Unit	Teaching (Periods)	Assessment (Periods)	Weightage %
12 Hydrocarbons	8	2	10

Introduction

Hydrocarbons are the simplest type of organic compounds. Hydrocarbons are composed entirely of carbon and hydrogen atoms, and are widely used as fuels. Diesel, Gasoline, natural gas and liquefied petroleum gas (LPG) are common examples of hydrocarbons. As they contain only carbon and hydrogen atoms, therefore hydrocarbons are non-polar covalently bonded compounds.

Fig. 12.1 Hydrocarbons are useful fuels

Scientists classify hydrocarbons as saturated hydrocarbons and unsaturated hydrocarbons. Saturated hydrocarbons are called alkanes and unsaturated hydrocarbons are alkenes and alkynes. In this unit, you will study the names, structures and types of organic reactions of hydrocarbons.

Real world link

If you have travelled in a bus or car, you have used hydrocarbons. The diesel and gasoline that are used in bus, trucks and cars as fuels are hydrocarbons. Beside this, the gas, which you use in your homes for cooking is also hydrocarbon.

12.1 Alkanes

An **alkane** is a hydrocarbon that has only single bonds, also known as saturated hydrocarbons. Alkanes that do not contain rings have the general formula C_nH_{2n+2}, where "n" is the number of carbon atoms.

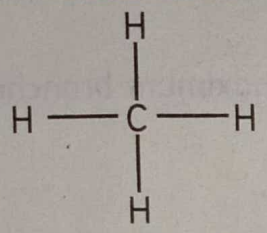
An alkane in the shape of a ring is called a cycloalkane. Cycloalkanes have the general formula C_nH_{2n}. In alkanes and cycloalkanes all the four bonds of carbon atoms are single. Therefore, they are saturated hydrocarbons. These compounds are less reactive and also called paraffins (para means little and affins means affinity).

Alkanes and cycloalkanes form a series of compounds, known as homologous series. Some of their group members and electron cross and dot structures of first five alkanes are shown in table 12.1.

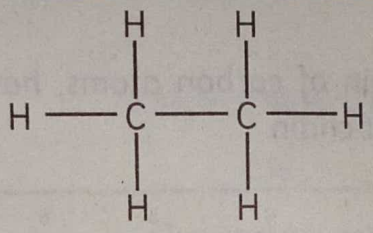
Table 12.1 Molecular, Condensed, Structural and Dot and Cross Formula of First Five Alkanes

Name	Molecular formula	Condensed formula
Methane	CH_4	CH_4
Ethane	C_2H_6	CH_3CH_3
Propane	C_3H_8	$CH_3CH_2CH_3$
Butane	C_4H_{10}	$CH_3(CH_2)_2CH_3$
Pentane	C_5H_{12}	$CH_3(CH_2)_3CH_3$

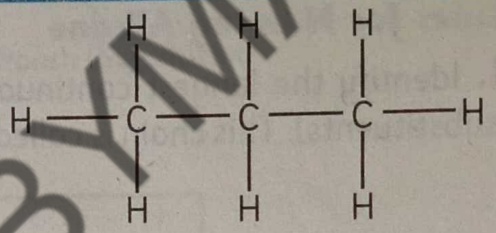
Structural formula of Alkanes up to Five Carbons



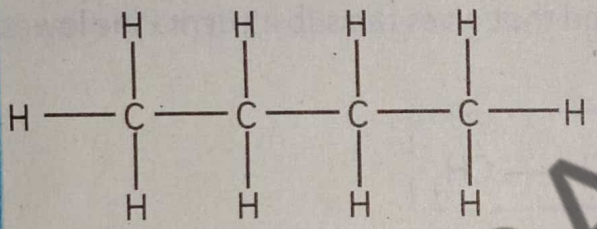
Methane



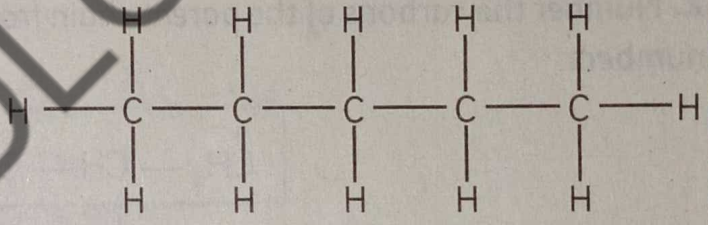
Ethane



Propane

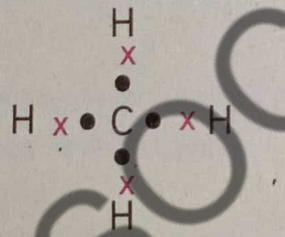


Butane

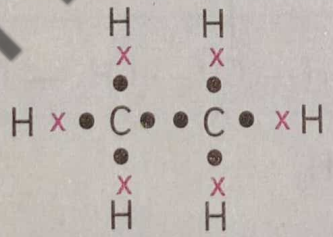


Pentane

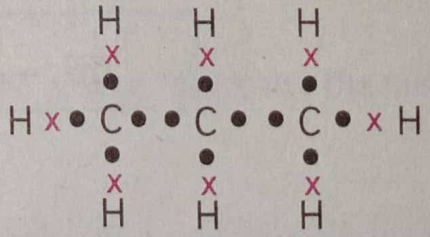
Electron Cross and Dot Structures of Alkanes up to Five Carbons



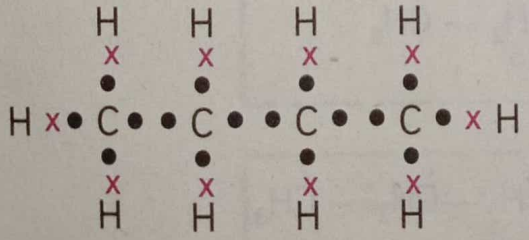
Methane



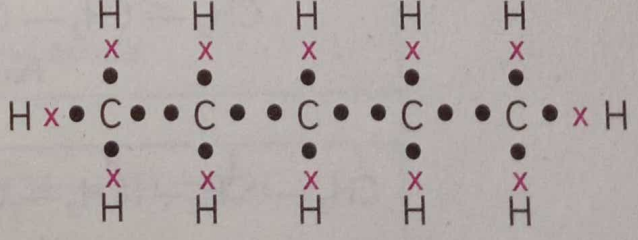
Ethane



Propane



Butane



Pentane

Nomenclature of Organic Compounds

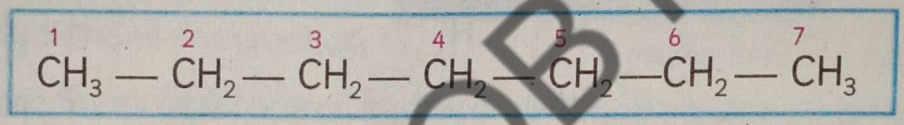
Reading Check

Describe the difference in the structural formula of propane and cyclopropane.

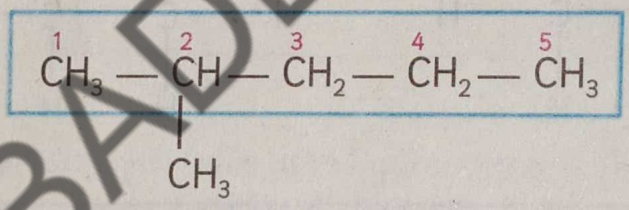
The naming of organic compounds before 1947 was based on the common system. As organic chemistry grew and developed, the scientists formed a committee called the International Union of Pure and Applied Chemistry (IUPAC) to establish an international standard of naming compounds to facilitate communication. The function of this committee is to suggest the systematic method of naming the organic compounds. IUPAC system of nomenclature is based on the principle. "Each different compound should have a different name". This committee formed some rules. These rules for naming alkanes are given below.

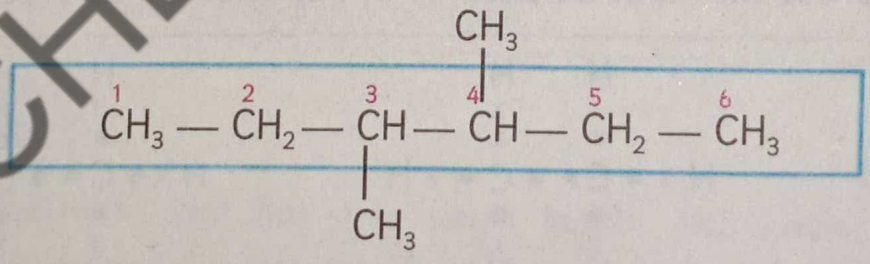
Rules for Naming Alkane

1. Identify the longest continuous chain of carbon atoms, having the maximum branches (substituents). This chain is called parent chain.

