Class: 12th

Subject: Chemistry

Chapter 8: ALIPHATIC HYDROCARBONS

Key MCQs on Hydrocarbons

1. Alkanes are:

(a) Unsaturated hydrocarbons

(b) Saturated hydrocarbons ✅

(c) Contain double bonds

(d) Highly reactive compounds

2. Halogenation of alkanes follows:

(a) Electrophilic addition

(b) Free radical mechanism ✅

(c) Nucleophilic substitution

(d) Electrophilic substitution

3. The hybridization of carbon atoms in alkenes is:

(a) sp^3

(b) sp^2 ✅

(c) sp

(d) None of these

4. The high reactivity of alkenes is due to:

(a) Sigma (σ) bond

(b) Pi (π) bond ✅

(c) Lone pair of electrons

(d) Hydrogen bonding

5. In the addition of HX to an unsymmetrical alkene, the halogen attaches to:

(a) Carbon with more hydrogens (Markownikov's rule)

(b) Carbon with fewer hydrogens ✅

(c) Randomly to any carbon

(d) Always terminal carbon

6. Alkenes can be oxidized by:

(a) Cold $KMnO_4$

(b) Ozone (O_3)

(c) Oxygen (O_2)

(d) All of the above ✅

7. Alkynes differ from alkenes because they:

(a) Contain a double bond

(b) Contain a triple bond ✅

(c) Contain only sigma bonds

(d) Are saturated hydrocarbons

8. In addition reactions of alkynes, the number of reagent molecules added is generally:

(a) One

(b) Two ✅

(c) Three

(d) None

9. Terminal alkynes contain:

(a) Strongly acidic hydrogen

(b) Weakly acidic hydrogen ✅

(c) No acidic hydrogen

(d) Only basic hydrogen

10. The decreasing reactivity order of hydrocarbons is:

(a) Alkanes > Alkenes > Alkynes

(b) Alkynes > Alkenes > Alkanes

(c) Alkenes > Alkynes > Alkanes ✅

(d) Alkanes > Alkynes > Alkenes

Important MCQs:

1. Hydrocarbons are compounds of:

(a) C and O

(b) C and H only ✅

(c) C, H and N

(d) C, H and O

2. The property responsible for the large number of hydrocarbons is:

(a) Isomerism

(b) Polymerization

(c) Catenation ✅

(d) Combustion

3. Hydrocarbons in which all carbon valencies are fully satisfied are called:

(a) Alkenes

(b) Alkynes

(c) Saturated hydrocarbons ✅

(d) Aromatic hydrocarbons

4. The hydrocarbons containing at least one double bond are called:

(a) Alkanes

(b) Alkenes ✅

(c) Alkynes

(d) Arenes

5. The hydrocarbons containing a triple bond are known as:

(a) Alkenes

(b) Alkynes ✅

(c) Alkanes

(d) Cycloalkanes

6. Marsh gas is the common name of:

(a) Ethane

(b) Propane

(c) Methane ✅

(d) Ethylene

7. The suffix used for alkanes in IUPAC nomenclature is:

(a) ene

(b) yne

(c) ane ✅

(d) yl

8. The prefix “iso” is used to differentiate:

(a) functional groups

(b) chain length

(c) isomers of same formula ✅

(d) number of carbons

9. The IUPAC naming system was first formally accepted in:

(a) 1892 Geneva Congress ✅

(b) 1930 Paris Congress

(c) 1947 New York

(d) 1979 Sydney

10. Removing one hydrogen from an alkane gives:

(a) Alkene

(b) Alkyne

(c) Alkyl group ✅

(d) Arene

11. Alkyl groups always end with the suffix:

(a) ane

(b) ene

(c) yl ✅

(d) yne

12. The first step in naming a branched alkane is to:

(a) Number the substituents

(b) Find the longest chain ✅

(c) Arrange substituents alphabetically

(d) Identify the functional group

13. In IUPAC nomenclature, numbers and words are separated by:

(a) Commas

(b) Semicolon

(c) Hyphen ✅

(d) Dash

14. If two substituents are identical, we use prefixes like:

(a) iso, neo

(b) di, tri, tetra ✅

(c) cyclo

(d) hydro

15. The parent chain is selected based on:

(a) Most carbons only

(b) Most substituents only

(c) Longest continuous chain with maximum substituents in tie cases ✅

(d) Lowest molecular mass

16. Alkenes are named by replacing “ane” of alkane with:

(a) yl

(b) yne

(c) ene ✅

(d) ane

17. In alkenes, numbering starts from the end:

(a) Farther from substituent

(b) Nearer to double bond ✅

(c) Nearer to substituent

(d) Nearer to triple bond

18. In naming alkenes, the position of double bond is shown by the number of:

(a) Second carbon of double bond

(b) First carbon of double bond ✅

(c) Middle carbon

(d) Last carbon

19. A compound with two double bonds is called:

(a) Alkadiene ✅

(b) Alkatriene

(c) Alkyne

(d) Cycloalkene

20. The suffix used for alkynes is:

(a) ene

(b) ane

(c) yne ✅

(d) yl

21. Triple bond in alkynes gets the number so that it has:

(a) Highest possible number

(b) Middle number

(c) Lowest possible number ✅

(d) Alphabetical number

22. Compounds having more than one triple bond are named as:

(a) Alkadienes

(b) Alkadiynes ✅

(c) Alkatrienes

(d) Polyalkenes

23. When both double and triple bonds exist, the name ends with:

(a) di-ene

(b) yl-ene

(c) enyne ✅

(d) ylene

24. If a double and triple bond are at equal distance from ends, priority is given to:

(a) Triple bond

(b) Substituent

(c) Double bond gets lower number ✅

(d) Longest chain

25. The correct name of $CH\equiv C-CH_2-CH_2-C\equiv CH$ is:

(a) 2,4-Hexadiyne

(b) 1,5-Hexadiyne ✅

(c) 3,4-Hexadiyne

(d) 1,3-Hexadiyne

26. The general formula of alkanes is:

(a) C_nH_{2n}

(b) C_nH_{2n-2}

(c) C_nH_{2n+2} ✅

(d) C_nH_{2n+4}

27. The simplest alkane is:

(a) Ethane

(b) Propane

(c) Butane

(d) Methane ✅

28. In alkanes, each carbon atom is:

(a) sp hybridized

(b) sp² hybridized

(c) sp³ hybridized ✅

(d) unhybridized

29. Hydrogenation of alkenes produces:

(a) Alcohols

(b) Aldehydes

(c) Alkanes ✅

(d) Ketones

30. Industrial hydrogenation uses the conversion of vegetable oil into:

(a) Soap

(b) Plastic

(c) Vegetable ghee (Banaspati) ✅

(d) Ethanol

31. In hydrogenation of alkenes, the catalyst generally used is:

(a) Iron

(b) Nickel (Ni) ✅

(c) Zinc

(d) Cobalt

32. Conversion of alkyl halide to alkane using Zn/H^+ is called:

(a) Hydrolysis

(b) Hydrogenolysis

(c) Reduction to alkane by Zn/H^+ reaction ✅

(d) Decarboxylation

33. Kolbe's electrolytic method produces:

(a) Unsymmetrical alkanes

(b) Only symmetrical alkanes (R–R) ✅

(c) Methane

(d) Alkynes

34. In Kolbe's method, methane cannot be prepared because:

(a) It is unstable

(b) Only symmetrical alkanes are produced ✅

(c) Electrolysis fails

(d) It forms alcohol instead

35. Clemmensen reduction uses:

(a) KOH / heat

(b) Hydrazine

(c) Zn–Hg/HCl to convert carbonyl to alkane ✅

(d) $NaBH_4$

36. Wolf–Kishner reduction converts aldehydes into alkanes using:

(a) Zn−Hg/HCl

(b) Hydrazine + KOH (200°C) ✅

(c) Ni catalyst

(d) H_2SO_4

37. Alkanes are soluble in:

(a) Water

(b) Alcohol

(c) Non-polar solvents like benzene & CCl_4 ✅

(d) Salt solutions

38. Boiling point of alkanes:

(a) Decreases with molecular mass

(b) Remains constant

(c) Increases as carbon number increases (20–30°C per CH_2) ✅

(d) Has no relation with size

39. Alkanes are less reactive because their C–H and C–C bonds are:

(a) Highly polar

(b) Very weak

(c) Non-polar and strong σ-bonds (stable) ✅

(d) Ionic in nature

40. Combustion of methane produces:

(a) CO and H_2O only

(b) CO_2, H_2O, and heat (exothermic) ✅

(c) CO_2 only

(d) Carbon black only

41. Alkenes have how many hydrogen atoms less than alkanes?

(a) One

(b) Two ✅

(c) Three

(d) Four

42. Alkenes are called Olefins because they:

(a) Burn with smokeless flame

(b) Form oily products with halogens ✅

(c) Are soluble in water

(d) Are aromatic

43. General formula of simple alkenes (mono-enes) is:

(a) CnH_2n+2

(b) CnH_2n+1

(c) CnH_2n+3

(d) CnH_2n ✅

44. Dehydrohalogenation of alkyl halides occurs with:

(a) Aqueous KOH

(b) Alcoholic KOH ✅

(c) NaOH

(d) H_2O_2

45. Removal of water from alcohols to form alkenes is called:

(a) Dehalogenation

(b) Polymerization

(c) Dehydration ✅

(d) Reduction

46. Best catalyst for dehydration of alcohol vapours is:

(a) Platinum

(b) Zinc dust

(c) Alumina (Al_2O_3) ✅

(d) Iron filings

47. Ease of dehydration of alcohols is highest in:

(a) Primary alcohols

(b) Secondary alcohols

(c) Tertiary alcohols ✅

(d) All equal

48. Vicinal dihalides when treated with Zn form:

(a) Alkynes

(b) Alcohols

(c) Alkanes

(d) Alkenes ✅

49. Partial hydrogenation of alkynes to alkenes uses:

(a) Raney Nickel

(b) Lindlar’s catalyst ✅

(c) Iron oxide

(d) Silver nitrate

50. First three members of alkenes at room temperature are:

(a) Solids

(b) Liquids

(c) Gases ✅

(d) Semi-solids

51. Alkenes are insoluble in water but soluble in:

(a) Ether

(b) Alcohol ✅

(c) Benzene

(d) Oil

52. Alkenes burn with a:

(a) Non-luminous flame

(b) Blue flame

(c) Luminous flame ✅

(d) Green flame

53. π-bond in alkenes breaks easily because it is:

