

Organic Chemistry

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It is the chemistry of specific carbon compounds except oxides, carbonates and carbides.

Hydrocarbons

Organic compounds composed of carbon and hydrogen only.

Examples: Methane (CH_4), ethane (C_2H_6)

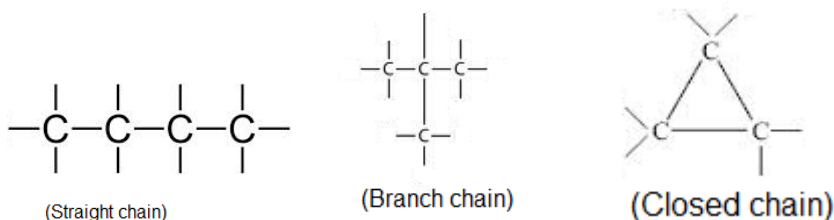
Unique Nature of Carbon

Tetravalency of Carbon

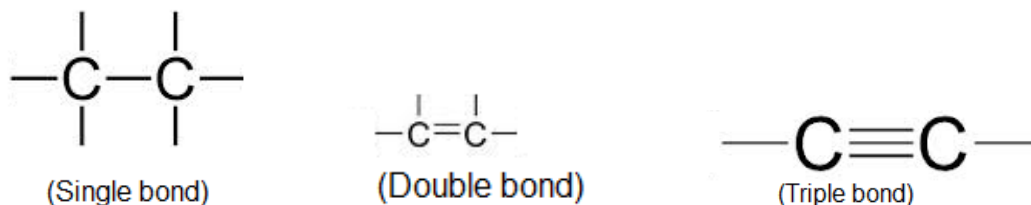
- Carbon forms four covalent bonds by mutually sharing its four electrons with other atoms.
- It is hence tetravalent or exhibits tetravalency.

Catenation

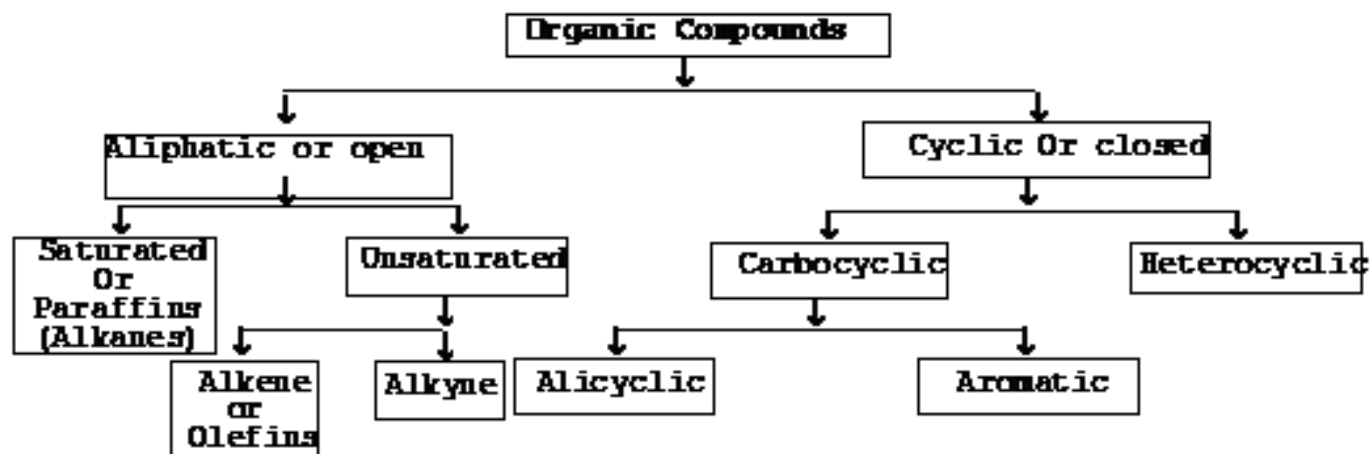
- It is the tendency of an element to form chains of identical atoms.
- Catenation is maximum in carbon because the value of the C–C bond energy is maximum.
- Carbon undergoes self-linking forming straight, branched and closed chains.



