrance

Answer: (c) Delocalisation of π electrons ✅

XI. Least stable carbocation is:

(a) $(CH_3)_2CH^+$

(b) $CH_3CH_2^+$

(c) CH_3^+

(d) $(CH_3)_3C^+$

Answer: (c) CH_3^+ ✅

XII. Repeating unit of poly(ethene) is:

(a) $–CH_2–CH_3–$

(b) $–CH=CH–$

(c) $–CH_2–CH_2–$

(d) $–CH(CH_3)–CH_2–$

Answer: (c) $–CH_2–CH_2–$ ✅

Q.2 Attempt the following short-answer questions:

a. Define the following:

i) Cycloalkanes

Cycloalkanes are saturated hydrocarbons in which carbon atoms are arranged in a closed ring (cyclic structure) and are connected by single bonds. Their general formula is C_nH_{2n}.

Example: Cyclopropane (C_3H_6), Cyclohexane (C_6H_{12})

ii) Isomerism

Isomerism is the phenomenon in which two or more compounds have the same molecular formula but different structural arrangement of atoms and different properties.

Example: Butane (C_4H_{10}) exists as n-butane and isobutane.

iii) Conjugated dienes

Conjugated dienes are compounds containing two double bonds separated by one single bond (–C=C–C=C–). This arrangement allows delocalization of π electrons, which increases stability.

Example: 1,3-butadiene ($CH_2=CH–CH=CH_2$)

iv) Inductive effect

Inductive effect is the permanent displacement of σ (sigma) electrons along a carbon chain due to electronegativity differences of atoms or groups.

- Electron donating groups show +I effect
- Electron withdrawing groups show –I effect

Example: $–CH_3$ (+I), –Cl (–I)

b. Differentiate between:

i) Aliphatic and Aromatic hydrocarbons

Aliphatic hydrocarbons are open-chain or non-aromatic cyclic compounds and may be saturated (alkanes) or unsaturated (alkenes, alkynes). They do not contain a benzene ring.

Example: Ethane, Ethene

Aromatic hydrocarbons are cyclic, planar compounds containing a benzene ring with delocalized π electrons and show special stability (resonance).

Example: Benzene, Toluene

ii) Homolytic and Heterolytic fission

In homolytic fission, a covalent bond breaks symmetrically, and each atom takes one electron, forming free radicals. It is represented by single-headed (fish hook) arrows.

Example: $Cl_2 \rightarrow Cl\bullet + Cl\bullet$

In heterolytic fission, a covalent bond breaks asymmetrically, and one atom takes both electrons, forming ions (cation and anion). It is represented by double-headed arrows.

Example: $HCl \longrightarrow H^+ + Cl^-$

iii) Electrophile and Nucleophile

An **electrophile** is an electron-deficient species that accepts an electron pair and attacks electron-rich regions.

Example: H^+, NO_2^+

A **nucleophile** is an electron-rich species that donates an electron pair and attacks electron-deficient regions.

Example: OH^-, NH_3

c. Explain why alkanes do not undergo addition reactions.

Alkanes do not undergo addition reactions because they are saturated hydrocarbons and contain only single (σ) bonds. Addition reactions require a π bond (double or triple bond) to break and allow new atoms to add across it.

In alkanes, C–C and C–H σ bonds are strong and stable, and electrons are tightly held between nuclei. Therefore, there is no reactive site for addition, and alkanes prefer substitution reactions instead.

d. How is an elimination reaction the opposite of an addition reaction?

Elimination reaction is considered the opposite of addition reaction because:

- In an **addition reaction**, atoms or groups are added across a double bond, converting an unsaturated compound into a saturated one.
- In an **elimination reaction,** atoms or small molecules (like H_2O, HCl) are removed from adjacent carbon atoms, forming a double bond (unsaturated compound).

Example:

- **Addition:** $CH_2{=}CH_2 + H_2 \longrightarrow CH_3{-}CH_3$
- **Elimination:** $CH_3{-}CH_2OH \longrightarrow CH_2{=}CH_2 + H_2O$

Thus, addition increases saturation, while elimination increases unsaturation.

e. Compare the carbocation stability in propene and 2-butene.

