UNIQUE NOTES | CHEMISTRY – 10

CHAPTER 22

HYDROCARBONS

i. Alkenes ii. Important Reactions of Alkenes iii. Alkynes iv. Sources of Organic Compounds v. Refining of Petroleum

Descriptive Questions

Alkenes

Q.1 ***What are alkenes? Describe two methods of preparation of ethene.***

Alkenes

Alkenes are unsaturated hydrocarbons containing one or more carbon-carbon double bond. They are also called olefins.

- General formula for alkenes is CnH2n.
- They are known for their unique physical and chemical properties.
- They are widely used in the synthesis of various products, like plastics and fuels.

Preparation of Ethene

Alkenes may be prepared either by dehydration of alcohols or dehydrohalogenation of alkyl halides.

- Dehydration means removal of a water molecule.
- In dehydrohalogenation a molecule of hydrogen halide (HX) is removed from a molecule of alkyl halide.
- Alkenes can also be prepared by cracking of alkanes.

(a) By dehydration of alcohols — carried out with a dehydrating agent like concentrated sulphuric acid:

$$\underset{\text{(Ethanol)}}{CH_3\text{-}CH_2\text{-}OH} \xrightarrow{(180^\circ C,\ H_2SO_4)} \underset{\text{(Ethene)}}{CH_2{=}CH_2} + H_2O$$

(b) By dehydrohalogenation of alkyl halides — done with potassium hydroxide dissolved in ethanol:

$$\underset{\text{(Chloroethane)}}{CH_3\text{-}CH_2Cl} + KOH \xrightarrow{(180^\circ C,\ \text{Alcohol})} \underset{\text{(Ethene)}}{CH_2{=}CH_2} + KCl + H_2O$$

Note — This is an example of an Elimination reaction. These reactions occur when a molecule is removed from a saturated compound to produce an unsaturated compound.

S.Q. How is alkene important for ripening of fruits and vegetables? — Alkenes occur abundantly in nature. Ethylene, for example, is a plant hormone that induces ripening in fruit. An alkene β-carotene is an orange pigment responsible for the colour of carrots.

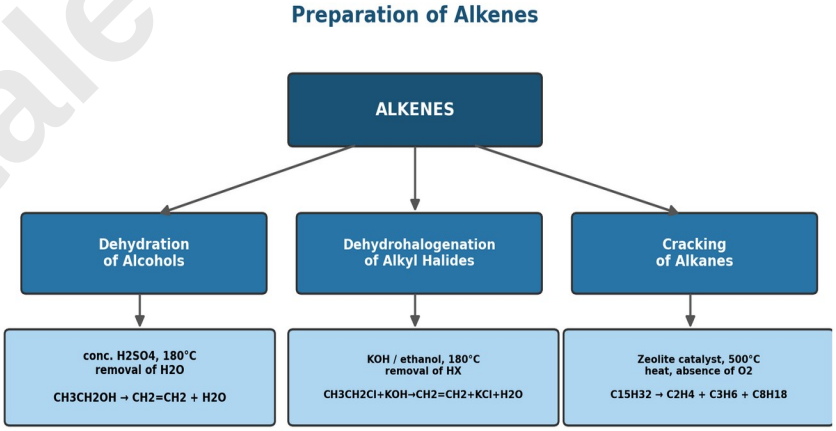

Fig. 1 — Three Methods of Preparing Alkenes

Q.2 ***What do you know about cracking? What is its importance commercially?***

Cracking of Alkanes to Alkenes

Cracking is a process which is carried out to convert high molecular mass alkanes to lower alkanes and alkenes. The process is carried out by heating alkanes at high temperature in the absence of oxygen and in the presence of zeolites as catalysts.

Commercial Importance

Cracking provides a mixture of smaller hydrocarbons which are more volatile and possess lower boiling point, making them easier to use as fuel. Cracking is important commercially because it produces smaller alkanes which are useful as fuel as well as alkenes (ethene and propene) which are useful starting materials to produce many commercially important chemicals.

Examples: Kerosene oil and diesel oil, which contain higher molecular mass alkanes, are often cracked to give petrol, alkenes and hydrogen gas.

$$\text{Kerosene oil} \xrightarrow{\text{(Catalyst, } 500^\circ\text{C)}} \text{Petrol} + \text{Alkenes} + \text{Hydrogen gas}$$

$$C_{15}H_{32} \xrightarrow{\text{(Zeolite, } 500^\circ\text{C)}} {}_2\,C_2H_4 + C_3H_6 + C_8H_{18}$$

(Ethene) (Propene) (Octane)

Important Reactions of Alkenes

Q.3 ***What are addition reactions? How are hydrogen and halogens added to alkenes?***

Important Reactions of Alkenes

Alkenes are very reactive compounds. Their chemical reactivity is due to the presence of a carbon-carbon double bond. Alkenes undergo addition reactions.

Addition reactions: those reactions in which reactants combine to form a single new product.

