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Grade 10 Chemistry

Unit 1

Introduction to Organic Chemistry

(Revision + UEE)

Part 1 & Part 2

- Before the beginning of the nineteenth century, chemists classified compounds into two classes; **organic** and **inorganic**.
- Those derived from living things (plants and animals) were classified as **organic compounds**,
- While those that came from mineral constituents of the earth or were found with non-living things are classified as **inorganic compounds**.

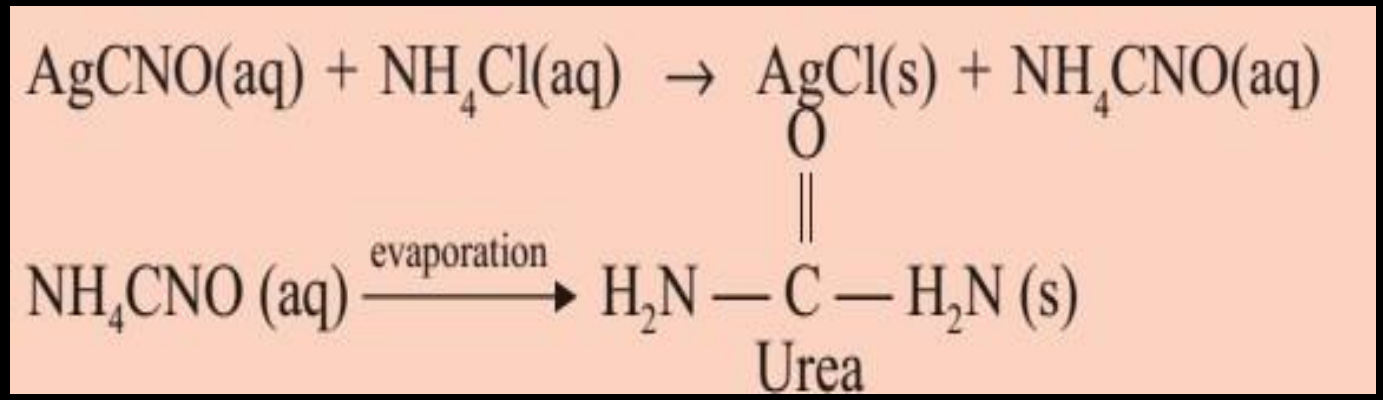
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What was the basis of this classification?

- Early chemists believed that organic compounds differed from inorganic compounds because living things had a special ‘life force’ within them, which was invisible and hard to detect.
- According to the **theory of ‘life force’,** the only source of organic compounds was nature itself (plants and animals).
- It was thought impossible to synthesize them in the laboratory.
- This was because man could not add or create the ‘life force’ within them.

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- The belief in the ‘life force’ theory continued until **Friedrich Wöhler** synthesized **urea** for the first time in 1828.
- **Urea** was the first organic compound synthesized in the laboratory.
- The synthesis of urea by Friedrich Wöhler and subsequent synthesis of other organic compounds marked the downfall of the ‘life force’ theory.



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How do you explain organic compounds at present and define organic chemistry?

- The common feature of organic compounds is that they all contain the element carbon.
- **Organic compounds** are the compounds of carbon found in and derived from plants and animals.
- They also include those substances synthesized in laboratories except the oxides of carbon, carbonates, hydrogen carbonates, cyanides and cyanates.

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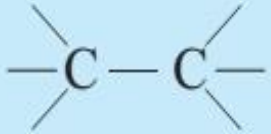
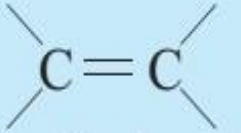
- Besides carbon, these compounds contain a few other elements such as hydrogen, oxygen, nitrogen, sulphur, halogens and phosphorus.
- The branch of chemistry that studies carbon compounds is called **organic chemistry.**
- At present, millions of organic compounds have been discovered, synthesized, and used.
- The main reason for the presence of millions of carbon compounds is the unique property of carbon called **catenation**.
- **Catenation** is the ability of atoms of the same element to join together forming short or long chains and rings.

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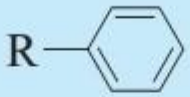
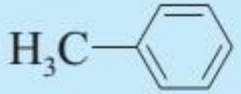
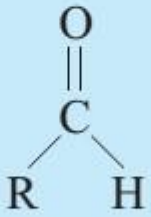
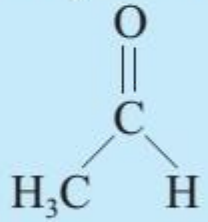
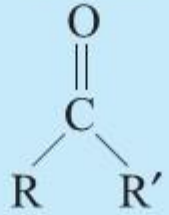
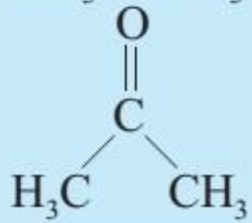
Classification of Organic Compounds

- Organic compounds are generally classified based on their **functional group.**
- The **functional group** is the part of a molecule or a compound that determines the chemical properties of that molecule or compound.
- This group also determines some of the physical properties of a compound.
- Based on the functional groups they possess, the most common classification of organic compounds including **alkanes**, **alkenes**, **alkynes**, **aromatics**, **alcohols**, **aldehydes**, **ketones**, **carboxylic acids** and **esters**.

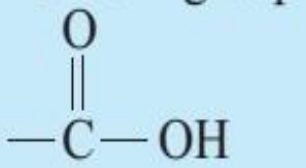
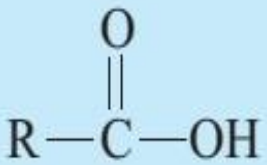
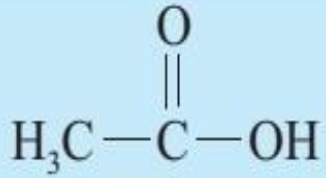
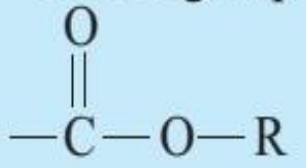
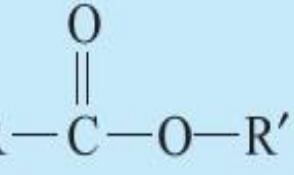
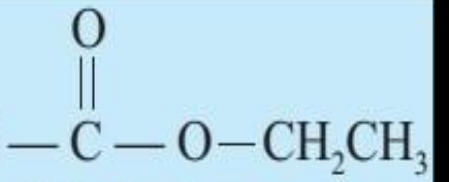
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Organic Compound	Functional Group	General Structure	Example
Alkane	 (single bond)	$R-CH_2-CH_3$	$H_3C-CH_2-CH_3$ Propane
Alkene	 (double bond)	$R-CH=CH_2$	$H_2C=CH_2$ Ethene
Alkyne	$-C\equiv C-$ (triple bond)	$R-C\equiv C-R$	$H-C\equiv C-H$ Ethyne

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Organic Compound	Functional Group	General Structure	Example
Aromatic	 (benzene ring)		 Toluene
Alcohols	— OH	R — OH	CH_3CH_2—OH Ethanol
Aldehydes	— CHO group 	R — CHO 	CH_3 — CHO  Ethanal
Ketone	— CO — group 	RCOR′ 	CH_3COCH_3  Propanone

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Carboxylic Acid	— COOH group 	R — COOH 	 Ethanoic acid
Ester	— COOR group 	RCOOR′ 	 Ethyl ethanoate

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HYDROCARBONS

- Hydrocarbons are organic compounds composed of the elements carbon and hydrogen only.
- Hydrocarbons are subdivided into two groups, based on the type of bonding between carbon atoms, as

Saturated hydrocarbons

Unsaturated hydrocarbons.

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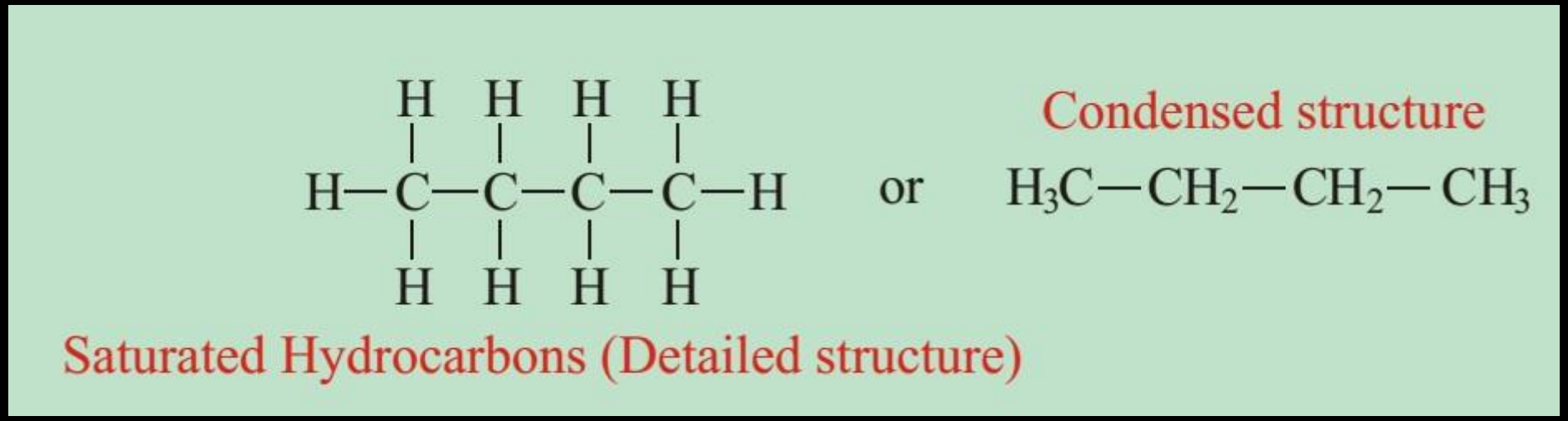
- **Saturated Hydrocarbons** are those compounds of carbon and hydrogen containing only carbon-carbon single bonds.

  Example: Alkane

- **Unsaturated Hydrocarbons** are those compounds of carbon and hydrogen possessing two or more multiple bonds (double or triple bonds) between carbon atoms.
- **Example:** Alkenes, alkynes and aromatic hydrocarbons

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- A formula that shows all the bonds and atoms is called a **detailed structure.**
- The shorter structure is called **condensed structure.**



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Alkanes or Paraffins

- Alkanes are saturated hydrocarbons.
- They contain chains of carbon atoms linked by single bonds only.
- Alkanes have the general formula C_nH_{2n+2}, where, n= 1, 2, 3 . . .
- A group of compounds in which each member of the group differs from the next member by a –CH2, is called a **homologous series.**
- The individual members of the group are called **homologues.**

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Physical Properties of Alkanes

- At room temperature, the first four alkanes, methane to butane, are gases; whereas pentane (C_5H_{12}) to heptadecane ($C_{17}H_{36}$) are liquids, and the alkanes containing eighteen and more carbon atoms are solids.
- Alkanes are non-polar organic compounds.
- Weak intermolecular forces called **Van der Waal's forces** hold their molecules together.
- The strength of these forces increases with the increasing surface area (molecular mass) of the alkanes.

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- Since alkanes are non-polar, they are almost insoluble in polar solvents like water, but, they are soluble in non-polar solvents like benzene, toluene, ether and carbon tetrachloride.
- The density, melting point, and boiling point of the homologous series of alkanes increase as the carbon number increases.

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- For alkanes of the same carbon number, branched-chain isomers have lower boiling points than the straight-chain (normal) alkanes.
- The reason is, as branching increases, there is a decrease in surface area and the strength of the intermolecular force, which, in turn, results in a decrease in boiling point;
- e.g., the boiling points of n-pentane, iso-pentane and neo-pentane are 36°C, 28°C and 9.5°C, respectively.

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- Alkanes containing all the carbon atoms in one continuous chain are called **normal** or **straight-chain alkanes**
- and those containing chains with branches are known as **branched-chain alkanes**.

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Nomenclature (naming) of Alkanes

- Organic chemistry uses a simplified and systematic way of naming organic compounds.
- The names of alkanes and most of the organic compounds are derived from:

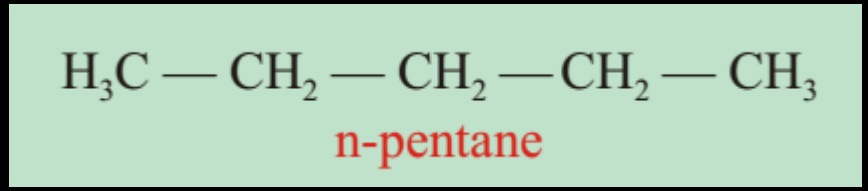
i) **prefix**- indicating the number of carbon atoms and

ii)–**suffix** indicating the type of the functional group present in the molecule.

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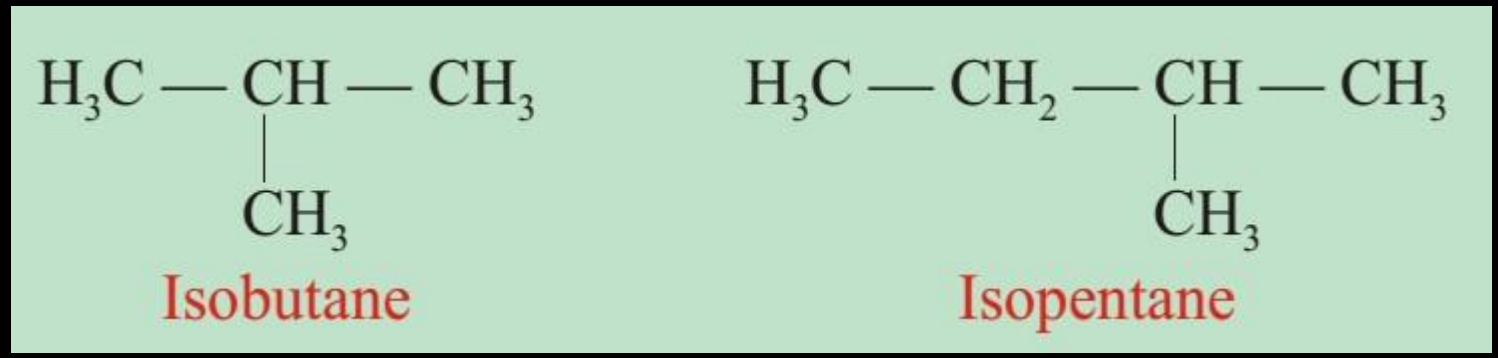
Common Names of Alkanes

- Lower members of the alkane homologous series have common names.
- The prefixes used in the common names are **n- (normal)** , **'iso-'** and **'neo**
- The **prefix n**-is used when all the carbon atoms form a continuous chain.



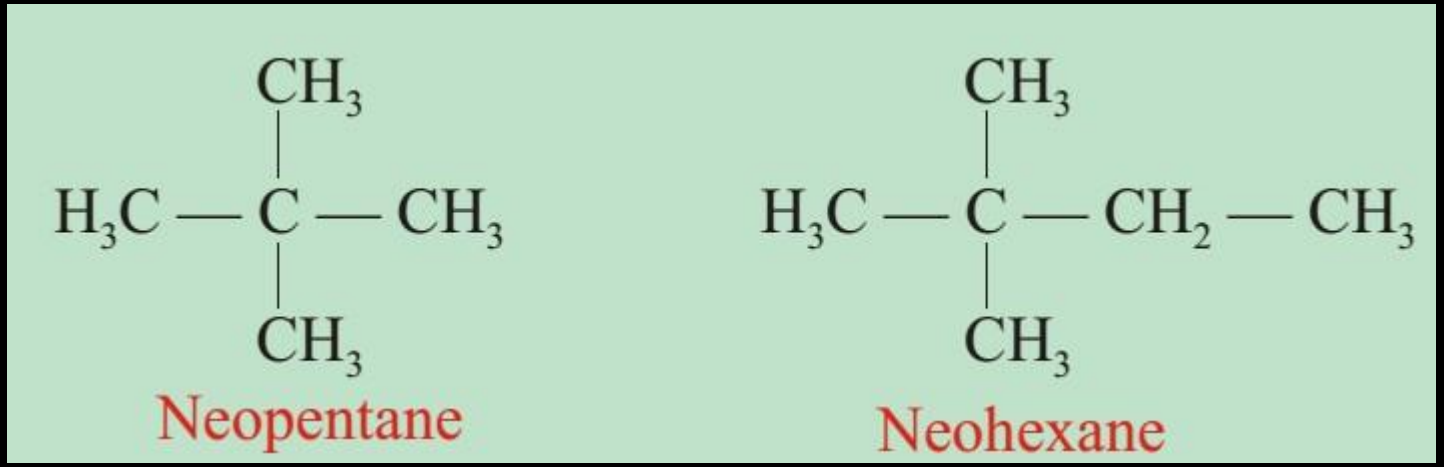
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- **Iso-** is used when all of the carbon atoms form a continuous chain, except for the one next to the last carbon.



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- **Neo-is used when the central carbon is bonded to four other carbon atoms.**



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IUPAC System of Nomenclature of Alkanes

- It is difficult to have common names for the more branched and complex alkanes.
- In naming such alkanes, the more systematic, convenient and appropriate one is the International Union of Pure and Applied Chemistry (IUPAC) system.
- In order to apply this system, it is very important to know the rules to be followed, what alkyl radicals are, and how they are named.

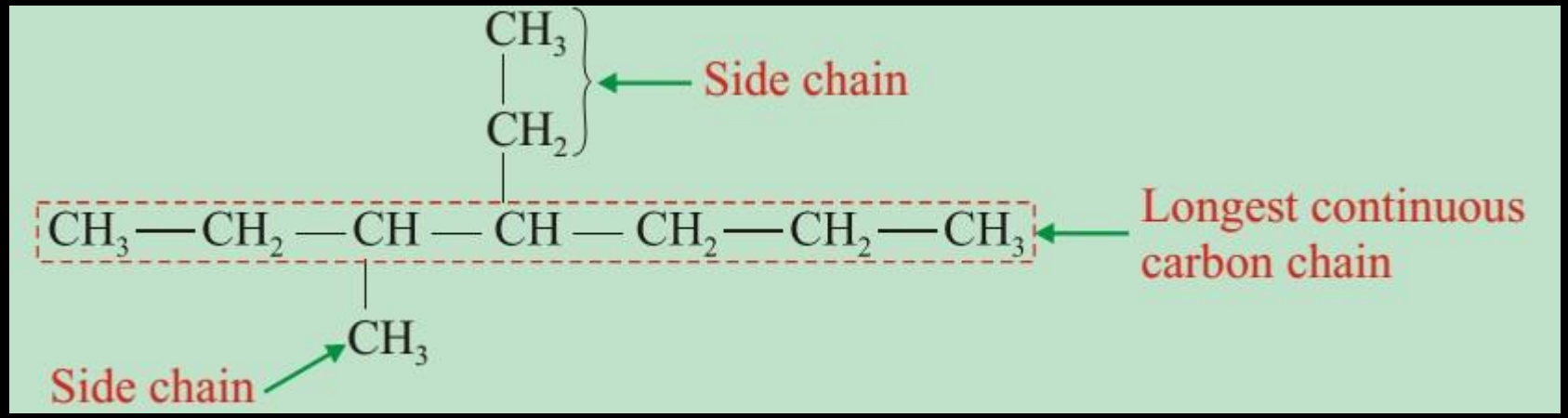
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- **Alkyl radicals** are obtained by removing one hydrogen atom from the corresponding alkanes.
- Their general formula is C_nH_{2n+1}, where n= 1, 2, 3 . . . .
- The names of alkyl radicals are derived from the names of the corresponding parent alkanes by changing the suffix **-ane** to **-yl.**

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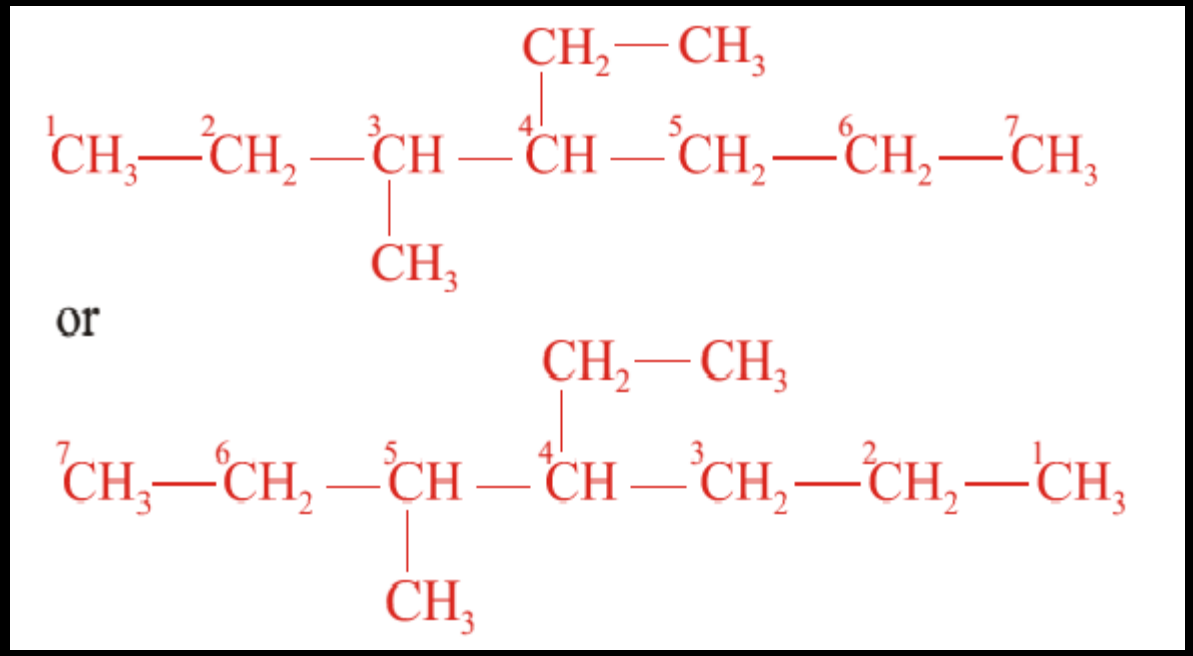
The following are the rules established by IUPAC to name branched-chain hydrocarbons.

