CARBON AND ITS COMPOUNDS

Question (1): What is organic chemistry?

Answer: Organic chemistry is the study of carbon compounds of living matter i.e., plants and animals (CO_2, carbonates, bicarbonates etc. do not fall in this category).

Question (2): What are hydrocarbons?

Answer: Compounds containing only the elements carbon and hydrogen are called hydrocarbons. They are a parent class of organic carbon compounds from which all other classes of hydrocarbon sub groupings of compounds can be made. Examples: Ethane (C_2H_4) alkane group; hexene (C_6H_{12}) alkene group; acetylene (C_2H_2) alkyne group and benzene C_6H_6 (arene or aromatic group).

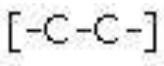
Question (3): What are the different types of covalent bonds found in carbons compounds? Briefly explain with examples.

Answer: There are three classes of covalent bonds, mainly found in hydrocarbons compounds of the aliphatic type:

Alkanes :

These hydrocarbons have a single covalent bond between the 'C' atoms throughout the molecule i.e., only one pair of electrons is shared between any two carbon atoms.

Examples: C_2H_6, C_3H_8, C_4H_{10} ---------

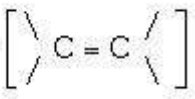


Alkenes :

These are aliphatic hydrocarbons in which at least one pair of 'C' atoms are linked by a double bond in the molecule.

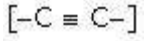
Examples:

C_2H_4, C_3H_6, C_4H_8 ---------



Alkynes

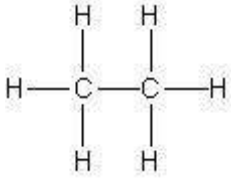
These are aliphatic hydrocarbons in which at least one pair of 'C' atoms are linked by a triple bond in the molecule



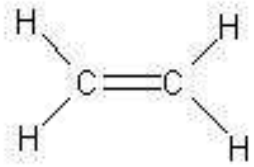
Examples: C_2H_2, C_3H_4, C_4H_6

Question (4): What is the difference between saturated and unsaturated carbon compounds?

Answer: carbon compounds in which all the four valencies of carbon atom are satisfied by forming single covalent bonds are known saturated carbon compounds. For example, ethane:



In unsaturated carbon compounds, at least one or more double covalent bond or triple bonds satisfy the four valencies of a carbon atom. For example, ethylene or acetylene:



ethylene

acetylene

The main differences between saturated and unsaturated hydrocarbons are:

SATURATED COMPOUNDS	UNSATURATED COMPOUNDS
These compounds contain all single carbon - carbon covalent bond.	These compounds contain at least one double or triple covalent bond.
These compounds are less reactive.	These compounds are more reactive.
Saturated compounds undergo substitution reactions.	Unsaturated compounds under go addition reactions.
These compounds have more number of hydrogen atoms.	The number of hydrogen atoms is less here.

Question (5): Three hydrocarbons have molecular formula:

a)

1) C_4H_8
2) C_2H_2
3) C_3H_8 Identify them.

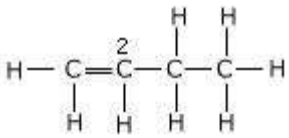
b) Draw their structural formulae and give their IUPAC names. **Answer:** a)

1) In C_4H_8, n = 4 and it fits into the formula C_nH_{2n} Therefore it is an alkene

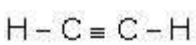
2) In C_2H_2, n = 2 and it fits into the formula C_nH_{2n-2} Therefore it is an alkyne

3) In C_3H_8, n = 3 and it fits into the formula C_nH_{2n+2} Therefore it is an alkane

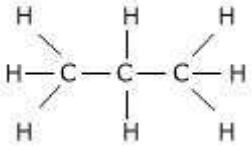
b) 1) C_4H_8 - alkene - Butene IUPAC name: 1-butene



