

HYDROCARBONS

Conceptual Linkage

Before reading this chapter, the student must know the:

- Introduction of Organic Compounds
- Bonding in the Organic Compounds
- Difference in Saturated and Unsaturated
- Cyclic Structure of Organic Compounds

Time Allocation

Teaching periods	= 08
Assessment periods	= 02
Weightage	= 05%

LEARNING OUTCOMES

Students will be able to:

- Explain why a systematic method of naming chemical compounds is necessary. (Analyzing)
- Characterize a hydrocarbon. (Understanding)
- Draw electron cross and dot structures of simple alkanes. (Applying)
- Write a chemical equation to show the preparation of alkanes from hydrogenation of alkenes and alkynes and reduction of alkyl halides. (Remembering)
- Draw structural formulas of alkanes, alkenes and alkynes up to 5 carbon atoms. (Understanding)
- Write a chemical equation to show the preparation of alkenes from dehydration of alcohols and dehydrohalogenation of alkyl halides. (Remembering)
- Write a chemical equation to show the preparation of alkynes from Dehalogenation of 1, 2- dihalides and tetrahalides. (Remembering)
- Write chemical equations showing halogenation for alkanes, alkenes and alkynes. (Remembering)
- Write chemical equation showing reaction of KMnO_4 with, alkenes and alkynes. (Remembering)

Introduction

The Hydrocarbons are the simplest organic compounds which are made up of atoms of carbon and hydrogen only, (The hydro here stands for hydrogen and carbon for the carbon atoms).

The hydrocarbons are important to us in the sense that the fuels we use in our modern life is almost all composed of the hydrocarbons. The hydrocarbons are also helpful for us as they are used in the manufacture of most of the valuable substances of our daily usage.

Activity 12.1

Although the Hydrocarbons are widely used as energy resources but they produce some health hazard products on burning, pollute the environment and cause Green house effect, which is increasing the temperature of earth.

Can you suggest some sources of energy other than these hydrocarbons that can be used as alternate source of energy?

12.1 Classification of Hydrocarbons

The hydrocarbons are classified into two major groups, i.e the acyclic or open chain also called (aliphatic compounds) and the cyclic or closed chain compounds. They are described in detail separately in following section.

Open Chain or Acyclic hydrocarbons:

The acyclic hydrocarbons or the straight chain compounds are those in which the chain of carbon grows in two or more directions without cycle formation. All the "C" atoms in the chain are primary carbon atoms, (the primary carbon atom also called " 1° " is that which is linked with the carbon atoms not more than 1 in number).

The branched aliphatic compounds are those which have at least one secondary or tertiary carbon atom in the chain, (The Secondary carbon or " 2° " is that one which has two carbon atom directly attached with it, the tertiary carbon atom or " 3° " is that

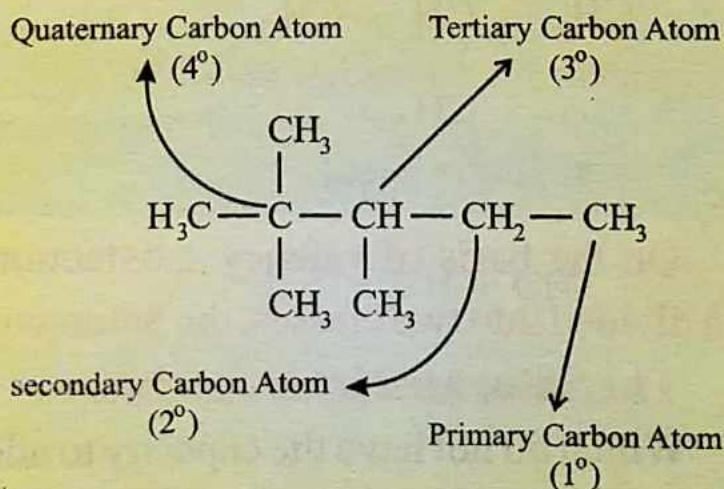


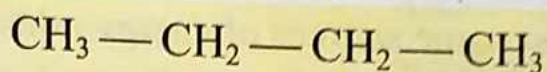
Fig. 12.1: Distinction between primary, secondary, tertiary and quaternary carbon atoms.

which is attached with three carbon atoms and the carbon atom which is linked at all four bonds with carbon is called quaternary carbon atom or " 4° ", see figure-12.1.

The acyclic hydrocarbons are further divided into two subtypes, which are explained here in following.

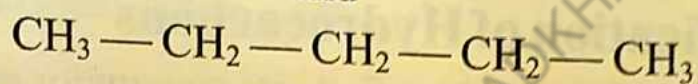
I) Straight Chained Hydrocarbons

In these hydrocarbons the chain of carbon atoms runs in two directions only and all carbon atoms present are either primary or secondary e.g.



n-Butane

and



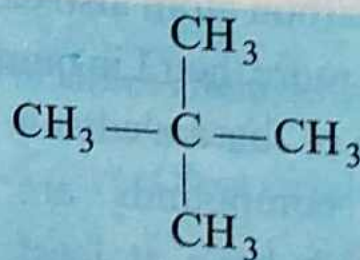
n-pentane

II) Branched Hydrocarbons

In this type certain branches appear upon the main carbon chain. Note that a branch is also a chain of carbon but it has lesser number of carbon atoms than the main chain, at branching a carbon atom is attached with '3' or '4' carbons and thus here tertiary (3°) or quaternary (4°) carbon atoms are seen e.g. 2-Methyl propane and 2,2-dimethyl propane.



2- Methyl propane



2,2- Dimethyl propane

On the basis of valency satisfaction, the open chain compounds are again divided into two classes, the Saturated and the unsaturated compounds.

i) The Saturated hydrocarbons

Which do not have the capacity to add any atom further, they are called **Alkanes** and are composed of only the single bond between the carbon atoms. Examples of such compounds include.

Saturated Hydrocarbons	Line formula
Methane	CH_4
Ethane	$\text{H}_3\text{C}-\text{CH}_3$
Propane	$\text{H}_3\text{C}-\text{CH}_2-\text{CH}_3$
Butane	$\text{H}_3\text{C}-\text{CH}_2-\text{CH}_2-\text{CH}_3$

Table 12.1 Some Saturated Hydrocarbons

ii) The Unsaturated hydrocarbons

Those which can add atoms further, e.g. the alkenes and the alkynes are unsaturated hydrocarbons because the valency of carbon is not fully satisfied in these which contain double and triple bonds respectively.



Fig 12.2 Unsaturated hydrocarbons

The **Alkenes** contain at least one double bonds between the two Carbon atoms in the chain, while the **Alkynes** have at least one triple bond between the Carbon atoms of the chain, the addition of atoms during reactions takes place at this double or triple bonds of the compound.

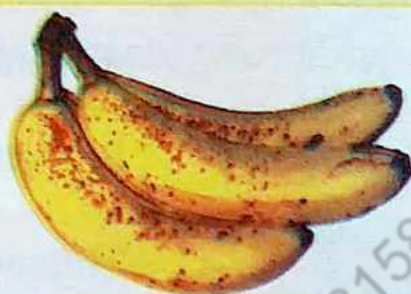
Some of the simplest alkenes are shown in the following table.