1. Select the longest continuous chain of carbon atoms in the molecule as the parent structure.



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2.Assign numbers to the carbon atoms of the longest chain starting from one end to the other so that the carbon atoms to which side chains are attached get the lowest possible number.



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3. Indicate the position of the side chain by using the number assigned to the carbon atom to which it is attached. If the same substituents appear more than once, use the prefix di-, tri-, tetra-etc. before the name of the substituent to show two, three, four,etc. substituents, respectively.
4. Numbers are separated from each other by commas while they are separated from substituent names by hyphens.
5. Arrange the names of the side chains before the parent name in alphabetical order. The complete name of the alkane given in the aboveexample will then be 4-ethyl-3-methylheptane (substituents in alphabetical order).

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Note:

When F, Cl, Br and I appear as substituents, change the names fluorine, chlorine, bromine and iodine to fluoro, chloro, bromo and iodo, respectively.

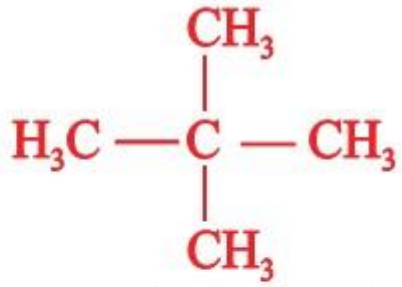
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Isomerism

- The existence of two or more chemical compounds with the same molecular formula but different structures is called **isomerism.**
- Alkanes exhibit a type of structural isomerism called **chain** or **skeletal isomerism.**

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n-pentane



Neopentane or 2, 2-dimethylpropane



Isopentane or 2-methylbutane

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Preparation of Alkanes

- Alkanes are the major constituents of petroleum and natural gas.
- They are mainly obtained by fractional distillation of petroleum.
- Alkanes can also be prepared in the laboratory. Some methods of their preparation are as follows:

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1. Hydrogenation of alkenes with a metal catalyst.

General Reaction: $R-CH=CH_2 + H_2 \xrightarrow[\text{heat}]{Pt} R-CH_2-CH_3$

Alkene Alkane

Example

$CH_2=CH_2 + H_2 \xrightarrow[\text{heat}]{Pt} CH_3-CH_3$

Ethene Ethane

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2. **Wűrtz** Synthesis (*reaction*). This method involves the reaction of a halogenated alkane with sodium and the reaction is somewhat exothermic.

General Reaction:

$$2R-X + 2Na \longrightarrow R-R + 2NaX$$

Halogenated Alkane — Alkane — Sodium halide

Example

$$2CH_3I + 2Na \longrightarrow CH_3-CH_3 + 2NaI$$

Methyl iodide — Ethane — Sodium iodide

This reaction is named as Wűrtz reaction after the French chemist Charles-Adolphe Wűrtz (1817–1884).

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3. Heating sodium salt of an organic acid with soda lime (*mixture of sodium hydroxide and calcium oxide*); the reaction brings about the removal of the carboxylate group from the sodium salt of the carboxylic acid. This type of reaction is called decarboxylation.

General Reaction:

$$RCOONa + 2NaOH \xrightarrow[heat]{CaO} R-H + Na_2CO_3(s)$$

Sodium salt of or anic acid

Alkane

$$CH_3COONa + 2NaOH \xrightarrow[heat]{CaO} CH_4(g) + Na_2CO_3(s)$$

Sodium acetate (Sodium ethanoate)

Methane

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Chemical Properties of Alkanes

- Alkanes are generally not considered to be very reactive organic compounds.
- The name paraffin for alkanes arose from two Latin words ‘parum’ meaning little and ‘affinis’ means affinity.
- Thus, paraffin means little affinity.

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The major reactions of alkanes are the following:

1. **Combustion Reactions:** If alkanes are burned with limited supply of oxygen, they will form water and carbon monoxide and will liberate lesser amounts of heat energy. Alkanes burn in excess oxygen to form carbon dioxide and water, liberating a greater amounts of heat. The general equation for the reaction is:

$$C_nH_{2n+2} + \left(\frac{3n+1}{2}\right)O_2 \rightarrow nCO_2 + (n+1)H_2O + \text{heat}$$

where n is the number of carbon atoms in the alkane molecule.

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2. Substitution Reaction: This is a reaction that involves the replacement of one atom or a group of atoms by another atom or group of atoms. Halogenation of alkanes is a very good example of substitution reaction. This reaction involves reacting alkanes with chlorine and bromine. The reaction of chlorine and bromine with alkanes proceeds in presence of heat or sunlight. This type of reaction is called photochemical reaction. The reaction of alkanes with chlorine and bromine proceeds in a sequence of steps. For example, let us consider the photochemical reaction of methane with chlorine (*chlorination*):

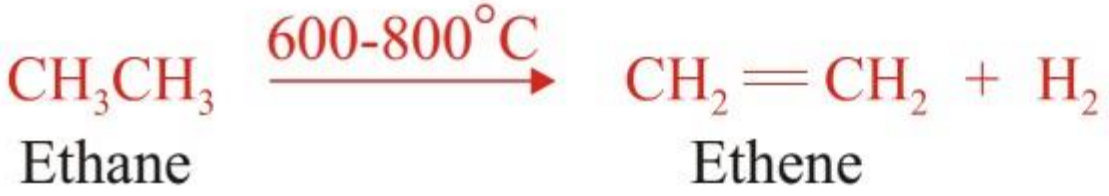
$$CH_4(g) + Cl_2(g) \rightarrow CH_3Cl(g) + HCl(g)$$

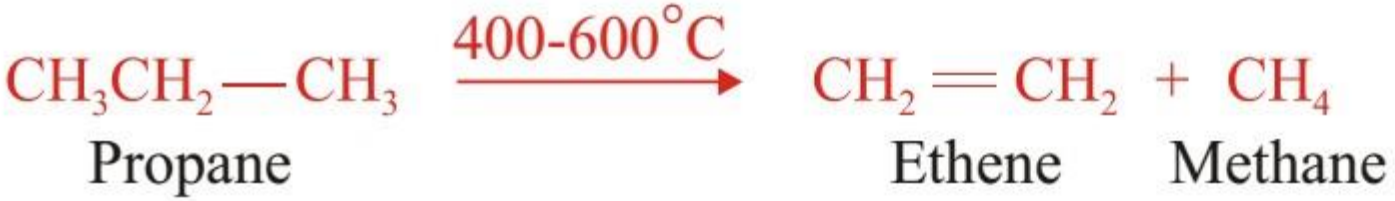
Methyl chloride

$$CH_3Cl(g) + Cl_2(g) \rightarrow CH_2Cl_2(g) + HCl(g)$$

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3. **Elimination reaction:** This type of reaction involves the removal of smaller molecules from a compound and leads to the formation of a compound containing a multiple bond (unsaturated compound). It can also involve the removal of hydrogen atoms from adjacent carbon atoms at relatively high temperatures.



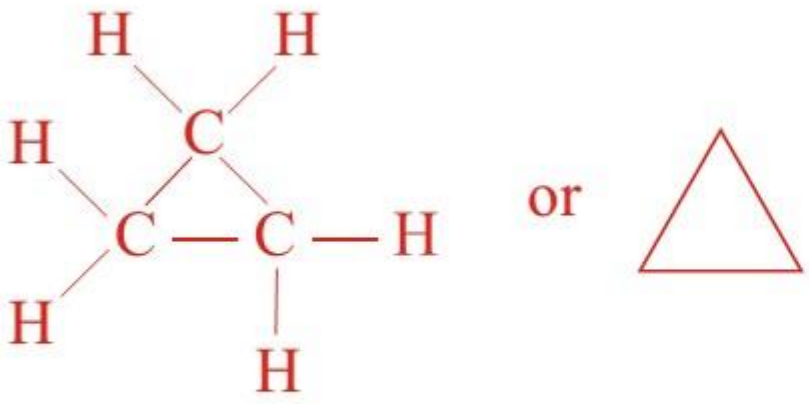


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Cycloalkanes

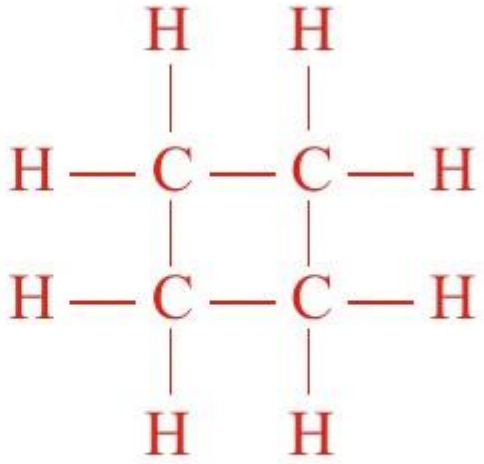
- Cycloalkanes are saturated hydrocarbons in which the carbon atoms are linked in such a manner as to form closed chains or ring structures.
- They are represented by the general formula, C_nH_{2n}, where $n \geq 3$.
- Cycloalkanes are isomeric with open-chain alkenes.
- Their names are obtained by prefixing "cyclo" to the name of an alkane containing the same number of carbon atoms.

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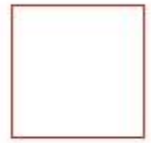


or

Cylopentane (C_3H_6)



or



Cylobutane (C_4H_8)

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Uses of Alkanes

- Alkanes are primarily used as fuels.
- They are also used as solvents, raw materials for making alkenes, alcohols, soaps, detergents and plastics.

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1. What is the molecular formula of an alkane having 13 carbon atoms?

A. $C_{13}H_{20}$

B. $C_{13}H_{26}$

C. $C_{13}H_{24}$

D. $C_{13}H_{28}$

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2. Which one is correct about the early (before 1828) historical development of organic compounds? They are

A. Obtained from inorganic sources

B. Obtained by mining process

C. Governed by the vital force theory.

D. Synthesized in the laboratory.

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3. The term that is used to describe chemicals that are mainly obtained from the Earth and are NOT associated with living things is known as

A. Organic

B. Inorganic

C. Homologous

D. Isomer

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4. Which of the following reactions could produce alkanes in the laboratory?

A. $R\text{-}CH = CH_2 + H_2 \rightarrow$

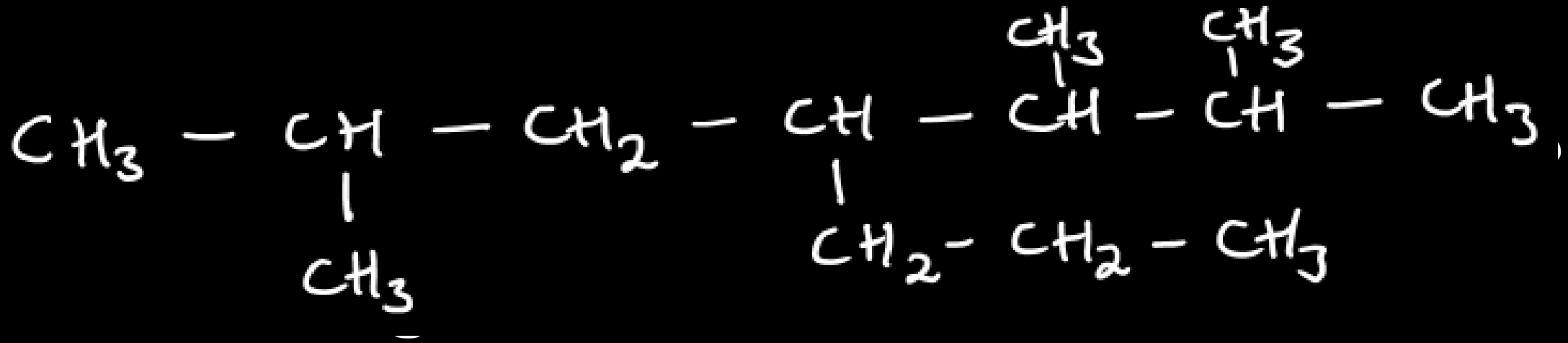
B. $R\text{-}CH_2 - CH_2\text{-}OH \rightarrow$

C. $R\text{-}CH_2 - CH_2\text{-}X + KOH \rightarrow$

D. $R\text{-}CH = CH_2 + H_2O \rightarrow$

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5. The IUPAC name for the molecule having the following structure.



A. 2, 5, 6-trimethyl-4-propylheptane

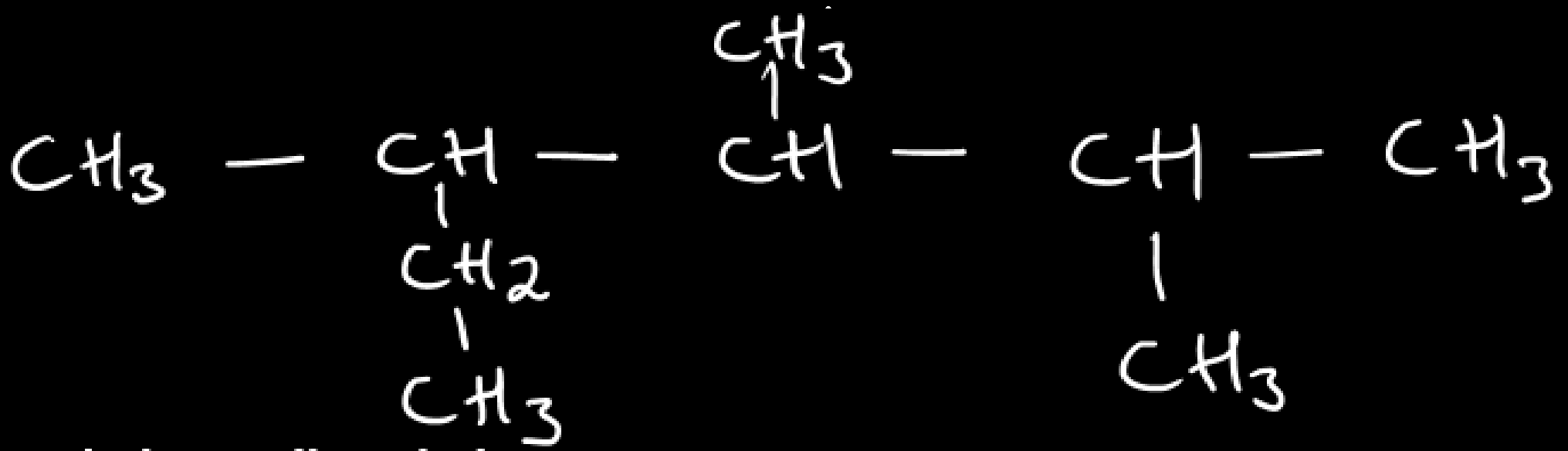
B. 2-methyl-4-n propyl-5-isopropyl hexane

C. 2-isopropyl-3-propyl-5-methyl hexane

D. 2, 3, 6-trimethyl-4-propylheptane

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6. The IUPAC name of the compound with the following structure is:



A. 2-Ethyl-3, 4-dimethylpentane

B. 3, 4, 5-Trimethylhexane

C. 2, 3, 4-Trimethylhexane

D. 4-Ethyl-2, 3-dimethylpentane

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7. What are hydrocarbons? Compounds that contain

A. hydrogen and carbon only.

B. hydrogen and carbon with no benzene rings.

C. benzene and its derivatives only

D. benzene rings only

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9. Which of the following is true about the homologous series? The homologous series is

A. A group of molecules each differing from the next member by a certain group

B. The property of an element to form chains with the repetition of the same atom

C. A structure in which the isomers have different positions of groups with respect to the double bond

D. The existence of chemical compounds that have the same molecular formula but different structural formulas.

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THE END

Exam Based Tutorial (Revision + UEE)

Grade 10 Unit 1

Introduction to Organic Chemistry

Part 3

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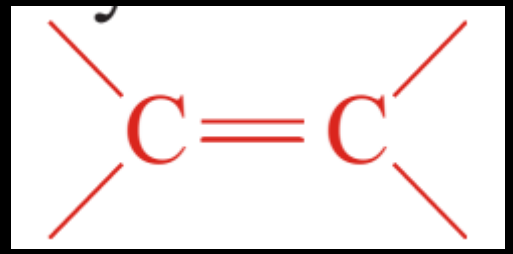
Unsaturated hydrocarbons

- Unsaturated hydrocarbons are those compounds of carbon and hydrogen containing either double or triple bonds.
- These groups of hydrocarbons include alkenes and alkynes.

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Alkenes or Olefins

- Alkenes are unsaturated hydrocarbons containing a carbon-carbon double bond as their functional group:



- They are also known as **olefins.**
- They form a homologous series represented by the general formula C_nH_{2n}, where n= 2, 3, 4….

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Physical Properties of Alkenes

- At room temperature, alkenes containing two to four carbon atoms are gases.
- Those containing five to seventeen carbon atoms are liquids, and those containing eighteen or more carbon atoms are solids.
- Alkenes are non-polar.
- Therefore, their molecules are held together by weak intermolecular forces.
- Since they are non-polar, they are almost insoluble in polar solvents like water, but soluble in non-polar solvents like ether, benzene, toluene and carbon tetrachloride.