- Catenation and tetravalency also result in the formation of single, double and triple bonds.



Classification of Organic Compounds

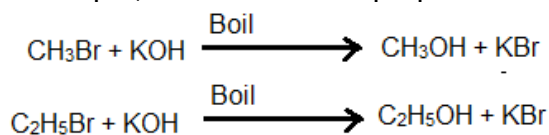


Homologous Series

It is a group of organic compounds with a similar structure and similar chemical properties in which the successive compounds differ by a CH_2 group.

Characteristics of a homologous series

- Each member of the series differs from the preceding one by the addition of a CH_2 group and by 14 amu.
- All members of a homologous series share a general formula.
For example, the general formula for alkane is $\text{C}_n\text{H}_{2n+2}$ and that for alkene is C_nH_{2n} .
- The physical properties of the members show gradation in properties as molecular mass increases.
- The chemical properties also show gradient similarity.
For example, methane and ethane react with chlorine to form methyl chloride and ethyl chloride, respectively.
 $\text{CH}_4 + \text{Cl}_2 \rightarrow \text{CH}_3\text{Cl}$
 $\text{C}_2\text{H}_6 + \text{Cl}_2 \rightarrow \text{C}_2\text{H}_5\text{Cl}$
- All members of a homologous series can be prepared by the same general method of preparation.
For example, alcohols can be prepared from alkyl halides.



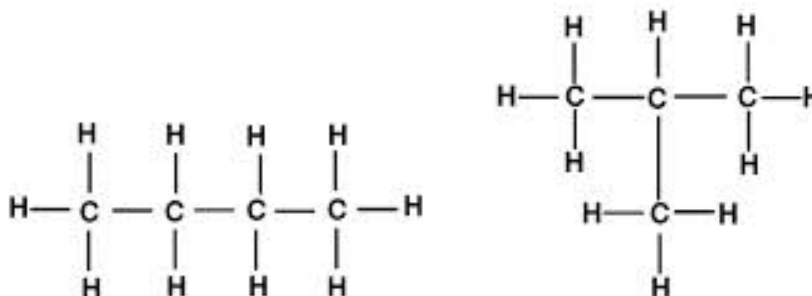
Significance of a Homologous Series

- Helps in the systematic study of organic compounds.
- Predicts the properties and the nature of other elements of the series if the same is known of the first few members.

Isomers

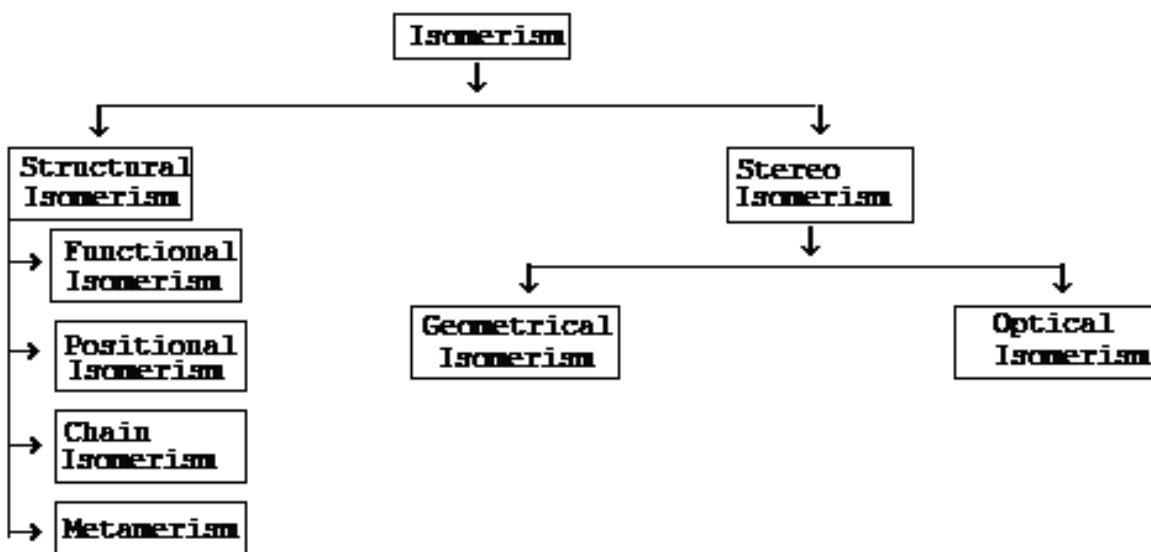
Compounds with the same molecular formula but different structural formula are known as isomers, and the phenomenon is known as isomerism.