1. Addition of hydrogen / hydrogenation / catalytic reduction — hydrogen is added to alkenes in the presence of nickel metal as a catalyst to give alkanes as the products. This reaction is called catalytic hydrogenation or catalytic reduction.

$$CH_2{=}CH_2 + H_2 \xrightarrow{\text{(Ni, } 150^\circ\text{C, }{}_2\text{atm pressure)}} CH_3\text{-}CH_3$$

(Ethene) (Ethane)

2. Addition of halogens / halogenation — halogens are readily added to alkenes in the presence of a non-polar solvent to give alkyl dihalides. This reaction is also called halogenation of alkenes.

$$CH_2{=}CH_2 + Br_2 \xrightarrow{(CCl_4)} CH_2Br\text{-}CH_2Br \quad (_{1,2}\text{-Dibromoethane})$$

Q.4 ***What is oxidation of alkenes with KMnO4? How can an alkene be identified?***

Oxidation with KMnO4 (Baeyer's Test)

Alkenes can also react with cold and dilute alkaline potassium permanganate to give an important compound called ethylene glycol or ethane-1,2-diol.

$$CH_2{=}CH_2 + H_2O + [O] \xrightarrow{(KMnO_4)} CH_2(OH)\text{-}CH_2(OH)$$

(Ethan-$_{1,2}$-diol / Glycol)

Identification of Alkenes

Both halogenation and oxidation reactions may be used to detect the presence of an alkene. The reddish brown colour of bromine or purple colour of potassium permanganate is rapidly discharged when either of the two reacts with an alkene. Similarly, alkenes also discharge the violet colour of iodine. These reactions are not given by saturated compounds or alkanes, and thus they are used to distinguish between saturated and unsaturated compounds (alkenes).

Q.5 *How are hydrogen halides and water added to alkenes?*

(1) Addition of Hydrogen Halides / Hydrohalogenation

Like halogens, hydrogen halides can also be added to a double bond of an alkene. These reactions are known as hydrohalogenation of alkenes.

$$CH_2{=}CH_2 + HBr \;\text{-->}\; CH_3\text{-}CH_2Br \;(\text{Ethene})\;\; (\text{Hydrogen Bromide})\;\; (\text{Bromoethane})$$

(2) Addition of Water (Steam)

Alkenes react with water in the presence of sulphuric acid. The reaction takes place at around 300°C. This is also called a hydration reaction.

$$\text{But-}_1\text{-ene} + H_2O \;\text{--}(H_2SO_4,\ {}_{300}\text{°C})\text{-->}\; \text{Butan-}_2\text{-ol}$$

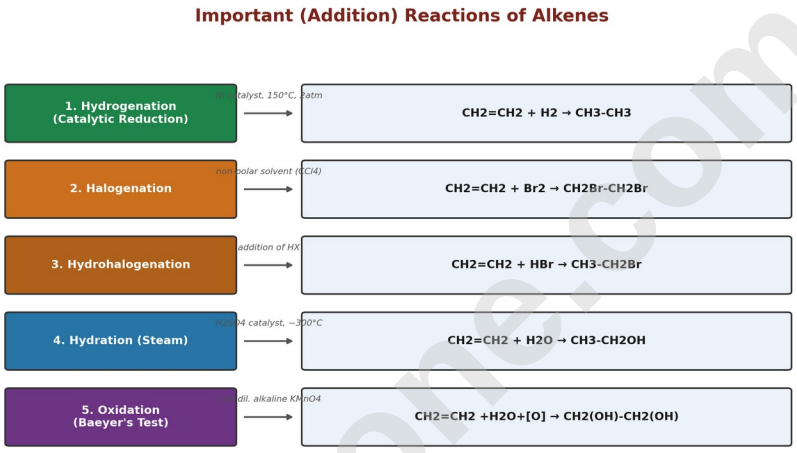

Fig. 2 — Important (Addition) Reactions of Alkenes

Alkynes

Q.6 *What are alkynes? Elaborate their importance.*

Alkynes

Alkynes are unsaturated hydrocarbons which contain at least one −C≡C− bond (triple bond). They are represented by the general formula CnH2n-2. Just like alkenes, alkynes are also named by counting the number of carbon atoms present in the longest continuous chain that contains the triple bond.

$HC{\equiv}CH$ (Ethyne) $CH_3\text{-}C{\equiv}CH$ (Propyne) $HC{\equiv}C\text{-}CH_2\text{-}CH_3$ (But-$_1$-yne) $CH_3\text{-}C{\equiv}C\text{-}CH_3$ (But-$_2$-yne)

Commercial Importance of Ethyne (Acetylene)

The simplest unsaturated hydrocarbon containing a triple bond is called ethyne or acetylene gas.

(i) Cutting and welding: It is commonly used for welding and cutting purposes because it produces a large amount of heat when it is ignited in the presence of oxygen or air.

$$_2\,CH{\equiv}CH + {}_5\,O_2 \;\text{-->}\; {}_4\,CO_2 + {}_2\,H_2O + Heat$$

Oxy-acetylene Flame

In the acetylene torch, acetylene gas burns in oxygen to produce CO2 and H2O. The high temperature of the oxy-acetylene flame up to 3200°C speeds up the cutting and welding processes.