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Nomenclature of Alkenes

- Alkenes can have common names as well as IUPAC names.
- The common names of alkenes are obtained by using the prefixes in and adding the suffix **'-ylene'**:

Formula of Alkene	Condensed Structure	Common Name
C_2H_4	$CH_2 = CH_2$	Ethylene
C_3H_6	$CH_2 = CH - CH_3$	Propylene
C_4H_8	$CH_2 = CH - CH_2 - CH_3$	Butylene

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IUPAC System

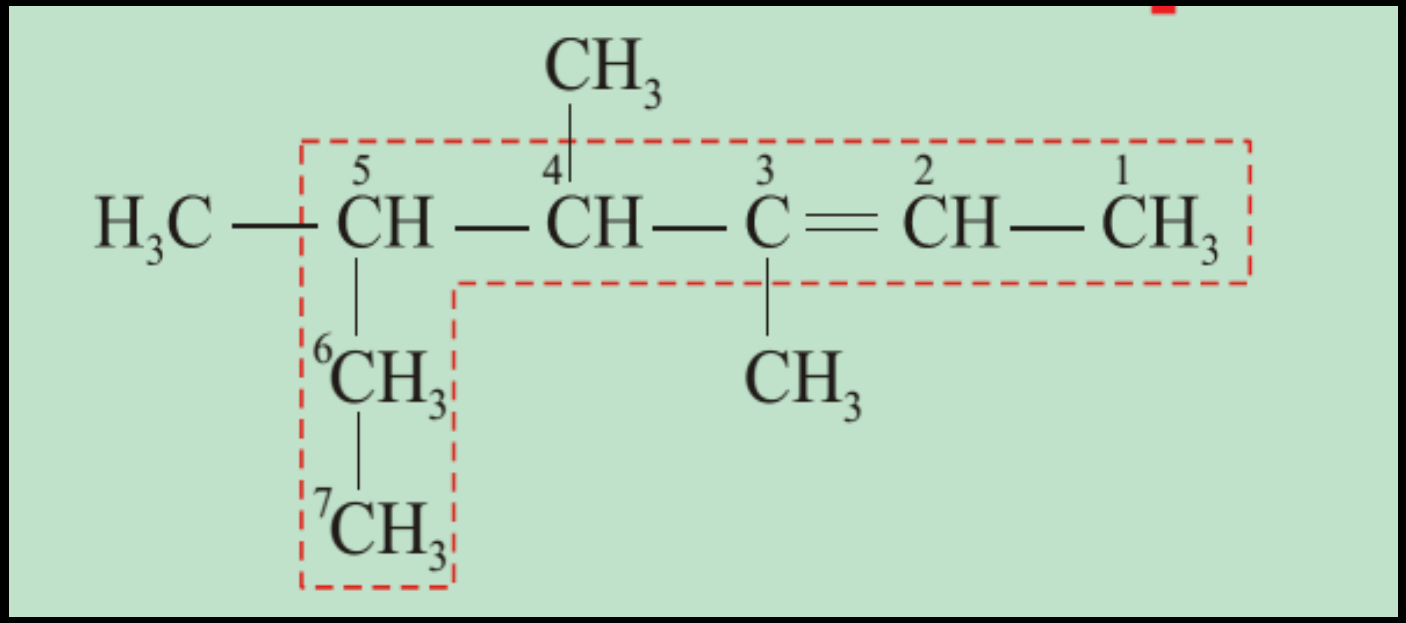
- The IUPAC names of alkenes to indicate the number of carbon atoms in the molecule and adding the suffix ‘-ene’.
- The suffix ‘-ene’ indicates the presence of a double bond.

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In the IUPAC system of naming alkenes, the rules we follow are similar to those rules we follow for naming alkanes with slight modifications. These are:

1. Select the longest continuous chain of carbon atoms in the molecule that includes the double bond as a parent structure. Its name will be the same as the alkene containing the same number of carbon atoms.

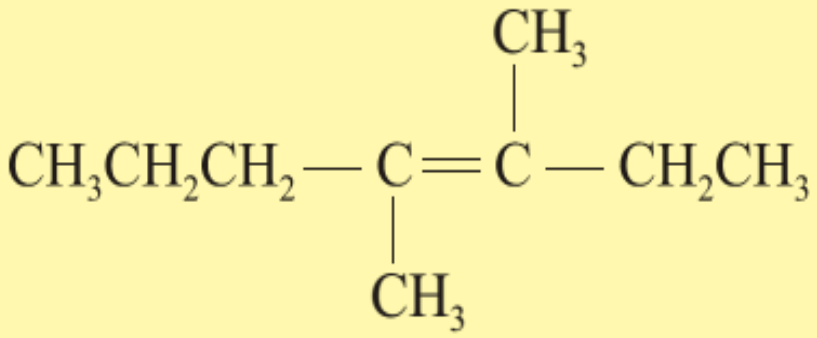
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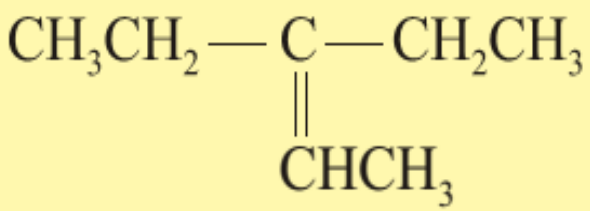


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Exercise 1.5

1. Write the names of the following compounds, using IUPAC rules:

a 

b 

2. Write the structure of each of the following compounds:

a 3-methyl-3-heptene

b 3,4-diethyl-1-hexene

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Isomerism in Alkenes

- Alkenes containing two and three carbon atoms have only one possible structure.
- Alkenes containing four or more carbon atoms exhibit isomerism.
- Alkenes show the following three types of isomerism:

Chain isomerism

Position isomerism

Geometrical isomerism.

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1.Chain isomerism: This is due to the difference in the arrangement of the carbon atoms in the longest continuous carbon chain.

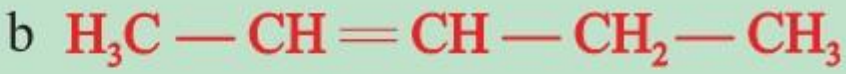
2.Position isomerism: This is due to the difference in the position of the double bond in the carbon chain.

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Consider the following compounds with the same molecular formula (C_5H_{12}):

a 

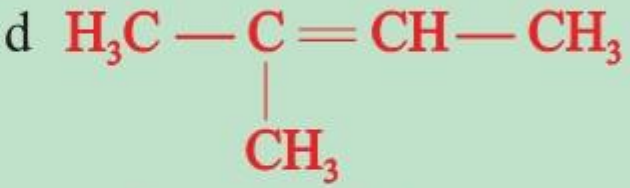
1-pentene

b 

2-pentene

c 

2-methyl-1-butene

d 

2-methyl-2-butene

e 

3-methyl-1-butene

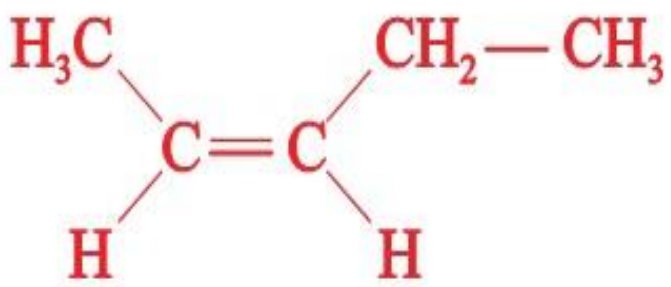
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3. Geometrical isomerism.

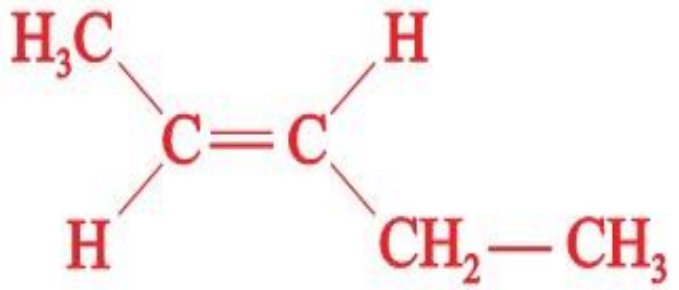
- This results from the difference in the relative spatial arrangement of atoms or groups about the double bond.
- To differentiate geometrical isomers, we use the prefix ‘cis’ if two similar groups are on the same side of the double bond and ‘trans’ when the two similar groups are on opposite sides of it;
- ‘cis’ means the same and ‘trans’ means across

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The geometrical isomers of 2-pentene are:



cis-2-pentene or *cis*-pent-2-ene



trans-2-pentene or *trans*-pent-2-ene

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Preparation of Alkenes

Do you know the major source of alkenes and the process that leads to their formation?
Alkenes are mainly obtained during fractional distillation of petroleum when the process called cracking is carried out.

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In the laboratory, alkenes can be prepared by:

1. Dehydration of alcohols with concentrated sulphuric acid or alumina (Al_2O_3). Dehydration means removal of water.

General Reaction:

$$R-CH_2-CH_2-OH \xrightarrow[heat]{H_2SO_4} R-CH=CH_2 + H_2O$$

Alcohol — Alkene

$$CH_3-CH_2-OH \xrightarrow[heat]{H_2SO_4} CH_2=CH_2 + H_2O$$

Ethanol — Ethene

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2. Dehydrohalogenation of alkyl halides with a base (KOH). Dehydrohalogenation means removal of hydrogen and a halogen atom.

Alkyl halides are compounds of an alkyl group and a halogen such as CH_3Cl and $CH_3 - CH_2 - Br$.

General reaction:

$$R—CH_2—CH_2—X + KOH \longrightarrow R—CH=CH_2 + KX + H_2O$$

Alkylhalide — Alkene

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Chemical properties of Alkenes

Alkenes are unsaturated hydrocarbons containing double bond (a strong bond and a weak bond) between the two carbon atoms. They are more reactive than alkanes, because the weak bond can be used for further reaction. They undergo several types of reactions.

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1. **Combustion reaction.** Alkenes burn in oxygen with a luminous flame to form carbon dioxide and water.

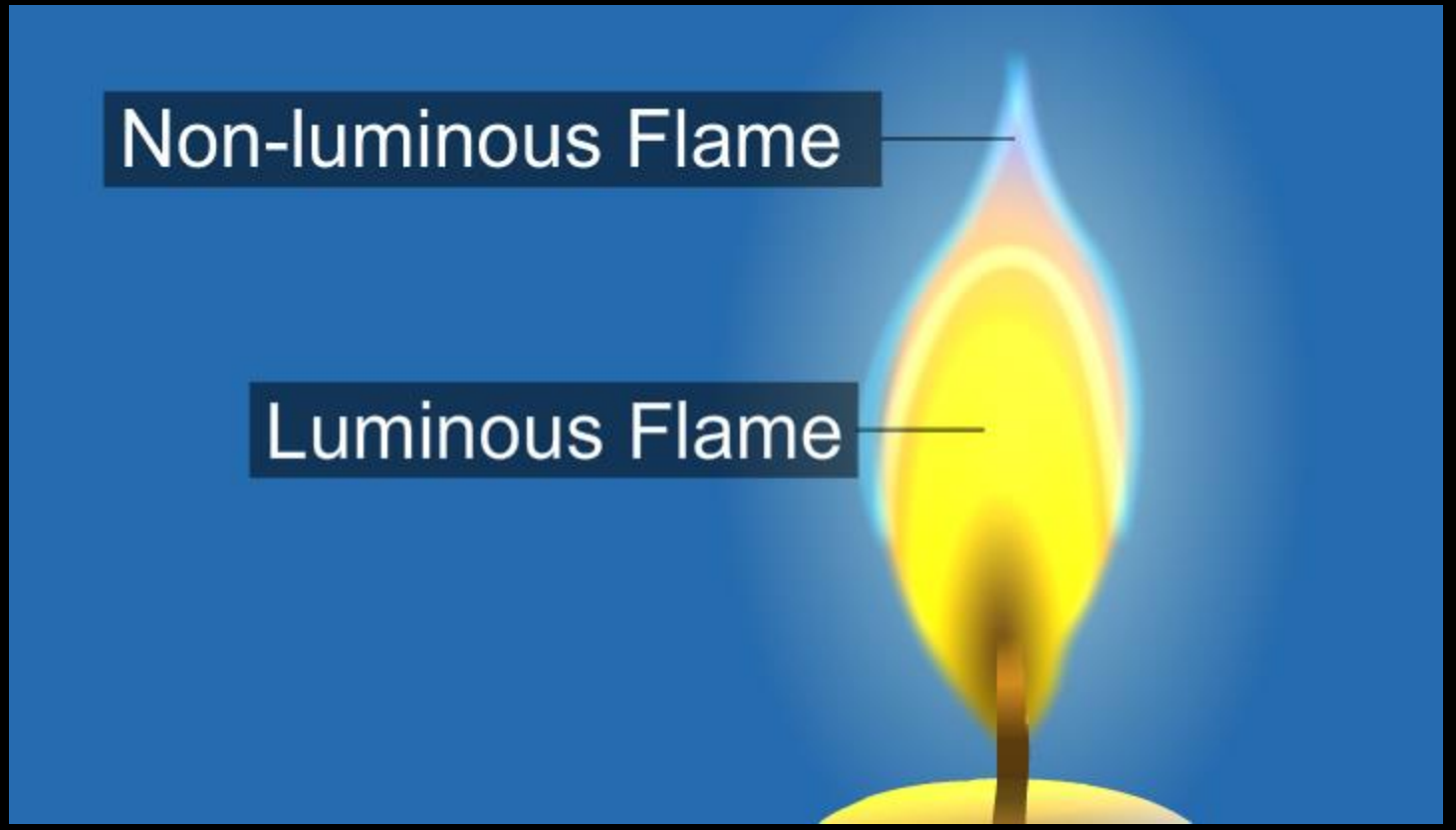
General reaction: $C_nH_{2n} + \left(\frac{3n}{2}\right)O_2 \rightarrow nCO_2 + nH_2O + \text{heat}$

Example

$C_4H_8(g) + 6O_2(g) \rightarrow 4CO_2(g) + 4H_2O(g) + \text{heat}$

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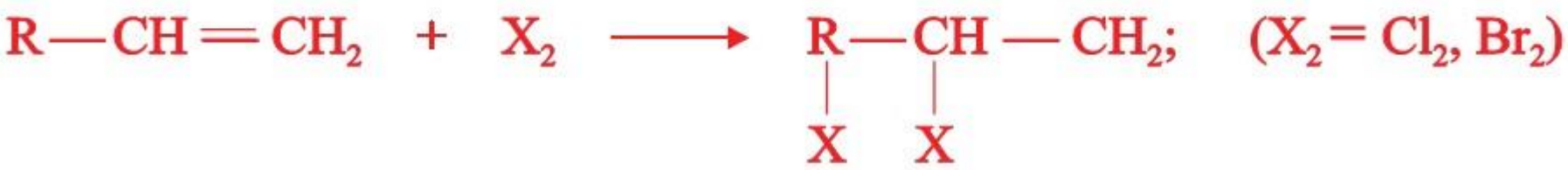


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2. **Addition reaction.** Alkenes undergo mainly addition reactions. The addition occurs at the carbon-carbon double bond.

a **Addition of halogens (halogenation):** When a halogen molecule, X_2, (where, $X_2 = Cl_2$ or Br_2) is added to alkenes, the product is a dihaloalkane.

General reaction:



Alkene Halogen Dihaloalkane

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b **Addition of hydrogen (Hydrogenation):** Addition of hydrogen molecule to alkenes in the presence of a nickel or platinum catalyst yields alkanes.

General reaction: $R-CH=CH_2 + H_2 \xrightarrow{Pt} R-CH_2-CH_3$

Alkene — Alkane

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c **Addition of hydrogen halides, HX (hydrohalogenation):** Addition of hydrogen halide (HCl, HBr or HI) to alkenes leads to the formation of alkyl halides. The product of the reaction can be predicted by Markovnikov's rule; which states that "when an alkene reacts with a hydrogen halide to give an alkyl halide, the hydrogen adds to the carbon atom of the double bond that has the greater number of hydrogen atoms, and the halogen to the carbon that has the fewer number of hydrogen atoms".

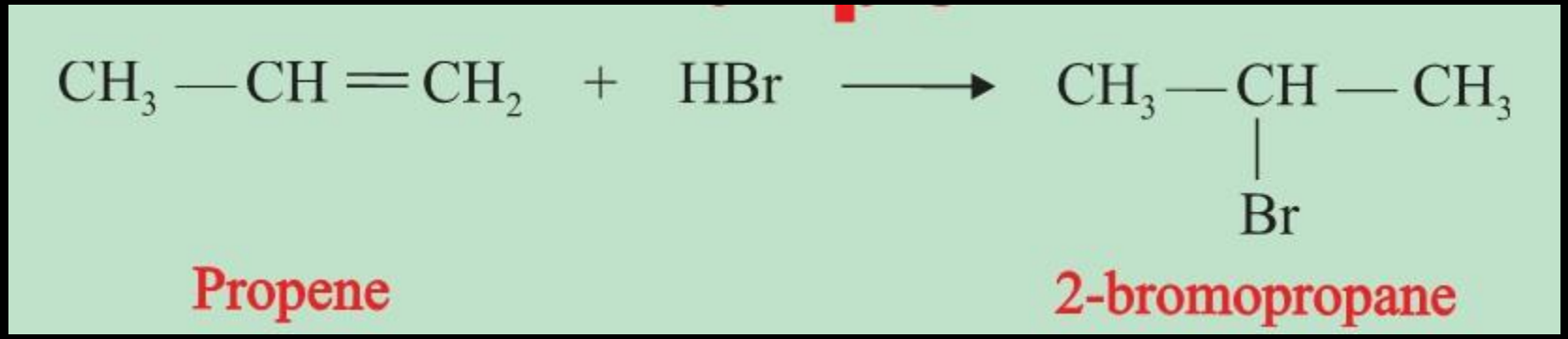
The same is true when an alkene reacts with water in an addition reaction to form an alcohol.

General reaction:



Alkene Alkyl halide

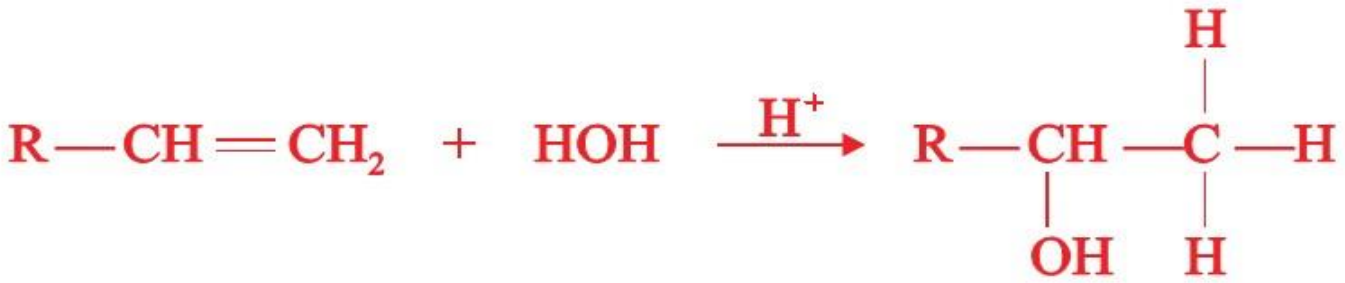
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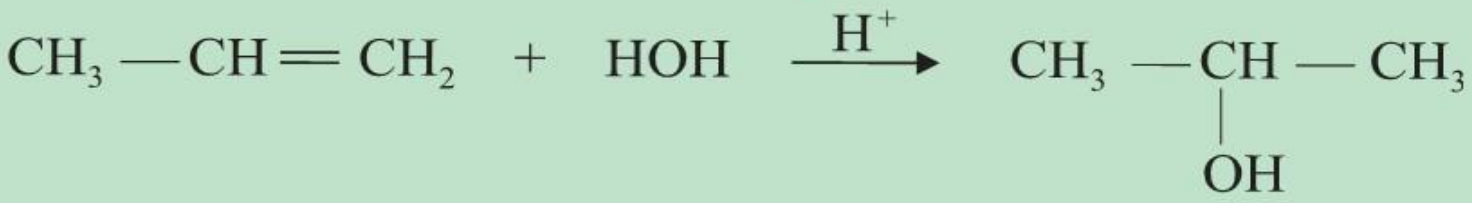
d **Addition of water (hydration):** When alkenes are hydrated in the presence of an acid catalyst, they produce alcohols, in accordance with Markovnikov's rule.