Examples: Butane and isobutane are two different compounds with the same molecular formula C_4H_{10} .



Butane

Isobutane



Causes of Isomerism

- Difference in the mode of linking of atoms.
- Difference in the arrangement of atoms or groups in space.

Different Types of Structural Isomerism

i. Chain isomerism

Two or more compounds which have a similar molecular formula but different arrangement of carbon atoms in straight or branched chains are referred to as chain isomers, and the phenomenon is known as chain isomerism.

ii. Position isomerism

When two or more compounds with the same molecular formula differ in the position of the substituent atom or functional group on the carbon atom, they are called position isomers, and the phenomenon is known as position isomerism.

iii. Functional isomerism

Two or more compounds with the same molecular formula but different functional groups are called functional isomers, and the phenomenon is known as functional isomerism.

iv. Metamerism

It arises because of unequal distribution of alkyl groups on either side of the functional groups in the molecules.

Nomenclature

It is the system of assigning names to organic compounds.

The Systems of Nomenclature Are

- Trivial system
- IUPAC (International Union of Pure and Applied Chemistry) system

According to the IUPAC system, the name of an organic compound consists of three parts:

- Root word
- Suffix
- Prefix

i. Root word

It depends on the number of carbon atoms present in the longest carbon chain selected.

Number of carbon atoms	Root word
One carbon atom C_1	Meth
Two carbon atoms C_2	Eth
Three carbon atoms C_3	Prop
Four carbon atoms C_4	But
Five carbon atoms C_5	Pent
Six carbon atoms C_6	Hex
Seven carbon atoms C_7	Hept
Eight carbon atoms C_8	Oct
Nine carbon atoms C_9	Non
Ten carbon atoms C_{10}	Dec

ii. Suffix

The root word is followed by an appropriate suffix, which represents the nature of the bond in a carbon-carbon atom.

Nature of bond	Suffix	General name	General formula
Single bond (C-C)	-ane	Alkane	C_nH_{2n+2}
Double bond (C=C)	-ene	Alkene	C_nH_{2n}
Triple bond ($C \equiv C$)	-yne	Alkyne	C_nH_{2n-2}
Group (R-)	-yl	Alkyl	C_nH_{2n+1}

iii. Prefix

It denotes the substituent, alkyl or functional group and its position in the carbon chain.

Di-, tri- and tetra- are used for two, three and four groups of the same type, respectively.

Functional Group

It is an atom or a group of atoms which defines the structure (or the properties of a particular family) of organic compounds.

Characteristics of a Functional Group

- Compounds of the same functional group are identified using the same types of tests.
- The physical and chemical properties of the compounds of different functional groups are different.
- There exists a homologous series of compounds containing a particular type of functional group.

