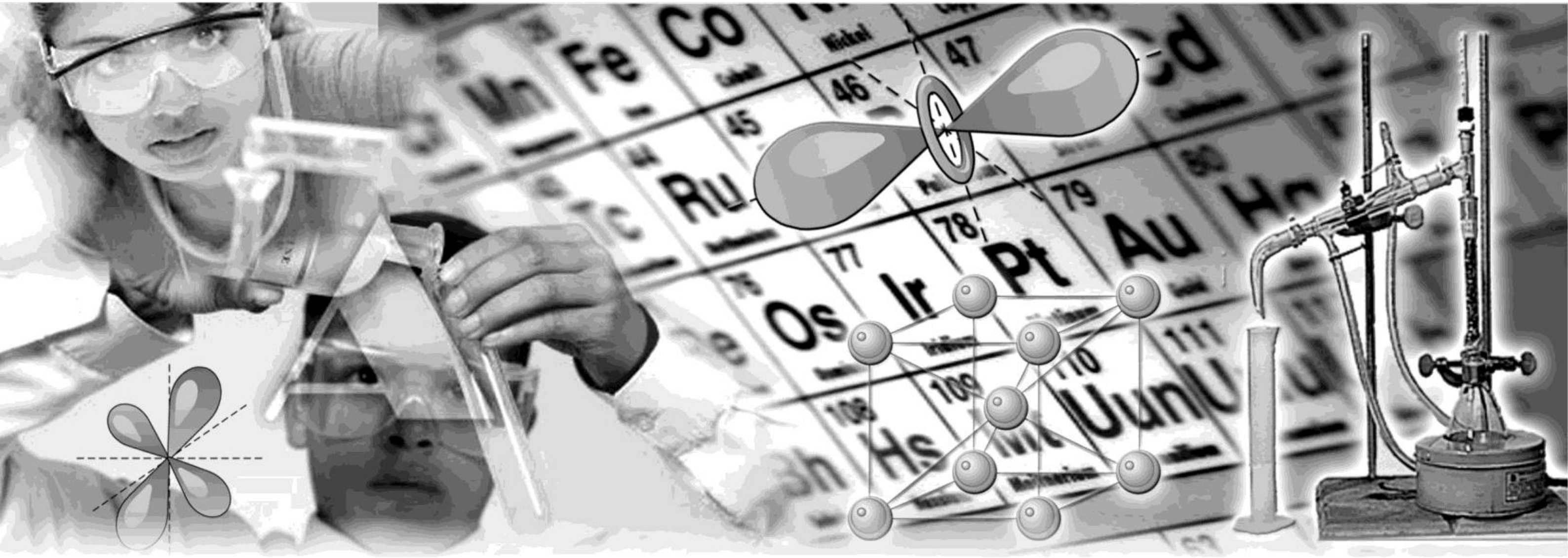


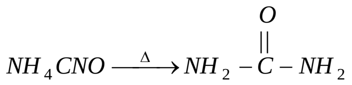
Chapter
22

Purification, Classification and Nomenclature of Organic compounds

The word '*organic' signifies life*. Therefore, all substances which were obtained directly or indirectly from living organisms, plants and animals were called *organic compounds* and the branch of chemistry which deals with these compounds was called *organic chemistry.*

Modern definition of organic chemistry : Organic chemistry is a chemistry of hydrocarbons and their derivatives in which covalently bonded carbon is an essential constituent.

Berzelius put forward a theory in 1815 known as *vital force theory*. According to this theory, "*organic compounds could be prepared only by living organism under the influence of a mysterious force known as vital force*". Accidental synthesis of urea by ***Wohler*** and synthesis of acetic acid by ***Kolbe*** led to the fall of this theory.



$$NH_4CNO \xrightarrow{\Delta} NH_2-\overset{\overset{O}{||}}{C}-NH_2$$

(Ammonium

Urea
(First organic compound synthesised in laboratory)

$$CH_3-CHO \xrightarrow{[O]} CH_3-COOH$$

Acetaldehyde

Acetic acid
(First organic compound synthesised from its elements)

Berthelot prepared ***methane*** in laboratory and the most abundant organic compound is ***cellulose*** which is a polymer of glucose. ***Kekule*** and ***Couper*** proposed the tetravalency of carbon and wrote the first structural formula. In 1874, ***Van't Hoff*** and ***Le Bell*** suggested a tetrahedron model of carbon.

Purification and Characterisation of organic compounds

The study of organic compounds starts with the characterisation of the compound and the determination of its molecular structure. The procedure generally employed for this purpose consists of the following steps :

(1) Purification of organic compounds

(2) Qualitative analysis of organic compounds

(3) Quantitative analysis of organic compounds

(4) Determination of molecular mass of organic compounds

(5) Calculation of Empirical formula and Molecular formula of organic compounds

(6) Determination of structure of organic compounds by spectroscopic and diffraction methods

(1) **Purification of organic compounds :** A large number of methods are available for the purification of substances. The choice of method, however, depends upon the nature of substance (whether solid or liquid) and the type of impurities present in it. Following methods are commonly used for this purpose,

(i) Simple crystallisation

(ii) Fractional crystallisation,

(iii) Sublimation

(iv) Simple distillation

(v) Fractional distillation

(vi) Distillation under reduced pressure

(vii) Steam distillation

(viii) Azeotropic distillation

(ix) Chromatography

(x) Differential extraction

(xi) Chemical methods

(i) ***Simple crystallisation* :** This is the most common method used to purify organic solids. It is based upon the fact that whenever a crystal is formed, it tends to leave out the impurities. For crystallisation, a suitable solvent is one (a) which dissolves more of the substance at higher temperature than at room temperature (b) in which impurities are either insoluble or dissolve to an extent that they remain in solution (in the mother liquor) upon crystallisation, (c) which is not highly inflammable and (d) which does not react chemically with the compound to be crystallized. The most commonly used solvents for crystallisation are : water, alcohol, ether, chloroform, carbon- tetrachloride, acetone, benzene, petroleum ether etc.

Examples : (a) Sugar having an impurity of common salt can be crystallized from hot ethanol since sugar dissolves in hot ethanol but common salt does not.

(b) *A mixture of benzoic acid and naphthalene* can be separated from hot water in which benzoic acid dissolves but naphthalene does not.

(ii) ***Fractional crystallisation* :** The process of separation of different components of a mixture by repeated crystallisations is called fractional crystallisation. The mixture is dissolved in a solvent in which the two components have different solubilities. When a hot saturated solution of this mixture is allowed to cool, the less soluble component crystallises out first while the more soluble substance remains in solution. The mother liquor left after crystallisation of the less soluble component is again concentrated and then allowed to cool when the crystals of the more soluble component are obtained. The two components thus separated are recrystallized from the same or different solvent to yield both the components of the mixture in pure form.

Fractional crystallisation can be used to separate a *mixture of* $KClO_3$ (less soluble) and KCl (more soluble).

(iii) ***Sublimation* :** Certain organic solids on heating directly change from solid to vapour state without passing through a liquid state, such substances are called *sublimable* and this process is called *sublimation.*

$$\text{Solid} \underset{\text{Cool}}{\overset{\text{Heat}}{\rightleftharpoons}} \text{Vapour}$$

The *sublimation process* is used for the separation of sublimable volatile compounds from non sublimable impurities. The process is generally used for the *purification of camphor, naphthalene, anthracene, benzoic acid* $NH_4Cl, HgCl_2$, *solid* SO_2, *Iodine and salicylic acid* etc *containing non-volatile impurities.*

(iv) ***Simple distillation* :** Distillation is the joint process of vapourisation and condensation. This method is used for the purification of liquids which boil without decomposition and contain non-volatile impurities. This method can also be used for separating liquids having sufficient difference in their boiling points. This method can be used to separate a mixture of

(a) chloroform (b. p. 334 *K*) and aniline (b. p. 457 *K*)

(b) ether (b. p. 308 *K*) and toluene (b. p. 384 *K*)

(v) ***Fractional distillation* :** This process is used to separate a mixture of two or more miscible liquids which have boiling points close to each other. Since in this process, the distillate is collected in fractions under different temperatures, it is known as fractional distillation. This process is carried out by using *fractionating columns.* Fractionating column is a special type of long glass tube provided with obstructions to the passage of the vapour upwards and that of liquid downwards. This method may be used to *separate a mixture of acetone* (b. p. 330 *K*) *and methyl alcohol* (b. p. 338 *K*) or *a mixture of benzene and toluene.* One of the technological applications of fractional distillation is to separate different *fractions of crude oil in petroleum industry into various useful fractions such as gasoline, kerosene oil, diesel oil, lubricating oil etc.*

(vi) ***Distillation under reduced pressure* :** This method is used for the purification of high boiling liquids and liquids which decompose at or below their boiling points.

The crude liquid is heated in distillation flask fitted with a water condenser, receiver and vacuum pump. As the pressure is reduced, the liquid begins to boil at a much lower temperature than its normal boiling point. The vapour is condensed by water condenser and the pure liquid collects in the receiver.

Glycerol which decomposes at its boiling point (563 *K*) under atmospheric pressure can be distilled without decomposition at 453 *K* under 12 *mm* of *Hg*. Similarly, sugarcane juice is concentrated in sugar industry by evaporation under reduced pressure which saves a lot of fuel.

(vii) ***Steam distillation* :** This method is applicable for the separation and purification of those organic compounds (solids or liquids) which (a) are insoluble in water (b) are volatile in steam (c) possess a high vapour pressure (10-15 *mm Hg*) at 373 *K* and (d) contain non-volatile impurities.

Aniline (b. p. 457 *K*) can be purified by steam distillation since it boils at a temperature of 371.5 *K* in presence of steam. Other compounds which can be purified by steam distillation are: nitrobenzene, bromobenzene, *o*-nitrophenol, salicylaldehyde, o-hydroxyacetophenone, essential oils, turpentine oil etc.

(viii) ***Azeotropic distillation*** **:** Azeotropic mixture is a mixture having constant boiling point. The most familiar example is a mixture of ethanol and water in the ratio of 95.87 : 4.13 (a ratio present in rectified spirit). It boils at $78.13^{o}C$. The constituents of an azeotropic mixture can't be separated by fractional distillation. Hence a special type of distillation (azeotropic distillation) is used for separating the constituents of an azeotropic mixture.

In this method a third compound is used in distillation. The process is based on the fact that dehydrating agents like $C_6H_{6,}$ CCl_4, diethyl ether etc. depress the partial pressure of one of the original components. As a result, the boiling point of that component is raised sufficiently and thus the other component will distil over.

Dehydrating agents having low boiling point (*e.g.* $C_6H_{6,}$ $CCl_{4,}$ ether) depress the partial pressure of alcohol more than that of water; on the other hand, dehydrating agents having high boiling point (glycerol, glycol) depress the partial pressure of water more than that of alcohol.

(ix) ***Chromatography*** **:** This is a modern method used for the separation of mixtures into its components, purification of compounds and also to test the purity of compounds. The name chromatography is based on the *Greek word 'chroma' meaning colour and 'graphy' for writing* because the method was first used for the separation of coloured substances found in plants. This method was described by ***Tswett*** in 1906.

(a) *Principle of chromatography :* The technique of chromatography is based on the difference in the rates at which the components of a mixture move through a porous medium (*called stationary phase*) under the influence of some solvent or gas (*called moving phase*). Thus, this technique consists of two phases- one is a stationary phase of large surface area while the second is a moving phase which is allowed to move slowly over the stationary phase. *The stationary phase is either a solid or a liquid while the moving phase may be a liquid or a gas.*

(b) *Types of chromatography :* Depending upon the nature of the stationary and the mobile phases, the different types of chromatographic techniques commonly used are in a given table,

Table : 22.1

Type of Chromatography	Mobile/Stationary Phase	Uses
Adsorption or column chromatography	Liquid/Solid	Large scale separations
Thin-layer chromatography	Liquid/Solid	Qualitative analysis (identification and characterization of organic compounds)
High performance liquid chromatography	Liquid/Solid	Qualitative and quantitative analysis
Gas-liquid chromatography (GLC)	Gas/Liquid	Qualitative and quantitative analysis
Partition chromatography or ascending paper chromatography	Liquid/Liquid	Qualitative and quantitative analysis of polar organic compounds (sugars, α-amino acids and inorganic compounds)

It is constant for a given substance (component) under a given set of conditions. Therefore, it is possible to identify the various components by determining their R_f values.

(x) ***Differential extraction*** **:** This method is used for the separation of an organic compound (solid or liquid) from its aqueous solution by shaking with a suitable solvent (e.g. ether, benzene, chloroform, carbon tetrachloride etc.) in a separating funnel. The selected solvent should be immiscible with water but should dissolve the organic compound to an appreciable extent.

It is important to note that extraction is more efficient (*i.e.,* more complete) when a given volume of the extracting solvent is used in several installments.

This method is normally applied *to nonvolatile compounds.* For example, *benzoic acid can be extracted from its water solution using benzene.*

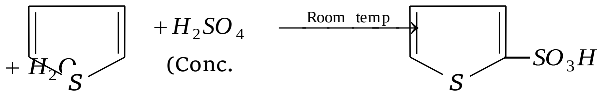
(xi) ***Chemical methods*** **:** Besides these physical methods, a number of chemical methods have also been used to separate a mixture of organic compounds. These methods are based upon the distinguishing chemical properties of one class of organic compounds from the others. For example,

(a) Phenols can be separated from carboxylic acids on treatment with an aqueous solution of $NaHCO_3$. Since carboxylic acids dissolve in $NaHCO_3$ solution evolving CO_2 but phenols usually do not react.

(b) Destructive distillation of wood gives *pyroligneous* acid which contains acetic acid (10%), acetone (0.5%) and methanol (3%). Acetic acid can be separated from this mixture by treating it with milk of lime when acetic acid forms the calcium salt. The reaction mixture on distillation gives a mixture of acetone and methanol (which can be further separated by fractional distillation into individual components as mentioned above) while the calcium salt remains as residue in the flask. The calcium salt is then decomposed with dil *HCl* and distilled to afford acetic acid.

(c) A mixture of 1°, 2° and 3° amines can be separated using either benzenesulphonyl chloride (*Hinsberg's reagent*) or diethyl oxalate (*Hoffmann's method*).

(d) *Purification of commercial benzene :* Commercial benzene obtained from coal-tar distillation contains 3-5% thiophene as an impurity which can be removed by extraction with conc. H_2SO_4. This purification is based upon the fact that thiophene undergoes sulphonation much more easily than benzene. Thus, when commercial benzene is shaken with conc. H_2SO_4 in a separating funnel, thiophene undergoes sulphonation to form thiophene-2-sulphonic acid which dissolves in conc. H_2SO_4 while benzene does not.



Thiophen

Thiophene-2-sulphonic acid
(Dissolves in conc

After this treatment, the benzene layer is removed, washed with water to remove unreacted H_2SO_4, dried over anhyd. $CaCl_2$ and then distilled to give pure benzene.

(e) *Absolute alcohol from rectified spirit :* The rectified spirit (ethanol : $H_2O, 95.87:4.13$ by weight) is kept over a calculated amount of active quick lime (*CaO*) for few hours and then refluxed. During this process, water present in rectified spirit combines with *CaO* to form $Ca(OH)_2$. When the resulting mixture is distilled, absolute alcohol distils over leaving behind, $Ca(OH)_2$.

Drying of Organic Substances. (1) ***For solids :*** Most solids are dried first by pressing them gently between folds of filter papers. Compounds which neither decompose on heating nor melt below 100°*C* are dried by keeping them in steam or oven maintained at 110°*C*. Substances, which decompose on heating are dried by keeping them in a vacuum desiccator containing a suitable dehydrating agent like fused $CaCl_2$, conc. H_2SO_4, P_4O_{10}, solid *KOH* or *NaOH,* etc (desiccant).

(2) ***For liquids :*** Organic liquids are generally dried by keeping them over night in contact with a dehydrating (desiccating) agent which does not react chemically with the liquid to be dried. Commonly used *dehydrating agents* are quick lime, anhydrous $CaCl_2$, fused $CuSO_4$ or $CaSO_4, KOH$, metallic sodium or potassium, etc.

Criteria of purity of organic compounds : The purity of an organic compound can be ascertained by determining its some physical constants like m.p., b.p., specific gravity, refractive index and viscosity. In usual practice, sharp m.p. (in case of solids) and boiling point (in case of liquids) are used as criteria for purity because their determination is feasible in the laboratory. *A pure organic solid has a definite and sharp (sudden, rapid and complete) melting point, while an impure substance has a lower and indefinite melting point.*

(1) **Mixed melting point :** The melting point of two thoroughly mixed substances is called mixed melting point. This can also be used for ascertaining the purity of a compound .

The substance, whose purity is to be tested, is mixed with a pure sample of the same compound. The melting point of the mixture is determined. If the melting point of the mixture is sharp and comes out to be the same as that of pure compound, it is sure that the compound under test is pure. On the other hand, if the melting point of the mixture is less than the melting point of the pure compound, the compound in question is not pure.

(2) **Qualitative analysis :** (Detection of Elements)

The qualitative analysis of an organic compound involves the detection of all the elements present in it.

Carbon is an essential constituent of an organic compound whereas hydrogen is nearly always present. On heating the organic compound with dry cupric oxide, carbon is oxidized to CO_2 and hydrogen to H_2O. CO_2 is detected by lime water which turns milky while H_2O is detected by anhydrous $CuSO_4$ (white) which turns it blue. This method is known as ***copper oxide test***.

$$C + 2CuO \xrightarrow{\text{Heat}} CO_2 + 2Cu \;;$$

$$\underset{\text{Lime water}}{Ca(OH)_2} + CO_2 \longrightarrow \underset{\text{Milky}}{CaCO_3} + H_2O$$

$$H_2 + CuO \xrightarrow{\text{Heat}} H_2O + Cu \;;$$

$$\underset{\substack{\text{Colourless}\\ \text{(Anhydrous)}}}{CuSO_4} + 5H_2O \longrightarrow \underset{\substack{\text{Blue}\\ \text{(Hydrated)}}}{CuSO_4.5H_2O}$$

If the substance under investigation is a volatile liquid or gas, the vapours are passed over heated copper oxide kept in combustion tube and the gaseous products are tested as above.

Lassaigne method

This is used to detect nitrogen, halogen and sulphur. Organic compounds are fused with dry sodium in a fusion-tube and fused mass after extraction with H_2O is boiled and filtered. Filtrate called sodium extract (S.E.) is used to detect elements (other than C and H) and the tests are given in the table.

- Organic compounds being covalents normally do not have ionisable groups, hence direct test is not possible.
- Fusion with Na forms soluble salt (like $NaCl, NaCN$ etc.) which can be easily detected.
- This test fails in case of diazo compounds.
- Sometimes when the amount of nitrogen present is small, the prussian blue is present in colloidal form and the solution looks green.

Table : 22.2 ***Lassaigne method*** (Detection of elements)

Element	Sodium Extract (S.E.)	Confirmed Test	Reaction
Nitrogen	$Na + C + N \xrightarrow{\Delta} \underset{(S.E.)}{NaCN}$	S.E.+ $FeSO_4 + NaOH$, boil and cool + $FeCl_3 + conc.HCl$ Blue or green colour	$2NaCN + FeSO_4 \longrightarrow Fe(CN)_2 + Na_2SO_4$ $Fe(CN)_2 + 4NaCN \longrightarrow \underset{\text{Sodium ferrocyanide}}{Na_4[Fe(CN)_6]}$ $3Na_4[Fe(CN)_6] + 4FeCl_3 \xrightarrow{HCl} \underset{\substack{\text{Ferric ferrocyanide} \\ \text{(Prussian blue)}}}{Fe_4[Fe(CN)_6]_3} + 12NaCl$
Sulphur	$2Na + S \xrightarrow{\Delta} \underset{\text{(S.E.)}}{Na_2S}$	(i) S.E. + sodium nitro prusside (ii)S.E+ $CH_3CO_2H + (CH_3CO_2)_2Pb$ A black ppt.	(i) $Na_2S + \underset{\text{Sodium nitroprusside}}{Na_2[Fe(CN)_5NO]} \longrightarrow \underset{\text{(Purple)}}{Na_4[Fe(CN)_5NO.S]}$ or $\underset{\substack{\text{Sodium thionitro prusside} \\ \text{(Violet)}}}{Na_3[Fe(ONSNa)(CN)_5]}$ (ii) $Na_2S + (CH_3COO)_2Pb \xrightarrow{CH_3COOH} \underset{black\ ppt.}{PbS \downarrow} + 2CH_3COONa$
Halogen	$Na + X \xrightarrow{\Delta} \underset{(S.E.)}{NaX}$ (X = Cl, Br, I)	S.E. $+HNO_3 + AgNO_3$ (i) White *ppt* soluble in *aq* NH_3 confirms Cl . (ii) Pale yellow *ppt* partially soluble in aq. NH_3 confirms *Br*. (iii) Yellow *ppt* insoluble in *aq* NH_3 confirms *I*.	$NaX + AgNO_3 \xrightarrow{HNO_3} \underset{ppt}{AgX \downarrow}$ $\underset{\text{White ppt}}{AgCl} + 2NH_3(aq) \longrightarrow \underset{\text{soluble}}{[Ag(NH_3)_2]Cl}$ $\underset{\text{Yellow ppt.}}{AgBr} + 2NH_3(aq) \rightarrow \underset{\text{Partially soluble}}{[Ag(NH_3)_2]Br}$ $AgI + NH_3(aq) \longrightarrow \text{Insoluble}$
Nitrogen and sulphur together	$Na + C + N + S \xrightarrow{\Delta} \underset{\text{(S.E.)}}{NaCNS}$ with excess of *Na* the thiocyanate formed decomposes into cyanide and sulphide. $NaCNS + 2Na \rightarrow NaCN$ $+Na_2S$	As in test for nitrogen; instead of green or blue colour, blood red colouration confirms presence of N and S both.	$3NaCNS + FeCl_3 \longrightarrow \underset{\substack{\text{Ferric sulphocyanide} \\ \text{(Blood red colour)}}}{[Fe(SCN)_3 \text{ or } [Fe(SCN)]Cl_2} + 3NaCl$

Table : 22.3 ***Other methods for detection of elements***

Element	Test
Nitrogen	***Soda lime test :*** A pinch of an organic compound is heated strongly with soda lime $(NaOH + CaO)$ in a test tube. If ammonia gas evolves, it indicates nitrogen. $\underset{\text{Acetamide}}{CH_3CONH_2} + NaOH \xrightarrow{CaO} CH_3COONa + NH_3$. This test is, however, not reliable since certain compounds like nitro, azo etc do not evolve NH_3 when heated with soda lime.

Sulphur	***Oxidation test :*** Sulphur can also be tested by oxidation test. The organic compound is fused with fusion mixture (a mixture of sodium carbonate and potassium nitrate). The sulphur, if present in the organic compound, is oxidised to sodium sulphate. $Na_2CO_3 + S + 3O \longrightarrow Na_2SO_4 + CO_2$. The fused mass is dissolved in water and the solution is acidified with hydrochloric acid. Barium chloride solution is then added. The formation of a white precipitate indicates the presence of sulphur. $Na_2SO_4 + BaCl_2 \longrightarrow \underset{\text{(White ppt.)}}{BaSO_4} + 2NaCl$.
Halogens	***Beilstein's test*** *(copper wire test) :* A clean copper wire is heated in the Bunsen flame till it does not impart any green colour to the flame. The heated end is dipped in the organic compound and heated again. The appearance of a green or bluish green flame due to the formation of volatile cupric halides indicates the presence of some halogen in the organic compound. Though this test is very sensitive yet it does not confirm the presence of halogens in an organic compound since certain organic compounds like urea, thiourea, pyridine, organic acids etc. which do not contain halogens give this test due to the formation of volatile cupric cyanide. It does not tell as to which halogen is present. ***Special test for bromine and iodine*** *(layer test) :* Boil a portion of the Lassaigne's extract with nitric acid. Add a few drops of CS_2 and then add chlorine water slowly with constant shaking. An *orange colouration* in CS_2 layer confirms the presence of bromine where as a *violet colouration* in the layer confirms the presence of iodine. $2NaBr + Cl_2 \longrightarrow \underset{\text{tums } CS_2 \text{ layer orange}}{2NaCl + Br_2}$; $2NaI + Cl_2 \longrightarrow \underset{\text{turns } CS_2 \text{ layer violet}}{2NaCl + I_2}$
Phosphorus	Phosphorus is detected by fusing the organic compound with sodium peroxide when phosphorus is converted into sodium phosphate. $2P + 5Na_2O_2 \longrightarrow 2Na_3PO_4 + 2Na_2O$. The fused mass is extracted with H_2O, boiled with conc. HNO_3 and then ammonium molybdate is added. Appearance of yellow ppt. or colouration due to the formation of ammonium phosphomolybdate indicates the presence of phosphorus. $Na_3PO_4 + 3HNO_3 \xrightarrow{\Delta} H_3PO_4 + 3NaNO_3$ $H_3PO_4 + 12\underset{\text{Amm.molybdate}}{(NH_4)_2MoO_4} + 21HNO_3 \longrightarrow \underset{\substack{\text{Amm.Phosphomolybdate} \\ \text{(yellow ppt.)}}}{(NH_4)_3PO_4.12MoO_3} + 21NH_4NO_3 + 12H_2O$
Oxygen	There is no satisfactory qualitative method for the detection of oxygen. However, its presence can be inferred indirectly. (i) If the organic compound is heated alone in a dry test tube in the presence of nitrogen, the formation of water drops on cooler parts of the tube may indicate the presence of oxygen. (ii) The presence of oxygen can be inferred by testing the presence of functional groups known to contain oxygen, *e.g.,* hydroxyl (–*OH*), aldehydic (–*CHO*), carboxyl (–*COOH*) groups, etc.

(3) **Quantitative analysis** (Estimation of Elements) **:** After qualitative analysis of elements, the next step in the determination of molecular formula of an organic compound is the estimation of various elements by mass, *i.e.* finding the percentage composition of the elements by mass. The various methods commonly employed for the estimation of principal elements are discussed in the table.