General reaction:



Alkene Alcohol

Example

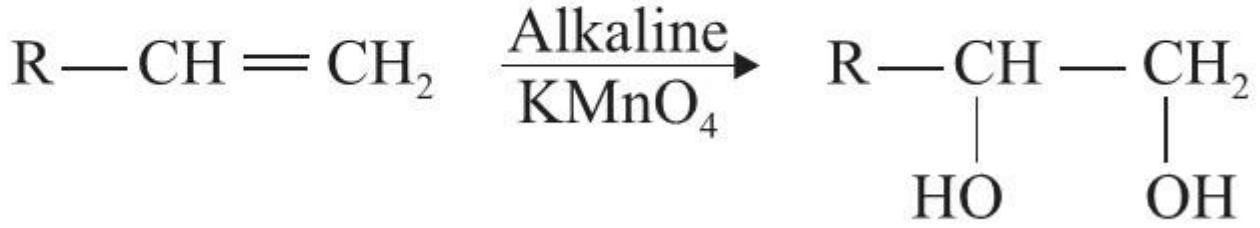


Propene 2-propanol

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e **Oxidation of alkenes:** Oxidation of alkenes with cold alkaline potassium permanganate solution ($KMnO_4$) forms diols (compounds containing two hydroxyl groups).

General reaction:



Alkene Diol



Ethene 1,2-ethanediol

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f **Polymerization (self-addition) of alkenes:** Polymerization is the union of small molecules called monomers to form a large molecule called a polymer.

Example

$$n(CH_2{=}CH_2) \xrightarrow[O_2\,(\text{Catalyst})]{1000\ \text{atm},\ 473K} (-CH_2-CH_2-)_n$$

Ethene — Polyethene

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Uses of Ethene (Ethylene)

- Ethene is used in the production of ethanol, and polymers such as polyethene, polyvinylchloride (PVC), polystyrene and Teflon.
- It is also used in the production of 1,2-ethanediol, which is used as an antifreeze material; and for the preservation as well as artificial ripening of fruits

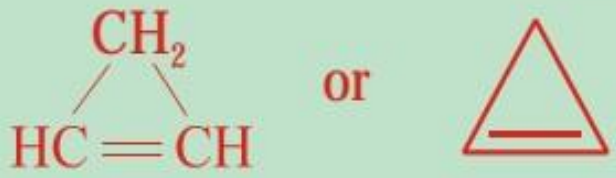
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Cycloalkenes

- Cycloalkenes are unsaturated cyclic hydrocarbons.
- They contain a double bond between carbon atoms and are represented by the general formula C_nH_{2n-2}, where n should be equal to or greater than 3.
- They are isomeric with alkynes.
- They are named by prefixing “cyclo” to the name of alkenes containing the same number of carbon atoms

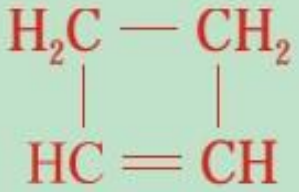
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Examples



or

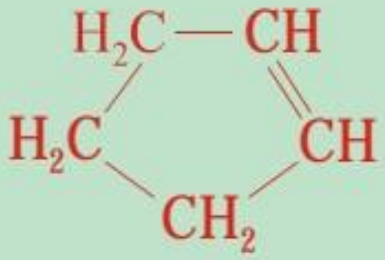
Cyclopropene



or



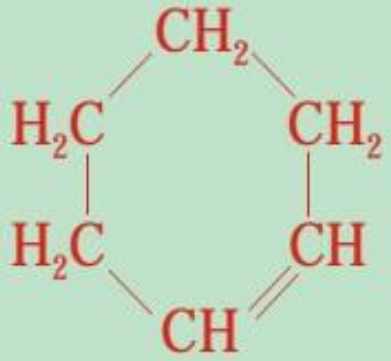
Cyclobutene



or



Cyclopentene



or



Cyclohexene

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1. What is the general molecular formula for olefins?

A. C_nH_{2n-6}

B. CnH_{2n}

C. C_nH_{2n-2}

D. C_nH_{2n+1}

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2. The formula for an alkene containing three (3) carbon atoms is given by

A. C_3H_6

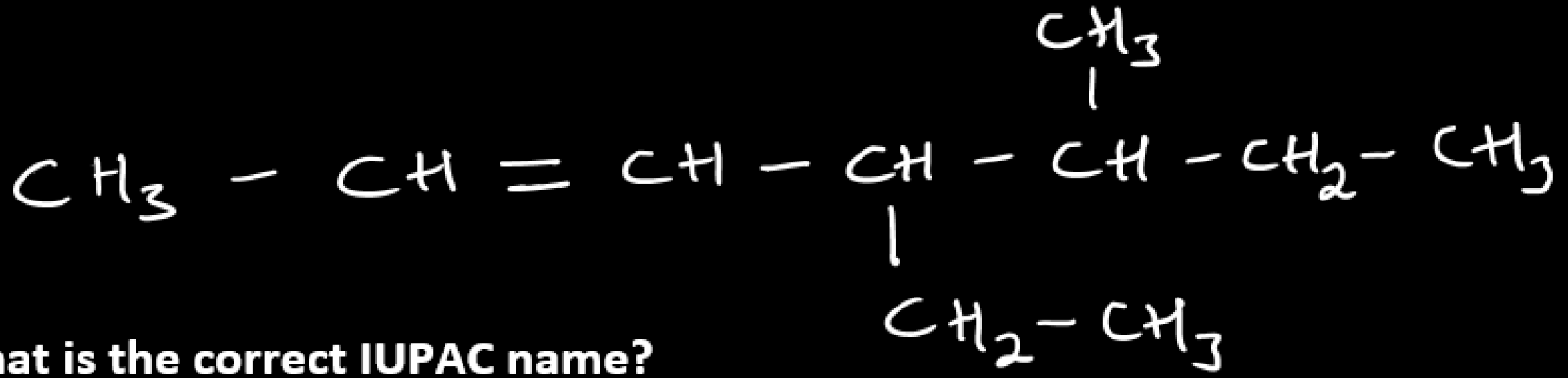
B. C_3H_4

C. C_3H_7

D. C_3H_8

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3. Given the structural formula representing a hydrocarbon



What is the correct IUPAC name?

A. 4-ethyl-5-methyl-2-heptene

B. 3-methyl-4-ethyl-5-heptene

C. 2-butyl-4-hexane

D. 4-butyl-2-hexene

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5. The spatial arrangement of atoms or groups about a double bond is known as

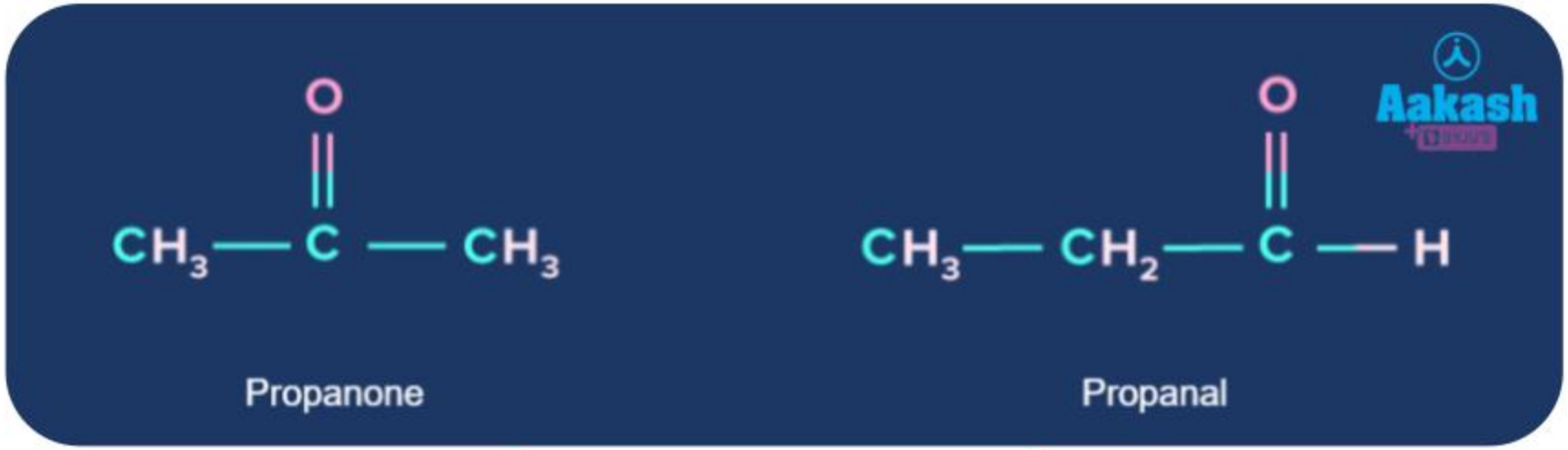
A. Position

B. Geometrical

C. Functional

D. Chain isomerism.

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Functional isomers

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4. Which of the following molecules does NOT exhibit geometrical isomerism?

A. 3-hexene

B. 2-butene

C. 1-hexene

D. 2-pentene



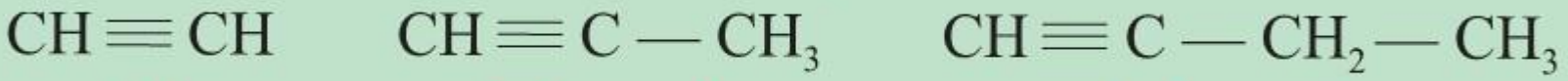
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Alkynes

- Alkynes are another group of unsaturated hydrocarbons possessing a triple bond as their functional group.
- The homologous series of alkynes is represented by the general formula C_nH_{2n-2}, where n =2,3,4.....
- The first member of the group is commonly known as acetylene.
- The homologous series of alkynes is also called acetylene series.

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Example



acetylene | methyl acetylene | ethyl acetylene

Formula of Alkyne	Condensed Structure	IUPAC Name	Melting Point (°C)	Boiling Point (°C)
C_2H_2	$CH \equiv CH$	Ethyne	– 82	–75
C_3H_4	$CH \equiv C - CH_3$	Propyne	–101.5	–23
C_4H_6	$CH \equiv C - CH_2$	1 - butyne	–122	9

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What is the general formula of alkynes?

A. C_nH_{n-2} (n>2)

B. C_nH_{2n-2} (n≥2)

C. C_nH_{2n+2}(n≥1)

D. C_nH_{2n} (n≥3)

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Physical Properties of Alkynes

- Alkynes are non-polar compounds whose molecules are held together by weak intermolecular forces.
- The strength of the intermolecular forces increases with increasing molecular size.
- The physical properties of alkynes are almost similar to those of alkenes.

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Which of the following statements is correct regarding alkenes and alkynes?

A. Alkenes are soluble in polar solvents, while alkynes are not soluble in polar solvents.

B. Alkenes and alkynes are soluble in polar solvents.

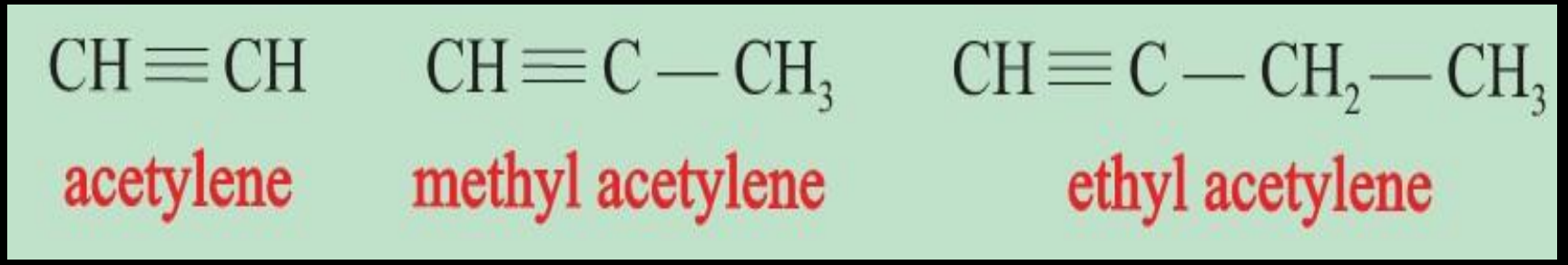
C. The molecules of alkenes and alkynes are held together by weak inter-molecular force.

D. Alkynes have longer bond length and less surface area than alkenes..

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Nomenclature of Alkynes

Alkynes are commonly named as a derivative of acetylene.

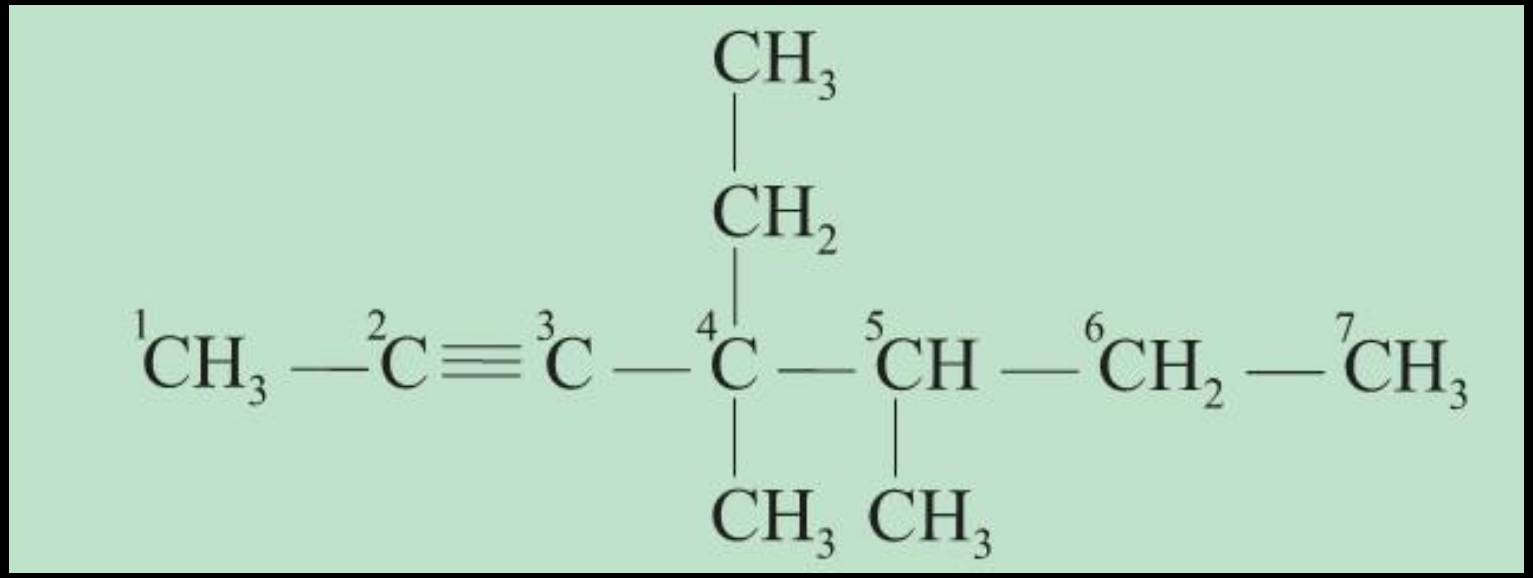


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IUPAC System:

- The IUPAC names for alkynes are obtained by using the prefixes.
- The suffix ‘-yne’ is added to the prefixes.
- ‘-yne’ indicate the presence of a triple bond between a pair of adjacent carbon atoms.
- Alkynes are named in the same way as alkenes.

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Isomerism in Alkynes

Alkynes show both chain and position isomerism, but not geometrical isomerism.

Isomers of butyne, C_4H_6



1-butyne or but-1-yne



2-butyne or but-2-yne

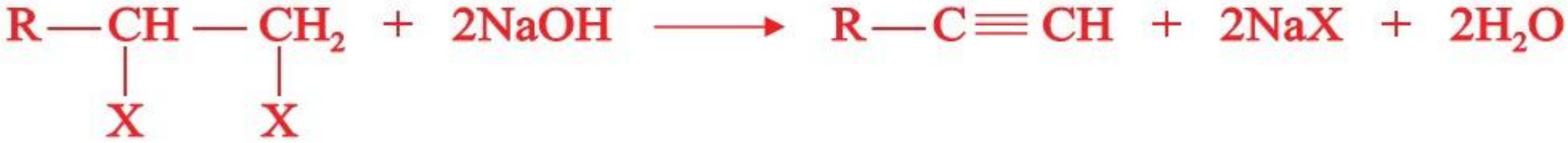
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Preparation of Alkynes

Alkynes can be prepared by several methods. Some of the general methods of preparation of alkynes are:

1. Dehydrohalogenation of vicinal (adjacent) dihalides with a base NaOH or KOH or $NaNH_2$.

General reaction:



Vicinal dihalide Alkyne

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2. Alkylation of sodium acetylide (dicarbide) with a primary alkyl halide.

General reaction:



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Which of the following is the **CORRECT** method of preparation of alkenes in the laboratory?.....UEE 2016

A. Alkylation of sodium acetylide with a primary alkyl halide.

B. Heating of sodium salt of an organic acid with soda lime.

C. Reaction of halogenated alkane with sodium.

D. Dehydration of alcohols with concentrated sulfuric acid.

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2. **Wűrtz** Synthesis (*reaction*). This method involves the reaction of a halogenated alkane with sodium and the reaction is somewhat exothermic.

General Reaction:

$$2R-X + 2Na \longrightarrow R-R + 2NaX$$

Halogenated Alkane — Alkane — Sodium halide

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3. Heating sodium salt of an organic acid with soda lime (*mixture of sodium hydroxide and calcium oxide*); the reaction brings about the removal of the carboxylate group from the sodium salt of the carboxylic acid. This type of reaction is called decarboxylation.

General Reaction:

$$RCOONa + 2NaOH \xrightarrow[heat]{CaO} R-H + Na_2CO_3(s)$$

Sodium salt of or anic acid

Alkane

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Which of the following methods can be used to prepare alkynes in laboratory?

A. Dehydration of primary alcohol

B. Hydrogenation of alkenes with a metal catalyst.

C. Alkylation reaction of sodium acetylide with a primary alkyl halide

D. Dehydrohalogenation of vicinal dihalides with an acid such HCl and H_2SO_4

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Which one of the following methods can be used in the laboratory for the preparation of alkynes?

A. Heating of sodium salt of an organic acid with soda lime.

B. Dehydration of alcohols with concentrated sulphuric acid.

C. Hydrogenation of alkenes with a metal catalyst.

D. Dehydrohalogenation of adjacent dihalides with sodium hydroxide.

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Chemical Properties of Alkynes

- Alkynes are more reactive than alkanes and alkenes.
- Alkynes are more unsaturated than alkanes and alkenes due to the presence of a carbon-carbon triple bond.
- They can undergo combustion and addition reactions.

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Some of the common reactions of alkynes are:

1. **Combustion reaction:** Alkynes burn with a smoky luminous flame, forming CO_2 and water. Smoky luminous flames result from the combustion of alkynes due to their high carbon content.

General reaction: $$C_nH_{2n-2} + \frac{3-1}{2} O_2 \rightarrow nCO_2 + (n-1)\,H_2O$$

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2. Addtion reaction: Alkynes undergo addition reaction at the carbon-carbon triple bond. Some of the addition reactions of alkynes are the following:

a **Addition of hydrogen (hydrogenation):** In the presence of nickel or palladium catalyst, alkynes produce alkanes.