(ii) Artificial ripening: Acetylene gas is also used for ripening of green fruits. When solid calcium carbide reacts with moisture present in the air, it produces acetylene gas which accelerates the ripening of green fruits and induces a colour change.

S.Q. Why is the use of calcium carbide prohibited in Pakistan? — The use of calcium carbide in our country is prohibited because it is known to cause serious health problems like dizziness, vomiting and skin ulcer.

Sources of Organic Compounds

Q.7 *What are different sources of organic compounds?*

Sources of Organic Compounds

Organic compounds can be obtained from many sources. Coal, petroleum and natural gas are, however, three major sources of organic compounds.

- Natural gas and petroleum are chief sources of aliphatic hydrocarbons, while coal is a major source of aromatic hydrocarbons.
- Natural gas is a mixture of many hydrocarbon gases, with methane (CH4) being the largest component.

Q.8 *What is petroleum? Discuss its sources and uses as fuel.*

Petroleum

The name petroleum is derived from Latin words, petra meaning rock and oleum meaning oil.

Source of Petroleum

Petroleum and natural gas are mostly found together, held between the layers of non-porous rocks underground.

(a) Extraction: When a well is drilled through the rock, the gas is released, carrying with it some of the more volatile liquids. After the flow of gases ceases, the liquid petroleum is then taken out with the help of pumps.

(b) Composition of Petroleum: Liquid petroleum is a complex mixture of mainly aliphatic hydrocarbons. It has been estimated that when petroleum is boiled up to 400°C, at least 500 compounds can be obtained.

Uses of Petroleum

Fuel and important chemicals: Although the principal products of petroleum refining are various types of fuels, yet a large number of other important chemicals can also be produced from these fuels.

Example: Petroleum products produce alkenes which are starting material to prepare plastics. Similarly, benzene, an aromatic hydrocarbon, may be produced from n-hexane. Benzene may be used to produce thousands of useful aromatic compounds like perfumes, drugs, dyes and photographic developers etc.

Refining of Petroleum

Q.9 ***How is petroleum refined by fractional distillation process?***

Refining of Petroleum

Petroleum: petroleum in a crude state is a mixture of many hydrocarbons which do not burn easily.

Refining of petroleum: to make it useful, petroleum must be separated into different fractions by a process called refining of petroleum.

Fractional distillation: a process used to separate components of a liquid mixture based on their different boiling points is called fractional distillation. The refining process involves the fractional distillation of petroleum at about 400°C, whereby it is separated into many useful fractions.

Steps in the Refining Process

- (a) Neutralization: the first step is neutralization of the crude oil by washing with acidic or basic solution as required.
- (b) Heating in furnace: the neutralized oil is then heated in an electric furnace above 400°C.
- (c) Fractionating column: the resulting gases and vapours are allowed to pass into a tall fractionating column. The column has a number of compartments divided into shelves having holes in them; these holes are covered with bubble caps.
- (d) Separation of different fractions: when the oil is heated, the dissolved gases known as refinery gases first go to the top of the fractionating column and escape from the outlet. As the temperature rises, the vapour goes up in the column, where the hydrocarbon fractions with high boiling points are easily condensed to liquids in the lower part of the column.
- (e) Condensation: fractions with lower boiling point ranges rise up near the top of the column as vapours, which are then condensed into the liquid state. These condensed liquid fractions are collected on the various shelves, from where they can be drained off into separate storage tanks.
- (f) Re-distillation: the fractions thus separated are not without impurities from the other fractions. They are then redistilled to have a better separation of hydrocarbons.
- (g) Fractions of petroleum: various fractions obtained in this process have different boiling ranges and are used for various purposes.