Carbocation stability depends on the number of alkyl groups attached to the positively charged carbon (+I effect).

Propene ($CH_3–CH=CH_2$):

Forms a secondary (2°) carbocation during reaction.

2-Butene ($CH_3–CH=CH–CH_3$):

Also forms a secondary (2°) carbocation, but it is more stable due to greater electron donation from two methyl groups.

👉 **Therefore**, carbocation formed from 2-butene is more stable than that from propene due to stronger +I effect and better stabilization.

f. Given the molecular formula C_5H_{10}, list all possible structural isomers (alkenes only).

C_5H_{10} alkenes have the following structural isomers:

- Pent-1-ene ⟶ $CH_2=CH–CH_2–CH_2–CH_3$
- Pent-2-ene ⟶ $CH_3–CH=CH–CH_2–CH_3$
- 2-Methylbut-1-ene ⟶ $CH_2=C(CH_3)–CH_2–CH_3$
- 3-Methylbut-1-ene ⟶ $CH_2=CH–CH(CH_3)–CH_3$
- 2-Methylbut-2-ene ⟶ $CH_3–C(CH_3)=CH–CH_3$

👉 **Total:** 5 structural isomers

g. When propene (C_3H_6) reacts with HBr, 2-bromopropane is the major product. Explain using carbocation stability.

When HBr adds to propene, the first step is formation of a carbocation. The π bond breaks and H^+ can attach to either carbon, forming two possible carbocations.

- If H^+ adds to terminal carbon ⟶ a secondary carbocation (more stable) is formed.
- If H^+ adds to middle carbon ⟶ a primary carbocation (less stable) is formed.

The secondary carbocation is more stable due to the +I (electron donating) effect of alkyl groups, so it forms more easily. Therefore, Br^- attacks this more stable carbocation, producing 2-bromopropane as the major product (Markovnikov product).

h. Explain why conjugated alkenes show different reactivity compared to isolated alkenes.

Conjugated alkenes have alternating double and single bonds (–C=C–C=C–), which allows overlap of p-orbitals and delocalization of π electrons across the system.

Because of this delocalization:

- The molecule becomes more stable than isolated alkenes.
- Electron density is spread out, so reactions occur differently.
- They may undergo addition reactions more slowly or give different products compared to isolated alkenes.

Thus, conjugation changes both stability and reactivity of the molecule.

i. Explain how inductive effects from alkyl groups stabilize carbocations in alkenes.

Alkyl groups attached to a positively charged carbon show a +I (electron donating) inductive effect. They push electron density toward the positively charged carbon atom.

This helps in two ways:

- It reduces the positive charge intensity on the carbocation.
- It increases electron density around the carbocation, making it more stable.

Therefore, carbocation stability increases in the order:

methyl < primary < secondary < tertiary

More alkyl groups mean greater stabilization due to stronger inductive effect.

j. Write the equation for each reaction.

(i) Hydrogenation

$CH_3CH_2CH{=}CH_2 + H_2 \longrightarrow (Ni) \longrightarrow CH_3CH_2CH_2CH_3$

(ii) Halogenation

$CH_3CH{=}CH_2 + Cl_2 \longrightarrow CH_3CHClCH_2Cl$

(iii) Hydration (acid-catalyzed)

$CH_3CH_2CH{=}CHCH_2CH_3 + H_2O \longrightarrow (H_2SO_4) \longrightarrow CH_3CH_2CH(OH)CH_2CH_2CH_3$

k. Write structural formulas for each of the following compounds:

i) Isobutylene

- Isobutylene is also called 2-methylpropene.

Structural formula:

$CH_2=C(CH_3)_2$

ii) 2,3,4,4-Tetramethyl-2-pentene

- **Parent chain:** pent-2-ene (5 carbon chain with double bond at C-2)
- **Substituents:** methyl groups at C-2, C-3, and two methyl groups at C-4

Structural formula:

$CH_3–C(CH_3)=C(CH_3)–C(CH_3)_2–CH_3$

iii) 2,5-Heptadiene

- A 7-carbon chain with double bonds at C-2 and C-5

Structural formula:

$CH_3–CH=CH–CH_2–CH=CH–CH_3$

iv) 4,5-Dimethyl-2-hexene

- Parent chain: hex-2-ene (double bond at C-2)
- Methyl groups at C-4 and C-5

Structural formula:

$CH_3–CH=CH–CH(CH_3)–CH(CH_3)–CH_3$

v) Vinylacetylene

$CH_2=CH–C\equiv CH$

vi) 1,3-Pentadiene

$CH_2=CH–CH=CH–CH_3$

vii) 1-Butyne

$CH\equiv C–CH_2–CH_3$

viii) 3-n-Propyl-1,4-pentadiene

$CH_2=CH–CH(CH_2CH_2CH_3)–CH=CH_2$

ix) Vinyl bromide

$CH_2=CH–Br$

x) But-1-en-3-yne

$CH_2=CH–C\equiv CH$

xi) 4-Methyl-2-pentyne

$CH_3–C\equiv C–CH(CH_3)–CH_3$

xii) Isopentane

$(CH_3)_2CH–CH_2–CH_3$

❖ DESCRIPTIVE QUESTIONS

🌟 Q3. Describe the free radical halogenation of methane using Cl_2 as an example.

Answer:

Free radical halogenation is a substitution reaction of alkanes in which one or more hydrogen atoms are replaced by halogen atoms (such as chlorine) in the presence of sunlight (UV light) or heat. Methane reacts with chlorine to form chloromethane.

Reaction:

$CH_4 + Cl_2 \longrightarrow \text{(UV light)} \rightarrow CH_3Cl + HCl$

Further substitution may continue to form CH_2Cl_2, $CHCl_3$, and CCl_4.

Mechanism of Free Radical Halogenation

The reaction takes place in three steps: Initiation, Propagation, and Termination.

1. Initiation Step

In this step, chlorine molecule absorbs UV light and breaks homolytically:

$Cl_2 \longrightarrow 2Cl\bullet$

This produces chlorine free radicals ($Cl\bullet$) which are highly reactive.

2. Propagation Steps

These steps continue in a chain reaction:

Step 1:

$Cl\bullet + CH_4 \longrightarrow HCl + CH_3\bullet$

A methyl free radical ($CH_3\bullet$) is formed.

Step 2:

$CH_3\bullet + Cl_2 \longrightarrow CH_3Cl + Cl\bullet$

A new chlorine radical is regenerated, so the reaction continues.

3. Termination Step

Free radicals combine and the reaction stops:

$Cl\bullet + Cl\bullet \longrightarrow Cl_2$

$CH_3\bullet + Cl\bullet \longrightarrow CH_3Cl$

$CH_3\bullet + CH_3\bullet \longrightarrow C_2H_6$

Summary:

Free radical halogenation of methane is a chain reaction involving radicals. It proceeds via UV light-induced homolytic cleavage of Cl_2, followed by propagation steps that form chloromethane and termination steps that end the reaction.

🌟 Q4. Describe the following methods for the preparation of alkenes:

Answer:

i) Dehydrohalogenation of alkyl halides

Dehydrohalogenation is an elimination reaction in which a hydrogen atom and a halogen atom are removed from adjacent carbon atoms of an alkyl halide to form an alkene.

It is carried out by heating an alkyl halide with alcoholic KOH.

Example: Formation of ethene

$CH_3CH_2Br + KOH \text{ (alcoholic, heat)} \longrightarrow CH_2{=}CH_2 + KBr + H_2O$

Explanation:

- KOH removes a hydrogen atom from one carbon.
- At the same time, the halogen (Br or Cl) is removed from the adjacent carbon.
- A double bond (C=C) is formed.

ii) Dehydration of alcohols

Dehydration of alcohols is an elimination reaction in which a water molecule (H_2O) is removed from an alcohol to form an alkene.

It is carried out by heating alcohol with concentrated H_2SO_4 at high temperature (about 170–180°C).

Example: Formation of ethene

$CH_3CH_2OH \xrightarrow{\text{conc. } H_2SO_4,\ 180°C} CH_2{=}CH_2 + H_2O$

Explanation:

- First, the alcohol reacts with acid to form an intermediate.
- Then water is eliminated from adjacent carbon atoms.
- A carbon-carbon double bond is formed.