(a) Strong

(b) Double localized

(c) Weak & exposed to attack ✅

(d) Magnetic

54. Hydrogenation of alkenes requires:

(a) Al_2O_3

(b) Pt, Pd or Ni catalysts ✅

(c) $KMnO_4$

(d) $CuSO_4$

55. Heat released during hydrogenation of alkenes is called:

(a) Heat of reaction

(b) Heat of formation

(c) Heat of hydrogenation ✅

(d) Heat of oxidation

56. Addition of HX to unsymmetrical alkenes follows:

(a) Saytzeff's rule

(b) Markownikov's rule ✅

(c) Gillman's rule

(d) Dalton's law

57. Alkenes react with Br_2 in CCl_4 to form:

(a) Halohydrin

(b) Vicinal dihalide ✅

(c) Alcohol

(d) Aldehyde

58. Cold dilute alkaline $KMnO_4$ oxidizes alkenes to:

(a) Ketones

(b) Aldehydes

(c) Vicinal glycols (diols) ✅

(d) Alkanes

59. Reaction of ozone with alkenes gives:

(a) Alkynes

(b) Ozonides ✅

(c) Esters

(d) Ethers

60. Ethene is used for:

(a) Making fertilizers

(b) Artificial ripening of fruits ✅

(c) Acid production

(d) Soft drinks

61. Alkynes are hydrocarbons containing:

(a) Single bond

(b) Double bond

(c) Triple bond ✅

(d) Aromatic ring

62. General formula of alkynes is:

(a) CnH_2n

(b) CnH_2n+2

(c) CnH_2n-2 ✅

(d) CnH_2n-1

63. The first member of the alkyne series is:

(a) Ethene

(b) Ethane

(c) Ethyne ✅

(d) Propene

64. Ethyne is also known as:

(a) Methane

(b) Acetaldehyde

(c) Acetylene ✅

(d) Ketene

65. Vicinal dihalides form alkynes by:

(a) Hydrogenation

(b) Dehydration

(c) Dehydrohalogenation ✅

(d) Polymerization

66. Removal of the second molecule of hydrogen halide from vic-dihalide requires:

(a) Mild conditions

(b) Very low temperature

(c) Drastic conditions ✅

(d) No heat

67. Tetrahalides give alkynes when treated with:

(a) NaOH

(b) H_2SO_4

(c) Active metals like Zn or Mg ✅

(d) Alcohol

68. Industrially, ethyne is prepared by reacting calcium carbide with:

(a) HCl

(b) Water ✅

(c) Alcohol

(d) CO_2

69. Calcium carbide (CaC_2) is prepared by heating lime with:

(a) Hydrogen

(b) Sodium

(c) Coke (carbon) ✅

(d) Nitrogen

70. Alkynes are mostly:

(a) Coloured

(b) Odourless (except acetylene) ✅

(c) Strong-smelling

(d) Sweet-smelling

71. The first three alkynes (C_2–C_4) are:

(a) Solids

(b) Liquids

(c) Gases ✅

(d) Semi-solids

72. Alkynes are soluble in:

(a) Water

(b) Ether, benzene, CCl_4 ✅

(c) Brine

(d) Sugar solution

73. Electrons in a triple bond are:

(a) Highly exposed

(b) Less exposed to electrophiles ✅

(c) Completely free

(d) Non-bonding

74. Alkynes add how many molecules of reagent?

(a) Half

(b) One

(c) Two ✅

(d) Three

75. Hydrogenation of alkynes first gives:

(a) Alkanes

(b) Alkenes ✅

(c) Alcohols

(d) Ethers

76. Complete hydrogenation of alkyne produces:

(a) Alkene

(b) Alkane ✅

(c) Aldehyde

(d) Acid

77. Alkyne + HBr forms products according to:

(a) Zaitsev's rule

(b) Markownikov's rule ✅

(c) Henry's law

(d) Boyle's law

78. Hydration of ethyne produces first:

(a) Ketone

(b) Alcohol

(c) Vinyl alcohol (enol) ✅

(d) Carboxylic acid

79. Vinyl alcohol rearranges to form:

(a) Ethanol

(b) Acetaldehyde ✅

(c) Ethanoic acid

(d) Butanone

80. Alkynes show acidic nature due to:

(a) sp^3 hybridization

(b) sp^2 hybridization

(c) sp hybridization (50% s-character) ✅

(d) No hybridization

🩸 Important Short Questions:

1. Define hydrocarbons and give one example.

Answer:

Hydrocarbons are organic compounds containing only carbon and hydrogen.

Example: Methane (CH_4).

2. What is the difference between saturated and unsaturated hydrocarbons?

Answer:

👉 **Saturated** hydrocarbons (alkanes) have all carbon valencies fully satisfied with single bonds.

👉 **Unsaturated** hydrocarbons contain double or triple bonds (alkenes and alkynes).

3. What are alkanes, alkenes, and alkynes?

Answer:

👉 **Alkanes**: Saturated hydrocarbons with single bonds only.

👉 **Alkenes**: Unsaturated hydrocarbons with at least one double bond.

👉 **Alkynes**: Unsaturated hydrocarbons with at least one triple bond.

4. Explain the term “trivial or common name” of organic compounds with an example.

Answer:

Names based on history, source, or person; e.g., Methane called “marsh gas,” Acetic acid from vinegar (acetum).

5. What is the general formula of alkanes, alkenes, and alkynes?

Answer:

- **Alkanes**: CnH_2n+_2
- **Alkenes**: CnH_2n
- **Alkynes**: CnH_2n-2

6. Define an alkyl group and give one example.

Answer:

Alkyl group is obtained by removing one hydrogen from an alkane.

Example: CH_3- (methyl), C_2H_5- (ethyl).

7. State any three rules for naming branched-chain alkanes (IUPAC system).

Answer:

👉 Identify the longest continuous chain as parent chain.

👉 Number the chain from the end nearer to substituent.

👉 Substituents are named and numbered; use di, tri, etc., for multiples.

8. How are alkenes named according to IUPAC rules?

Answer:

- **Select** the **longest chain** containing the double bond.
- **Replace** "ane" of parent alkane with "ene."
- **Number the chain** from the end nearer to the double bond and indicate position.

9. How are alkynes named according to IUPAC rules?

Answer:

Longest chain containing the triple bond is selected.

Replace “ane” with “yne.”

Number chain to give minimum position to triple bond; indicate multiple triple bonds with di, tri, etc.

10. How is a hydrocarbon named if it contains both double and triple bonds?

Answer:

- Use the **suffix -enyne**.
- **Assign the lowest** possible numbers to double or triple bonds.
- **Double bond** is given lower number if both have same position.

Example: 3-Penten-1-yne

11. Define alkanes.

Answer:

Alkanes are saturated hydrocarbons containing only carbon and hydrogen, with single bonds and general formula C_nH_{2n+2}.

Example: Methane (CH_4).

12. What is the hybridization and geometry of carbon atoms in alkanes?

Answer:

Each carbon atom in an alkane is sp³ hybridized and has tetrahedral geometry.

13. State Sabatier-Sendem's reaction.

Answer:

Hydrogenation of alkenes or alkynes in the presence of nickel at 200–300°C gives alkanes.

Example: $CH_2=CH_2 + H_2 \longrightarrow (Ni) \longrightarrow CH_3\text{-}CH_3$ (Ethane)

14. How are alkanes prepared from alkyl halides?

Answer:

Alkyl halides react with Zn/H^+ or Pd/C in hydrogenolysis to give alkanes.

Example: CH_3-I + Zn + H^+ ⟶ CH_4 + ZnI_2

15. Explain decarboxylation method for preparation of alkanes.

Answer:

Sodium salts of carboxylic acids are heated with soda-lime to remove CO_2, forming alkanes.

Example: R-COONa + NaOH ⟶ R-H + Na_2CO_3

16. What is Kolbe's electrolytic method for alkanes?

Answer:

Electrolysis of sodium/potassium salts of monocarboxylic acids forms symmetrical alkanes (R-R) and CO_2.

17. How are alkanes prepared from carbonyl compounds?

Answer:

👉 **Aldehydes**: Reduced by Wolff-Kishner (N_2H_4/KOH) ⟶ Alkane

👉 **Ketones:** Reduced by Clemmensen (Zn/Hg + HCl) ⟶ Alkane

18. How are alkanes obtained from Grignard reagents?

Answer:

Alkyl magnesium halides (Grignard reagents) react with water/dilute acid to give alkanes.

Example: $CH_3\text{-}MgBr + H_2O \rightarrow CH_4 + Mg(OH)\mathbf{Br}$

19. Describe physical state and solubility of alkanes.

Answer:

👉 **C_1–C_4:** Gases, C_5–C_{17}: Liquids, higher: Waxy solids.

👉 **Non-polar**, insoluble in water, soluble in benzene, ether, CCl_4.

20. Why are alkanes generally unreactive?

Answer:

Bonds are non-polar (C-H & C-C), stable σ-bonds.

Electrons in σ-bond are tightly held, resistant to electrophilic/nucleophilic attack.

21. Write the general reaction of combustion of alkanes.

Answer:

Alkane + $O_2 \longrightarrow CO_2 + H_2O$ + heat

Example: $CH_4 + 2O_2 \longrightarrow CO_2 + 2H_2O$ + 891 kJ/mol

22. What is incomplete oxidation of methane?

Answer:

Limited O_2 supply gives CO and C (carbon black) along with H_2O.

Example: $3CH_4 + 4O_2 \longrightarrow 2CO + 6H_2O + C$

23. Explain catalytic oxidation of lower alkanes.

Answer:

Lower alkanes in presence of metallic catalysts at high temp/pressure give alcohols, aldehydes, acids.

Example: $CH_4 \longrightarrow CH_3OH \longrightarrow HCHO \longrightarrow HCOOH \longrightarrow CO_2 + H_2O$

24. What is nitration of alkanes?

Answer:

Substitution reaction where H of alkane is replaced by $-NO_2$ under 400–500°C, giving nitroalkanes.

Example: $CH_4 + HONO \longrightarrow CH_3NO_2 + H_2O$

25. Describe halogenation of alkanes.

Answer:

Replacement of H with halogen (Cl, Br) in presence of light/UV via free radical mechanism.

👉 F_2 is highly reactive, I_2 reacts very slowly.

Example: $CH_4 + Cl_2 \rightarrow CH_3Cl + HCl$

26. Define alkenes and give their general formula.

Answer:

Alkenes are unsaturated hydrocarbons containing one or more double bonds.

Mono-enes: CH_2n

Dienes (two double bonds): CnH2n-2

Example: Ethene (C_2H_4).

27. What are the common methods for preparing alkenes?

Answer:

1. Dehydrohalogenation of alkyl halides

2. Dehydration of alcohols

3. Dehalogenation of vicinal dihalides

4. Electrolysis of salts of dicarboxylic acids

5. Partial hydrogenation of alkynes

28. Explain dehydrohalogenation of alkyl halides.

Answer:

Alkyl halides react with alcoholic KOH, eliminating HX to form alkenes.

Example: $CH_3\text{-}CH_2\text{-}Br + KOH \longrightarrow CH_2{=}CH_2 + KBr + H_2O$

29. How are alkenes obtained by dehydration of alcohols?

Answer:

Alcohols are heated with alumina or concentrated H_2SO_4/H_3PO_4 to remove water, forming alkenes.

Example: $CH_3\text{-}CH_2\text{-}OH \longrightarrow CH_2{=}CH_2 + H_2O$

30. What is the difference between cis and trans alkenes?

Answer:

- **Cis**: Substituents on the same side of the double bond
- **Trans**: Substituents on opposite sides of the double bond

Trans alkenes can be formed using Na/NH_3 treatment of alkynes.

31. Describe physical properties of alkenes.

Answer:

$C_2\text{–}C_4$: Gases, $C_5\text{–}C_{15}$: Liquids, higher: Solids

- **Insoluble** in water, soluble in alcohol
- **Weakly polar** due to sp^2 hybridization
- **Characteristic smell,** burn with luminous flame

32. Why is the π-bond in alkenes reactive?

Answer:

π-electrons are loosely held above/below the plane, making the bond weaker than σ-bond. This makes alkenes reactive to electrophilic addition.