Alkene Hydrocarbons	Molecular Structural Formula
Ethene or Ethylene	$\text{H}_2\text{C} = \text{CH}_2$
Propene	$\text{H}_2\text{C} = \text{CH} - \text{CH}_3$
1-Butene	$\text{H}_2\text{C} = \text{CH} - \text{CH}_2 - \text{CH}_3$
2-Hexene	$\text{H}_3\text{C} - \text{CH} = \text{CH} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$

Table 12.2 Some alkenes

Interesting Information

During ripening of bananas ethene gas is produced which makes fruits ripen faster and can lead to speed spoilage, that is the reason they enhance and accelerate the decaying process in the fruits at their neighbourhood. So, they should not be kept along with other fruits.



And the simple alkynes are written in the following table:

Alkyne Hydrocarbons	Molecular Structural Formula
Acetylene or Ethyne	$\text{HC} \equiv \text{HC}$
Propyne	$\text{HC} \equiv \text{C} - \text{CH}_3$
1-Butyne	$\text{HC} \equiv \text{C} - \text{CH}_2 - \text{CH}_3$
1-Pentyne	$\text{HC} \equiv \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$
2-Hexyne	$\text{H}_3\text{C} - \text{C} \equiv \text{C} - \text{CH}_2 - \text{CH}_2 - \text{CH}_3$

Table 12.3 Some alkynes

12.1.2 Cyclic hydrocarbons

Another class of the hydrocarbons is the cyclic or closed chained hydrocarbons which are the compounds having a closed structure where the carbon chain increases in a manner that a closed type ring is formed between the carbon atoms of chain. For such closed systems there must be at least 3 carbon atoms in the compound.

The cyclic compounds are divided into two further divisions, i.e. alicyclic compounds and the Aromatic compounds. The **aromatic compounds** are the organic compounds which contain at least one benzene ring in their structure, the benzene ring is shown here in figure-12.2.

Examples of such compounds include benzene itself, Naphthalene, Anthracene etc. Such compounds have special features e.g. they contain conjugate (alternate) double bonds, and although they are unsaturated but they do not react like aliphatic unsaturated compounds.

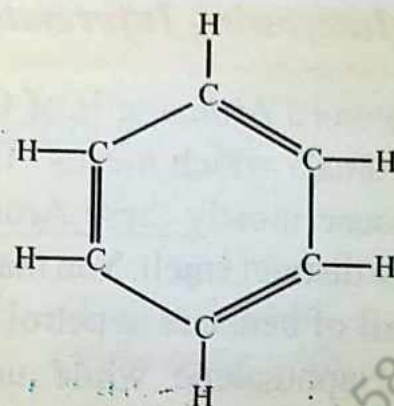


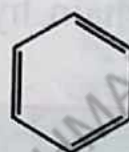
Fig 12.3 Benzene

Aromatic Hydrocarbons

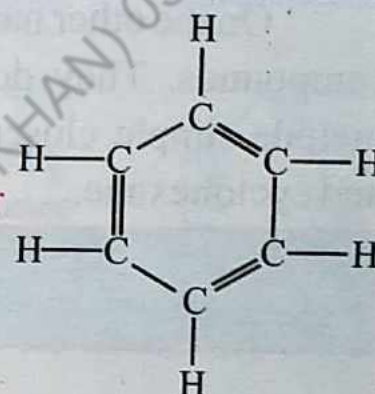
Molecular Formula

Benzene

C_6H_6

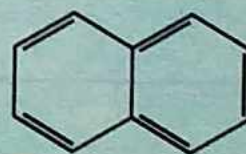


or



Naphthalene

$C_{10}H_8$



Anthracene

$C_{14}H_{10}$

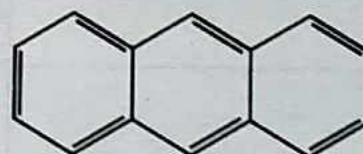


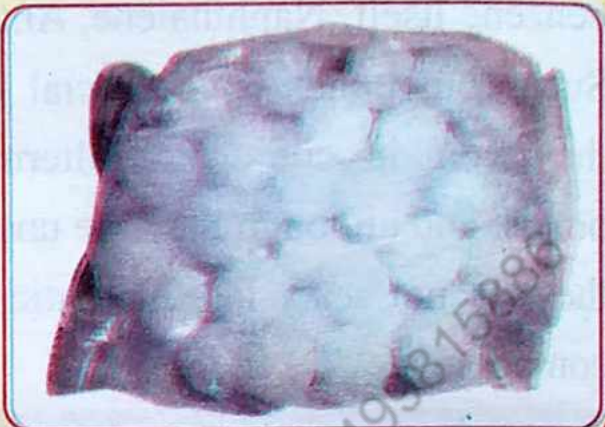
Table 12.4: Some Aromatic Hydrocarbon

Fig. 12. 4: In the cherries the odour is produced by an aromatic compound benzaldehyde.



Interesting Information

The word Aromatic is of Greek origin from "Aroma", which means "fragrance". This is because mostly these Aromatic compounds have distinct smell. You may have noticed the smell of benzene at petrol pumps, and smell of Naphthalene while using Naphthalene balls (the Naphthalene balls are kept in almirah and trunks to keep cloths moth free.)



On the other hand the **Alicyclic compounds** are other than the aromatic compounds. They do not have the Benzene ring in their skeleton, these include simple closed chain hydrocarbons like cyclopropane, cyclobutane and cyclohexane.

Number of Carbon atoms	Structure	Name
3	$\begin{array}{c} \text{HC} - \text{CH}_2 \\ \quad \diagdown \quad \diagup \\ \quad \text{CH}_2 \end{array}$	Cyclopropane
4	$\begin{array}{c} \text{HC} - \text{CH}_2 \\ \quad \\ \text{HC} - \text{CH}_2 \end{array}$	Cyclobutane
5	$\begin{array}{c} \text{HC} - \text{CH}_2 \\ \quad \\ \text{HC} \quad \text{CH}_2 \\ \quad \diagdown \quad \diagup \\ \quad \text{CH}_2 \end{array}$	Cyclopentane
6	$\begin{array}{c} \text{CH}_2 \\ \diagdown \quad \diagup \\ \text{HC} \quad \text{CH}_2 \\ \quad \\ \text{HC} \quad \text{CH}_2 \\ \quad \diagdown \quad \diagup \\ \quad \text{CH}_2 \end{array}$	Cyclohexane

Table 12.5: Some Alicyclic Hydrocarbon

This whole classification of hydrocarbons is well explained in the flow sheet of figure-12.3.

