CARBON AND ITS COMPOUNDS

CONTENTS

INTRODUCTION

Carbon is most important element because it forms largest number of compounds which are useful in our daily life. In this chapter, we shall study about carbon and its compounds.

❖ **Important Terms and Concepts :**

1. **Carbon :** Its atomic number is 6. Its mass number is 1.20. Its atomic mass is 12.011. Its melting point is 3550ºC and boiling point is 4830ºC. It occurs in free state as well as in combined state. 70% of our body is made up of carbon. It forms largest number of compounds. The earth crust contains only 0.02% of carbon.

2. **Organic Compounds :** Those compounds which consist of carbon essentially and hydrogen mostly along with other elements like oxygen, sulphur, nitrogen, halogens, etc. are called organic compounds.

3. **Coal :** It is a naturally occurring solid fuel which exists in the form of varying depths below the earth's surface. It is formed by decay of vegetation that grew 40 to 300 million years ago, followed by chemical processes of condensation and polymerization under influence of temperature, pressure and time.

4. **Petroleum :** It is an oil found in rocks. It is a mixture of solid, liquid and gaseous hydrocarbons. It is a source of petrol, diesel, kerosene, petroleum ether, petroleum coke, petroleum wax, etc.

5. **Carbonates :** They are compounds of carbonic acid. They are found in earth crust, *e.g.*, $CaCO_3$, $MgCO_3$, Na_2CO_3, Na_2CO_3, $ZnCO_3$. They are thermally stable.

6. **Hydrogen Carbonates :** They contain HCO_3^- ions. They are formed by replacing one H^+ of carbonic acid, *e.g.*, $NaHCO_3$, $Ca(HCO_3)_2$, $Mg(HCO_3)_2$. They are soluble in water. They are thermally unstable, *i.e.*, decompose on heating to form carbonates, CO_2 and H_2O.

7. **Chemical Bond :** It is a force of attraction which holds the two atoms together.

8. **Covalent Bond :** It is the bond formed by equal sharing of electrons, *e.g.*, Hydrogen has one valence electron. It can share one valence electron with other hydrogen atom to form H_2 molecule so as to acquire nearest noble gas configuration. The bond between two hydrogen atoms by sharing one electron each is called covalent bond.

9. **Covalency of Carbon :** Carbon has four valence electrons. It cannot lose four electrons since very high amount of energy will be required to lose four electrons to form C^{4+} ion. There is strong force of attraction between nucleus and valence electrons.

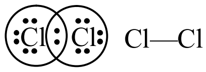
   Carbon cannot gain four electrons to form C^{4-} ion because six protons cannot hold 10 electrons easily and there will be strong interelectronic repulsion.

   Carbon can share four electrons easily with other atoms of carbon and other elements to acquire stable electronic configuration.

10. Hydrogen Molecule : When two atoms of hydrogen share one electron each, a single covalent bond is formed as shown below

(Single covalent bond between two hydrogen atoms)

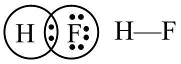
11. Chlorine Molecule : Chlorine has 7 valence electrons. It can share one electron with other chlorine atom to form Cl_2.



(Single covalent bond between two chlorine atoms)

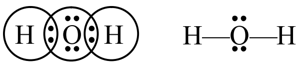
12. Single Covalent Bond : It is a bond formed by sharing of one electron by each of the atoms. It is represented by a line between two atoms.

13. Hydrogen Fluoride : When one hydrogen atom shares one electron with one electron of fluorine, hydrogen acquires two electrons whereas fluorine acquires 8 electrons and becomes stable. They form single covalent bond.

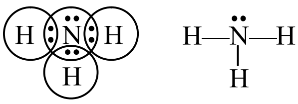


(Single Covalent bond between hydrogen and fluorine)

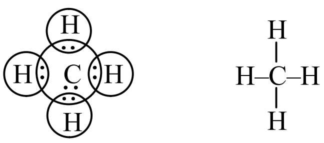
14. Water : In formation of H_2O, each hydrogen atoms shares one electron with oxygen atom so that oxygen completes its octet and hydrogen acquires nearest nobles gas configuration.



15. Ammonia : Nitrogen has five valence electrons. It shares one electron with each of the three hydrogen atoms to form NH_3.



16. Methane : Carbon has four valence electrons. It needs four electrons to complete its octet. It shares four electrons with four hydrogen atoms and forms four single covalent bonds.

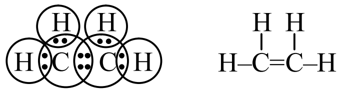


17. Double Covalent Bond: When two atoms share two electrons each to acquire stable electronic configuration, double covalent bond is formed. It is denoted by = (two lines)

18. Oxygen Molecule : When two oxygen atoms share two electrons each to complete their octet, double covalent bond is formed.

(A double covalent bond between two oxygen atoms)

19. Ethene (C_2H_4) : When two carbon atoms share two electrons with each other and each 'C' shares two electrons with two hydrogen atoms, they complete their octet and form double covalent bond between two carbon atoms.

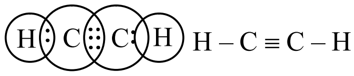


20. Triple Covalent Bond : When an atom shares three valence electrons with each other or other atom, triple covalent bond is formed. It is denoted by ≡(three lines)

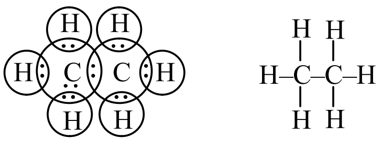
21. Nitrogen : Nitrogen has five valence electrons. It needs three more electrons to complete its octet. It shares three electrons with other atom of nitrogen to form triple covalent bond.

(Triple covalent bond between two nitrogen atoms)

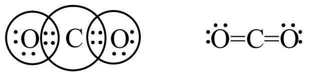
22. Ethyne (C_2H_2) : When two carbon atoms share three electrons with each other and each carbon shares one electron with hydrogen atom, they complete their octet and form triple covalent bond with each other.



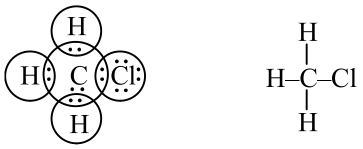
23. Ethane (C_2H_6) : In the ethane, two carbon atoms share one electron each forming single covalent bond with each other. Each carbon shares one electron with three hydrogen atoms to complete their octet, *e.g.*,



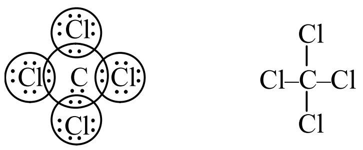
24. Carbon dioxide : Carbon has four valence electron. It shares two electron with one of the oxygen and two electrons with other atom of oxygen to form double covalent bond.



25. Methyl chloride (CH_3Cl) : Carbon has four valence electrons. It shares one electron with chlorine atom and one electron with each of three hydrogen atoms forming four single bond.



26. Carbon tetrachloride (CCl_4) : Carbon shares one electron with each of four chlorine atoms forming four single covalent bonds.



27. Properties of Covalent Compounds :

(i) Physical State : Covalent compounds can exist in solid, liquid as well as gaseous state *e.g.*, CH_4 is gas, $CHCl_3$ is liquid, glucose is solid.

(ii) Solubility :

(a) They are generally insoluble in water and in polar solvents because they cannot form ions in aqueous solution.

(b) They are soluble in non-polar organic solvents like ether, benzene, CCl_4, CS_2, $CHCl_3$, acetone etc.

(iii) Electrical Conductivity : Covalent compounds are poor conductors of electricity because they do not contain ions or free electrons for conduction of electricity, *e.g.*, CCl_4, benzene, toluene do not conduct electricity.

(iv) Melting and Boiling Point : Melting and boiling points of covalent compounds are low due to weak forces of attraction between molecules. Less energy is required to overcome these forces of attraction, e.g.,

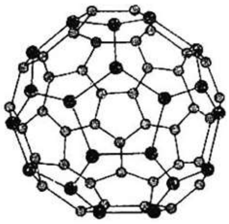
Compound	Melting point (in K)	Boiling Point (in K)
1. Acetic acid (CH_3COOH)	290	391
2. Chloroform ($CHCl_3$)	209	334
3. Carbon tetrachloride (CCl_4)	250	349.5
4 Ethanol (C_2H_5OH)	156	351
5. Methane (CH_4)	90	111
6. Methanoic acid (HCOOH)	281.4	373.5

28. Allotropy : It is a property due to which an element can exist in more than one form which differ in physical properties but have similar chemical properties, e.g., carbon, sulphur, phosphorus, oxygen show allotropy,

29. Isotopes of Carbon : Naturally occurring carbon has two stable isotopes ${}^{12}_{6}C$ (98.9%) and ${}^{13}_{6}C$ (1.1%) in addition to traces of radioactive ${}^{14}_{6}C$ isotope which is used to determine the age of archaeological specimen of organic origin. The isotope ${}^{12}_{6}C$ is the international standard for atomic mass measurement and assigned a mass of 12.00000 units.