Table : 22.4 ***Quantitative estimation of elements in organic compounds***

Element	**Method and its principle**	**Formula**
Carbon and Hydrogen	**Liebig's combustion method :** In this method, a known weight of organic compound is heated with pure and dry cupric oxide in a steam of pure and dry oxygen, when carbon is oxidised to carbon dioxide while hydrogen is oxidised to water. From the weight of CO_2 and H_2O, the percentage of *C* and *H* can be calculated. $C_xH_y + \left(x + \frac{y}{4}\right)O_2 \xrightarrow{\Delta} xCO_2 + \frac{y}{2}H_2O$	(i) $\%\text{ of }C = \frac{\text{Weight of }CO_2}{\text{Weight of org. compound}} \times \frac{12}{44} \times 100$ (ii) $\%\text{ of }H = \frac{\text{Weight of }H_2O}{\text{Weight of org. compound}} \times \frac{2}{18} \times 100$
Nitrogen	(i) ***Duma's method*** **:** Elemental nitrogen is converted into molecular nitrogen by a suitable chemical method and its voiume is changed to STP data. $C + 2H + 3CuO \rightarrow CO_2 + H_2O + 3Cu$ $2N + 2CuO \rightarrow N_2 +$ oxide of nitrogen $\text{Oxides of nitrogen} + Cu \longrightarrow N_2 + CuO$ (ii) ***Kjeldahl's method*** **:** *Nitrogen in organic compound is converted into* NH_3 *by suitable chemical method which, in turn, is absorbed by* $V_1 mL$ *of* $N_1 H_2SO_4$. $N(\text{from organic compound}) + \text{conc. } H_2SO_4 \xrightarrow{\Delta} (NH_4)_2SO_4$ $(NH_4)_2SO_4 + 2NaOH \longrightarrow Na_2SO_4 + 2H_2O + 2NH_3$	**%** of N **=** $\frac{28}{22400} \times \frac{V}{W} \times 100$ Where, *V*= volume of N_2 in nitrometer (in *ml*) at NTP, *W*= Weight of substance taken; $\%\text{ of }N = \frac{1.4 \times N \times V}{W}$ ***Note*** *: This method is, however, not applicable to compounds containing nitrogen in the ring (e.g. Pyridine, quinoline etc) and compounds containing nitro and azo (– N = N –) groups since nitrogen in these compounds is not completely converted into* $(NH_4)_2SO_4$ *during digestion.*
Halogens	(i) ***Carius method*** *:* The method is based on the fact that when an organic compound containing halogen (*Cl, Br,* or *I*) is heated in a sealed tube with fuming nitric acid in presence of silver nitrate, silver halide is formed. From the mass of silver halide formed, the percentage of the halogen can be calculated.	$\%\text{ of }Cl = \frac{35.5}{143.5} \times \frac{\text{Mass of }AgCl\text{ formed}}{\text{Mass of substance taken}} \times 100$ $\%\text{ of }Br = \frac{80}{188} \times \frac{\text{Mass of }AgBr\text{ formed}}{\text{Mass of substance taken}} \times 100$ $\%\text{ of }I = \frac{127}{235} \times \frac{\text{Mass of }Agl\text{ formed}}{\text{Mass of substance taken}} \times 100$
	(ii) ***Schiff's and Piria method*** *:* In this method the accurately weighed organic compound (0.15 – 0.25 *g*) is taken in a small platinum crucible with a mixture of lime and sodium carbonate, $(CaO + Na_2CO_3)$. It is now heated strongly and then cooled and dissolved in dilute nitric acid in a beaker. The solution is then filtered and the halide is precipitated with silver nitrate solution. Halogen is now calculated as in Carius method.	
Sulphur	***Carius method*** **:** When an organic compound containing sulphur is heated with fuming nitric acid, sulphur is oxidised to sulphuric acid. This is precipitated as barium sulphate by adding barium chloride solution. From the amount of barium sulphate, percentage of sulphur can be calculated. $S + HNO_3(\text{fuming}) \xrightarrow{\text{heat}} H_2SO_4$ $H_2SO_4 + BaCl_2 \longrightarrow \underset{\text{white ppt}}{BaSO_4} + 2HCl$	$\%\text{ of }S = \frac{32}{233} \times \frac{\text{Mass of }BaSO_4\text{ formed}}{\text{Mass of substance taken}} \times 100$
phosphorous	***Carius method*** *:* The organic compound containing phosphorus is heated with fuming nitric acid. Phosphorus is oxidised to phosphoric acid. It is precipitated as magnesium ammonium	$\%\text{ of P} = \frac{62}{222} \times \frac{\text{Mass of }Mg_2P_2O_7\text{ formed}}{\text{Mass of substance taken}} \times 100$

	phosphate, $MgNH_4PO_4$, by the addition of magnesia mixture $(MgSO_4 + NH_4OH + NH_4Cl)$. The magnesium ammonium phosphate is washed, dried and ignited when it is converted to magnesium pyrophosphate $(Mg_2P_2O_7)$. $2MgNH_4PO_4 \xrightarrow{heat} Mg_2P_2O_7 + 2NH_3 + H_2O$ From the mass of magnesium pyro-phosphate, the percentage of phosphorus in the compound can be calculated.	
Oxygen	(i) The usual method of determining the percentage of oxygen in an organic compound is by the method of difference. All the elements except oxygen present in the organic compound are estimated and the total of their percentages subtracted from 100 to get the percentage of oxygen. (ii) ***Aluise's method*** :. Organic compound containing oxygen is heated with graphite and *CO* formed is quantitatively converted into CO_2 on reaction with I_2O_5. $\text{Org. compound} \xrightarrow{\text{Pyrolysis}} \text{Oxygen}$ $O_2 + 2C \xrightarrow{1100^o C} 2CO$ $5CO + I_2O_5 \longrightarrow I_2 + 5CO_2$	Percentage of oxygen = 100 – (Sum of the percentages of all other elements) $\underset{16\,g}{O} \equiv CO \equiv \underset{44\,g}{CO_2}$ $\%\text{ of } O = \frac{16}{44} \times \frac{\text{mass of CO}_2}{\text{mass of org. compd.}} \times 100$

(4) **Determination of Molecular Mass :** The molecular mass of the organic compounds can be determined by various methods.

(i) ***Physical methods for volatile compounds***

(a) *Victor Meyer's method* : Molecular mass of volatile liquids and solids can be easily determined from the application of ***Avogadro hypothesis*** according to which the mass of 22.4 litres or 22400*ml* of the vapour of any volatile substance at NTP is equal to the molecular mass of the substance.

In Victor Meyer's method, a known mass of the volatile substance is vaporised in a Victor Meyer's tube. The vapours formed displace an equal volume of air into a graduated tube. The volume of air collected in graduated tube is measured under experimental conditions. This volume is converted to NTP conditions.

Calculations : Mass of the organic substance $= W\,g$

Let the volume of the air displaced be $= V_1\,ml$;

Temperature $= T_1 K$

Pressure (after deducting aqueous tension) $= p_1 mm$

Let the volume at NTP be $= V_2\,ml$

Applying gas equation, $V_2 = \frac{p_1 \times V_1}{T_1} \times \frac{273}{760}$

$\because$ V_2 *ml* of vapours weight at NTP = *Wg*

$\therefore$ 22400 *ml* of vapour weight at NTP = $\frac{W}{V_2} \times 22400 = M$

Alternatemethod : Vapour density of substance

$$= \frac{\text{Mass of 1 ml of vapours at NTP}}{\text{Mass of 1 ml of hydrogen at NTP}}$$

or $V.\,D. = \frac{W/V_2}{0.00009}$ ($\because$ Mass of 1 *ml* of H_2 at NTP $= 0.00009\ g$ or $2/22400$)

or $V.\,D. = \frac{W}{V_2 \times 0.00009}$;

Mol. Mass, $M = 2 \times V.D. = \frac{2W}{V_2 \times 0.00009}$

(b) *Hofmann's method :* The method is applied to those substances which are not stable at their boiling points, but which may be volatilised without decomposition under reduced pressure. A known mass of the substance is vaporised above a mercury column in a barometric tube and the volume of the vapour formed is recorded. It is then reduced to NTP conditions. The molecular mass of the organic substance can be calculated by the application of following relationship,

$$\text{Mol. Mass} = \frac{\text{Mass of the substance}}{\text{volume of the vapours at NTP}} \times 22400$$

(ii) **Physical methods for Non-volatile substances :** The molecular mass of a non-volatile organic compound can be determined by noting either the elevation in boiling point of the solvent (Ebullioscopic method) or the depression in freezing point of the solvent (Cryoscopic method) produced by dissolving a definite mass of the substance in a known mass of the solvent. The molecular mass of the compound can be calculated from the following mathematical relationships :

(a) *Elevation in boiling point :* Mol. Mass $= \frac{1000\,K_b \times w}{W \times \Delta T}$

Where, $K_b =$ Molal elevation constant of the solvent, $w =$ Mass of the compound, $W =$ Mass of the solvent

$\Delta T =$ Elevation in boiling point of the solvent (determined experimentally)

(b) *Depression in freezing point : M*ol. Mass $= \frac{1000\,K_f \times w}{W \times \Delta T}$

Where, $K_f =$ Molal depression constant of the solvent, $w =$ Mass of the compound, $W =$ Mass of the solvent

$\Delta T =$ Depression in freezing point of the solvent (determined experimentally)

(iii) **Chemical methods**

(a) *Silver salt method for acids :* It is based on the fact that silver salt of an organic acid on heating gives residue of metallic silver.

$$\underset{\text{Silver salt}}{RCOOAg} \xrightarrow{heat} \underset{\text{Silver (residue)}}{Ag}$$

From the mass of the silver salt taken and the mass of the silver residue obtained, the equivalent mass of the silver salt can be calculated.

$$\frac{\text{Equivalent mass of silver salt}}{\text{Equivalent mass of silver}} = \frac{\text{Mass of silver salt}}{\text{Mass of silver}}$$

Knowing the equivalent mass of silver salt, the equivalent mass of the acid can be obtained. The molecular mass of an acid can be determined with the help of the following relationship,

Mol. mass of the acid = Equivalent mass of the acid × basicity

Calculations : (i) Mass of silver salt taken $= w g$

(ii) Mass of metallic silver $= x\,g$

$\frac{\text{Eq. mass of silver salt}}{\text{Eq. mass of silver}} = \frac{w}{x}$; Eq. mass of silver salt

$$= \frac{w}{x} \times 108$$

Let the equivalent mass of the acid be E. In the preparation of silver salt, a hydrogen atom of the carboxylic group is replaced by a silver atom.

Thus, Equivalent mass of silver salt $= E - 1 + 108$ $= E + 107$

Thus, $E + 107 = \frac{w}{x} \times 108$ or $E = \left[\frac{w}{x} \times 108 - 107\right]$

If n be the basicity of the acid, then Mol. Mass of the acid $= \left[\frac{w}{x} \times 108 - 107\right] \times n$

(b) *Platinichloride method for bases :* Organic bases combine with chloroplatinic acid, H_2PtCl_6 to form insoluble platinichlorides, which, on ignition, leave a residue of metallic platinum. Knowing the mass of platinum salt and the mass of metallic platinum, the molecular mass of the platinum salt can be determined. Let B represents one molecule of the base. If the base is mono-acidic, the formula of the salt will be $B_2H_2PtCl_6$.

$$B_2H_2PtCl_6 \xrightarrow{heat} Pt$$

$$\frac{\text{Molecular mass of the salt}}{\text{Atomic mass of platinum}} = \frac{\text{Mass of platinum salt}}{\text{Mass of platinum}}$$

Let E be the equivalent mass of the base.

Molecular mass of the salt

$$= 2E + 2 + 195 + 213 = 2E + 410$$

So $\frac{2E + 410}{195} = \frac{w}{x} = \frac{\text{Mass of platinum salt}}{\text{Mass of platinum}}$;

$$2E = \left[\frac{w}{x} \times 195 - 410\right] \;;\; E = \frac{1}{2}\left[\frac{w}{x} \times 195 - 410\right]$$

Mol. mass of the base = Eq. mass × acidity $= E \times n$

where n is the acidity of the base.

(c) *Volumetric method for acids and bases :* Molecular mass of an acid can be determined by dissolving a known mass of the acid in water and titrating the solution against a standard solution of an alkali using phenolphthalein as an indicator. Knowing the volume of alkali solution used, the mass of the acid, which will require 1000 *ml* of a normal alkali solution for complete neutralisation can be calculated. This mass of the acid will be its equivalent mass.

$\underbrace{1000\ ml\ 1N \text{ alkali solution}}_{\text{One gram equivalent of alkali}} \equiv$ One gram equivalent of the acid

Calculations : Suppose $w\ g$ of the organic acid requires $V\ ml\ \ N_1$ alkali solution for complete neutralisation.

$V\ ml\ N_1$ alkali solution $\equiv w\,gm$ acid

So 1000 *ml* N_1 alkali solution $\equiv \frac{w}{V \times N_1} \times 1000\ g$ acid

$\equiv$ one gram equivalent acid

Equivalent mass of the acid $\equiv \frac{w}{V \times N_1} \times 1000$

Thus, Molecular mass of the acid = Eq. mass × basicity

In the case of organic bases, the known mass of the base is titrated against a standard solution of an acid. Knowing the volume of the acid solution used, the mass of the organic base which will require 1000 *ml* of a normal acid solution for complete neutralisation can be calculated. This mass will be the equivalent mass of the base.

$\underbrace{1000\ ml\ N \text{ acid solution}}_{\text{One gram equivalent of the acid}} \equiv$ One gram equivalent of the base

Molecular mass of the base $=$ Eq. mass $\times$ acidity

(5) **Calculation of Empirical and Molecular formula**

(i) ***Empirical formula*** **:** *Empirical formula of a substance gives the simplest whole number ratio between the atoms of the various elements present in one molecule of the substance.* For example, empirical formula of glucose is CH_2O, *i.e.* for each carbon atom, there are two *H*-atoms and one oxygen atom. Its molecular formula is however, $C_6H_{12}O_6$.

Calculation of empirical formula **:** The steps involved in the calculation are as follows,

(a) Divide the percentage of each element by its atomic mass. This gives the relative number of atoms.

(b) Divide the figures obtained in step (i) by the lowest one. This gives the simplest ratio of the various elements present.

(c) If the simplest ratio obtained in step (ii) is not a whole number ratio, then multiply all the figures with a suitable integer *i.e.,* 2, 3, etc. to make it simplest whole number ratio.

(d) Write down the symbols of the various elements side by side with the above numbers at the lower right corner of each. This gives the empirical or the simplest formula.

(ii) ***Molecular formula*** **:** *Molecular formula of a substance gives the actual number of atoms present in one molecule of the substance.*

Molecular formula = $n \times$ Empirical formula

Where, *n* is a simple integer 1, 2, 3,...... etc. given by the equation,

$$n = \frac{\text{Molecular mass of the compound}}{\text{Empirical formula mass of the compound}}$$

where the molecular mass of the compound is determined experimentally by any one of the methods discussed former, empirical formula mass is calculated by adding the atomic masses of all the atoms present in the empirical formula.

(iii) ***Molecular formula of gaseous hydrocarbons*** **(Eudiometry)**

Eudiometry is a direct method for determination of molecular formula of gaseous hydrocarbons without determining the percentage composition of various elements in it and without knowing the molecular weight of the hydrocarbon. The actual method used involves the following steps,

(a) A known volume of the gaseous hydrocarbon is mixed with an excess (known or unknown volume) of oxygen in the eudiometer tube kept in a trough of mercury.

(b) The mixture is exploded by passing an electric spark between the platinum electrodes. As a result, carbon and hydrogen of the hydrocarbon are oxidised to CO_2 and H_2O vapours respectively.

(c) The tube is allowed to cool to room temperature when water vapours condense to give liquid water which has a negligible volume as compared to the volume of water vapours, Thus, the gaseous mixture left behind in the eudiometer tube after explosion and cooling consists of only CO_2 and unused O_2.

(d) Caustic potash or caustic soda solution is then introduced into the eudiometer tube which absorbs CO_2 completely and only unused O_2 is left behind.

$$2NaOH + CO_2 \longrightarrow Na_2CO_3 + H_2O$$

Thus, the decrease in volume on introducing $NaOH$ or KOH solution gives the volume of CO_2 formed. Sometimes, the volume of O_2 left unused is found by introducing pyrogallol and noting the decrease in volume.

Calculation : From the volume of CO_2 formed and the total volume of O_2 used, it is possible to calculate the molecular formula of gaseous hydrocarbon with the help of the following equation.

$$\begin{array}{llll} C_xH_y + (x + y/4)O_2 & \longrightarrow xCO_2 & + y/2H_2O \\ 1\,\text{vol} \quad (x + y/4)\,\text{vol} & x\,\text{vol} & y/2\,\text{vol} \end{array}$$

(Negligible volume on condensation)

From the above equation, it is evident that for one volume of hydrocarbon,

(a) $(x + y/4)$ volume of O_2 is used

(b) x volume of CO_2 is produced

(c) $y/2$ volume of H_2O vapours is produced which condense to give liquid H_2O with negligible volume.

(d) Contraction on explosion and cooling

$= [(1 + x + y/4) - x] = 1 + y/4$

By equating the experimental values with the theoretical values from the above combustion equation, the values of x and y and hence the molecular formula of the gaseous hydrocarbon can be easily determined.

(6) **Determination of structure by spectroscopic and diffraction methods :** The structures of organic substances are determined by spectroscopic and diffraction methods.

Classification of organic compounds

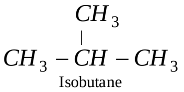
Organic compounds have been classified on the basis of carbon skeleton (structure) or functional groups or the concept of homology.

(1) **Classification based on structure**

(i) ***Acyclic or open-chain compounds* :** Organic compounds in which all the carbon atoms are linked to one another to form open chains (straight or branched) are called acyclic or open chain compounds. These may be either saturated or unsaturated. For example,

$CH_3CH_2CH_2CH_3$

Butane

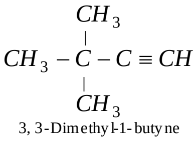


$$CH_3 - \underset{}{\overset{CH_3}{\overset{|}{C}H}} - CH_3$$

Isobutane

$CH_3CH_2CH = CH_2$

1-Butene



$$CH_3 - \underset{CH_3}{\underset{|}{\overset{CH_3}{\overset{|}{C}}}} - C \equiv CH$$

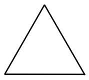
3, 3-Dimethyl-1-butyne

These compounds are also called as aliphatic compounds.

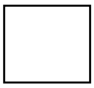
(ii) ***Cyclic or closed-chain compounds* :** Cyclic compounds contain at least one ring or closed chain of atoms. The compounds with only one ring of atoms in the molecule are known as *monocyclic* but those with more than one ring of atoms are termed as *polycyclic*. These are further divided into two subgroups.

(a) *Homocyclic or carbocyclic :* These are the compounds having a ring or rings of carbon atoms only in the molecule. The carbocyclic or homocyclic compounds may again be divided into two types :

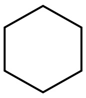
Alicyclic compounds : These are the compounds which contain rings of three or more carbon atoms. These resemble with aliphatic compounds than aromatic compounds in many respects. That is why these are named alicyclic, *i.e.*, aliphatic cyclic. These are also termed as polymethylenes. Some of the examples are,



Cyclopropane

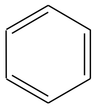


Cyclobutane

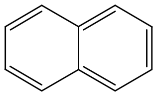


Cyclohexane

Aromatic compounds : These compounds consist of at least one benzene ring, *i.e.*, a six-membered carbocyclic ring having alternate single and double bonds. Generally, these compounds have some fragrant odour and hence, named as aromatic (*Greek word aroma meaning sweet smell*).



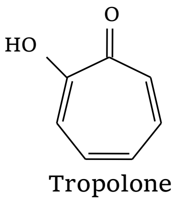
Benzene



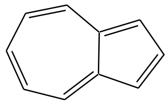
Naphthalene

These are also called benzenoid aromatics.

Non-benzenoid aromatics **:** *There are aromatic compounds, which have structural units different from benzenoid type and are known as Non-benzenoid aromatics e.g. Tropolone, azulene etc.*



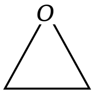
Tropolone



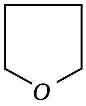
Azulene

(b) *Heterocyclic compounds :* Cyclic compounds containing one or more hetero atoms (e.g. *O, N, S* etc.) in the ring are called heterocyclic compounds. These are of two types :

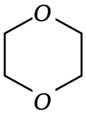
Alicyclic heterocyclic compounds : Heterocyclic compounds which resemble aliphatic compounds in their properties are called *Alicyclic heterocyclic compounds*. For example,



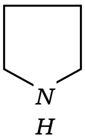
Oxirane or



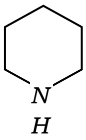
Tetrahydrofuran



1, 4-

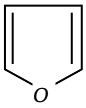


Pyrrolidine

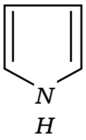


Piperidine

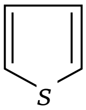
Aromatic heterocyclic compounds : Heterocyclic compounds which resemble benzene and other aromatic compounds in most of their properties are called *Aromatic heterocyclic compounds*. For example,



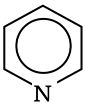
Furan



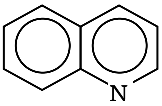
Pyrrol



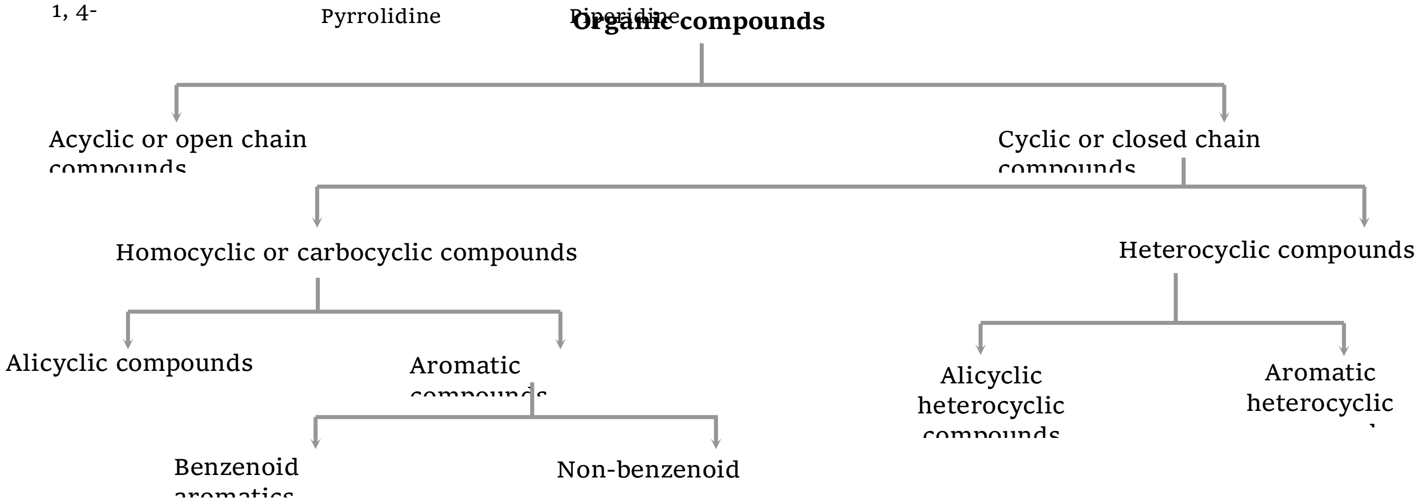
Thiophen



Pyridine



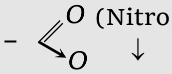
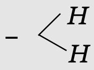
Quinoline



(2) **Classification based on functional groups :** *A functional group is an atom or group of atoms in a molecule that gives the molecule its characteristic chemical properties. Double and triple bonds are also considered as functional groups.*

All compounds with the same functional group belong to the same class. Various classes of compounds having some of the common functional groups are listed in the table.

Table : 22.5

Class	Functional group	Class	Functional group
Olefins/Alkenes (ene)	$>C=C<$	Acid halides (Alkanoyl halids)	$-\overset{O}{\overset{\|}{C}}-X$ (Acylhalide)
Acetylenes/Alkynes (yne)	$-C\equiv C-$	Amides (Alkanamides)	$-\overset{O}{\overset{\|}{C}}-NH_2$ (Amide)
Alkyl Halides	$-F,-Cl,-Br,-I$ (Halo)	Acid anhydrides (Alkanoic anhydrides)	$-\overset{O}{\overset{\|}{C}}-O-\overset{O}{\overset{\|}{C}}-$ (Anhydride)
Alcohols (Alkanols)	$-OH$ (Hydroxy)	Esters (Alkylalkanoates)	$-\overset{O}{\overset{\|}{C}}-O-\overset{\|}{\underset{\|}{C}}-$ (Ester)
Ethers (Alkoxyalkanes)	$-\overset{\|}{\underset{\|}{C}}-O-\overset{\|}{\underset{\|}{C}}-$(Alkoxy)	Cyanides/Nitriles (Alkanenitrile)	$-C\equiv N$ (Cyano)
Aldehydes (Alkanals)	$-\underset{\underset{O}{\|}}{C}-H$ (Aldehydic)	Isocyanides	$-N\rightleftarrows C$ (Isocyano)
Ketones (Alkanones)	$-\overset{O}{\overset{\|}{C}}-$ (Carbonyl)	Nitro compounds (Nitroalkanes)	 (Nitro)
Carboxylic acid (Alkanoic acid)	$-\overset{O}{\overset{\|}{C}}-OH$ (Carboxyl)	Amines	 (Amino)

(3) **Homologous series :** *A homologous series can be defined as a group of compounds in which the various members have similar structural features and similar chemical properties and the successive members differ in their molecular formula by* CH_2 group.

Characteristics of homologous series

(i) All the members of a series can be represented by the general formula. For example, the members of the alcohol family are represented by the formula $C_nH_{2n+1}OH$ where *n* may have values 1, 2, 3..... etc.

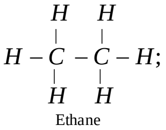
(ii) Two successive members differ in their formula by $-CH_2$ group or by 14 atomic mass units $(12+2\times1)$.

(iii) Different members in a family have common functional group *e.g.,* the members of the alcohol family have $-OH$ group as the functional group.

(iv) The members in any particular family have almost identical chemical properties and their physical properties such as melting point, boiling point, density, solubility etc., show a proper gradation with the increase in the molecular mass.

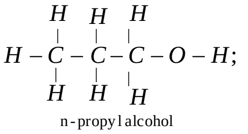
(v) The members present in a particular series can be prepared almost by similar methods known as the general methods of preparation.

(4) **Saturated and unsaturated compounds :** If, in an organic compound containing two or more carbon atoms, there are only single bonds between carbon atoms, then the compound is said to be saturated, *e.g.* ethane, *n*-propyl alcohol, acetaldehyde etc.



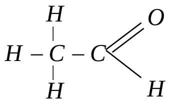
$H-\overset{H}{\overset{|}{\underset{\underset{H}{|}}{C}}}-\overset{H}{\overset{|}{\underset{\underset{H}{|}}{C}}}-H$;

Ethane



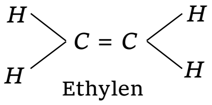
$H-\overset{H}{\overset{|}{\underset{\underset{H}{|}}{C}}}-\overset{H}{\overset{|}{\underset{\underset{H}{|}}{C}}}-\overset{H}{\overset{|}{\underset{\underset{H}{|}}{C}}}-O-H$;

n-propyl alcohol



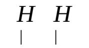
Acetaldehyde

On the other hand, if the compound contains at least one pair of adjacent carbon atoms linked by a multiple bond, then that compound is said to be **unsaturated**, *e.g,* ethylene, acetylene, vinyl alcohol, acraldehyde etc.