General relation:

$$\underset{\text{Alkyne}}{C_nH_{2n-2}} + H_2 \xrightarrow[\text{heat}]{Ni} \underset{\text{Alkene}}{C_nH_{2n}} \xrightarrow[Ni/\text{heat}]{H_2} \underset{\text{Alkane}}{C_nH_{2n+2}}$$

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Partial hydrogenation of alkynes in the presence of Lindlar's catalyst gives alkenes. Lindlar's catalyst is powdered palladium partially deactivated with lead acetate.



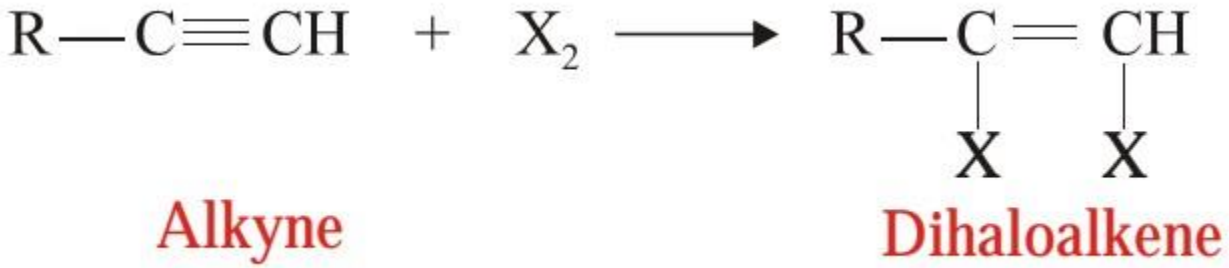
2- butyne

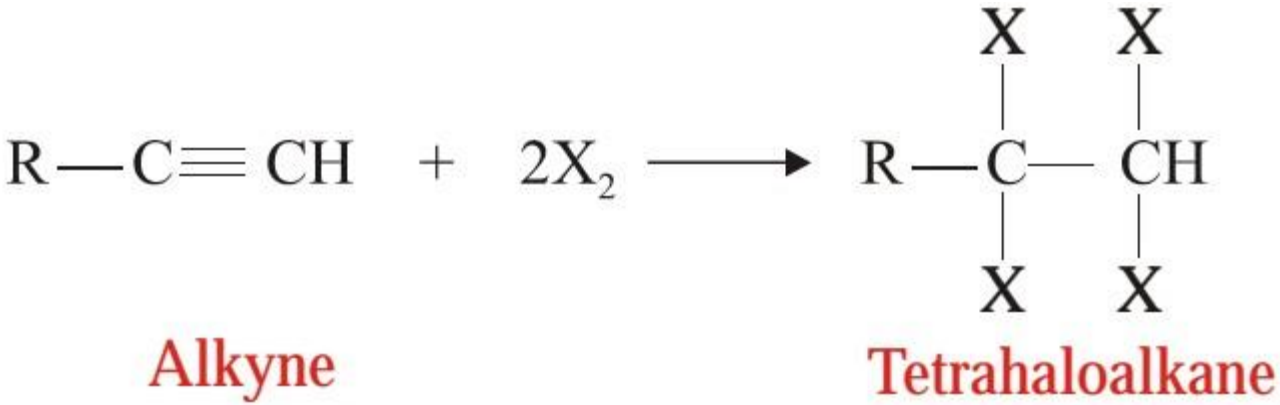
2- butene

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b **Addition of halogens:** When molecule of an alkyne reacts with one and two molecules of halogens, it gives a dihaloalkene and a tetrahaloalkane, respectively.

General Reaction:

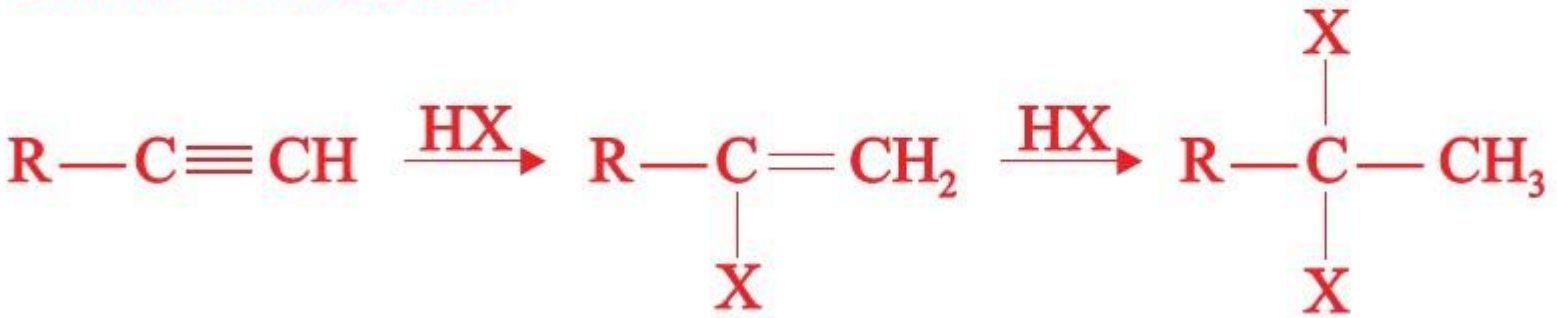




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c **Addition of Hydrogen Halides:** Alkynes react with hydrogen halides to form a monohaloalkene and a dihaloalkane. The addition reaction occurs according to Markovnikov's rule.

General Reaction:



Alkyne Monohaloalkene Dihaloalkane

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3. Trimerization of Acetylene: Acetylene, on prolonged heating at 600 – 700°C, yields benzene.



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Properties and uses of Acetylene or Ethyne

- Acetylene is a colourless, sweet-smelling gas in pure form and is insoluble in water.
- Combustion of acetylene with oxygen produces an intensely hot flame of about 3000^{o}C.
- Thus, a large quantity of acetylene is used as a fuel in oxy-acetylene torches for cutting and welding metals.

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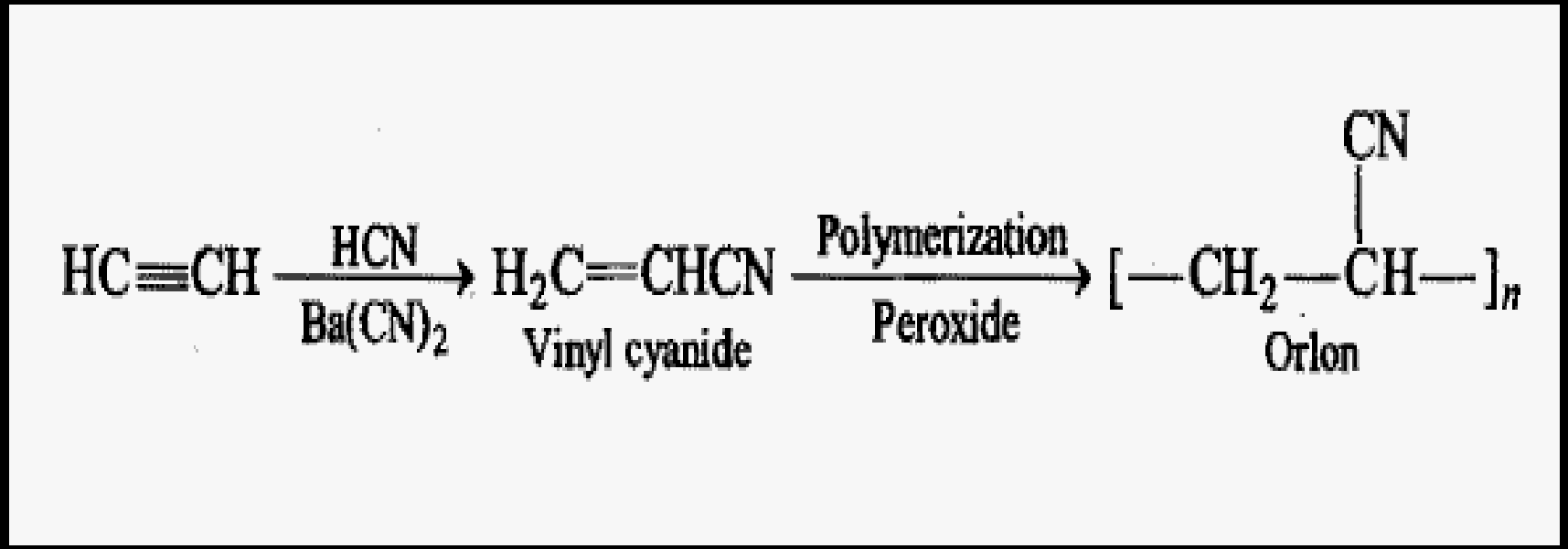
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- Acetylene is also used to prepare acrylonitrile which is a starting material for producing polyacrylonitrile, a raw material for textile fibre.
- It is also used for making vinyl chloride which polymerizes to give polyvinyl chloride (PVC) commonly used for making floor tiles, electrical insulators, shoe soles, water pipes etc.
- Acetylene is used to produce 1,1,2,2-tetrachloroethane that serves as a solvent for wax, grease, rubber etc.

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Property	Ethane	Ethene	Ethyne
Nature of flame	Non-luminous	Luminous	Smoky luminous
Effect on colour of Br_2 in CCl_4	No effect	Decolorizes	Decolorizes
Effect on colour of alkaline $KMnO_4$	No effect	Decolorizes	Decolorizes

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1. Acetylene is commonly used

A. In the production of polymers

B. For making detergents and plastics.

C. In the production of ethanol.

D. As a fuel in oxy-acetylene torches for cutting and welding metals.

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2. What are the molecular formulae of an alkene and alkyne containing seven carbon atoms, respectively?...UEE 2016

A. C_7H_{14} and C_7H_{12}

B. C_7H_{16} and C_7H_{14}

C. C_7H1_4 and C_7H_{16}

D. C_7H_{12} and C_7H_{14}

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Grade 10 Chemistry

Unit 1

Introduction to Organic Chemistry (Revision + UEE)

Part 5

AROMATIC HYDROCARBONS

- The term aromatic is derived from the word ‘aroma’ meaning pleasant smell, which was originally used to describe naturally occurring compounds with pleasant smells.
- Aromatic hydrocarbons are generally obtained from petroleum and coal tar.
- They are a group of hydrocarbons characterized by the presence of a benzene ring or related structures.

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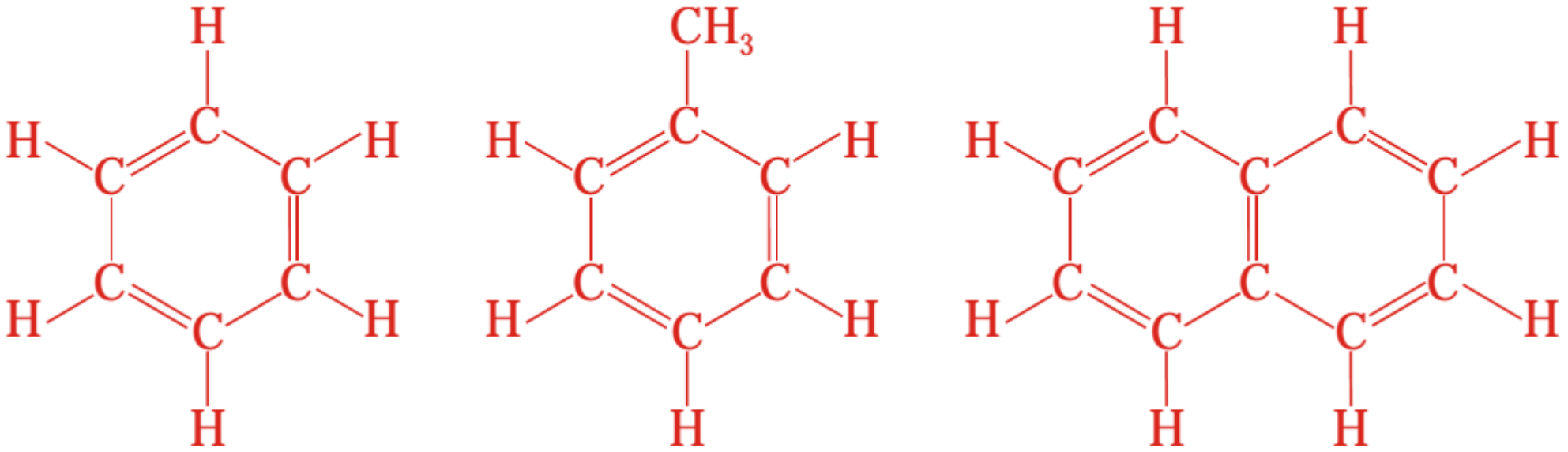


Figure 1.9 Structures of some Aromatic Hydrocarbons.

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Benzene

- Benzene is the simplest aromatic hydrocarbon.
- Its molecular formula is C_6H_6.
- **Friedrich A. Kekule**, in 1865, suggested that the six carbon atoms of benzene are arranged in the shape of a hexagon.

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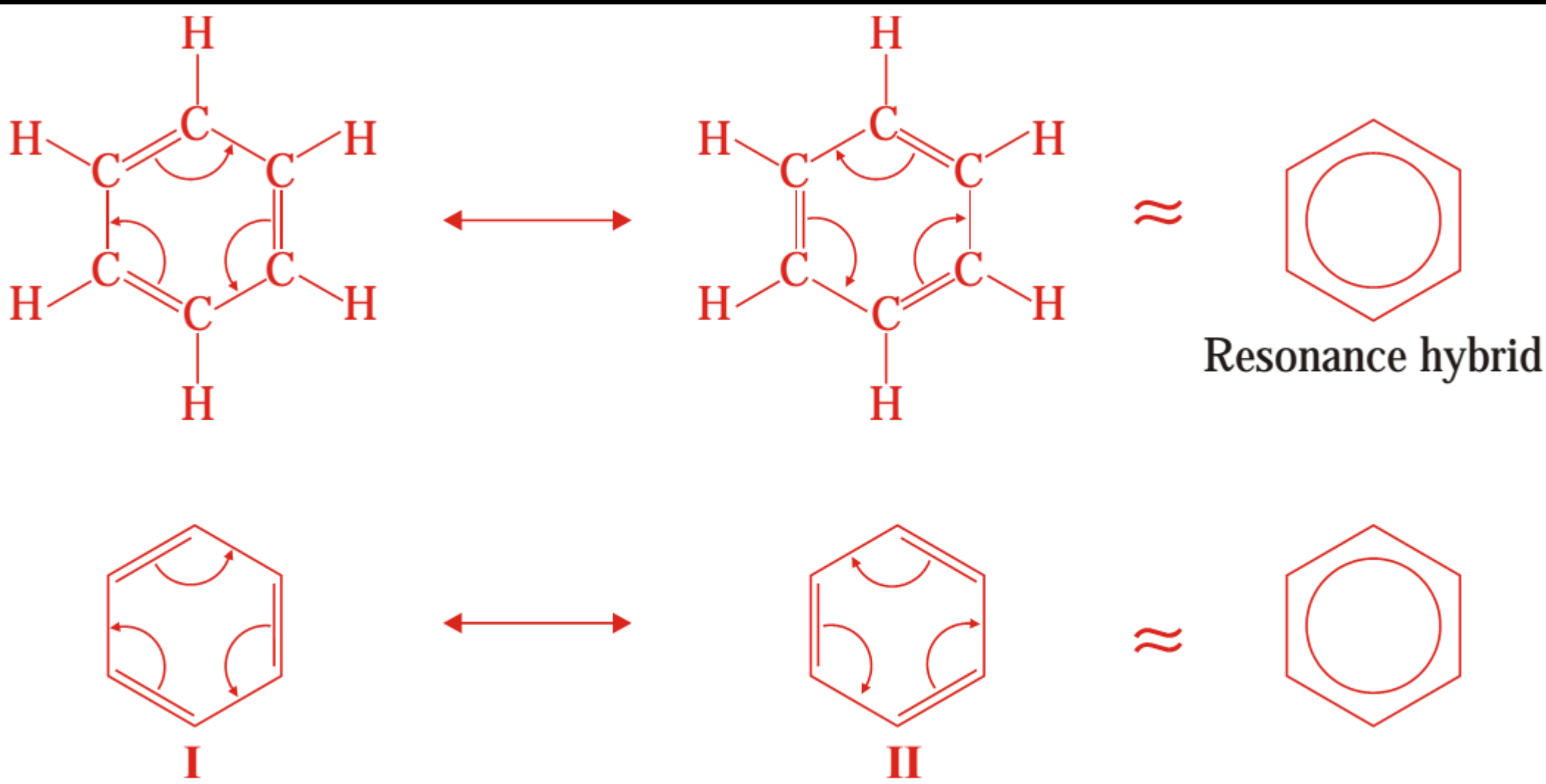


Figure 1.10 Resonance structures of benzene.

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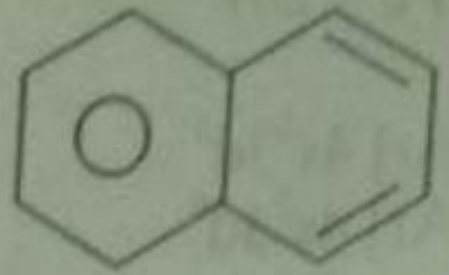
- The bonds in benzene are neither single nor double but have an intermediate character between those of single and double bonds.
- All the carbon-carbon bonds in the molecule are same in length and nature.
- Since structure I or II given above are not the true structures of the benzene molecule, the benzene ring is written, in most cases, in its resonance hybrid

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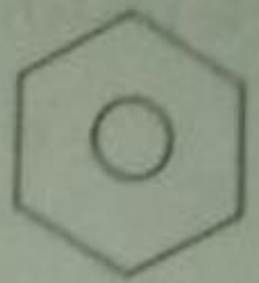
- Benzene and other aromatic hydrocarbons are not as unsaturated as alkenes because the three double bonds in benzene are delocalized due to resonance.
- They are more stable than alkenes.
- They undergo substitution reactions to a far greater extent than addition reactions, which is a different characteristic compared to alkenes.

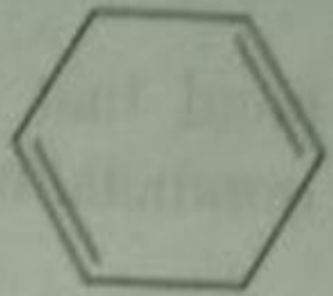
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Which of the following is the **CORRECT** structure of benzene?

A. 

B. 

C. 

D. 

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Physical Properties of Benzene

- Benzene is a flammable, colourless, and volatile liquid with a characteristic smell.
- It is nonpolar and immiscible with water but miscible with non-polar solvents like ether and carbon tetrachloride.
- It freezes at 5.4^{o}C and boils at 80.4^{o}C.
- It is a carcinogenic(cancer causing) substance.
- Benzene is a good solvent for fats, gums, rubber etc., and is used in the manufacture of dyes, drugs and explosives.

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Chemical Properties of Benzene

- Benzene and other aromatic hydrocarbons are more stable than alkenes and alkynes due to the stability of the aromatic ring.
- It neither decolorizes bromine water (Br_2 in CCl_4) nor is reactive towards cold potassium permanganate solution.
- However, benzene undergoes the following reactions:

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1. **Combustion reaction:** Benzene is highly inflammable. It burns with a smoky luminous flame to form CO_2 and H_2O.

$$2C_6H_6 + 15O_2 \rightarrow 12CO_2 + 6H_2O + \text{Heat}$$

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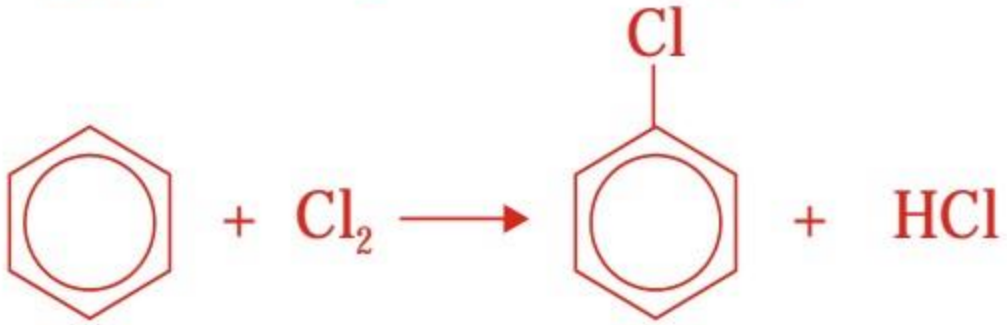
2. Substitution reaction:

- The reactions of benzene are chiefly substitution but not addition reactions.
- In this reaction, hydrogen atom from the benzene ring is replaced by another atom or group.