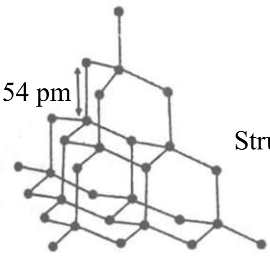
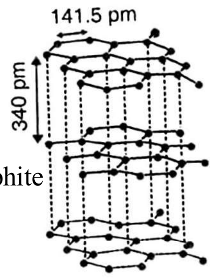
30. Allotropes of Carbon : The carbon exists both in crystalline and amorphous forms. The two well known allotropes of carbon are diamond and graphite.

31. Fullerenes : A third form of carbon known as *fullerenes* were discovered by H.W. Kroto, R.F. Curt and R.E. Smalley. Fullerenes consist of hollow cage of carbon atoms. They are large spheroidal molecules of composition C_{2n}; two important members of this family are C_{60} and C_{70}. The 1996 Nobel Prize was awarded to above scientists for the discovery of fullerenes.



The structure of C_{60}, Buckminsterfullerene : Note that the molecule has the shape of a soccer ball (football)

32. Differences between Diamond and Graphite

Diamond	Graphite
1. It is hardest substance known and its density is 3.5 g/ml.	1. Graphite is soft and slippery with density of 2.3 g/ml
2. Its crystals are octahedral, colourless and transparent	2. It is black coloured, opaque and has hexagonal crystals.
3. In diamond, each carbon atom is covalently bonded to four other carbon atoms along four corners of regular tetrahedron. This pattern extends in three dimensions. Diamond is hard due to strong covalent bonds present in it.	3. In graphite, carbon atoms are bonded together in flat layers by strong covalent bonds in a regular hexagon. These layers are held together by much weaker van der Waal's forces, therefore the crystals of graphite are soft and slippery.
4. Diamond is non-conductor of electricity	4. Graphite is conductor of electricity.
5. The standard heat of formation (ΔH_f^o) of diamond is 29 kJ mol^{-1}.	5. It is thermodynamically most stable. Its $\Delta H_f^o = 0$
 Structure of diamond	Structure of graphite 

33. Other forms of Carbon : Other forms of elemental carbon are carbon black, coke and charcoal. They are impure forms of graphite or fullerenes. Carbon black is obtained by burning hydrocarbons in a limited supply of air. Charcoal and coke are obtained by heating wood or coal respectively at high temperatures in absence of air.

34. Uses of Carbon :

Forms of carbon	**Uses**
Diamond	Gemstone, cutting, drilling, grinding, polishing, industry.
Graphite	Steel manufacture (reducing agent

	refractories, pencils, high temperature crucibles, electrodes in electrolytic extraction of elements, neutron moderator in nuclear reactors, high strength composite materials.
Coke	Steel manufacture, fuel.
Carbon black	Rubber industry, pigments in ink, paints and plastics
Activated charcoal	Decolourizing agent in sugar industry, purification of chemicals and gases by adsorption, catalyst.
Wood charcoal	Fuel

35. Unique Nature of Carbon : Carbon has small size and therefore can form strong covalent bond with other atoms. It forms maximum number of compounds. Our body is made up of carbon compounds like proteins fats, nucleic acids.

36. Catenation : It is a property due to which carbon can from bonds with other atoms of carbon. Carbon shows the property of catenation to maximum extent because it is small in size and can form strong covalent bonds.

37. Tetravalency of carbon : Carbon has four valence electrons. It can share four electrons with other atoms of carbon as well as oxygen, hydrogen, nitrogen, sulphur and halogen.

38. Large number of organic compounds : They are due to tetravalency of carbon and property of catenation.

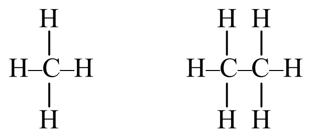
39. Vital Force Theory : It was proposed that 'vital force' is necessary for formation of these organic compounds. They can only be obtained from living organisms.

40. Preparation of First Organic Compound in Laboratory : In 1828, Wohlar prepared first organic compound urea by heating ammonium cyanate by isomerisation reaction.

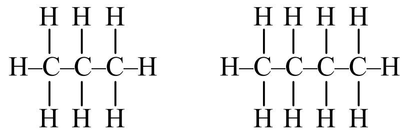
$$\underset{\text{Ammonium cyanate}}{NH_4CNO} \xrightarrow{\text{heat}} \underset{\text{Urea}}{NH_2CONH_2}$$

41. Hydrocarbons : Those compounds which contain carbon and hydrogen only are called hydrocabons, *e.g.*, CH_4(methane), C_2H_6 (ethane), C_2H_4 (ethene), C_2H_2 (ethyne), etc.

42. Saturated hydrocarbons : Those hydrocarbons which contain single bonds only are called saturated hydrocarbons. *e.g.*, CH_4 (methane), C_2H_6(ethane), C_3H_8(propene),C_4H_{10} (butane) etc.

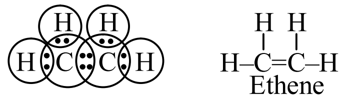


Methane Ethane

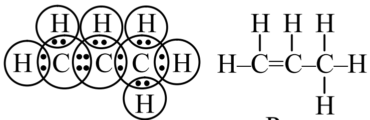


Propane Butane

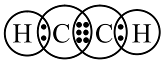
43. Unsaturated hydrocarbons : Those hydrocarbons in which valency of carbon is satisfied by double or triple bond are called unsaturated hydrocarbons, *e.g.*, C_2H_4, C_3H_6, C_2H_2.



Ethene



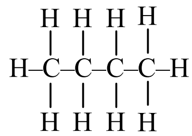
Propene



$H-C\equiv C-H$

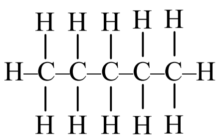
Ethyne

44. Straight Chain Compounds : Those compounds which contain straight carbon chains are called straight chain compounds, e.g.,



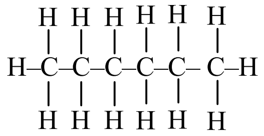
$CH_3-CH_2-CH_2-CH_3$

n-Butane



$CH_3-CH_2-CH_2-CH_2-CH_3$

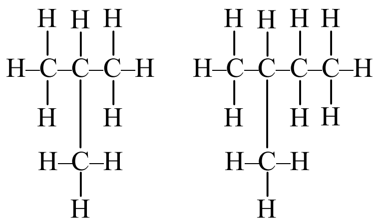
n-Pentane

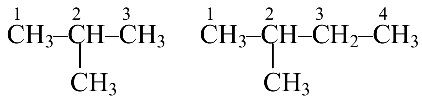


$CH_3–CH_2–CH_2–CH_2–CH_2–CH_3$

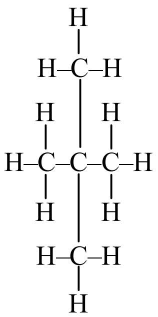
n-Hexane

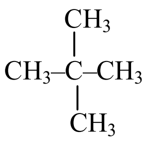
45. Branched Chain Compounds: Those compounds which are branched are called branched chain compounds, e.g.,





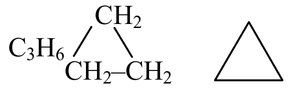
2-Methylpropane 2-Methylbutane



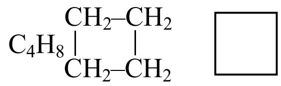


2,2-Dimethylpropane

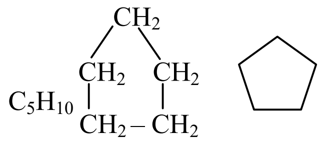
46. Closed Chain Compounds or Ring Comounds: Cyclic compounds are called closed chain or ring compounds, e.g.,