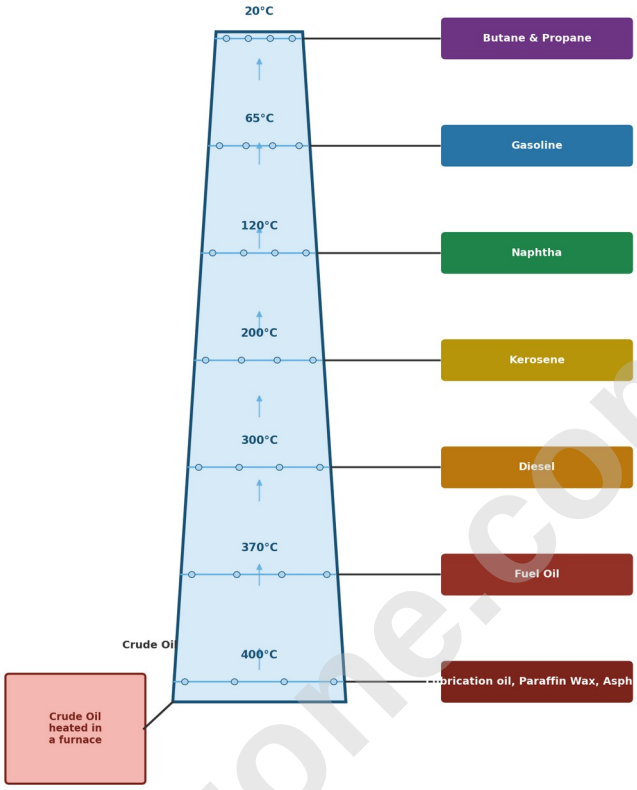

Fig. 3 — Fractional Distillation of Petroleum

Q.10 ***What are fractions of petroleum? Write their uses and boiling range.***

Fractions of Petroleum

Various fractions are obtained in the process of fractional distillation of petroleum. These fractions along with their boiling ranges are shown in Table 22.1. The table gives detailed information about the petroleum fractions and their uses for a variety of purposes.

Table 22.1 — Fractions of Petroleum and Their Uses

Fraction	Boiling Range (°C)	Carbon Atoms	Uses
(i) Refinery gases	Below 0	1–4	Liquefied and sold as fuels for stoves.
(ii) Gasoline (petrol)	0–65	5–6	Used to drive automobiles.
(iii) Naphtha	65–170	6–10	Used as source of many useful hydrocarbons.
(iv) Kerosene oil	170–250	10–14	A fuel used in jet engines.
(v) Diesel oil	250–340	14–19	Used to run cars, buses and trucks.
(vi) Lubricating oil	340–500	19–35	Used as lubricant, waxes and polishes.
(vii) Fuel oil	340–500	Above 20	Used in ships and to run power plants.
(viii) Bitumen	Above 500	Above 35	Used to construct roads and make waterproof roofs and pipes.

Q.11 ***Which properties of petroleum fractions change with their boiling points?***

Physical Properties of Different Petroleum Fractions

Each petroleum fraction contains a mixture of hydrocarbons. They have similar physical properties which depend upon the following factors:

- (i) Number of carbon and hydrogen atoms present in the molecule of a fraction.
- (ii) Volatility
- (iii) Boiling point range
- (iv) Viscosity

Number of carbon and hydrogen atoms — physical properties of compounds:

- As the number of carbon and hydrogen atoms in the molecule of a hydrocarbon increases, so does their molecular mass. This changes the strength of intermolecular forces between the molecules.
- Higher the molecular mass of a hydrocarbon, the stronger the intermolecular forces between its molecules. This fact affects the physical properties of hydrocarbons as well.
- Lower hydrocarbons have high volatility, low boiling points and lower viscosities.
- As the chain length increases, their properties also show upward trends. So the fractions of petroleum obtained at the top of the column have high volatility, lower boiling ranges, lower viscosities, and they are highly inflammable.

Multiple Choice Questions

A. Choose and Tick the Correct Answer

1. Which of the following compounds is expected to give addition reaction?
(a) CH_3-CH_3 (b) CH_2=CH_2 (c) CH_4 (d) CH_3-CH_2-CH_3

2. Which of the followings is not used as a fuel?
(a) LPG (b) CNG (c) Diesel (d) Asphalt

3. Indicate the type of the following reaction: $CH_4 + {}_2O_2 \rightarrow CO_2 + {}_2H_2O$
(a) Substitution (b) Oxidation (c) Reduction (d) Addition

4. Which species acts as a reducing agent in the reaction between ethene and $KMnO_4$?
(a) H_2O (b) CH_2=CH_2 (c) $KMnO_4$ (d) NaOH

5. The product formed when propene reacts with a bromine molecule:
(a) ${}_{1,2}$-Dibromopropane (b) ${}_{1,1}$-Dibromopropane (c) ${}_{2,3}$-Dibromopropane (d) ${}_{1,3}$-Dibromopropane

6. Select the name of the petroleum fraction which generates electricity in power plants.
(a) Bitumen (b) Lubricating oil (c) Kerosene oil (d) Fuel oil

7. The molecule eliminated in the reaction: CH_3-CH_2-Br + KOH --Ethanol--> CH_2=CH_2 + KBr + H_2O is:
(a) Br_2 (b) H_2 (c) HBr (d) H_2O

8. Fractional distillation of petroleum is based on:
(a) Viscosity (b) Boiling point range (c) Flammability (d) Melting point range

SLO Based Multiple Choice Questions

Alkenes

9. Alkenes are classified as hydrocarbons:
(a) Saturated (b) Unsaturated (c) Aromatic (d) Cyclic

10. The type of bond present between the carbon atoms of alkene:
(a) Single covalent (b) Double covalent (c) Triple covalent (d) Coordinate covalent

11. Alkenes are also called:
(a) Olefins (b) Paraffins (c) Petroleum (d) Acetylene

12. Dehydrohalogenation of alkyl halides produces ethene using which reagent?
(a) H_2SO_4 (b) KOH in ethanol (c) NaOH in water (d) HCl

13. The temperature required for the dehydration of alcohols to produce ethene:
(a) ${}_{110}$°C (b) ${}_{140}$°C (c) ${}_{160}$°C (d) ${}_{180}$°C