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a **Halogenation:** Benzene reacts with bromine and chlorine in the presence of iron (III) chloride or aluminium chloride catalyst to form substitution products.

$$C_6H_6 + Cl_2 \xrightarrow{AlCl_3} C_6H_5Cl + HCl$$

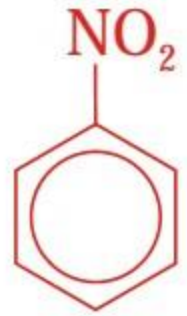


Benzene Chlorobenzene

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b **Nitration:** Concentrated nitric acid mixed with some concentrated sulphuric acid reacts with benzene at moderate temperatures to form nitrobenzene.

$$C_6H_6 + \underbrace{HO-NO_2}_{HNO_3} \xrightarrow[50^\circ C]{H_2SO_4} C_6H_5NO_2 + H_2O$$


+ $\underbrace{HO-NO_2}_{HNO_3}$ $\xrightarrow[50^\circ C]{H_2SO_4}$ 

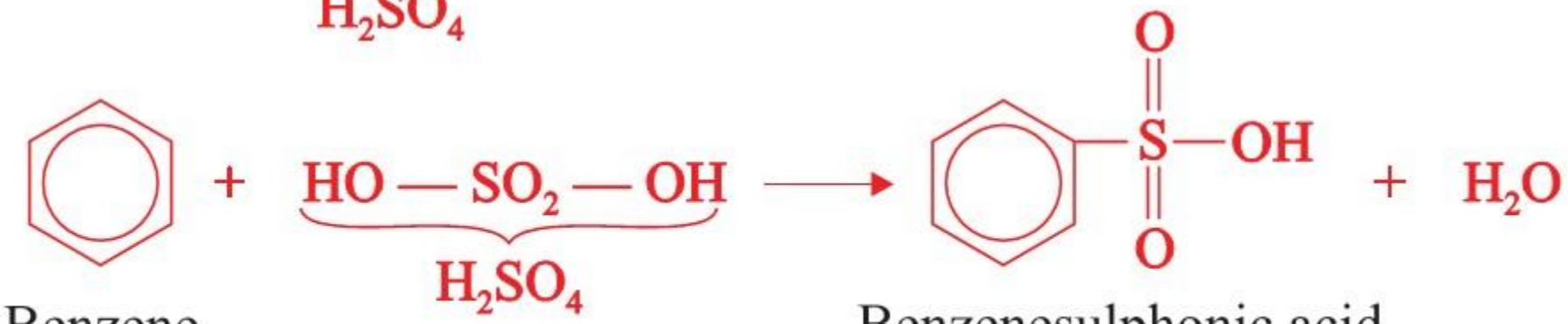
+ H_2O

Nitrobenzene

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c **Sulphonation:** Benzene reacts with concentrated sulphuric acid, H_2SO_4, at room temperature to form benzenesulphonic acid.

$$C_6H_6 + \underbrace{HO-SO_2OH}_{H_2SO_4} \longrightarrow C_6H_5SO_2OH + H_2O$$



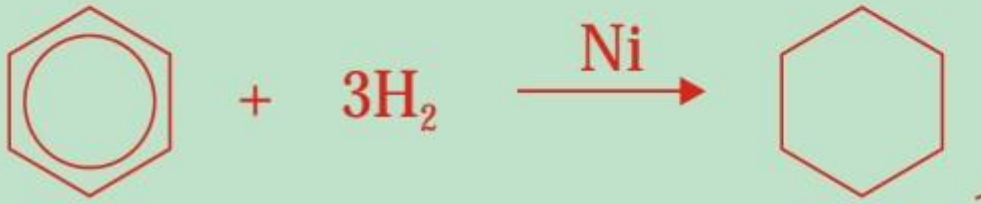
Benzene Benzenesulphonic acid

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3. Addition reaction: **Benzene undergoes addition reactions under special conditions.**

When a mixture of benzene vapour and hydrogen is passed over finely divided nickel catalyst at 200°C, cyclohexane is formed.

$$C_6H_6 + 3H_2 \xrightarrow[200°C]{Ni} C_6H_{12}$$



Cyclohexane

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1. In which solvent will both alkenes and alkynes dissolve?

A. Benzene

B. Water

C. Acetic acids

D. Alcohols

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2. Which one of the following is a colorless, flammable volatile liquid and miscible with non-polar solvents?

A. Ethanol

B. Benzene

C. Methane

D. Methanol

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3. What is the addition product formed when a mixture of benzene vapor and hydrogen is passed over finely divided nickel catalyst at 200°C?

A. C_6H_{13}

B. C_6H_{10}

C. C_6H_{12}

D. C_6H_{14}

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NATURAL SOURCES OF HYDROCARBONS

A. Natural Gas

- The principal sources of hydrocarbons are **natural gas**, **crude oil** and **coal**.
- Natural gas is found in association with petroleum or alone.
- Natural gas mainly contains **methane (more than 90%)**, ethane, propane, butane and small quantities of higher alkanes.
- Natural gas is widely used as a **fuel**

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B. Petroleum

- The word petroleum is derived from two Latin words, ‘petra’ meaning rock, and ‘oleum’ meaning oil.
- Thus, petroleum means rock oil.
- The term petroleum refers to a broad range of fossil hydrocarbons that are found as gases, liquids or solids beneath the surface of the earth

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- **The crude oil** is generally found along with natural gas in the form of a dark-coloured viscous liquid, which is a complex mixture of hydrocarbons.
- Its composition varies according to its place of origin.
- However, crude oil mainly contains **alkanes**, **cycloalkanes** and **aromatic hydrocarbons.**
- It also contains organic compounds consisting of **nitrogen**, **Sulphur** and **oxygen** in small amounts.

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Refining of Crude Oil

- Crude oil or petroleum is obtained by drilling wells until the oil-bearing region is reached.
- After the crude oil is brought to the surface of the earth, it must be refined before it can be used.
- Crude oil is refined or separated into several components by fractional distillation based on the differences in boiling ranges of its fractions.

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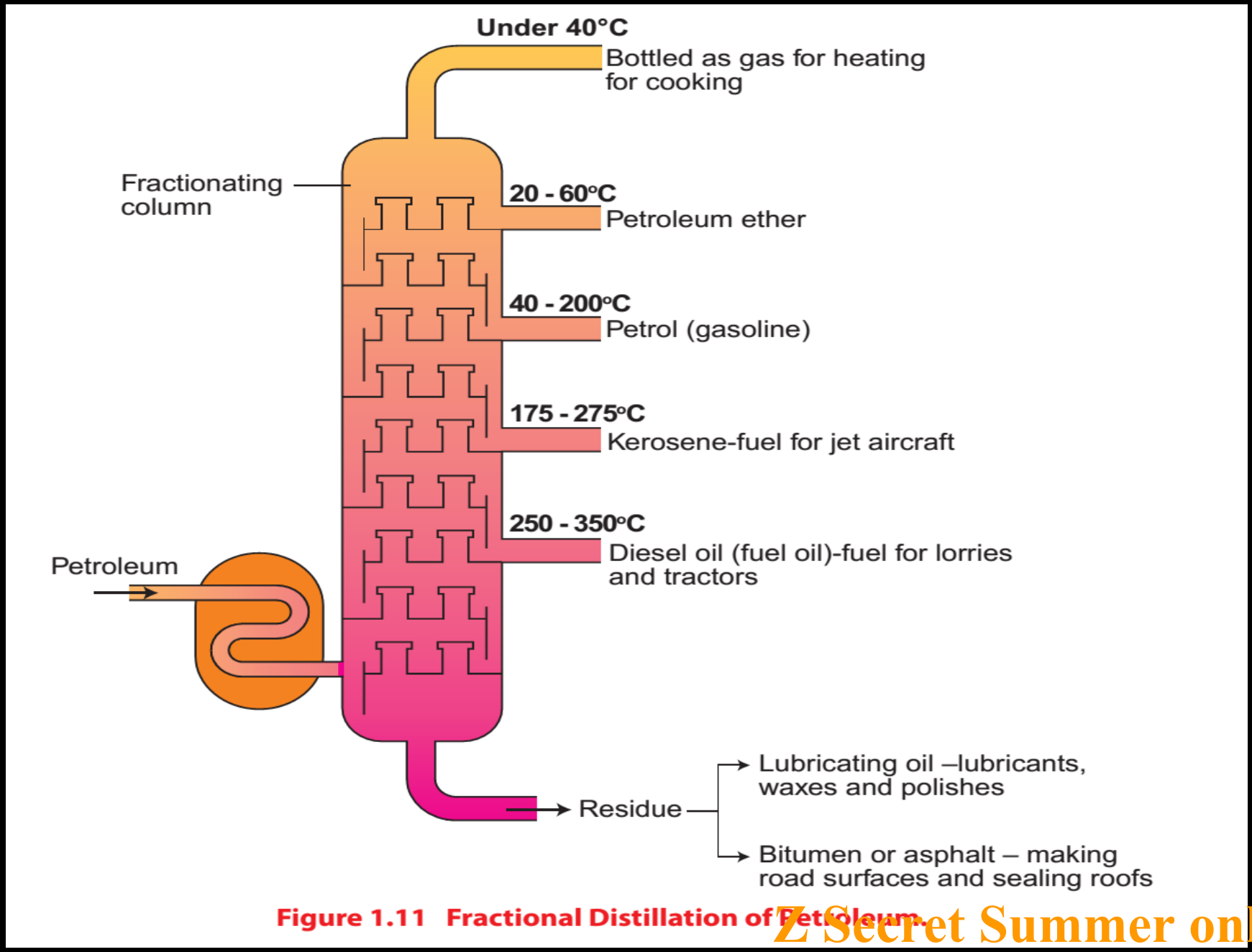


Figure 1.11 Fractional Distillation of Petroleum.

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The major products (*fractions*) obtained from fractional distillation of petroleum and their uses are given in Table 1.9.

Table 1.9 Common petroleum products.

Fractions	Approximate composition (carbon number)	Boiling point range (°C)	Uses
Gases	$C_1 \rightarrow C_4$	below 20	– As fuel in the form of bottled gas.
Petroleum ether	$C_5 \rightarrow C_7$	20 → 60	– As solvent, in dry cleaning
Gasoline (petrol)	$C_5 \rightarrow C_{10}$	40 → 200	– Motor fuel for internal combustion engines.
Kerosene	$C_{10} \rightarrow C_{16}$	175 → 275	– Jet engine fuel, – household fuel.

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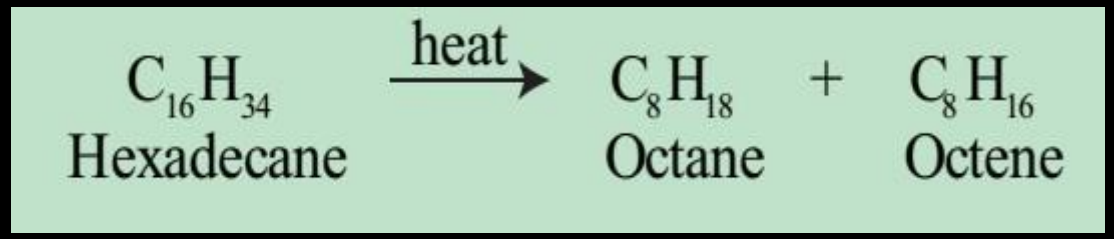
Fuel oil (diesel oil)	$C_{15} \rightarrow C_{18}$	250 → 350	– Furnace fuel, diesel engine fuel.
Lubricating oils Greases Petroleum jelly	$> C_{19}$	Non-volatile liquids	– Lubrication.
Paraffin wax Asphalt (bitumen) Coke	$> C_{20}$	Non-volatile solids	– Candles, polishes. – Roofing and road construction. – Electrodes, fuel for power stations.

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- Therefore, the amount of petrol obtained by fractional distillation of crude oil does not satisfy the demand for it.
- To satisfy the demand and maximize the output of petrol or gasoline, the process called **cracking** is carried out during fractional distillation.
- What does cracking mean? **Cracking** is the decomposition of large hydrocarbon molecules into smaller ones by the application of heat (**thermal cracking or pyrolysis**) or in the presence of catalysts (**catalytic cracking**).



- Hydrogen gas can be added during cracking to saturate the alkenes formed in the process.

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C. Coal

- Coal is formed naturally by the decomposition of plant matter over several millions of years.
- It is not a pure form of carbon.
- It is an important source of aromatic hydrocarbons.
- Heating mineral coal in the absence of air, or oxygen is called **destructive distillation of coal or coking of coal**.
- When coal is heated in the absence of air it gives **volatile products** and **coke**.
- The volatile products separate into coal gas and a liquid, called **coal tar** when cooled.

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- **Coke**, which is a solid and relatively pure form of carbon, is used as a fuel in the blast furnace during the extraction of iron.
- It is also used to produce gaseous fuels, such as **water gas** (**mixture of H_2** and **CO**) and **producer gas** (**mixture of N_2** and **CO**).

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1. Which one of the following petroleum products is used as a solvent and in dry cleaning?

A. Petroleum ether

B. Kerosene

C. Diesel oil

D. Paraffin wax

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2. All of the following are the major sources of hydrocarbons EXCEPT?

A. Crude oil
B. Petroleum.
C. Coal.
D. Coke.

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3. Which of the following substances remains as a residue after heating coal in the absence of air?

A. Coke.

B. Volatile hydrocarbons

C. Crude oil

D. Petroleum

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4. What is the fraction obtained from fractional distillation of petroleum at a boiling point range of (175 - 275)^{O}C?

A. Petroleum ether
B. Fuel Oil (Diesel Oil)
C. Kerosene
D. Gasoline(Petrol)

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Fractions	Approximate composition (carbon number)	Boiling point range (°C)	Uses
Gases	$C_1 \rightarrow C_4$	below 20	– As fuel in the form of bottled gas.
Petroleum ether	$C_5 \rightarrow C_7$	20 → 60	– As solvent, in dry cleaning
Gasoline (petrol)	$C_5 \rightarrow C_{10}$	40 → 200	– Motor fuel for internal combustion engines.
Kerosene	$C_{10} \rightarrow C_{16}$	175 → 275	– Jet engine fuel, – household fuel.

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5. Coal is mainly composed of

A. Carbon and hydrogen
B. Hydrogen and oxygen.
C. Phosphorus and sulfur.
D. Fluorine and chlorine

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6. What are the compositions of coal? It is mainly composed of

A. Low percentage of carbon, compounds of nitrogen and Sulphur
B. Element carbon, low percentage of solid, liquid and gaseous hydrocarbons
C. Alkanes, cycloalkanes and aromatic hydrocarbons
D. Methane, ethane, propane, butane and small quantities of higher alkanes

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7. What is the name of a natural occurring unrefined petroleum produce composed of hydrocarbon deposits and other organic materials?

A. Petroleum ether
B. Crude oil
C. Gasoline
D. Kerosene

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8. Natural gas is mainly composed of

A. Gases such as carbon dioxide and nitrogen
B. All hydrocarbons
C. Methane gas
D. Gases such as oxygen and hydrogen disuplhide

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Grade 10 Chemistry

Unit 1

Introduction to Organic Chemistry (Revision + UEE)

Part 4

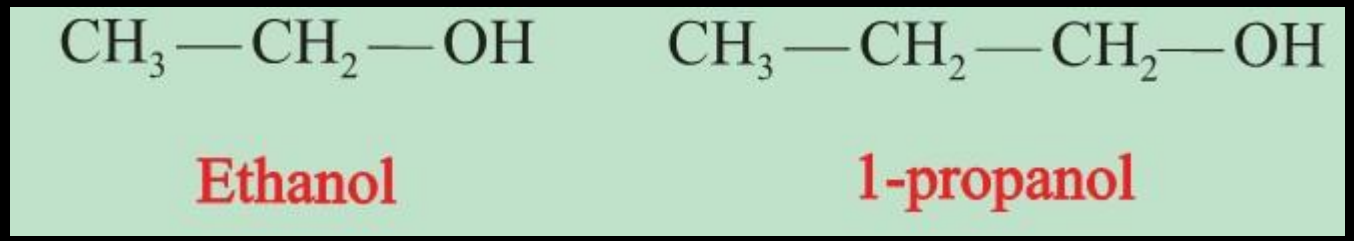
ALCOHOLS

- The only alcohol present in all alcoholic beverages is called **ethanol**.
- The **hydroxyl group** is the functional group of alcohols

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Classification of Alcohols

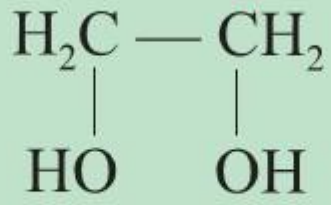
- Alcohols are generally classified as **monohydric**, **dihydric** and **trihydric** depending on the number of hydroxyl (–OH) groups they contain in their molecular structure.
- **Monohydric alcohols** are alcohols containing **only one hydroxyl group**



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Dihydric alcohols are those containing **two hydroxyl groups** per molecule. They are also named **glycols** or **diols**.

Example

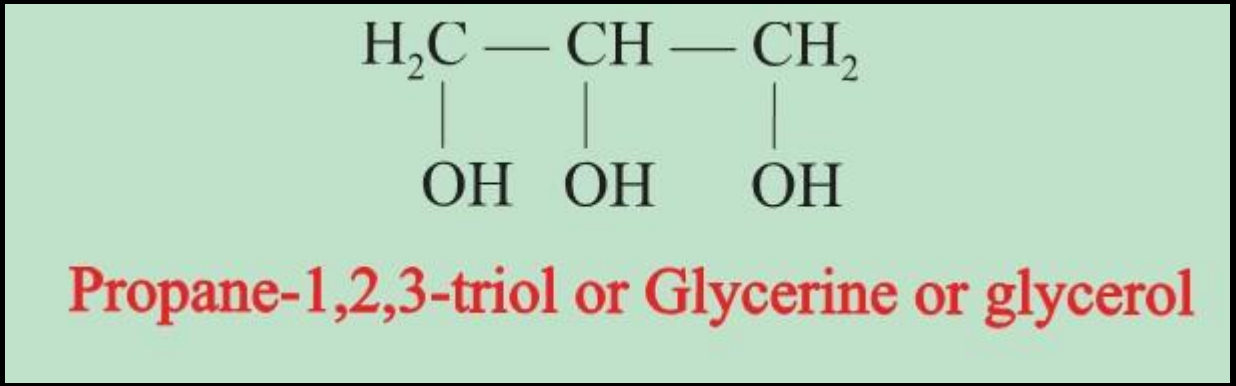


Ethane-1,2-diol (Ethylene glycol)

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- **Trihydric alcohols** are those containing **three hydroxyl groups** in their molecular structure.
- **Polyhydric alcohols** are those containing **three or more hydroxyl groups** in their molecular structure.
- **Trihydric alcohols** are also considered as polyhydric alcohols.