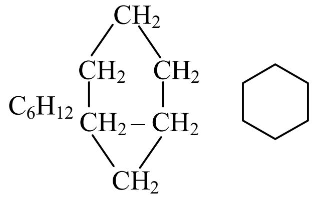
Cyclopropane



Cyclobutane

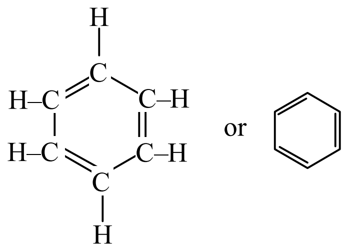


Cyclopentane

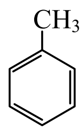


Cyclohexane

47. Aromatic Compounds : Benzene and its derivatives (which contain benzene ring) are called aromatic compounds, e.g., C_6H_6



Benzene



Toluene or Methylbenzene

48. Alkanes : All compounds in which carbon and hydrogen are attached with single bonds are called alkanes. The general formula of alkane from which all the members of family can be derived is C_nH_{2n+2}, e.g., CH_4, C_2H_6, C_3H_8 C_4H_{10}, C_5H_{12}, C_6H_{14}

49. Alkenes : Those unsaturated hydrocarbons which have one or more double bonds are called alkenes. Their general formula is

C_nH_{2n}, e.g., C_2H_4(ethene), C_3H_6 (propene), C_4H_8(butene), C_5H_{10}(pentene), etc

50. Alkynes : Those unsaturated hydrocarbons which contain one or more triple bonds are called alkynes. The general formula of alkynes is C_nH_{2n-2}, e.g., C_2H_2(ethyne), C_3H_4 (propyne), C_4H_6(butyne), C_5H_8 (pentyne), C_6H_{10} (hexyne).

51. Functional Group : It is atom or group of atoms or reactive part of compound which largely determines the chemical properties of compound, e.g., –OH(Alcohol), –CHO

(Aldehyde), $-\overset{\overset{O}{||}}{C}-$ (Ketone), $-\overset{\overset{O}{||}}{C}-OH$

(Carboxylic acid), –X(Halogens) where X is Cl, Br, F, I.

52. Homologous Series : It is a series of compounds which are derived from same general formula, having same functional group, similar chemical properties and show gradation in physical properties. Each member differs from successive member by $-CH_2-$. The difference in molecular weight between two successive members is 12 u.

53. Characteristic of Homologous Series :

(i) They have same general formula.

(ii) They have same functional group

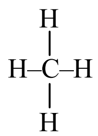
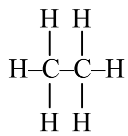
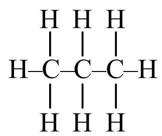
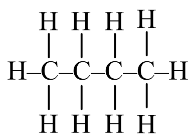
(iii) They have general methods of preparation.

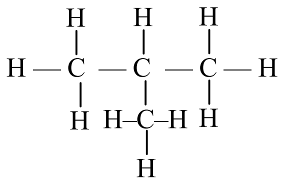
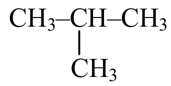
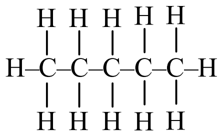
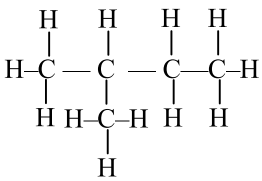
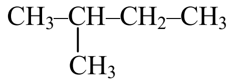
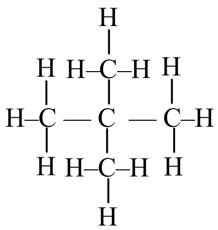
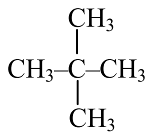
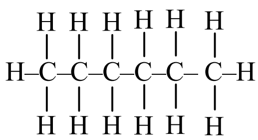
(iv) They have similar chemical properties.

(v) They show gradation in physical properties like melting and boiling points increase with increase in molecular weight. For example boiling point of alcohols goes on increasing with increase in molecular weight.

(vi) Solubility in a particular solvent shows gradation with increase in molecular weight, e.g., solubility of alcohols in water goes on decreasing with increase in molecular weight.

54. Alkanes:

General Formula Molecular Formula	**C_nH_{2n+2} Structural Formula**	**Where n is the number of carbon atoms Condensed Structural Formula**	**Name**
When n = 1, CH_4		CH_4	Methane
When n = 2, C_2H_6		$CH_3–CH_3$	Ethane
When n = 3, C_3H_8		$CH_3–CH_2–CH_3$	Propane
For n = 4, C_4H_{10} has two isomers		$CH_3–CH_2–CH_2–CH_3$	n-Butane

			Isobutane IUPAC name is 2-methylpropane
For n = 5, C_5H_{12} has three isomers		$CH_3–CH_2–CH_2–CH_2–CH_3$	n-Pentane
			Isopentane IUPAC name is 2-methylbutane
			Neopentane IUPAC name is 2, 2-dimethyl propane
			

55. IUPAC stands for International Union of Pure and Applied Chemistry. IUPAC names are used for International communication. Rules for IUPAC Naming of Organic Compounds :

(i) Select the possible longest chain containing the functional group.

e.g., $\overset{1}{CH_3}–\overset{2}{CH_2}–\overset{3}{\underset{\underset{CH_3}{|}}{CH}}–\overset{4}{CH_2}–\overset{5}{CH_3}$ longest chain contains 5 carbon atoms.

$\overset{4}{CH_3}–\overset{3}{CH_2}–\overset{2}{\underset{\underset{CH_3–CH_3}{|}}{C}}=\overset{1}{CH_2}$, longest chain contains 4 carbon atoms.

(ii) The number of carbon atoms in the parent compounds is denoted by proper prefix :

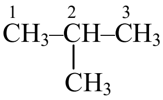
Meth for one eth for two Prop for three but for four pent for five hex for six hept for seven oct for eight non for nine

e.g.,in $CH_3–CH_2–CH_2–CH_2–CH_2–CH_3$ the parent chain contains 6 Carbon atoms, it is called

Hexane. ane is the suffix for alkanes (saturated hydrocarbons) having single bonds only.

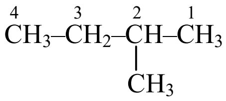
(iii) Groups attached to the parent chain are indicated by their names and prefixing the number of carbon to which they are attached in parent chain.

Alkyl group	CH_3— is called methyl
has general	C_2H_5—is called ethyl
formula C_nH_{2n+1}	$CH_3CH_2CH_2$— is called n-propyl

Example. 

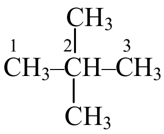
is called 2-methylpropane because methyl group is attached to second carbon atom.

(iv) The counting of carbon chain is done in such a way that the carbon attached to the alkyl group or functional group gets the minimum number, e.g.,

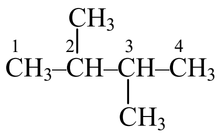


is 2-methylbutane and not 3-methylbutane.

(v) If more than one identical groups are attached to same or different carbon atoms, prefix the numbers of carbon to which they are attached. The number of these groups are indicated as : di for two, tri for three, tetra for four and so on, e.g.



2, 2-dimethylpropane because there are two methyl groups (dimethyl) and both are attached to second carbon therefore 2, 2-dimethylpropane because parent carbon chain contains three carbon atoms Similarly,



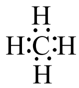
is 2, 3-dimethylbutane

(vi) For double bond in alkenes suffix-ene, for triple bond suffix-yne is used in alkynes. In alkenes and alkynes, number of carbon atoms after which double or triple bond is present is also prefixed, e.g.,

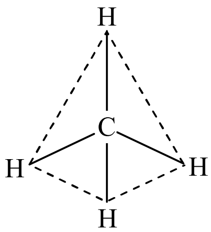
$\overset{1}{C}H_3-\overset{2}{C}H=\overset{3}{C}H-\overset{4}{C}H_3$

is but-2-ene because double bond is after second carbon atom.

56. Electronic Formula of CH_4 :

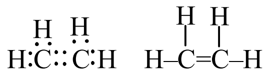


In methane, carbon atom shares four electrons one each with four hydrogen atoms forming four covalent bonds. The four atoms of hydrogen in methane are arranged in a regular tetrahedron and carbon atom at the centre of tetrahedron.



57. Unsaturated Hydrocarbons : Those hydrocarbons which contain at least on double or triple bond between two carbon atoms.