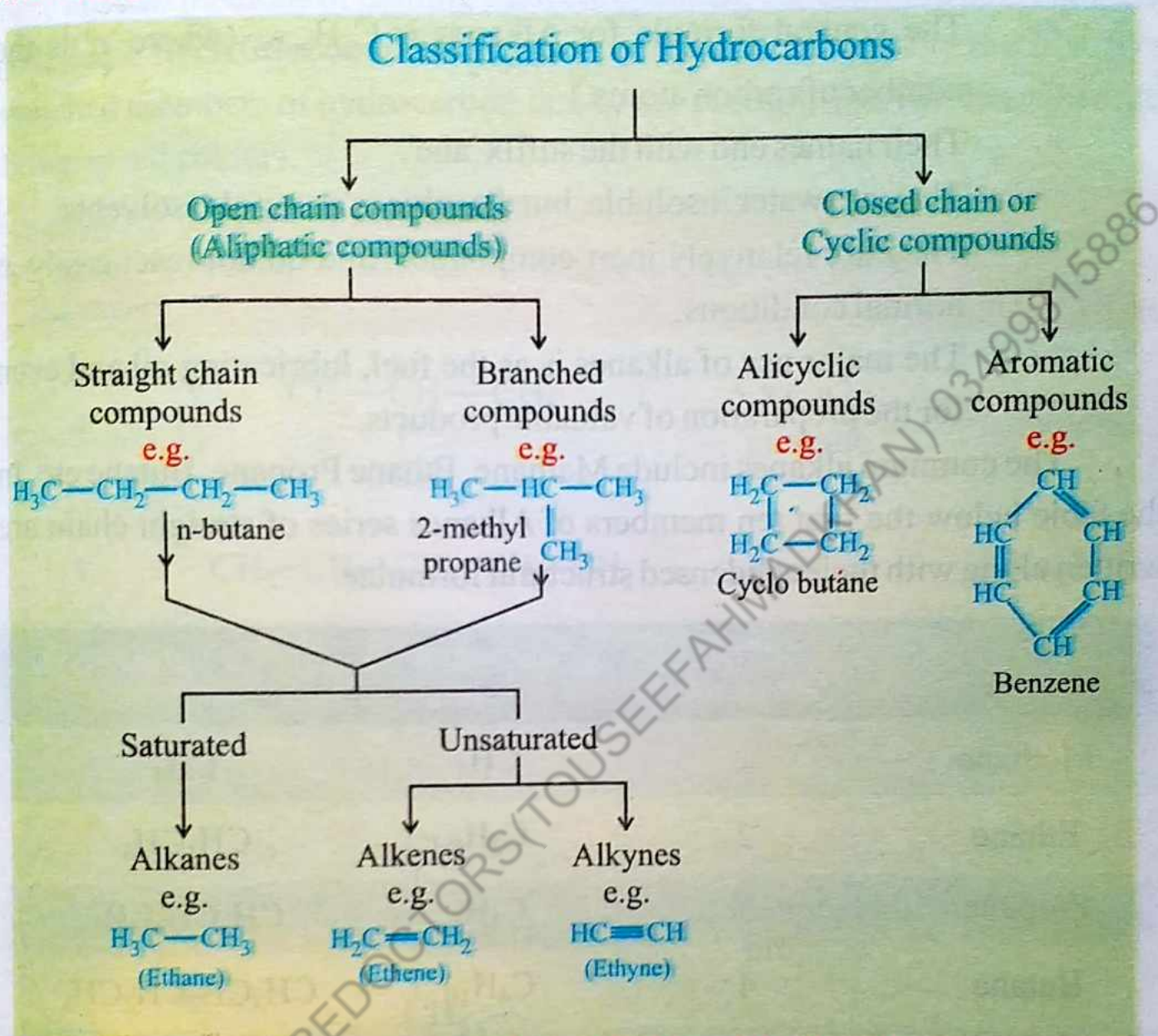


Fig. 12.5: Flow chart of classification of Hydrocarbons

In the subsequent sections we will discuss important and common members of these divisions.

12.2 The Alkanes

Alkanes comprise the class of organic compounds having only single bonds between the carbon atoms. The number of bonds that the carbon can form is '4', alkanes cannot add up any other atom in them so they are the saturated compounds.

The general characters that the alkanes possess are:

- They are called saturated compounds, and have only single bonds between the carbon atoms.
- The general formula for Alkanes is C_nH_{2n+2} , (where 'n' is the number of carbon atoms.)
- Their names end with the suffix 'ane'.
- They are water insoluble, but dissolve in non-polar solvents.
- They are relatively inert compounds, and do not react easily at normal conditions.
- The major use of alkanes is as the fuel, lubricating oil and even for the preparation of valuable products.

The common alkanes include Methane, Ethane Propane, Butane etc. In the table below the first ten members of Alkanes series of straight chain are written along with their condensed structural formulae.

Name	Number of Carbon atoms	Molecular Formula	Structural Formula
Methane	1	CH_4	CH_4
Ethane	2	C_2H_6	CH_3CH_3
Propane	3	C_3H_8	$CH_3CH_2CH_3$
Butane	4	C_4H_{10}	$CH_3CH_2CH_2CH_3$
Pentane	5	C_5H_{12}	$CH_3CH_2CH_2CH_2CH_3$
Hexane	6	C_6H_{14}	$CH_3(CH_2)_4CH_3$
Heptane	7	C_7H_{16}	$CH_3(CH_2)_5CH_3$
Octane	8	C_8H_{18}	$CH_3(CH_2)_6CH_3$
Nonane	9	C_9H_{20}	$CH_3(CH_2)_7CH_3$
Decane	10	$C_{10}H_{22}$	$CH_3(CH_2)_8CH_3$

Table 12.6 Straight chain alkanes having 1—10 carbon atoms

There can also arise branching in the chain of Alkanes, in such cases there are two methods of naming such compounds, the common name and the systematic IUPAC recommended name, in the following table the first five branched members of hydrocarbon family are exemplified, (the branches are shown in red colour).

Number of Carbon Atom	Structure	IUPAC name	Common name
4	$ \begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_3 \\ \\ \text{CH}_3 \end{array} $	2-Methylpropane	isobutene
5	$ \text{CH}_3 - \text{CH}_2 - \text{CH}_2 - \text{CH}_2 - \text{CH}_3 $	Pentane	n-Pentane
5	$ \begin{array}{c} \text{CH}_3 - \text{CH} - \text{CH}_2 - \text{CH}_3 \\ \\ \text{CH}_3 \end{array} $	2-Methylbutane	isopentane
5	$ \begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{CH}_3 \\ \\ \text{CH}_3 \end{array} $	2,2-Dimethylpropane	neopentane
6	$ \begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{CH}_2 - \text{CH}_3 \\ \\ \text{CH}_3 \end{array} $	2,2-Dimethylbutane	neohexane
6	$ \begin{array}{c} \text{CH}_3 \\ \\ \text{CH}_3 - \text{C} - \text{CH} - \text{CH}_3 \\ \quad \\ \text{H} \quad \text{CH}_3 \end{array} $	2,3-Dimethylbutane	—

Table 12.7 Some branched alkanes

The Alkanes not only exist in straight chain linear form, as branched or unbranched hydrocarbon but cyclic alkanes also exist in nature, (remember in cyclic structures members do not follow the general formula C_nH_{2n+2} rule.). In the table 12.5 some important cyclo alkanes are shown.

Alkanes are obtained from natural sources of natural gas and petroleum crude oil, where they are present in the form of varying composition mixture. This mixture is distilled in oil refineries using the technique called "fractional distillation" and each fraction according to the market need is supplied.

Structurally the alkanes form single covalent bonds with carbon and hydrogen, the usual manner of the covalent bond is the line representation, but it can also be represented using cross-dot structure of Lewis form as well. The angles between $H-C-H$ is 109.5° and the bond length between $C-C$ is $1.54\text{\AA}$ (154pm), while in $C-H$ is the bond length is $1.10\text{\AA}$ (110pm). (Remember that $1\text{\AA} = 10^{-10}\text{m}$ and $1\text{pm} = 10^{-9}\text{m}$)

The first member of the Alkane series is the methane which has the molecular formula CH_4 . Where the carbon atom is bonded with four hydrogen atoms through covalent bond. These bonds are drawn by a line representation normally. They can also be represented by the help of their cross and dot structures to show the electron of each of the atom more clearly. All these structure are shown here in the following figure-12.4.

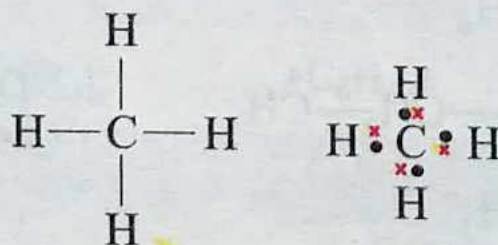


Fig 12.6 Methane molecule

The molecule of methane forms a regular tetrahedral structure, the bond angles and bond distance are typical and as per standard of other alkanes, these representation of methane are shown in figure-12.5.