2) C_2H_2 - alkyne Ethyne - IUPAC name

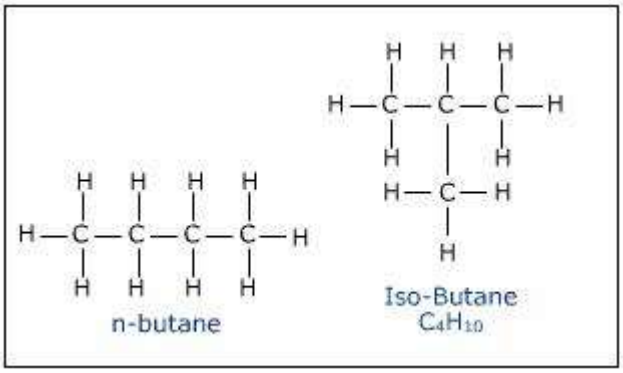


3) C_3H_8 - alkane - Propane - IUPAC name



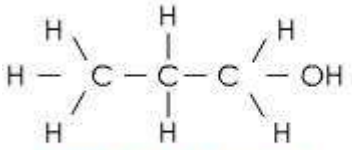
Question (6): Draw the two structural formulae for butane and name the isomers.

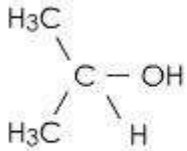
Answer: Butane is C_4H_{10} with general formula of alkane C_nH_{2n+2}.

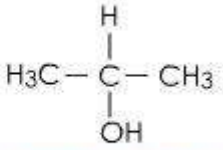


Question (7): Draw the two isomers for propyl alcohol and name the isomers.

Answer: Propyl alcohol is C_3H_7 - OH

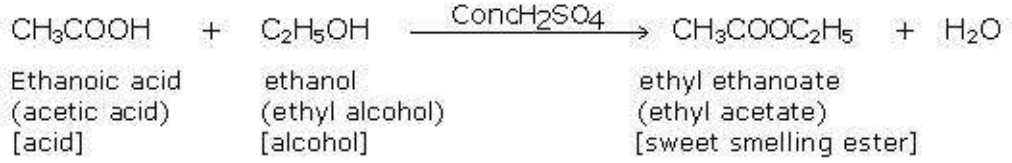






Question (8): What is esterification? Give an example.

Answer: When an alcohol reacts with an acid, it forms ester and water. This process is known as esterification. For example, ethanol reacts with organic acids to form esters. Unlike neutralization, this is a reversible, non-ionic and slow process carried out in the presence of a dehydrating agent like concentrated sulphuric acid.



Question (9): Mention a few important uses of ethanol.

Answer: Ethanol is used in the manufacture of:

1) In manufacturing paints and varnishes
2) As a constituent of alcoholic beverages
3) ether, chloroform, iodoform and other organic compounds
4) In alcohol thermometers and spirit levels.

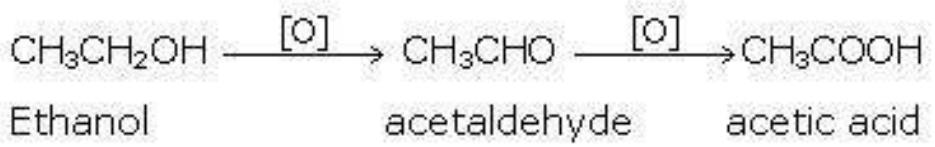
5) In the manufacture of chemical dyes
6) As a solvent in the manufacture of transparent soaps.

Question (10): Choose and give reason for the one which does not belong to the set: C_2H_2, C_3H_4, C_3H_6

Answer: C_3H_6 because it is an alkene (C_nH_{2n}) while the other two are alkynes CnH_{2n-2}.

Question (11): An organic compound A with the formula C_2H_6O gives the compound B with the same number of carbon atoms when oxidized, which further undergoes oxidation to acetic acid. Identify the compound A.

Answer: Compound A is ethanol (C_2H_5OH). It undergoes oxidation to give acetaldehyde (CH_3CHO) with the same number of carbon atoms. Acetaldehyde further undergoes oxidation to give acetic acid (CH_3COOH), again with the same number of carbon atoms.