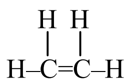
Double bond is formed by sharing of two pairs of electrons, e.g.,

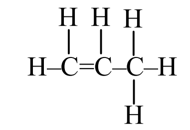
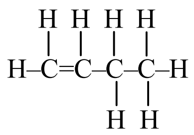
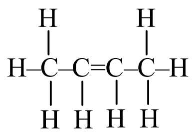
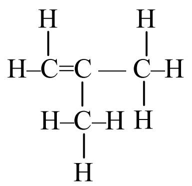
Ethene is 

Triple bond is formed by sharing of three pairs of electrons between two carbon atoms, e.g.,

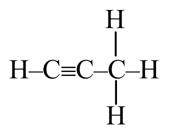
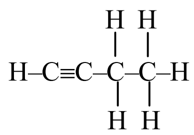
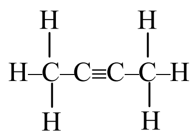
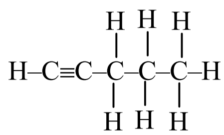
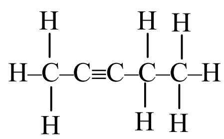
Ethyne is H:C⋮⋮C:H, H –C≡C–H

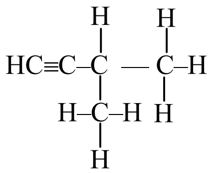
58. Alkenes : They have general formula C_nH_{2n} where n is the number of carbon atoms.

Molecular Formula	Structural Formula	Condensed Structural Formula	Name
n = 2, C_2H_4		$CH_2=CH_2$	Ethene

n = 3, C_3H_6		$CH_2=CH-CH_3$	Propene
n = 4, C_4H_8 has three isomers		$CH_2=CH-CH_2-CH_3$	But-1-ene
		$CH_3-CH=CH-CH_3$	But-2-ene
		$H_2C=\underset{\mid \atop CH_3}{C}-CH_3$	2-Methylpropene

59. Alkynes : General formula is C_nH_{2n-2}.

n = 2, C_2H_2	$H-C\equiv C-H$	$CH\equiv CH$	Ethyne
n = 3, C_3H_4		$CH\equiv C-CH_3$	Propyne
n = 4, C_4H_6 has two isomers		$CH\equiv C-CH_2-CH_3$	But-1-yne
		$CH_3-CH\equiv CH-CH_3$	But-2-yne
n = 5, C_5H_8 has three isomers		$CH\equiv C-CH_2-CH_2-CH_3$	Pent-1-yne
		$CH_3-C\equiv C-CH_2-CH_3$	Pent-2-yne

		$\overset{1}{HC}\equiv\overset{2}{C}-\underset{\mid\atop CH_3}{\overset{3}{C}H}-\overset{4}{C}H_3$	3-methylbut-1-yne

60. Alcohols : Alcohols are carbon compounds containing –OH group attached to carbon atom. The general formula of alcohol is R–OH where 'R' is an alkyl group and –OH is a functional group.

The name of alcohol is derived by replacing – e in the name of alkane from which it is derived by the suffix -ol. For example methanol (CH_3OH), an alcohol is derived by substituting 'H' of methane by –OH.

Alkanes	Formula of Alcohol	Common Name	IUPAC Name
CH_4(Methane)	CH_3OH	Methyl alcohol	Methanol
C_2H_6 (Ethane)	C_2H_5OH	Ethyl alcohol	Ethanol
C_3H_8 (Propane)	C_3H_7OH	Propyl alcohol	Propanol
C_4H_{10} (Butane)	C_4H_9OH	Butyl alcohol	Butanol

61. Alkyl halide : General formula is C_nH_{2n+1} X, where X is Cl, Br, I, F

Molecular Formula	Structural Formula	Common Name	IUPAC Name
n = 1 CH_3Cl	CH_3Cl	Methyl chloride	Chloromethane
n = 2 C_2H_5Cl	CH_3CH_2Cl	Ethyl chloride	Chloroethane
n = 3 C_3H_7Cl	$CH_3CH_2CH_2Cl$	n-propyl chloride	1-Chloropropane
n = 4 C_4H_9Cl	$CH_3CH_2CH_2CH_2Cl$	n-Butyl chloride	1-Chlorobutane

62. Aldehydes and Ketones : Aldehydes and Ketones are compounds containing carbonyl ($>C=O$) group. In aldehydes, carbon of $>C=O$ group is attached to an alkyl group and a hydrogen atom. In ketones, carbon of carbonyl group is attached to two alkyl groups. The two alkyl groups may be same or different. For example,

$\genfrac{}{}{0pt}{}{R}{H}\!>C=O$ or RCHO is an Aldehyde. $\genfrac{}{}{0pt}{}{R}{R'}\!>C=O$ or RCOR' is a Ketone

Where R and R' are different alkyl groups. They can be same also.

Aldehydes are named by replacing -e from the name of alkane by the suffix –al and Ketones are named by replacing –e of alkane by the suffix -one.

Aldehydes : General formula is $C_nH_{2n+1}-\overset{O}{\overset{\|}{C}}-H$.

Molecular Formula	Structural Formula	Common Name	IUPAC Name
n = 0 HCHO	$H-\overset{O}{\overset{\|}{C}}-H$	Formaldehyde	Methanal
n = 1 CH_3CHO	$CH_3-\overset{O}{\overset{\|}{C}}-H$	Acetaldehyde	Ethanal

n = 2 C_2H_5CHO	$CH_3CH_2-\overset{\overset{O}{\|}}{C}-H$	Propionaldehyde	Propanal
n = 3 C_3H_7CHO	$CH_3CH_2CH_2-\overset{\overset{O}{\|}}{C}-H$	Butyraldehyde	Butanal

Ketones : General formula is $C_nH_{2n+1}-\overset{\overset{O}{\|}}{C}-C_nH_{2n+1}$

Molecular Formula	**Structural Formula**	**Common Name**	**IUPAC Name**
n = 1 CH_3COCH_3	$CH_3-\overset{\overset{O}{\|}}{C}-CH_3$	Acetone	Propanone
n =1, 2 $CH_3COC_2H_5$	$CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_3$	Ethyl methyl ketone	Butanone
n = 1,3 $CH_3COCH_2CH_2CH_3$	$CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_2-CH_3$	Methyl propyl ketone	Pentanone
n=1,4 $CH_3COCH2CH_2CH_2CH_3$	$CH_3-\overset{\overset{O}{\|}}{C}-CH_2-CH_2-CH_2-CH_3$	Butyl methyl ketone	Hexanone

63. Carboxylic acid : The compounds containing carboxyl (– COOH) group are known as carboxylic acids. Carboxylic acids are named by substituting 'e' of the corresponding alkane by –oic acid. Their general formula is $C_nH_{2n+1}-COOH$

Molecular Formula	**Structural Formula**	**Common Name**	**IUPAC Name**
n = 0 HCOOH	$H-\overset{\overset{O}{\|}}{C}-OH$	Formic acid	methanoic acid
n =1 CH_3COOH	$CH_3-\overset{\overset{O}{\|}}{C}-OH$	Acetic acid	Ethanoic acid
n = 2 C_2H_5COOH	$CH_3-CH_2-\overset{\overset{O}{\|}}{C}-OH$	Propionic acid	Propanoic acid
n = 3 C_3H_7COOH	$CH_3-CH_2CH_2-\overset{\overset{O}{\|}}{C}-OH$	Butyric acid	Butanoic acid

➢ Chemical Properties of carbon compounds

64. Combustion of Carbon: Carbon, in all allotropic forms, burns in presence of oxygen to form carbon dioxide with evolution of heat and light energy. In case of diamond, graphite and fullerene, they burn completely to form CO_2 because they are purest form of carbon.

$$C + O_2 \longrightarrow CO_2 + \text{Heat} + \text{light}$$

Most of the carbon compounds are combustible and burn in presence of oxygen to form CO_2 and H_2O. e.g.,

$CH_4(g) + 2O_2(g) \rightarrow$

$CO_2(g) + 2H_2O(l) + \text{heat} + \text{light}$

$2H_2H_6(g) + 7O_2(g) \rightarrow$

$4CO_2(g) + 6H_2O(l) + \text{Heat} + \text{light}$

$2CH_3OH(g) + 3O_2(g) \rightarrow$

$2CO_2(g) + 4H_2O(l) + \text{heat light}$

$CH_3CH_2OH(l) + 3O_2 \rightarrow$

$2CO_2(g) + 3H_2O(l) + \text{heat}$

$CH_3COOH\ (l) + 2O_2(g) \rightarrow$

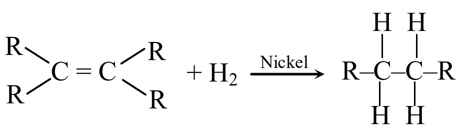
$2CO_2(g) + 2H_2O(l) + \text{heat}$

65. Combustion of Hydrocarbons : If hydrocarbons are burnt in limited supply of oxygen then smoky flame is produced due to incomplete combustion whereas in excess of oxygen, complete combustion takes place and non-luminous bluish flame with high temperature is produced.