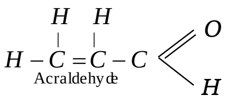
Ethylen

$H-C\equiv C-H$
Acetylene



$H-\overset{H}{\overset{|}{C}}=\overset{H}{\overset{|}{C}}-OH$

Vinylalcohol



Acraldehyde

Nomenclature of organic compounds

Nomenclature means the assignment of names to organic compounds. There are two main systems of nomenclature of organic compounds.

(1) **Trivial system :** This is the oldest system of naming organic compounds. The trivial name was generally based on the source, some property or some other reason. Quite frequently, the names chosen had Latin or Greek roots. For example,

(i) Acetic acid derives its name from vinegar of which it is the chief constituent (Latin : *acetum* = vinegar).

(ii) Formic acid was named as it was obtained from red ants. The Greek word for the red ants is *formicus*.

(iii) The names oxalic acid (*oxalus*), malic acid (*pyrus malus*), citric acid (*citrus*) have been derived from botanical sources given in parentheses.

(iv) Urea and uric acid have derived their names from urine in which both are present.

(v) The liquid obtained by the destructive distillation of wood was named as wood spirit. Later on, it was named methyl alcohol (Greek : *methu* = spirit; *hule* = wood).

(vi) Names like glucose (sweet), pentane (five), hexane (six), etc. were derived from Greek words describing their properties or structures.

(vii) Methane was named as marsh gas because it was produced in marshes. It was also named as fire damp as it formed explosive mixture with air.

Table : 22.6 ***Common or trivial names of some organic compounds.***

Compound	Common name	Compound	Common name
CH_4	Methane	$CHCl_3$	Chloroform
C_2H_2	Acetylene	CHI_3	Iodoform
$H_3CCH_2CH_2CH_3$	*n*-Butane	CH_3CN	Acetonitrile
$(H_3C)_2CHCH_3$	Isobutane	CH_3COOH	Acetic acid
$(H_3C)_4C$	Neopentane	C_6H_6	Benzene
$HCHO$	Formaldehyde	$C_6H_5CH_3$	Toluene
$(H_3C)_2CO$	Acetone	$C_6H_5NH_2$	Aniline
CH_3CH_2OH	Ethyl alcohol	C_6H_5OH	Phenol
CH_3CONH_2	Acetamide	$C_6H_5OCH_3$	Anisole
CH_3OCH_3	Dimethyl ether	$C_6H_5COCH_3$	Acetophenone
$(CH_3CH_2)_2O$	Diethyl ether	$C_6H_5CONH_2$	Benzamide

(2) **IUPAC system :** In order to rationalise the system of naming, an *International Congress of Chemists* was held in Geneva in 1892. They adopted certain uniform rules for naming the compounds.

The system of nomenclature was named as *Geneva system*. Since then the system of naming has been improved from time to time by the *International Union of Pure and Applied Chemistry* and the new system is called *IUPAC system* of naming. This system of nomenclature was first introduced in 1947 and was modified from time to time. The most exhaustic rules for nomenclature were first published in 1979 and later revised and updated in 1993. The rules discussed in the present chapter are based on guide books published by IUPAC in 1979 (**Nomenclature of Organic Chemistry** by J. Rigandy and S.P. Klesney) and 1993 (**A Guide to IUPAC Nomenclature for Organic Chemistry** by R. Panico, W.H. Powell and J.C. Richer). With the help of this system, an organic compound having any number of carbon atoms can be easily named.

IUPAC System of Naming Organic Compounds : In the IUPAC system, the name of an organic compound consist of three parts : (i) Word root (ii) Suffix (iii) Prefix

(i) ***Word root*** : The word root denotes the number of carbon atoms present in the chain.

Table : 22.7

Chain length	Word root	Chain length	Word root
C_1	Meth-	C_{11}	Undec-
C_2	Eth-	C_{12}	Dodec-
C_3	Prop-	C_{13}	Tridec-
C_4	But-	C_{14}	Tetradec-
C_5	Pent-	C_{15}	Pentadec-
C_6	Hex-	C_{16}	Hexadec-
C_7	Hept-	C_{17}	Heptadec-
C_8	Oct-	C_{18}	Octadec-
C_9	Non-	C_{19}	Nonadec-
C_{10}	Dec-	C_{20}	Eicos

(ii) ***Suffix* :** The word root is linked to the suffix which may be primary or secondary or both.

(a) *Primary suffix :* A primary suffix is added to the word root to indicate whether the carbon chain is saturated or unsaturated.

Table : 22.8

Type of carbon chain	Primary suffix	General name
Saturated ($C - C$)	–ane	Alkane
Unsaturated ($C = C$)	–ene	Alkene
Unsaturated ($C \equiv C$)	–yne	Alkyne

If the parent chain contains two, three or more double or triple bonds, then the numerical prefixes such as **di** (for two), **tri** (for three), **tetra** (for four), etc. are added to the primary suffix.

(b) *Secondary suffix :* A secondary suffix is then added to the word root after the primary suffix to indicate the functional group present in the organic compound.

Table : 22.9

Class of org. compound	Functional group	Secondary suffix
Alcohols	$-OH$	–ol
Aldehydes	$-CHO$	–al
Ketones	$> C = O$	–one
Carboxylic acids	$-COOH$	–oic acid
Esters	$-COOR$	alkyl.... oate
Acid chlorides	$-COCl$	–oyl chloride
Acid amides	$-CONH_2$	–amide
Nitriles	$-C\equiv N$	–nitrile
Amines	$-NH_2$	–amine
Thiol	$-SH$	thiol

It may be noted that while adding the secondary suffix to the primary suffix, the terminal '*e*' of the primary suffix (*i.e.* ane, ene and yne) is droped if the secondary suffix begins with a vowel but is retained if the secondary suffix begins with a consonant. For example

Organic compound	CH_3CH_2OH	CH_3CH_2CN
Word root	Eth	Prop
Primary suffix	an (e)*	ane
Secondary suffix	ol	nitrile
IUPAC name	Ethanol	Propanenitrile

The terminal '*e*' from the primary suffix has been dropped because the secondary suffix *i.e.* '*ol*' begins with a vowel '*o*'.

(iii) ***Prefix* :** There are many groups which are not regarded as functional groups in the *IUPAC* name of the compound. These are regarded as **substituents** or **side chains**. These are represented as **prefixes** and are placed before the word root while naming a particular compound. These may be :

(a) *Alkyl groups* : These groups contain one hydrogen atom less than the alkane. These are named by substituting the suffix **ane** of the name of the corresponding alkane by **yl**. *i.e.* alkane – ane + yl = **alkyl.**

For example,

CH_4 : Methane becomes

CH_3- : Methyl

CH_3CH_3 : Ethane becomes

CH_3CH_2- : Ethyl

$CH_3CH_2CH_3$: Propane becomes

$CH_3CH_2CH_2-$: Propyl etc.

(b) *Functional groups not regarded as principal functional groups* : If a compound contains more than one functional group, then one of the functional group is regarded as principal functional group and other is treated as secondary suffix. The other functional groups are regarded as substituents and are indicated by prefixes.

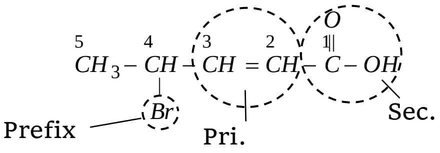
Table : 22.10

Substituent	Prefix
$-F$	Fluoro

$-Cl$	Chloro
$-Br$	Bromo
$-I$	Iodo
$-NO$	Nitroso
$-N=N-$	Diazo
$-OCH_3$	Methoxy
$-OC_2H_5$	Ethoxy
$-NO_2$	Nitro
$-NH_2$	Amino
$-OH$	Hydroxo

Thus, a complete IUPAC name of an organic compound may be represented as:

Prefix + word root + Primary suffix + Secondary suffix



Word root : Pent (five $C-C-C-C-C$)

Primary suffix : ene (double bond at $C-2$)

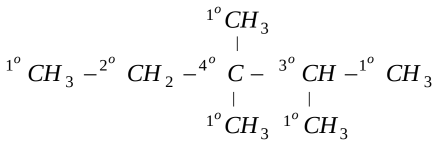
Secondary suffix : oic acid ($-COOH$ group)

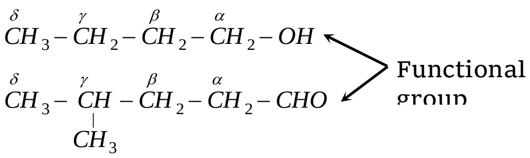
Prifix : Bromo ($-Br$ group at $C-4$)

IUPAC name : Bromo + pent + ene + oic acid or 4-Bromopent -2-en-1-oic acid

Classification of carbon atoms in organic compounds

The carbon atoms in an alkane molecule may be classified into four types as *primary* (1°), *secondary* (2°), *tertiary* (3°) and *quaternary* (4°). The carbon atoms in an organic compound containing functional group can be designated as α, β, γ, δ.





Alkyl groups

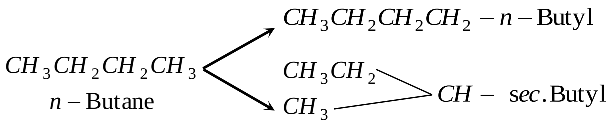
These are univalent groups or radicals obtained by the removal of one hydrogen atom from a molecule of a paraffin. The symbol 'R' is often used to represent an alkyl group.

$$\underset{(R-H)}{(\text{Alkane})\ C_nH_{2n+2}} \xrightarrow{-H} \underset{(R-)}{C_nH_{2n+1}}\ (\text{Alkylgroup})$$

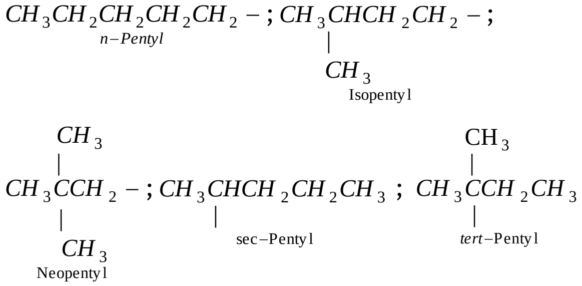
Alkyl groups are named by dropping-ane from the name of corresponding paraffin and adding the ending–yl.

Parent saturated hydrocarbon	Name of the alkyl group	Structure
Methane	Methyl	CH_3-
Ethane	Ethyl	CH_3-CH_2-
Propane	*n*-Propyl	$CH_3-CH_2-CH_2-$
Butane	*n*-Butyl	$CH_3-CH_2-CH_2-CH_2-$

Alkyl groups derived from saturated hydrocarbons having three or more carbon atoms exist in isomeric forms.



Similarly, removal of different H atoms in pentane gives the following radicals :



$$\underset{n-Pentyl}{CH_3CH_2CH_2CH_2CH_2-}\ ;\ \underset{\text{Isopentyl}}{CH_3\underset{\substack{|\\CH_3}}{C}HCH_2CH_2-}\ ;$$

$$\underset{\text{Neopentyl}}{CH_3\overset{\substack{CH_3\\|}}{\underset{\substack{|\\CH_3}}{C}}CH_2-}\ ;\ \underset{\text{sec-Pentyl}}{CH_3\underset{|}{C}HCH_2CH_2CH_3}\ ;\ \underset{tert-\text{Pentyl}}{CH_3\overset{\substack{CH_3\\|}}{\underset{|}{C}}CH_2CH_3}$$

Table : 22.11 ***Unsaturated groups or radicals***

Group	Common name	IUPAC name
$CH_2=CH-$	Vinyl	Ethenyl
$CH_2=\overset{2}{C}H-\overset{1}{C}H_2-$	Allyl	2-Propenyl
$CH_3-CH=\overset{1}{C}H-$	–	1-Propenyl
$HC\equiv C-$	Acetylide	Ethynyl
$HC\equiv\overset{2}{C}-\overset{1}{C}H_2-$	Propargyl	2-Propynyl

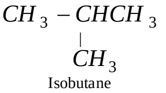
General rules for naming organic compounds

In the common system, all the isomeric alkanes (having same molecular formula) have the same parent name. The names of various isomers are distinguished by prefixes. The prefix indicates the type of branching in the molecule. For example,

(1) **Prefix *n*-**(*normal*) is used for those alkanes in which all the carbon atoms form a continuous chain with no branching.

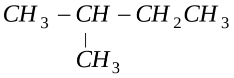
$\underset{n-\text{Butane}}{CH_3CH_2CH_2CH_3}$; $\underset{n-\text{Pentane}}{CH_3CH_2CH_2CH_2CH_3}$

(2) **Prefix iso** is used for those alkanes in which one methyl group is attached to the next-to-end carbon atom (second last) of the continuous chain.



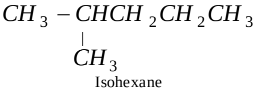
$CH_3-\underset{\substack{|\\ CH_3}}{CH}CH_3$

Isobutane



$CH_3-\underset{\substack{|\\ CH_3}}{CH}-CH_2CH_3$

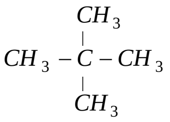
Isopentane



$CH_3-\underset{\substack{|\\ CH_3}}{CH}CH_2CH_2CH_3$

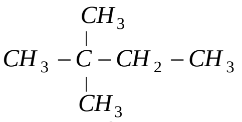
Isohexane

(3) **Prefix neo** is used for those alkanes which have two methyl groups attached to the second last carbon atom of the continuous chain.



$CH_3-\underset{\substack{|\\ CH_3}}{\overset{\substack{CH_3\\ |}}{C}}-CH_3$

Neopentane



$CH_3-\underset{\substack{|\\ CH_3}}{\overset{\substack{CH_3\\ |}}{C}}-CH_2-CH_3$

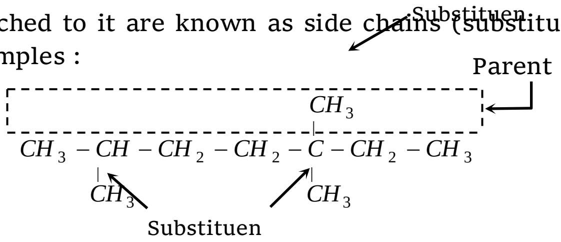
Neohexane

IUPAC system of nomenclature of complex compounds

The naming of any organic compound depends on the name of normal parent hydrocarbon from which it has been derived. IUPAC system has framed a set of rules for various types of organic compounds.

(1) **Rules for Naming complex aliphatic compounds when no functional group is present (saturated hydrocarbon or paraffins or Alkanes)**

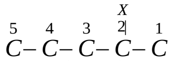
(i) ***Longest chain rule* :** The first step in naming an organic compound is to select the longest continuous chain of carbon atoms which may or may not be horizontal (straight). This continuous chain is called parent chain or main chain and other carbon chains attached to it are known as side chains (substituents). Examples :



$CH_3-\underset{\substack{|\\ CH_3}}{CH}-CH_2-CH_2-\underset{\substack{|\\ CH_3}}{\overset{\substack{CH_3\\ |}}{C}}-CH_2-CH_3$

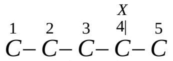
If two different chains of equal length are possible, the chain with maximum number of side chains or alkyl groups is selected.

(ii) ***Position of the substituent* :** Number of the carbon atoms in the parent chain as 1, 2, 3,……. etc. starting from the end which gives lower number to the carbon atoms carrying the substituents. For examples,



$\overset{5}{C}-\overset{4}{C}-\overset{3}{C}-\overset{\substack{X\\ 2|}}{C}-\overset{1}{C}$

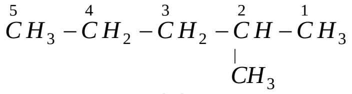
A(Correct)



$\overset{1}{C}-\overset{2}{C}-\overset{3}{C}-\overset{\substack{X\\ 4|}}{C}-\overset{5}{C}$

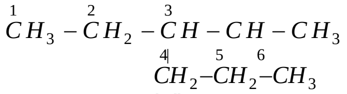
B(Wrong)

The number that indicates the position of the substituent or side chain is called *locant*.



$\overset{5}{C}H_3-\overset{4}{C}H_2-\overset{3}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{2}{C}H}-\overset{1}{C}H_3$

2–Methylpentane

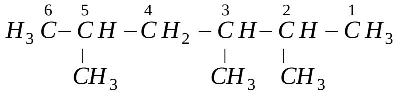


$\overset{1}{C}H_3-\overset{2}{C}H_2-\underset{\substack{4|\\ CH_2-\overset{5}{C}H_2-\overset{6}{C}H_3}}{\overset{3}{C}H}-CH-CH_3$

3–Ethylhexane

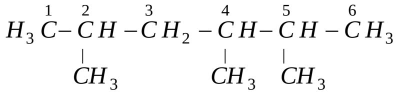
(iii) ***Lowest set of locants* :** When two or more substituents are present, then end of the parent chain which gives the lowest set of the locants is preferred for numbering.

This rule is called **lowest set of locants.** This means that when two or more different sets of locants are possible, that set of locants which when compared term by term with other sets, each in order of increasing magnitude, has the lowest term at the first point of difference. This rule is used irrespective of the nature of the substituent. For example,



$H_3\overset{6}{C}-\underset{\substack{|\\ CH_3}}{\overset{5}{C}H}-\overset{4}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{3}{C}H}-\underset{\substack{|\\ CH_3}}{\overset{2}{C}H}-\overset{1}{C}H_3$

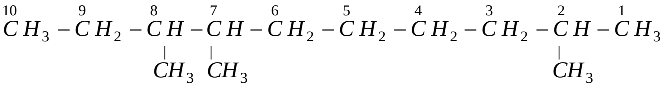
Set of locants : 2, 3, 5 (Correct)



$H_3\overset{1}{C}-\underset{\substack{|\\ CH_3}}{\overset{2}{C}H}-\overset{3}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{4}{C}H}-\underset{\substack{|\\ CH_3}}{\overset{5}{C}H}-\overset{6}{C}H_3$

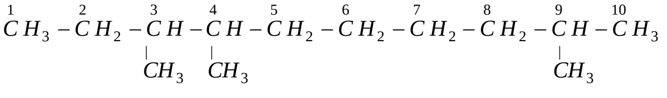
Set of locants : 2, 4, 5 (Wrong)

The correct set of locants is 2, 3, 5 and not 2, 4, 5. The first set is lower than the second set because at the **first difference** 3 is less than 4. (Note that first locant is same in both sets 2; 2 and the first difference is with the second locant 3, 4. We can compare term by term as 2-2, 3-4 (first difference), 5-5. **Only first point of difference is considered for preference.** Similarly for the compounds,



$\overset{10}{C}H_3-\overset{9}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{8}{C}H}-\underset{\substack{|\\ CH_3}}{\overset{7}{C}H}-\overset{6}{C}H_2-\overset{5}{C}H_2-\overset{4}{C}H_2-\overset{3}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{2}{C}H}-\overset{1}{C}H_3$

Set of locants : 2, 7, 8 (Correct)



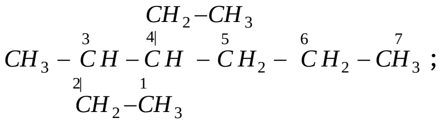
$\overset{1}{C}H_3-\overset{2}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{3}{C}H}-\underset{\substack{|\\ CH_3}}{\overset{4}{C}H}-\overset{5}{C}H_2-\overset{6}{C}H_2-\overset{7}{C}H_2-\overset{8}{C}H_2-\underset{\substack{|\\ CH_3}}{\overset{9}{C}H}-\overset{10}{C}H_3$

Set of locants : 3, 4, 9 (Wrong)

First set of locants 2, 7, 8 is lower than second set 3, 4, 9 because at the first point of difference 2 is lower than 3.

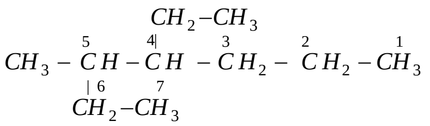
Lowest sum rule : It may be **noted** that earlier, the numbering of the parent chain containing two or more substituents was done in such a way that **sum of**

the locants is the lowest. This rule is called **lowest sum rule.** For example, the carbon chain of alkanes given below should be numbered as indicated in structures *A* and not according to structure *B*.



$CH_3-\underset{\begin{array}{c}2|\\CH_2-\overset{1}{C}H_3\end{array}}{\overset{3}{C}H}-\overset{\begin{array}{c}CH_2-CH_3\\4|\end{array}}{C}H-\overset{5}{C}H_2-\overset{6}{C}H_2-\overset{7}{C}H_3$;

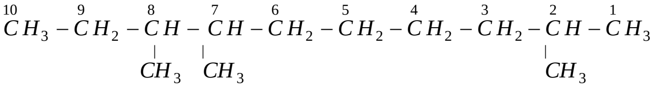
A (correct) Sum of locants =3+4=7



$CH_3-\underset{\begin{array}{c}|6\\CH_2-\overset{7}{C}H_3\end{array}}{\overset{5}{C}H}-\overset{\begin{array}{c}CH_2-CH_3\\4|\end{array}}{C}H-\overset{3}{C}H_2-\overset{2}{C}H_2-\overset{1}{C}H_3$

B (wrong) Sum of locants =4+5=9

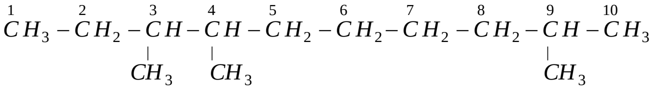
According to latest IUPAC system of nomenclature, the lowest set of locants is preferred even if it violates the lowest sum rule. For example,



$\overset{10}{C}H_3-\overset{9}{C}H_2-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{8}{C}H}-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{7}{C}H}-\overset{6}{C}H_2-\overset{5}{C}H_2-\overset{4}{C}H_2-\overset{3}{C}H_2-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{2}{C}H}-\overset{1}{C}H_3$

Structure (A) (Correct

Set of locants = 2, 7, 8
Sum of locants = 2 + 7 + 8



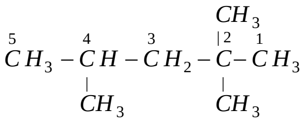
$\overset{1}{C}H_3-\overset{2}{C}H_2-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{3}{C}H}-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{4}{C}H}-\overset{5}{C}H_2-\overset{6}{C}H_2-\overset{7}{C}H_2-\overset{8}{C}H_2-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{9}{C}H}-\overset{10}{C}H_3$

Structure (B) (Wrong)

Set of locants = 3, 4, 9
Sum of locants = 3 + 4 + 9

This compound is numbered as 2, 7, 8 and not as 3, 4, 9 in accordance with latest lowest set of locants rule, even though it violates lowest sum rule.

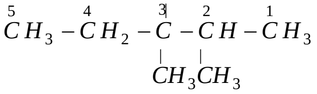
(iv) ***Presence of more than one same substituent* :** If the same substituent or side chain occurs more than once, the prefixes di, tri, tetra ....etc., are attached to the names of the substituents. For example,



$\overset{5}{C}H_3-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{4}{C}H}-\overset{3}{C}H_2-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{\begin{array}{c}CH_3\\|2\end{array}}{C}}-\overset{1}{C}H_3$

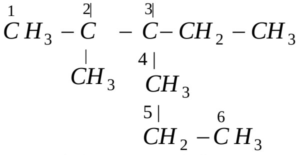
2, 2, 4-Trimethylpentane

(v) ***Naming different substituents* :** If two or more different substituents or side chains are present in the molecule, they are named in the alphabetical order along with their appropriate positions.



$\overset{5}{C}H_3-\overset{4}{C}H_2-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{\begin{array}{c}CH_2CH_3\\3|\end{array}}{C}}-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{2}{C}H}-\overset{1}{C}H_3$

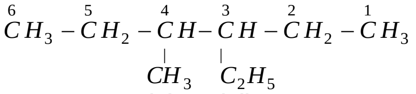
3-Ethyl-2, 3-dimethylpentane



$\overset{1}{C}H_3-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{\begin{array}{c}CH_3\\2|\end{array}}{C}}-\underset{\begin{array}{c}4|\\CH_3\\5|\\CH_2-\overset{6}{C}H_3\end{array}}{\overset{\begin{array}{c}CH_3\\3|\end{array}}{C}}-CH_2-CH_3$

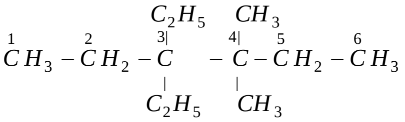
3-Ethyl-2, 2, 3-trimethylhexane

(vi) ***Naming different substituents at equivalent position* :** In case, there are different alkyl substituents at equivalent positions, then numbering of the parent chain is done in such a way that the alkyl group which comes first in the alphabetical order gets the lower number.



$\overset{6}{C}H_3-\overset{5}{C}H_2-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{4}{C}H}-\underset{\begin{array}{c}|\\C_2H_5\end{array}}{\overset{3}{C}H}-\overset{2}{C}H_2-\overset{1}{C}H_3$

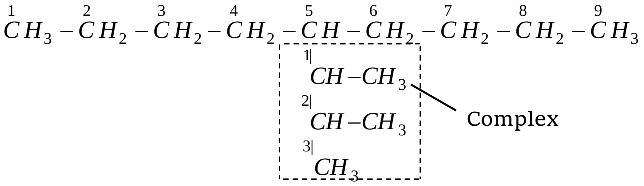
3-Ethyl-4-methylhexane



$\overset{1}{C}H_3-\overset{2}{C}H_2-\underset{\begin{array}{c}|\\C_2H_5\end{array}}{\overset{\begin{array}{c}C_2H_5\\3|\end{array}}{C}}-\underset{\begin{array}{c}|\\CH_3\end{array}}{\overset{\begin{array}{c}CH_3\\4|\end{array}}{C}}-\overset{5}{C}H_2-\overset{6}{C}H_3$

3, 3-Diethyl-4, 4-dimethylhexane

(vii) ***Naming the complex substituents*** (or substituted substituents) **:** If the substituent on the parent chain is complex (*i.e.* it is branched) it is named as substituted alkyl group by numbering the carbon atom of this group attached to the parent chain as 1. The name of such substituent is given in brackets in order to avoid confusion with the numbering of the parent chain. For example,

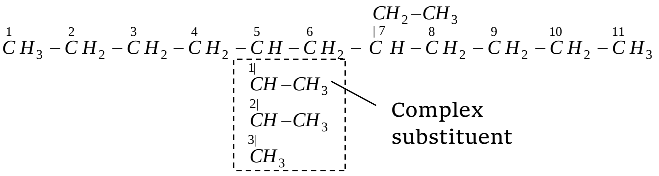


$\overset{1}{C}H_3-\overset{2}{C}H_2-\overset{3}{C}H_2-\overset{4}{C}H_2-\underset{\boxed{\begin{array}{l}1|\\CH-CH_3\\2|\\CH-CH_3\\3|\\CH_3\end{array}}}{\overset{5}{C}H}-\overset{6}{C}H_2-\overset{7}{C}H_2-\overset{8}{C}H_2-\overset{9}{C}H_3$

5-(1, 2-Dimethylpropyl)

The name of the complex substituent is always written in brackets.