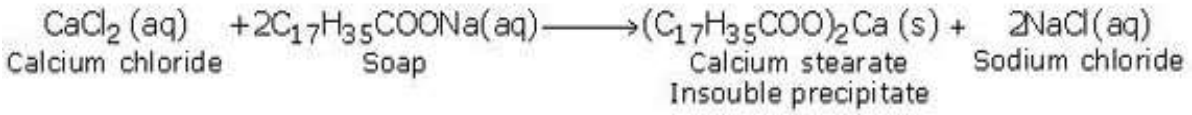


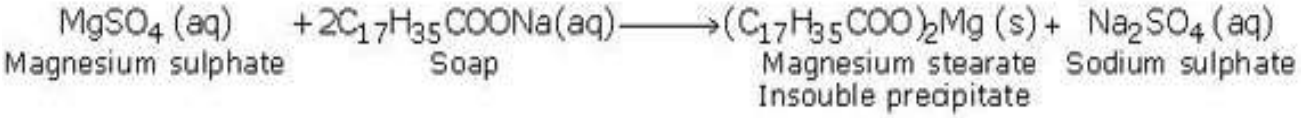
Question (12): Mention two uses of ethanoic acid.

Answer: Ethanoic acid is used in the manufacture of
1) dyes, perfumes and rayons.
2) rubber from latex and casein from milk. (It is used for coagulation).

Question (13): Why do soaps not give lather with hard water?

Answer: Hard water contains dissolved impurities like salts of calcium chloride, calcium sulphate or calcium carbonate (bicarbonate) and corresponding salts of magnesium. When soap is added to hard water it reacts with the calcium and magnesium salts present in it and forms an insoluble white curd like precipitate of calcium or magnesium stearate.





These impurities do not allow the soap to lather but instead form insoluble scum. Until all the calcium and magnesium ions precipitate from such water, soap will not produce lather with it. Thus, a part of the soap is wasted and washing becomes wasteful.

Question (14): In a molecule of a hydrocarbon, the number of 'C' atoms is '5'. What will be its formula if it is an alkane, alkene, alkyne?

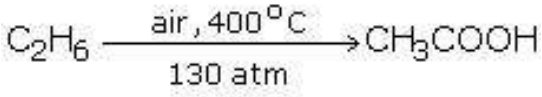
Answer: If the number of 'C' atoms is '5' then the formula of the alkane is C_5H_{12}, the formula of the alkene is C_5H_{10} and the formula of the alkyne is C_5H_8.

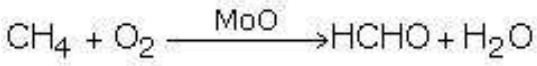
Question (15): How do you convert:

1) Ethane to ethanoic acid
2) Ethanol to ethene. Give conditions and equations relevant to these conversions.

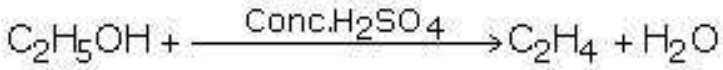
Answer:

1) Ethane to ethanoic acid Ethane when heated with air at 400°C under 130 atms gets converted to ethanoic acid or acetic acid.





2) Ethanol gets dehydrated by concentrated H_2SO_4 at 170°C to ethene.

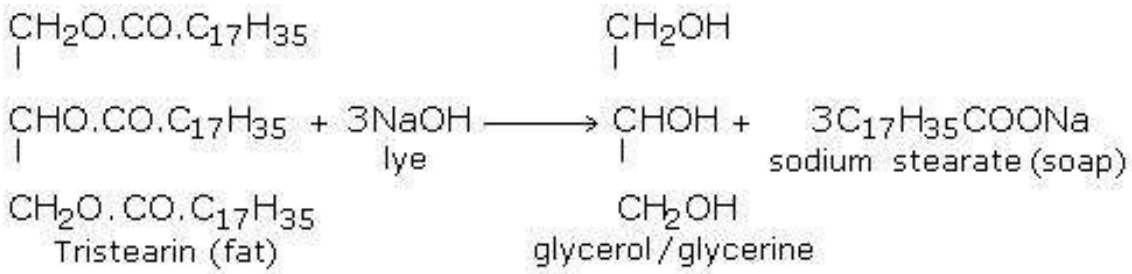


Question (16): Which is the ionic and non-ionic part in sodium stearate soap ($C_{17}H_{35}COONa$)?