66. Oxidising Agent : Those substances which can add oxygen to starting material are called oxidising agents, e.g., alkaline $KMnO_4$ and acidified potassium dichromate

67. Addition Reactions : Those reactions in which unsaturated compounds react with a molecule like H_2, Cl_2, etc., to form another saturated compounds are called addition reactions.

68. Hydrogenation : It is a process in which unsaturated compound reacts with hydrogen in presence of nickel as a catalyst to form saturated compound



$$\underset{\text{(Unsaturated)}}{\text{Vegetable oil}} + H_2 \xrightarrow{\text{Ni}} \underset{\text{(Saturated)}}{\text{Vegetable ghee}}$$

69. Catalyst : It is a substance which increases the rate of reaction without itself undergoing chemical change, e.g., Ni, Pt, V_2O_5 are used as catalyst.

70. Substitution Reactions : Those reaction in which an atom or group of atoms of a compound is replaced by other atom or group of atoms are called substitution reaction.

Saturated hydrocarbons are less reactive and do not react with most reagents.

They react with halogens in presence of sunlight and undergo substitution reaction. The reaction is very fast. It is photochemical reaction because it takes place in presence of sunlight.

$$CH_4(g) + Cl_2(g) \xrightarrow[\text{light}]{\text{Sun}} \underset{\text{Chloromethane}}{CH_3Cl(g)} + HCl(g)$$

$$CH_3Cl(g)+Cl_2(g) \xrightarrow[\text{light}]{\text{Sun}} \underset{\text{Dichloromethane}}{CH_2Cl_2(g)} + HCl(g)$$

$$CH_2Cl_2(g)+Cl_2(g) \xrightarrow[\text{light}]{\text{Sun}} \underset{\text{Trichloromethane}}{CHCl_3(g)} + HCl(g)$$

$$CJCl_3(l)+Cl_2(g) \xrightarrow[\text{light}]{\text{Sun}} \underset{\substack{\text{Tetrachloromethane}\\ \text{(Carbontetrachloride)}}}{CCl_4(l)} + HCl(g)$$

71. Test for Unsaturation : Add a few drops of bromine water to a test tube containing ethyne. Shake and observe.

$$HC{\equiv}CH + 2Br_2(aq) \longrightarrow \underset{\text{1,1,2,2–Tetrabromoethane}}{Br_2CH - CHBr_2}$$

72. Addition of Hydrogen : Ethyne reacts with hydrogen in the presence of a catalyst to give Ethane. Two molecules of hydrogen are added across the carbon-carbon triple bond.

$$\underset{\text{Ethyne}}{HC \equiv CH} + 2H_2 \xrightarrow[\text{573K}]{\text{Ni}} \underset{\text{Ethane}}{HC_3 - CH_3}$$

73. Addition of Chlorine : Two molecules of chlorine react with ethyne to form 1, 1, 2, 2-tetrachloroethane.

$$\underset{\text{Ethyne}}{HC \equiv CH} + 2Cl_2 \longrightarrow \underset{\text{1,1,2,2–Tetrachloroethane}}{Cl_2CH - CHCl_2}$$

74. Addition of HCl : Ethyne reacts with HCl in the presence of mercuric chloride ($HgCl_2$) to form vinyl chloride which is monomer of polyvinyl chloride (PVC) (used as plastic)

$$\underset{\text{Ethyne}}{H-C\equiv C-H} + HCl \xrightarrow{HgCl_2} \underset{\substack{\text{Vinyl chloride}\\ \text{(Chloroethene)}}}{CH_2=CHCl}$$

75. Combustion of Acetylene : Acetylene burns in presence of oxygen to form CO_2 and H_2O.

$$\underset{\text{Ethyne}}{2C_2H_2(g)} + 5O_2(g) \rightarrow 4CO_2(g) + 2H_2O(l) + \text{heat}$$

76. Uses of Ethyne :

(i) Oxy-acetylene flame is used for welding purposes.

(ii) It is used for lighting purposes

(iii) It is used to prepare Benzene (C_6H_6)

(iv) It is used for making Vinyl chloride which is used for making PVC (Plastic).

77. Physical Properties of Ethanol :

(i) Pure ethanol is a colourless liquid.

(ii) It has a specific smell and burning taste

(iii) Its boiling point is 351 K which is higher than corresponding alkanes

(iv) It is soluble in water. i.e., it is miscible with water in all proportions.

78. Chemical properties of Ethanol :

(i) Dehydration : Ethanol. when heated with Conc. H_2SO_4 at 443 K or Al_2O_3 at 623 K undergoes dehydration, i.e. loses water molecule to from alkene.

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[\text{or } Al_2O_3,\ 623K]{\text{Conc. } H_2SO_4,\ 443K} CH_2=CH_2 + H_2O$$

(ii) Reaction with Sodium : Alcohols are very weakly acidic. Ethanol reacts with sodium metal to form sodium ethoxide and hydrogen gas

$$\underset{\text{Ethanol}}{2C_2H_5OH} + \underset{\text{Sodium}}{2Na} \rightarrow \underset{\text{Sodiumethoxide}}{2C_2H_5ONa} + \underset{\text{Hydrogen}}{H_2}$$

(iii) Oxidation with Chromic anhydride (CrO_3) :

$$\underset{\text{Ethanol}}{CH_3CH_2OH} \xrightarrow[CH_3COOH]{CrO_3 In} \underset{\text{Ethanol}}{CH_3CHO}$$

(iv) Oxidation with alkaline $KMnO_4$:

$$\underset{\text{Ethanol}}{CH_3CH_2OH} + [O] \xrightarrow[KMnO_4]{\text{Alkaline}} \underset{\text{Ethanoic acid}}{CH_3COOH} + H_2O$$

(v) Oxidation with acidified Potassium dichromate : Ethanol is oxidized to ethanoic acid with the help of acidified $K_2Cr_2O_7$

$$\underset{\text{Ethanol}}{CH_3CH_2OH} + 2[O] \xrightarrow{K_2Cr_2O_7 / H_2SO_4 \text{ (Conc.)}} \underset{\text{Ethanoic acid}}{CH_3COOH} + H_2O$$

During this reaction, orange colour of $K_2Cr_2O_7$ changes to green. Therefore, this reaction can be used for the identification of alcohols.

(vi) Esterification : Ethanol reacts with ethanoic acid in presence of concentrated H_2SO_4 to form ethyl ethanoate and water. The compound formed by the reaction of an alcohol with carboxylic acid is known as ester and the reaction is called Esterification. Esters are sweet fruity smelling compounds because they occur in fruits. They are used in ice creams, cold drinks and perfumes. The reaction takes place as follows.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow{\text{Conc.} H_2SO_4} \underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O}$$

Conc. H_2SO_4 acts as dehydrating agent, i.e., it removes water formed otherwise ester formed will get hydrolysed.

(vii) Ethanol is highly inflammable liquid i.e., it catches fire very easily. It burns with blue flame in presence of oxygen to form carbon dioxide and water.

$$\underset{\text{Ethanol}}{C_2H_5OH} + \underset{\text{Oxygen}}{3O_2} \rightarrow \underset{\text{Carbon dioxide}}{2CO_2} + \underset{\text{Water}}{3H_2O(\ell)}$$

79. Uses of Ethanol :

(i) Ethanol is present in alcoholic beverages such as beer, wine, whisky.

(ii) Ethanol is used as antiseptic for sterilising wounds.

(iii) Ethanol is used incough syrups. digestive syrups and tonics.

(iv) Ethanol is being mixed with petrol and is used as motor fuel. This mixture is called power alcohol.

(v) A mixture of ethanol and water has lower freezing point than water. This mixture is known as antifreeze and is used in radiators of vehicles in cold countries and at hill stations.

(vi) Ethanol is used for preparation of chloroform, iodoform, ethanoic acid, ethanal, ethyl ethanoate etc.

(vii) Ethyl alcohol is used as hypnotic (induces sleep)

80. Harmful effects of drinking alcohol :

(i) If ethanol is mixed with CH_3OH (methanol) and consumed, it may cause serious poisoning and loss of eyesight.

(ii) It causes addiction (habit forming) and mixes with blood. It damages liver if taken regularly in large amount.