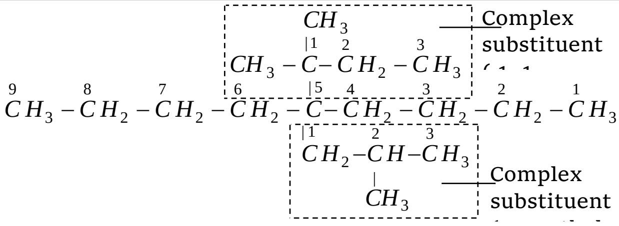
While deciding the alphabetical order of the various substituents, the name of the complex substituent is considered to begin with the first letter of the complete name. It may be **remembered** that in case of simple substituents, however, the multiplying prefixes are not considered. The names of simple substituents are first alphabetized and then multiplying prefixes are inserted. For example,



$\overset{1}{C}H_3-\overset{2}{C}H_2-\overset{3}{C}H_2-\overset{4}{C}H_2-\underset{\boxed{\begin{array}{l}1|\\CH-CH_3\\2|\\CH-CH_3\\3|\\CH_3\end{array}}}{\overset{5}{C}H}-\overset{6}{C}H_2-\overset{\begin{array}{c}CH_2-CH_3\\|7\end{array}}{C}H-\overset{8}{C}H_2-\overset{9}{C}H_2-\overset{10}{C}H_2-\overset{11}{C}H_3$

5-(1, 2-Dimethylpropyl)-7-ethyl

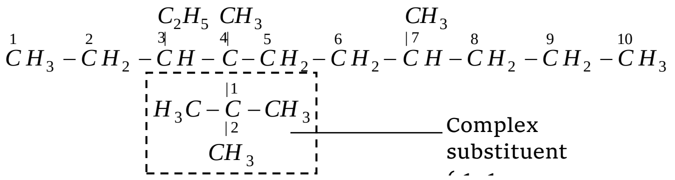
It may be noted that dimethyl propyl (a complex substituent) is alphabetized under ***d*** and not under ***m***. Therefore, it is cited before ethyl (e).



$$CH_3-CH_2-CH_2-CH_2-\overset{\displaystyle CH_3-\overset{CH_3}{C}-CH_2-CH_3}{\underset{\displaystyle CH_2-\underset{CH_3}{CH}-CH_3}{C}}-CH_2-CH_2-CH_2-CH_3$$

5-(1, 1-Dimethylpropyl) –5-(2-methylpropyl)

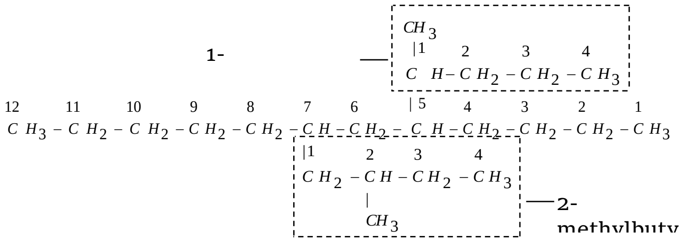
The substituent dimethyl is cited first because it is alphabetized under *d*. Similarly,



$$CH_3-CH_2-\overset{C_2H_5}{CH}-\overset{CH_3}{\underset{\displaystyle H_3C-\underset{CH_3}{C}-CH_3}{C}}-CH_2-CH_2-\overset{CH_3}{CH}-CH_2-CH_2-CH_3$$

4-(1, 1-Dimethylpropyl) –3-ethyl-4, 7-

When the names of two or more complex substituents are composed of identical words, priority for citation is given to the substituent which has lowest locant at the first cited point of difference within the complex substituent. For example,

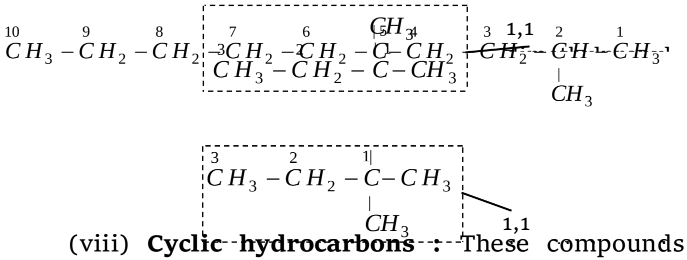


$$CH_3-CH_2-CH_2-CH_2-CH_2-\underset{\displaystyle CH_2-\underset{CH_3}{CH}-CH_2-CH_3}{CH}-CH_2-\overset{\displaystyle \overset{CH_3}{C}H-CH_2-CH_2-CH_3}{CH}-CH_2-CH_2-CH_2-CH_3$$

– 5(1-methyl butyl)-7-(2-methyl butyl) dodecane

The substituent (1-methylbutyl) is written first because it has lower locant than the substituent (2-methylbutyl).

When the same complex substituent (substituted in the same way) occurs more than once, it is indicated by the multiplying prefix *bis* (for two), *tris* (for three), *tetra kis* (for four) etc.

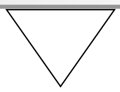


$$CH_3-CH_2-CH_2-CH_2-CH_2-\overset{\displaystyle CH_3-CH_2-\overset{CH_3}{C}-CH_3}{\underset{\displaystyle CH_3-CH_2-\underset{CH_3}{C}-CH_3}{C}}-CH_2-\underset{CH_3}{CH}-CH_3$$

5, 5-Bis (1, 1-dimethylpropyl)-2-

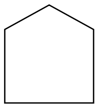
(viii) **Cyclic hydrocarbons :** These compounds contain carbon chain skeletons which are closed to form rings. The saturated hydrocarbons with ring of carbon atoms in the molecule are called *cycloalkanes*. These have the general formula C_nH_{2n}.

The cyclic compound is named by prefixing **cyclo** to the name of the corresponding straight chain alkane. For example,

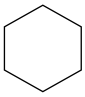


C_3H_6, Cyclopropane

C_4H_8, Cyclobutane

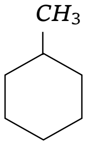


C_5H_{10}, Cyclopentane

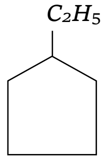


C_6H_{12}, Cyclohexane

If side chains are present, then the rules given in the previous section are applied. For example,

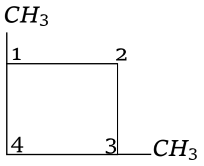


Methylcyclohexa

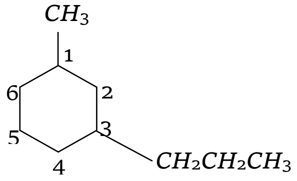


Ethylcyclopentan

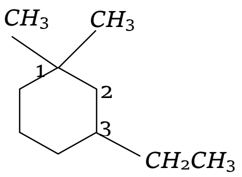
When more than one side chains are present, the numbering is done beginning with one side chain so that the next side chain gets the lower possible number. For example,



1.3-
Dimethylcyclobutane

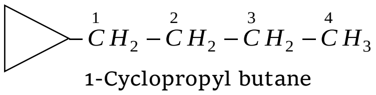


1-Methyl-3-propylcyclohexane
(Not 5-Methyl-1-propyl

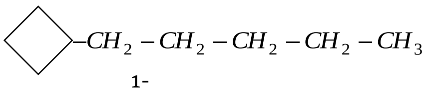


3-Ethyl-1, 1-dimethylcyclohexane
(Not 1-Ethyl-3,3-

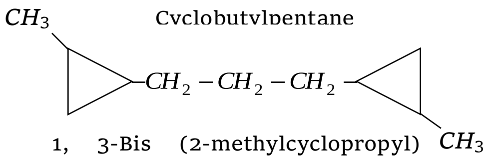
When a single ring system is attached to a single chain with a greater number of carbon atoms or when more than one ring system is attached to a single chain, then it is named as cycloalkylalkanes. For example,



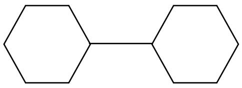
1-Cyclopropyl butane



1-
Cyclobutylpentane

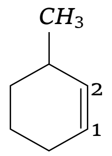


1, 3-Bis (2-methylcyclopropyl)
propane

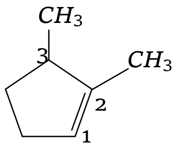


Cyclohexyl

In case of substituted cycloalkenes, the double bond is given the lowest possible number and numbering is done in such a way that the substituents get the lowest number.



3-Methylcyclohex-1-ene

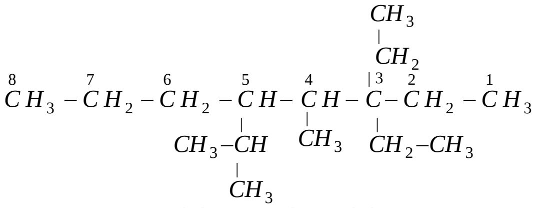


2, 3-Dimethylcyclopent-

According to the IUPAC system of Nomenclature, certain trivial or semi- systematic names may be used for unsubstituted radicals. For example, the following names may be used,

$(CH_3)_2CH-$	Isopropyl
$CH_3-CH_2-\underset{CH_3}{\underset{\vert}{CH}}-$	*Sec*- Butyl
$(CH_3)_2CH-CH_2-CH_2-$	Isopentyl
$CH_3-CH_2-\overset{CH_3}{\overset{\vert}{\underset{CH_3}{\underset{\vert}{C}}}}-$	*tert*-Pentyl
$(CH_3)_2CH-CH_2-$	Isobutyl
$(CH_3)_3C-$	tert-Butyl
$(CH_3)_3C-CH_2-$	Neopentyl
$(CH_3)_2CH-CH_2-CH_2-CH-$	Isohexyl

However, when these are substituted, these names cannot be used as such. For example,



$$\overset{8}{C}H_3-\overset{7}{C}H_2-\overset{6}{C}H_2-\underset{CH_3-\underset{CH_3}{\underset{\vert}{CH}}}{\underset{\vert}{\overset{5}{C}H}}-\underset{CH_3}{\underset{\vert}{\overset{4}{C}H}}-\overset{CH_3}{\overset{\vert}{\overset{CH_2}{\overset{\vert}{\underset{CH_2-CH_3}{\underset{\vert}{\overset{3}{C}}}}}}}-\overset{2}{C}H_2-\overset{1}{C}H_3$$

3,3–Diethyl–5–isopropyl–4–methyloctane

It may be noted that while writing the substituent's name in alphabetical order, the prefixes *iso*-and *neo*-are considered to be part of the fundamental name. However, the prefixes *sec*-and *tert*-are not considered to be the part of the fundamental name.

(2) **Rules for IUPAC names of polyfunctional organic compounds**

Organic compounds which contain two or more functional groups are called polyfunctional compounds. Their IUPAC names are obtained as follows,

(i) ***Principal functional group*** **:** If the organic compound contains two or more functional groups, one of the functional groups is selected as the principal functional group while all the remaining functional groups (also called the secondary functional groups) are treated as substituents. The following order of preference is used while selecting the principal functional group.

Sulphonic acids > carboxylic acids > anhydrides > esters > acid chlorides > acid amides > nitriles > aldehydes > ketones > thiols > alcohols >alkenes > alkynes.

All the remaining functional groups such as halo (fluoro, chloro, bromo, iodo), nitroso ($-NO$), –nitro ($-NO_2$), amino ($-NH_2$) and alkoxy ($-OR$) are treated as substituents.

Table : 22.12

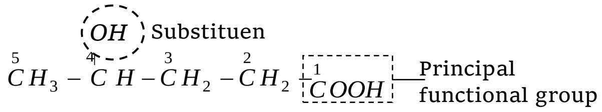
Order of preference	Preflx	Suffix (ending)
$-SO_3H$	Sulpho	Sulphonic acid
$-COOH$	Carboxy	– oic acid
$-COOR$	Alkoxy carbonyl	Alkyl alkanoate
$-COX$	Haloformyl	Oyl halide
$-CONH_2$	Carbamoyl	– amide
$-C\equiv N$	Cyano	– nitrile
$-CHO$	Formyl	– al
$>C=O$	Keto	– one
$-OH$	Hydroxy	– ol
$-NH_2$	Amine	– amine
$C=C$	–	– ene
$-C\equiv C-$	–	– yne
$-O-$	Epoxy	–
$-X$	Halo	–
$-NO_2$	Nitro	–

(ii) ***Selecting the principal chain*** **:** Select the longest continuous chain of carbon atoms containing the principal functional group and maximum number of secondary functional groups and multiple bonds, if any.

(iii) ***Numbering the principal chain*** **:** Number the principal chain in such a way that the principal functional group gets the lowest possible number followed by double bond and triple bond and the substituents, *i.e.*

Principal functional group > double bond > triple bond > substituents

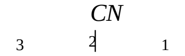
(iv) ***Alphabetical order*** **:** Identify the prefixes and the positional numbers (also called locants) for the secondary functional groups and other substituents and place them in alphabetical order before the word root.



$$\overset{5}{C}H_3-\overset{\overset{OH}{4}}{C}H-\overset{3}{C}H_2-\overset{2}{C}H_2-\overset{1}{C}OOH$$

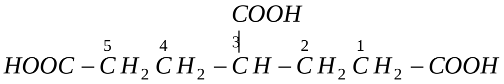
4-Hydroxy pentanoic

(3) **Polyfunctional compounds containing more than two like functional groups :** According to latest convention (1993 recommendations for IUPAC nomenclature), if an unbranched carbon chain is directly linked to more than two like functional groups, the organic compound is named as a derivative of the parent alkane which does not include carbon atoms of the functional groups. For example,



$$NC-\overset{3}{C}H_2-\overset{\overset{CN}{|}}{\overset{2}{C}}H-\overset{1}{C}H_2-CN$$

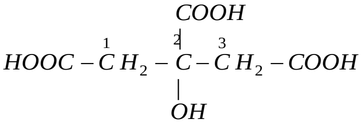
Propane-1,2,3-tricarbonitrile
(Formerly 3 cyanopentane, 1,5 dinitrile)



$$HOOC-\overset{5}{C}H_2\overset{4}{C}H_2-\overset{\overset{COOH}{|}}{\overset{3}{C}}H-\overset{2}{C}H_2\overset{1}{C}H_2-COOH$$

Pentance-1,3,5-tricarboxylic acid
(Formerly 4-carboxyheptane-1,7-dioic acid)

Following the above rule, citric acid may be named as,



$$HOOC-\overset{1}{C}H_2-\underset{\underset{OH}{|}}{\overset{\overset{COOH}{|}}{\overset{2}{C}}}-\overset{3}{C}H_2-COOH$$

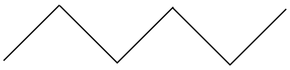
2-Hydroxypropane-1, 2, 3-tricarboxylic acid
(formerly 3-carboxy-3-hydroxypentane-1, 5-dioic acid)

Bond-line Notation of organic compounds

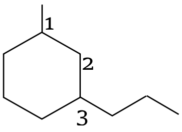
Sometimes, the bonds between carbon atoms are represented by lines. For example, *n*-hexane has a continuous chain of six carbon atoms which may be represented as,

$$CH_3-CH_2-CH_2-CH_2-CH_2-CH_3$$

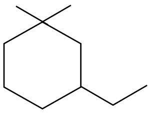
$n-$Hexane



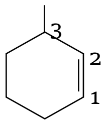
In this notation, the carbon atoms are represented by line ends and intersections. It is assumed that the required number of hydrogen atoms are present wherever they are necessary to satisfy the tetravalency of carbon. A single line represents a single bond ($C-C$), two parallel lines represent a double bond ($C=C$) and three parallel lines represent a triple bond ($C\equiv C$). For example,



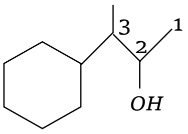
1-Methyl-3-



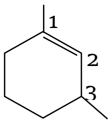
3-Ethyl-1, 1-dimethylcyclohexane
(Not 1-ethyl-3, 3-



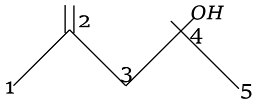
3-Methyl cyclohex-1-ene



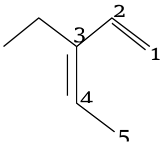
3-Cyclohexyl butan-2-ol



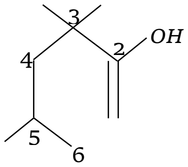
1, 3-Dimethyl cyclohex-1-



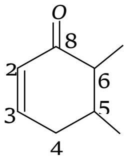
4-Hydroxy-4-methyl pentan-2-



3-Ethyl penta-1, 3-diene



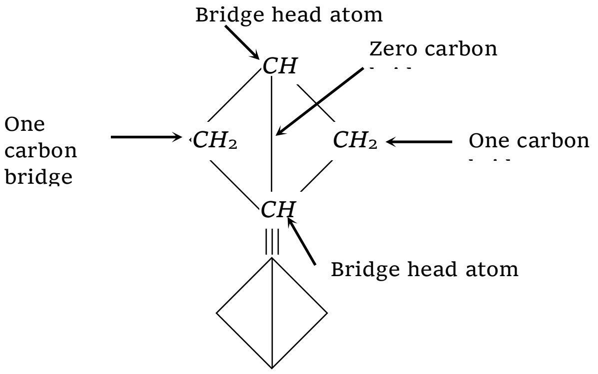
3, 3, 5-trimethylhex-1-en-2-

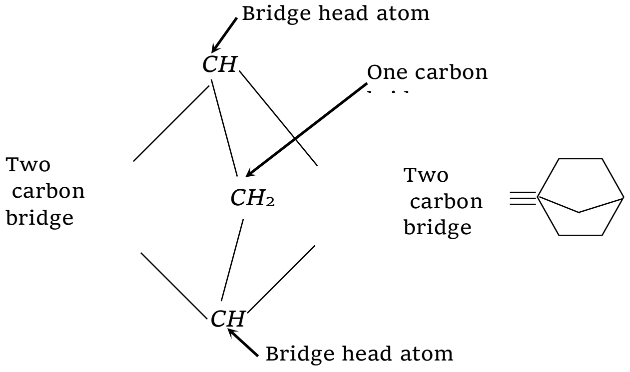


5, 6-Dimethylcyclohex-2-en-1-

Nomenclature of Bicyclic compounds

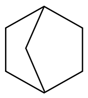
Many hydrocarbons and their derivatives contain two fused or bridged rings. The carbon atoms common to both rings are called bridge head atoms and each bond or chain of carbon atoms connecting both the bridge head atoms is called as bridge. The bridge may contain 0, 1, 2.... etc. carbon atoms. For example,



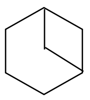


$$\left\{\begin{matrix} CH_2 \\ | \\ CH_2 \end{matrix}\right. \qquad \left.\begin{matrix} CH_2 \\ | \\ CH_2 \end{matrix}\right\}$$

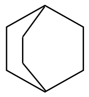
These bicyclic compounds are named by attaching the prefix '*bicyclo*' to the name of the hydrocarbon having the same total number of carbon atoms as in the two rings. The number of carbon atoms in each of the three bridges connecting the two bridge head carbon atoms is indicated by arabic numerals, *i.e.,* 0, 1, 2.....etc. These arabic numerals are arranged in descending order; separated from one another by full stops and then enclosed in square brackets. The complete IUPAC name of the hydrocarbon is then obtained by placing these square brackets containing the arabic numerals between the prefix bicyclo and the name of alkane. For example,



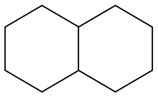
Bicyclo [2, 2, 1] heptane
(also called norbornane)



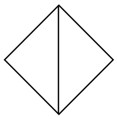
Bicyclo [3, 1, 1] heptane



Bicyclo [2, 2, 2] octane

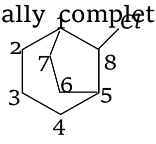


Bicyclo [4, 4, 0] decane
(also called decalin)

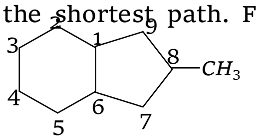


Bicyclo [1, 1, 0] butane

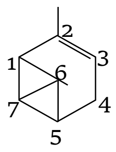
If a substituent is present, the bicyclic ring system is numbered. The numbering begins with one of the bridge head atoms, proceeds first along the longest bridge to the second bridge head atom, continues along the next longest bridge to the first bridge head atom and is finally completed along the shortest path. For example,



8-Chlorobicyclo [3, 2, 1]



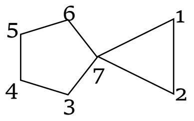
8-Methylbicyclo [4, 3, 0]



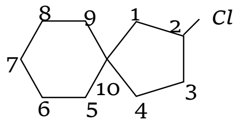
2, 6, 6-Trimethylbicyclo [3, 1, 1] hept-

Nomenclature of spiro compounds

Compounds in which one carbon atom is common to two different rings are called ***spiro compounds***. The IUPAC name for a spiro compound begins with the word spiro followed by square brackets containing the number of carbon atoms, in ascending order, in each ring connected to the common carbon atom and then by the name of the parent hydrocarbon corresponding to the total number of the carbon atoms in the two rings. The position of substituents are indicated by numbers ; the numbering beginning with the carbon atom adjacent to the spiro carbon and proceeding first around the smaller ring and then to the spiro atom and finally around the larger ring For example,



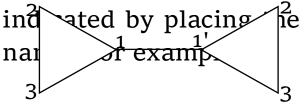
Spiro [2.4]



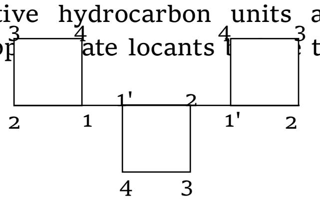
2-Chlorospiro [3.5]

Nomenclature of special compounds

Unbranched assemblies consisting of two or more identical hydrocarbon units joined by a single bond are named by placing a suitable numerical prefix such as *bi* for two, *ter* for three, *quater* for four, *quinque* for five etc. before the name of the repititive hydrocarbon unit. Starting from either end, the carbon atoms of each repititive hydrocarbon unit are numbered with unprimed and primed arabic numerals such as 1, 2, 3...., 1', 2', 3' ....., 1'', 2'', 3''..... etc. The points of attachment of the repititive hydrocarbon units are indicated by placing the appropriate locants before the name. For example,

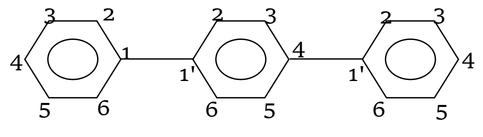


1, 1' -



1, 1', 2', 1'' - Tercyclobutane

As an exception, unbranched assemblies consisting of benzene rings are named by using appropriate prefix with the name phenyl instead of benzene. For example,

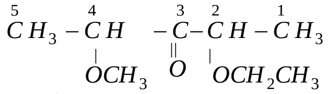


1, 1', 4', 1'' -

❑ If two atoms/groups of same preference occupy identical positions from either end of the parent chain, the lower number must be given to the atom/group whose prefix comes first in the alphabetical order. For example,

$$Cl\overset{4}{C}H_2\overset{3}{C}H_2\overset{2}{C}H_2\overset{1}{C}H_2Br$$

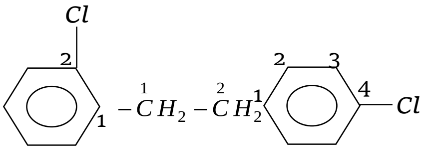
1-Bromo-4-chlorobutane



$$\overset{5}{C}H_3-\underset{OCH_3}{\underset{|}{\overset{4}{C}H}}-\underset{O}{\underset{\|}{\overset{3}{C}}}-\underset{OCH_2CH_3}{\underset{|}{\overset{2}{C}H}}-\overset{1}{C}H_3$$

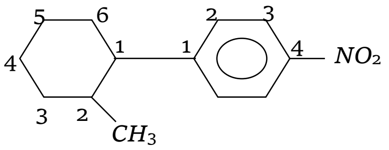
2 ethoxy -4-methoxy pentan -3-one

❑ When two or more prefixes consist of identical words, the priority for citation is given to that group which contains the lowest locant at the first point of difference. For example,



1-(2-chlorolphenyl)-2-(4-chlorophenyl)

❑ If a compound contains a benzene ring coupled to an alicyclic ring, it is named as a derivative of benzene, *i.e.* compound having lowest state of hydrogenation. For example,



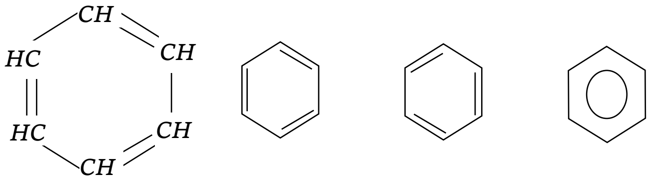
1-(2-Methylcyclohexyl)-4-nitro

In the common system of nomenclature, prefixes iso and neo are used only for compounds containing an isopropyl group, $(CH_3)_2CH$ and a tert-butyl group, $(CH_3)_3C$ respectively at the end of the carbon chain.

Nomenclature of simple aromatic compounds

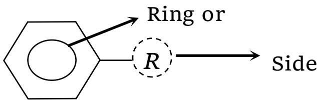
Aromatic compounds are those which contain one or more benzene rings in them. An aromatic compound has two main parts : (1) Nucleus, (2) Side chain

(1) **Nucleus :**The benzene ring represented by regular hexagon of six carbon atoms with three double bonds in the alternate positions is referred to as **nucleus.** The ring may be represented by any of the following ways,



(i) (ii) (iii)
(iv)

(2) **Side chain :** The alkyl or any other aliphatic group containing at least one carbon atom attached to the nucleus is called **side chain.** These are formed by replacing one or more hydrogen atoms in the ring by alkyl radicals *i.e.,* R (R may be $-CH_3$, $-C_2H_5$, $-C_3H_7$ etc.)



If one atom of hydrogen of benzene molecule is replaced by another atom or group of atoms, the derivative formed is called **monovalent substituted derivative.** It can exist only in one form because all the six hydrogens of benzene represent equivalent positions. For example, C_6H_5X, where X is a monovalent group.