Answer: The sodium stearate soap molecule ($C_{17}H_{35}COONa$) has a tadpole shaped structure, whose ends have different polarities. One end has a long hydrocarbon $CH_3(CH_2)_{16}$- chain and is non-ionic or non polar part. The other end is a short ionic or polar part containing -COO^-Na^+ group.

Question (17): What is saponification? Give an example.

Answer: Saponification is the process where a natural oil or fat is treated with sodium hydroxide solution called lye, to form soap and glycerine. For example, tristearin is heated with lye to give sodium stearate and glycerine.

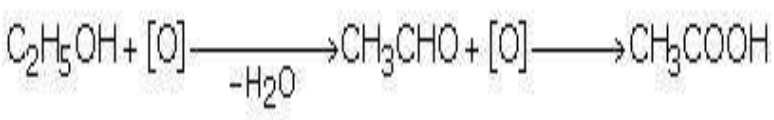


Question (18): What is alcohol? What is the general formula of alcohol?

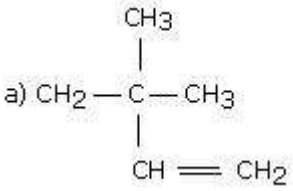
Answer: Alcohol is a derivative of alkane, obtained by replacing one 'H' atom of alkane by a - OH group. The general formula of alcohol is $C_nH_{2n+1}OH$.

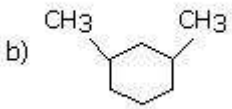
Question (19): What happens when ethyl alcohol is treated with $K_2Cr_2O_7$ and H_2SO_4?

Answer: When ethyl alcohol is treated with $K_2Cr_2O_7$ and H_2SO_4 it gets oxidized first to ethanal and then to ethanoic acid.

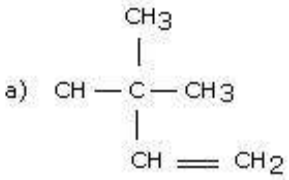
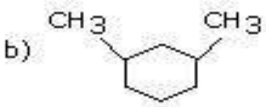


Question (20): What are the molecular, general and the structural formula for each of the following compounds? Give the names of these compound and the homologous groups to which they belong.



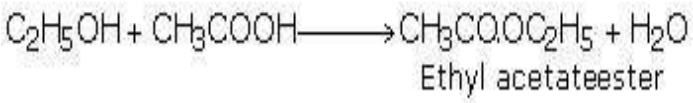


Answer:

HYDROCARBON	MOLECULAR FORMULA	GENERAL FORMULA
	C_6H_{12} (Hexene)	C_nH_{2n} (Alkene)
	C_8H_{16} (Cyclooctane)	C_nH_{2n} (Cycloalkane)

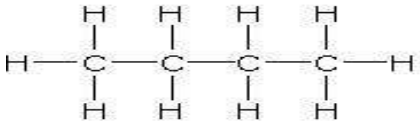
Question (21): What happens when a mixture of ethyl alcohol, acetic acid and concentrated H_2SO_4 is heated?

Answer: When a mixture of ethyl alcohol, acetic acid and concentrated H_2SO_4 is heated ester formation takes place with the elimination of a water molecule as follows.

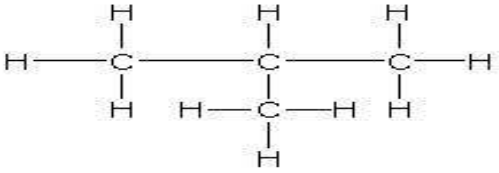


Question (22): What are isomers? Give an example.