(iii) The person loses sense of discrimination under its influence.

(iv) Higher amount of consumption of ethanol leads to loss of body control and consciousness. It may ever cause death.

Therefore, we should not drink alcohol under any circumstances because it leads to wastage of time, wealth and spoils health.

81. Alcohol as a fuel : Alcohol is added to petrol upto 20%. The mixture is called 'gasol'. It is a cleaner fuel because it creates less pollution. Alcohol, on combustion, gives CO_2 and H_2O only

82. Fermentation : It is a process in which controlled microbial action takes place to give useful products, e.g., Ethanol can be prepared by fermentation of molasses.

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

$$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

83. Ethanoic acid (Acetic acid) CH_3COOH : Ethanoic acid is most commonly known as acetic acid. Its dilute solution in water (5-8%) is known as vinegar, which is used for preserving food-sausage, pickles etc.

84. Physical properties :

(i) Ethanoic acid is vinegar smelling liquid. The lower carboxylic acids are liquids whereas higher ones are solids.

(ii) Ethanoic acid is sour in taste. Other lower carboxylic acids are also sour in taste.

(iii) Ethanoic acid has boiling point 391 K. Carboxylic acids have higher boiling points than corresponding alcohols, aldehydes and ketones.

(iv) Acetic acid is soluble in water, i.e., it is miscible with water in all proportions. The lower carboxylic acids are soluble in water but solubility in water decreases with increase in molecular weight.

(v) Acetic acid freezes at 290 K. Thus, in cold weather crystallization of acetic acid may take place that is why pure acetic acid is called glacial acetic acid.

85. Chemical Properties :

(i) Ethanoic acid is weak acid but it turns blue litmus red.

(ii) Reaction with Metale. Ethanoic acid reacts with metals like Na, K, Zn etc. to form metal ethanoates and hydrogen gas.

$$2CH_3COOH + 2Na \rightarrow \underset{\text{Sodium ethanoate}}{2CH_3COONa} + H_2$$

$$\underset{\text{Ethanoic acid}}{2CH_3COOH} + Zn \rightarrow \underset{\text{Zinc ethanoate}}{(CH_3COO)_2Zn} + H_2$$

(iii) Reaction with Carbonates. Ethanoic acid reacts with bicarbonates and carbonates and produces brisk effervescence due to formation of carbon dioxide.

$$\underset{\text{Ethanoic acid}}{2CH_3COOH} + \underset{\text{Sodium carbonate}}{Na_2CO_3} \longrightarrow$$

$$2CH_3COONa + CO_2 + H_2O$$

$$CH_3COOH + \underset{\text{Sodium bicarbonate (Sodiumhydrogen carbonate)}}{NaHCO_3} \longrightarrow$$

$$\underset{\text{Sodium ethanoate}}{CH_3COONa} + H_2O + CO_2$$

(iv) Reaction with Base. Ethanoic acid reacts with sodium hydroxide to form sodium ethanoate and water

$$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow$$

$$\underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Water}}{H_2O}$$

(v) Decarboxylation (Removal of CO_2). When sodium salt of ethanoic acid, i.e., sodium ethanoate is heated with soda lime (3 parts of NaOH and 1 part of CaO), methane gas is formed.

$$\underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Soda lime}}{NaOH(CaO)} \xrightarrow{\text{Heat}}$$

$$CH_4 + Na_2CO_3$$

This reaction is known as decarboxylation because a molecule of CO_2 is removed from a molecule of acid

(vi) Reaction with alcohols. Ethanoic acid reacts with ethanol in presence of concentrated sulphuric acid to form esters which are pleasant fruity smelling compounds.

$$\underset{\text{Ethanoic acid}}{CH_3COOH(\ell)} + \underset{\text{Ethanol}}{C_2H_5OH(\ell)} \xrightarrow{\text{Conc. } H_2SO_4}$$

$$\underset{\text{Ethyl Ethanoate}}{CH_3COOC_2H_5(\ell)} + H_2O(\ell)$$

(vii) Reduction. Acetic acid, on reduction with lithium aluminium hydride, results in formation of ethanal, which on further reduction gives ethanol.

$$\underset{\text{Ethanoic acid}}{CH_3COOH} \xrightarrow{LiAlH_4} \underset{\text{Ethanal}}{CH_3CHO} \xrightarrow{LiAlH_4}$$

$$\underset{\text{Ethanol}}{CH_3CH_2OH}$$

86. Uses of Ethanoic acid :

(i) It is used for making vinegar

(ii) It is used as a laboratory reagent

(iii) It is used for preparation of white lead $[2PbCO_3.Pb(OH)_2]$ which is used in white paints.

(iv) It is used for coagulation of rubber from latex and casein (protein) from milk

(v) It is used in preparation of acetone, ethyl acetate, acetic anhydride, aspirin which is used in medicines.

(vi) It is used in preparation of cellulose acetate which is used for making photographic film.

(vii) Its esters are used in artificial flavours in perfumes.

(viii) Its 5% solution is bactericidal (destroys bacteria)

(ix) Its compound basic copper acetate (verdigris) is used as green pigment.

(x) Aluminium acetate and chromium acetate are used as mordants in dyeing and waterproofing of fabrics.

87. Esters : They are pleasant fruity smelling compounds. They are formed by reaction of carboxylic acids and alcohols. They are used in making ice creams, cold drinks, perfumes and in flavouring agents.

88. Acidic hydrolysis of Esters : Esters, on hydrolysis in presence of H^+ give carboxylic acid and alcohol.

$$\underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5} + \underset{\text{Water}}{H_2O} \xrightarrow{H^+} \underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH}$$

89. Saponification : It is a process in which an ester reacts with sodium hydroxide to form sodium salt of acid and alcohol is formed.

$$\underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5} + \underset{\text{Sodium hydroxide}}{NaOH} \longrightarrow \underset{\text{Sodium ethanoate}}{CH_3COONa} + \underset{\text{Ethanol}}{C_2H_5OH}$$

Saponification is also used for preparation of soap.

90. Soaps and Synthetic Detergents :

Soaps : Soaps are sodium or potassium salts of higher fatty acids. Fatty acids are carboxylic acids containing 12 or more carbon atoms, e.g.,

The common fatty acids and their formula are given below :

Table : Some Examples of fatty acids

Formula	**Name of fatty acid**	**Formula**	***Name of Fatty acid***
$C_{15}H_{31}COOH$	Palmitic acid	$C_{17}H_{35}COOH$	*Stearic acid*
$C_{17}H_{33}COOH$	Oleic acid	$C_{11}H_{23}COOH$	*Lauric acid*
$C_{17}H_{31}COOH$	*Linoleic acid*	*$C_{13}H_{27}COOH$*	*Myristic acid*

91. Glycerides : They are esters of glycerol, an alcohol containing three hydroxyl group and fatty acids. Glycerides are present in fats or oils of animal and vegetable origin

92. Saponification : The process in which oil or fat (glyceride) is hydrolysed with sodium hydroxide to get soap and glycerol is called saponification.

$$\underset{\text{Glyceryl stearate}}{\begin{array}{l} CH_2-O-\overset{\overset{\displaystyle O}{\|}}{C}-C_{17}H_{35} \\ | \\ CH-O-\overset{\overset{\displaystyle O}{\|}}{C}-C_{17}H_{35} \\ | \\ CH_2-O-\overset{\overset{\displaystyle O}{\|}}{C}-C_{17}H_{35} \end{array}} + 3NaOH \rightarrow \underset{\text{Glycerol}}{\begin{array}{l} CH_2OH \\ | \\ CHOH \\ | \\ CH_2OH \end{array}} + \underset{\substack{\text{Sodium stearate} \\ \text{(Soap)}}}{3C_{17}H_{35}COONa}$$

Other examples of soaps are Sodium palmitate ($C_{15}H_{31}COONa$), Sodium oleate ($C_{17}H_{33}COONa$)

Sodium linoleate ($C_{17}H_{31}COONa$) etc.

93. Advantages of Soap :

(i) Soap is cheaper and readily available.

(ii) It works well for cleaning of clothes with soft water (water which does not contain Ca^{2+} and Mg^{2+})

(iii) Soaps are 100% biodegradable, i.e., decomposed by micro-organisms present in sewage, therefore, they do not create water pollution.