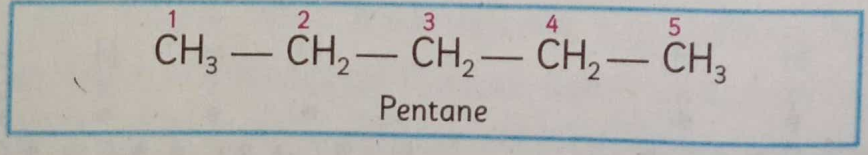


2. Number the carbons of the parent chain from the end that gives the substituents the lowest numbers.

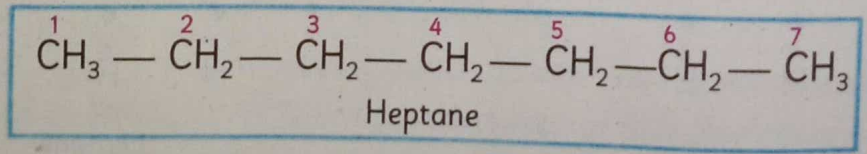




3. The parent name of alkane is derived from the common system, to the selected chain.

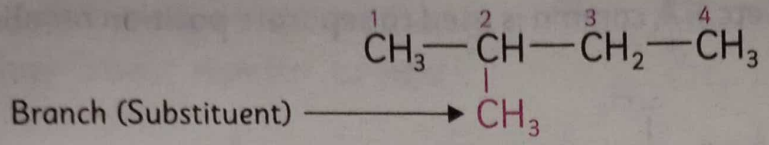


Pentane

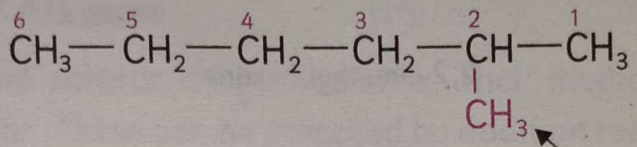


Heptane

4. The parent name is placed last and the substituent (branch) is preceded by the number showing its location on the chain.

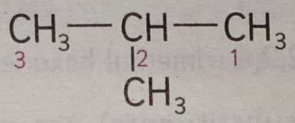


2-methyl butane



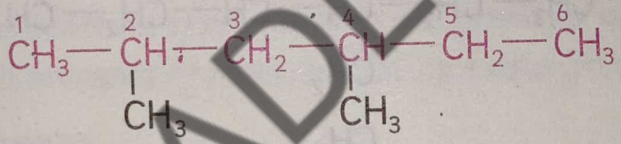
2-methyl hexane

Branch (Substituent)

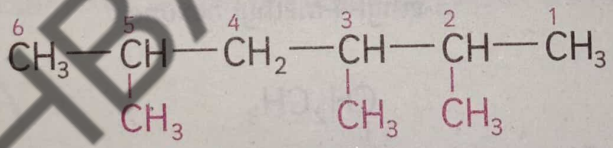


2-methyl propane

5. When two or more branches (substituents) are present, give each substituent a number corresponding to its location on the longest chain.

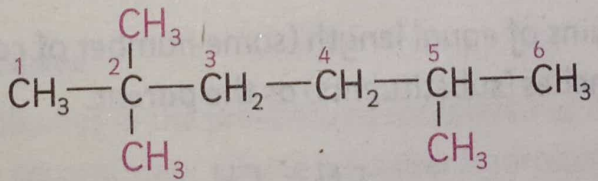


2,4-dimethyl hexane

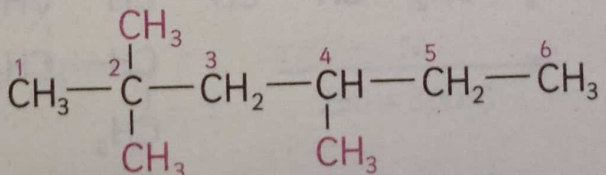


2,3,5-trimethyl hexane

6. When two branches (substituents) are present on the same carbon atom; use the number of that carbon twice.

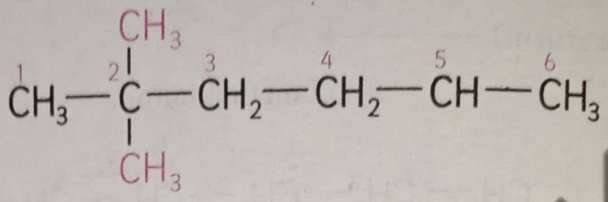


2,2,5-trimethyl hexane

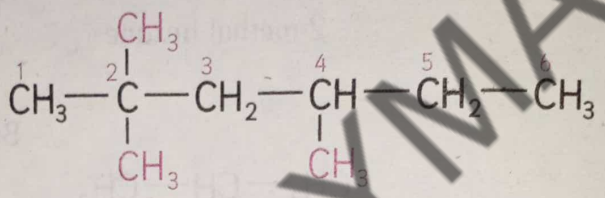


2,2,4-trimethyl hexane

7. If the same substituent occurs more than once, the location of each point on which substituent occurs is given. In addition, the number of times the substituent group occurs is indicated by prefix (di, tri, tetra, etc.). A comma is used to separate position numbers.

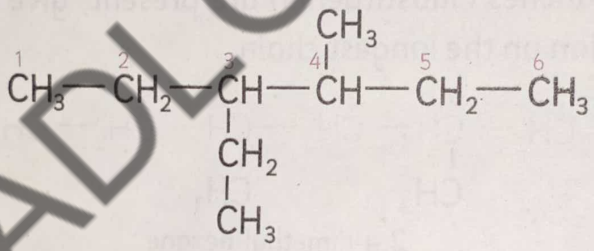


2,2-dimethyl hexane

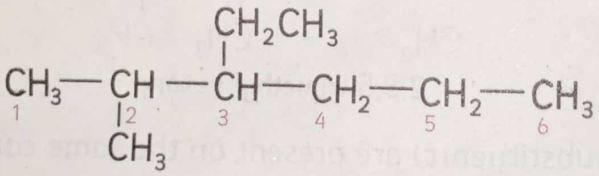


2,2,4-trimethyl hexane

8. When two or more branches (substituents) are not identical then they are arranged alphabetically. Such as ethyl before methyl etc.

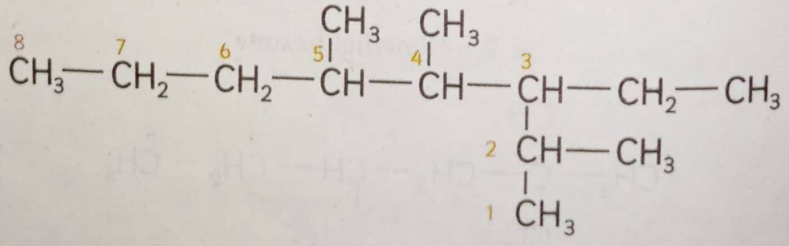


3-ethyl-4-methyl hexane



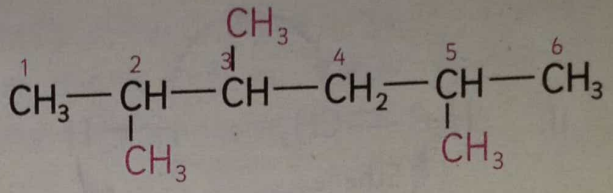
3-ethyl-2-methyl hexane

9. When there are two chains of equal length (same number of carbons), choose the one with the greater number of branches (substituents) as the parent.



3-ethyl-2,4,5-trimethyl octane

10. When first substituent occurs at an equal distance from either end of the longest chain, start numbering from that end which gives lowest number to next substituent.



2,3,5-trimethyl hexane

12.1.1 Preparation of Alkanes

Alkanes and cycloalkanes are saturated hydrocarbons. Their methods of preparation and chemical properties are similar. These can be prepared by addition reaction from alkenes and alkynes and by reduction reaction from alkyl halides.

12.1.1.1 Addition reaction

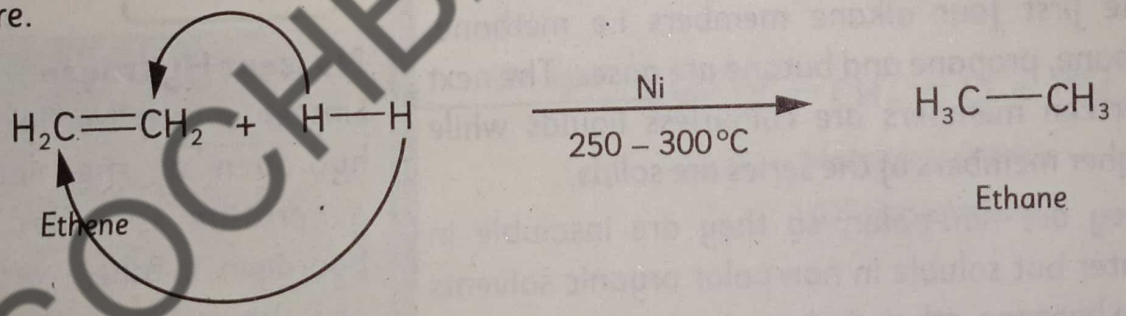
The reaction in which an atom or group of atoms are added to a compound that has a double or triple bond is called an addition reaction. Unsaturated compounds (alkenes or alkynes) are associated with addition reactions.