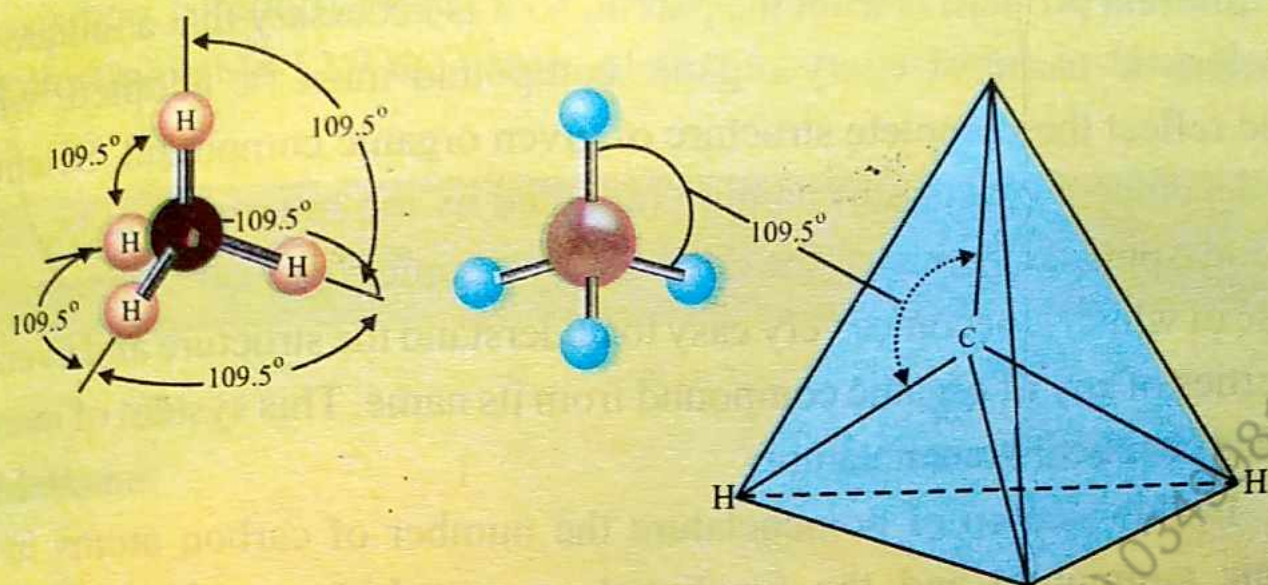


Fig. 12.7: The structure of Methane Molecule

Notice that angle between each of the H—C—H atoms is 109.5° and thus a regular tetrahedron structure is achieved.

The second member of this class of alkanes is the ethane, which has two carbon and six hydrogen atoms, its molecular formula is ' C_2H_6 '. Its structure is shown in figure-12.6.

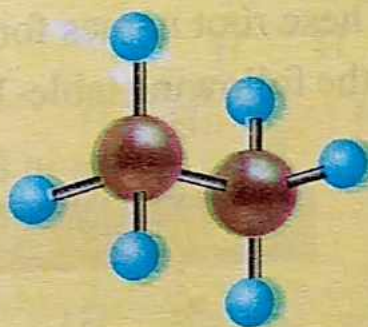
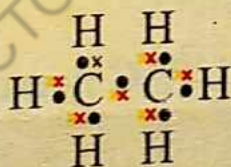
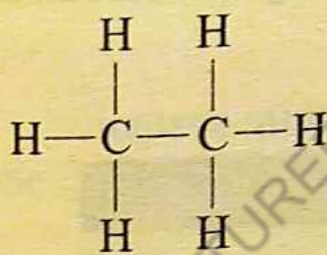


Fig. 12.8: Structure of Ethane Molecule

Activity 12.2

Write electron cross-dot structure of n-propane and n-butane.

12.2.1 Naming the Alkane hydrocarbons

This is clear from the above discussion that in the hydrocarbons chain a slight change i.e. (CH_2) results in the generation of new compounds which

have different properties from the parent, so it is necessary that a unique and characteristic name of every organic compound must be adopted, which should reflect the complete structure of given organic compound. Scientists have developed a system of naming (adopted by the International Union of Pure and Applied Chemistry, the IUPAC) the organic chemical compounds by the use of which it becomes very easy to understand the structure and even the properties of any of organic compound from its name. This system of naming is called chemical nomenclature.

In this system of nomenclature the number of carbon atoms in the organic compound and the functional group which provides the basic classification of the organic compounds are used as the basis of the naming, and different prefixes or suffixes are used to distinguish between different compounds.

The root name for an organic compound indicates the number of carbon atoms in the longest continuous chain of carbon atoms containing the functional group. Thus the root name is a code which tells the number of carbons in a molecule. This root name is derived from the Greek name for the number. These root names for the compounds having five carbon atoms are written in the following table-12.8.

Root names in the IUPAC nomenclature system

Number of Carbon Atoms	Root Name
1	Meth
2	Eth
3	Prop
4	But
5	Pent

Table 12.8 Root names for 1—5 carbon

For example, the compound having one carbon atom from 'meth' will be methane where 'suffix 'ane' indicates saturated. It is the simple

hydrocarbon. Similarly ethane is the hydrocarbon with two carbon atoms. In the following table-12.9 the names of first 5 straight chain hydrocarbons is given.

Name	No of carbon atoms in chain	Structural formula
Methane	1	$ \begin{array}{c} \text{H} \\ \\ \text{H} - \text{C} - \text{H} \\ \\ \text{H} \end{array} $
Ethane	2	$ \begin{array}{c} \text{H} \quad \text{H} \\ \quad \\ \text{H} - \text{C} - \text{C} - \text{H} \\ \quad \\ \text{H} \quad \text{H} \end{array} $
Propane	3	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \end{array} $
Butane	4	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} $
Pentane	5	$ \begin{array}{c} \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \\ \quad \quad \quad \quad \\ \text{H} - \text{C} - \text{C} - \text{C} - \text{C} - \text{C} - \text{H} \\ \quad \quad \quad \quad \\ \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \quad \text{H} \end{array} $

Table 12.9 Names of first five straight chained hydrocarbons

There is also the possibility that a branch arise from the hydrocarbon chain, in such case the whole chain is counted from the side at which the branch is at nearest position and the branch is named as radical.



Fig. 12.9: Counting sequence of Carbon in chain

This compound is called 2-Methyl butane because the branch is of one carbon, and is situated at carbon number 2 of chain, so branch name is methyl, and the main chain is of four carbon so it is butane, hence name is 2-Methyl butane.

In the same way following compound is 2-Methyl pentane.