33. Explain catalytic hydrogenation of alkenes.

Answer:

- **Addition** of H_2 to alkenes in presence of catalysts (Pt, Pd, Raney Ni) gives alkanes.
- **Highly exothermic;** Heat of hydrogenation ≈ 120 kJ/mol per double bond

Example: $CH_2{=}CH_2 + H_2 \rightarrow CH_3\text{-}CH_3$

34. What is Markownikoff's Rule in addition reactions?

Answer:

In addition of unsymmetrical reagents (e.g., HBr) to unsymmetrical alkenes, the negative part of the reagent attaches to the carbon with fewer H atoms.

35. How do alkenes react with concentrated H_2SO_4?

Answer:

Alkenes form alkyl hydrogen sulphates via addition. On boiling with water, they give alcohols (hydration reaction).

36. Describe halogenation of alkenes.

Answer:

Alkenes react with Cl_2 or Br_2 in inert solvent to give vicinal dihalides (1,2-dihalogenated products) via free radical or electrophilic addition.

➤ Fluorine too reactive, Iodine too slow.

37. What is halohydrin formation?

Answer:

Halogenation of alkenes in aqueous solution forms haloalcohols (halohydrins).

Example: $CH_2=CH_2 + Br_2 + H_2O \longrightarrow CH_2Br\text{-}CH_2OH$

38. How are alkenes oxidized to epoxides?

Answer:

Alkenes react with oxygen/air over Ag_2O at high temperature/pressure to give epoxides (oxiranes).

Example: $CH_2=CH_2 \longrightarrow CH_2\text{-}O\text{-}CH_2$ (Ethylene oxide)

39. Describe hydroxylation of alkenes.

Answer:

Alkenes react with dilute alkaline $KMnO_4$ (Baeyer's reagent) to form vicinal glycols (diols).

- **Test for unsaturation:** $KMnO_4$ color turns from purple to colorless.

40. Give some industrial uses of ethene.

Answer:

1. Manufacture of polythene (plastic)

2. Artificial ripening of fruits

3. As general anaesthetic

4. Preparation of Mustard gas

5. Starting material for chemicals like glycols, ethyl alcohol, ethyl halide

41. Define alkynes and give their general formula.

Answer:

Alkynes are unsaturated hydrocarbons containing a triple bond.

General formula: CnH2n-2

Example: Ethyne (C_2H_2)

42. What are the common methods for preparing alkynes?

Answer:

1. Dehydrohalogenation of vicinal dihalides
2. Dehalogenation of tetrahalides
3. Electrolysis of salts of unsaturated dicarboxylic acids
4. Industrial preparation from calcium carbide

43. Explain dehydrohalogenation of vicinal dihalides.

Answer:

Vicinal dihalides react with strong bases to remove two molecules of HX, forming an alkyne.

Example: $HC \equiv CH_2Br + KOH \longrightarrow HC \equiv CH$

44. How are alkynes obtained by dehalogenation of tetrahalides?

Answer:

Tetrahaloalkanes react with active metals like Zn or Mg to eliminate halogens and form alkynes.

Example: $C_2H_2Br_4 + Zn \longrightarrow C_2H_2 + 2\ ZnBr_2$

45. How is ethyne prepared industrially?

Answer:

Ethyne is prepared by reacting calcium carbide (CaC_2) with water:

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

46. Describe physical properties of alkynes.

Answer:

Colourless, odourless (except acetylene has garlic-like odour)

$C_2–C_4$: Gases, $C_5–C_{12}$: Liquids, higher: Solids

- **Non-polar**, soluble in ether, benzene, CCl_4
- **Melting & boiling** points increase with molecular mass

47. Why are alkynes less reactive than alkenes towards electrophilic reagents?

Answer:

Triple bond electrons are less exposed due to high electron density and short bond distance, making π-electrons less available.

48. Describe addition reactions of alkynes.

Answer:

Alkynes undergo addition reactions like alkenes but add two molecules of reagents:

1. Hydrogenation → Alkane

2. Halogenation → Dihalides or tetrahalides

3. Hydrogen halide addition → Dihaloalkanes (Markownikoff's rule)

4. Hydration ⟶ Alcohols or ketones

5. Addition of NH_3/HCN ⟶ Nitriles

49. What is the industrial importance of alkyne hydration?

Answer:

Alkynes react with water in presence of $HgSO_4/H_2SO_4$ to form aldehydes or ketones.

Example: $HC{\equiv}CH \longrightarrow CH_3CHO$ (acetaldehyde)

50. How can acetylene be converted to divinyl acetylene and chloroprene?

Answer:

👉 Acetylene + Cu_2Cl_2/NH_4Cl ⟶ Vinyl acetylene ⟶ Divinyl acetylene

👉 Vinyl acetylene + HCl ⟶ Chloroprene ⟶ Polymerized to neoprene (synthetic rubber)

51. How is acetylene converted to benzene?

Answer:

Passing acetylene through a copper tube at 300°C polymerizes it to benzene.

52. Explain the acidic nature of terminal alkynes.

Answer:

Terminal alkynes have H bonded to sp-hybridized carbon. The sp carbon is more electronegative, making the H slightly acidic.

Reacts with $NaNH_2$ to form sodium acetylide:

$HC{\equiv}CH + NaNH_2 \longrightarrow HC{\equiv}CNa + NH_3$

53. What are silver and copper acetylides used for?

Answer:

Silver and copper acetylides are used for preparation, purification, separation, and identification of alkynes.

54. List the uses of ethyne.

Answer:

1. Oxyacetylene torch for welding/cutting metals

2. Preparation of alcohols, acetic acid, acetaldehyde

3. Manufacture of polymers: PVC, polyvinyl acetate, neoprene

4. Preparation of acetylene tetrachloride (solvent)

5. Ripening of fruits

55. Compare the reactivities of alkanes, alkenes, and alkynes.

Answer:

👉 **General order**: Alkenes > Alkynes > Alkanes

👉 **Reason**: π-bond in alkenes is weak and exposed → very reactive

- **Alkynes less** reactive to electrophiles but more reactive to nucleophiles

🩸 EXERCISE

Q1. Fill in the blanks:

(i) Ozone reacts with ethene to form ______.

Answer: ozonide ✅

(ii) Lindlar's catalyst is used for ______ of alkynes.

Answer: partial hydrogenation ✅

(iii) Divinyl acetylene is a ______ acetylene.

Answer: polymerized ✅

(iv) Vicinal dihalides have two halogens on ______ carbon atoms.

Answer: adjacent ✅

(v) Ethyne is acidic in character because of ______ hybridization.

Answer: sp ✅

(vi) Halohydrins are formed due to addition of ______ in ethene.

Answer: HOX (hypohalous acid) ✅

(vii) Ethylene glycol is produced when ______ reacts with cold alkaline $KMnO_4$ solution.

Answer: ethene ✅

(viii) Mustard gas is a high boiling ______.

Answer: halo compound ✅

(ix) Ethyne has ______ like odour.

Answer: garlic-like ✅

(x) Ethyne is obtained by the reaction of ______ with calcium carbide.

Answer: water ✅

Q.2. Indicate True or False.

1. Addition of HX to unsymmetrical alkanes takes place according to Markownikov's rule.

Answer: False ❌

(**Reason**: Markownikov's rule applies to alkenes, not alkanes.)

2. Methane reacts with bromine water and its colour is discharged.

Answer: False ❌

(Alkanes do not decolourize bromine water.)

3. Mustard gas is a blistering agent.

Answer: True ✅

4. Methane is also called marsh gas.

Answer: True ✅

5. Ethyne is a saturated compound.

Answer: False ❌

(Ethyne is an unsaturated alkyne.)

6. Baeyer's reagent is used to locate a double bond in an alkene.

Answer: True ✅

7. Alkanes usually undergo substitution reactions.

Answer: True ✅

8. Benzene is a polymer of ethene.

Answer: False ❌

9. Acrylonitrile can be obtained from ethyne.

Answer: True ✅

10. Ethyne is more reactive towards electrophilic reagents than ethene.

Answer: False ❌

(Ethene is more reactive than ethyne.)

Q.3. Multiple choice questions. Encircle the correct answer.

i) Preparation of vegetable ghee involves

(a) Halogenation

(b) Hydrogenation ✅

(c) Hydroxylation

(d) Dehydrogenation

ii) Formula of chloroform is:

(a) CH_3Cl

(b) CCl_4

(c) CH_2Cl_2

(d) $CHCl_3$ ✅

iii) The presence of a double bond in a compound is the sign of

(a) Saturation

(b) Unsaturation ✅

(c) Substitution

(d) None

iv) Vinyl acetylene combines with HCl to form

(a) Polyacetylene

(b) Benzene

(c) Chloroprene ✅

(d) Divinyl acetylene

v) The addition of unsymmetrical reagent to an unsymmetrical alkene is in accordance with the rule

(a) Hund's rule

(b) Markownikov's rule ✅

(c) Pauli's Exclusion Principle

(d) Aufbau Principle

vi) Synthetic rubber is made by polymerization of

(a) Chloroform

(b) Acetylene

(c) Divinylacetylene

(d) Chloroprene ✅

vii) β-β'- dichloroethyl sulphide is commonly known as

(a) Mustard gas ✅

(b) Laughing gas

(c) Phosgene gas

(d) Bio-gas

ix) When methane reacts with Cl_2 in the presence of diffused sunlight the products obtained are:

(a) Chloroform only

(b) Carbon tetrachloride only

(c) Chloromethane and dichloromethane

(d) Mixture of a, b, c ✅

x) Which one of the following gases is used for artificial ripening of fruits.

(a) Ethene ✅

(b) Ethyne

(c) Methane

(d) Propane

🌟 **Q. 4. Write the structural formula for each of the following compounds**

❖ **Answer:**

i) 2-Methylpropane (isobutane)

Condensed: $(CH_3)_2CH-CH_3$

Pictorial: $CH_3-CH(CH_3)-CH_3$

ii) Neopentane (same as 2,2-dimethylpropane)

Condensed: $C(CH_3)_4$

Pictorial: $(CH_3)_4C$

iii) 3-Ethylpentane

Condensed: $CH_3-CH_2-CH(C_2H_5)-CH_2-CH_3$

Pictorial: $CH_3-CH_2-CH(-CH_2CH_3)-CH_2-CH_3$

iv) 4-Ethyl-3,4-dimethylheptane

Condensed: $CH_3-CH_2-CH(CH_3)-C(CH_3)(C_2H_5)-CH_2-CH_2-CH_3$

Pictorial (numbered chain C1 → C7):

C1 CH_3 – C2 CH_2 – C3 $CH(CH_3)$ – C4 $C(CH_3)(C_2H_5)$ – C5 CH_2 – C6 CH_2 – C7 CH_3

v) 2,2,3,4-Tetrame thylpentane

Condensed: $CH_3-C(CH_3)_2-CH(CH_3)-CH(CH_3)-CH_3$

Pictorial: $CH_3-C(=CH_3)(-CH_3)-CH(CH_3)-CH(CH_3)-CH_3$ (read as C2 has two methyls; C3 and C4 each have one methyl)

vi) 4-iso-Propylheptane

(iso-propyl = $-CH(CH_3)_2$)

Condensed: $CH_3-CH_2-CH_2-CH[CH(CH_3)_2]-CH_2-CH_2-CH_3$

Pictorial: $CH_3-(CH_2)_2-CH[-CH(CH_3)_2]-(CH_2)_2-CH_3$

vii) 2,2-Dimethylbutane

Condensed: $CH_3{-}C(CH_3)_2{-}CH_2{-}CH_3$

Pictorial: $CH_3{-}C({=}CH_3)({-}CH_3){-}CH_2{-}CH_3$

viii) 2,2-Dimethylpropane (same as neopentane — $C(CH_3)_4$)

Condensed: $C(CH_3)_4$

Pictorial: $(CH_3)_4C$

🌟 Q. 5. Write down names of the following compounds according to IUPAC-system.