1. Hydrogenation of Alkenes and Alkynes

Hydrogenation means addition of hydrogen to alkene or alkyne. In hydrogenation reaction, the unsaturated hydrocarbons (alkene or alkynes) are converted into saturated hydrocarbons (alkanes). This reaction takes place in the presence of nickel as a catalyst at 250–300°C temperature or in presence of platinum (Pt) as a catalyst at room temperature.

(a) Hydrogenation of Alkenes

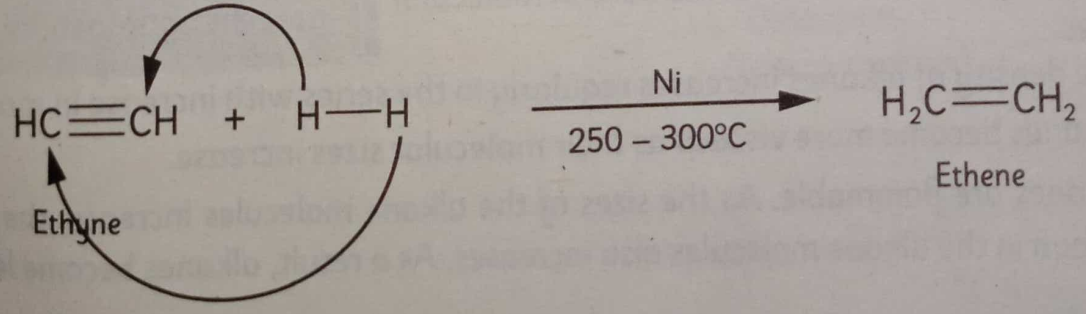
Alkenes are hydrogenated to alkanes in the presence of nickel (Ni) catalyst at 250–300°C temperature.



(b). Hydrogenation of Alkynes

Alkynes are hydrogenated to alkenes in the presence of nickel (Ni) as a catalyst at 250–300°C temperature in first step and in second step, alkene is further hydrogenated and converted into alkanes.

i.



ii. $H_2C{=}CH_2 + H{-}H \xrightarrow[250-300^{\circ}C]{Ni} H_3C{-}CH_3$

Ethene — Ethane

12.1.1.2 Reduction of alkyl halides

Reduction means addition of (nascent) hydrogen. It is the removal of halogen such as (Cl_2, Br_2, or I_2) with the addition of hydrogen. This reaction occurs in the presence of zinc dust and hydrochloric acid (HCl). Methyl iodide gives methane and hydrogen iodide (HI) reduction.

$$R{-}X + 2[H] \xrightarrow{Zn/HCl} R{-}H + H{-}X$$

$$\underset{\text{Methyl iodide}}{CH_3{-}I} + 2[H] \xrightarrow{Zn/HCl} \underset{\text{Methane}}{CH_3{-}H} + H{-}I$$

Similarly, ethyl bromide on reduction gives ethane and hydrogen bromide (HBr).

$$\underset{\text{Ethyl bromide}}{CH_3{-}CH_2{-}Br} + 2[H] \xrightarrow{Zn/HCl} \underset{\text{Ethane}}{CH_3{-}CH_2{-}H} + H{-}Br$$

Physical Properties of Alkanes

i. The first four alkane members i.e methane, ethane, propane and butane are gases. The next thirteen members are colourless liquids while higher members of the series are solids.

ii. They are non-polar, so they are insoluble in water but soluble in non-polar organic solvents like benzene, ether, acetone etc.

iii. They have low melting and boiling points. The melting and boiling points of alkanes increase regularly in the series with increase in molecular sizes.

iv. The density of alkanes increases regularly in the series with increase in molecular mass.

v. Alkanes become more viscous as their molecular sizes increase.

vi. Alkanes are flammable. As the sizes of the alkane molecules increase, the percentage of carbon in the alkane molecules also increases. As a result, alkanes become less flammable

Tidbit

Nascent Hydrogen

Nascent means 'Newly born'. The hydrogen at the time of its generation is called nascent hydrogen. In other words, we can say that the atomic hydrogen, which is more reactive than the ordinary Hydrogen at the time of its preparation is called the nascent hydrogen.

12.1.2 Important Reactions of Alkanes (Chemical Properties)

Alkanes are saturated hydrocarbons, consist of only carbon–carbon single (C–C) bonds and carbon–hydrogen (C–H) bonds. These bonds are strong and are difficult to break. Thus, alkanes are generally unreactive. Important reactions of alkanes are following;

12.1.2.1 Halogenation

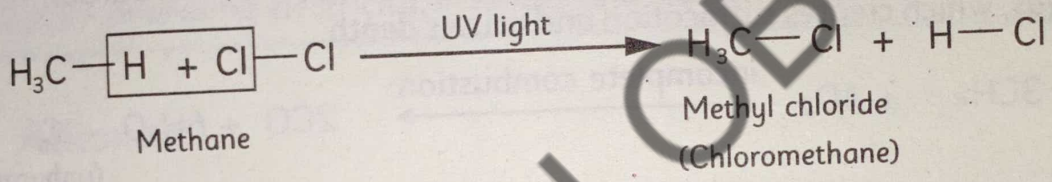
Alkanes are saturated hydrocarbons, so they mostly undergo substitution reactions. The substitution of hydrogen by halogen such as chlorine and bromine in alkanes is called halogenation.

Alkanes react with halogens in presence of ultra violet (UV) light and produce alkyl halide and hydrogen halide. For example, methane reacts with chlorine in diffused sunlight and produce methyl chloride.

Tidbit

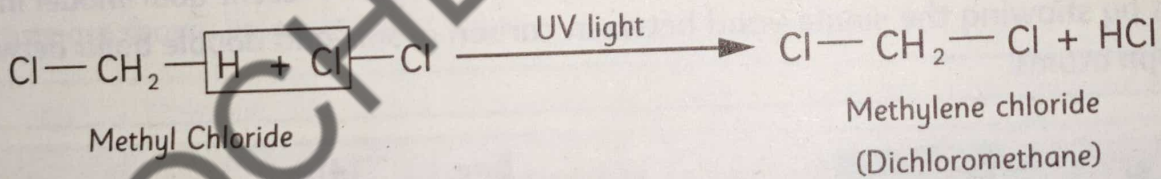
Substitution Reaction

A substitution reaction is a reaction in which, an atom (hydrogen atom) or a functional group (X, OH etc) is replaced by a different functional group.

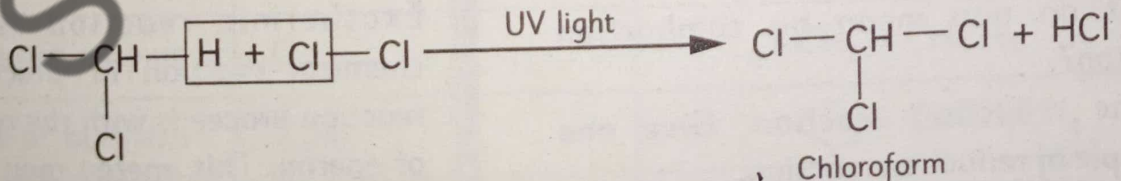


Methane → Methyl chloride (Chloromethane)

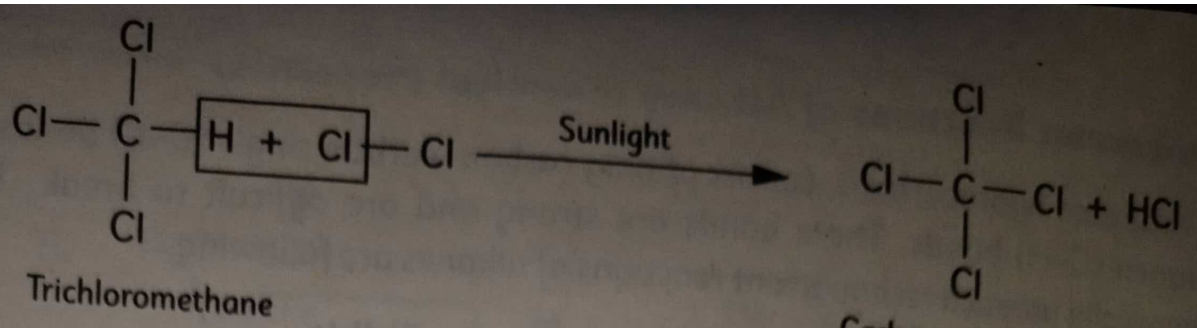
In excess of chlorine, this reaction does not stop at this stage. In a series of reactions, in each step one hydrogen atom is replaced by chlorine atom, so that all the three hydrogen atoms are replaced by chlorine atoms one by one, to give di, tri and tetra-chloromethane respectively.