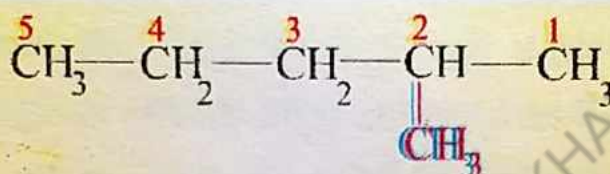
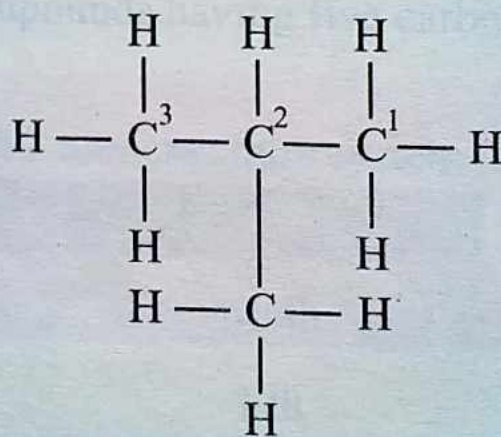


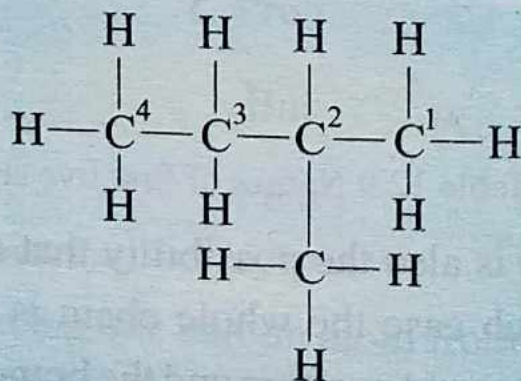
Fig. 12.10: Counting sequence of Carbon in 2-methyl pentane

Notice that here counting is done from right side of the chain because if the counting is done from left side, it will bring the position of chain farthest instead of being at lowest which is not according to rules framed by IUPAC. Some of the branched examples are described here in the following table-12.10.

2-Methyl-propane



2-Methyl-butane



2,2-Dimethyl-propane

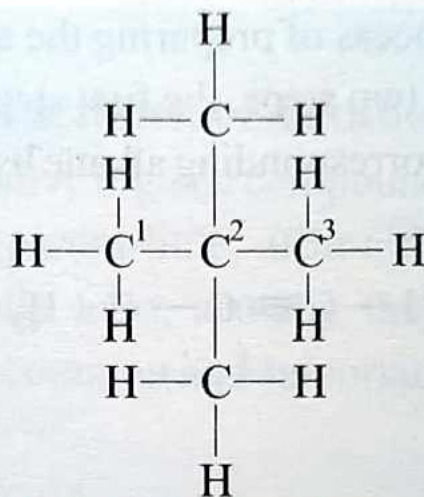


Table 12.10 Names of some branched hydrocarbons

Activity 12.3

Write structures of the following alkanes.

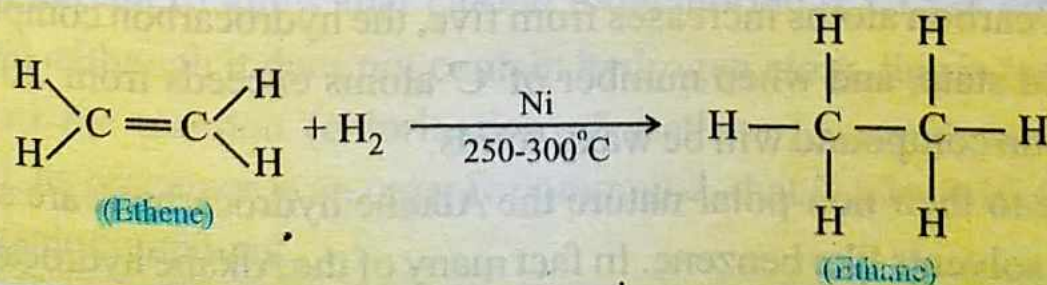
- ① 4-Methyl-pentane.
- ② 2,3-Dimethyl-hexane,
- ③ 2,2-Dimethyl-butane

12.2.2 Preparation of Alkanes

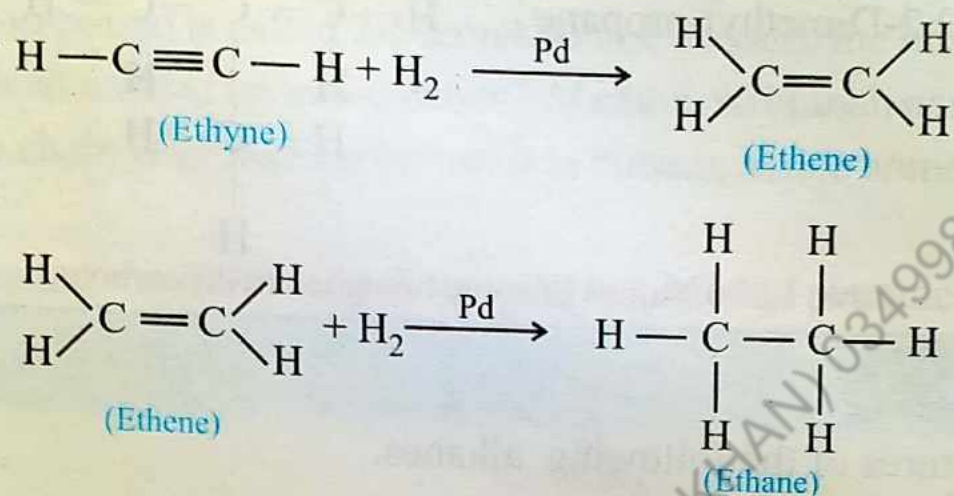
The alkanes are generally purified from the petroleum or natural gas sources. Although there are various methods available for the preparation of the alkanes. Two methods which are widely used and easy to perform are discussed here.

I Hydrogenation of Alkenes and Alkynes

hydrogenation means addition of hydrogen. As alkenes and alkynes are deficient of hydrogen, so if we add the required number of hydrogen atoms to them, they form corresponding alkanes. This is done by reacting the Alkene and Alkyne by Hydrogen in presence of a catalyst (usually Nickel, Platinum or Palladium). This addition of hydrogen is called Hydrogenation. e.g.

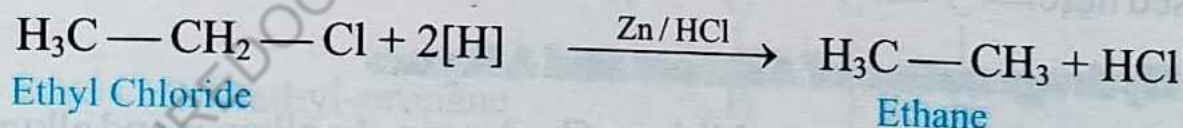


The process of preparing the alkanes from the alkynes is same but this takes place in two steps, the first step is the preparation of an alkene which is converted to corresponding alkane by the same process described earlier. i.e.



II. Reduction of Alkyl halides

Another method of preparing Alkanes is the reduction of Alkyl halides. The Alkyl halides are the compounds where the halogen atom is present in the alkyl chain. They are relatively more reactive compounds, so this reaction is easy to carry out without the need of any catalyst or much heat, just room temperature is enough. Only a suitable reducing agent like Zn metal is required. e.g.



12.2.3 Physical properties of Alkanes

The Alkanes are covalent, non-polar compounds, their melting and boiling points increases with the increase of number of carbon atoms first four members of these are gaseous state at normal temperature and pressure, when number of carbon atoms increases from five, the hydrocarbon compound will be in liquid state, and when number of 'C' atoms exceeds from '20' then the hydrocarbon compound will be waxy solids.

Due to their non-polar nature the Alkane hydrocarbons are soluble in non-polar solvents like benzene. In fact many of the Alkane hydrocarbons are

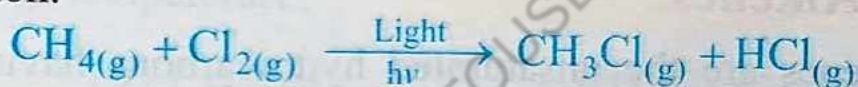
used as the good non-polar solvent.