Functional group	General formulae	Organic compound	Suffix	Examples with common and IUPAC name
Halide -X (F, Cl, Br, I)	R-X	Haloalkanes	ane	CH ₃ Cl Common name: Methyl chloride IUPAC name: Chloromethane
Hydroxyl -OH	R-OH	Alcohols	ol	C ₂ H ₅ OH Common name: Ethyl alcohol IUPAC name: Ethanol
Aldehyde -CHO	$\begin{array}{c} \text{H} \\ \diagup \\ \text{R} - \text{C} = \text{O} \end{array}$	Aldehydes	al	CH ₃ CHO Common name: Acetaldehyde IUPAC name: Ethanal
Carboxyl -COOH	$\begin{array}{c} \text{O} \\ \parallel \\ \text{R} - \text{C} - \text{O} - \text{H} \end{array}$	Carboxylic acids	oic acid	CH ₃ CH ₂ COOH Common name: Propionic acid IUPAC name: Propanoic acid
Keto $\begin{array}{c} \text{O} \\ \parallel \\ - \text{C} - \end{array}$	$\begin{array}{c} \text{O} \\ \parallel \\ \text{R} - \text{C} - \text{R}' \end{array}$	Ketones	one	CH ₃ COC ₂ H ₅ Common name: Diethyl ketone IUPAC name: Pentanone
Ethers $\begin{array}{c} & & \\ - \text{C} - & \text{O} - & \text{C} - \\ & & \end{array}$	R-O-R'	Ethers	oxy	CH ₃ -O-C ₂ H ₅ Common name: Ethyl methyl ether IUPAC name: Methoxy ethane

Alkanes

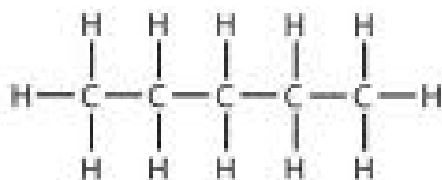
- Alkanes are hydrocarbons in which all the linkages between the carbon atoms are single covalent bonds.
- Compounds are known as saturated hydrocarbons because all the four valencies of carbon are fully satisfied.
- General formula : C_nH_{2n+2}
- These hydrocarbons are relatively unreactive under ordinary conditions so they are also called paraffins.

Isomerism in Alkanes

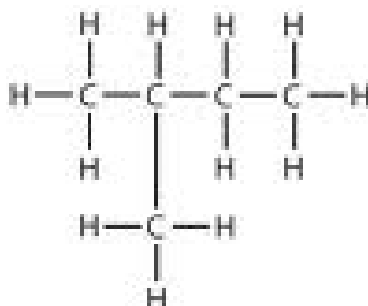
- Alkanes with more than three carbon atoms form isomers.
- The various isomers differ in the framework of the carbon chains.

Example:

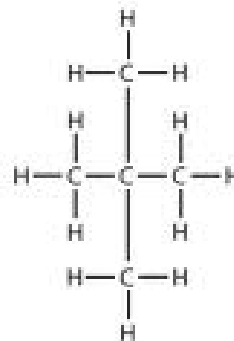
Isomers of Pentane (C₅H₁₂)



n-pentane

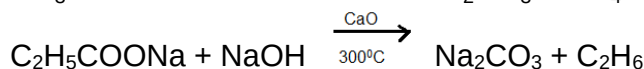
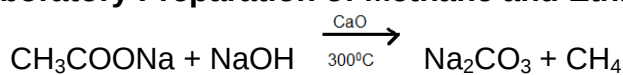


isopentane



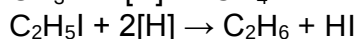
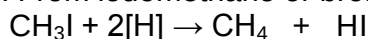
neo-pentane

Laboratory Preparation of Methane and Ethane

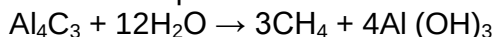


Methods of Preparation of Methane and Ethane

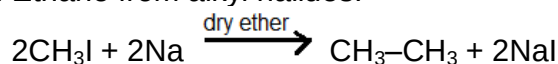
- From iodomethane or bromoethane:



- Methane is produced on addition of water to aluminium carbide at room temperature.