Methyl Chloride → Methylene chloride (Dichloromethane)



Methylene Chloride → Chloroform (Trichloromethane)



Trichloromethane

Carbon tetrachloride
(Tetrachloromethane)

12.1.2.1 Combustion

Combustion reaction is a class of chemical reactions, which is commonly referred as burning. Alkanes burn completely in the presence of excess of air (oxygen) to produce a lot of heat, carbon dioxide (CO_2) and water (H_2O) only. This reaction is highly exothermic and due to this, alkanes are used as fuel.

$$CH_4 + 2O_2 \xrightarrow{\text{complete combustion}} CO_2 + 2H_2O + \text{Heat}$$

In a limited supply of oxygen, incomplete combustion of alkanes takes place, which produces poisonous gas carbon monoxide (CO), water and unburnt carbon. Carbon monoxide is a poisonous gas, which creates suffocation and causes death.

$$3CH_4 + 4O_2 \xrightarrow{\text{incomplete combustion}} 2CO + 6H_2O + \underset{\text{(unburnt) Carbon}}{C}$$

Activity 12.1 **Making models of first five alkanes and alkenes**

For making models of alkanes and alkenes use low cost things such as Styrofoam (packing material) or plastic beads or small plastic balls.

- Use different colours to represent carbon and hydrogen. Present your model in the class by showing the single bond between carbon atoms and double bond between carbon atoms.

Self Assessment

1. Name the simplest alkane.
2. What do you mean by combustion reaction?
3. Define reduction reaction. Give one example of reduction reaction.
4. Write the condensed formula of pentane and heptane.

Tidbit

Exothermic reaction

Exothermic reaction is the chemical reaction in which the reaction proceeds with the release of energy. This energy may be in the form of heat or light. In this reaction, the energy (heat or light) is given out to the surroundings.

Hydrocarbons as Fuel

Fuels are the substances that are used for burning and heating purposes. Fuels consist of natural gas, petroleum and coal. The chemical composition of fuels shows that they are mainly composed of carbon and hydrogen. Therefore, they are commonly referred as hydrocarbons.

Hydrocarbons are currently the main sources of the world's energy (heat) sources (such as home heating to large industrial processes), because they produce energy when burnt. When these hydrocarbons are burnt in air, they produces carbon dioxide (CO_2), water (H_2O) and large amount of energy. These reactions are commonly known as combustion reactions.

$$CH_{4(g)} + 2O_{2(g)} \longrightarrow 2H_2O_{(g)} + CO_{2(g)} + \text{Heat}$$

The energy produced during the reaction is used for useful purposes such as transportation, generating electricity, in homes and industrial operations.

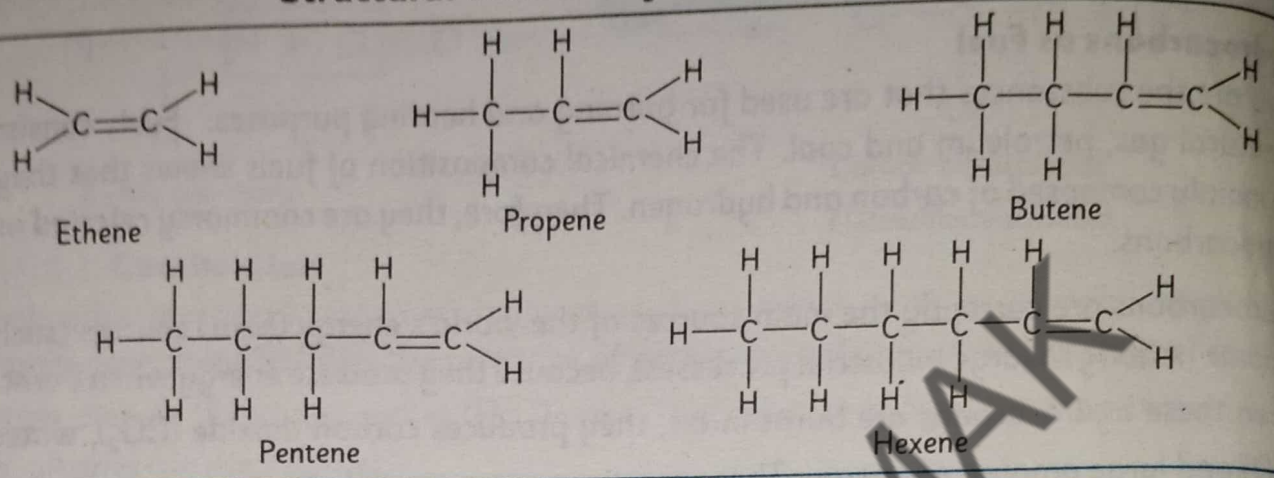
12.2 Alkenes

Alkenes are unsaturated hydrocarbons that contain atleast one carbon–carbon double bond. Alkenes are also called Olefins. Olefins is a Latin word which means oil forming. The general molecular formula of alkenes is C_nH_{2n}. The double bond in alkenes make them more reactive than alkanes. The functional group for an alkene is the double bond. The simplest alkene is ethene having molecular formula C_2H_4. First five alkenes with their electron cross and dot structure are shown below in table 12.2.

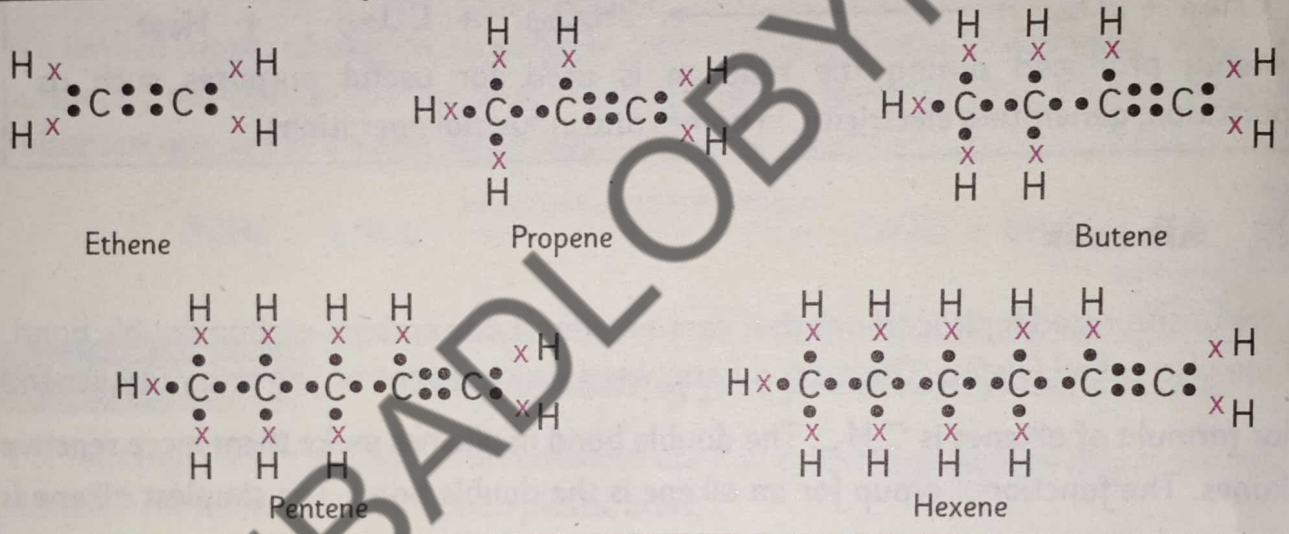
Table12.2 Molecular, Condensed, Structural and Dot and Cross Formula of First Five Alkenes

Name	Molecular formulae	Condensed formula
Ethene or ethylene	C_2H_4	$CH_2 = CH_2$
Propene or propylene	C_3H_6	$CH_2 = CHCH_3$
Butene or butylene	C_4H_8	$CH_2 = CHCH_2CH_3$
Pentene	C_5H_{10}	$CH_2 = CH(CH_2)_2CH_3$
Hexene	C_6H_{12}	$CH_2 = CH(CH_2)_3CH_3$

Structural Formula of First Five Alkenes



Electron Cross and dot formula of first five alkenes.



Rules for Naming Alkenes

The IUPAC rules for alkenes are similar in many respects to those for naming alkanes.

i. Select the longest continuous chain that contains the double bond (C = C) as th parent chain.

ii. The parent name is derived from the name of the identical alkane, in which th last – ane of alkane is replaced by – ene.