14. In the dehydration of ethanol to form ethene, the role of H_2SO_4 is:
(a) Catalyst and dehydrating agent (b) Reducing agent (c) Oxidizing agent (d) Solvent only

15. The alkene responsible for imparting orange colour to carrot is:
(a) Citrosene (b) Cytosine (c) Heptene (d) β-carotene

16. Dehydrohalogenation is an example of which type of reaction?
(a) Addition reaction (b) Substitution reaction (c) Elimination reaction (d) Polymerization

17. Which property is not associated with cracking?
(a) High temperature (b) Use of catalyst (c) Abundant supply of oxygen (d) Breaking of higher hydrocarbon to lower

Important Reactions of Alkenes

18. The chemical reactivity of alkene is due to:
(a) Low molecular mass (b) High boiling point (c) Carbon-carbon double bond (d) Less number of carbon atoms

19. Which one is not an addition reaction:
(a) Cracking (b) Halogenation (c) Hydrogenation (d) Hydration

20. In halogenation of alkene, which solvent is used?
(a) Methanol (b) H_2O (c) Benzene (d) Carbon tetrachloride

21. Ethane-$_{1,2}$-diol is also called:
(a) Oxalic acid (b) Propanol (c) Phenol (d) Ethylene glycol

22. Which reagent is used to distinguish unsaturated from saturated compounds?
(a) Bromine water (b) Lime water (c) HCl (d) NaOH

23. Hydration of but-$_1$-ene yields:
(a) Butan-$_1$-ol (b) Butan-$_2$-ol (c) Butane (d) Ethanol

Alkynes

24. Simplest hydrocarbon containing a triple bond:
(a) Methyne (b) Ethylene (c) Acetylene (d) Xylene

25. Oxy-acetylene is used in:
(a) Burning as fuel (b) Ripening of fruit (c) Cutting stones (d) Welding

26. Use of calcium carbide is prohibited because it:
(a) Is injurious to health (b) Promotes infectious diseases (c) Causes pollution (d) Kills birds

Sources of Organic Compounds

27. Which of the following is a major source of aromatic hydrocarbons?
(a) Natural gas (b) Petroleum (c) Coal (d) Methane

28. Natural gas and petroleum are chief sources of which compounds:
(a) Aromatic (b) Cyclic (c) Aliphatic (d) Unsaturated compounds

29. The major component of natural gas is:
(a) Methane (b) Ethene (c) Benzene (d) Hexane

30. Where is petroleum typically found?
(a) In porous rocks above ground (b) In volcanic lava (c) In ocean sediments (d) Between layers of non-porous rocks

31. What is the main composition of liquid petroleum?
(a) Aromatic hydrocarbons only (b) Mainly aliphatic hydrocarbons (c) Only inorganic salts (d) Pure water and gases

32. How many compounds can be obtained when petroleum is boiled up to $_{400}$°C?
(a) At least $_{500}$ (b) About $_{100}$ (c) More than $_{1000}$ (d) Exactly $_{200}$

33. Which one is not a major use of petroleum products?
(a) Use as fuel (b) Making plastics (c) Making other chemicals (d) Making explosives

Refining of Petroleum

34. First step in the refining of petroleum is:
(a) Neutralization (b) Fractional distillation (c) Crystallization (d) Predistillation

35. In fractional distillation the crude oil is heated to approximately:
(a) $_{200}$°C (b) $_{300}$°C (c) $_{400}$°C (d) $_{500}$°C

36. The device used in the fractionating tower to allow vapours to pass through shelves:
(a) Bubble caps (b) Perforated plates (c) Filters (d) Condensers

37. What happens to the refinery gases during fractional distillation?
(a) They condense at the bottom of the column (b) They escape from the top of the column (c) They remain in the liquid state (d) They are removed by pumps only

38. In order to remove impurities from petroleum fractions, they are further:
(a) Evaporated (b) Condensed (c) Redistilled (d) Liquefied

39. Which petroleum fraction has the lowest boiling range?
(a) Gasoline (b) Refinery gases (c) Kerosene (d) Diesel

40. The fraction collected at $_{170}$-$_{250}$℃ is:
(a) Naphtha (b) Diesel oil (c) Kerosene oil (d) Fuel oil

41. Which fraction is used as a fuel in jet engines?
(a) Gasoline (b) Naphtha (c) Kerosene oil (d) Diesel oil

42. Which of the following has the longest carbon chain in its fraction?
(a) Refinery gases (b) Gasoline (c) Diesel (d) Bitumen

Answer Key

1	2	3	4	5	6	7
b	d	b	b	a	d	c
8	9	10	11	12	13	14
b	b	b	a	b	d	a
15	16	17	18	19	20	21
d	c	c	c	a	d	d
22	23	24	25	26	27	28
a	b	c	d	a	c	c
29	30	31	32	33	34	35
a	d	b	a	d	a	c
36	37	38	39	40	41	42
a	b	c	b	a	c	c