🌟 Q.6: Rules for Naming Alkanes:

Rules for Naming Alkanes (IUPAC System)

Alkanes are saturated hydrocarbons containing only single bonds between carbon atoms. Their names are assigned according to the IUPAC rules as follows:

1. Identify the Longest Carbon Chain (Parent Chain)

The longest continuous chain of carbon atoms determines the parent name.

Count the number of carbons in the chain and use the corresponding alkane name:

No. of C atoms	Alkane name

1	Methane
2	Ethane
3	Propane
4	Butane
5	Pentane
6	Hexane
7	Heptane
8	Octane

Example:

$CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_3$ ⟶ Longest chain has 4 C ⟶ Butane

2. Number the Carbon Chain

👉 **Number** the carbon atoms in the parent chain from the end nearest to the first substituent.

👉 **This ensures** the substituents get the lowest possible numbers.

Example:

$CH_3\text{-}CH(CH_3)\text{-}CH_2\text{-}CH_3$ ⟶ Number from left: methyl group at C2 ⟶ 2-Methylbutane

3. Identify and Name Substituents

Substituents are groups attached to the main chain.

Common substituents include:

👉 **Alkyl groups:** methyl (-CH_3), ethyl (-C_2H_5), propyl (-C_3H_7)

👉 **Halo groups:** chloro (-Cl), bromo (-Br), iodo (-I)

Example:

CH_3-CH_2-$CH(CH_3)$-CH_3 ⟶ Substituent: methyl group at C3 ⟶ 3-Methylpentane

4. Assign Numbers to Substituents

👉 Assign numbers to each substituent according to the lowest locant rule.

👉 If multiple substituents are present, alphabetical order is used in the name.

Example:

$(CH_3)_2CH$-CH_2-CH_3 ⟶ Two methyl groups at C2 ⟶ 2,2-Dimethylbutane

5. Combine the Name

👉 **Combine** substituent names, locants, and parent chain name in one word.

👉 Use prefixes like di-, tri-, tetra- for multiple identical substituents.

Example:

$CH_3\text{-}C(CH_3)_2\text{-}CH_2\text{-}CH_3$ ⟶

Parent chain = Butane

Substituents = two methyls at C2 ⟶ 2,2-Dimethylbutane

6. Multiple Substituents with Different Groups

👉 **List substituents** in alphabetical order, ignoring prefixes like di-, tri-.

👉 **Use hyphens** to separate numbers and commas to separate multiple locants.

Example:

$CH_3\text{-}CH(CH_3)\text{-}CH_2\text{-}CH(CH_3)\text{-}CH_3$ ⟶

Substituents: methyl at C2 and C4 ⟶ 2,4-Dimethylpentane

🌟 Q.7 (a) Structural Formulas and Names of Hexane Isomers

Hexane (C_6H_{14}) has five isomers. Their structural formulas and IUPAC names are as follows:

1. n-Hexane (Normal Hexane)

Formula: $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_2\text{-}CH_3$

2. 2-Methylpentane

Formula: $CH_3\text{-}CH(CH_3)\text{-}CH_2\text{-}CH_2\text{-}CH_3$

3. 3-Methylpentane

Formula: CH_3-CH_2-$CH(CH_3)$-CH_2-CH_3

4. 2,3-Dimethylbutane

Formula: CH_3-$CH(CH_3)$-$CH(CH_3)$-CH_3

5. 2,2-Dimethylbutane

Formula: CH_3-$C(CH_3)_2$-CH_2-CH_3

🌟 Q.7 (b) Correct IUPAC Names

i) 4-Methylpentane → Incorrect

The longest chain must include the substituent for the lowest number.

Correct name: 2-Methylpentane

ii) 3,5,5-Trimethylhexane → Incorrect

Chain numbering should give substituents lowest numbers.

Correct name: 2,2,4-Trimethylhexane

iii) 2-Methyl-3-Ethylbutane → Incorrect

The longest chain should be chosen to include the largest substituent.

Correct name: 2-Ethyl-3-methylpentane

🌟**Q.8. (a) Explain why alkanes are less reactive than alkenes? What is the effect of branching on the melting point of alkanes ?**

1. Reactivity of Alkanes vs Alkenes

👉 Alkanes are saturated hydrocarbons containing only single C–C and C–H bonds.

👉 These σ-bonds are strong and electrons are tightly held, making alkanes chemically stable.

👉 Alkanes mainly undergo substitution reactions (e.g., halogenation).

👉 Alkenes are unsaturated hydrocarbons with at least one C=C double bond.

👉 The double bond consists of one σ-bond and one π-bond.

👉 π-electrons are loosely held above and below the plane of the σ-bond.

👉 These electrons are easily attacked by electrophiles, making alkenes highly reactive.

Conclusion: Alkanes < Alkynes < Alkenes (in terms of reactivity towards electrophiles).

🌟 **Q.8 (b) Three different alkanes yield 2-methylbutane when they are hydrogenated in the presence of a metal**

catalyst. Give their structures and write equations for the reactions involved.

(b) Three different alkenes yielding 2-methylbutane on hydrogenation

Reaction type: Catalytic hydrogenation (Alkene + H_2 ⟶ Alkane)

Catalyst: Ni / Pt / Pd

1️⃣From 2-Methyl-1-butene

Reaction:

CH3

|

CH2 = CH — CH2 — CH3 + H2

Ni/Pt/Pd

------------------------>

CH3

|

CH3 — CH — CH2 — CH3

Product: 2-Methylbutane

2️⃣From 2-Methyl-2-butene

Reaction:

CH3

|

CH3 — C = CH2 + H2

Ni/Pt/Pd

------------------>

CH3

|

CH3 — CH — CH2 — CH3

Product: 2-Methylbutane

3️⃣ From 3-Methyl-1-butene

Reaction:

CH3

|

CH2 = CH — CH — CH3 + H2

Ni/Pt/Pd

---------------------------->

CH3

|

CH3 – CH – CH2 – CH3

Product: 2-Methylbutane

✦ **Summary:**

- All three alkenes are structural isomers of C_5H_{10}.
- Hydrogenation saturates the double bond, forming the same alkane.

Final Answer (Product for all reactions):

- 2-Methylbutane (C_5H_{12})

🌟 Q.9 (a) Methods for the Preparation of Alkanes

Alkanes can be prepared by the following methods:

1. Hydrogenation of Alkenes and Alkynes

Alkenes/Alkynes + $H_2 \longrightarrow$ Alkanes

Catalyst: Ni / Pt / Pd

Example:

$CH_2{=}CH_2 + H_2 \longrightarrow CH_3{-}CH_3$

2. Reduction of Alkyl Halides

Alkyl halide + H_2 (Ni catalyst) $\longrightarrow$ Alkane

Example:

$CH_3Cl + H_2 \longrightarrow CH_4 + HCl$

3. Wurtz Reaction

Two alkyl halides react with Na in dry ether → higher alkane.

Example:

$2CH_3Cl + 2Na \longrightarrow C_2H_6 + 2NaCl$

4. Decarboxylation of Sodium Salts of Carboxylic Acids

Sodium salt + NaOH (CaO) $\longrightarrow$ Alkane + Na_2CO_3

Example:

$CH_3COONa + NaOH \longrightarrow CH_4 + Na_2CO_3$

5. Kolbe Electrolysis

Electrolysis of sodium salts of fatty acids → Alkane (even carbon number).

Example:

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

6. From Grignard Reagents

$RMgX + H_2O \longrightarrow RH + Mg(OH)X$

Example:

$CH_3MgBr + H_2O \longrightarrow CH_4$

🌟 (b) How will you bring about the following conversions?

i) Methane Ethane

Method: Kolbe Electrolysis

Reaction:

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

So methane is first converted to sodium acetate → Kolbe electrolysis → ethane.

ii) Ethane → Methane

Method: Decarboxylation route

Ethane → Ethyl chloride → Grignard reagent → Methane

Steps:

1. Ethane → Ethyl chloride

$C_2H_6 + Cl_2 \longrightarrow C_2H_5Cl + HCl$

2. Ethyl chloride → Ethyl magnesium chloride

$C_2H_5Cl + Mg \longrightarrow C_2H_5MgCl$

3. Grignard reagent + water → Methane

$C_2H_5MgCl + H_2O \longrightarrow CH_4 + Mg(OH)Cl$

iii) Acetic acid → Ethane

Method: Kolbe Electrolysis

Reaction:

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

iv) Methane ⟶ Nitromethane (CH_3NO_2)

Method: Direct nitration

Reaction:

$CH_4 + HNO_3 \longrightarrow CH_3NO_2 + H_2O$

⭐ Answers Summary:

(a) Alkanes Preparation:

👉 Hydrogenation

👉 Reduction of alkyl halides

👉 Wurtz reaction

👉 Decarboxylation

👉 Kolbe electrolysis

👉 From Grignard reagents

(b) Conversions:

1. $CH_4 \longrightarrow C_2H_6$: Kolbe electrolysis
2. $C_2H_6 \longrightarrow CH_4$: Through Grignard reagent
3. $CH_3COOH \longrightarrow C_2H_6$: Kolbe electrolysis

4. $CH_4 \longrightarrow CH_3NO_2$: Nitration

🌟 Q.10. (a) What is meant by octane number? Why does a high octane fuel have a less tendency to knock in an automobile engine?

Answer:

👉 **Octane Number:** It is a measure of the ability of a fuel to resist knocking (premature ignition) in a petrol engine.

👉 **High Octane Fuel:** Fuels with a higher octane number resist knocking better because they burn smoothly and do not ignite prematurely under compression, reducing engine knocking.

Example:

Iso-octane (2,2,4-trimethylpentane) → Octane number = 100

n-Heptane → Octane number = 0

🌟 Q.10. (b) Explain free radical mechanism for the reaction of chlorine with methane in the presence of sunlight.

❖ **Answer:**

Overall Reaction:

$CH4 + Cl2 \longrightarrow CH3Cl + HCl$

Step 1: Initiation

$Cl_2 \longrightarrow 2\ Cl\cdot$

Step 2: Propagation

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

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

Step 3: Termination

$Cl\cdot + Cl\cdot \longrightarrow Cl_2$

$CH_3\cdot + Cl\cdot \longrightarrow CH_3Cl$

$CH_3\cdot + CH_3\cdot \longrightarrow C_2H_6$

Explanation:

1. Initiation: Chlorine molecule splits into two chlorine radicals by light energy.

2. Propagation: Chlorine radicals react with methane forming methyl radicals and HCl, which react further with Cl_2 to form CH_3Cl and regenerate $Cl\cdot$.