- Ethane from alkyl halides:

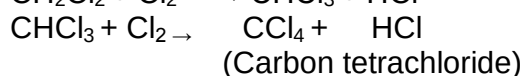
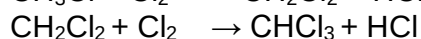
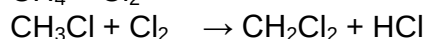
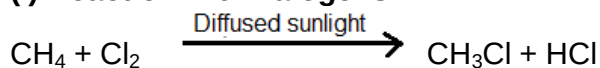


This reaction is known as the Wurtz reaction.

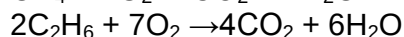
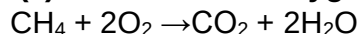
Chemical Properties

1. Substitution reaction

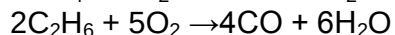
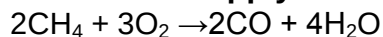
(i) Reaction with halogens



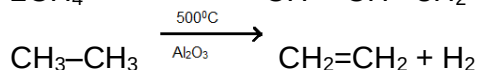
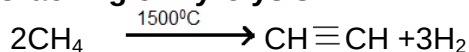
(ii) Reaction with oxygen



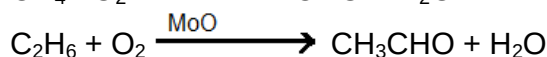
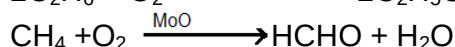
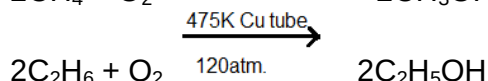
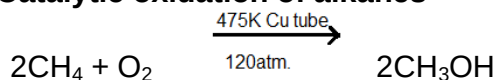
Insufficient supply of air



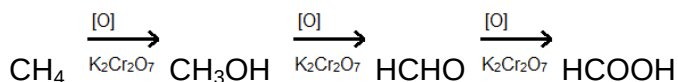
2. Cracking or Pyrolysis



3. Catalytic oxidation of alkanes



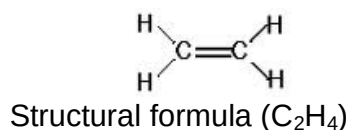
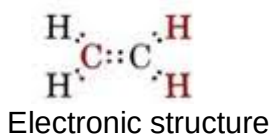
4. Slow combustion



Alkenes

- Alkenes are unsaturated aliphatic hydrocarbons containing a carbon–carbon double bond.
- They are also called olefins because of their tendency to form oily products.
- The general formula of alkenes is C_nH_{2n} .

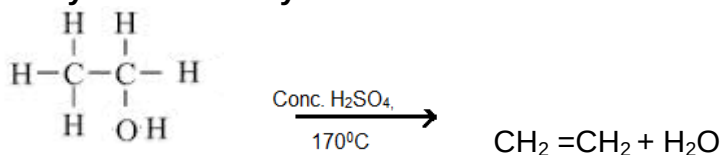
Structure of Ethene



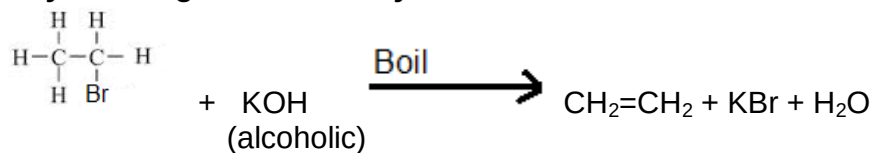
- Two carbon atoms linked by a double covalent bond.
- A double covalent bond is formed by sharing of two pairs of electrons between the two carbon atoms.
- Four C–H single covalent bonds and one C=C double covalent bond.
- It is a planar molecule and all bond angles (H–C–H and H–C=C) are of 120° .