Answer: Two or more compounds having the same molecular formula but different molecular structures are called isomers of each other. When the compounds with the same molecular formula have their atoms attached in a different order; they have different structures and are called structural isomers of each other. This phenomenon is known as isomerism. The four carbon atom alkane C_4H_{10} has two isomers:



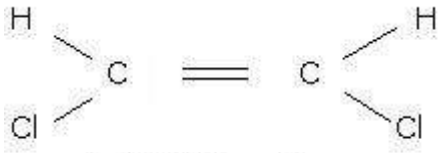
Butane (C_4H_{10})
(Continuous chain alkane)



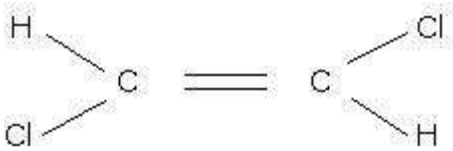
2-methyl propane (C_4H_{10})
(Branched chain alkane)

Question (28): Write the structural formulae of all the possible isomers of $C_2H_2Cl_2$.

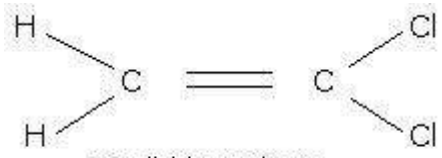
Answer: The structural formulae are:



cis-1,2-dichloroethene



trans-1,2-dichloroethene



1,1-dichloroethene

Question (29): What is 'denatured' alcohol?

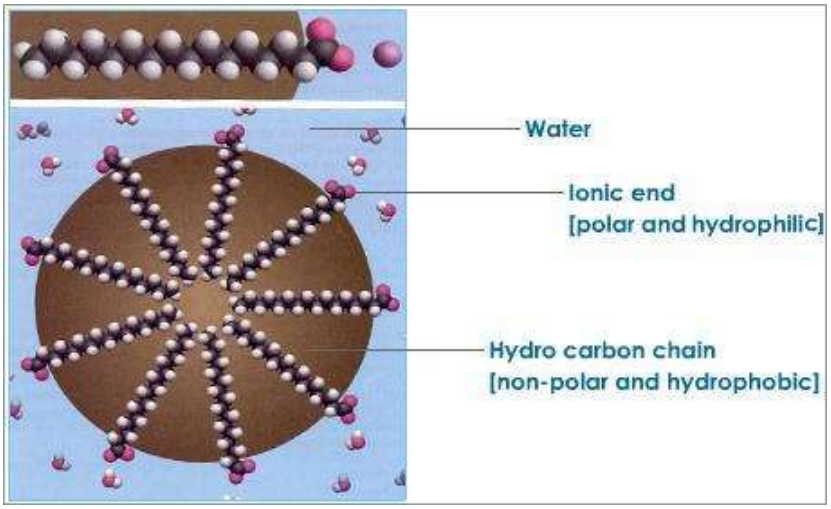
Answer: When methyl alcohol is present in a small quantity with ethyl alcohol, it renders the latter unfit for drinking. This is called denatured alcohol.

Question (30): What is the danger of drinking ethyl alcohol by youngsters?

Answer: Large amounts of alcoholic intake, affects the nerves that control respiration, action of pancreas and heart action. Hence it is a health hazard and needs immediate and expensive medical attention. It can therefore cause economic problems for many poor and middle income group families.

Question (31): Describe the cleansing mechanism of soap or detergents?

Answer: All soaps and detergents are polar molecules, which allow for the cleansing action of dirt in water. One end consists of a large non-polar hydrocarbon group that is hydrophobic i.e., repels water but attracts oil and dirt particles. The other end has a highly polar short group that is hydrophilic i.e., attracts water and not oil or dirt.

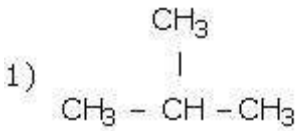


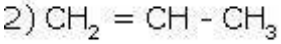
Soap forms a colloidal solution in water and when soap is applied to the surface of a wet dirty cloth, the non-polar long end hydrocarbon of soap attaches itself to the dirt and grease. The short polar or ionic end of the soap molecule remains attached to water molecules. The latter form very small globules or structures called 'micelles' in which the oily dirt particle is surrounded with the tails of soap molecules carrying negative charge, while the polar head with positive charge interacts with the water. The subsequent mechanical action of rubbing or tumbling dislodges the dirt and grease. These are washed away with excess of water leaving the fabric clean.

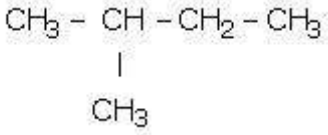
Question (32): How can detergents be used for washing in hard water?