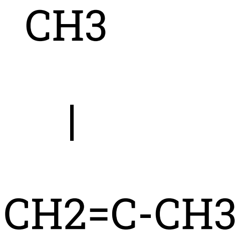
3. Termination: Two radicals combine to form stable molecules, stopping the chain reaction.

🌟 **Q.11. (a) Write structural formulas for each of the following compounds.**

❖ **Answer:**

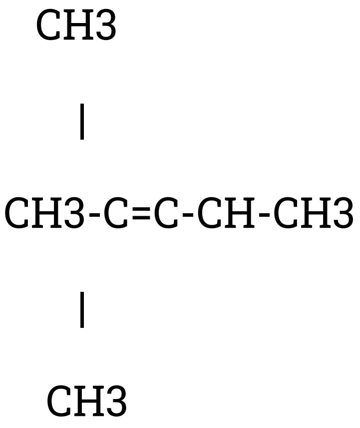
i) Isobutylene (2-Methylpropene)

Formula: $(CH_3)_2C=CH_2$



$$CH_2=\overset{\overset{CH_3}{|}}{C}-CH_3$$

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



$$CH_3-\underset{\underset{CH_3}{|}}{\overset{\overset{CH_3}{|}}{C}}=C-CH-CH_3$$

iii) 2,5-Heptadiene

$CH_2=CH-CH_2-CH_2-CH=CH-CH_3$

iv) 4,5-Dimethyl-2-hexene

$CH_3-CH=C-CH(CH_3)-CH(CH_3)-CH_3$

v) Vinylacetylene (1-Buten-3-yne)

$CH_2=CH-C\equiv CH$

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

$CH_2=CH-CH-CH=CH_2$

|

$CH_2-CH_2-CH_3$

ix) Vinyl bromide (Bromoethene)

$CH_2=CH-Br$

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 (2-Methylbutane)

CH_3

|

$CH_3-CH-CH_2-CH_3$

🌟 **Q.12. (a) Describe different methods for the preparation of alkenes. How would you establish that ethylene contains a double bond?**

❖ **Answer:**

1. Methods for the Preparation of Alkenes

Alkenes (unsaturated hydrocarbons with C=C) can be prepared by several methods:

A. Dehydrohalogenation of Alkyl Halides

- Alkyl halides on heating with alcoholic KOH undergo elimination of HX to form alkenes.

Example:

$CH_3-CH_2-Br + \text{Alc. } KOH \longrightarrow CH_2=CH_2 + HBr$

B. Dehydration of Alcohols

- Alcohols when heated with acid catalysts (conc. H_2SO_4, H_3PO_4) or passed over heated alumina, lose H_2O to form alkenes.

Example:

$CH_3-CH_2-OH \longrightarrow CH_2=CH_2 + H_2O$

C. Dehalogenation of Vicinal Dihalides

- Vicinal dihalides (halogens on adjacent carbons) react with Zn in alcohol to form alkenes.

Example:

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

D. Electrolytic Method (Kolbe’s method)

- Salts of dicarboxylic acids when electrolyzed give alkenes.

E. Partial Hydrogenation of Alkynes

- Alkynes react with H_2 in the presence of Lindlar’s catalyst to give cis-alkenes.

2. Test to Establish that Ethylene Contains a Double Bond

A. Bromine Test (Addition Reaction)

- Ethylene decolorizes bromine water due to the addition across the double bond.

$CH_2=CH_2 + Br_2 \longrightarrow CH_2Br\text{-}CH_2Br$

Observation: Brown color of Br_2 disappears ⟶ confirms double bond.

B. Baeyer's Test (Oxidation with KMnO4)

- Cold dilute $KMnO_4$ reacts with ethylene to form ethylene glycol (vicinal diol).

$CH_2=CH_2 + [O] \longrightarrow HO\text{-}CH_2\text{-}CH_2\text{-}OH$

Observation: Purple $KMnO_4$ turns colorless ⟶ confirms C=C.

✦ **Summary:**

- **Alkenes** can be prepared by elimination (dehydration or dehalogenation), electrolysis, or partial hydrogenation.
- **The double bond** in ethylene is confirmed by additional reactions (Br2 and KMnO4 tests).

🌟 Q.12 (b) Give structural formulas of the alkenes expected to form by the dehydrohalogenation of the following compounds with a strong base:

❖ **Answer:**

Reaction:

- Dehydrohalogenation involves elimination of HX from an alkyl halide in the presence of a strong base (like alcoholic KOH), forming an alkene.

i) 1-Chloropentane

Elimination of HCl from adjacent carbon:

CH3-CH2-CH2-CH2-CH2Cl + Alc. KOH ⟶
CH2=CH-CH2-CH2-CH3 + HCl

Product: Pent-1-ene

Structure formula:

➢ CH2=CH-CH2-CH2-CH3

ii) 2-Chloro-3-methylbutane

- Elimination of HCl can occur from the adjacent carbons to form the most stable (more substituted) alkene.

Cl

|

CH3-CH-CH-CH3 + Alc. KOH → CH3-C=CH-CH3 + HCl

|

CH3

Product: 2-Methylbut-2-ene (major, more substituted)

Minor product: 2-Methylbut-1-ene

CH2=C(CH3)-CH2-CH3

iii) 1-Chloro-2,2-dimethylpropane

Only one possible elimination:

Cl

|

CH3-C-CH3 + Alc. KOH ⟶ (CH3)2C=CH2 + HCl

CH3

Product: 2-Methylprop-1-ene

🌟 Q.13 a) Write down chemical equations for the preparation of propene from the following compounds.

(a) Preparation of Propene

Propene ($CH_3-CH=CH_2$) is an alkene with the molecular formula C_3H_6. It can be prepared from alcohols, alkynes, and alkyl halides using elimination or hydrogenation reactions.

i) From 1-Propanol ($CH_3-CH_2-CH_2-OH$)

Method: Dehydration of alcohol

Alcohols lose a water molecule when heated with a strong acid like H_2SO_4.

This elimination reaction converts 1-propanol into propene.

Equation:

$CH_3-CH_2-CH_2-OH \longrightarrow [H_2SO_4, 170°C] \longrightarrow CH_3-CH=CH_2 + H_2O$

Explanation:

- OH and H from adjacent carbon atoms are removed.
- A double bond is formed between the second and third carbon.

ii) From Propyne ($CH_3-C\equiv CH$)

Method: Partial hydrogenation of alkyne

- Alkynes have a triple bond and can be partially hydrogenated to form alkenes.
- **Lindlar's catalyst** (Pd/$BaSO_4$ poisoned with quinoline) allows controlled addition of H_2 to form a cis-alkene.

Equation:

$CH_3\text{-}C{\equiv}CH + H_2 \longrightarrow$ [Lindlar catalyst] $\longrightarrow CH_3\text{-}CH{=}CH_2$

Explanation:

Only one H_2 molecule is added.

Triple bond (C≡C) becomes double bond (C=C).

iii) From iso-Propyl chloride ($CH_3\text{-}CHCl\text{-}CH_3$)

Method: Dehydrohalogenation of alkyl halide

- **Alkyl halides** react with alcoholic KOH.
- **A hydrogen** atom from the β-carbon and a halogen atom (Cl) are eliminated.
- **This forms** a double bond between carbon atoms.

Equation:

$CH_3\text{-}CHCl\text{-}CH_3 + \text{Alc. } KOH \longrightarrow CH_3\text{-}CH{=}CH_2 + HCl$

Explanation:

- **This is an** elimination reaction (E2 type).
- **Alcoholic** KOH acts as a strong base, removing H and Cl to form propene.

🌟 Q.13 (b) Write skeleton formula showing only the arrangement of carbon atoms for all the possible alkenes of the molecular formula C_5H_{10}

(b) Structural isomers of C_5H_{10}

- C5H10 has 5 carbon atoms and one double bond. The double bond can be located in different positions, and the chain can be branched.

All possible alkenes (skeleton formulas):

1. Pent-1-ene: CH2=CH-CH2-CH2-CH3

Double bond at the end of the chain.

2. Pent-2-ene: CH3-CH=CH-CH2-CH3

Double bond in the middle of the chain.

3. 2-Methylbut-1-ene: CH2=C(CH3)-CH2-CH3

Branch on second carbon, double bond at the end.

4. 2-Methylbut-2-ene: CH3-C(CH3)=CH-CH3

Branch on second carbon, double bond in the middle.

5. 3-Methylbut-1-ene: CH2=CH-CH(CH3)-CH3

Branch on third carbon, double bond at the end.

Explanation:

- These are all structural isomers of C_5H_{10}
- Chain isomerism and position of double bond creates five unique alkenes.

✅ **Key Points to Remember:**

1. Alcohol ⟶ Alkene: Dehydration

2. Alkyne ⟶ Alkene: Partial hydrogenation

3. Alkyl halide ⟶ Alkene: Dehydrohalogenation

4. Structural isomers: Consider chain length, branching, and double bond position.

🌟 **Q.14.(a) How may ethene be converted into ethyl alcohol?**

🌟 **(b) Starting from ethene, outline the reactions for the preparation of the following compounds:**

i) 1,2-Dibromoethane

ii) Ethyne

iii) Ethane

iv) Ethylene glycol

🌟 **(c) How will you bring about the following conversions:**

i) 1-Butene ⟶ 1-Butyne

ii) 1-Propanol ⟶ CH3-CH2-CH2Cl

❖ **Answer:**

(a) Conversion of Ethene into Ethyl Alcohol

Objective: Convert CH2=CH2 ⟶ CH3-CH2OH

Method: Acid-catalyzed hydration

Reaction:

CH2=CH2 + H2O ⟶ [H2SO4, 300°C, high pressure] ⟶ CH3-CH2OH

Explanation:

1. The π-bond in ethene acts as a nucleophile and attacks H^+ from H2SO4.

2. A carbocation intermediate forms.

3. Water (H2O) adds to the carbocation forming ethyl hydrogen sulfate.

4. Hydrolysis of ethyl hydrogen sulfate yields ethyl alcohol.

✅ **Result:** Ethene is converted to ethanol.

(b) Preparation of Compounds from Ethene

i) 1,2-Dibromoethane

Method: Halogenation of ethene

Reaction:

$CH2=CH2 + Br2 \longrightarrow CH2Br\text{-}CH2Br$

Explanation:

- The double bond reacts with Br2.
- A **vicinal** dibromide is formed by addition of bromine across the double bond.

ii) Ethyne (Acetylene)

Method: Dehydrohalogenation of 1,2-dibromoethane

Reaction:

$CH2Br\text{-}CH2Br + 2[KOH\ (alc.)] \longrightarrow HC{\equiv}CH + 2KBr + 2H2O$

Explanation:

A strong base removes two molecules of HBr.

Product: ethyne

iii) Ethane

Method: Hydrogenation of ethene

Reaction:

$CH2=CH2 + H2 \longrightarrow [Ni/Pt] \longrightarrow CH3\text{-}CH3$

Explanation:

- Hydrogen adds to the double bond in presence of a catalyst.