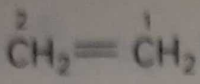
iii. Number the chain so as to include both carbon atoms of the double bond. Numbering begins from the end which is nearer to the double bond.

iv. The position of double bond is shown by numbering the alkene, so that minimum number is assigned to the double bond.

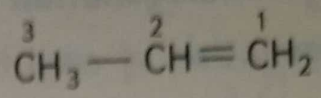
v. Designate the location of the double bond by using the number of the first atom of the double bond as a prefix.

vi. Indicate the location of the branches (substituents) by numbers of the carbon atoms to which they are attached.

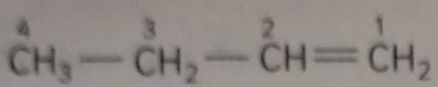
Rest of the rules will be the same as discussed in alkanes



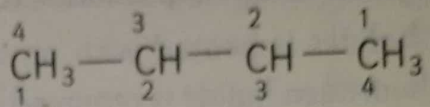
Ethene



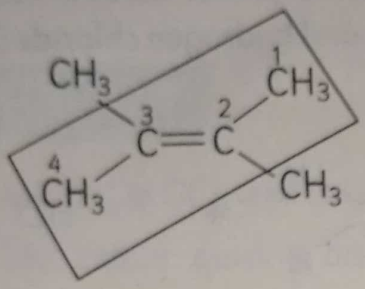
Propene



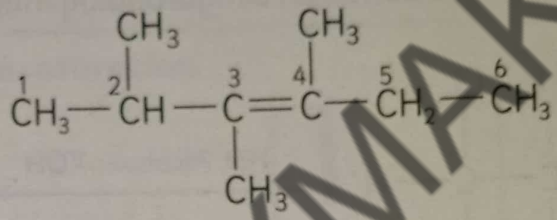
1-Butene



2-Butene



2, 3-Dimethyl -2-butene



2, 3, 4 - Tri-methyl -3-hexene

12.2.1 Preparation of Alkene

Alkene is an unsaturated hydrocarbon, so it can be prepared from a saturated organic compound by an elimination reaction.

In preparation of alkene, atom or groups of atoms are removed from two adjacent carbon atoms of the saturated organic compound to produce the double bond.

Tidbit

Elimination Reaction

In an elimination reaction, atoms are removed from a molecule (adjacent carbons) to form a double or triple bond. This type of reaction is the opposite of an addition reaction.

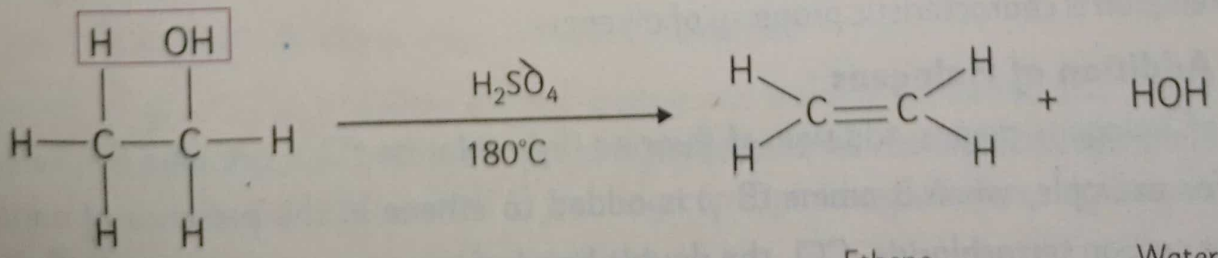
12.2.1.1 Dehydration of alcohols

Dehydration of alcohols means removal of water from alcohol. It is a process in which alcohol lose water and form a double bond. For example, ethene is prepared from dehydrating ethyl alcohol (ethanol.)

This reaction is carried out in the presence of concentrated sulphuric acid (H_2SO_4) at 180°C. In this reaction, the sulphuric acid acts as dehydrating agent.

Reading Check

What are Olefins?

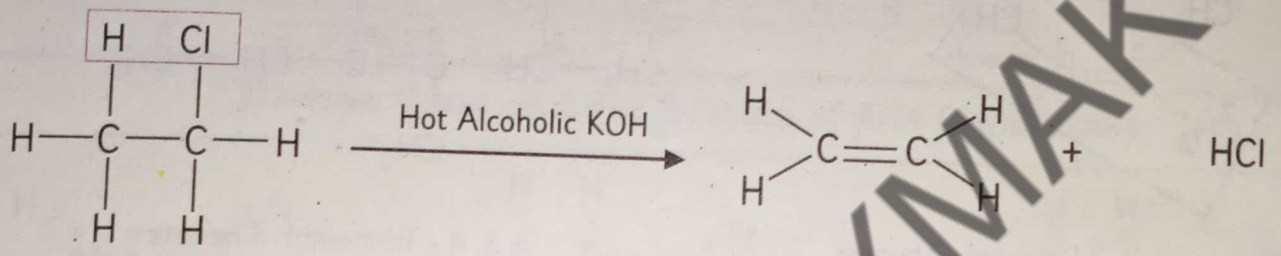


Ethyl Alcohol (Ethanol) — Ethene — Water

12.2.1.2 Dehydrohalogenation of Alkyl Halides

Dehydrohalogenation of alkyl halides means **removal of hydrogen and halogen** (F_2, Cl_2, Br_2, or I_2) from adjacent carbon atoms. For example, ethene is prepared from dehydrohalogenation of ethyl chloride (Chloroethane).

When alkyl halides is heated with an alcoholic solution of potassium hydroxide (KOH), a molecule of hydrogen halide is removed and an alkene is formed. In this elimination, halogen is removed from one carbon and hydrogen from the other adjacent carbon atom. For example, ethyl chloride on dehydrohalogenation gives ethene and hydrogen chloride (HCl).



Ethyl Chloride (Chloroethane) — Ethene — Hydrochloric acid

Hydrochloric acid (HCl) reacts with potassium hydroxide (KOH) to produce potassium chloride (KCl) and water (H_2O).

$$H{-}Cl + KOH \longrightarrow KCl + H_2O$$

Physical Properties of Alkenes

i. The first three members of alkenes, ethene, propene and butene are gases. Others are liquids and higher are solids.
ii. Alkenes are non-polar, therefore, they are insoluble in water but soluble in organic solvents.
iii. The melting and boiling points and density gradually increase with an increase in molecular mass.

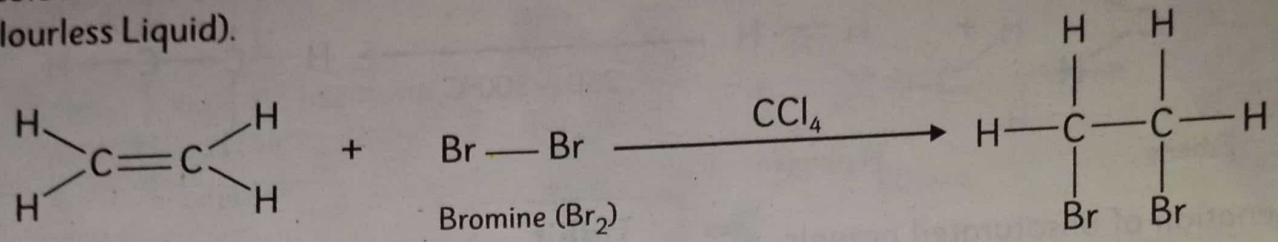
12.2.2 Important Reactions of Alkenes (Chemical properties)

Alkenes are unsaturated hydrocarbons. Due to the unsaturated nature of alkenes, they easily undergo addition reactions and in this way they are converted into saturated compounds. Addition reaction is characteristic property of alkenes.

12.2.2.1 Addition of Halogens

Addition of halogens means addition of fluorine (F_2), chlorine (Cl_2), bromine (Br_2) etc, to alkenes. For example, when Bromine (Br_2) is added to ethene in the presence of an inert solvent like carbon tetrachloride, CCl_4 the double bond of it is converted into single bond. It

decolourizes the reddish brown colour of bromine and produces 1, 2-dibromoethane (colourless Liquid).