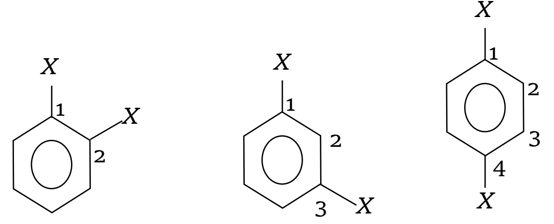
When two hydrogen atoms of benzene are replaced by two monovalent atoms or group of atoms, the resulting product disubstituted benzene derivative can have three different forms. These forms are distinguished by giving the numbers. The position occupied by the principle functional group is given as 1 and the other position is numbered in a clockwise direction which gvies lower locatant to the substituents.

(i) ***Ortho*** (or 1, 2-) **:** The compound is said to be ortho (or 1, 2-) if the two substituents are on the adjacent carbon atoms.

(ii) ***Meta*** (or 1, 3-) **:** The compound is said to be meta or (1, 3-) if the two substituents are on alternate carbon atoms.

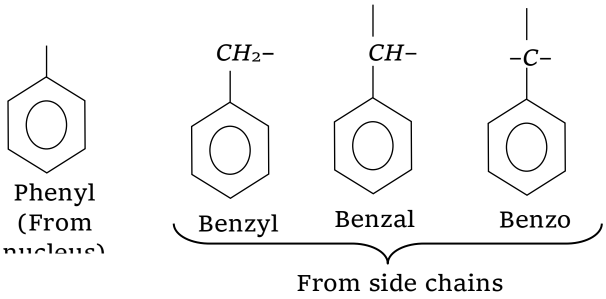
(iii) ***Para*** (or 1, 4-) **:** The compound is said to be para or (1, 4-) if the two substituents are on diagonally situated carbon atoms.

Ortho, meta and para are generally represented as *o-, m-* and *p-* respectively as shown below,



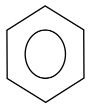
(1, 2-) (1, 3-) (1, 4-)

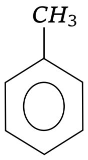
Aryl group : The radicals obtained by removal of one or more hydrogen atoms of the aromatic hydrocarbon molecules are known as aryl radicals or aryl groups. For example,



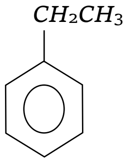
Nomenclature of different aromatic compounds : The names of few simple aromatic compounds are given below :

Hydrocarbons

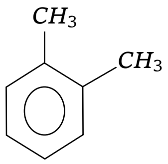

Benzene



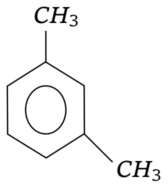
Toluene



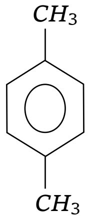
Ethylbenzene



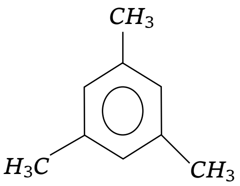
1, 2-Dimethyl benzene
(*o*-xylene)



1, 3-Dimethylbenzene
(*m*-Xylene)

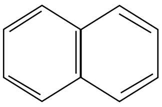


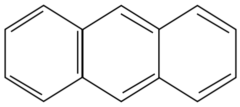
1, 4-
Dimethylbenzene
(*p*-Xylene)

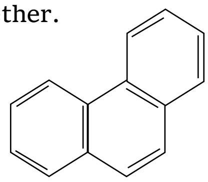


1, 3, 5-Trimethyl
benzene
(Mesitylene)

The aromatic hydrocarbons may also contain two or more benzene rings condensed together.

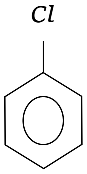

Naphthalene


Anthracene

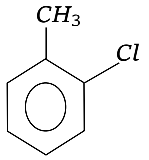

Phenanthrene

Halogen derivatives

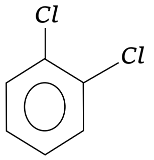
Nuclear substituted



Chlorobenzene

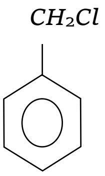


2-Chlorotoluene
(*o*-

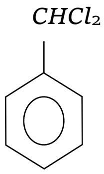


1,2-Dichlorobenzene
(*o*-

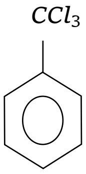
Side chain substituted



Phenyl
chloromethane

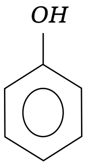


Phenyl dichloromethane
(Benzal chloride)

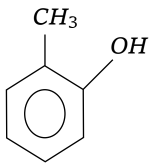


Phenyl
trichloromethane

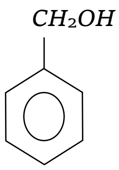
Hydroxy derivatives



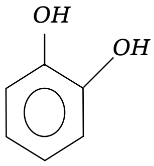
Phenol



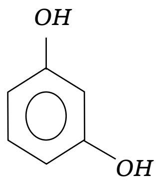
2-Methyl
phenol



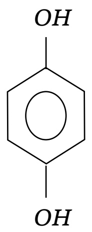
Benzyl



1, 2-
Dihydroxybenzene
(Catechol)

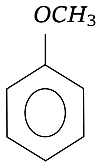


1, 3-
Dihydroxybenzene
(Resorcinol)

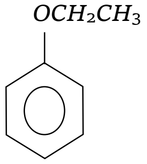


1, 4-
dihydroxy-
benzene

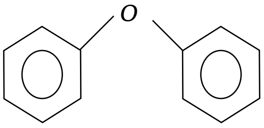
Ethers



Methoxybenzene

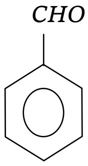


Ethoxybenzene
(Phenetole)

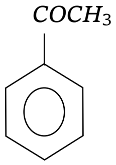


Phenoxybenzene

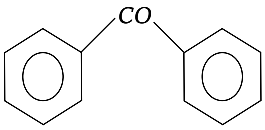
Aldehydes and ketones (Nuclear substituted)



Benzaldehyde

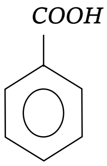


Methyl phenyl
ketone

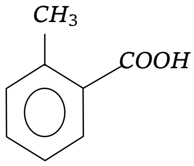


Diphenyl ketone
(Benzophenone)
or diphenyl

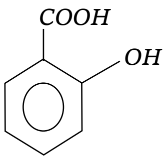
Carboxylic acids (Nuclear substituted)



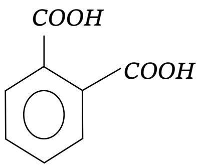
Benzoic acid



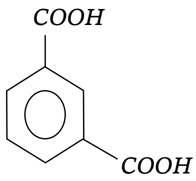
o-Toluic acid



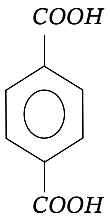
2-Hydroxy benzoic
acid



Phthalic acid
(1,2 benzene
dicarboxylic

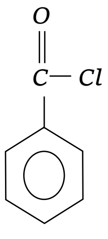


Isophthalic acid
(1,3 benzene
dicarboxylic acid)

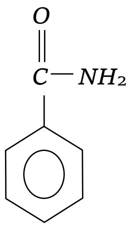


Terephthalic acid
(1,4 benzene
dicarboxylic acid)

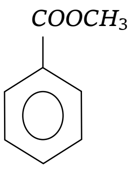
Acid derivatives



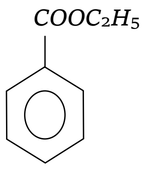
Benzoyl



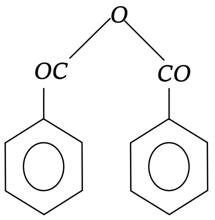
Benzamide



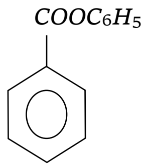
Methyl



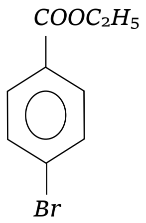
Ethyl benzoate



Benzoic

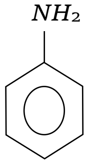


Phenyl

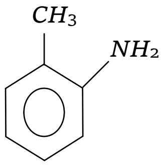


Ethyl 4-

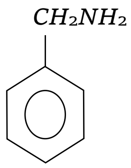
Amino derivatives (Nuclear substituted)



Aniline (Aminobenzene)

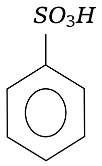


2-Amino toluene or *o*-Toluidine



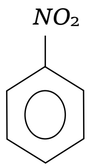
Benzyl amine or phenyl methanamine

Sulphonic acids

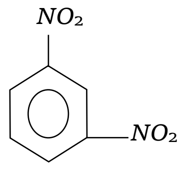


Benzene sulphonic

Nitro derivatives



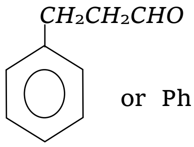
Nitrobenzen



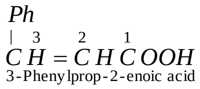
1, 3-Dinitrobenzene

Some tips for nomenclature of aromatic compounds : For IUPAC nomenclature of substituted benzene compounds, the substituent is placed as prefix to the word benzene. It may be noted that common names of many substituted benzene compounds are still universally used. Some important tips for nomenclature of organic compounds are given below,

(i) When the benzene ring is named as substituent on the other molecule, it is named as **phenyl group.** It is treated in the nomenclature just like the name of an alkyl group. It is abbreviated as Ph. For example,

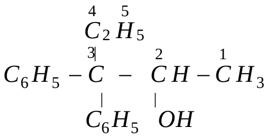


or Ph CH_2CH_2CHO 3-Phenylpropanal



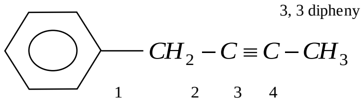
$\overset{Ph}{\overset{3}{C}H} = \overset{2}{C}H\overset{1}{C}OOH$

3-Phenylprop-2-enoic acid



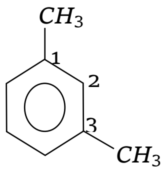
$C_6H_5-\underset{C_6H_5}{\overset{\overset{4\ 5}{C_2H_5}}{\overset{3}{C}}}-\underset{OH}{\overset{2}{C}H}-\overset{1}{C}H_3$

3, 3 diphenyl pentan-2-ol

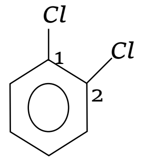


or Ph $\overset{1}{C}H_2-\overset{2}{C}\equiv\overset{3}{C}-\overset{4}{C}H_3$ Phenylbut-2-yne

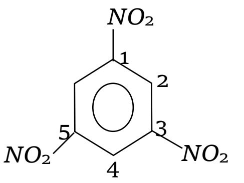
(ii) Disubstituted, trisubstituted or tetrasubstituted benzenes are named by using the numbers for the positions of the substituents.



1, 3-Dimethyl



1, 2-



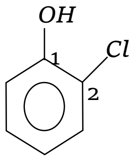
1, 3, 5-

(iii) If different groups are attached to the benzene ring, then the following rules are *kept in mind,*

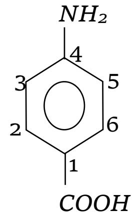
(a) The principal group is fixed as number 1.

(b) The numbering of the chain is done in any direction (clockwise or anticlockwise) which gives lower number to the substituents.

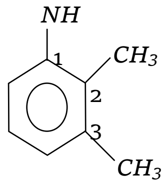
(c) The substituents are written in alphabetical order. For example,



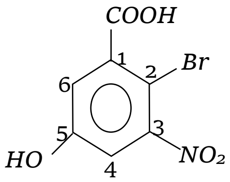
2-Chlorophenol



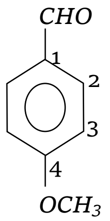
4-Aminobenzoic acid
(–*COOH* is principal group)



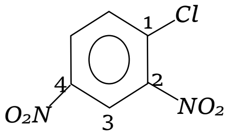
2, 3-Dimethyl



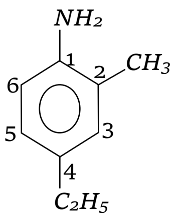
2-Bromo-5-hydroxy-



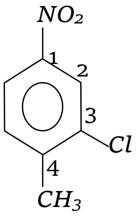
4-Methoxy



1-Chloro, 2, 4, dinitrobenzene



4-Ethyl-2-methylaniline



3-Chloro-4-methyl

Tips & Tricks

- Steam distillation may be regarded analogous to distillation under reduced pressure.
- Seeding-sometimes crystal formation can be initiated by the addition of crystals of a substance. It is known as seeding.
- Vanillin can be extracted from vanilla beans by soxhlet extractor.
- Concentration of raw juice in sugar factories is done by vacuum distillation.
- Lithium is not used in Lassaigne's test because it reacts slowly and its compounds are covalent. Potassium is also not used because it reacts vigorously and cannot be handled properly.
- In the Lassaigne's test for nitrogen, if Fe^{3+} ions (with yellow colour) are in excess, it makes the blue colour of ferric ferrocyanide to appear green.
- In Kjeldahl's method for estimation of nitrogen, potassium sulphate is added to raise the boiling point of sulphuric acid.
- Ter Meulen's method is used for the estimation of nitrogen, stepanow's method, Schiff's and piria method for halogen and messenger's method for the estimation of sulphur.

✍ Microanalysis is for products available is small then boiling point can be determined by Siwolowoff's method.

✍ Carius method does not give satisfactory results with iodine as silver iodide is slightly soluble in nitric acid and some iodine is also produced even in the presence of excess of silver nitrate.

✍ Beilestein's test is not given by fluorine because copper fluoride is not volatile.

✍ **Nitrogen rule :** All compounds containing an odd number of nitrogen atoms (*i.e.* 1, 3, 5, 7...... etc.) have odd molecular masses while those compounds which contain an even number of nitrogen atoms (*i.e.* 2, 4, 6, 8...... etc.) have even molecular masses.

✍ Boiling point is not as reliable test of purity as is the melting point for the solid.

✍ In the messenger's method for estimation of sulphur. The given organic compound is heated with alkaline $KMnO_4$ solution when the sulphur present in the compound is oxidised to K_2SO_4 which is then estimated as $BaSO_4$.

✍ Name of an amine is always written as one word for *e.g.* CH_3NH_2 is written as methylamine and not methyl amine.

Ordinary Thinking

Objective Questions

Chemical analysis of organic compounds

1. Formula which represents a simple ratio of atoms of different elements present in a molecule of the substance is called

(a) Molecular formula (b) Empirical formula
(c) Structural formula (d) Condensed formula

2. Actual number of atoms of different elements present in a molecule of a compound is given by

(a) Molecular formula (b) Structural formula
(c) Empirical formula (d) None of these

3. A compound contains $C = 90\%$ and $H = 10\%$. Empirical formula of the compound is **[NCERT 1976; EAMCET 1978]**

(a) C_3H_{10} (b) CH_2
(c) C_3H_2 (d) C_3H_4

4. An organic compound contains $C = 36\%$ $H = 6\%$ and rest oxygen. Its Empirical formula is

(a) CH_2O (b) $C_2H_3O_3$
(c) CH_2O_2 (d) $C_2H_2O_2$

5. Empirical formula of a compound is CH_2O and its vapour density is 30. Molecular formula of the compound is **[MP PMT 1993; AIIMS 1998; CBSE PMT 2000; KCET (Med.) 2000; Pb. PMT 2000]**

(a) $C_3H_6O_3$ (b) $C_2H_4O_2$
(c) C_2H_4O (d) CH_2O

6. An organic compound on analysis gave *C* = 48 *gm*, *H* = 8 *gm* and *N* = 56 *gm*. Volume of 1.0 *g* of the compound was found to be 200 *ml* at NTP. Molecular formula of the compound is**[MP PET 1986]**

(a) $C_4H_8N_4$ (b) $C_2H_4N_2$
(c) $C_{12}H_{24}N_{12}$ (d) $C_{16}H_{32}N_{16}$

7. Insulin contains 3.4% sulphur. The minimum molecular weight of insulin is **[MP PET 1993]**

(a) 350 (b) 470
(c) 560 (d) 940

8. Which element is estimated by Carius method

(a) Carbon (b) Hydrogen
(c) Halogen (d) Nitrogen

9. On complete combustion 1.4 *g* hydrocarbon gave 1.8 g water. Empirical formula of the hydrocarbon is

(a) CH (b) CH_2
(c) CH_3 (d) CH_4

10. In the estimation of sulphur organic compound on treating with conc. HNO_3 is converted to

(a) SO_2 (b) H_2S
(c) H_2SO_4 (d) SO_3

11. In Carius method 0.099 *g* organic compound gave 0.287 *g* $AgCl$. The percentage of chlorine in the compound will be

(a) 28.6 (b) 71.7
(c) 35.4 (d) 64.2

12. 0.24 *g* of an organic compound gave 0.22 *g* CO_2 on complete combustion. If it contains 1.66 % hydrogen, then the percentage of *C* and *O* will be**[MP PET**

(a) 12.5 and 36.6 (b) 25 and 75
(c) 25 and 36.6 (d) 25 and 80

13. An organic compound contains $C = 74.0\%$, $H = 8.65\%$ and $N = 17.3\%$. Its Empirical formula is **[MP PMT 1986]**

(a) C_5H_8N (b) $C_{10}H_{12}N$
(c) C_5H_7N (d) $C_{10}H_{14}N$

14. An appropriate method for molecular weight determination of chloroform is

(a) Regnault's method
(b) Diffusion method

(c) Vapour pressure method

(d) Victor Meyer's method

15. Molecular weight of an organic acid is given by

(a) Equivalent weight × basicity

(b) $\frac{\text{Equivalent weight}}{\text{Basicity}}$

(c) $\frac{\text{Basicity}}{\text{Equivalent weight}}$

(d) Equivalent weight × valency

16. If two compounds have the same empirical formula but different molecular formulae they must have **[IIT-JEE 1987; Kurukshetra CEE 1998]**

(a) Different percentage composition

(b) Different molecular weight

(c) Same viscosity

(d) Same vapour density

17. Empirical formula of a compound is C_2H_5O and its molecular weight is 90. Molecular formula of the compound is **[NCERT 1971]**

(a) C_2H_5O (b) $C_3H_6O_3$

(c) $C_4H_{10}O_2$ (d) $C_5H_{14}O$

18. 60 *g* of a compound on analysis gave $C = 24\ g$, $H = 4\ g$ and O = 32 *g*. Its Empirical formula is **[CPMT 1971, 81]**

(a) $C_2H_4O_2$ (b) C_2H_2O

(c) CH_2O_2 (d) CH_2O

19. An organic compound contains $C = 38.8\%$, $H = 16\%$ and $N = 45.2\%$. Empirical formula of the compound is **[CPMT 1973, 83]**

(a) CH_3NH_2 (b) CH_3CN

(c) C_2H_5CN (d) $CH_2(NH)_2$

20. In Kjeldahl's method for the estimation of nitrogen, the formula used is

(a) $\%N = \frac{1.4\ V\ W}{N}$ (b) $\%N = \frac{1.4\ N\ W}{V}$

(c) $\%N = \frac{V\ N\ W}{1.8}$ (d) $\%N = \frac{1.4\ V\ N}{W}$

21. An organic compound on analysis gave the following results : *C* = 54.5%, *O* = 36.4%, *H* = 9.1%. The Empirical formula of the compound is **[CPMT 1977; KCET 1998; MP PET 2003; UPSEAT 2004; IIT-JEE (Screening) 2004]**

(a) CH_3O (b) C_2H_4O

(c) C_3H_4O (d) C_4H_8O

22. An organic compound gave *C* = 92.31% and $H = 7.69\%$. If molecular weight of the compound is 78, its molecular formula is

(a) C_6H_6 (b) C_7H_7

(c) C_6H_{18} (d) C_8H_{20}

23. An organic compound gave the following results $C = 53.3\%, H = 15.6, N = 31.1\%,$ mol. wt. = 45, What is molecular formula of the compound ?

(a) $C_2H_5N_2$ (b) C_2H_5N

(c) C_2H_7N (d) C_2H_6N

24. A compound gave 80% carbon and 20 % hydrogen on analysis. The compound is possibly **[MADT Bihar 1984; MP PMT 1986]**

(a) C_6H_6 (b) C_2H_5OH

(c) C_2H_6 (d) $CHCl_3$

25. A compound has 50% carbon, 50% oxygen and approximate molecular weight is 290. Its molecular formula is **[MP PET 1995]**

(a) CO (b) C_4O_3

(c) $C_{12}O_9$ (d) C_3O_3

26. On analysis, a saturated hydrocarbon is found to contain 83.70 percent carbon and 16.30% hydrogen. The empirical formula will be (at. wt. of *C*=12, at. wt. of *H* = 1) **[MP PMT 1995]**

(a) C_3H_6 (b) C_3H_8

(c) C_3H_7 (d) C_6H_{12}

27. An organic compound has *C* = 60%, H = 13.3% and *O* = 26.7%. Its empirical formula will be

(a) C_3H_6O (b) $C_2H_6O_2$

(c) $C_4H_8O_2$ (d) C_3H_8O

28. A hydrocarbon has *C*=85.72% and remaining *H*. The hydrocarbon is **[MP PET 1996]**

(a) C_2H_4 (b) C_2H_6

(c) C_2H_2 (d) CH_4

29. 64 *gm* of an organic compound contains 24 *gm* of carbon, 8 *gm* of hydrogen and the rest oxygen. The empirical formula of the compound is **[MP PMT 1996]**

(a) CH_2O (b) C_2H_4O

(c) CH_4O (d) $C_2H_8O_2$

30. An organic compound contains *C*, *H* and *O* in the proportion of 6 : 1 : 8 by weight, respectively. Its vapour density is 30. Its molecular formula will be

(a) $C_2H_4O_2$ (b) CH_4O

(c) CH_2O (d) C_3HO

31. The vapour density of the methyl ester of an organic monocarboxylic acid is 37. What is the molecular weight of the acid

(a) 46 (b) 60

(c) 70 (d) 74

32. Empirical formula of a hydrocarbon containing 80% carbon and 20% hydrogen is **[MP PET 1997; EAMCET 1998; JIPMER 2002]**

(a) CH (b) CH_2

(c) CH_3 (d) CH_4

33. An organic compound with *C* = 40% and *H* = 6.7% will have the empirical formula **[MP PET 1999; JIPMER 200**

(a) CH_2 (b) CH_2O

(c) $C_3H_6O_3$ (d) $C_2H_4O_2$

34. Which of the following relations gives the value of *n* = **[Bihar MEE 1996]**

(a) $\frac{\text{Moleculer Mass}}{\text{Atomic Mass}}$ (b) $\frac{\text{Molecular Mass}}{\text{Empirical Mass}}$

(c) $\frac{\text{Empirical Mass}}{\text{Molecular Mass}}$ (d) None of these

35. An organic compound containing *C*, *H* and *N* gave following analysis : *C* = 40%, *H* = 13.33% and *N* = 46.67%. Its empirical formula would be **[CBSE PMT 1998, 99; AFMC 2000; KCET 2002; Pb. PMT 2004]**

(a) $C_2H_7N_2$ (b) CH_5N

(c) CH_4N (d) C_2H_7N

36. If a compound on analysis was found to contain *C* = 18.5%, *H* = 1.55%, *Cl* = 55.04% and *O* = 24.81%, then its empirical formula is **[AIIMS 1998]**

(a) $CHClO$ (b) CH_2ClO

(c) C_2H_2OCl (d) $ClCH_2O$

37. An organic compound has % of C and % of *H* in the ratio 6 : 1 and % of *C* and % of *O* in the ratio 3 : 4. The compound is **[Roorkee 1999]**

(a) $HCHO$ (b) CH_3OH

(c) CH_3CH_2OH (d) $(COOH)_2$

38. 0.2595*g* of an organic substance in a quantitative analysis yielded 0.35 *g* of the barium sulphate. The percentage of sulphur in the substance is **[CPMT 2000; AFMC 2001; Pb. CET 2000]**

(a) 18.52*g* (b) 182.2 *g*

(c) 17. 5 *g* (d) 175.2*g*

39. In kjeldahl's method, $CuSO_4$ acts as **[AFMC 2001]**

(a) Oxidising agent (b) Reducing agent

(c) Hydrolysing agent (d) Catalytic agent

40. In the qualitative analysis of nitrate a brown ring is formed due to the formation of **[AMU 2001]**

(a) NO_2 (b) $FeSO_4NO_2$

(c) $N_2O.FeSO_4$ (d) $FeSO_4.NO$

41. Percentage composition of an organic compounds is as follows:

C = 10.06, *H* = 0.84, *Cl* = 89.10. Which of the following corresponds to its molecular formula if the vapour density is 60.0

(a) CH_2Cl_2 (b) $CHCl_3$

(c) CH_3Cl (d) None of these

42. The percentage of N_2 in urea is about **[KCET (Med.) 2001]**

(a) 18.05 (b) 28.29

(c) 46.66 (d) 85.56

43. A compound of carbon hydrogen and nitrogen contains three elements in the respective ratio of 9 : 1 : 35 *grams*. The Empirical formula for the compound is **[DCE 2001]**

(a) C_2H_4N (b) C_3H_4N

(c) C_3H_6N (d) C_2H_6N

44. Which of the following is the best scientific method to test the presence of water in a liquid**[JIPMER 2**

(a) Use of anhydrous copper sulphate

(b) Use of litmus paper

(c) Taste

(d) Smell

45. Chromatography is a valuable method for the separation, isolation, purification and identification of the constituents of a mixture and it is based on general principle of **[Kerala (Med.) 2002]**

(a) Phase rule

(b) Phase distribution

(c) Interphase separation

(d) Phase operation

46. To differentiate between carbon-12, carbon-13 and carbon-14, the instrument that you would use in **[Kerala (Engg.) 2002]**

(a) Infra-red spectrometer

(b) Atomic absorption spectrometer

(c) Mass spectrometer

(d) Ultraviolet spectrometer

47. Chromatography is used for the purification of **[KCET 2002]**

(a) Solids (b) liquids

(c) Gases (d) All of these

48. An organic compound has been found to possess the Empirical formula CH_2O and molecular weight 90. The molecular formula of it is $(C = 12, H = 1, \text{and } O = 16)$ **[CPMT 2000; MP PET 2002]**

(a) $C_3H_6O_3$ (b) CH_2O

(c) $C_2H_6O_2$ (d) C_2H_2O

49. An organic compound containing carbon hydrogen and oxygen contains 52.20% carbon and 13.04% hydrogen. Vapour density of the compound is 23. Its molecular formula will be **[MP PMT 2002]**

(a) C_2H_6O (b) C_3H_8O

(c) C_4H_8O (d) $C_5H_{10}O$

[AMU 2001]

50. Lassaigne's test is used to detect**[Kerala (Engg.) 2002]**

(a) Nitrogen and halogens (b)Sodium and halogens

(c) Halogens and sulphur (d)Nitrogen and sulphur

(e) All of the above

51. In Lassaigne's test the organic compound is fused with *Na* followed by extraction with distilled water. Which of the following is not the possible product of this fusion reaction **[AMU 2002]**