Example



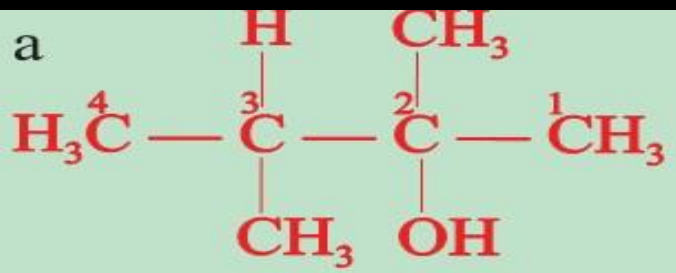
Propane-1,2,3-triol or Glycerine or glycerol

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Nomenclature of Alcohols

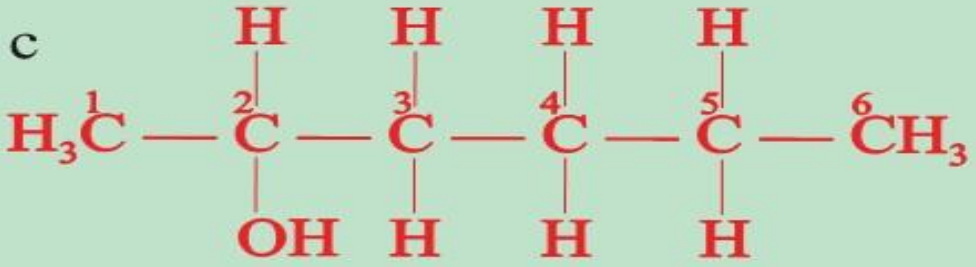
- An alcohol can be considered to be derived from a hydrocarbon by the replacement of at least one H atom by hydroxyl group.
- Hence, alcohols can be systematically named by using the suffix **-ol** to replace the terminal –e in the corresponding alkane name.

a



2,3-dimethyl-2-butanol

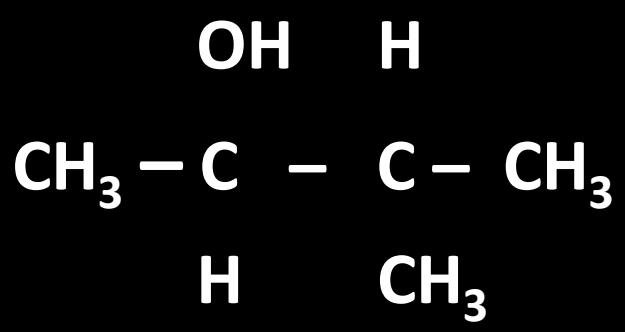
c



2-hexanol

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1.What is the IUPAC name of the following organic molecule?



A. 3, 3-dimethyl-2-butanol

B. 2-methyl-3-butanol

C. 2,2-dimethyl-2-butanol

D. 3-methyl-2-butanol

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2. Which functional group containing compound is named using the suffix "-ol"?

A. Aryl
B. Carboxyl
C. Phenyl
D. Hydroxyl

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3. Which of the following represents the general formula of monohydric alcohols?

A. $C_nH_{n-2}(OH)_2$

B. $C_nH_{2n-2}(OH)$

C. $C_nH_{2n+1}0H$

D. C_nH_2OH

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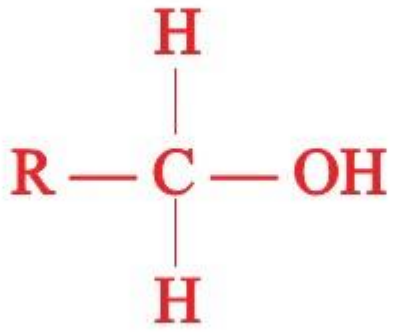
Classification of Monohydric Alcohols

Carbon atoms can be classified as primary (1°), secondary (2°), tertiary (3°) and quaternary (4°) if they are bonded to one, two, three and four carbon atoms, respectively.

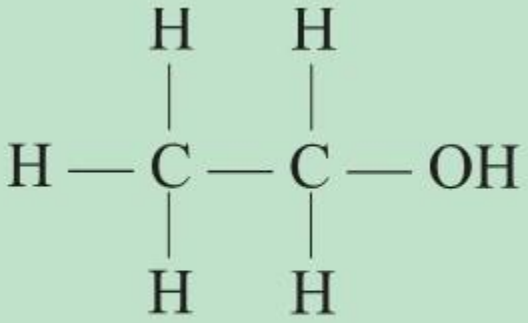
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Primary alcohols are those alcohols which have the hydroxyl group connected to a primary carbon. They can also be defined as a molecule containing a "–CH_2OH" group.

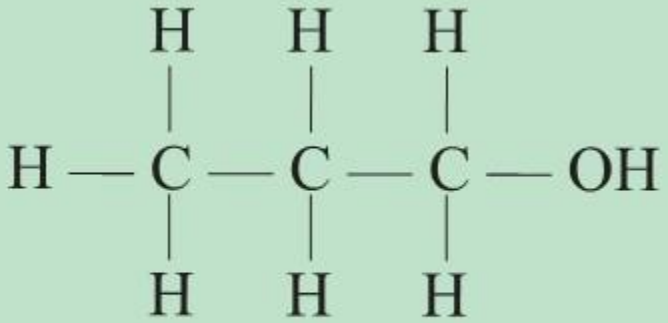
General Structure:



Primary (1°) alcohol



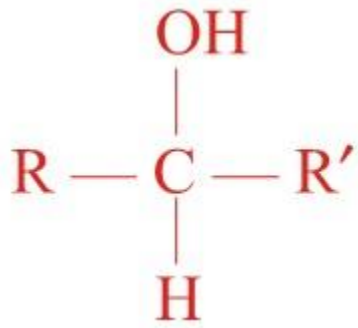
Ethanol



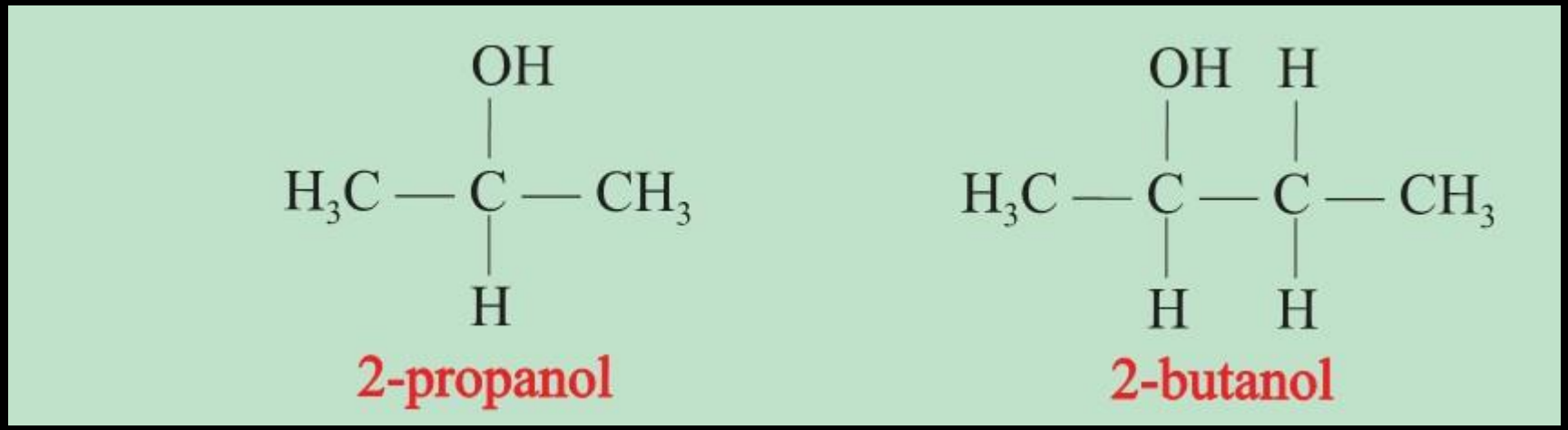
1-propanol

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Secondary alcohols are those in which the carbon atom bonded to the hydroxyl group is attached to two alkyl groups or contains an –OH group bonded to a secondary carbon atom.

General structure:  where R and R′ may be same or different

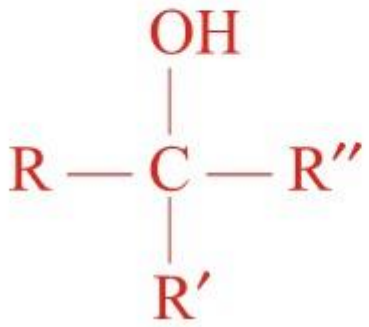
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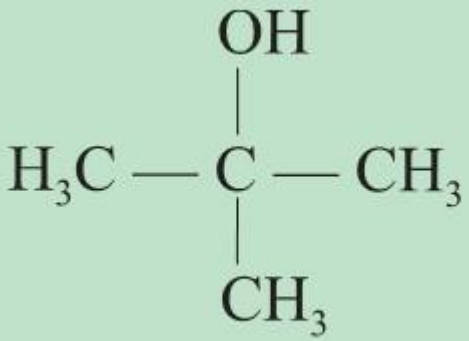
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Tertiary alcohols are those in which the carbon atom bonded to the hydroxyl group is attached to three hydrocarbon (*alkyl*) groups or contain –OH group attached to a tertiary carbon atom.

General Structure:



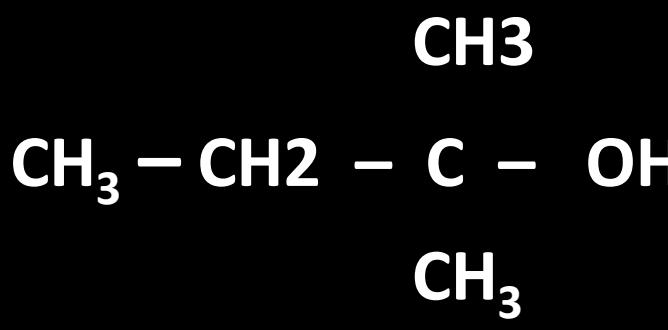
where R, R′ and R′′ may be same or different



2-methyl-2-propanol

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1. Given the structural formula representing an organic molecule:



A. Primary alcohol.
B. Secondary alcohol
C. Tertiary alcohol.
D. Dihydric alcohol.

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2. Given the structural formula representing an organic molecule: $CH_3CH(CH_3)CH(OH)CH_3$ It is a

A. Primary alcohol.

B. Secondary alcohol

C. Tertiary alcohol.

D. Dihydric alcohol.

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Physical Properties of Alcohols

- Due to the hydrogen bonding in alcohols, they have higher melting and boiling points than hydrocarbons of comparable molecular size (mass).
- Hydrogen bonding is also the cause for even lower members to be liquids at room temperature.
- The boiling point of more branched isomer is lower than that of its isomeric straight-chain alcohol.
- Dihydric and the trihydric alcohols have higher boiling points than monohydric alcohols of similar molecular size (mass).

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Why are the melting points of alcohols much higher than those of alkanes having similar molecular mass? This is because, alcohols

A. Are liquids whereas alkanes are gases.
B. Are polar whereas alkanes are non polar.
C. Contain less number of hydrogen atoms than alkanes.
D. Are organic whereas alkanes are inorganic.

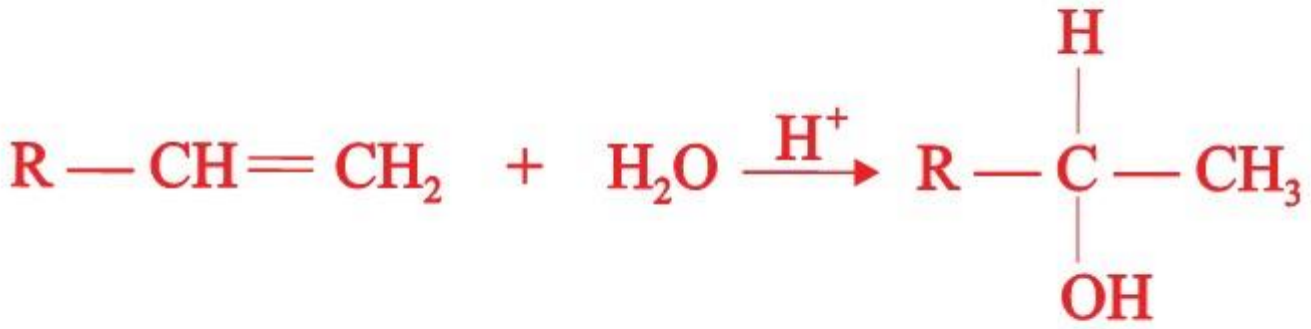
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Preparation of Alcohols

The general laboratory methods of preparation of alcohols are:

a Acid-catalyzed hydration of alkenes:

General Reaction:



Alkene Alcohol

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b Hydrolysis of alkyl halides:

Warming alkyl halides with sodium hydroxide forms alcohols.

General Reaction:

$$R-CH_2X + NaOH \xrightarrow{heat} R-CH_2OH + NaX$$

Alkyl halide
(where X = Cl, Br or I)

Alcohol

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c **Hydrolysis of Esters:**

Heating esters with potassium hydroxide produce alcohols.

General Reaction:

$$RCOOR' + KOH \xrightarrow{heat} RCOOK + R'OH$$

Ester — Alcohol

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Industrial preparation of Ethanol

Ethanol is manufactured industrially by:

1. **Fermentation of carbohydrates such as sugar:** Fermentation is the slow decomposition of carbohydrates such as sucrose, starch and cellulose in the presence of suitable enzyme, that results in the formation of ethanol and carbon dioxide:

$$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow{\text{invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \longrightarrow \underset{\text{Ethanol}}{2CH_3CH_2OH} + 2CO_2$$

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$$2(C_6H_{10}O_5)_n + nH_2O \xrightarrow{\text{Diastase}} nC_{12}H_{22}O_{11} \xrightarrow[\text{Maltase}]{nH_2O} 2nC_6H_{12}O_6$$

Starch — Maltose — Glucose

$$C_6H_{12}O_6 \xrightarrow{\text{Zymase}} CH_3CH_2OH + CO_2$$

Glucose — Ethanol

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2. **Catalytic Hydration of Ethene:** Most ethanol is manufactured at present by this method. In this process, ethene is treated with steam at 573 K and 60 atm pressures in the presence of phosphoric acid, H_3PO_4, catalyst.

$$\underset{\text{Ethene}}{CH_2{=}CH_2\,(g)} + H_2O\,(g) \xrightarrow[573\ k/60\ atm]{H_3PO_4} \underset{\text{Ethanol}}{CH_3CH_2OH\,(g)}$$

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1. Which of the following is the general laboratory method for the preparation of alcohols?

A. Hydrolysis of alkyl halides.

B. Fermentation of carbohydrates.

C. Hydrolysis of ethers.

D. Dehydrohalogenation of alkyl halides.

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2. Dehydrohalogenation of alkyl halides with a base (KOH). Dehydrohalogenation means removal of hydrogen and a halogen atom.

Alkyl halides are compounds of an alkyl group and a halogen such as CH_3Cl and $CH_3 - CH_2 - Br$.

General reaction:

$$R-CH_2-CH_2-X + KOH \longrightarrow R-CH=CH_2 + KX + H_2O$$

Alkylhalide — Alkene

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2. Which of the following methods can be used to produce ethanol in industry?

A. Hydration of ethene with steam at 573K and 60 atm in the presence of a catalyst.

B. Hydrolysis of alkyl halides by heating with sodium hydroxide.

C. Hydrolysis or esters with potassium hydroxide solution.

D. Dehydration of ammonium carbamate.

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3. Industrially ethanol can be prepared by

A. The reaction between CH3COONa and soda lime

B. The reaction between calcium carbide and water

C. Fermentation of carbohydrates such as sugar

D. Dehydrohalogenation of ethyl halide with KOH

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Chemical Properties of Alcohols

The reactions of alcohols involving the –O–H bond cleavage are:

a Alcohols react with strongly electropositive metals like Na, K and Ca to form alkoxides and liberating H_2 gas.

General reaction:

$$2R-CH_2-O-H + 2Na \longrightarrow 2R-CH_2-O^-Na^+ + H_2$$

Alcohol — Sodium ethoxide

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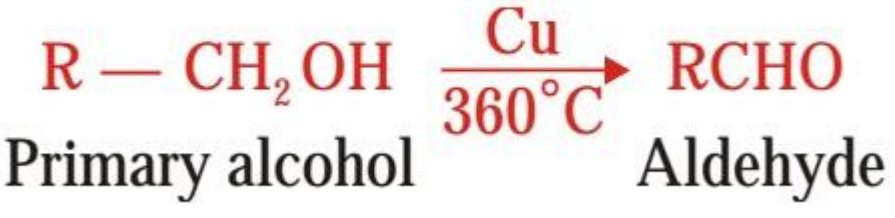
b. Oxidation of alcohols:

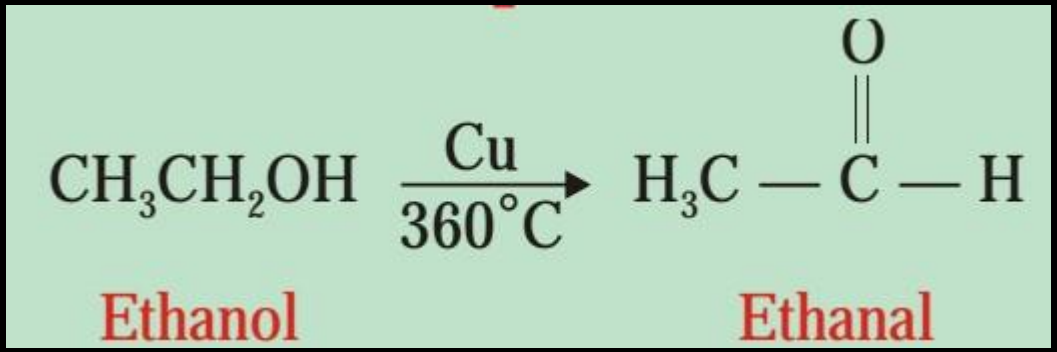
- The oxidation products of alcohols depend on the type of alcohol and the nature of oxidizing agents.
- Oxidation of alcohols is a very important method for the production of other oxygen-containing compounds of hydrocarbons, such as aldehydes, ketones and carboxylic acids.

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i) Oxidation of primary alcohols in the presence of mild oxidizing agents yields aldehydes.

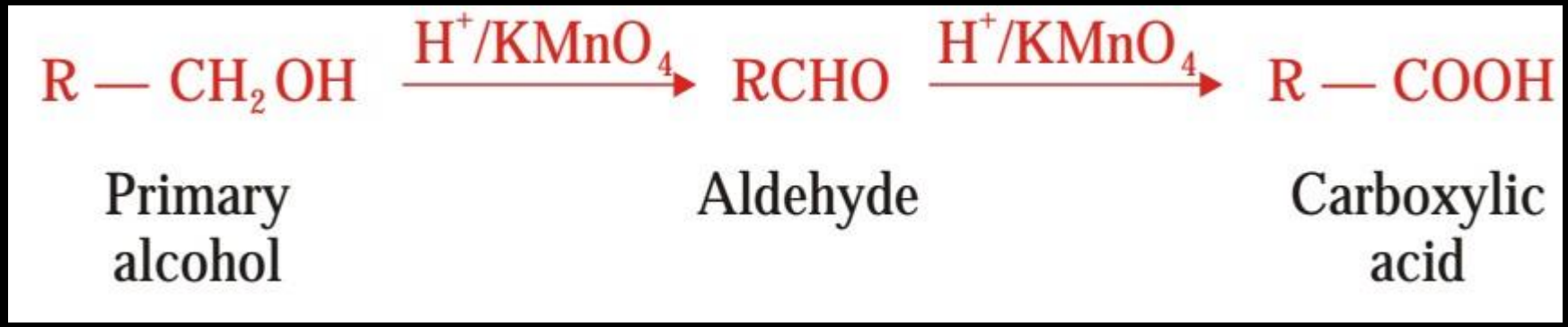
General reaction:





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- Strong oxidizing agents, such as acidified $KMnO_4$ or $K_2Cr_2O_7$and CrO_3 in H_2SO_4, oxidize primary alcohol first to aldehydes and then to carboxylic acids.
- It is difficult to stop the reaction at the aldehyde stage.