Short Answer Questions

1. *Give two examples of addition reactions.*

Ans. Examples of addition reactions:

i. Addition of hydrogen/hydrogenation: $CH_2{=}CH_2 + H_2 \xrightarrow{(Ni,\ 150°C,\ 2atm)} CH_3\text{-}CH_3$ ii. Addition of halogen/halogenation: $CH_2{=}CH_2 + Br_2 \xrightarrow{(CCl_4)} CH_2Br\text{-}CH_2Br$

2. *Give the names of the compounds obtained from coal tar and petroleum.*

Compounds from coal tar:

- Benzene
- Toluene
- Naphthalene
- Phenol

Fractions of petroleum:

- LPG
- Petrol
- Kerosene oil
- Diesel oil
- Lubricating oil
- Fuel oil
- Bitumen

3. *How is ethene oxidized by cold aqueous solution of potassium permanganate?*

Ans. Ethene reacts with cold aqueous solution of $KMnO_4$ (Baeyer's test):

$$CH_2{=}CH_2 + H_2O + [O] \xrightarrow{(KMnO_4)} CH_2(OH)\text{-}CH_2(OH) \quad (Ethan\text{-}_{1,2}\text{-}diol\ /\ Glycol)$$

Ans. Ethene is oxidized to ethan-$_{1,2}$-diol (glycol); the purple colour of $KMnO_4$ changes to dark brown precipitates of MnO_2.

4. *Differentiate between elimination and addition reactions.*

Addition Reactions	Elimination Reactions
Addition reactions are those reactions in which reactants combine to form a single new product. During addition reactions the double bond is broken to form a single bond. $CH_2{=}CH_2 + Br_2 \rightarrow CH_2Br\text{-}CH_2Br$	These are reactions in which a molecule is removed from a saturated compound to produce an unsaturated compound. During elimination reactions a single bond becomes a double bond. $CH_3\text{-}CH_2Cl + KOH \xrightarrow{(180°C,\ Alcohol)} CH_2{=}CH_2 + KCl + H_2O$

5. *Name the starting materials used to generate oxyacetylene flame.*

Ans. Oxygen and acetylene are the starting materials used to generate the oxyacetylene flame.

$$2\ CH{\equiv}CH + 5\ O_2 \rightarrow 4\ CO_2 + 2\ H_2O + Heat$$

6. *How can an alkene be identified?*

Alkenes can be identified by:

- Bromine water test: an alkene decolourizes the reddish-brown colour of bromine water.
- KMnO4 test (Baeyer's test): the purple colour of KMnO4 solution becomes colourless in the presence of an alkene.

SLO Based Short Answer Questions

Alkenes

7. *What are alkenes? Give their general formula.*

Ans. Alkenes are unsaturated hydrocarbons containing one or more carbon-carbon double bonds. They have the general formula CnH_2n.

8. *Why are alkenes called olefins?*

Ans. Alkenes are generally called olefins because most of its members form oily products; therefore they are named olefins (Latin word: which means oil + forming).

9. *Write some uses of ethene.*

Ethene is widely used in:

- Making polyethylene (plastics)
- Producing ethylene glycol (for antifreeze) and detergents
- Making polyvinyl chloride and used as fuel
- Artificial ripening of fruits

10. *What do you mean by the terms dehydration and dehydrohalogenation?*

Ans. Dehydration: means removal of water from any compound. Dehydrohalogenation: means removal of hydrogen and halogen in the form of (HX) from an organic compound (usually an alkyl halide); it will produce alkenes.

11. *How can alkene be prepared from alcohol?*

Ans. By dehydration of alcohols. Dehydration of alcohols is carried out with a dehydrating agent like concentrated sulphuric acid:

$$CH_3\text{-}CH_2\text{-}OH \xrightarrow{(180^\circ C,\ H_2SO_4)} CH_2{=}CH_2 + H_2O$$

12. *How can alkenes be prepared from alkyl halides?*

Ans. By dehydrohalogenation of alkyl halides. Dehydrohalogenation of alkyl halides is done with potassium hydroxide dissolved in ethanol:

$$CH_3\text{-}CH_2Cl + KOH \xrightarrow{(180^\circ C,\ Alcohol)} CH_2{=}CH_2 + KCl + H_2O$$

13. *What do you mean by elimination reactions?*

Ans. Those reactions which involve removal of two groups simultaneously from adjacent carbon atoms of a compound to produce an unsaturated compound are called elimination reactions.

$$CH_3\text{-}CH_2Cl + KOH \xrightarrow{(180^\circ C,\ Alcohol)} CH_2{=}CH_2 + KCl + H_2O$$

Ans. In the above reaction hydrogen and halogen in the form of (HX) is removed from the alkyl halide (chloroethane).

14. *Define cracking. How is it important commercially?*

Ans. Cracking is a process which is carried out to convert high molecular mass alkanes to lower alkanes and alkenes. The process is carried out by heating alkanes at high temperature in the absence of oxygen and in the presence of a catalyst.

$$C_{15}H_{32} \xrightarrow{(Zeolite,\ 500^\circ C)} {}_2\,C_2H_4 + C_3H_6 + C_8H_{18}$$

Ans. Importance: it is commercially important for producing smaller alkanes as fuel and starting materials to synthesize commercially important chemicals.