(a) NaX (b) $NaCN$
(c) $NaNC$ (d) Na_2S

52. The Empirical formula of a compound is CH_2O and its molecular weight is 120. The molecular formula of the compound is **[Kerala (Med.) 2003]**
(a) $C_2H_4O_2$ (b) $C_3H_6O_3$
(c) $C_4H_8O_4$ (d) CH_2O

53. In Victor Mayer's method 0.2 *gm* of an organic substance displaced 56 *ml* of air at STP the molecular weight of the compound **[Kerala (Med.) 2003]**
(a) 56 (b) 112
(c) 80 (d) 28

54. If we want to study relative arrangement of atoms in a molecule we study **[Orissa JEE 2003]**
(a) Empirical formula (b) Molecular formula
(c) Structural formula (d) None of these

55. Which one of the following reagents is used for detection of unsaturation in alkenes **[EAMCET 2003]**
(a) $NaOH + CaO$
(b) Cold dilute alkaline $KMnO_4$
(c) Cl_2 / hv
(d) KOH / C_2H_5OH

56. The decomposition of organic compounds in the presence of oxygen and without formation of odoriferous substances, is called **[CBSE PMT 1999]**
(a) Decay (b) N_2 fixation
(c) Nitrification (d) Denitrification

57. Which of the following compounds is used as a refrigerants **[Bihar CEE 1995]**
(a) NH_3 (b) CH_2F_2
(c) CCl_4 (d) CH_3COONH_4

58. The latest technique for the purification of organic compounds is **[Pb. CET 2001]**
(a) Fractional distillation (b) Chromatography
(c) Vacuum distillation (d) Crystallisation

59. The presence of halogen, in an organic compounds, is detected by **[Pb. CET 2002]**
(a) Iodoform test (b) Silver nitrate test
(c) Beilstein's test (d) Millon's test

60. *p*-nitrophenol and o-nitrophenol are separated by **[BVP 2004]**
(a) Crystallisation (b) Fractional crystallisation
(c) Distillation (d) Steam distillation

61. Nitrating mixture is **[MH CET 2004]**
(a) Fuming nitric acid
(b) Mixture of conc. H_2SO_4 and conc. HNO_3
(c) Mixture of nitric acid and anhydrous zinc chloride
(d) None of these

62. Quantitative measurement of nitrogen in an organic compounds is done by the method **[CPMT 2004]**
(a) Berthelot method (b) Belstein method
(c) Lassaigne test (d) Kjheldahl's method

63. Which kind of fission is favoured by sunlight **[CPMT 2004]**
(a) Heterolytic fission (b) Homolytic fission
(c) Both (a) and (b) (d) None of these

64. The ammonia evolved from the treatment of 0.30 *g* of an organic compound for the estimation of nitrogen was passed in 100 *mL* of 0.1 *M* sulphuric acid. The excess of acid required 20 *mL* of 0.5 *M* sodium hydroxide solution for complete neutralization. The organic compound is **[AIEEE 2004]**
(a) Urea (b) Benzamide
(c) Acetamide (d) Thiourea

65. The best method for the separation of naphthalene and benzoic acid from their mixture is **[CBSE PMT 2005]**
(a) Chromatography (b) Crystallisation
(c) Distillation (d) Sublimation

66. A compound has an empirical formula C_2H_4O. An independent analysis gave a value of 132.16 for its molecular mass. What is the correct molecular formula **[Kerala PMT 2004]**
(a) $C_4H_4O_5$ (b) $C_{10}H_{12}$
(c) C_7O_3 (d) $C_6H_{12}O_3$
(e) $C_4H_8O_5$

67. An organic compound has an empirical formula CH_2O, its vapour density is 45. The molecular formula of the compounds is **[DCE 2004]**
(a) CH_2O (b) C_2H_5O
(c) C_2H_2O (d) $C_3H_6O_3$

68. The study of organic compounds even at present is done separate from other compounds because **[CPMT 19**
(a) The formation of organic compounds is not based on chemical combination
(b) Organic compounds are covalent
(c) Catenation is the main characteristics
(d) It is the easiest method of study

69. Which of the following pair of the species has the same percentage of carbon **[BHU 1999]**
(a) CH_3COOH and C_2H_5OH
(b) $C_6H_{12}O_6$ and $C_{12}H_{22}O_{11}$
(c) $HCOOCH_3$ and $C_{12}O_{22}O_{11}$
(d) CH_3COOH and $C_6H_{12}O_6$

70. In Kjeldahl's method of estimation of $N, CuSO_4$ acts as **[DCE 2002]**
(a) Oxidising agent (b) Reducing agent
(c) Catalytic agent (d) Hydrolysis agent

71. An organic compound having molecular mass 60 is found to contain C = 20%, H= 6.67% and N=46.67% while rest is oxygen. On heating it gives NH_3 alongwith a solid residue. The solid residue give violet colour with alkaline copper sulphate solution. the compound is **[AIEEE 2005]**

(a) CH_3NCO (b) CH_3CONH_2

(c) $(NH_2)_2CO$ (d) $CH_3CH_2CONH_2$

72. How will you separate a solution (miscible) of benzene $+CHCl_3$ **[AFMC 2005]**

(a) Sublimation (b) Filtration

(c) Distillation (d) Crystallisation

73. A mixture of camphor and benzoic acid can be separated by

[BHU 2005]

(a) Chemical method (b) Sublimation

(c) Fractional distillation (d)Extraction with a solvent

74. Dumas method involves the determination of nitrogen content in the organic compound in the form of

[BHU 2005]

(a) NH_3 (b) N_2

(c) $NaCN$ (d) $(NH_4)_2SO_4$

75. When 32.25gm ethyl chloride dehydro halogenated, if gives 50%. Alkene, what is the mass of product. (atomic mass of chlorine = 35.5) **[Kerala CET 2005]**

(a) 14 *gm* (b) 28 *gm*

(c) 64.5 *gm* (d) 56 *gm*

(e) 7 *gm*

76. How much sulphur is present in organic compound if on analysis 0.53 *gm* of this compound gives 1.158 *gm* of $BaSO_4$ **[Kerala CET 2005]**

(a) 10% (b) 15%

(c) 20% (d) 25%

(e) 30%

Classification and nomenclature of organic compounds

1. The systematic name of $CH_3-CHBr-CH_2OH$ is

[BHU 1982]

(a) 3-hydroxy-2-bromopropane

(b) 2-bromopropanol-1

(c) 2-bromo-3-propanol

(d) 3-hydroxy isopropyl bromide

2. IUPAC name of acetyl salicylic acid is **[CPMT 1994]**

(a) *m*-benzoic acid (b) 2-acetoxy benzoic acid

(c) *p*-benzoic acid (d) *p*-acetyl benzoic acid

3. IUPAC name of CH_3CHO is

[NCERT 1981; CBSE PMT 1990; MP PMT 1989, 96]

(a) Acetaldehyde (b) Methyl aldehyde

(c) Ethanol (d) Ethanal

4. IUPAC name of $CH_3CH(OH)CH_2CH_2COOH$ is

[MP PET 1990]

(a) 4-hydroxy pentanoic acid

(b) 1-carboxy-3-butanoic acid

(c) 1-carboxy-4-butanol

(d) 4-carboxy-2-butanol

5. IUPAC name of $CH_3-O-C_2H_5$ is

[MNR 1986; MP PET 2000]

(a) Ethoxymethane (b) Methoxyethane

(c) Methylethyl ether (d) Ethylmethyl ether

6. Which of the following compound has the functional group $-OH$

(a) 1, 2-ethandiol (b) 2-butanone

(c) Nitrobenzene (d) Ethanal

7. IUPAC name of the $(CH_3)_2CHCH(CH_3)_2$ is

[MP PMT 1986]

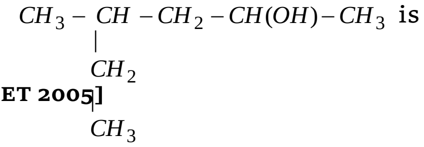
(a) 1, 1, 2, 3-tetramethylethane

(b) 1, 2-di-isopropylethane

(c) 2, 3-dimethylbutane

(d) 2, 3, 3-trimethylbutane

8. IUPAC name of the compound is

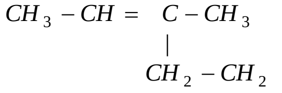

$CH_3-\underset{\substack{|\\CH_2\\|\\CH_3}}{CH}-CH_2-CH(OH)-CH_3$ is

[DPMT 1985; MP PMT 1987; AFMC 1997]

(a) 4-ethyl-2-pentanol (b) 4-methyl-2-hexanol

(c) 2-ethyl-2-pentanol (d) 3-methyl-2-hexanol

9. IUPAC name of the compound is


$CH_3-CH=\underset{\substack{|\\CH_2-CH_2}}{C}-CH_3$

[NCERT 1983; MP PMT 1989, 96; BHU 1997]

(a) 2-ethyl-2-butene (b) 3-ethyl-2-butene

(c) 3-Methyl-3-pentene (d) 3-methyl-2-pentene

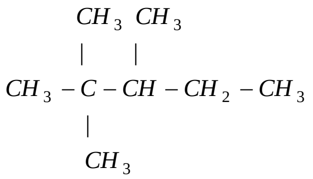
10. The IUPAC name of $CH_3C\equiv N$ is **[CPMT 1990]**

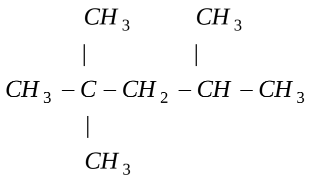
(a) Acetonitrile (b) Ethanenitrile

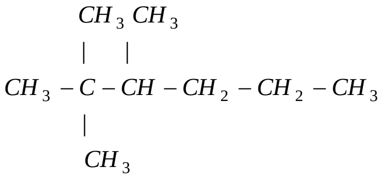
(c) Methyl cyanide (d) Cyanoethane

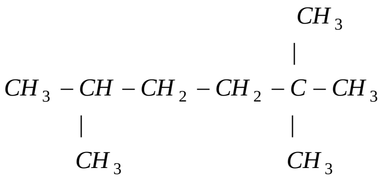
11. Which compound is 2, 2, 3-trimethylhexane

[IIT-JEE 1986]

(a)

$CH_3-\overset{\substack{CH_3\\|}}{\underset{\substack{|\\CH_3}}{C}}-\overset{\substack{CH_3\\|}}{CH}-CH_2-CH_3$

(b)

$CH_3-\overset{\substack{CH_3\\|}}{\underset{\substack{|\\CH_3}}{C}}-CH_2-\overset{\substack{CH_3\\|}}{CH}-CH_3$

(c) 
$CH_3-\underset{CH_3}{\overset{CH_3}{C}}-\overset{CH_3}{CH}-CH_2-CH_2-CH_3$

(d) 
$CH_3-\underset{CH_3}{CH}-CH_2-CH_2-\underset{CH_3}{\overset{CH_3}{C}}-CH_3$

12. The IUPAC name of $CH_3CH_2COCH_2CH_3$ is

[EAMCET 1992]

(a) 3-pentanone (b) 2-pentanone

(c) Diethyl ketone (d) All the above

13. The IUPAC name of $CH_3COOC_2H_5$ will be

[MP PMT/PET 1988; Kurukshetra CEE 1998]

(a) Ethyl acetate (b) Ethyl ethanoate

(c) Methyl propanoate (d) None of these

14. IUPAC name of $(CH_3)_2CH-CH=CH-CH_3$ is

[CPMT 1987; AMU 1985]

(a) 2-methyl-3-pentene

(b) 4-methyl-2-pentene

(c) 1, 2-isopropyl-1-propene

(d) 3-isopropyl-2-propene

15. IUPAC name of $CH_2=CH-CH(CH_3)_2$ is

[IIT-JEE 1987; CBSE PMT 1988; CPMT 1989; MNR 1995; UPSEAT 2001; RPMT 2002]

(a) 1, 1-dimethyl-2-propene

(b) 3-methyl-1-butene

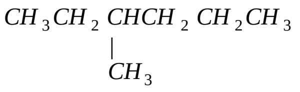
(c) 2-vinyl propane

(d) 1-isopropyl ethylene

16. Alicyclic compounds are **[CPMT 1976]**

(a) Aromatic (b) Aliphatic

(c) Heterocyclic (d) Aliphatic cyclic

17. The IUPAC name of  is
$CH_3CH_2\underset{CH_3}{CH}CH_2CH_2CH_3$

[EAMCET 1991]

(a) 4-methylhexane (b) 3-methylhexane

(c) 2-propylbutane (d) 2-ethylpentane

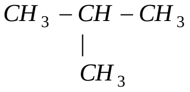
18. The most appropriate statement regarding organic compounds is

(a) They possess ionic and covalent bonds

(b) Presence of carbon is not essential

(c) They are found in a large number

(d) Their reactions are fast

19. Correct name of the compound  is
$CH_3-\underset{CH_3}{CH}-CH_3$

[CPMT 1973; MP PMT 1994]

(a) Butane (b) Isopropyl methane

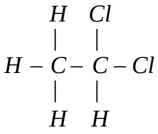
(c) 2-methyl propane (d) Dimethyl ethane

20. General formula of alkyne is

[MNR 1983; CPMT 1975, 93; MP PET 1999]

(a) C_nH_{2n+2} (b) C_nH_{2n}

(c) C_nH_{2n-2} (d) C_nH_n

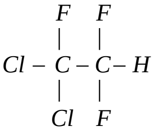
21. IUPAC name of  is **[CPMT 1973, 75, 85]**
$H-\underset{H}{\overset{H}{C}}-\underset{H}{\overset{Cl}{C}}-Cl$

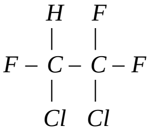
(a) 1, 2-dichloroethane (b) 2, 2-dichloroethane

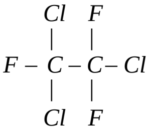
(c) 1, 1-dichloroethane (d) Dichloroethane

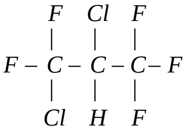
22. Freon-114 used in refrigerator and air conditioners is 1, 2-dichorotetrafluoroethane. Its structural formula is

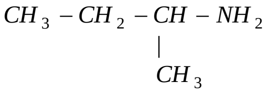
[CPMT 1979, 81; NCERT 1975]

(a) 
$Cl-\underset{Cl}{\overset{F}{C}}-\underset{F}{\overset{F}{C}}-H$

(b) 
$F-\underset{Cl}{\overset{H}{C}}-\underset{Cl}{\overset{F}{C}}-F$

(c) 
$F-\underset{Cl}{\overset{Cl}{C}}-\underset{F}{\overset{F}{C}}-Cl$

(d) 
$F-\underset{Cl}{\overset{F}{C}}-\underset{H}{\overset{Cl}{C}}-\underset{F}{\overset{F}{C}}-F$

23. IUPAC name of  is
$CH_3-CH_2-\underset{CH_3}{CH}-NH_2$

[CPMT 1983, 84]

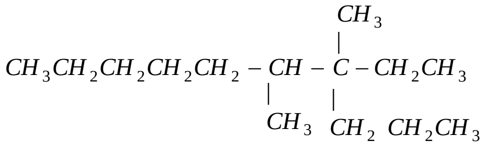
(a) 1-methyl-1-aminopropane

(b) 2-aminobutane

(c) 2-methyl-3-aminopropane

(d) None of the above

24. IUPAC name of the compound is


$CH_3CH_2CH_2CH_2CH_2-\underset{CH_3}{CH}-\underset{CH_2\ CH_2CH_3}{\overset{CH_3}{C}}-CH_2CH_3$

[NCERT 1982; MP PET 1994]

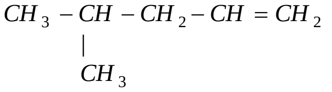
(a) 3, 4-dimethyl-3-n-propyl nonane

(b) 5, 7-dimethyl-7-n-propyl nonane

(c) 4, 5-dimethyl-4-ethyl decane

(d) 6, 7-dimethyl-7-ethyl decane

25. IUPAC name of

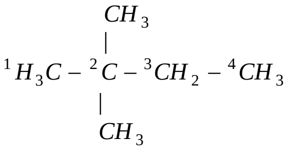


$CH_3-\underset{\substack{|\\ CH_3}}{CH}-CH_2-CH=CH_2$ is

[DPMT 1982, 83; Manipal MEE 1995]

(a) 2-methyl pentene (b) 4-methyl pentene-1
(c) 1-hexene (d) 2-methyl pentene-1

26. In the structure

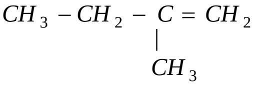


$^{1}H_3C-{}^{2}\underset{\substack{|\\ CH_3}}{\overset{\substack{CH_3\\ |}}{C}}-{}^{3}CH_2-{}^{4}CH_3$

Which one is quarterary carbon atom

(a) $C-1$ (b) $C-2$
(c) $C-3$ (d) $C-5$

27. The IUPAC name of



$CH_3-CH_2-\underset{\substack{|\\ CH_3}}{C}=CH_2$ is **[EAMCET 1992; Pb. PMT 99]**

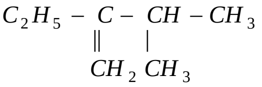
(a) 2-methylbutene-1
(b) 3-methylbutene-1
(c) Vinyl methylethane
(d) Propylethene-1

28. The IUPAC name of $CH_3C\equiv CCH(CH_3)_2$ is

[MNR 1993; Pb CET 2004]

(a) 4-methyl-2-pentyne
(b) 4, 4-dimethyl-2-butyne
(c) Methyl isopropyl acetylene
(d) 2-methyl-4-pentyne

29. The IUPAC name of the compound having structure



$C_2H_5-\underset{\substack{\|\\ CH_2}}{C}-\underset{\substack{|\\ CH_3}}{CH}-CH_3$ is **[AFMC 1990]**

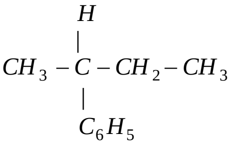
(a) 3-methyl-2-ethyl butene-1
(b) 2-ethyl-3-methyl butene-1
(c) 3-ethyl-3-methyl butene-1
(d) Ethyl isopropyl ethene

30. The IUPAC name of $(C_2H_5)_2CHCH_2OH$ is

[MP PMT 1986; AFMC 1990]

(a) 2-ethyl butanol-1
(b) 2-methyl pentanol-1
(c) 2-ethyl pentanol-1
(d) 3-ethyl butanol-1

31. IUPAC name of the following compound is



$CH_3-\underset{\substack{|\\ C_6H_5}}{\overset{\substack{H\\ |}}{C}}-CH_2-CH_3$ **[MP PMT 1986]**

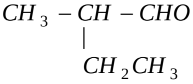
(a) 2-cyclohexylbutane (b) 2-phenylbutane
(c) 3-cyclohexylbutane (d) 3-phenylbutane

32. The IUPAC name of $CH_3CH(CH_3)COOH$ is

[CPMT 1988; RPMT 2000]

(a) Dimethyl acetic acid (b) 2-methyl propanoic acid
(c) Propanoic acid (d) Butyric acid

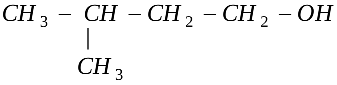
33. IUPAC name of



$CH_3-\underset{\substack{|\\ CH_2CH_3}}{CH}-CHO$ is **[IIT-JEE 1993]**

(a) Butan-2-aldehyde
(b) 2-methylbutanal
(c) 3-methyl isobutyraldehyde
(d) 2-ethylpropanal

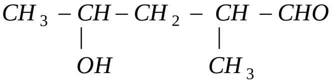
34. The IUPAC name of the compound



$CH_3-\underset{\substack{|\\ CH_3}}{CH}-CH_2-CH_2-OH$ is **[KCET 1990]**

(a) 1-pentanol (b) Pentanol
(c) 2-methyl-4-butanol (d) 3-methyl-1-butanol

35. The IUPAC name of



$CH_3-\underset{\substack{|\\ OH}}{CH}-CH_2-\underset{\substack{|\\ CH_3}}{CH}-CHO$

will be

[CBSE PMT 1992; JIPMER (Med.) 2002]

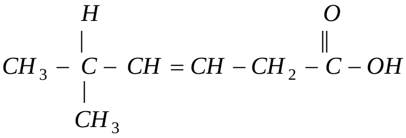
(a) 4-hydroxy-1-methylpentanal
(b) 4-hydroxy-2-methylpentanal
(c) 3-hydroxy-2-methylpentanal
(d) 3-hydroxy-3-methylpentanal

36. IUPAC name of tertiary butyl alcohol is

[CPMT 1994]

(a) Butan-1-ol (b) Butan-2-ol
(c) 2-methyl propan-1-ol (d) 2-methyl propan-2-ol

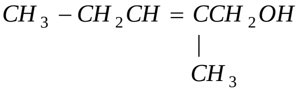
37. What is the correct IUPAC name for



$CH_3-\underset{\substack{|\\ CH_3}}{\overset{\substack{H\\ |}}{C}}-CH=CH-CH_2-\overset{\substack{O\\ \|}}{C}-OH$ **[MP PET 1995]**

(a) 5-methyl-3-hexenoic acid
(b) 5-carboxyl-2-methylpentene
(c) 4-isopropyl-3-butenoic acid
(d) None of above

38. The IUPAC name of



$CH_3-CH_2CH=\underset{\substack{|\\ CH_3}}{C}CH_2OH$ will be

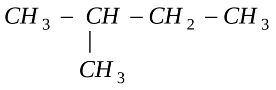
[MP PET/PMT 1988]

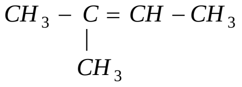
(a) 2-methyl pentyl alcohol
(b) 4-methyl-3-pentene-ol
(c) 2-methyl pent-2-ene-1-ol
(d) 4-methyl pentyl alcohol

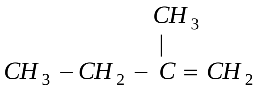
39. The structure of 4-methyl pentene-2 is **[BHU 1988]**

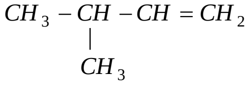
(a) $(CH_3)_2CH-CH_2CH=CH_2$
(b) $(CH_3)_2CH-CH=CH-CH_3$
(c) $(CH_3)_2CH-CH_2CH=CH-CH_3$
(d) $(CH_3)_2C=CHCH_2CH_3$

40. 2-methyl-2-butene will be represented as **[CBSE PMT 1992]**

(a) 
$CH_3-\underset{\substack{|\\CH_3}}{CH}-CH_2-CH_3$

(b) 
$CH_3-\underset{\substack{|\\CH_3}}{C}=CH-CH_3$

(c) 
$CH_3-CH_2-\overset{\substack{CH_3\\|}}{C}=CH_2$

(d) 
$CH_3-\underset{\substack{|\\CH_3}}{CH}-CH=CH_2$

41. $Cl-C-Cl$ angle in 1, 1, 2, 2 - tetrachloroethene and tetrachloromethane respectively are about **[IIT-JEE 1988]**

(a) 120^o and 109.5^o (b) 90^o and 109.5^o

(c) 109.5^o and 90^o (d) 109.5^o and 120^o

42. The IUPAC name of succinic acid is **[IIT-JEE 1994]**

(a) 1, 4-butanedioic acid (b) Dimethyl-2-acid

(c) 1, 2-dimethyldioic acid (d) None of these

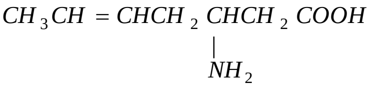
43. IUPAC name of $(CH_3)_2CH-CH_2-CH_2Br$ is **[CBSE PMT 1996]**

(a) 1-bromopentane

(b) 2-methyl-4-bromobutane

(c) 1-bromo-3-methylbutane

(d) 2-methyl-3-romopropane

44. The IUPAC name for 
$CH_3CH=CHCH_2\underset{\substack{|\\NH_2}}{CH}CH_2COOH$ is **[CBSE PMT 1995]**

(a) 5-aminohex-2-ene carboxylic acid

(b) 5-amino-2-heptenoic acid

(c) 3-amino-5-heptenoic acid

(d) $\beta-$ amino-$\delta-$heptenoic acid

45. The IUPAC name of $CH_2=CH-CH_2Cl$ is **[MP PMT 1995]**

(a) Allyl chloride (b) 1-chloro-3-propene

(c) Vinyl chloride (d) 3-chloro-1-propene

46. The IUPAC name of CH_3CH_2COCl is

(a) Propanoyl chloride (b) Ethanoyl chloride

(c) Acetyl chloride (d) Chloroethane

47. IUPAC name of the compound

$\overset{4}{C}H_2=\overset{3}{C}H-\overset{2}{C}H_2-\overset{1}{C}H_2OH$ is

(a) 1-buten-4-ol (b) 3-buten-1-ol

(c) 4-hydroxy-1-butene (d) 1-butenol-4

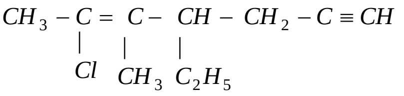
48. Which is the correct structure of the compound 3-hexyn-1-oic acid

(a) $CH_3-CH_2-CH_2-C\equiv C-COOH$

(b) $CH_3-CH_2-C\equiv C-CH_2-COOH$

(c) $CH_3-C\equiv C-CH_2-CH_2-COOH$

(d) $CH_3-CH_2-CH=CH-CH_2-COOH$

49. The IUPAC name of 
$CH_3-\underset{\substack{|\\Cl}}{C}=\underset{\substack{|\\CH_3}}{C}-\underset{\substack{|\\C_2H_5}}{CH}-CH_2-C\equiv CH$ is

[MP PET 1997]

(a) 6-chloro-4-ethyl-5-methyl-hept-5-en-1-yne

(b) 6-chloro-4-ethyl-5-methyl-hept-1-yn-5-ene

(c) 2-chloro-4-ethyl-3-methyl-hept-2-en-6-yne

(d) 2-chloro-4-ethyl-3-methyl-hept-6-yn-2-ene

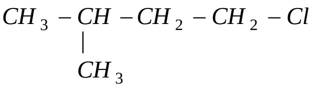
50. The IUPAC name of the compound having the formula $Cl_3C.CH_2CHO$ is **[MP PET/PMT 1998]**

(a) 3, 3, 3-trichloropropanal

(b) 1, 1, 1-trichloropropanal

(c) 2, 2, 2-trichloropropanal

(d) Chloral

51. The IUPAC name of the compound 
$CH_3-\underset{\substack{|\\CH_3}}{CH}-CH_2-CH_2-Cl$ is

[MP PET 1999; MH CET 2001]

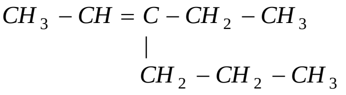
(a) 1-chloro-3-methylbutane (b)2-methyl-4-chlorobutane