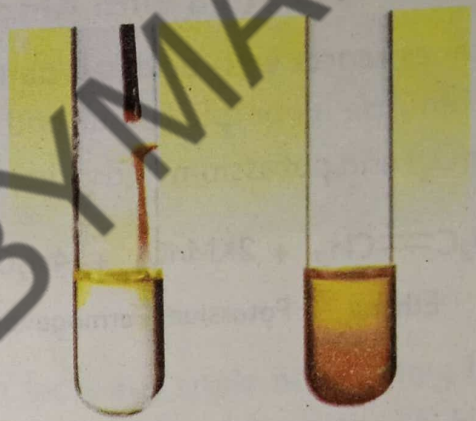
Ethene

Bromine (Br_2)

1,2-dibromoethane
(colourless liquid)

Activity 12.2 **Test for Unsaturation**

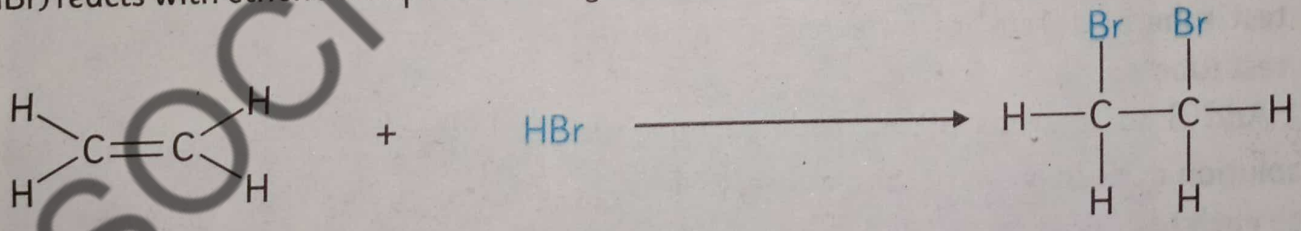
- Add Br_2 in CCl_4 (red colour) to an alkene.
- The colour quickly disappears as the bromine is added to alkene.
- If there is no double bond present, the reddish brown colour will remain. (Alkane)
- Thus "Decolourizing bromine" is the chemical test for the presence of a double bond. (Alkene)



Alkene Alkane

12.2.2.2 Addition of Hydrogen Halides

Addition of hydrogen halides means **addition of hydrogen and halogens,** such as hydrogen chloride (HCl), Hydrogen bromide (HBr), hydrogen iodide (HI) etc. The order of reactivity of alkenes with hydrogen halides is HI>HBr>HCl. For example, hydrogen bromide (HBr) reacts with ethene and produce Ethyl Bromide (bromoethane).



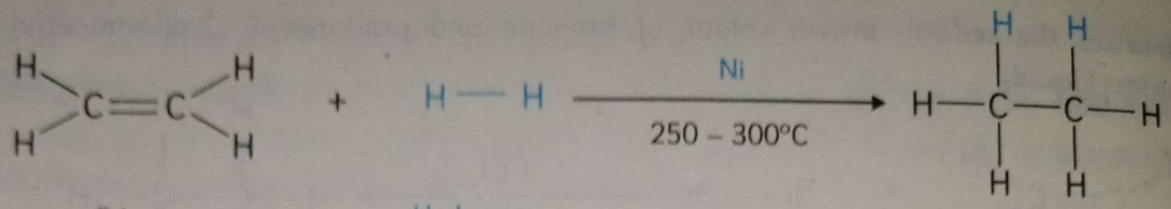
Ethene

Hydrobromic acid

Ethyl Bromide
(Bromo ethane)

12.2.2.4 Addition of Hydrogen (Hydrogenation)

When hydrogen (H_2) is added to ethene, the double bond is converted into single bond and produces the ethane. The addition of hydrogen to alkenes readily occurs in the presence of nickel as a catalyst at 250 – 300°C forming corresponding alkanes. Hydrogenation is an exothermic process.



Ethene + Hydrogen → Ethane

Hydrogenation of unsaturated organic compounds is industrially used for the conversion of vegetable oils into Ghee.

Tidbit

Glycols are alcohols which contain two hydroxyl groups (—OH) on two adjacent carbons.

12.2.2.3 Oxidation with $KMnO_4$

Alkenes reacts with acidified aqueous solution of potassium permanganate ($KMnO_4$). They decolourise its purple colour and form ethylene glycol (1,2-ethanediol), manganese dioxide (MnO_2) and potassium hydroxide (KOH).

$$3H_2C{=}CH_2 + 2KMnO_4 + 4H_2O \xrightarrow{\text{Acid}} 3H_2C(OH){-}CH_2(OH) + 2MnO_2 + 2KOH$$

Ethene + Potassium Permaganate → Ethylene Glycol (1,2-Ethanediol)

Test for Unsaturation: The purple color of an acidified aqueous solution of potassium permanganate ($KMnO_4$) decolourises when it is treated with alkenes. This test is used for the detection of alkenes and commonly called as **Baeyer's test.**

Activity 12.3 **Test for Unsaturation**

i. Take 2 test tubes. Take 1cm^3 n-hexane in one test tube and 1cm^3 of n-hexene in the other test tube.

ii. Add 3 to 4 drops of an acidified aqueous solution of potassium permaganate, $KMnO_{4(aq)}$ to each test tube.

iii. Place the stopper on the test tubes and shake it.

iv. Record the initial observation (colours in both test tubes).

v. After 1 hour, the two test tubes containing n-hexane and n-hexene are compared.

vi. Record the observation(s) and interpret the result.

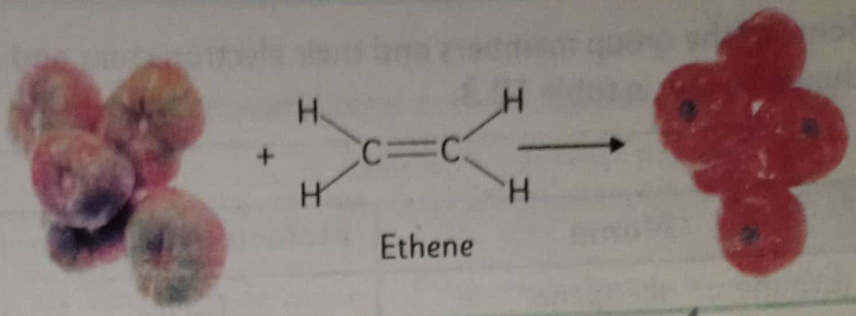
(a). Alkane (b). Alkene

(a). There is no reaction with alkane, as there is no decolourization in alkane.

(b). The alkenes decolourises the acidified potassium permaganate ($KMnO_4$).

Tidbit

Ethene is a plant hormone that triggers fruit ripening. Its small size allows it to travel as a gas.



Ethene

Self Assessment

1. Alkenes are more reactive than alkanes, why?
2. State the conditions used in the reaction between an alkene and hydrogen.
3. Name the product formed when propene reacts with chlorine.
4. What will be formed when ethene gas is bubbled through a concentrated solution of hydrochloric acid?
5. Distinguish between propane and propene using Baeyer's test.

12.3 Alkynes

Alkynes are unsaturated hydrocarbons which contain at least one triple bond. They have two hydrogen atoms less than the corresponding alkenes. Their general formula is C_nH_{2n-2}. Examples of alkynes or ethyne, propyne, butyne etc. The simplest alkyne is ethyne having molecular formula C_2H_2.

Fig. 12.2 Ethyne is the fuel used in oxyacetylene torches. Oxyacetylene torches can reach temperatures of over 3000°C.

Tidbit

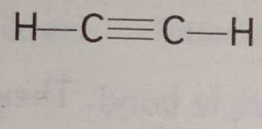
The combustion of ethyne when it is mixed with pure oxygen produces large amount of heat used for welding. The common name of ethyne is acetylene and these welding torches are commonly called **oxyacetylene** torches.

Some of the group members and their electron cross and dot structures of simple alkynes are shown bellow in table 12.3.

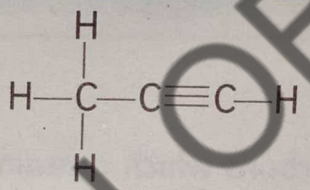
Table12.3 Molecular, Condensed, Structural and Dot and Cross Formula of First Five Alkynes

Name	Molecular formula	Condensed formula
Ethyne or acetylene	C_2H_2	$CH{\equiv}CH$
Propyne or methyl acetylene	C_3H_4	$CH{\equiv}C{-}CH_3$
Butyne or dimethyl acetylene	C_4H_6	$CH{\equiv}C{-}CH_2{-}CH_3$
Pentyne	C_5H_8	$CH{\equiv}C{-}(CH_2)_2{-}CH_3$
Hexyne	C_6H_{10}	$CH{\equiv}C{-}(CH_2)_3{-}CH_3$

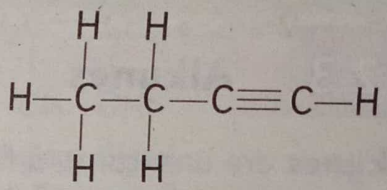
Structural formula of first five alkynes