Preparation of Ethene

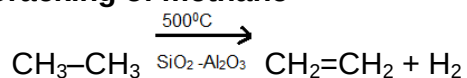
i. Dehydration of ethyl alcohol



ii. Dehydrohalogenation of ethyl bromide



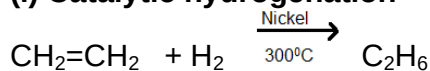
iii. Cracking of methane



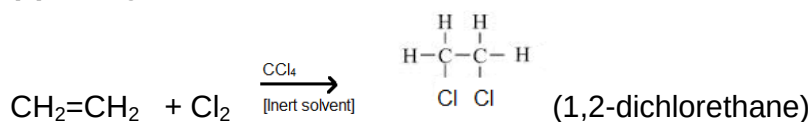
Chemical properties

1. Addition Reactions

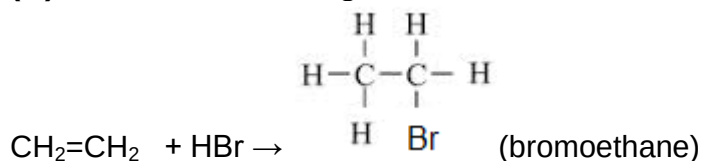
(i) Catalytic hydrogenation



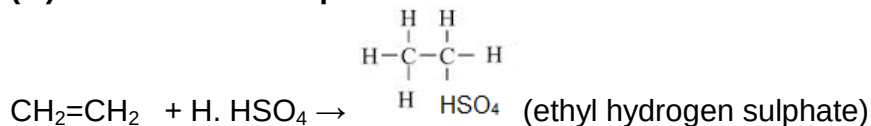
(ii) Halogenation



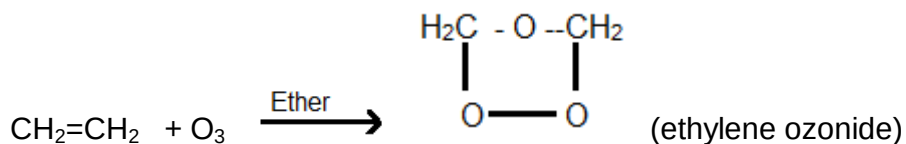
(iii) Reaction with Halogen Acids



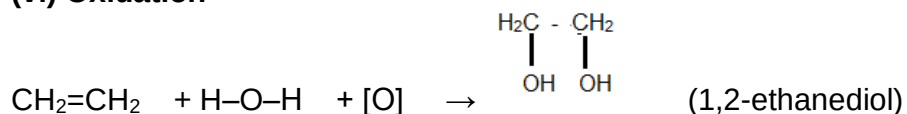
(iv) Reaction with Sulphuric acid



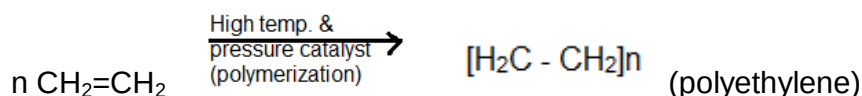
(v) Ozone



(vi) Oxidation



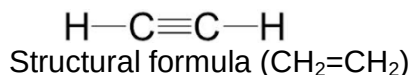
(vii) Polymerisation



Alkynes

- Alkynes are unsaturated aliphatic hydrocarbons containing a carbon–carbon triple bond in their molecule.
- The general formula of alkynes is $\text{C}_n\text{H}_{2n-2}$.
- They are more reactive than alkenes because of the presence of a triple bond, often referred to as an acetylenic linkage.