Product: saturated hydrocarbon (ethane)

iv) Ethylene Glycol

Method: Oxidation with cold alkaline $KMnO_4$

Reaction:

$CH_2=CH_2 + [O] \longrightarrow CH_2OH\text{-}CH_2OH$

Explanation:

- Cold dilute $KMnO_4$ oxidizes ethene to vicinal diol (glycol).
- Both carbon atoms of the double bond receive an −OH group.

(c) Specific Conversions

i) 1-Butene → 1-Butyne

Step 1: Convert 1-butene to 1-bromobutane (addition of HBr)

$CH_2=CH\text{-}CH_2\text{-}CH_3 + HBr \longrightarrow CH_3\text{-}CHBr\text{-}CH_2\text{-}CH_3$

Step 2: Dehydrohalogenation with alc. KOH

$CH_3\text{-}CHBr\text{-}CH_2\text{-}CH_3 + \text{alc. } KOH \longrightarrow CH\equiv C\text{-}CH_2\text{-}CH_3 + H_2O$

Explanation:

Elimination of HX converts alkene → alkyne.

ii) 1-Propanol → $CH_3\text{-}CH_2\text{-}CH_2Cl$

Method: Substitution reaction with HCl or SOCl2

Reaction:

CH3-CH2-CH2OH + HCl → CH3-CH2-CH2Cl + H2O

Explanation:

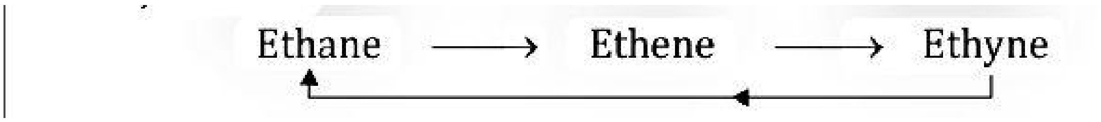
OH is replaced by Cl via nucleophilic substitution.

Product: 1-chloropropane

✅ Key Points for Exams

1. Ethene → Ethanol: Acid-catalyzed hydration
2. Ethene → 1,2-Dibromoethane: Halogenation
3. 1,2-Dibromoethane → Ethyne: Dehydrohalogenation
4. Ethene → Ethane: Hydrogenation
5. Ethene → Ethylene Glycol: Oxidation with cold KMnO4
6. Alkene → Alkyne: Via elimination reaction
7. Alcohol → Alkyl halide: Substitution reaction

🌟 Q.15 Show by means of chemical equations how the following cycle of changes may be affected:



Step 1: Conversion of Ethane to Ethene

Reaction:

$CH_3-CH_3 \longrightarrow CH_2=CH_2 + H_2$ [Ni or Pt, heat]

Explanation:

👉 Ethane is a saturated hydrocarbon and contains only single bonds.

👉 On heating in the presence of a metal catalyst like nickel or platinum, two hydrogen atoms are removed.

👉 This forms ethene (C_2H_4), an unsaturated hydrocarbon with a double bond.

Step 2: Conversion of Ethene to Ethyne

Step 2a: Formation of 1,2-Dibromoethane

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

Step 2b: Dehydrohalogenation

$CH_2Br-CH_2Br + 2\ KOH\ (alc.) \longrightarrow HC\equiv CH + 2\ KBr + 2\ H_2O$

This method is known as dehydrohalogenation of vicinal dihalides.

Step 3: Conversion of Ethyne to Ethene

$HC\equiv CH + H_2 \longrightarrow CH_2=CH_2$ [Lindlars catalyst]

Product: ethene.

Step 4: Conversion of Ethene to Ethane

CH2=CH2 + H2 ⟶ CH3−CH3   [Ni or Pt catalyst]

This completes the cycle of transformations.

✦ **Summary Explanation:**

Ethane ⟶ **Ethene:** Dehydrogenation (removal of H2).

Ethene ⟶ **Ethyne:** Addition of Br2 followed by dehydrohalogenation.

Ethyne ⟶ Ethene: Partial hydrogenation (Lindlar's catalyst).

Ethene ⟶ Ethane: Complete hydrogenation (Ni/Pt).

✅ **Tip for exams:** Remember the cycle as "Hydrogen removed ⟶ Halogen added ⟶ Triple bond ⟶ Partial H ⟶ Complete H".

🌟 **Q.16 Write down the products formed when 1-butene (CH_2=CH-CH_2-CH_3) reacts with the following reagents:**

1. Hydrogenation (H_2 / Pt)

Reaction: $CH_2=CH-CH_2-CH_3 + H_2 \longrightarrow CH_3-CH_2-CH_2-CH_3$

Product: Butane ✅

Explanation: The double bond becomes a single bond; alkene is converted into a saturated alkane.

2. Bromination (Br_2 in CCl_4)

Reaction: $CH_2=CH-CH_2-CH_3 + Br_2 \longrightarrow CH_2Br-CHBr-CH_2-CH_3$

Product: 1,2-Dibromobutane ✅

Explanation: Bromine adds across the double bond, forming a vicinal dibromide.

3. Addition of HBr

Reaction: $CH_2=CH-CH_2-CH_3 + HBr \longrightarrow CH_3-CHBr-CH_2-CH_3$

Product: 2-Bromobutane ✅

Explanation: Following Markownikov's rule, H attaches to the carbon with more H atoms.

4. Hydration with dilute H_2SO_4

Reaction: $CH_2=CH-CH_2-CH_3 + H_2O \longrightarrow CH_3-CH(OH)-CH_2-CH_3$

Product: 2-Butanol ✅

Explanation: Water adds across the double bond in acidic medium, OH attaches to the more substituted carbon.

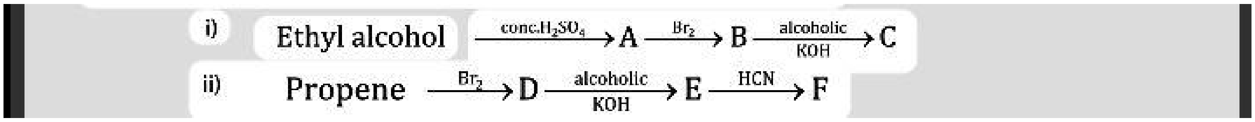
5. Oxidation with cold dilute $KMnO_4$

Reaction: $CH_2=CH-CH_2-CH_3 + [O] \longrightarrow CH_2(OH)-CH(OH)-CH_2-CH_3$

Product: 1,2-Butanediol ✅

Explanation: Cold $KMnO_4$ adds OH groups to both carbons of the double bond; used to test unsaturation.

🌟 Q.17. In the following reactions, identify each lettered product



i) Ethyl alcohol $\xrightarrow{\text{conc.}H_2SO_4} A \xrightarrow{Br_2} B \xrightarrow[\text{KOH}]{\text{alcoholic}} C$

ii) Propene $\xrightarrow{Br_2} D \xrightarrow[\text{KOH}]{\text{alcoholic}} E \xrightarrow{HCN} F$

Given Reaction i:

CH_3-CH_2-OH (conc. H_2SO_4) A ⟶ (Br_2) B ⟶ (alcoholic KOH) C

1. Step 1: CH_3-CH_2-OH + conc. H_2SO_4 ⟶ A

Reaction: Dehydration of alcohol.

Product A: CH_2=CH_2 (Ethene) ✅

Explanation: Ethanol loses water under conc. H_2SO_4 at high temperature to form alkene.

2. Step 2: CH_2=CH_2 + Br_2 ⟶ B

Reaction: Bromination (Addition of Br_2).

Product B: CH_2Br-CH_2Br (1,2-Dibromoethane) ✅

Explanation: Bromine adds across the double bond.

3. Step 3: CH_2Br-CH_2Br + alcoholic KOH ⟶ C

Reaction: Dehydrohalogenation (elimination of HBr).

Product C: CH≡CH (Ethyne / Acetylene) ✅

Explanation: Alcoholic KOH removes HBr from vicinal dibromide to give alkyne.

Given Reaction ii:

CH_3-CH=CH_2 (Propene) ⟶ B ⟶ (Br_2) D ⟶ (alcoholic KOH) E ⟶ HCN

1. **Step 1:** CH_3-CH=CH_2 ⟶ B

This is already Propene, so B = CH_3-CH=CH_2

2. **Step 2:** CH_3-CH=CH_2 + Br_2 ⟶ D

Reaction: Addition of bromine.

Product D: CH_3-CHBr-CH_2Br (1,2-Dibromopropane) ✅

3. **Step 3:** CH_3-CHBr-CH_2Br + alcoholic KOH ⟶ E

Reaction: Dehydrohalogenation (elimination of HBr).

Product E: CH_3-C≡CH (Propyne / Methylacetylene) ✅

4. **Step 4:** CH_3-C≡CH + HCN ⟶ CH_3-C(CN)=CH_2

Reaction: Addition of HCN to terminal alkyne.

Product: CH_3-C(CN)=CH_2 (Methylpropenenitrile) ✅

✅ Summary of Products:

Reaction i:

- **A:** CH_2=CH_2 (Ethene)

- **B**: CH_2Br-CH_2Br (1,2-Dibromoethane)
- **C**: $CH\equiv CH$ (Ethyne)

Reaction ii:

- **B**: $CH_3-CH=CH_2$ (Propene)
- **D**: $CH_3-CHBr-CH_2Br$ (1,2-Dibromopropane)
- **E**: $CH_3-C\equiv CH$ (Propyne)

🌟 **Q.18. After an ozonolysis experiment, the only product obtained was acetalde-hydeCH_3CHO Can you guess the structural formula of this compound**.

Question:

After an ozonolysis experiment, the only product obtained was acetaldehyde (CH_3CHO). Can you guess the structural formula of the original compound?

Step 1: Recall the ozonolysis reaction

- Ozonolysis of an alkene cleaves the double bond and produces carbonyl compounds (aldehydes or ketones).

General reaction:

$R-CH=CH-R' + O_3 \longrightarrow R-CHO + R'-CHO$ (if symmetrical alkene)

Step 2: Analyze the product

- The only product obtained is acetaldehyde (CH_3CHO).

- **This means** the alkene must be symmetrical so that cleavage of the double bond gives two identical CH_3CHO molecules.

Step 3: Deduce the original compound

Acetaldehyde: CH_3-CHO

Two identical CH_3CHO molecules ⟶ the original alkene must have the structure:

CH_3-CH=CH-CH_3 ⟶ Wait, cleavage gives CH_3-CHO + CH_3-CHO

✅ Therefore, the original compound is ethene with one methyl group on each carbon of the double bond:

Structural formula:

H

|

CH3-C= C-CH3

|

H

Name: But-2-ene (symmetrical)

Step 4: Conclusion

Symmetrical alkenes produce identical carbonyl compounds on ozonolysis.

Here, But-2-ene → ozonolysis → 2 molecules of acetaldehyde.

🌟 **Q. 19. (a) The addition of sulphuric acid to an alkene obeys Markownikov's rule.**

Predict the structures of the alcohols obtained by the addition of the acid to the following compounds.

i) Propene

ii) 1-Butene

iii) 2-Butene

(b) Predict the most likely product of the addition of hydrogen chloride to 2-methyl-2-butene. Explain the formation of this product.

Q.19 (a)

Statement:

The addition of sulphuric acid (H_2SO_4) to an alkene obeys Markownikov's rule.