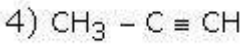
Answer: Synthetic detergents are the sodium or potassium salts of sulphonic acids that have cleansing action exactly similar to that of soaps. However, synthetic detergents lather well even in hard water. This is because calcium and magnesium salts of detergents like their sodium and potassium salts are soluble in water. Thus, they do not form insoluble calcium or magnesium salts on reacting with the calcium ions or magnesium ions present therein. This is a major advantage of the cleansing property of detergents over soap.

Question (33): Write the IUPAC names of:

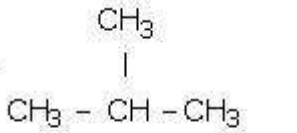
1) 

2) 

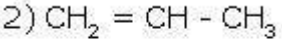
3) 

4) 

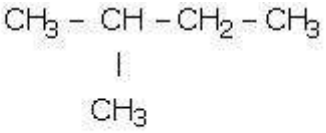
Answer:

1) 

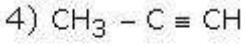
2 - methyl propane

2) 

Propene

3) 

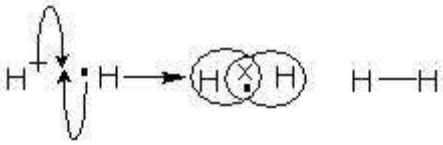
2 - methyl butane

4) 

Propyne

Question (34): What is a covalent bond? Explain with an example.

Answer: When a pair of electrons is shared between atoms in such a way that each contributes an electron, covalent bond is formed. It was G.N. Lewis who proposed that sharing of electrons is possible. It may be defined as the attraction between atoms arising due to electron pair sharing. For example, consider the formation of hydrogen molecule (H_2). Each hydrogen atom contributes an electron and the shared pair belongs to both the atoms. By sharing, both the hydrogen atoms acquire the stable, nearest inert gas (He) configuration. This bonding can be represented by the Lewis dot structure as follows:



Question (35): What are the characteristics of covalent compounds?

Answer: The characteristics of covalent compounds are:

1) The molecules are non-ionic and hence do not conduct electricity either in solution or in fused state.

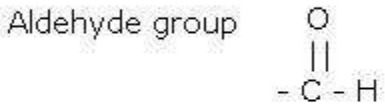
2) They are generally gases, liquids or low melting solids because of the weak forces holding the molecules together

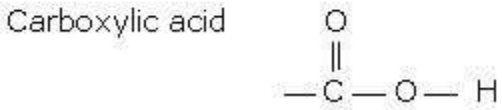
3) They are generally insoluble in water or polar solvents but are soluble in non-polar solvents like benzene, ether etc.

4) Covalent bond is rigid and directional

Question (36): What is a functional group? Give some examples.

Answer: An atom or a group of atoms, which makes an organic compound reactive and decides its functions is called a functional group. Examples of functional groups are:

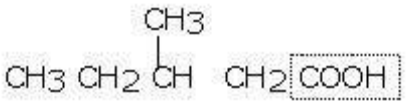




Question (37): Write down the steps involved in IUPAC nomenclature of compound containing functional groups.

Answer: The following four steps are involved in naming the compound containing functional group.

1) Identify the functional group present. This enables us to chose the appropriate suffix or prefix. For example, the functional group present in the following compound is carboxylic acid and the suffix is oic acid.



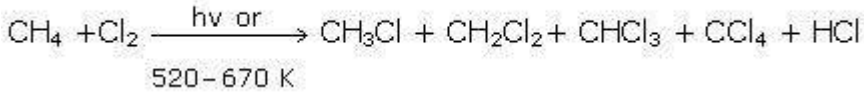
2) Determine the longest continuous chain containing the functional group. The longest continuous chain in the above compound contains five carbon atoms. Therefore the base name is pentane.

3) Following the principle of assigning the lowest possible number to the functional group, the chain is numbered. In the above compound, carboxylic acid carbon is number 1 and the carbon at which the branching is present is carbon 3.