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Note that aldehydes are represented by the general structural formula R — C(=O) — H or RCHO, where R is an alkyl group. In the case of methanal R = H. For naming aldehydes, use the suffix *-al* to replace the terminal *-e* in the corresponding alkane name. The suffix "-al" indicates the functional group –CHO. The names and condensed structures of the first six aldehydes are given in Table 1.11.

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Molecular formula of aldehyde	Structure of aldehyde	IUPAC name
CH_2O	HCHO	Methanal
C_2H_4O	CH_3CHO	Ethanal
C_3H_6O	CH_3CH_2CHO	Propanal
C_4H_8O	$CH_3(CH_2)_2CHO$	Butanal
$C_5H_{10}O$	$CH_3(CH_2)_3CHO$	Pentanal
$C_6H_{12}O$	$CH_3(CH_2)_4CHO$	Hexanal

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What is the molecular formula for butanal?

A. C_4H_8O

B. $C_4H_{10}O$

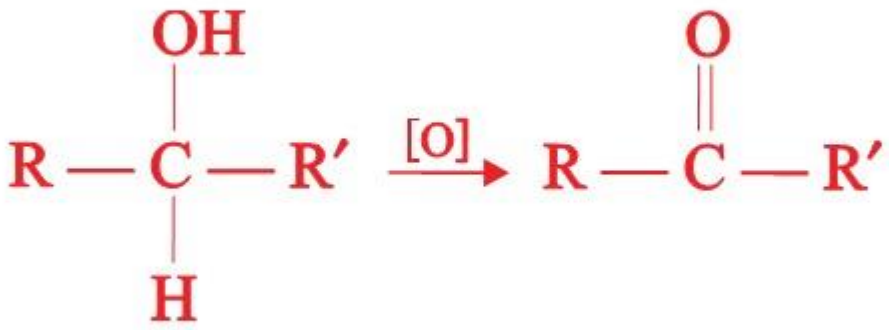
C. $C_4H_9O_2$

D. $C_4H_8O_2$

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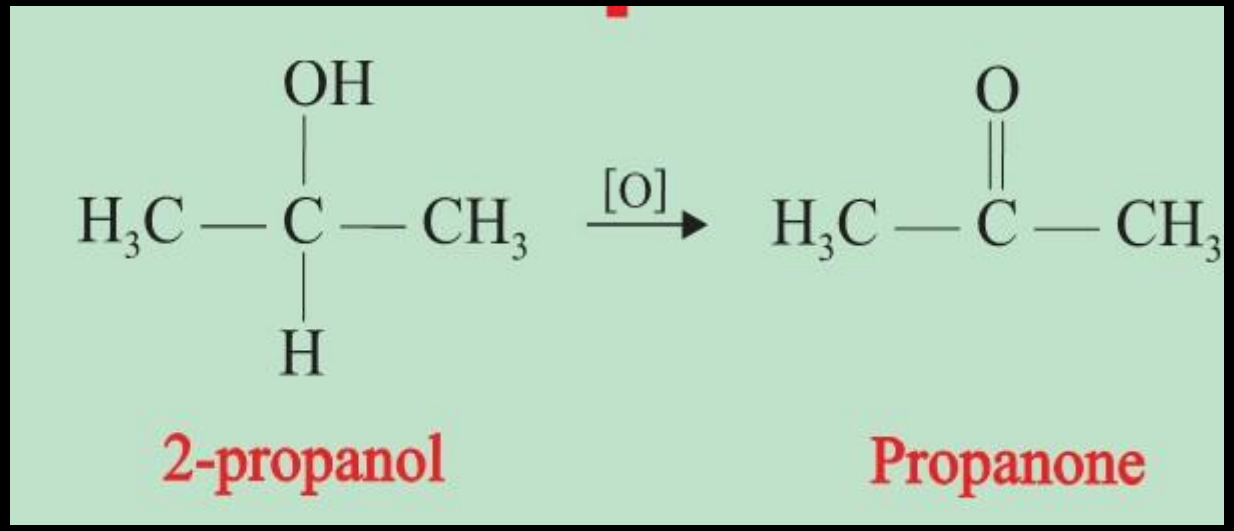
ii) Oxidation of secondary alcohols yields ketones.

General reaction:



Secondary alcohol Ketone

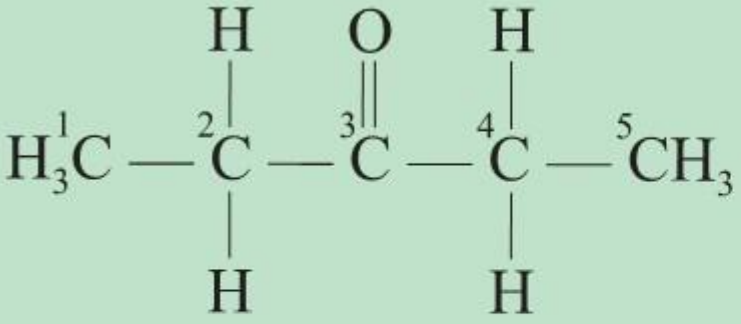
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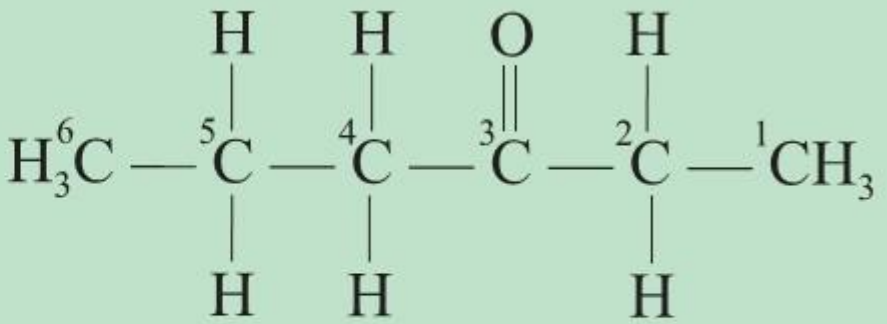
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The general structural formula of ketones is: $R-\overset{\overset{O}{\|}}{C}-R'$ or RCOR' where R and R' may be same or different. The IUPAC names of ketones are obtained by using the suffix *-one* to replace the terminal *-e* in the corresponding alkane name. The suffix '*-one*' indicates the functional group. Unlike aldehydes, the position of the functional group must be indicated in the name of higher ketones. To do so, the longest chain containing the functional group is chosen as a parent structure and then the carbon atoms of the chain are numbered starting from the end closer to the carbonyl group.

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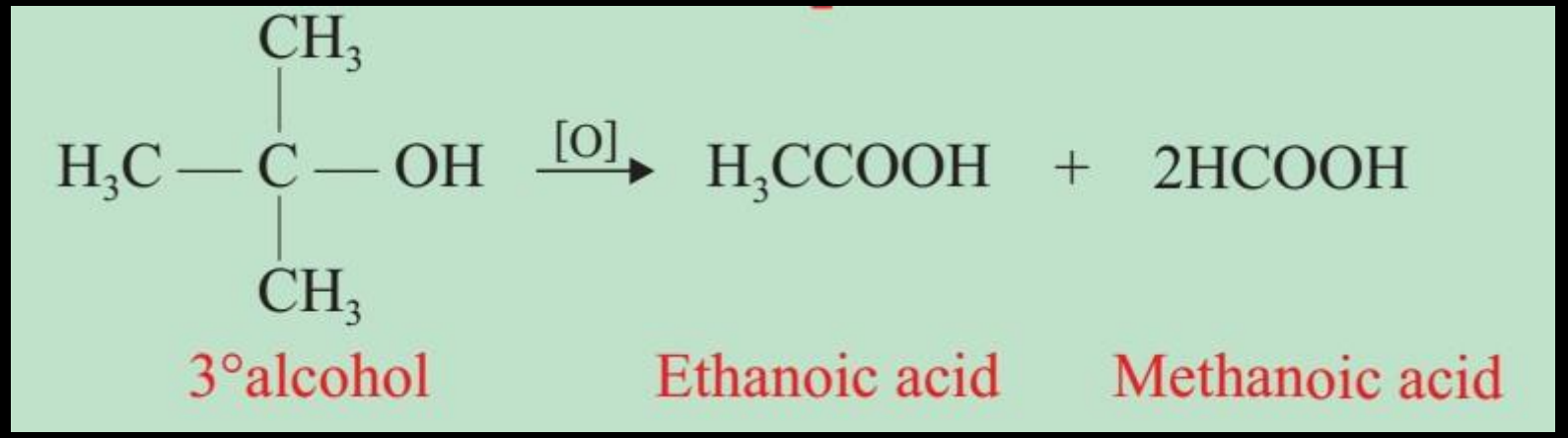
3-pentanone or
pent-3-one



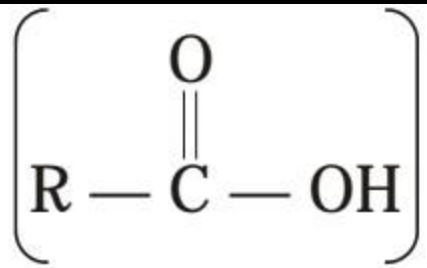
3-hexanone or
hexan-3-one

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iii) Tertiary alcohols and ketones are generally resistant to oxidation. However, they can undergo oxidation under drastic conditions to form a mixture of carboxylic acids.



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The general structural formula of carboxylic acids is  or simply R– COOH where R – is an alkyl group or hydrogen in case of the first member of the carboxylic acid homologous series. The IUPAC names of carboxylic acids are derived by replacing the final *-e* of the corresponding alkane with *-oic acid*. The suffix '-oic acid' representing the functional group –COOH. The molecular formulas, condensed structure and IUPAC names of the first six carboxylic acids are shown in the Table 1.12.

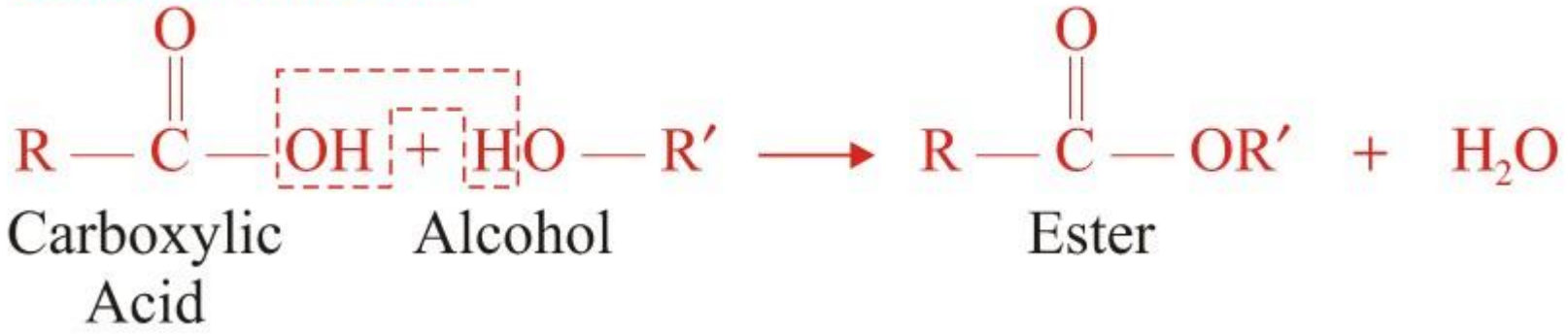
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Formula of carboxylic acid	Condensed structure	IUPAC name of the acid
$HCOOH$	$HCOOH$	Methanoic acid
CH_3COOH	CH_3COOH	Ethanoic acid
C_2H_5COOH	CH_3CH_2COOH	Propanoic acid
C_3H_7COOH	$CH_3 \rightarrow (CH_2)_2\ COOH$	Butanoic acid
C_4H_9COOH	$CH_3 \rightarrow (CH_2)_3 \rightarrow COOH$	Pentanoic acid
$C_5H_{11}COOH$	$CH_3 \rightarrow (CH_2)_4 \rightarrow COOH$	Hexanoic acid

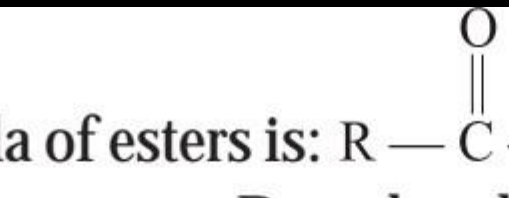
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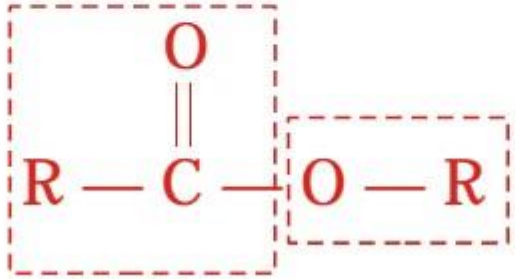
c **Esterification:** Carboxylic acids react with alcohols to form esters. This reaction is known as esterification.

General reaction:



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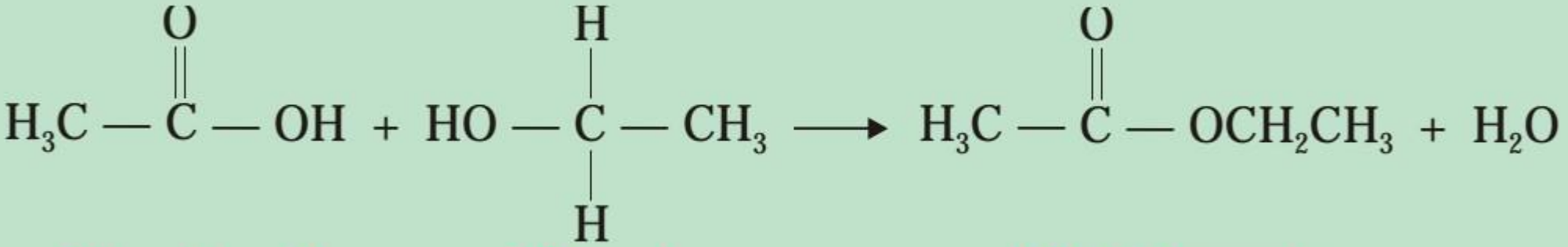
The general structural formula of esters is:  or simply RCOOR′ where R and R′ are alkyl groups. In some cases, R can be a hydrogen atom. In the nomenclature of esters they are considered as derivatives of both carboxylic acids and alcohols.



Acid portion Alcohol portion

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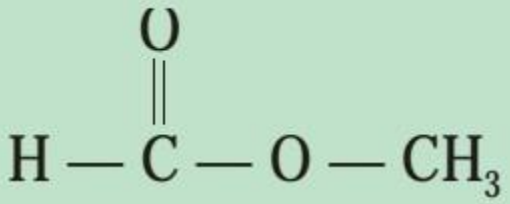
Example



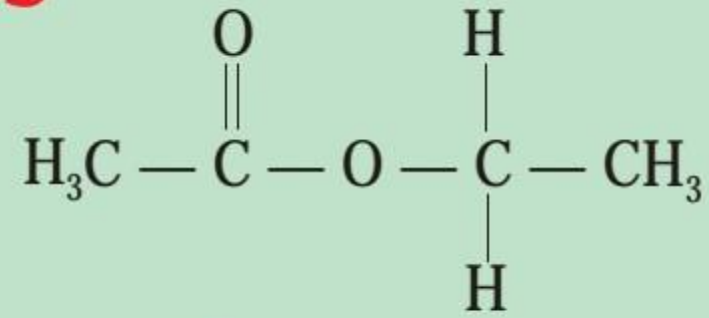
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- **Esters** are named first by naming the alkyl group derived from the alcohol followed by the name of the acid changing the suffix **"-ic acid" to "-ate".**

Examples



Methyl methanoate



Ethyl ethanoate

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Which structure represents n-butyl methanoate?

A. $CH_3CH_2CH_2COOCH_3$

B. $CH_3COOCH_2CH_2CH_3$

C. $HOOCCH_2CH_2CH_2CH_3$

D. $HCOOCH_2CH_2CH_2CH_3$

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INDUSTRIAL AND AGRICULTURAL APPLICATIONS OF ORGANIC COMPOUNDS

Industrial application

- Organic chemicals are used for the manufacturing of a large number of industrial products that have a variety of uses.
- Some of these products include alcoholic beverages, pharmaceuticals, soaps and detergents etc.

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A. Alcoholic beverages

- All alcoholic beverages commonly contain the alcohol known as **ethanol.**
- The ethanol content of all alcoholic beverages is not the same.
- These alcoholic beverages can be either undistilled or distilled.
- The **undistilled alcoholic beverages** include beer, wine, “Tella”, ‘Tej’ etc
- while ouzo, gin, brandy, whisky, ‘Katikalla’, and vodka are among the **distilled alcoholic beverages.**

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Beer:

- The common raw materials for its production are **barley** and **hops**.
- The average beer has alcohol content between **3-6 percent** by volume.

Wine:

- The most common raw material for producing wine are **grapes**
- Most wines have an alcohol content varying from **10-15% by volume**.

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B. Pharmaceuticals

- Organic chemicals are used to manufacture drugs and medicines for various uses.
- These drugs and medicines are collectively known as **pharmaceuticals.**

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Analgesics: These are substances that reduce pain. For example: aspirin and paracetamol.

Antiseptics: These are substances that help to prevent infections in wounds by killing bacteria; for example, acriflavine.

Sedatives: These are drugs that make a person go to sleep or make them feel calm and relaxed. Examples of such type of medicines are the barbiturates, which include several important drugs.

Disinfectants: These are substances used to disinfect something or to kill bacteria; for example, Dettol.

Sulphonamides: These are medicines used as antibiotics. For example: penicillin.

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Soaps and Detergents

- animal fat and vegetable oils are used for manufacturing soap.
- They are also called surfactants or surface active agents.
- Soaps that are sodium salts are called hard soaps and those that are potassium salts are soft soaps.
- Soaps are prepared by boiling animal fat or vegetable oil with a base.
- The reaction that produces soap is called saponification.
- Detergents contain either a sulfate or a sulphonate group.
- One example of detergents is sodium lauryl sulfate,

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Dry Cleaning

- Dry cleaning refers to the use of different chemicals that are capable of dissolving grease and other dirt stains in a similar manner as soaps without the use of water.
- The most commonly used chemicals in dry cleaning are organic chemicals such as tetra chloromethane; tetrachloroethylene, ; benzene and gasoline.

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Agricultural Applications

- Organic compounds also play an important role in agriculture, specially to increase crop productivity by controlling the damages caused by insects, rodents, fungi, birds and weeds.

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Pesticides

- Are the chemicals used for controlling the damage that can be caused by fungi,insects and other pests that attack crops.
- Among the pesticides, **Bordeaux mixture** is used as fungicide.
- Other chemicals like **DDT**, **aldrine**, **dieldrine**, **malathion** are used as **insecticides.**

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Herbicides

- are the chemicals that are applied on agricultural lands to remove unwanted plants or weeds.
- Some examples of compounds that are used as herbicides include paraquat, diquat, ammonium sulphamate, ammonium glyphosinate, sodium chlorate etc.

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Fertilizers:

- In order to increase crop productivity we use either synthetic or natural fertilizers.
- Synthetic fertilizers are grouped into three classes as nitrogen, potash and phosphate fertilizers.

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Which of the following substances is correctly matches with its use?

- ○ Tetra chloromethane → Dry cleaning.
- ○ Sodiumlaurylsulfate → fuel
- ○ Malathion → Herbicide
- ○ DDT → Detergent

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THE END