(c) 2-methyl-1-chlorobutane (d) 1-chloropentane

52. The IUPAC name of crotonaldehyde is **[MP PMT 1999]**

(a) Prop-2-ene-1-al (b) Propenal

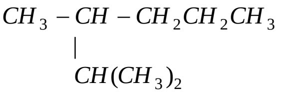
(c) But-2-ene-1-al (d) Butenal

53. IUPAC name of the following compound will be 
$CH_3-CH=\underset{\substack{|\\CH_2-CH_2-CH_3}}{C}-CH_2-CH_3$

[CPMT 1999, 2002; Pb. CET 2001]

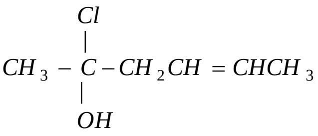
(a) 3-ethyl-2-hexene (b) 3-propyl-2-hexene

(c) 3-propyl-3-hexene (d) 4-ethyl-4-hexene

54. The IUPAC name of the following compound is **[Bihar CEE 1995]** 
$CH_3-\underset{\substack{|\\CH(CH_3)_2}}{CH}-CH_2CH_2CH_3$

(a) 2-isopropylpentane (b) 2, 3-dimethylhexane

(c) Isononane (d) 2, 4-dimethylhexane

55. The IUPAC name of 
$CH_3-\overset{\substack{Cl\\|}}{\underset{\substack{|\\OH}}{C}}-CH_2CH=CHCH_3$ is **[DPMT 1996]**

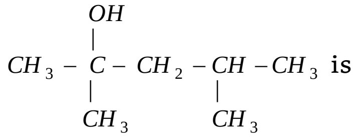
(a) 5-chloro-2-hydroxyhexene

(b) 2-chloro-5-hydroxyhexene

(c) 2-chloro-2-hydroxy-5-hexene

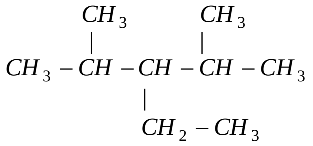
(d) 2-chloro-4-hexenol-2

56. IUPAC name of


$CH_3-\underset{CH_3}{\overset{OH}{C}}-CH_2-\underset{CH_3}{CH}-CH_3$ is **[CPMT 1996]**

(a) 2, 4-dimethyl pentanol-2
(b) 2, 4-dimethyl pentanol-4
(c) 2, 2-dimethyl butanol-2
(d) None of these

57. Which is correct IUPAC name of the following compound **[Orissa JEE 1997]**

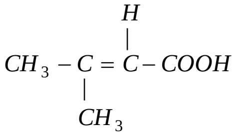

$CH_3-\overset{CH_3}{CH}-\underset{CH_2-CH_3}{CH}-\overset{CH_3}{CH}-CH_3$

(a) 3-isopropyl-2-methylpentane
(b) 3-ethyl-2,4-dimethylpentane
(c) 2,4-dimethyl-3-ethylpentane
(d) 3-isopropyl-4-methylpentane

58. IUPAC name of $CH_3-CH=CH-C\equiv CH$ is **[CPMT 1997]**

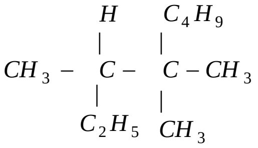
(a) Pent-2-en-4-yne
(b) Pent-3-en-1-yne
(c) Pent-3-yne-1-en
(d) Pent-2-yne-1-en

59. The IUPAC name for the formula


$CH_3-\underset{CH_3}{C}=\overset{H}{C}-COOH$ **[Pb. PMT 1998]**

(a) 2-methyl-2-butenoic acid
(b) 3-methyl-3-butenoic acid
(c) 3-methyl-2-butenoic acid
(d) 2-methyl-3-butenoic acid

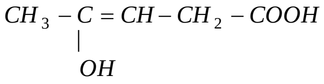
60. IUPAC name of


$CH_3-\underset{C_2H_5}{\overset{H}{C}}-\underset{CH_3}{\overset{C_4H_9}{C}}-CH_3$ is

[BHU 1998; KCET (Engg./Med) 2000]

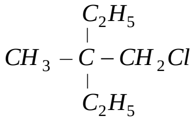
(a) 2-butyl-2-methyl-3-ethylbutane
(b) 2-ethyl-3, 3-dimethylheptane
(c) 3, 4, 4-trimethylheptane
(d) 3, 4, 4-trimethyloctane

61. The IUPAC name of the compound


$CH_3-\underset{OH}{C}=CH-CH_2-COOH$ is **[AIIMS 1998]**

(a) Hydroxypentenoic acid
(b) 4-hydroxy-3-pentenoic acid
(c) 4-hydroxy-4-pentenoic acid
(d) 4-hydroxy-4-methyl-3-butenoic acid

62. Which is the IUPAC name of


$CH_3-\underset{C_2H_5}{\overset{C_2H_5}{C}}-CH_2Cl$

[KCET (Engg./Med.) 1999]

(a) 1-chloro-2, 2-diethylpropane
(b) 3-chloro-2, 2-diethylpropane
(c) 1-chloro-2-ethyl-2 methylbutane
(d) 1-chloro-2, 2-diethyl-2 methylethane

63. The IUPAC name of the compound
$CHO-(CH_2)_4-COOH$ **[DCE 1999]**

(a) Heaxan-1-al-6-oic acid
(b) Formyl-hexanoic acid
(c) Hexanal-1-carboxylic acid
(d) Hexanoic acid 5-al-1

64. IUPAC name of $CH_3-CH=CH-COOH$ **[RPET 2000]**

(a) 2-butenoic acid
(b) 1-butenoic acid
(c) β-butenoic acid
(d) 1-carboxy -1-propene

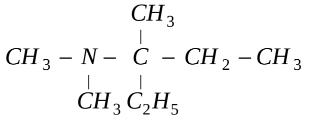
65. IUPAC name of $(CH_3)_2CH-CHO$ is: **[RPET 2000]**

(a) 2-methyl propanal
(b) 1-methyl-2 propanal
(c) 2, 2-dimethyl propanal
(d) None of these

66. IUPAC name of the compound $CH_3-CH_2-CH_2(CH_3)_2-C-CH_3$ **[RPET 2000]**

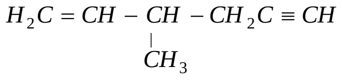
(a) 1, 1-dimethyl pentane
(b) 2, 2-dimethyl pentane
(c) 1, 2-dimethyl pentane
(d) None of these

67. IUPAC name of the following are


$CH_3-\underset{CH_3}{N}-\underset{C_2H_5}{\overset{CH_3}{C}}-CH_2-CH_3$ **[DCE 2000]**

(a) 3-dimethylamino-3-methyl pentane
(b) 3 (N, N-Trimethyl)-3-aminopentane
(c) 3, (N, N-Trimethyl) pentanammine
(d) 3-N, N dimethyl amino-3- methyl pentane

68. The correct IUPAC name of


$H_2C=CH-\underset{CH_3}{CH}-CH_2C\equiv CH$ **[Roorkee 2000]**

(a) 3-methyl-1-hexen-5-yne
(b) 4-methyl-5-hexen-1-yne
(c) 4-(ethenyl)-1-pentyne
(d) 3-(2-propenyl) butene-1

69. The IUPAC name of
$(CH_3)_2CH-CH_2-CH_2Br$ is

[MH CET 2001; CBSE PMT 2001; Pb. PMT 2004]

(a) 1-bromo pentane
(b) 2-methyl and 4 bromo butane
(c) 1-bromo and 3-methyl butane

(d) 2-methyl and 3 bromo propane

70. Which *C*-atoms is the most electronegative in this structure $\overset{\text{III}}{C}H_3-\overset{\text{II}}{C}H_2-C\equiv\overset{\text{I}}{C}H$ **[CPMT 2001]**

(a) I

(b) II

(c) III

(d) All are equal electronegative

71. The IUPAC name of compound $CH_3-C(CH_3)_2-CH_2-CH=CH_2$ is **[CPMT 2001]**

(a) 2, 2-dimethyl pent-4-ene

(b) 2, 2 dimethyl-2-pentene

(c) 1, 1, 1-trimethyl but-3-ene

(d) 4, 4-dimethyl pent-1-ene

72. Which of the following alkanes contains primary, secondary, tertiary and quaternary carbon atoms together

[MP PET 2001]

(a) $(CH_3)_3CH$

(b) $(C_2H_5)_3CH$

(c) $(CH_3)_3CCH_2CH(CH_3)_2$

(d) $(CH_3)_4C$

73. The number of tertiary carbon atoms in the compound $(CH_3)_2CHCH_2C(CH_3)_3$ is **[MP PMT 2001]**

(a) 2 (b) 3

(c) 1 (d) 4

74. The compound which has one isopropyl group is

[IIT-JEE 1989; MP PMT 2001]

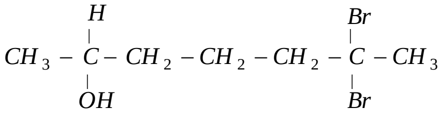
(a) 2, 2, 3, 3-tetramethyl pentane

(b) 3, 3-dimethyl pentane

(c) 2, 2, 3-trimethyl pentane

(d) 2-methyl pentane

75. Write the IUPAC name of



$$CH_3-\underset{OH}{\overset{H}{C}}-CH_2-CH_2-CH_2-\underset{Br}{\overset{Br}{C}}-CH_3$$

[DCE 2001]

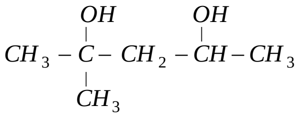
(a) 6, 6-dibromoheptane-2-ol

(b) 2, 2-dibromoheptane-6-ol

(c) 6, 6 dibromoheptane-2-ol

(d) None of these

76. The IUPAC name of



$$CH_3-\underset{CH_3}{\overset{OH}{C}}-CH_2-\overset{OH}{C}H-CH_3$$ is

[KCET (Med.) 2001; UPSEAT 1999, 2002]

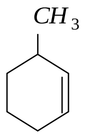
(a) 4-methyl-2, 4, pentanediol

(b) 1, 1-dimethyl 1, 1, 3 butanediol

(c) 2-methyl-2, 4 pentanediol

(d) 1, 2, 3-trimethyl-1, 3 propanediol

77. IUPAC name of the following compound is **[AIIMS 2003]**



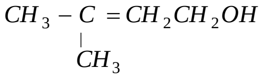
(a) 3-methyl cyclohexene

(b) 1-methyl cyclohex-2-ene

(c) 6-methyl cyclohexene

(d) 1-methyl cyclohex-5-ene

78. The IUPAC name of the compound



$$CH_3-\underset{CH_3}{C}=CH_2CH_2OH$$ is **[BHU 2001]**

(a) 2-methyl-2-butenol

(b) 2-methyl-3-butenol

(c) 3-methyl-2-butenol

(d) 3-methyl- but-2-ene-1-ol

79. The IUPAC name of $CH_3C\equiv CCH(CH_3)_2$ is

[UPSEAT 2001]

(a) 4 methyl-2 pentyne

(b) 4, 4-dimethyl-2-butyne

(c) Methyl isopropyl acetylene

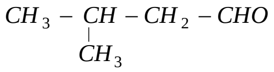
(d) 2-methyl-4-pentyne

80. Which of the following compound have wrong IUPAC name

[AIEEE 2002]

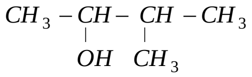
(a) $CH_3-CH_2-CH_2-COO-CH_2CH_3$ → ethyl butanoate

(b)



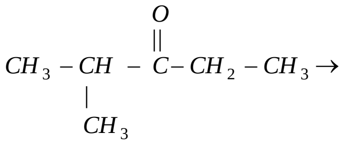
$CH_3-\underset{CH_3}{C}H-CH_2-CHO$ →3-methyl-butanal

(c)



$CH_3-\underset{OH}{C}H-\underset{CH_3}{C}H-CH_3$ → 2-methyl-3-butanol

(d)



$CH_3-\underset{CH_3}{C}H-\overset{O}{\overset{\|}{C}}-CH_2-CH_3$ →2-methyl-3 pentanone

81. If CH_4 is known as methane, then C_9H_{20} is known as

[Kerala (Med.) 2002]

(a) Hexane (b) Nonane

(c) Octane (d) Butane

82. The IUPAC name of *n*-butyl chloride is

[Kerala (Med.) 2002]

(a) 1-chlorobutane (b) *n*-chlorobutane

(c) ter-butylchloride (d) 2-methylbutane

83. General formula of alkanes is **[MP PET/PMT 2002]**

(a) C_nH_{2n+1} (b) C_nH_{2n+2}

(c) C_nH_{2n-1} (d) C_nH_{2n}

84. General formula of alkene and alkane are **[MP PMT 2002]**

(a) C_nH_{2n} and C_nH_{2n+1}

(b) C_nH_{2n} and C_nH_{2n+2}

(c) C_nH_{2n-1} and C_nH_{2n}

(d) C_nH_{2n-1} and C_nH_{2n+2}

85. The IUPAC name of picric acid is **[KCET 2002]**

(a) 2,4,6-trinitrophenol

(b) 2,4,6-trinitrobenzoic acid

(c) 4-nitrophenol

(d) None of these

86. General formula of paraffin is **[RPMT 2002]**

(a) C_nH_{2n} (b) C_nH_{2n-2}

(c) C_nH_{2n+2} (d) $C_{2n}H_{2n}$

87. IUPAC name of compound is

$CH_3-CH_2-CH(CH_3)-CH_2-COCl$ **[RPMT 2002]**

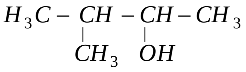
(a) 3-methyl pentanoyl chloride

(b) 3-methyl butanoyl chloride

(c) 1-chloro-3-methyl pentanol

(d) None of these

88. The name of



$H_3C-\underset{CH_3}{\underset{|}{CH}}-\underset{OH}{\underset{|}{CH}}-CH_3$

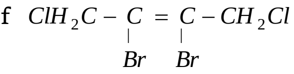
IUPAC nomenclature system is

[MP PMT 2002; MH CET 2002]

(a) Butanol (b) 2-methyl butanol-3

(c) 3-methyl butanol-2 (d) Pentanol

89. The name of



$ClH_2C-\underset{Br}{\underset{|}{C}}=\underset{Br}{\underset{|}{C}}-CH_2Cl$

according to IUPAC nomenclature system is : **[MP PMT 2002]**

(a) 2,3 dibromo-1, 4-dichlorobutene-2

(b) 1, 4-dichloro-2, 3-bromobutene-2

(c) Dichlorodibromobutene

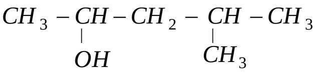
(d) Dichlorodibromobutane

90. The IUPAC name of acraldehyde is **[MP PMT 2000]**

(a) Prop-2-ene–1–al (b) Propenyl aldehyde

(c) But-2-ene–1–al (d) Propenal

91. IUPAC name of the compound



$CH_3-\underset{OH}{\underset{|}{CH}}-CH_2-\underset{CH_3}{\underset{|}{CH}}-CH_3$

is..... **[Orissa JEE 2002]**

(a) 4-methyl pentene-2-*ol* (b)2-methyl pentanol-4

(c) 4, 4-dimethyl butan-2-*ol* (d)4-methyl pentane-2-*ol*

92. Cycloalkane has the formula **[Kerala (Engg.) 2002]**

(a) C_nH_{2n+2} (b) C_nH_{2n-2}

(c) C_nH_{2n} (d) $C_{2n}H_2$

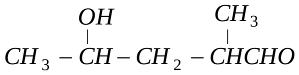
93. The IUPAC name of the compound $CH_2=CH-CH_2-CH_2-C\equiv CH$ is

[CBSE PMT 2002; MP PMT 2003]

(a) 1, 5-hexenyne (b) 1-hexyne-5-ene

(c) 1, 5-hexynene (d) 1-hexene-5-yne

94. The IUPAC name of



$CH_3-\overset{OH}{\overset{|}{CH}}-CH_2-\overset{CH_3}{\overset{|}{C}}HCHO$

is **[JIPMER 2002]**

(a) 4 Hydroxy-2-methylpentanal

(b) 2-hydroxy-4 methyl pentanal

(c) 2-methyl pent-4-ol-1-al

(d) None of these

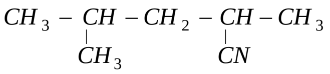
95. The IUPAC name of the compound

$CH_3-CH(C_2H_5)-CH=CH-CH_3$ is **[BHU 2002]**

(a) 4-ethyl-2-pentene (b) 4-methyl 2-hexene

(c) 3-ethyl-2-pentene (d) 2-ethyl-3-pentene

96. IUPAC name of



$CH_3-\underset{CH_3}{\underset{|}{CH}}-CH_2-\underset{CN}{\underset{|}{CH}}-CH_3$

[AIIMS 2002]

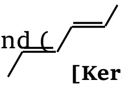
(a) 2-cyno, 3-methyl, hexane

(b) 3-methyl, 5-cyanohexane

(c) 2-4 dimethyl, cyanopentane

(d) 2-cyno, 3-methylhexane

97. The IUPAC name of compound (



) is **[Kerala CET 2005]**

(a) (2Z, 4Z) –2, 4-hexa di-ene

(b) (2Z, 4E)–2, 4 hexa di ene

(c) (4Z, 4Z)–2, 4 hexa di ene

(d) (2E, 4Z)–2, 4 hexa di ene

(e) (2E, 4E)–2, 4 hexa di ene

98. Name the alkene with molecular formula $C_{10}H_{20}$

[Kerala (Med.) 2003]

(a) Dodecene (b) Undecene

(c) Decene (d) Heptene

99. The IUPAC name of following compounds is

$HOOC-CH_2-\underset{COOH}{\underset{|}{CH}}-CH_2-CH_2-COOH$

[Kerala CET 2005]

(a) 2-(Carboxy methyl)-pentane-1, 5-dioic acid

(b) 3-Carboxy hexane –1, 6 dioic acid

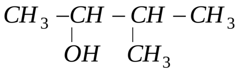
(c) Butane, 1, 2, 4,-Tricarboxylic acid

(d) 4-Carboxy hexane-1, 6 dioic acid

(e) 1, 2 dicarboxypentanoic acid

100. Names of some compounds are given. Which one is not in IUPAC system **[CBSE PMT 2005]**

(a)



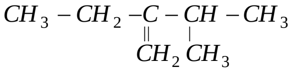
$CH_3-\underset{OH}{\underset{|}{CH}}-\underset{CH_3}{\underset{|}{CH}}-CH_3$

3-Methyl-2-bulanol

(b) $CH_3-C\equiv C-CH(CH_3)_2$

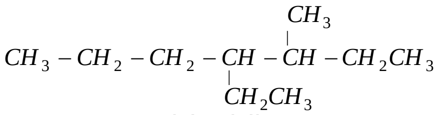
4-Methyl-2-pentyne

(c)



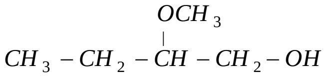
$CH_3-CH_2-\underset{CH_2}{\underset{\|}{C}}-\underset{CH_3}{\underset{|}{CH}}-CH_3$

2-Ethyl-3-methyl-bul-1-ene

(d) 
$CH_3-CH_2-CH_2-\underset{CH_2CH_3}{\underset{|}{C}H}-\overset{CH_3}{\overset{|}{C}H}-CH_2CH_3$

3-Methyl-4-ethylheptane

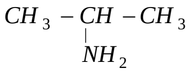
101. The IUPAC name of the compound


$CH_3-CH_2-\overset{OCH_3}{\overset{|}{C}H}-CH_2-OH$ is **[BHU 2004]**

(a) 2-methoxy-1-butanol (b) 3-methoxy-1-butanol

(c) 2-methoxy-1-butanol (d) 1, 2-methoxy-butanol

102. IUPAC name of


$CH_3-\underset{NH_2}{\underset{|}{C}H}-CH_3$ is **[MH CET 2004]**

(a) Dimethyl amine (b) 2-aminopropane

(c) Isopropylamine (d) 2-propanamine

103. The compound having only primary hydrogen atoms is

[AIIMS 2004]

(a) Isobutene (b) 2,3-Dimethylbutene

(c) Cyclohexane (d) Propyne

104. The compound formed in the positive test for nitrogen with the lassaigne solution of an organic compounds is

[AIEEE 2004]

(a) $Fe(CN)_3$ (b) $Na_3[Fe(CN)_6]$

(c) $Fe_4[Fe(CN)_6]_3$ (d) $Na_4[Fe(CN)_5NOS]$

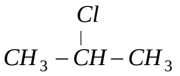
105. The IUPAC name of Gamaxene is **[MP PET 2004]**

(a) Benzene hexachloride

(b) Hexachlorobenzene

(c) 1, 2, 3, 4, 5, 6, hexachlorobenzene

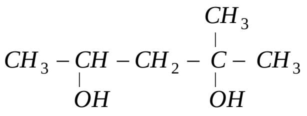
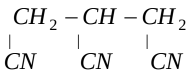
(d) 1, 2, 3, 4, 5, 6, hexachlorocyclohexane

106. The IUPAC name of 
$CH_3-\overset{Cl}{\overset{|}{C}H}-CH_3$ is **[Pb. CET 2000]**

(a) 2-chloropropane (b) Chloropropane

(c) 1-chloropropane (d) 2-chlorobutane

107. The IUPAC name of


$CH_3-\underset{OH}{\underset{|}{C}H}-CH_2-\overset{CH_3}{\overset{|}{\underset{OH}{\underset{|}{C}}}}-CH_3$ and 
$\underset{CN}{\underset{|}{CH_2}}-\underset{CN}{\underset{|}{CH}}-\underset{CN}{\underset{|}{CH_2}}$

[Pb. CET 2004; DCE 2002; MNR 1984; CPMT 1983, 93; RPMT 1999]

(a) 1, 1-dimethyl-1, 3-butanediol and propanetricarbyl amine

(b) 4-methyl-2, 4-pentanediol and 1, 2, 3 propanetrinitrile

(c) 2-methyl 2, 4-pentanediol and 3 cyano 1, 5-pentanedinitrile

(d) 1, 3, 3-trimethyl 1,3-propanediol and 1, 2, 3 tricyano propane

108. The IUPAC name of $CH_3CH_2C(Br)=CH-Cl$ is

[CPMT 2004]

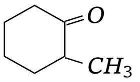
(a) 2-bromo-1-chloro butene

(b) 1-chloro-2-bromo-butene

(c) 3-chloro-2-bromo butene-2

(d) None of these

109. IUPAC name for the compounds



is **[DPMT 2004]**

(a) α-Methyl cyclohexanone

(b) 2-Methyl cyclohexanone

(c) Heptanone-2

(d) Methyl cyclo-hexanone

110. Which of the following compounds is not chiral

[AIEEE 2004]

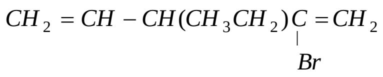
(a) 1-chloro-2-methyl pentane

(b) 2-chloropentane

(c) 1-chloropentane

(d) 3-chloro-2-methyl pentane

111. IUPAC name of


$CH_2=CH-CH(CH_3CH_2)\underset{Br}{\underset{|}{C}}=CH_2$ is .....