94. Disadvantages of Soap :

(i) It does not work well with hard water containing Ca^{2+} or Mg^{2+}. It reacts with Ca^{2+} and Mg^{2+} to form white precipitate which is called scum and soap goes waste. The reaction which takes place is a follows.

$$\underset{\substack{\text{(Present in} \\ \text{Hard water)}}}{Ca^{2+}} + \underset{\substack{\text{Sodium stearate} \\ \text{(Soap)}}}{2C_{17}H_{35}COONa} \longrightarrow \underset{\text{Calciumstearate}}{(C_{17}H_{35}COO)_2Ca} + 2Na^+$$

$$\underset{\substack{\text{(Present in} \\ \text{Hard water)}}}{Mg^{2+}} + 2C_{17}H_{35}COONa \longrightarrow \underset{\text{Magnesium stearate}}{(C_{17}H_{35}COO)_2Mg}$$

Thus, soap solution forms less lather with hard water.

(ii) Soap is not suitable for washing woolen garments because it is basic in nature and woolen garments have acidic dyes.

(iii) Soap are less effective in saline water and acidic water.

95. Detergents : Detergents are sodium or potassium salts of sulphonic acids of hydrocarbons of alkene type. They have –SO_3H group, i.e., sulphonic acid group.

Examples :

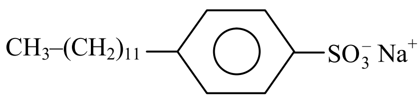
(i) Sodium lauryl sulphate

$CH_3(CH_2)_{10}CH_2O\,SO_3^-\,Na^+$

(ii) Sodium dodecylbenzenesulphonate

$C_{12}H_{25}–C_6H_4–SO_3^-\,Na^+$

OR



96. Advantages of Detergents over soaps :

(i) Detergents work well even with hard water but soaps do not.

(ii) Detergents may be used in saline or acidic water

(iii) Detergents are more easily soluble in water than soaps.

(iv) Detergents can be used for washing woolen garments whereas soaps cannot be used.

(v) Detergents having linear hydrocarbon chain are biodegradable.

97. Disadvantages of Detergents over Soaps :

(i) Synthetic detergents having branched hydrocarbon chain are not fully biodegradable, i.e., they are not decomposed by micro-organisms in sewage and create water pollution.

(ii) They are more expensive than soaps. Let us take up differences between soaps and detergents.

Table : Difference between soaps and detergents

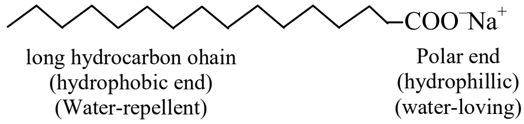
Soaps	Detergents
1. They are sodium or potassium salts of fatty acids	1. They are sodium or potassium salts of sulphonic acids.
2. They have –COONa group	2. They have– SO_3Na group
3. They do not work well with hard water, acidic water and saline water	3. They work well with hard water, acidic water and saline water.
4. They are fully biodegradable	4. Some detergents having branched hydrocarbon chain are non-biodegradable
5. They do not work well with woolen garments.	5. They work well with woolen garments
6.It may cause irritation to skin	6. They do not cause irritation to skin
7.They take time to dissolve in water	7. They dissolve faster in water
8. Example : Sodium stearate, Sodium palmitate	8. Examples : Sodium lauryl sulphate, sodium dodecylbenzenesulphonate.

98. Cleansing Actions of Soaps and Detergents : Soaps and detergents consist of a large hydrocarbon taill with a negatively charged head as shown in figures. The hydrocarbon tail is hydrophobic (water-hating or water repelling) and negatively charged head is hydrophilic (water-loving).

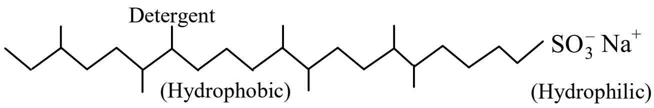
In aqueous solution, water molecules being polar in nature, surround the ions and not the hydrocarbon part of the molecule

When a soap or detergent is dissolved in water, the molecules associate together as clusters called

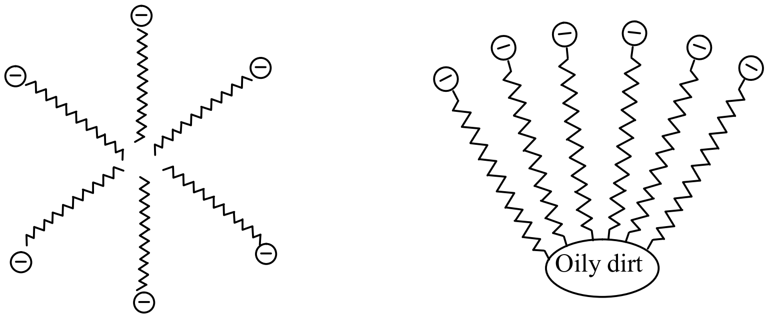
micelles as shown in figure (C)



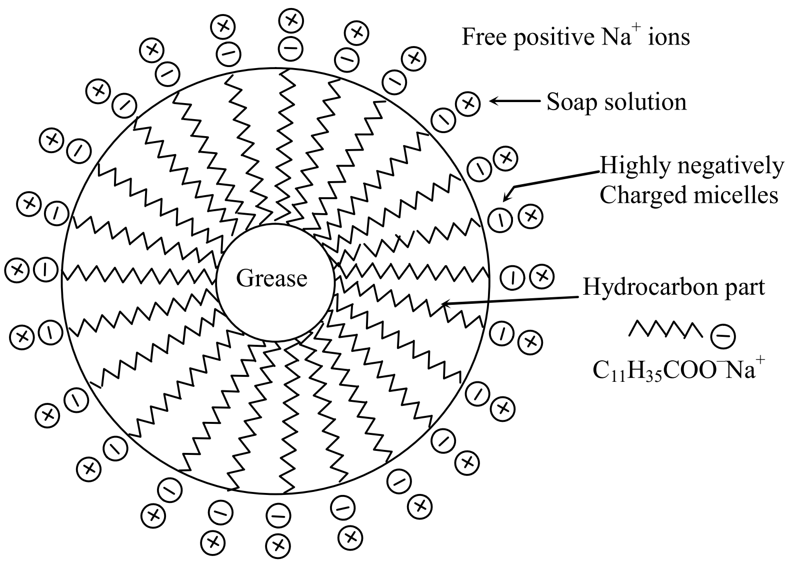
(a) Hydrophilic (water-loving) and hydrophobic (water-repellent) ends of a soap molecule



(b) Hydrophilic and hydrophobic ends of a detergent



(c) Micelle Formed by detergent molecules in water The hydrocarbon tails stick the oily dirt



Cleansing action of soap. Soap micelle entraps the oily dirt particle

The tails stick inwards and the heads outwards.

In cleansing, the hydrocarbon tail attaches itself to oily dirt. When water is agitated (Shaken vigorously),the oily dirt tends to lift off from the dirty surface and dissociate into fragments.

This gives opportunity to other tails to stick to oil. The solution now contains small globules of oil surround by detergent molecules.

The negatively charged heads present in water prevent the small globules from coming together and form aggregates. Thus, the oily dirt is removed.

In the past, detergents caused pollution in rivers and waterbodies. The long carbon chain present in detergents used earlier, contained lot of branching. These branched chain detergent molecules were degraded very slowly by the micro-organims present in sewage discharge septic tanks and water bodies. Thus, the detergents persisted in water for long time and made water unfit for aquatic life. Nowadays, the detergents are made up of molecules in which branching is kept at minimum. These are degraded more easily than branched chain detergents.