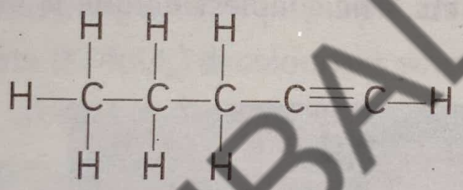
Ethyne



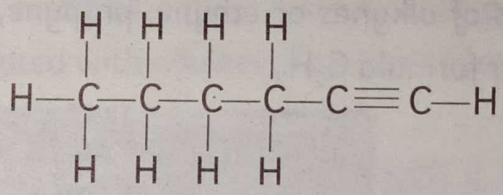
Propyne



Butyne



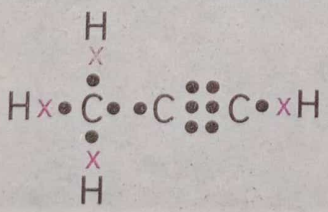
Pentyne



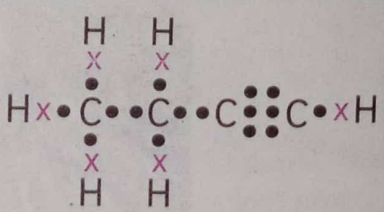
Hexyne

Electron Cross and dot formula of first five alkynes

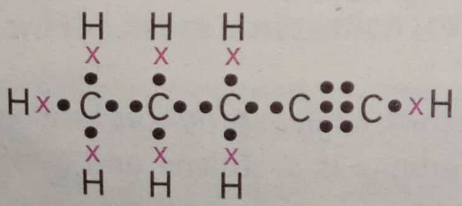
Ethyne



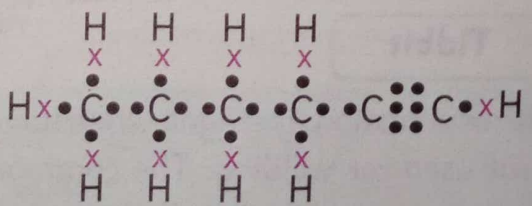
Propyne



Butyne



Pentyne

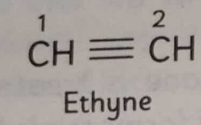


Hexyne

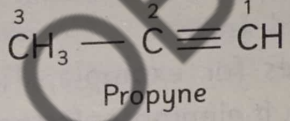
Rules for Naming Alkynes

i. Select the longest continuous carbon chain containing carbon- carbon (C≡C) triple bond.
ii. The parent name is derived from the name of the identical alkane, in which the last –ane of alkane is replaced by –yne.
iii. Number the chain so as to include both carbon atoms of the triple bond. Numbering begins from the end which is nearer to the triple bond.
iv. The position of triple bond is shown by numbering the alkyne, so that minimum number is assigned to the triple bond.
v. Designate the location of triple bond by using the number of the first atom of the triple bond as a prefix.
vi. Indicate the location of the substituents by number of the carbon atoms to which they are attached.

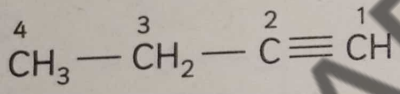
Rest of the rules will be the same as discussed in alkanes.



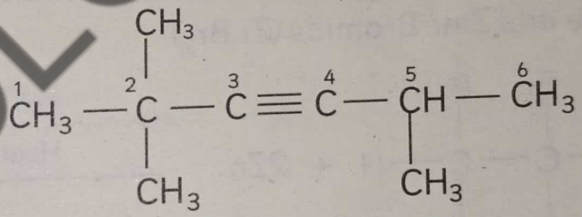
Ethyne



Propyne



1-Butyne



2,2,5-Trimethyl -3-Hexyne

12.3.1 Preparation

Alkyne is an unsaturated hydrocarbon, It can be prepared from saturated organic compounds by an elimination reaction. Alkynes are prepared by the following methods.

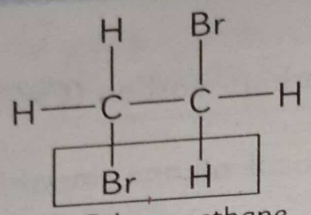
Reading Check

For what purpose oxyacetylene flame is used?

12.3.1.1 Dehalogenation of Adjacent Dihalides

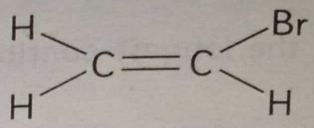
Organic compounds in which dihalides are attached to the adjacent carbon atoms are called vicinal dihalides. This reaction occurs in two steps.

In the first step, vicinal dihalides such as 1, 2-dibromoethane is heated with alcoholic potassium hydroxide (KOH) solution, removal of hydrogen takes place form one carbon and bromine from other. It creates a double bond and produces bromoethene and hydrogen bromide (HBr).



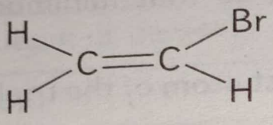
1,2- Dibromoethane

$$\xrightarrow[\text{Heat}]{\text{Alcoholic KOH}}$$



Bromoethene + HBr

In the 2nd step, another molecule of hydrogen bromide (HBr) is removed and the double bond is converted into triple bond thus producing the ethyne (acetylene).



Bromoethene

$$\xrightarrow{\text{Alcoholic KOH}} H—C\equiv C—H + HBr$$

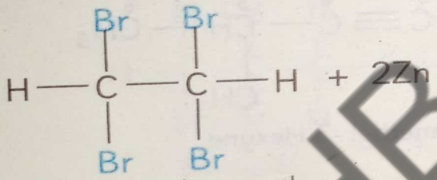
Ethyne (Acetylene)

$$2HBr + 2KOH \longrightarrow 2KBr + 2H_2O$$

12.3.1.2 Dehalogenation of Tetrahalides

Tetrahalides: Compounds that contain four halogen atoms at the two adjacent carbon atoms are called tetrahalides.

When alkyl tetrahalides for example, 1,1,2,2-tetrabromoethane is treated with reactive metal like zinc (Zn) dust. It eliminates (removes) the bromine and forms triple bond, producing ethyne and Zinc Bromide ($ZnBr_2$).



1,1,2,2- Tetrabromoethane + 2Zn

$$\xrightarrow{\text{Heat}} H—C\equiv C—H + 2ZnBr_2$$

Ethyne — Zinc Bromide

Physical Properties of Alkynes

i. The first three members of alkynes ethyne (acetylene), propyne and butyne are gases. Others are liquids and higher are solids.
ii. Alkynes are non-polar; therefore, they are insoluble in water, but soluble in organic solvents.
iii. On complete combustion, they produce carbon dioxide and water, with the release of a very huge amount of energy.
iv. The melting and boiling points and density increase with an increase in the molecular mass.

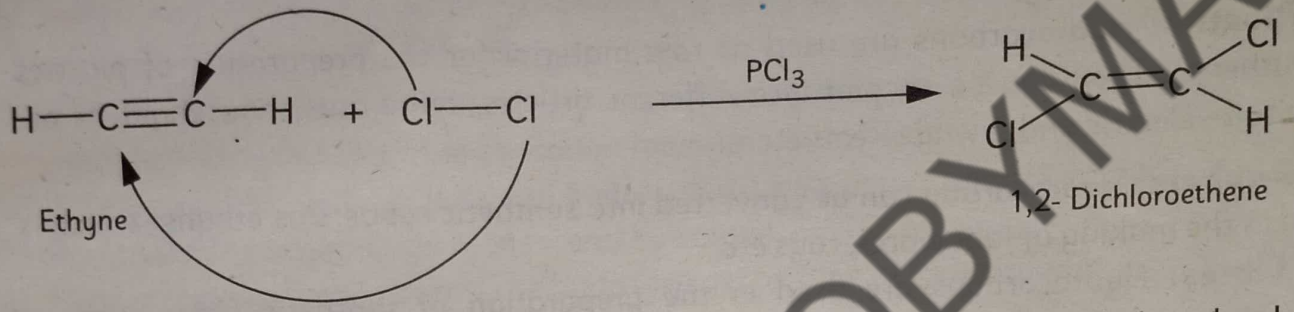
12.3.2 Important Reactions of Alkynes (Chemical properties)

Alkynes are unsaturated hydrocarbons. They easily undergo addition reactions and in this way, they are converted into saturated hydrocarbons.