Structural formula of Ethyne

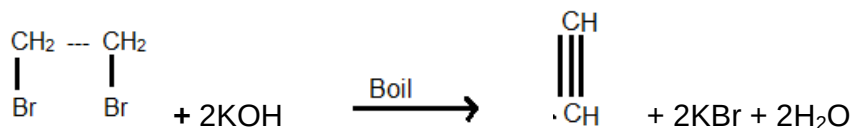


Preparation of Ethyne

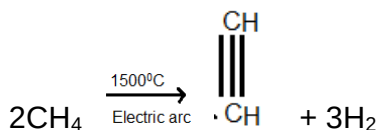
i. Laboratory preparation from calcium carbide



ii. From 1,2-dibromoethane



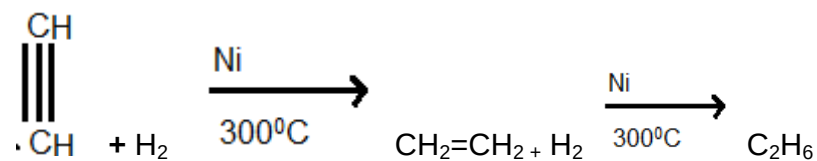
iii. From methane



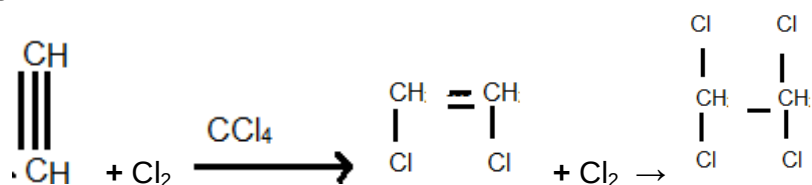
Chemical Properties

1. Addition Reactions

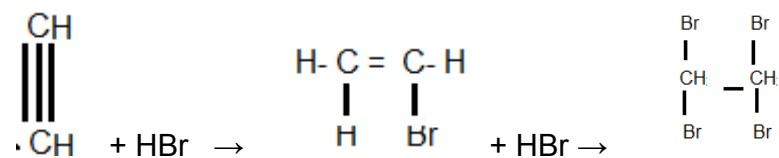
a] Catalytic Hydrogenation



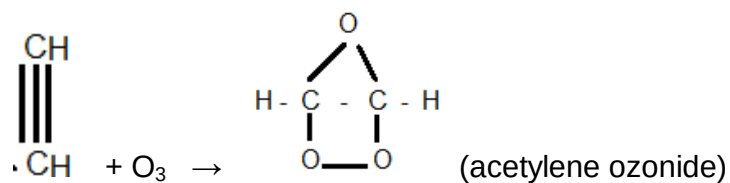
b] Halogenation



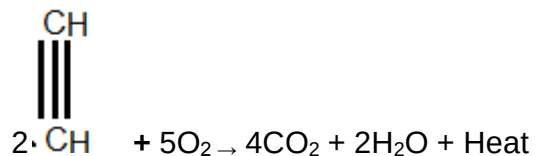
c] Reaction with Halogen Acids



d] Ozone



e] Oxidation of ethyne (Combustion)

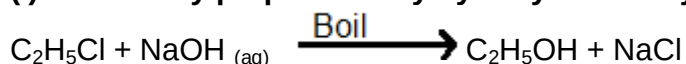


Alcohols

- Alcohols are hydroxyl derivatives of alkanes obtained by replacement of one, two or three hydrogen atoms of alkanes by the corresponding number of –OH groups.
- The hydroxyl group is the functional group of alcohols.
- The general molecular formula of alcohols is $C_nH_{2n+1}OH$.