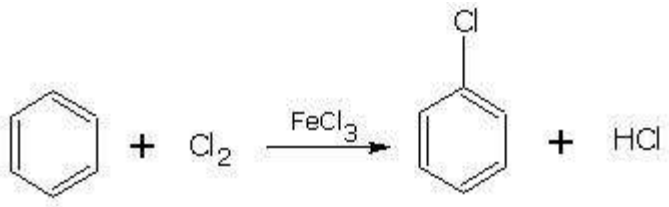
4) Then the name is arrived at. The alkyl group (CH_3) at carbon 3 comes as a prefix. Hence, the name of the compound is completed.

Question (38): Write a short note on substitution reactions?

Answer: The replacement of a hydrogen atom of a hydrocarbon molecule by an atom or a group of atoms is known as substitution reaction. Alkanes, due to their structure, can undergo substitution reactions only in the presence of sunlight or ultraviolet light or at high temperatures. For example, methane reacts with chlorine either on heading at 520 - 670 K or on exposure to sunlight to give a mixture of chloro methane.

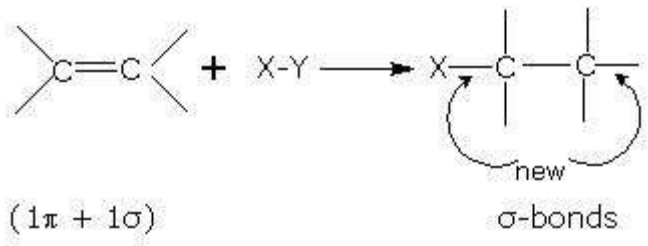


Arenes, though unsaturated, also undergoes substitution reactions due to special stability associated with electron cloud.



Question (39): What are addition reactions? Which of the following will not give addition reactions and why? Propane, propyne, propene, benzene.

Answer: Addition reactions are those in which one reacting molecule adds on to the multiple bond of the other reacting molecule. In the process, the -bond of the multiple bond is broken and two new ?-bonds are formed. For example, in the case of an alkene, we have



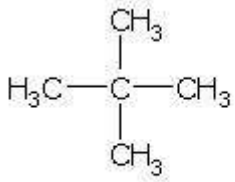
Propane, being a saturated hydrocarbon (no -bond) will not give addition reaction. Arenes are also stable due to delocalisation of -electron cloud and gives addition reaction only in the presence of sunlight. Propene and propyne gives addition reactions under normal conditions.

Question (40): The following organic compounds are popularly known by their common names. Write their structural formulas and IUPAC names.

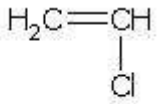
1) Neopentane
2) Vinyl chloride
3) Iso-butyl bromide
4) Acetonitrile

Answer:

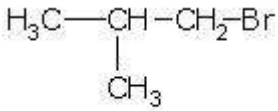
1) Neopentane



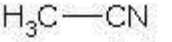
2,2-Dimethylpropane

2) Vinyl chloride 

Chloroethene

3) Iso-butyl bromide 

1-bromo-2-methylpropane

4) Acetonitrile 

Ethanenitrile

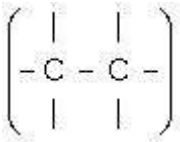
Question (41): What is allotropy? Name some elements which exhibit allotropy.

Answer: Allotropy is the phenomenon of an existence of an element in two or more distinct forms in the same physical state. Elements which exhibit allotropy are:

1) Carbon diamond, graphite, buck minster fullerene
2) Phosphorus White phosphorus, red phosphorus.
3) Sulphur rhombic sulphur, monoclinic sulphur

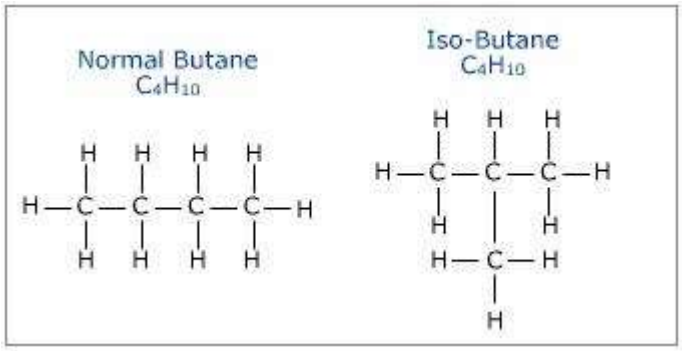
Question (42): Give three reasons for the existence of a large number of carbon compounds?