12.3.2.1 Halogenation

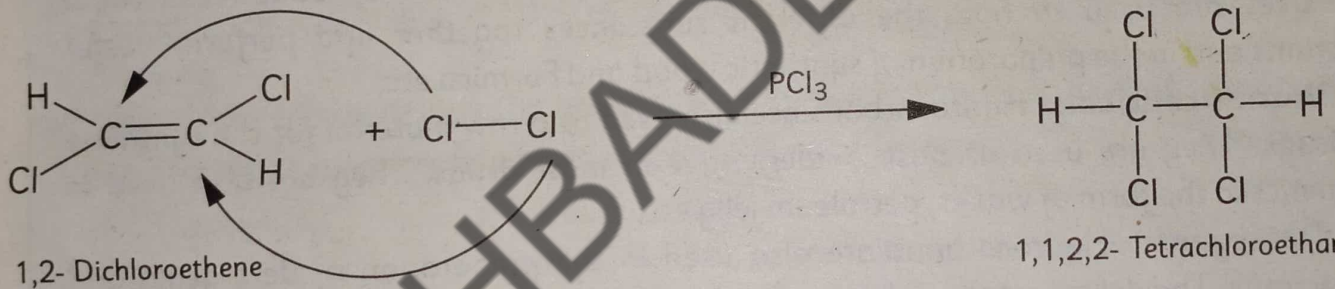
Halogenation means addition of halogens such as chlorine (Cl_2), bromine (Br_2), iodine (I_2) etc. In this reaction phosphorus trichloride (PCl_3) is used as a catalyst. The addition of chlorine and bromine takes place readily while addition of iodine occurs slowly. The addition of halogens to alkynes (ethyne) takes place in two steps.

Step I: In the first step a halogen, Chlorine (Cl_2) molecule is added to the triple bond. The triple bond is converted into double bond and forms 1,2-dichloroethene.



1,2- Dichloroethene

Step II: In the second step another halogen, chorine (Cl_2) molecule is added to the double bond. The double bond is converted into single bond and forms 1,1,2,2-tetrachloroethane.

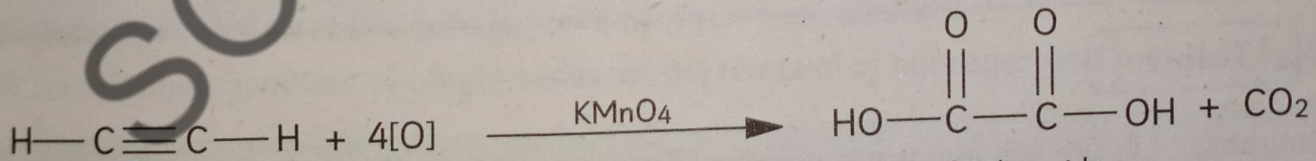


1,2- Dichloroethene

1,1,2,2- Tetrachloroethane

12.3.2.2 Oxidation with $KMnO_4$

The oxidation of ethyne with ethyne potassium permanganate gives carboxylic acid and carbon dioxide on breaking the molecule at carbon – carbon triple bond.



Oxalic acid

Self Assessment

1. Write the steps to show the reaction between Ethyne and Bromine.

Key Points

- Hydrocarbons contain only carbon and hydrogen atoms, they are non-polar covalently bonded compounds.
- An alkane is a hydrocarbon that has only single bonds, it is also known as saturated hydrocarbons.
- The general formula of alkanes is C_nH_{2n+2}, where "n" is the number of carbon atoms.
- An alkane in the shape of a ring is called a cycloalkane.
- Cycloalkanes have the formula C_nH_{2n}.
- The reaction in which an atoms or group of atoms are added to a compound that has a double or triple bond is called addition reaction.
- Hydrogenation means addition of hydrogen to unsaturated organic compounds.
- Reduction means addition of (nascent) hydrogen.
- Nascent means 'newly born'. The hydrogen at the time of its generation is called nascent hydrogen.
- A substitution reaction is a reaction in which, an atom (hydrogen atom) or a functional group (X, OH etc) is replaced by a different functional group.
- Combustion reaction is a class of chemical reaction, which is commonly referred as burning.
- Incomplete combustion is the process where there is limited supply of oxygen, so the hydrocarbons incompletely burn and produce carbon dioxide (CO_2), carbon monoxide (CO), water (H_2O) and unburnt carbon (C).
- Alkenes are unsaturated hydrocarbons that contain double covalent bonds between carbon atoms.
- Alkenes are also called Olefins, olefins is a Latin word which means oil forming.
- In the elimination reaction, atoms are removed from a molecule (adjacent carbons) to form the double or triple bonds. This type of reaction is the opposite of an addition reaction.
- Dehydration of alcohol means removal of water from alcohol.
- Dehydrohalogenation of alkyl halides means removal of hydrogen and halogen (F_2, Cl_2, Br_2, or I_2).
- Addition of halogen means addition of fluorine (F_2), chlorine (Cl_2), bromine (Br_2) etc.
- Addition of hydrogen halide means addition of hydrogen and halogens, such as hydrogen chloride (HCl), hydrogen bromide (HBr), hydrogen iodide (HI) etc.
- Baeyer's test is used for the detection of double bonds in alkenes.
- An alkyne is unsaturated hydrocarbons, which contain at least one triple bond.
- The general formula of alkyne is CnH_{2n-2}.

Exercise

A. Choose the Correct Option.

1. Which one of the following is a substitution reaction?
   a. Halogenation of alkynes
   b. Halogenation of alkenes
   c. Halogenation of alkanes
   d. Oxidation of alkene
2. When ethene reacts with HBr, the compound formed is
   a. $CH_3 - CH_2 - Br$
   b. $Br - CH_2 - CH_2 - Br$
   c. $CH_3 - CH_2 - CH_8$
   d. $CH \equiv CH$
3. Halogenation of methane in the presence of diffused sunlight occurs
   a. Quickly, only in one step
   b. Slowly, only in one step
   c. In a series of four steps
   d. Quickly, in two step
4. Dehydrohalogenation of alkylhalide is
   a. Removal of hydrogen
   b. Removal of halogen
   c. Removal of hydrogen and halogen
   d. Addition of hydrogen and halogen
5. Which one of the following decolourises Br_2 water?
   a. Ethane b. Ethene c. Propane d. Methane
6. The general formula of alkane is
   a. C_nH_{2n} b. $C_nH_{2n\times 2}$ c. C_nH_{2n+2} d. C_nH_{2n-2}
7. Dehydration of ethyl alcohol with conc. H_2SO_4 results in the formation of
   a. Ethane b. Methane c. Ethyne d. Ethene
8. Substitution reaction is the characteristic of
   a. Alkynes b. Alkenes c. Alkanes d. None of these
9. Which one is the least reactive?
   a. Ethyne b. Propene c. Ethene d. Ethane
10. The order of reactivity of hydrogen halides with alkenes is
    a. HI>HCl>HBr
    b. HI<HBr<HCl
    c. HCl>HBr> HI
    d. HI>HBr>HCl

B. Short questions

How would you test that alkenes undergo an addition reaction?

1. Which one is more reactive between alkane and alkene? Explain.
2. Justify alkenes and alkynes as unsaturated hydrocarbons.
3. Why alkanes are inert in nature?
4. What happens when alkyl halide is reduced?
5. Can you predict the product if $KMnO_4$ solution reacts with alkene.
6. Why the colour of Bromine water discharges on addition to ethene?
7. Compare the reactivity of alkane and alkene.
8. Why addition reactions take place in ethene and ethyne but not in ethane?
9. Write equations for the preparation of ethene from ethyl alcohol and ethyl chloride.
10.

C. Long Questions

1. (i). Write down the equations for the preparation of alkanes, alkenes and alkynes.

   (ii). Draw the molecular, dot and cross, condensed and structural formula of each of the following.

   (a). Propene (b). Butyne (c). Pentane
   (d). Heptyne (e). Butane

2. (i). The general formula of alkanes is C_nH_{2n+2}. Determine the general formula of cycloalknes.

   (ii). Write a balanced equation for the complete combustion of each of the following:

   (a). Methane (b). Ethene (c). Ethyne

   (iii). Expalin breifly that why ethyene (actylene) undergoes addition reaction in two steps.

3. (i). Give an example reaction that would yield the following products. Name the organic reactant and product in each reaction.

   (a). Alkane (b). Monohalogenated alkane
   (c). Dihalogenated alkane (d). Tetrahalogenated alkane

   (ii). (a). Alkenes are unsaturated hydrocarbons. Explain the word unsaturated.
   (b). Describe the bonding between the two carbon atoms in Ethene.
   (c). Which functional group is present in alkenes?
   (d). Describe a simple chemical test to determine whether an unknown hydrocarbon is unsaturated. Describe the result if the test is positive.

4. Using structural formulae, give balanced equations for the following reactions.
   (a). Ethene with chlorine.
   (b). Ethene with hydrogen. Name the catalyst used. Which industrial process uses a similar reaction?
   (c). Ethene with hydrogen bromide.
   (d). Ethene with $KMnO_4$.

5. Illustrate the following accordingly as been instructed:
   (a). Alkane from Alkyl Halide
   (b). Bromoethane from Ethene
   (c). Ethylene glycol (1,2-ethanediol) from Ethene
   (d). Ethyne from Tetrahalides
   (e). Oxalic acid from Acetylene

Project

Make a market survey and identify the industrial uses of various hydrocarbons. Examine their importance in our life.