12.2.4 Chemical properties (reactions) of Alkanes

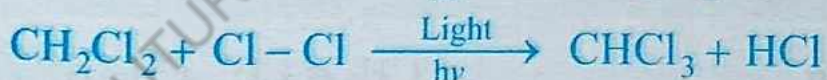
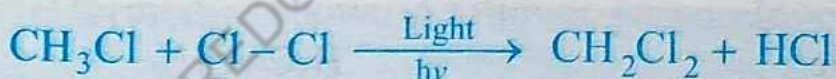
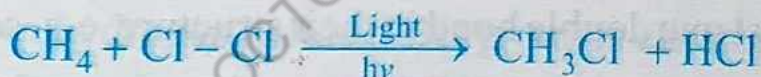
The alkanes are relatively less reactive organic compounds. Due to less reactivity they are also called paraffin (parum-little, affin-affinity to react). But it doesn't mean that they are totally inert, actually they react under vigorous conditions. Some of the most common and important reactions of alkanes are following.

1. Halogenation

The reaction with the halogens is termed as the halogenation. The halogens are quite reactive elements, and the reactivity decreases down the group. Hence the fluorine is more reactive and reacts violently. The Alkanes react with the halogens in the presence of some energy source, generally the light provides the required energy sufficiently. e.g. the Cl_2 with methane reacts to give the chloro methane, that is called photo chemical reaction.



The reaction proceeds further and more hydrogen atoms are replaced by the 'Cl' atoms (this depends upon the availability of 'Cl' atoms).



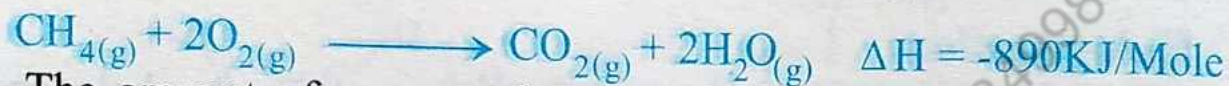
Interesting Information

This is important to know that carbon tetrachloride (CCl_4) is an organic compound, although it does not contain hydrogen atom, this is because of the fact of the reaction (chlorination of methane) through which it is produced, its precursor is an organic compound, that is why it is classified as the organic compound.

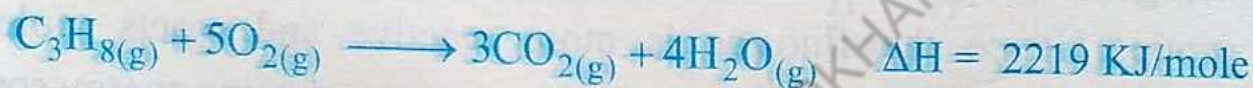
II. Combustion

The combustion or complete oxidation of alkanes is vital for human beings as most of the fuel in petroleum products is in the form of alkane hydrocarbon and burning of this fuel is the chief source of energy for our requirements.

As the number of carbon atoms (and of course the hydrogen too) increases, the amount of energy released in the reaction also increases, e.g.



The amount of energy released in this combustion of methane is 890 KJ/mole.



The amount of energy released in combustion of propane is 2219 KJ/mole.

12.3 The Alkenes

The alkenes are the unsaturated hydrocarbons having the general formula C_nH_{2n} (but remember that this general formula is true for the compounds when only one double bond is there in the carbon chain). The alkenes have at least one double bond in their structure, e.g. see table 12.11.

Ethene	$\text{H}_2\text{C}=\text{CH}_2$
Propene	$\text{CH}_2 = \text{CH} - \text{CH}_3$
1-Butene	$\text{H}_3\text{C}-\text{CH}_2-\text{CH}=\text{CH}_2$
2-Butene	$\text{H}_3\text{C}-\text{CH}=\text{CH}-\text{CH}_3$

Table 12.11 Some alkenes

Notice that the alkenes are also named likewise of their Alkane members, but the suffix 'ane' replaces with 'ene' where 'e' indicates the double bond.

The alkenes are important in the sense that they are more reactive compounds than the alkanes and are therefore used as the starting material for the preparation of many important organic compounds.

Activity 12.4

Draw electron dot structure of:

(a) Ethene, (b) Propene

12.3.1 Preparation of Alkenes

The Alkenes are prepared by a number of methods, some important of which are following.

I. Dehydration of alcohols

When an alcohol is dehydrated (dehydration-loss of water), an alkene is formed. The dehydration is brought by a strong dehydrating agent like H_2SO_4 at high temperature.



II. Dehydrohalogenation of Alkyl halides

When a hydrogen halide (HX) group is eliminated from alkyl halides, the alkene is formed, as shown in following example.



12.3.2 Reactions of Alkenes

The alkenes are highly reactive compounds. They are also called "Olefins" meaning oil forming compounds, because they form oily products with halogens. In addition they form many important products. Some of the typical reactions of alkenes are given here.

I. Addition of Halogens

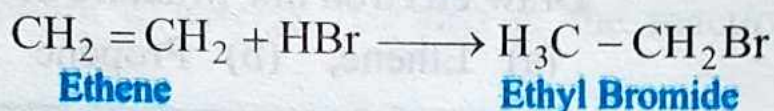
The alkenes readily react with halogens to form the products.



The reaction takes place at room temperature.

II. Hydrohalogenation of alkenes

In hydrohalogenation alkenes are reacted with haloacids (HX) as a result of which both the hydrogen and halogen of haloacids bind at double bond of alkenes yielding alkyl halides, e.g. Again the HBr add to alkene readily at room temperature to form ethyl bromide.



This reaction is used to prepare alkyl halides.

III. Oxidation with KMnO_4

The water solution of KMnO_4 (1% alkaline KMnO_4 called Baeyer's reagent) forms glycols (compounds where the -OH substituent is at adjacent positions), at room temperature and the pink colour of KMnO_4 is discharged as a result. For example:



12.2.3 Uses of Alkenes

The Alkenes are used as starting materials for many of the valuable organic compounds like Polythene, Glycols, Organic halogen derivatives, Alcohols etc.

The process of Ghee making is an example of hydrogenation of Alkenes. Ethene is used for the manufacture of plastic "Polythene", in ripening of fruits and as general anaesthetic agent.

Most of the organic compounds are prepared using alkenes as starting material.

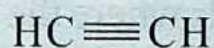
Interesting Information

Reactions of alkenes with Cl_2 , Br_2 and KMnO_4 results in the formation of colourless products from intensely coloured reactants, the colour change is thus used for the identification of double bond (and also triple bond) in the reacting substance.

12.4 The Alkynes

The Alkynes are also the unsaturated hydrocarbons having the general formula C_nH_{2n-2} which shows that they are more unsaturated, as compared to alkenes. The alkynes have at least one triple bond between two carbon atoms of the chain. In their structure, e.g.