Answer: Catenation The unique property of the 'C' element to be able to form continuous links with other 'C' atoms through covalency called catenation, is one reason for the existence of a large number of organic compounds. Formation of Multiple Bonds Two 'C' atoms can either be linked through a single bond .


or a double bond

.

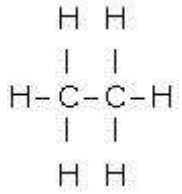
This leads to the formation of a variety of organic compounds. Isomerism This property, shown by organic compounds, which have same molecular formula but different structural formulae is also a reason for formation of a large number of organic compounds. Example: For C_4H_{10} formula there could be two isomers.



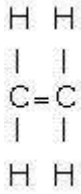
Question (43): How do the prefixes and suffixes for the open chain hydrocarbons indicate their formula?

Answer: The prefixes meth-, eth-, prop-, but-, pent-, hex-, hept-, oct-, non- deca- indicate that the number of 'C' atoms in the molecule of hydrocarbons is 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 respectively. The suffix ane or ene or yne with these, indicate whether they belong to the family of alkane or alkene or alkyne respectively. Examples:

Methane CH_4	Methene Does not exist	Methyne Does not exist
Ethane C_2H_6	Ethylene or Ethene C_2H_4	Acetylene or Ethyne C_2H_2 $H-C\equiv C-H$

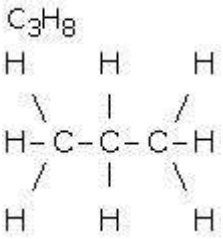


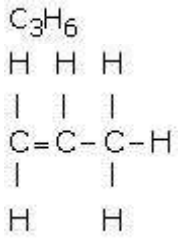
Propane

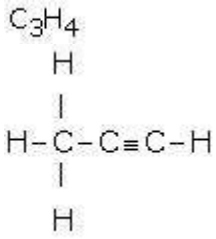


Propylene or Propene

Propyne

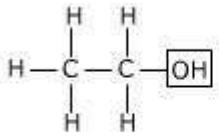




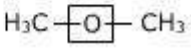


Question (44): An alcohol and an ether have same molecular formula C_2H_6O. Draw their structural formula, indicating their functional groups.

Answer:



Ethyl alcohol



Ether

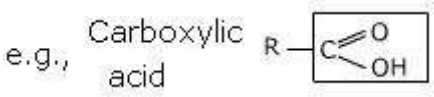
-OH is the functional group in ethyl alcohol while O- is the functional group in ether. Ethyl alcohol is an isomer of dimethyl ether.

Question (45): What are functional groups? write the functional groups of:

1) acids
2) aldehydes.

Answer: The functional group is an atom, or a group of atoms which can replace one or more hydrogen in a hydrocarbon. This group when present in organic compounds defines the characteristic physical and chemical properties of that particular family of organic compounds.

1) The functional group of acids is -COOH



'R' can be 'H' or alkyl group attached to an carboxylic acid group (-COOH)

2) The functional group of aldehydes is -CHO

'R' can be a 'H' atom or an alkyl group attached to an aldehdye group (-CHO).

Question (46): What are homologous series? Write a short note.

Answer: The extremely large numbers of carbon compounds discovered so far are better and more systematically studied by classifying them into families. Such groupings contain members, which are similar to one another in chemical properties, due to their common functional groups. These families form homologous series.

The properties of such homologous series are:

1) Members of the same family have a general formula. For e.g., for alkanes the general formula is C_nH_{2n+2}, for alkenes the general formula is C_nH_{2n}; for alkyne the general formula is C_nH_{2n-2}

2) They have common methods of preparation

3) Their chemical properties are similar

4) Their physical properties like colour, solubility, density, melting and boiling ponits etc. are graded .

5) Each member differs from the next by a CH_2 moiety in its formula