Markownikov's rule:

> When an unsymmetrical reagent (like H^+ from H_2SO_4) adds to an unsymmetrical alkene, the H^+ attaches to the carbon of the double bond that has more hydrogen atoms, and the negative part (HSO_4^-) attaches to the carbon with fewer hydrogen atoms.

👉 The intermediate alkyl hydrogen sulfate can be hydrolyzed to give the alcohol.

i) Propene (CH_3-$CH=CH_2$)

Step 1: Protonation of double bond according to Markownikov's rule:

H^+ adds to CH_2 end (more H atoms) ⟶ carbocation forms on middle carbon (CH).

Step 2: Addition of HSO_4^- ⟶ alkyl hydrogen sulfate:

CH_3-$CH(OSO_3H)$-CH_3

Step 3: Hydrolysis with water ⟶ alcohol:

Product:

CH_3

|

CH_3-CH-CH_2 ⟶ CH_3-$CH(OH)$-CH_3

Name: 2-Propanol

ii) 1-Butene ($CH_2=CH$-CH_2-CH_3)

Step 1: H^+ adds to CH_2 (more H atoms) ⟶ carbocation on CH (second carbon).

Step 2: Addition of HSO_4^- ⟶ CH_3-$CH(OSO_3H)$-CH_2-CH_3

Step 3: Hydrolysis ⟶ alcohol:

Product:

CH_3-CH-CH_2-CH_3

|

OH

Name: 2-Butanol

iii) 2-Butene (CH_3-CH=CH-CH_3)

- Double bond is symmetrical, so H^+ can add to either carbon.

Hydrolysis gives the same product:

Product:

CH_3-CH(OH)-CH_2-CH_3

Name: 2-Butanol

🌟 **Q.19 (b) Predict the most likely product of the addition of hydrogen chloride to 2-methyl-2-butene. Explain the formation of this product.**

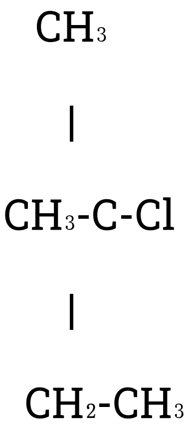
Reaction: Addition of HCl to 2-methyl-2-butene (CH_3-C(CH_3)=CH-CH_3)

Step 1: Protonation of double bond (Markownikov's rule)

H^+ adds to the CH carbon of the double bond with more hydrogens ⟶ carbocation forms at the tertiary carbon (more stable).

Step 2: Cl^- attacks the carbocation ⟶ forms alkyl halide.

Product:



$$\begin{array}{c} CH_3 \\ | \\ CH_3\text{-}C\text{-}Cl \\ | \\ CH_2\text{-}CH_3 \end{array}$$

Name: 2-Chloro-2-methylbutane

Explanation:

- The tertiary carbocation is more stable than secondary or primary carbocations.

Therefore, the chloride attaches to the carbon forming the most stable carbocation.

🌟 Q.20 Why are some hydrocarbons called saturated and others unsaturated? What type of reactions are characteristic of them?

❖ **Answer:**

1. Saturated Hydrocarbons:

Definition: Hydrocarbons in which all carbon atoms are bonded to the maximum possible number of hydrogen atoms and contain only single bonds (C−C) are called saturated hydrocarbons.

Example: Methane (CH_4), Ethane (C_2H_6), Propane (C_3H_8)

Characteristic Reaction:

- Substitution reactions are typical.

Example: Halogenation of methane:

$CH_4 + Cl_2 \longrightarrow CH_3Cl + HCl$ (in sunlight)

2. Unsaturated Hydrocarbons:

Definition: Hydrocarbons that contain one or more double (C=C) or triple (C≡C) bonds are called unsaturated hydrocarbons.

Examples:

Alkenes (C=C): Ethene ($CH_2{=}CH_2$), Propene ($CH_3{-}CH{=}CH_2$)

Alkynes (C≡C): Ethyne (C_2H_2), Propyne ($CH_3{-}C{\equiv}CH$)

Characteristic Reaction:

Additional reactions are typical, because the double or triple bonds can break to add new atoms.

Example: Addition of H_2 to ethene:

$CH_2{=}CH_2 + H_2 \longrightarrow CH_3{-}CH_3$ (in the presence of Pt)

✦ Summary (Conceptual):

Saturated Hydrocarbons: Single bonds → substitution reactions

Unsaturated Hydrocarbons: Double/triple bonds → addition reactions

Reason:

Single bonds are strong and electrons are not easily attacked → substitution.

Double/triple bonds have π electrons which are exposed → addition reactions occur easily.

🌟 Q.21 (a) Methods for the preparation of Ethyne (C_2H_2)

1. From Calcium Carbide (Industrial Method):

Reaction: Calcium carbide reacts with water to produce ethyne.

Equation:

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

Notes: This is the most common industrial method.

2. Dehydrohalogenation of Vicinal Dihalides:

A vicinal dihalide is treated with a strong base like alcoholic KOH, which removes two molecules of HX to give an alkyne.

Example:

$CH_2Br{-}CH_2Br + 2KOH$ (alc.) $\longrightarrow HC{\equiv}CH + 2KBr + 2H_2O$

3. Dehalogenation of Tetrahalides:

Tetrahalides (C_2X_4) react with active metals like Zn or Mg to give ethyne.

Example:

$CHBr_2{-}CHBr_2 + 2[Zn] \longrightarrow HC{\equiv}CH + 2ZnBr_2$

4. Electrolysis of Sodium or Potassium Salts of Unsaturated Dicarboxylic Acids (Kolbe's Electrolytic Method):

Example: Potassium salt of malonic acid is electrolyzed to produce ethyne.

Equation:

$CH_2(COO)K{-}CH_2(COO)K \longrightarrow HC{\equiv}CH + 2CO_2 + 2K$

🌟 (b) Reactions of Ethyne

i) Reaction with Hydrogen (Hydrogenation)

Catalyst: Ni, Pt, or Pd

Reaction: Ethyne reacts with 1 molecule of H_2 to give ethene, and with 2 molecules of H_2 to give ethane.

Equations:

$HC\equiv CH + H_2 \longrightarrow H_2C{=}CH_2$ (Ethene)

$H_2C{=}CH_2 + H_2 \longrightarrow CH_3{-}CH_3$ (Ethane)

ii) Reaction with Halogen Acids (HX Addition)

Follows Markownikov's rule for unsymmetrical alkynes.

Example: Ethyne reacts with HBr:

$HC\equiv CH + HBr \longrightarrow CH_2{=}CHBr$ (Vinyl bromide)

$CH_2{=}CHBr + HBr \longrightarrow CH_3{-}CHBr_2$ (1,1-Dibromoethane)

iii) Reaction with Alkaline $KMnO_4$

- Mild oxidizing agent (cold, dilute) reacts with ethyne to form glyoxal or other diols.

Example:

$HC\equiv CH + [O] \longrightarrow HC{-}CHO$ (Glyoxal)

iv) Reaction with 10% H_2SO_4 in the Presence of $HgSO_4$ (Hydration)

Forms enol, which tautomerizes to acetaldehyde.

Equation:

$HC\equiv CH + H_2O \longrightarrow H_2C{=}CH{-}OH$ (Vinyl alcohol) $\longrightarrow CH_3{-}CHO$ (Acetaldehyde)

v) Reaction with Ammonical Cuprous Chloride

Ethyne reacts with CuCl in an ammoniacal solution to form copper acetylide, a useful reagent.

Equation:

$HC\equiv CH + 2CuCl + 2NH_4OH \rightarrow CuC\equiv CCu + 2NH_4Cl + 2H_2O$

🌟 (c) Uses of Methane, Ethene, and Ethyne

1. Methane (CH_4):

- Fuel for heating and cooking.
- Raw material for methanol, chloroform, and other chemicals.

2. Ethene (C_2H_4):

- **Polythene production** (plastic bags, toys, containers).
- **Artificial ripening** of fruits.
- **Manufacture of ethanol,** ethyl halides, and other chemicals.

3. Ethyne (C_2H_2):

- **Fuel in oxyacetylene** torches for welding and cutting metals.
- **Raw material** for PVC, polymers, alcohols, acetic acid.
- **Production** of synthetic rubber (neoprene).

✦ Summary:

Ethyne preparation: Industrial ($CaC_2 + H_2O$), dehydrohalogenation, dehalogenation, Kolbe's method.

Reactions: Hydrogenation, halogen addition, hydration, oxidation, acetylide formation.

Uses: Methane (fuel/chemical), Ethene (plastics/ripening), Ethyne (welding/polymers).

🌟 **Q.22 Describe how you could distinguish ethane, ethene, and ethyne from one another by chemical reactions.**

1. Ethane (C_2H_6)

Type: Saturated hydrocarbon (alkane)

Reactivity: Very low; does not react with bromine water in the dark or cold conditions.

Test:

Reaction with bromine water (Br_2 in CCl_4): No reaction in the absence of sunlight.

Observation: No decolorization of bromine water.

Equation:

$CH_3{-}CH_3 + Br_2 \longrightarrow$ No reaction (in dark)

2. Ethene (C_2H_4)

Type: Unsaturated hydrocarbon (alkene with a C=C double bond)

Reactivity: Highly reactive; undergoes additional reactions.

Tests:

1. Bromine water test:

- Ethene reacts with bromine water to decolorize it.

Equation:

$CH_2=CH_2 + Br_2 \longrightarrow BrCH_2-CH_2Br$

Observation: Bromine water turns colorless.

2. Baeyer's Test ($KMnO_4$ test):

- Cold dilute potassium permanganate reacts with ethene to give a glycol.

Equation:

$CH_2=CH_2 + [O] \longrightarrow HO-CH_2-CH_2-OH$ (Ethylene glycol)

Observation: Purple $KMnO_4$ decolorizes and a brown precipitate may form.

3. Ethyne (C_2H_2)

Type: Unsaturated hydrocarbon (alkyne with a C≡C triple bond)

Reactivity: More reactive than alkanes, slightly less than alkenes towards electrophiles.

Tests:

1. Bromine water test:

- Ethyne also reacts and decolorizes bromine water.

Equation:

$HC{\equiv}CH + Br_2 \longrightarrow BrCH{=}CHBr \longrightarrow Br_2CH{-}CHBr_2$

Observation: Bromine water becomes colorless, similar to ethene.

2. Ammoniacal silver nitrate test:

- Terminal alkynes like ethyne react to form silver acetylide (white precipitate).

Equation:

$HC{\equiv}CH + 2AgNO_3 + 2NH_4OH \longrightarrow AgC{\equiv}CAg + 2NH_4NO_3 + 2H_2O$

Observation: Formation of white precipitate confirms terminal alkyne.

3. Difference from ethene:

- Ethyne reacts with ammoniacal CuCl or $AgNO_3$ to give a precipitate.
- Ethene does not react in this way.

✦ Summary:

Ethane: No reaction with Br_2 in dark ⟶ Saturated

Ethene: Decolorizes Br_2, $KMnO_4$ ⟶ Double bond present

Ethyne: Decolorizes Br_2, forms silver acetylide ⟶ Triple bond with terminal hydrogen

✅ Conclusion:

- **Use Bromine** water to distinguish saturated (ethane) from unsaturated (ethene, ethyne).
- **Use Ammoniacal** silver nitrate to identify ethyne specifically.
- **$KMnO_4$** test confirms double bond in ethene.