15. *Explain why alkenes are considered to be reactive compounds.*

Ans. Alkenes are very reactive compounds. Their chemical reactivity is due to the presence of a carbon-carbon double bond. In a double bond, one is a sigma bond and the other is a pi bond. Pi-electrons in pi-bonds are considered to be more reactive than sigma bonds. So, due to pi-electrons, alkenes are reactive compounds.

16. *Define addition reactions.*

Ans. Addition reactions are those reactions in which reactants combine to form a single new product.

$$CH_2{=}CH_2 + H_2 \xrightarrow{(Ni,\ {}_{150}{}^{\circ}C,\ {}_{2}atm)} CH_3\text{-}CH_3$$

Ans. So an addition reaction leads to the formation of a saturated compound from an unsaturated compound.

17. *Why is hydrogenation also called catalytic reduction?*

Ans. Hydrogenation is also called catalytic reduction because it adds hydrogen to a compound, typically reducing double/triple bonds to single bonds, using a catalyst like Ni/Pt/Pd. Reduction is called the gaining of hydrogen.

$$CH_2{=}CH_2 + H_2 \xrightarrow{(Ni,\ {}_{150}{}^{\circ}C,\ {}_{2}atm)} CH_3\text{-}CH_3$$

18. *Why is a non-polar solvent required for the addition of halogen in alkene?*

Ans. Addition of halogens (Cl_2, Br_2) requires a non-polar solvent like CCl_4 because it keeps the reaction mechanism smooth and easier for halogens to add across the double bond. It does not create temporary dipoles or intermediates.

$$CH_2{=}CH_2 + Br_2 \xrightarrow{(CCl_4)} CH_2Br\text{-}CH_2Br$$

Alkynes

19. *What are alkynes? Give their general formula and examples.*

Ans. Alkynes are unsaturated hydrocarbons which contain at least one $-C{\equiv}C-$ bond. They are represented by the general formula $CnH_{2}n\text{-}_{2}$.

$$HC{\equiv}CH \text{ (Ethyne)} \qquad CH_3\text{-}C{\equiv}CH \text{ (Propyne)}$$

20. *Write some uses of ethyne.*

Ethyne, also known as acetylene, is used in:

- Oxyacetylene flame used in welding and cutting, producing chemicals like PVC
- Making synthetic fibres and plastics
- Pharmaceutical synthesis

21. *Explain how acetylene gas is involved in the ripening of fruits.*

Ans. Acetylene gas is used for ripening green fruits. When solid calcium carbide reacts with moisture in the air, it produces acetylene gas which accelerates the ripening of green fruits and induces a colour change.

Sources of Organic Compounds

22. *What are sources of organic compounds?*

There are three major sources of organic compounds:

- i. Coal
- ii. Natural gas
- iii. Petroleum

23. *How is petroleum extracted from earth?*

Ans. Petroleum and natural gas are mostly found together, held between the layers of non-porous rocks underground.

Extraction of petroleum:

- A well is drilled through the rock.
- Gas is released along with some volatile liquid.
- After the gas, the liquid petroleum is taken out by pumps.

Refining of Petroleum

24. *What is the purpose of refining of petroleum?*

Ans. Petroleum in a crude state is a mixture of many hydrocarbons which do not burn easily. To make it useful, petroleum must be separated into different fractions by a process called refining of petroleum.

25. *What is the principle behind the fractional distillation of petroleum?*

Ans. Fractional distillation of petroleum is the separation of petroleum into different fractions on the basis of the difference in their boiling points. Petroleum (crude oil) is divided into several fractions; each fraction has its specific boiling range and composition.

26. *How does the boiling point of fractions change from the bottom to the top of the fractionating column?*

Ans. As we move from bottom to top, the chain length of carbon atoms in different fractions gradually decreases. Thus their boiling points and viscosity also decrease.

Ans. Examples: refinery gas (LPG) has the lowest boiling point at the top, and bitumen has the highest boiling point at the bottom of the fractionating column.

27. *What is the first step in petroleum refining?*

Ans. Neutralization. The first step in the refining process is neutralization of the crude oil by washing with acidic or basic solution as required. Neutralization removes impurities like sulphur and other acidic or basic components.

28. *Why is crude oil heated at higher temperature before entering the fractionating tower?*

Ans. Crude oil is heated in a furnace before entering the fractionating tower to vaporize the lighter fractions, making it easier to separate them from heavier ones based on boiling points.

29. *What happens in the fractionating column during refining?*

Ans. In the fractionating column, vapours rise; high boiling fractions condense lower because the temperature is higher at the lower part of the fractionating tower. Low boiling gases escape at the top.