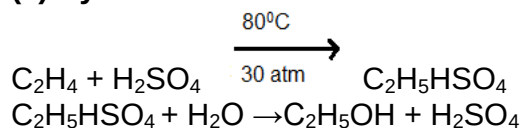
Preparation of Ethanol

(i) Laboratory preparation by hydrolysis of alkyl halides

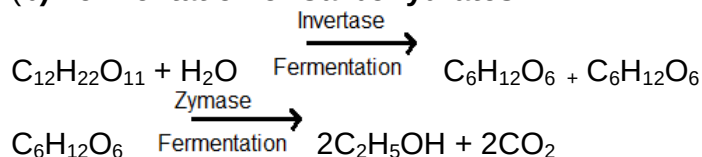


(ii) Industrial Method

(a) Hydration of Ethene

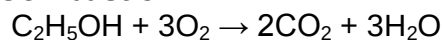


(b) Fermentation of Carbohydrates

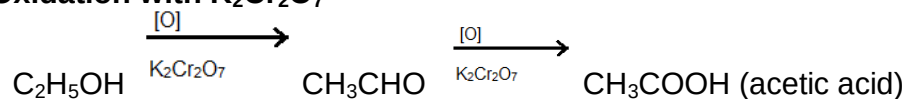


Chemical properties

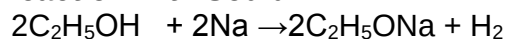
1. Combustion



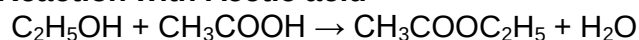
2. Oxidation with $K_2Cr_2O_7$



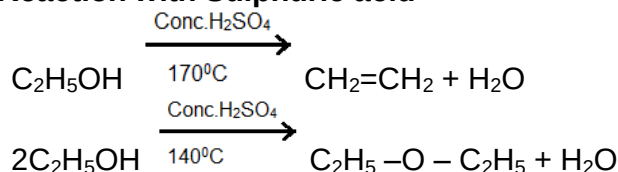
3. Reaction with Sodium



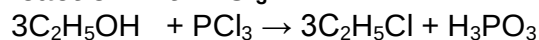
4. Reaction with Acetic acid



5. Reaction with Sulphuric acid



6. Reaction with PCl_3

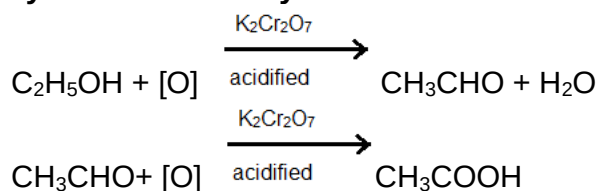


Carboxylic Acids

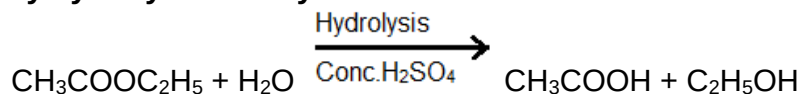
- Carboxylic acids are organic compounds containing a carboxylic group ($-\text{COOH}$) attached to an alkyl group or to a hydrogen atom.
- Representation of carboxylic acids: $\text{R}-\text{COOH}$ (R is either $-\text{H}$ or alkyl)
- The functional group of carboxylic acids: $-\text{COOH}$ (carboxylic)
- The acidic character in carboxylic acids is because of the presence of the replaceable hydrogen atom in the carboxylic group.

Preparation of Acetic Acid

A] By oxidation of ethyl alcohol



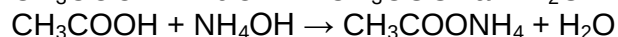
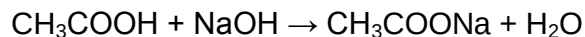
B] By hydrolysis of ethyl acetate



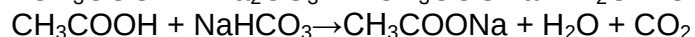
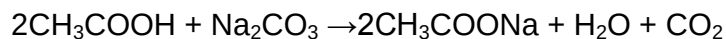
Chemical Properties

1. It is a weak acid and turns blue litmus red.

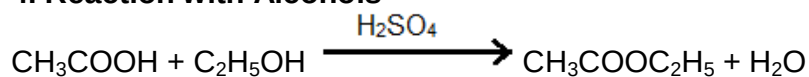
2. Reaction with Alkalis



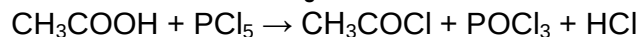
3. Reaction with Carbonates



4. Reaction with Alcohols



5. Reaction with PCl_3



6. Reduction