Summary:

Both methods are elimination reactions that produce alkenes by removing small molecules:

Dehydrohalogenation → removes HX (H + halogen)

Dehydration → removes H_2O (water)

🌟 **Q5. Describe the mechanism of electrophilic addition of hydrogen halides to alkenes. Discuss Markovnikov's rule in the context of hydrogen halide addition.**

Answer:

Alkenes undergo electrophilic addition reactions due to the presence of a π (pi) bond, which is electron-rich and easily attacked by electrophiles. Hydrogen halides (HCl, HBr, HI) add across the double bond to form halogenoalkanes.

Mechanism of Electrophilic Addition of Hydrogen Halides

The reaction occurs in two main steps:

Step 1: Formation of Carbocation (Rate-determining step)

The π electrons of the alkene attack the hydrogen atom of the hydrogen halide. The H–X bond breaks heterolytically, producing H^+ and X^- ions.

The hydrogen (H^+) attaches to one carbon of the double bond, forming a carbocation intermediate on the other carbon.

Example (propene + HBr):

$CH_3–CH=CH_2 + H^+ \longrightarrow CH_3–CH^+–CH_3$ (secondary carbocation, major)

OR

$CH_3–CH_2–CH_2^+$ (primary carbocation, minor)

Step 2: Attack by Halide Ion

The halide ion (Br^-, Cl^-, I^-) attacks the carbocation to form the final product.

$CH_3–CH^+–CH_3 + Br^- \longrightarrow CH_3–CHBr–CH_3$ (2-bromopropane)

Markovnikov's Rule

Markovnikov's rule states:

"When a polar reagent (like HX) adds to an unsymmetrical alkene, the hydrogen atom attaches to the carbon having more hydrogen atoms, while the halide ion attaches to the carbon having fewer hydrogen atoms.”

Explanation using propene + HBr:

Propene is unsymmetrical, so two carbocations can form:

- Secondary carbocation (more stable) ⟶ major pathway
- Primary carbocation (less stable) ⟶ minor pathway

Since the secondary carbocation is more stable (due to +I effect of alkyl groups), it forms preferentially. Therefore, the major product is:

👉 2-bromopropane (Markovnikov product)

Summary:

Electrophilic addition of hydrogen halides proceeds via a carbocation intermediate, and product formation follows Markovnikov’s rule, which is governed by carbocation stability.

🌟 Q6. Explain the following reactions of alkenes with examples:

Answer:

a) Halogenation

Halogenation is an electrophilic addition reaction in which halogens (Cl_2 or Br_2) add across the double bond of an alkene to form a dihaloalkane.

The π bond breaks and each carbon atom of the double bond forms a bond with a halogen atom.

Example:

$CH_2=CH_2 + Br_2 \longrightarrow CH_2Br–CH_2Br$

(ethene reacts with bromine to form 1,2-dibromoethane)

👉 Bromine water is decolorized, so it is used as a test for unsaturation.

b) Ozonolysis

Ozonolysis is an oxidative cleavage reaction in which ozone (O_3) breaks the carbon–carbon double bond of alkenes to form smaller carbonyl compounds (aldehydes or ketones).

Example:

$CH_2=CH_2 + O_3 \longrightarrow CH_2O + CH_2O$

(ethene gives methanal)

👉 It is used to determine the position of double bonds in unknown alkenes.

c) Epoxidation

Epoxidation is a reaction in which an alkene reacts with an oxidizing agent to form a three-membered cyclic ether called an epoxide.

Example:

$CH_2=CH_2 + [O] \longrightarrow$ ethylene oxide (epoxide)

👉 Ethene forms ethylene oxide in the presence of oxygen and a metal catalyst.

d) Polymerization

Polymerization is a process in which many small alkene molecules (monomers) join together to form a large molecule called a polymer.

In this process, the π bond breaks and forms long chains.

Example:

$nCH_2{=}CH_2 \longrightarrow (–CH_2–CH_2–)_n$

(ethene forms polyethene)

👉 Used in the manufacture of plastics like polythene, PVC, etc.

Summary:

Alkenes are highly reactive due to their π bond and undergo different addition and cleavage reactions such as halogenation, ozonolysis, epoxidation, and polymerization.