Ethyne or Acetylene



Propyne



1-Butyne

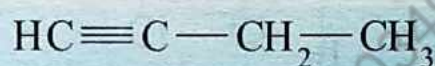
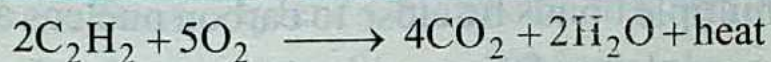
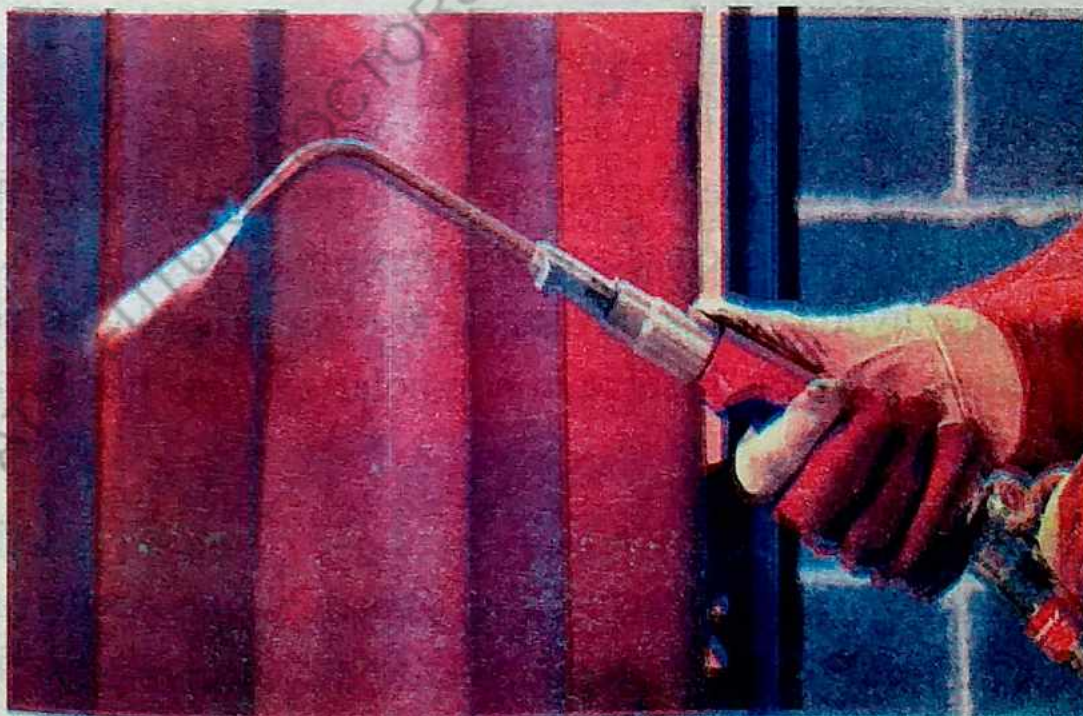


Table 12.12 Some alkynes

The alkynes are also reactive compounds and are used as the starting material for the preparation of many organic compounds.

Interesting Information

The acetylene when reacts with oxygen produces high temperature, that is why it is used in oxy-acetylene torches for cutting and welding the metals, and you may have seen this during gas welding process.

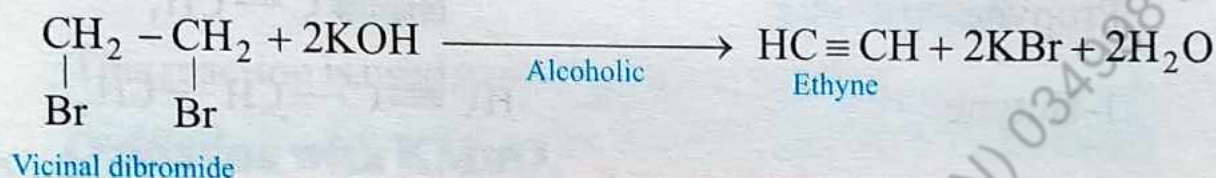


12.4.1 Preparation of Alkynes

The Alkynes are prepared by a number of methods. Some important of which are following.

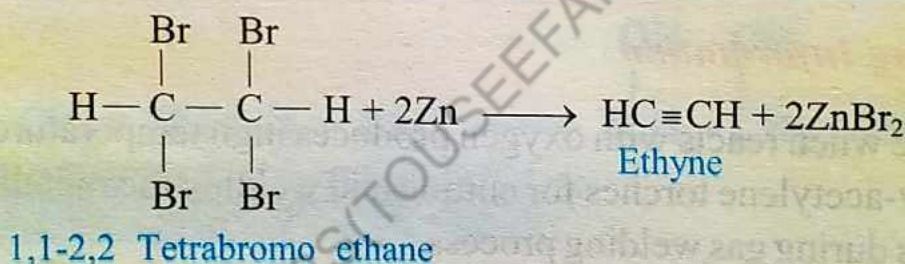
I. Dehydrohalogenation of adjacent alkyl dihalides

The dehalogenation of vicinal (Latin origin) dihalide (vicinal dihalides are the compounds where the halogens are present at adjacent carbons), yields the corresponding alkyne, e.g.



II. Dehalogenation of tetrahalides

The tetrahalides on treatment with the Zn dust yield the corresponding alkyne, e.g.



12.4.2 Physical properties of Alkynes

The initial members of alkynes series are gases but their boiling points are relatively higher than the corresponding alkenes and alkanes. Again the boiling and melting points increases with increase in chain of carbon.

Like other hydrocarbons alkynes are also water insoluble due to their non-polar nature, but they dissolve in non-polar solvents like benzene and ether etc.

12.4.3 Reactions of Alkynes

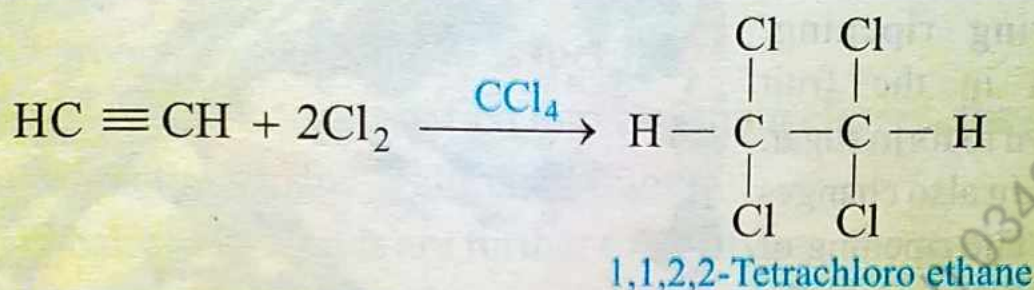
The alkynes are also reactive (but generally less reactive than the Alkenes due to decreased bond distance of 'C≡C', as a result of which pi electrons of the multiple bonds lie close to carbon nucleus and relatively held there with more strength.) and they are used for many of the organic synthesis

reactions.

Some of the important reactions of alkynes are given here,

I. Addition of Halogens

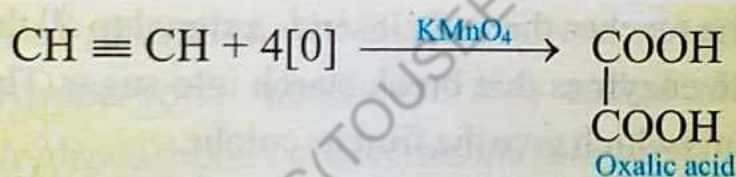
The alkynes readily react with halogens to form the corresponding halogen derivatives.



The reaction takes place at room temperature.

II. Oxidation with KMnO_4

The KMnO_4 in presence of an acid breaks the molecule of alkyne at the triple bond, e.g.



This reaction is used for locating position of triple bond in the chain.

12.4.4 Physical properties of Alkynes

The initial members of alkynes series are gases but their boiling points are relatively higher than the corresponding alkenes. Again the boiling and melting points increases with increase in chain of carbon.

Like other hydrocarbons alkynes are also water insoluble due to their non-polar nature, but they dissolve in non-polar solvents like benzene and ether etc.