30. *Write names of fractions obtained from petroleum.*

- i. Refinery gases
- ii. Gasoline (petrol)
- iii. Naphtha
- iv. Kerosene oil
- v. Diesel oil
- vi. Lubricating oil
- vii. Fuel oil
- viii. Bitumen

31. *What are the functions of kerosene oil, diesel oil and lubricating oil?*

Ans. Kerosene oil: fuel for jet planes, fuel for heating, lighting and cooking. Diesel / Gas oil: fuel for diesel engines of buses, trucks and cars etc. Lubricating oil: lubricant for machines and engines, waxes and polishes.

32. *Distinguish between bitumen and refinery gas.*

Bitumen	Refinery Gas
Number of carbon atoms per molecule is more than $_{35}$. Boiling point is more than $_{500}$°C. Used in paving roads and making roofing material.	Number of carbon atoms in molecule is from $_{1}$-$_{4}$. Boiling point is below $_{20}$°C. Used in cylinders for cooking and heating.

33. *What are the factors affecting the physical properties of fractions of petroleum?*

Each petroleum fraction contains a mixture of hydrocarbons. Their physical properties depend upon the following factors:

- i. Number of carbon and hydrogen atoms present in the molecule of a fraction
- ii. Volatility
- iii. Boiling point range
- iv. Viscosity

34. *What is the effect of the number of carbon atoms of fractions on their physical properties?*

Ans. As the number of carbon atoms increases, intermolecular forces also increase between its molecules. This affects the physical properties of hydrocarbons as well.

- Lower hydrocarbons have high volatility, low boiling points and low viscosities.
- Higher hydrocarbons have low volatility, high boiling points and viscosity.

Constructed Response Questions

1. *What is the difference between the terms dehydration and dehydrohalogenation?*

Dehydration	Dehydrohalogenation
It is a process in which removal of water from a molecule takes place. It usually occurs in alcohols. CH_3-CH_2-OH --($_{180}$°C, H_2SO_4)--> CH_2=CH_2 + H_2O	In this process, removal of hydrogen halide (HX) from a haloalkane takes place. It occurs in alkyl halides. CH_3-CH_2-Cl + KOH --> CH_2=CH_2 + KCl + H_2O

2. *You have two test tubes A and B containing a saturated and an unsaturated compound (alkene). How will you identify the two?*

Ans. Bromine water test — method:

- Add bromine water to both test tubes.
- Shake well. The compound that decolourizes bromine water is the unsaturated compound (alkene).
- The compound that does not change the reddish-brown colour of bromine water is the saturated compound (alkane).

Ans. Cold alkaline $KMnO_4$ (Baeyer's Test):

- Add cold KMnO4 solution to both test tubes.
- Shake well; the test tube in which the pink colour of alkaline KMnO4 solution is decolourized contains the alkene (unsaturated compound).
- The test tube in which the pink colour of KMnO4 does not decolourize contains the saturated hydrocarbon.

3. *Why is the oxyacetylene flame so hot?*

Ans. Oxyacetylene flame is produced by burning acetylene (ethyne) in pure oxygen.

$$_2\,CH{\equiv}CH + {}_5\,O_2 \;\text{-->}\; {}_4\,CO_2 + {}_2\,H_2O + \text{Heat}$$

- Complete combustion takes place.
- The reaction is highly exothermic and a large amount of heat is released; the temperature can reach up to 3200°C.

Ans. That is why it is so hot and used for welding and cutting metals.

4. *Do you expect ethyne to decolourize a cold solution of $KMnO_4$?*

Ans. Ethyne is an unsaturated hydrocarbon (alkyne). It reacts with cold, dilute, alkaline $KMnO_4$ and gets oxidized. The colour of the $KMnO_4$ solution disappears. So ethyne decolourizes the pink colour of a cold alkaline solution of $KMnO_4$.

5. *How do chlorine and hydrogen chloride add to ethene?*

Ans. Addition of chlorine (Cl_2) to ethene:

$$CH_2{=}CH_2 + Cl_2 \;\text{-->}\; CH_2Cl\text{-}CH_2Cl \quad (_{1,2}\text{-Dichloroethane})$$

Ans. Addition of hydrogen chloride (HCl) to ethene:

$$CH_2{=}CH_2 + HCl \;\text{-->}\; CH_3\text{-}CH_2Cl \quad (\text{Chloroethane})$$

Ans. Both are addition reactions because atoms are added across the double bond.

Descriptive Questions (Exercise)

1. *Describe two methods of preparation for ethene.*

Ans. See Q.$_1$ from theory section — Preparation of Ethene.

2. *Describe the fractional distillation of petroleum.*

Ans. See Q.$_9$ from theory section — Refining of Petroleum.

3. *Which properties of petroleum fractions change with their boiling points?*

Ans. See Q.$_{11}$ from theory section — Physical Properties of Petroleum Fractions.

4. *Explain with examples the cracking of alkanes.*

Ans. See Q.$_2$ from theory section — Cracking of Alkanes to Alkenes.

5. *Give uses of acetylene.*

Ans. See Q.$_6$ from theory section — Commercial Importance of Ethyne (Acetylene).