➤ Important Chemical Reactions

Decarboxylation :

1. $$\underset{\text{Sodium acetate}}{CH_3COONa} + \underset{\text{Soda lime}}{NaOH(CaO)} \xrightarrow{\text{heat}} \underset{\text{Methane}}{CH_4} + Na_2CO_3$$

2. $$\underset{\text{Ethene}}{CH_2 = CH_2} + H_2O \xrightarrow[\text{or } H_2SO_4]{H_3PO_4} \underset{\text{Ethanol}}{CH_3 - CH_2OH}$$

Fermentation :

3. $$\underset{\text{Sucrose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{(Yeast)}]{\text{Invertase}} \underset{\text{Glucose}}{C_6H_{12}O_6} + \underset{\text{Fructose}}{C_6H_{12}O_6}$$

4. $$\underset{\text{Glucose}}{C_6H_{12}O_6} \xrightarrow[\text{(Yeast)}]{\text{Zymase}} \underset{\text{Ethanol}}{2C_2H_5OH} + 2CO_2$$

5. $$\underset{\text{Starch}}{2(C_2H_{10}O_5)_n} + nH_2O \xrightarrow{\text{Diastase}} \underset{\text{Maltose}}{nC_{12}H_{22}O_{11}}$$

6. $$\underset{\text{Maltose}}{C_{12}H_{22}O_{11}} + H_2O \xrightarrow[\text{(Yeast)}]{\text{Maltase}} \underset{\text{Glucose}}{2C_6H_{12}O_6}$$

7. $$C_6H_{12}O_6 \xrightarrow[\text{(Yeast)}]{\text{Zymase}} 2C_2H_5OH + 2CO_2$$

8. $$\underset{\text{Methanol}}{2CH_3OH} + 2Na \longrightarrow \underset{\text{SodiumMethoxide}}{2CH_3ONa} + H_2$$

9. $$\underset{\text{Ethanol}}{2C_2H_5 - OH} + 2Na \longrightarrow \underset{\text{Sodium ethoxide}}{2C_2H_5ONa} + H_2$$

Combustion :

10. $$2CH_3OH + 3O_2 \longrightarrow 2CO_2 + 4H_2O$$

11. $$C_2H_5OH + 3O_2 \longrightarrow 2CO_2 + 3H_2O$$

Esterification :

12. $$\underset{\text{Ethanoic acid}}{CH_3COOH} + \underset{\text{Ethanol}}{C_2H_5OH} \xrightarrow{\text{Conc.}H_2SO_4} \underset{\text{Ethyl ethanoate}}{CH_3COOC_2H_5} + H_2O$$

13. CH_3COOH (Ethanoic acid) $+$ CH_3OH (Methanol) $\xrightarrow{\text{Conc.}H_2SO_4}$ CH_3COOCH_3 (Methyl ethanoate) $+$ H_2O

14. CH_3CH_2OH (Ethanol) $\xrightarrow[\text{Conc. }K_2Cr_2O_7/H_2SO_4]{[O]}$ CH_3COOH (Ethanoic acid)

15. CH_3CH_2OH (Ethyl alcohol) $+$ O_2 $\longrightarrow$ CH_3COOH (Acetic acid) $+$ H_2O

16. CH_3COOH (Ethanoic acid) $+$ $NaHCO_3$ (Sodium bicarbonate) $\longrightarrow$ CH_3COONa (Sodium acetate) $+$ H_2O $+ CO_2$

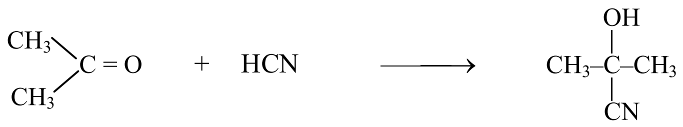
17. CH_3CH_2OH (Ethanol) $\xrightarrow[CH_3COOH]{CrO_3 \text{ in}}$ CH_3CHO (Ethanol) $+$ H_2O

18. CH_3CH_2OH $+$ $2[O]$ $\xrightarrow{\text{Alkaline KMnO}_4}$ CH_3COOH $+$ H_2O

19. $CH_3COOC_2H_5$ (Ethyl ethanoate) $+$ $NaOH$ $\longrightarrow$ CH_3COONa $+$ C_2H_5OH

20. 2CH3OH $+$ O_2 $\xrightarrow[MoO_3]{873\text{–}923K}$ $2HCHO$ (Methanal) $+$ $2H_2O$

21.



Propanone cyanohydrin

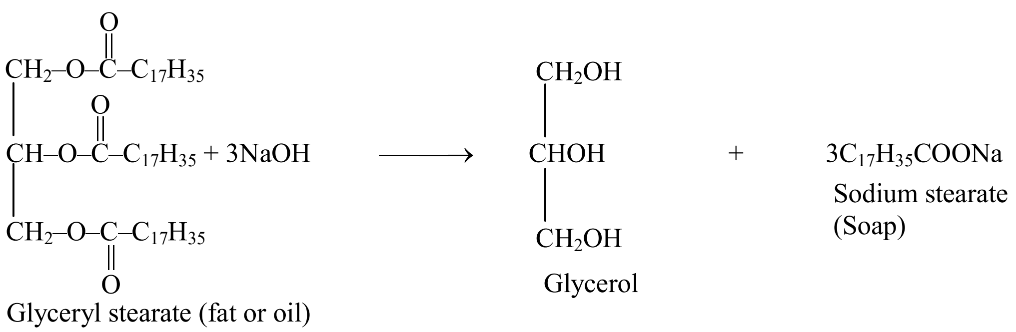
22. CH_3OH (Methanol) $+$ CO $\xrightarrow{I_2/Rh}$ CH_3COOH (Ethanoic acid)

23. 2CH3COOH $+$ $2Na$ $\longrightarrow$ $2CH_3COONa$ $+$ H_2

24. $2CH_3COOH$ $+$ Na_2CO_3 $\longrightarrow$ $2CH_3COONa$ $+$ H_2O $+$ CO_2

Saponification

26.



27. C_2H_5OH $\xrightarrow[\text{or }Al_2O_3,\ 623K]{\text{Conc. }H_2SO_4,\ 443K}$ $CH_2 = CH_2 + H_2O$

28. $\underset{\text{Ethanoic acid}}{CH_3COOH} \xrightarrow[\text{or } NaBH_4]{LiAlH_4} \underset{\text{Ethanal}}{CH_3CHO} \xrightarrow[\text{or } LiAlH_4]{NaBH_4} \underset{\text{Ethanol}}{CH_3CH_2OH}$

Addition Reaction

29. $CH_2 = CH_2 + Br_2(aq) \longrightarrow \underset{\text{1,2-Dibromoethane}}{BrCH_2 - CH_2Br}$

30. $CH_3OH + 2[O] \xrightarrow{CrO_3} \underset{\text{Methanoic acid}}{HCOOH} + H_2O$

31. $+ \underset{\text{Methanol}}{CH_3OH} \xrightarrow[573K]{\text{Cu or Ag}} \underset{\text{Methanal}}{H-\overset{\overset{O}{||}}{C}-H} + H_2$

➢ POINT TO REMEMER

- Carbon always forms covalent bonds.
- Carbon is present in all substances of animal and vegetable origin
- The ability of carbon to unite with an indefinite number of carbon atoms in straight, branched or cyclic chains is known as catenation.
- Caron and hydrogen combine together indifferent proportions to form a large number of compounds called hydrocarbons.
- There are two types of hydrocarbons-saturated and unsaturated
- Alkanes are represented by the general formula C_nH_{2n+2}
- Alkenes are represented by the general formula C_nH_{2n}
- Alkynes are represented by the general formula C_nH_{2n-2}
- Organic compounds having the same functional group and common properties, but differing in molecular formula from the next member by one CH_2 group, form a homologous series and such compounds are called homologues.
- Compounds with the same molecular formula but different structural formulae are known as isomers.
- The decomposition of alkanes on heating in the absence of oxygen is known as cracking.
- Methane is prepared by heating a mixture of sodium acetate and soda lime.
- When ethanol is heated with an excess of concentrated sulphuric acid at 160°C, ethene gas is produced.
- Natural gas is a mixture of gaseous hydrocarbons, mainly methane, ethane, propane and butane.
- Compressed Natural Gas (CNG) is used as an alternative to petrol as automobile fuel.
- Natural gas is a rich source of hydrogen gas which is required for the manufacture of fertilizers
- Liquefied Petroleum Gas (LPG) is used as a domestic fuel.
- Petrol is a complex mixture of hydrocarbons such as hexane, heptane and octane.
- Petrol is used as a motor fuel.
- Alcohols are organic compounds which contain hydroxyl group (–OH) bonded to a carbon atom.
- Alcohols are neutral to litmus.
- Alcohols are poor conductors of electricity.
- Alcohol reacts with sodium to liberate hydrogen gas.
- Ethanol is a constituent of beverages, like wine and beer.

- Ethanol is used as a hypnotic and is highly addictive.
- Organic compounds containing carboxyl group (–COOH) are called carboxylic acids.
- Ethanoic acid reacts with sodium carbonate to produce carbon dioxide gas.
- A dilute aqueous solution 4 – 6% of ethanoic acid is called vinegar
- A 99% pure solution of acetic acid is called glacial acetic acid.
- A soap is a sodium or potassium salt of a long-chain carboxylic acid. Sodium palmitate, sodium stearate, etc., are examples of soaps.
- The process of splitting fats or oils using alkalis is called saponification.
- Soaps do not work well with hard water, but synthetic detergents do.
- Soaps are biodegradable, but synthetic detergents are not.