🌟 Q.23 (a) Synthesis of compounds starting from ethyne (C_2H_2)

1. Acetaldehyde (CH_3CHO)

Reaction: Hydration of ethyne using mercuric sulfate in dilute sulfuric acid.

Equation:

$HC{\equiv}CH + H_2O \longrightarrow [HgSO_4/H_2SO_4] \longrightarrow CH_3{-}CHO$

Notes: Vinyl alcohol (enol) is first formed and tautomerizes to acetaldehyde.

2. Benzene (C_6H_6)

Reaction: Polymerization of ethyne in a heated copper tube (300°C).

Equation:

$3\ HC\equiv CH \longrightarrow [Cu\text{-tube}, 300°C] \longrightarrow C_6H_6$

3. Chloroprene (C_4H_5Cl)

Reaction: Ethyne → Vinyl acetylene → Reaction with HCl.

Equations:

$2\ HC\equiv CH \longrightarrow [Cu_2Cl_2/NH_4Cl] \longrightarrow H_2C=CH-C\equiv CH$ (Divinyl acetylene)

$H_2C=CH-C\equiv CH + HCl \longrightarrow H_2C=CH-CCl=CH_2$ (Chloroprene)

4. Glyoxal (OHC−CHO)

Reaction: Oxidation of ethyne with alkaline $KMnO_4$.

Equation:

$HC\equiv CH + [O] \longrightarrow OHC-CHO$ (Glyoxal)

5. Oxalic acid (HOOC−COOH)

Reaction: Further oxidation of glyoxal with $KMnO_4$.

Equation:

$OHC-CHO + 2[O] \longrightarrow HOOC-COOH$ (Oxalic acid)

6. Acrylonitrile ($CH_2=CH-CN$)

Reaction: Addition of HCN to ethyne in the presence of Cu_2Cl_2/NH_4Cl.

Equation:

$HC{\equiv}CH + HCN \longrightarrow [Cu_2Cl_2/NH_4Cl] \longrightarrow CH_2{=}CH{-}CN$

7. Ethane (C_2H_6)

Reaction: Hydrogenation of ethyne in the presence of a suitable catalyst (Ni/Pt).

Equation:

$HC{\equiv}CH + 2\ H_2 \longrightarrow [Ni/Pt] \longrightarrow CH_3{-}CH_3$

8. Methyl nitrile ($CH_3{-}C{\equiv}N$)

Reaction: Reaction of ethyne with ammonia or HCN to form nitriles.

Equation:

$HC{\equiv}CH + NH_3 \longrightarrow [300°C/Al_2O_3] \longrightarrow CH_3{-}C{\equiv}N + H_2$

(Also called acetonitrile or methyl cyanide)

🌟 (b) Acidity of Ethyne

Nature: Terminal alkynes (like ethyne) have a hydrogen attached to a carbon with sp hybridization.

Reason:

- **sp-hybridized** carbon is more electronegative than sp^2 or sp^3 carbon.
- **This pulls electron** density towards carbon, making the attached hydrogen slightly acidic.

Test/Reaction:

Reaction with sodamide ($NaNH_2$) or molten sodium forms acetylides.

Equations:

$HC \equiv CH + NaNH_2 \longrightarrow HC \equiv CNa + NH_3$

$HC \equiv CH + Na \longrightarrow HC \equiv CNa + \frac{1}{2} H_2$

Applications: Acetylides are valuable reagents for preparing longer chain alkynes or other organic compounds.

🌟 Q.24 (a) Comparison of Reactivity of Ethane, Ethene and Ethyne

Ethane (C_2H_6):

Ethane contains only single bonds (σ-bonds). These bonds are strong and the electrons are not exposed to attack by reagents. Therefore, ethane is least reactive and reacts mainly by substitution reactions, for example, halogenation with chlorine under sunlight.

Ethene (C_2H_4):

Ethene contains a double bond (one σ and one π bond). The π electrons are more exposed and easily attacked by electrophiles. This makes ethene highly reactive. It undergoes additional reactions such as hydrogenation, halogenation, hydrohalogenation, and hydration.

Ethyne (C_2H_2):

Ethyne has a triple bond (one σ and two π bonds). The π electrons are less exposed due to the shorter bond length, so ethyne is less reactive than ethene towards electrophiles, but more reactive towards nucleophiles. Alkynes undergo addition reactions, and two molecules of a reagent can add across the triple bond.

Reactivity order:

Ethene > Ethyne > Ethane

🌟 (b) Comparison of Physical Properties of Alkanes, Alkenes, and Alkynes

1. State at Room Temperature:

- First three members of each group (C_1–C_3) are gases.
- The next few members are liquids, and higher members are solids.

2. Melting and Boiling Points:

- Increase gradually with molecular mass.

- Alkanes have slightly lower boiling points than alkenes and alkynes.
- Branching decreases melting and boiling points.

3. Solubility:

All are nonpolar compounds, soluble in nonpolar solvents like ether, benzene, and carbon tetrachloride.

Insoluble in water.

4. Odour:

Alkanes: Odourless

Alkenes: Slightly sweet odour

Ethyne: Garlic-like odour

5. Density:

All are less dense than water.

6. Reactivity vs Physical Properties:

Alkanes: Chemically inert, low reactivity.

Alkenes: Reactive due to double bond.

Alkynes: Moderate reactivity; terminal alkynes are slightly acidic.

🌟 Q.25. How does propyne react with the following reagents?

(a) $AgNO_3/NH_4OH$

(b) Cu_2Cl_2/NH_4OH

(c) $H_2O/H_2SO_4/HgSO_4$

❖ **Answer**: Reactions of Propyne ($CH_3\text{-}C\equiv CH$)

(a) Reaction with Ammoniacal Silver Nitrate ($AgNO_3/NH_4OH$)

Reaction Type: Formation of silver acetylide

Reason: Propyne is a terminal alkyne. The hydrogen atom attached to the sp-hybridized carbon is slightly acidic.

Equation:

$CH_3\text{-}C\equiv CH + AgNO_3 + NH_4OH \rightarrow CH_3\text{-}C\equiv C\text{-}Ag$ ⬇️ $+ NH_4NO_3 + H_2O$

Observation: A white precipitate of silver acetylide is formed.

(b) Reaction with Ammoniacal Cuprous Chloride (Cu_2Cl_2/NH_4OH)

Reaction Type: Formation of dicopper acetylide

Equation:

$CH_3\text{-}C\equiv CH + Cu_2Cl_2 + 2NH_4OH \rightarrow CH_3\text{-}C\equiv C\text{-}Cu$ ⬇️ $+ 2NH_4Cl + H_2O$

Observation: A reddish-brown precipitate of copper acetylide forms.

Use: Helps in identification of terminal alkynes.

(c) Reaction with Water in the Presence of H_2SO_4 and $HgSO_4$

Reaction Type: Hydration of terminal alkyne ⟶ Ketone

Mechanism:

First, a vinyl alcohol (enol) is formed.

The enol is unstable and undergoes tautomerization to form a ketone.

Equation:

CH3−C≡CH + H2O ⟶ CH3−CO−CH3 [H2SO4, HgSO4]

Product: Propanone (Acetone)

🌟 **Q.26. A compound has a molecular formula C_4H_6. When it is treated with excess hydrogen in the presence of a Ni-catalyst, a new compound C_4H_{10} is formed. When C_4H_6 is treated with ammoniacal silver nitrate, a white precipitate is formed.**

Question: What is the structural formula of the given compound?

❖ **Answer:**

Step 1: Analyze the molecular formula

Compound: C_4H_6

- **Unsaturated** hydrocarbon → Alkyne (contains triple bond)
- **Hydrogenation** gives C_4H_{10} (butane) → confirms alkyne
- **Reaction** with ammoniacal $AgNO_3$ gives white precipitate → terminal alkyne (sp-hybridized carbon has acidic hydrogen)

Step 2: Identify possible terminal alkynes with 4 carbons

Terminal alkyne formula: $RC \equiv CH$

C_4H_6 → Butyne

Two possibilities:

1. 1-Butyne ($CH \equiv C\text{-}CH_2\text{-}CH_3$) → terminal alkyne

2. 2-Butyne ($CH_3\text{-}C \equiv C\text{-}CH_3$) → internal alkyne (does not give Ag precipitate)

Since white precipitate forms, it must be 1-butyne

Step 3: Hydrogenation reaction (with Ni)

CH≡C−CH2−CH3 + 2H2 → CH3−CH2−CH2−CH3 [Ni catalyst]

Product: C_4H_{10} (butane)

Step 4: Reaction with ammoniacal silver nitrate

$CH \equiv C\text{-}CH_2\text{-}CH_3 + 2AgNO_3 + 2NH_4OH \rightarrow Ag\text{-}C \equiv C\text{-}Ag$ ⬇️ + $2NH_4NO_3$

Observation: White precipitate confirms terminal alkyne

Step 5: Structural formula of the compound

$CH\equiv C-CH2-CH3$ (1-Butyne)

✅ **Conclusion:**

Molecular formula: C_4H_6

Type: Terminal alkyne

Structural formula: $CH\equiv C\text{-}CH_2\text{-}CH_3$

Reactivity:

- Forms butane on hydrogenation
- Forms silver acetylide with ammoniacal $AgNO_3$

🌟 Q.21. (a) Identify A and B

Given reaction:

$CH_3CH_2CH_2OH \longrightarrow (PCl_5) \longrightarrow A \longrightarrow (Na/Ether) \longrightarrow B$

Step 1: Alcohol reacts with PCl_5

$CH_3CH_2CH_2OH + PCl_5 \longrightarrow CH_3CH_2CH_2Cl + POCl_3 + HCl$

✅ A = $CH_3CH_2CH_2Cl$ (1-Chloropropane)

Step 2: Alkyl halide reacts with sodium in dry ether (Wurtz reaction)

$2\ CH_3CH_2CH_2Cl + 2\ Na \longrightarrow CH_3CH_2CH_2\text{-}CH_2CH_2CH_3 + 2\ NaCl$

✅ B = C_6H_{14} (Hexane)

🌟 (b) General mechanism of electrophilic addition reactions of alkenes

Electrophilic addition involves two main steps:

1. Formation of carbocation (Electrophilic attack):

- The π-electrons of the alkene attack the electrophile (E^+).
- One carbon forms a bond with E^+, creating a carbocation on the other carbon.

Example: $CH_2=CH_2 + H^+ \longrightarrow CH_3\text{-}CH_2^+$

2. Nucleophilic attack:

- The nucleophile (Nu^-) attacks the carbocation, forming the final addition product.

Example: $CH_3\text{-}CH_2^+ + OH^- \longrightarrow CH_3\text{-}CH_2OH$

Overall reaction:

$CH_2=CH_2 + H\text{-}X \longrightarrow CH_3\text{-}CH_2X$

> This mechanism explains Markownikov's rule: the electrophile attaches to the carbon with more hydrogens.

Note:

This chapter is designed to provide a solid foundation of knowledge, with the goal of deepening understanding and encouraging further exploration of the subject. The content has been carefully selected to support effective learning and inspire students to engage with the topic more deeply.

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Purpose: To contribute to education by offering insightful, valuable content that enhances learning and understanding.

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