Uses of Alkynes:

The Alkynes are also used as the starting material for organic synthesis, like in the manufacture of PVC (Poly Vinyl Chloride), synthetic rubber, alcohols, alkyl halides etc. Acetylene which is the first and important member of alkynes class is the cheap and readily available member of the class is used

for cutting, welding of metals in gas welding process. It is also used for artificial ripening of citrus and other fruits like mangoes and for the preparation of many important organic compounds.

Interesting Information

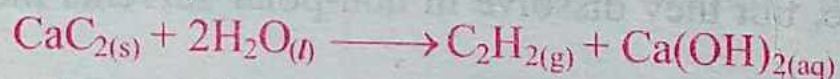
During ripening, the starch in the fruit breaks down to form sugar. The fruit skin also changes its colour. The ripening of a fruit depends on the season. For example, we get mangoes only in summer and apples only in start of winter. In ripening



the plant produces Acetylene (or also called ethyne) which spreads across the plant. When ethylene reaches the fruit, it sends a signal to all the cells in the fruit. The cells then make enzymes that break starch into sugar. The cells in the skin start making pigments which give the fruit its colour.

Sometimes the fruits are not yet ripe when they are to be sold. Hence they have to be artificially ripened. Fruits are kept in hay-lined wooden boxes called crates. These crates are stacked on shelves and a wood fire is lit below them. The smoke contains ethylene and acetylenes gases, which induce ripening. Sometimes, fruits are placed in a room in which ethylene gas or acetylene gas is introduced.

In another method, calcium carbide (CaC_2) is applied over fruits. It reacts with moisture to form acetylene.



This acetylene produced in the crates containing Calcium carbide enhances ripening process artificially.

While artificial ripening is fast, it doesn't give the fruit the flavour it gets when naturally ripened, and most important the direct contact of fruits with calcium carbide makes it health hazard, and upon handling such polluted fruit humans can also suffer the bad effect on their health.

Summary of the Chapter

- ❖ Hydrocarbons are the chemical compounds that contain only two type of elements, i.e. C and H.
- ❖ Hydrocarbons are obtained from their natural sources of Petroleum, coal and natural gas.
- ❖ Hydrocarbons are mostly used as fuel.
- ❖ The hydrocarbons are classified into two main classes, the straight chain (aliphatic) and the cyclic compounds.
- ❖ The aliphatic compounds are further of two types, the straight chain and the branched compounds.
- ❖ The carbon of the chain where the branch arises is either secondary carbon, or tertiary carbon or quaternary carbon.
- ❖ The cyclic compounds are again divided into two types, the aromatic and the alicyclic (non-aromatic) compounds.
- ❖ On the basis of saturation, the hydrocarbons are of two types the saturated hydrocarbons, which are also called alkanes, and the unsaturated hydrocarbons i.e. alkenes and alkynes.
- ❖ The unsaturated hydrocarbons can be divided into two major classes, one that posses double bond is called alkenes, and second which posses triple bond are called alkynes.
- ❖ Alkanes have the general formula C_nH_{2n+2} . Their name ends with suffix "ane".
- ❖ Alkenes have the general formula C_nH_{2n} . Their name ends with suffix "ene".
- ❖ Alkynes have the general formula C_nH_{2n-2} . Their name ends with suffix "yne".
- ❖ The alkanes which are saturated hydrocarbons are used mostly as fuel, they are relatively inert compounds.
- ❖ The unsaturated hydrocarbons are reactive compounds and are used as starting material for organic synthesis.

Exercise

Q1: Fill in the blanks with suitable words.

- i) The hydrocarbons are the compound containing and elements only.
- ii) Saturated hydrocarbons are relatively in reactivity.
- iii) Unsaturated hydrocarbons are reactive.
- iv) Alkenes react with halogens at temperature.
- v) The water solution of KMnO_4 forms with alkenes.
- vi) Alkenes are reactive than Alkynes.
- vii) Benzene is an hydrocarbon.
- viii) Acetylene gas is used in
- ix) Alkanes are also known as
- x) Hydrogenation process results in formation of from oils.

Q2: Choose the correct answer.

- i) The simplest member of hydrocarbon family is the
(a) C_4H_{10} (b) C_3H_8 (c) C_2H_6 (d) CH_4
- ii) The Alkynes have the general formula
(a) $\text{C}_n\text{H}_{2n+2}$ (b) $\text{C}_n\text{H}_{2n+0}$
(c) $\text{C}_n\text{H}_{2n-2}$ (d) $\text{C}_n\text{H}_{2n+4}$
- iii) Dehydration of alcohols with sulphuric acid yields:
(a) Alkene (b) Alkyne
(c) Alkane (d) Benzene
- iv) Glycols are the compounds having:
(a) adjacent halogens
(b) adjacent hydroxyl groups
(c) alternate hydroxyl groups
(d) alternate halogens

- v) To prepare ghee the vegetable oil is reacted with:
- (a) hydrogen
 - (b) halogen
 - (c) oxygen
 - (d) nitrogen
- vi) The secondary carbon atoms is linked with the number of carbon atoms
- (a) 1
 - (b) 2
 - (c) 3
 - (d) 4
- vii) Hydrogenation reaction utilizes catalyst:
- (a) Ni or Pd
 - (b) Zn
 - (c) H_2
 - (d) do not requires any catalyst
- viii) General formula of Alkanes is
- (a) C_nH_{2n-2}
 - (b) C_nH_{2n+2}
 - (c) C_nH_{2n}
 - (d) C_nH_{2n-1}
- ix) Halogenation means introduction of
- (a) Cl
 - (b) Br
 - (c) I
 - (d) All of these
- x) Olefin is another name for
- (a) Alkanes
 - (b) Alkenes
 - (c) Alkynes
 - (d) Aromatic compounds

Q3: Answer the following questions in short.

- i) Define hydrocarbons.
- ii) What is the difference between alicyclic and aromatic hydrocarbons?
- iii) Explain what is the difference between saturated and unsaturated compounds?
- iv) Why chlorine and methane react in light?
- v) Describe the chemistry of combustion.
- vi) What do you understand by the term "homologous series"?
- vii) Describe the difference between dehydrogenation and dehydrohalogenation?
- viii) What is meant by dehydration? What products are formed by

dehydration of alcohols?

- ix) What is the role of acetylene gas in fruit ripening?
- x) Write chemical test to distinguish between saturated and unsaturated organic compounds?

Q4: Answer the following questions with reasoning.

- i) Why alkenes are more reactive than alkanes?
- ii) Why hydrocarbons do not dissolve in water?
- iii) In your opinion, which is more reactive, Acetylene or Ethene? And why?
- iv) n-pentane boils at higher temperature than n-propane?
- v) Alkenes form addition products where as alkane form substituted products?

Q5: What do you understand by the term 'hydrocarbon'? how they have been produced in nature?

Q6: How the hydrocarbons are classified? Explain with examples.

Q7: Write a comprehensive note on chemistry of alkanes.

Q8: How you can prepare the alkenes? Describe the reactivity of alkenes too.

Q9: Explain various methods for the preparation of alkynes?

Q10: Explain the chemical properties of alkynes?

Q11: State the general rules for naming of alkanes by giving examples.

Q12: Draw the structure of following hydrocarbons?

- | | |
|-------------------------|--------------------------|
| i) 3,3-Dimethyl pentane | ii) 2-Methyl hexane |
| iii) n-Hexane | iv) 3,4-Dimethyl heptane |
| v) Isopentane. | vi) Cyclo hexane |