[JEE Orissa 2004]

(a) 4-bromo-3-ethyl-1, 4-pentadiene

(b) 2-bromo-3-ethyl-1, 4-pentadiene

(c) 2-bromo-3-ethyl-1, 5-pentadiene

(d) None of these

112. Write the IUPAC name of CH_3CH_2COOH **[AFMC 2004]**

(a) Ethyl formic acid

(b) Ethyl carboxylic acid

(c) Ethane methanoic acid

(d) Propanoic acid

113. IUPAC name of


$H_3C-\underset{C_2H_5}{\underset{|}{CH}}-CH_2-\underset{OH}{\underset{|}{CH}}-CH_2Cl$ is **[CPMT 1988, 93]**

(a) 1-chloro-4-methyl -2-hexanal

(b) 1-chloro--4-ethyl-2-pentanol

(c) 1-chloro-4-methyl-2-hexanol

(d) 1-chloro--2-hydroxy-4-methyl hexane

114. IUPAC name of $(CH_3)_3C-CH=CH_2$ is

[NCERT 1978, 81; IIT-JEE 1984; DPMT 1986; CPMT 1989; CBSE PMT 1991; AIIMS 1997; MP PMT 2001; KCET 2003]

(a) 3,3,3-trimethyl-1-propene

(b) 1,1,1-trimethyl-2-propene

(c) 3,3-dimethyl-1-butene

(d) 2,2-dimethyl-3-butene

115. The IUPAC name of $CH_3COCH(CH_3)_2$ is **[AIEEE 2003]**

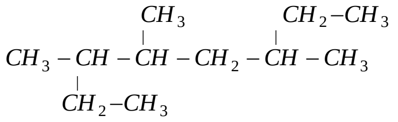
(a) Isopropylmethyl ketone

(b) 2-methyl-3-butanone

(c) 4-methylisopropyl ketone

(d) 3-methyl-2-butanone

116. What will be the IUPAC name of the given compound **[BHU 2005]**



$CH_3-\underset{CH_2-CH_3}{CH}-\overset{CH_3}{CH}-CH_2-\overset{CH_2-CH_3}{CH}-CH_3$

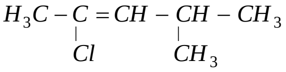
(a) 2, 5 – diethyl – 4 – methylexane

(b) 3, 4, 6 – trimethyloctane

(c) 2, 5, 6 – trimethyloctane

(d) 3, 5 – dimethyl – 6 – ehtylheptane

117. **[KCET 2005]**



$H_3C-\underset{Cl}{C}=CH-\underset{CH_3}{CH}-CH_3$

(a) 2-chloro-4-methyl-2-pentene

(b) 4-chloro-2-methyl-3-pentene

(c) 4-methyl-2-chloro-2-pentene

(d) 2-chloro-4, 4-dimethyl-2-butene

118. The IUPAC name for CH_3CO-CH_3 is **[J & K 2005]**

(a) Dimethyl ketone (b) Acetone

(c) Propanal (d) Propanone

Critical Thinking

Objective Questions

1. $116\,mg$ of a compound on vaporisation in a Victor Meyer's apparatus displaces $44.8\,ml$ of air measured at S.T.P. The molecular weight of the compounds is **[Kerala PMT 2004]**

(a) 116 (b) 232

(c) 58 (d) 44.8

(e) 46.4

2. An organic compound contains 49.3% carbon 6.84% hydrogen and its vapour density is 73. Molecular formula of the compound is

[MP PET 2000; Kerala PMT 2004; Pb. CET 2004]

(a) $C_3H_5O_2$ (b) $C_6H_{10}O_4$

(c) $C_3H_{10}O_2$ (d) $C_4H_{10}O_2$

3. If 0.228 *g* of silver salt of dibasic acid gave a residue of 0.162*g* of silver on ignition then molecular weight of the acid is **[AIIMS 2000]**

(a) 70 (b) 80

(c) 90 (d) 100

4. $0.0833\,mol$ of carbohydrate of empirical formula CH_2O contain $1g$ of hydrogen. The molecular formula of the carbohydrate is **[DCE 2003; BVP 2004]**

(a) $C_5H_{10}O_5$ (b) $C_3H_4O_3$

(c) $C_{12}H_{22}O_{11}$ (d) $C_6H_{12}O_6$

5. A gas mixture contains 50% helium and 50% methane by volume. What is the percent by weight of methane in the mixture **[Kerala PMT 2004]**

(a) 19.97% (b) 20.05%

(c) 50% (d) 75%

(e) 80.03%

6. 0.5 *g* of hydrocarbon gave 0.9 *g* water on combustion. The percentage of carbon in hydrocarbon is

(a) 75.8 (b) 80.0

(c) 56.6 (d) 28.6

7. Lassaigne's test for the detection of nitrogen fails in

[CBSE PMT 1994]

(a) $NH_2CONHNH_2.HCl$

(b) $NH_2NH_2.HCl$

(c) NH_2CONH_2

(d) $C_6H_5NHNH_2.HCl$

8. Camphor is often used in molecular mass determination because **[CBSE PMT 2004]**

(a) It is volatile

(b) It is solvent for organic substances

(c) It is readily available

(d) It has a very high cryoscopic constant

9. In Kjeldahl's method, the nitrogen present in the organic compound is quantitatively converted into **[DCE 2003]**

(a) Gaseous ammonia

(b) Ammonium sulphate

(c) Ammonium phosphate

(d) Ammonia

10. How many H-atoms are present in 0.046 *g* of ethanol

[DCE 2003]

(a) 6×10^{20} (b) 1.2×10^{21}

(c) 3×10^{21} (d) 3.6×10^{21}

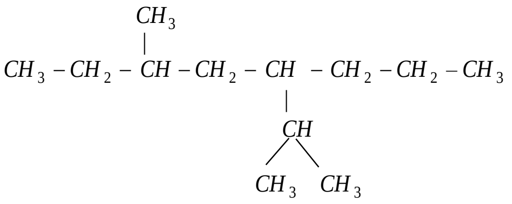
11. A hydrocarbon contains 10.5 *gm* carbon and 1*gm* hydrogen. Its 2.4 *gm* has 1 *litre* volume at 1 *atm* and 127^oC, hydrocarbon is

[UPSEAT 2003]

(a) C_6H_7 (b) C_6H_8

(c) C_5H_6 (d) None of these

12. IUPAC name of the compound

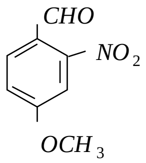


$$CH_3-CH_2-\overset{\overset{CH_3}{|}}{CH}-CH_2-\underset{\underset{CH_3\quad CH_3}{\underset{|}{CH}}}{\underset{|}{CH}}-CH_2-CH_2-CH_3$$

[Orissa JEE 2003]

(a) 4-isopropyl 1-6-methyl octane
(b) 3- methyl-5-(1'-methylethyl) octane
(c) 3-methyl-5-isopropyl octane
(d) 6-methyl-4-(1'methylethyl) octane

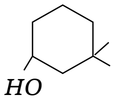
13. What is the correct IUPAC name of



[MP PMT 2003]

(a) 4-methoxy-2-nitrobenzaldehyde
(b) 4-formyl-3-nitro anisole
(c) 4-methoxy-6-nitrobenzaldehyde
(d) 2-formyl-5-methoxy nitrobenzene

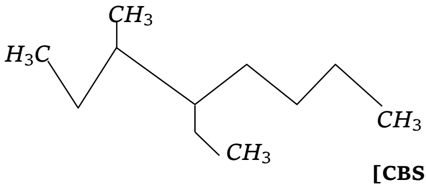
14. The IUPAC name of the compound is



[AIEEE 2004]

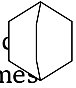
(a) 3, 3- dimethyl-1-cyclohexanol
(b) 1, 1-dimethyl-3-hydroxy cyclohexane
(c) 3, 3-dimethyl-1-hydroxy cyclohexane
(d) 1, 1-dimethyl-3-cyclohexanol

15. Name of the compound given below is



[CBSE PMT 2003]

(a) 5-ethyl-6-methyloctane
(b) 4-ethyl-3-methyloctane
(c) 3-methyl-4-ethyloctane
(d) 2, 3-diethylheptane

16. The compound  is known by which of the following names **[MP PET 1997]**

(a) Bicyclo-[2, 2, 2] octane (b)Bicyclo-[2, 2, 1] octane
(c) Bicyclo-[1, 2, 1] octane (d)Bicyclo-[1, 1, 1] octane

AR Assertion & Reason

For AIIMS Aspirants

Read the assertion and reason carefully to mark the correct option out of the options given below :

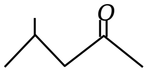
(a) If both assertion and reason are true and the reason is the correct explanation of the assertion.
(b) If both assertion and reason are true but reason is not the correct explanation of the assertion.
(c) If assertion is true but reason is false.
(d) If the assertion and reason both are false.
(e) If assertion is false but reason is true.

1. Assertion : A mixture of plant pigments can be separated by chromatography.
Reason : Chromatography is used for the separation of coloured substances into individual components.

2. Assertion : Moving phase is liquid and stationary phase is solid in paper chromatography.
Reason : Paper chromatography is used for analysis of polar organic compounds.

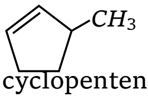
3. Assertion : During digestion with concentrated H_2SO_4, nitrogen of the organic compound is converted into $(NH_4)_2SO_4$.
Reason : $(NH_4)_2SO_4$ on heating with alkali liberates NH_3.

4. Assertion : Thiophene present in commercial benzene as an impurity can be removed by shaking the mixture with cold concentrated H_2SO_4.
Reason : Thiophene is a heterocyclic aromatic compound.

5. Assertion :  is 3-methyl butanoic acid.
Reason : In poly functional group, the substituent should be given lower number than the principal functional group.

6. Assertion : Refining of petroleum involves fractional distillation.
Reason : Fractional distillation involves repeated distillation.

7. Assertion : Potassium can be used in lassaigne test.
Reason : Potassium reacts vigorously.**[AIIMS 1997]**

8. Assertion :  is 3-methyl cyclopentene.

Reason : In numbering, double bonded carbon atoms gets preference to the alkyl group in cycloalkenes.

9. Assertion : During test for nitrogen with Lassaigne extract on adding $FeCl_3$ solution sometimes a red precipitate is obtained.

Reason : Sulphur is also present. **[AIIMS 2001]**

Answers

Chemical analysis of organic compounds

1	b	2	a	3	d	4	a	5	b
6	a	7	d	8	c	9	b	10	c
11	b	12	b	13	c	14	d	15	a
16	b	17	c	18	d	19	a	20	d
21	b	22	a	23	c	24	c	25	c
26	c	27	d	28	a	29	c	30	a
31	d	32	c	33	b	34	b	35	c
36	a	37	a	38	a	39	d	40	d
41	b	42	c	43	b	44	a	45	a
46	c	47	d	48	a	49	a	50	e
51	c	52	c	53	c	54	c	55	b
56	a	57	a	58	b	59	c	60	d
61	b	62	d	63	b	64	a	65	b
66	d	67	d	68	c	69	d	70	c
71	c	72	c	73	a	74	b	75	e
76	e								

Classification and nomenclature of organic compounds

1	b	2	b	3	d	4	a	5	b
6	a	7	c	8	b	9	d	10	b
11	c	12	a	13	b	14	b	15	b
16	d	17	b	18	c	19	c	20	c
21	c	22	c	23	b	24	c	25	b
26	b	27	a	28	a	29	b	30	a
31	b	32	b	33	b	34	d	35	b
36	d	37	a	38	c	39	b	40	b
41	a	42	a	43	c	44	c	45	d
46	a	47	b	48	b	49	a	50	a
51	a	52	c	53	a	54	b	55	d
56	a	57	b	58	b	59	c	60	d
61	b	62	c	63	b	64	a	65	a
66	b	67	d	68	a	69	c	70	a
71	d	72	c	73	c	74	d	75	a
76	c	77	a	78	d	79	a	80	c
81	b	82	a	83	b	84	b	85	a
86	c	87	a	88	c	89	a	90	a
91	d	92	c	93	d	94	a	95	b
96	c	97	e	98	c	99	b	100	d
101	a	102	b	103	d	104	c	105	c
106	a	107	c	108	a	109	b	110	a
111	b	112	d	113	c	114	c	115	d
116	b	117	a	118	d				

Critical Thinking Questions

1	c	2	b	3	c	4	d	5	e
6	b	7	b	8	a	9	d	10	d
11	a	12	b	13	a	14	a	15	b
16	a								

Assertion & Reason

1	b	2	e	3	b	4	b	5	c
6	b	7	e	8	a	9	a		

AS Answers and Solutions

Chemical analysis of organic compounds

3. (d)

Elements	No. of Moles	Simple ratio
C = 90%	90/12 = 7.5	7.5/7.5 = 1× 3 = 3
H = 10%	10/1 = 10	10/7.5 = 1.33 × 3 = 4

∴ Empirical formula = C_3H_4

4. (a)

Element	%	No. of Moles	Simple Ratio
C	36	36/12 = 3	3/3 = 1
H	6	6/1 = 6	6/3 = 2
O	58	58/16 = 3.62	3.62/3 = 1

Therefore, Empirical formula = CH_2O

5. (b) Empirical Formula = CH_2O

Empirical formula mass = 12 + 2 + 16 = 30

Mol. Mass = 2 × V.D. = 2 × 30 = 60

$$n = \frac{\text{Mol.mass}}{\text{Emperical mass}} = \frac{60}{30} = 2$$

Molecular formula = $(\text{Emperical formula})_n$

$= (CH_2O)_2 = C_2H_4O_2$.

6. (a)

Element	%	No. of Moles	Simple Ratio
C	48	48/12 = 4	1
H	8	8/1 = 8	2
N	56	56/14 = 4	1

Empirical formula = CH_2N

Empirical formula mass = 28

Now, 200 *ml* of compound = 1 *gm*

22400 *ml* of compound $\frac{1}{200} \times 22400 = 112$

$$n = \frac{\text{Mol. mass}}{\text{Emp formula mass}} = \frac{112}{28} = 4$$

Therefore, Molecular formula $= (CH_2N)_4 = C_4H_8N_4$.

7. (d) Minimum mass of sulphur = wt. of its one atom = 32

∵ 3.4 *gms* of sulphur present in 100 *gms*.

∴ 32 *gms* of sulphur present in $= \frac{100 \times 32}{3.4} = 940$

8. (c) Halogen is estimated by carius method.

9. (b) ∵ 1.8*gm* water obtained from 1.4*gm* hydrocarbon

∴ 18*gm* water obtained from – $\frac{1.4}{1.8} \times 18 = 14$ *gm*.

Empirical formula Mass = 14

∴ Empirical formula = CH_2.

10. (c) In carius method sulphur of organic compound is converted in to H_2SO_4

$$S + H_2O + 3O \xrightarrow[HNO_3]{\Delta} H_2SO_4$$

11. (b) % of chlorine = $\frac{35.5}{143.5} \times \frac{\text{Mass of } AgCl}{\text{Mass of substance}} \times 100$

$= \frac{35.5}{143.5} \times \frac{0.287}{0.099} \times 100 = 71.71\%$.

12. (b) % of C = $\frac{12}{44} \times \frac{\text{Mass of } CO_2}{\text{Mass of substance}} \times 100$

$= \frac{12 \times 0.22}{44 \times 0.24} \times 100$ = 25; C = 25, H = 1.66

Total = 26.6 = 100 – 26.6 = 73.4.

13. (c)

Element	No. of Moles	Simple Ratio
C = 74	74/12 = 6.1	6.1/1.2 = 5.08 or 5
H = 8.65	8.65/1= 8.65	8.6/1.2 = 7.16 or 7
N = 17.3	17.3/14 = 1.2	1.2/1.2 = 1 or 1

Therefore Empirical formula $= C_5H_7N$.

15. (a) Mol. mass of an acid = Equivalent wt. × basicity.

16. (b) If molecular formula is different than molecular weight is also different.

17. (c) Empirical formula mass = C_2H_5O = 24+ 5 +16= 45.

$$n = \frac{\text{Mol.mass}}{\text{Emp. mass}} = \frac{90}{45} = 2$$

Mol. formula = $(C_2H_5O)_2 = C_4H_{10}O_2$.

18. (d)

Element	No. of Moles	Simple Ratio
C = 24	24/12 = 2	1
H = 4	4/1 = 4	2
O = 32	32/16 = 2	1

Therefore CH_2O.

19. (a)

Element	No. of Moles	Simple Ratio
C = 38.8	38.8/12 = 3.2	1
H = 16	16/1 = 16	5
N = 45.2	45.2/14 = 3.2	1

Therefore, Empirical formula $= CH_5N$

20. (d) % of $N = \frac{1.4 \times V \times N}{W}$

where V = Volume of acid used

N = Normality of acid, W = Weight of substance

21. (b)

Element	No. of Moles	Simple Ratio
C = 54.5	54.5/12 = 4.54	2
H = 9.1	9.1/1 = 9.1	4
O = 36.4	36.4/16 = 2.27	1

Hence, C_2H_4O.

22. (a) Element No. of Moles Simple Ratio

C = 92.31	92.31/12 = 7.69	1
H = 7.69	7.69/1 = 7.69	1

Hence, CH

Empirical formula mass of CH = 13

$$n = \frac{\text{Mol.mass}}{\text{Emp. mass}} = \frac{78}{13} = 6$$

Molecular formula = $(CH)_6 = C_6H_6$.

23. (c)

Element	No. of Moles	Simple Ratio
C = 53.3	53.3/12 = 4.44	2
H = 15.6	15.6/1 = 15.6	7
N = 31.1	31.1/14 = 2.22	1

Hence, formula = $C_2H_7N \ (CH_3CH_2NH_2)$.

24. (c)

Element	No. of Moles	Simple Ratio
C = 80	80/12 = 6.66	1
H = 20	20/1 = 20	3

Hence formula = CH_3 or C_2H_6 .

25. (c)

Elements	Simple ratio
$C = 50$	$50/12 = 4$
$O = 50$	$50/16 = 3$

Empirical formula = C_4O_3

Empirical formula mass = 96

$$n = \frac{290}{96} = 3$$

Molecular formula = $(C_4O_3)_3 = C_{12}O_9$.

26. (c)

Element	No. of moles	Simple ratio
C = 83.7%	83.7/12 = 6.9	6.9/6.9 = 1 × 3 = 3
H = 16.3%	16.3/1 = 16.3	16.3/0.9 = 2.3 × 3 = 7

Empirical formula = C_3H_7 .

27. (d)

Elements		No. of moles	Simple ratio
C	60%	60/12 = 5	3.01
H	13.3%	13.3/1 = 13.3	8.01
O	26.7%	26.7/16 = 1.66	1

Empirical formula = C_3H_8O .

28. (a)

Element		No. of moles	Simple ratio
C	85.72%	85.72/12	7.14 = 1
H	14.18%	14.18/1	14.18 = 2

Empirical formula = C_2H_4 .

29. (c)

Elements		No. of moles	Simple ratio
C	(24 *gm*)	24/12 = 2	1
H	(8 *gm*)	8/1 = 8	4
O	(32 *gm*)	32/16 = 2	1

Empirical formula = CH_4O

30. (a)

Elements		No. of moles	Simple ratio
C	6	6/12 = 0.5 = 1	1
H	1	1/1 = 1 = 2	2
O	8	8/16 = 0.5 = 1	1

Thus, Empirical formula = CH_2O

Empirical formula mass = 30

Mol. mass = 2 × V.D. = 2 × 30 = 60

$$n = \frac{60}{30} = 2$$

Mol. formula = $(CH_2O)_2 = C_2H_4O_2$.

31. (d) Molecular mass = $2 \times V.D. = 2 \times 37 = 74$.

32. (c)

Elements	No.of moles	Simple ratio
C = 80%	80/12 = 6.66	1
H = 20%	20/1 = 20	3

Hence, Empirical Formula = CH_3 .

33. (b)

Elements	No. of moles		Simple ratio
C = 40%	40/12	3.33	1
H = 6.7%	6.7/1	6.7	2
O = 53.3%	5.33/16	3.33	1

Thus, Empirical formula = CH_2O .

34. (b) $n = \dfrac{\text{Molecular mass}}{\text{Emperical mass}}$

35. (c)

Element	No. of moles	Simple ratio	
C = 40%	40/12	3.33	1
H = 13.33%	13.33/1	13.33	4
N = 46.67%	46.67/14	3.33	1

Thus formula CH_4N .

36. (a)

Elements	No. of moles	Simple ratio	
C = 18.5%	18.5/12	⇒1.54	1
H = 1.55%	1.55/1	⇒1.55	1
Cl = 55.04%	55.04/35.5	⇒1.55	1
O = 24.81%	24.81/16	⇒1.55	1

Hence, formula = $CHClO$.

38. (a) $\% \text{ of S} = \dfrac{32}{233} \times \dfrac{\text{wt. of } BaSO_4}{\text{wt. of organic compound}} \times 100$

$$= \frac{32}{233} \times \frac{0.35}{0.2595} \times 100 = 18.52\% \ gm$$.

39. (d) Kjeldahl's method depends upon the fact that most of the organic compounds containing nitrogen are quantitatively decomposed to give $(NH_4)_2SO_4$ when heated strongly with conc. H_2SO_4. In this method $CuSO_4$ acts as catalytic agent.

40. (d) Nitrates on reaction with conc. H_2SO_4 and $FeSO_4$ give a brown ring due to formation of $FeSO_4.NO$ or $[Fe(H_2O)_5NO]SO_4$.

41. (b) Molecular of weight of $CHCl_3$ is 120

42. (c) Urea (NH_2CONH_2) has molecular wt. 60 and wt. of Nitrogen is 28

In 60 *gm* of urea nitrogen present = 28 *gm*

In 100 *gm* of urea nitrogen present $=\frac{2800}{60}=46.66\%$

44. (a) Anhydrous $CuSO_4$ is used to test presence of water in any liquid because it changes its colour white to blue.

48. (a) Molecular weight of $C_3H_6O_3$ is 90.

49. (a) Molecular weight = V.D. × 2 = 23 × 2 = 46

Molecular weight of $C_2H_6O=46$

52. (c) Molecular weight of $C_4H_8O_4$ is 120.

53. (c) Molecular mass

$$=\frac{\text{wt. of organic substance taken}}{\text{air displaced } at \text{ STP}}\times 22400$$

$$=\frac{0.2}{56}\times 22400 = 80\ .$$

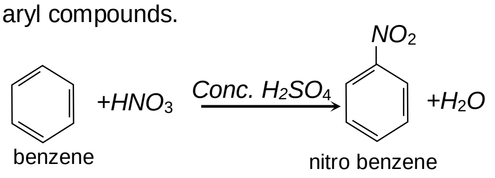
57. (a) Liquid ammonia is used as a coolant in ice factories and cold storages.

58. (b) Chromatography is the latest technique for the purification of organic compounds. Chromatography are of various type viz. Column chromatography, gas chromatography, paper chromatography etc.

59. (c) Halogens are detected by Beilstein's test. In this test, a copper wire is dipped in original solution and heated in a bunsen burner flame. Green colour is imparted to the flame, due to the formation of a volatile copper halide. This proves the presence of halogen.

60. (d) *o*-nitro phenol has intra molecular hydrogen bonding, while *p*-nitrophenol has intermolecular hydrogen bonding (comparitively stronger). Due to this reason, the boiling point of *o*-nitrophenol is found quite less than that of *p*-nitrophenol. Hence, *o*-nitrophenol is steam volatile and can be separated from *p*-nitrophenol by steam distillation.

61. (b) The mixture of conc. H_2SO_4 and conc. HNO_3 is called nitrating mixture. It is used in the nitration of aryl compounds.



62. (d) Kjeldahl's and Duma's methods are used for the quantitative estimation of nitrogen in an organic compound. In the Kjeldahl method, the nitrogen element of organic compound is changed to the ammonia.

63. (b) Homolytic fission is favoured by sunlight. In it, each bonded atom takes away its shared electrons and thus free radicals are produced.

64. (a) Equivalent of NH_3 evolved

$$=\frac{100\times 0.1\times 2}{1000}-\frac{20\times 0.5}{1000}=\frac{1}{100}$$

percent of nitrogen in the unknown organic compound

$$=\frac{1}{100}\times\frac{14}{0.3}\times 100=46.6\ \%$$

percent of nitrogen in urea $(NH_2)_2CO$

$$=\frac{14\times 2}{60}\times 100=46.6\ \%$$

∴ The compound must be urea.

65. (b) Mixture of benzoic acid and naphthalene can be separated from hot water in which benzoic acid dissolves but naphthalene does not.

66. (d) Empirical formula weight C_2H_4O

$=(12\times 2+4+16)=44$

Molecular formula $=\frac{\text{mol. wt}}{\text{eq. formula wt.}}\times$ Emp. Formula

$$=\frac{132.1}{44}\times\text{Emperical formula}$$

$$=3\times C_2H_4O=C_6H_{12}O_3$$

67. (d) Mol. wt = 2 × Vap. Density

$=2\times 45=90$

Empirical formula weight

$=12+2+16=30$

$$\therefore\ n=\frac{\text{mol. wt.}}{\text{empirical formula wt.}}$$

$$=\frac{90}{30}=3$$

∴ Molecular formula of the compounds

$=(CH_2O)_3=C_3H_6O_3$

69. (d) CH_3COOH and $C_6H_{12}O_6$ both have same percentage of carbon *i.e.* 40%.

72. (c) Distillation particularly fractional distillation because the boiling point of benzene (80^oC) and chloroform (61.5^oC) are close.

Fractional distillation involves repeated distillations and condensations, in a fractionating column. As a result of distillation and condensation at each point of the fractionating column, the vapours rising up become richer in more volatile component and the liquid falling back into the flask becomes richer in less volatile component. Thus, the low boiling liquid distils first while the higher boiling liquid distils afterwards.

73. (a) Chemical method using $NaHCO_3$ solution.

75. (e) $C_2H_5Cl\xrightarrow{-HCl}C_2H_4$

64.5 28

32.25 28

64.5 *gm* C_2H_5Cl gives 28 *gm* of C_2H_4

32.25 *gm* C_2H_5Cl gives $=\frac{28\times 32.25}{64.5}$

= 14 *gm* of C_2H_4

Obtained product is 50% so mass of obtained alkene

$$= \frac{14}{2} = 7\ gm$$

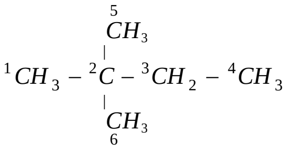
76. (e) Percentage of sulphur

$$= \frac{32}{233} \times \frac{\text{mass of } BaSO_4}{\text{mass of organic compound}} \times 100$$

$$= \frac{32}{233} \times \frac{1.158}{0.53} \times 100 = 30\%$$

Classification and nomenclature of organic compounds

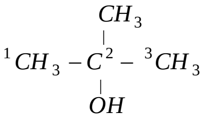
26. (b)



$${}^1CH_3 - {}^2\overset{\overset{5}{CH_3}}{\underset{\underset{6}{CH_3}}{C}} - {}^3CH_2 - {}^4CH_3$$

$C-2$ is quaternary carbon because it is attached to 4 other carbon atoms.

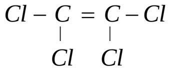
36. (d) Tertiary butyl alcohol;



$${}^1CH_3 - \overset{CH_3}{\underset{OH}{C^2}} - {}^3CH_3$$

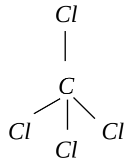
2-Methyl propan-2-ol

41. (a) $120°$ and $109.5°$



$$Cl - \underset{Cl}{C} = \underset{Cl}{C} - Cl$$

sp^2-hybridization
Bond angle $= 120^o$

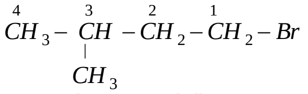


sp^3-hybridization
Bond angle $= 109.5^o$

42. (a) $\overset{1}{COOH} - \overset{2}{CH_2} - \overset{3}{CH_2} - \overset{4}{COOH}$

1,4–butandioic acid

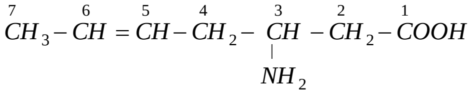
43. (c)



$$\overset{4}{CH_3} - \underset{CH_3}{\overset{3}{CH}} - \overset{2}{CH_2} - \overset{1}{CH_2} - Br$$

1–bromo–3–methylbutane

44. (c)



$$\overset{7}{CH_3} - \overset{6}{CH} = \overset{5}{CH} - \overset{4}{CH_2} - \underset{NH_2}{\overset{3}{CH}} - \overset{2}{CH_2} - \overset{1}{COOH}$$

3–amino-5-heptenoic acid

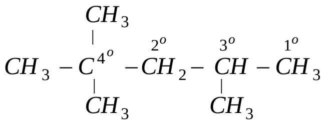
45. (d) $CH_2 = CH - CH_2 - Cl$

(3–chloro-1-propene)

52. (c) $\underset{4}{CH_3} - \underset{3}{CH} = \underset{2}{CH} - \underset{1}{CHO}$

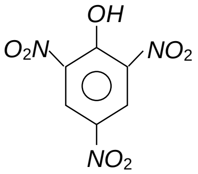
But-2-en-1-ol

72. (c)



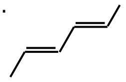
$$CH_3 - \overset{CH_3}{\underset{CH_3}{C^{4^o}}} - \overset{2^o}{CH_2} - \overset{3^o}{\underset{CH_3}{CH}} - \overset{1^o}{CH_3}$$

85. (a)



2, 4, 6-trinitrophenol (picric acid)

97. (e) If atom or group of higher priority are on opposite direction at the double bond of each carbon atom then the configuration is known as E and if they are in same direction then the configuration is known as Z configuration.



(2E, 4E) –2, 4-Hexa di ene

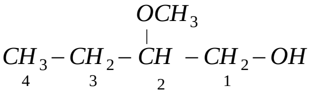
99. (b)

$$HOOC - CH_2 - \underset{COOH}{CH} - CH_2 - CH_2 - COOH$$

3 carboxy hexane -1, 6 dioic acid

100. (d) Ethyl should come before methyl.

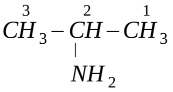
101. (a)



$$\underset{4}{CH_3} - \underset{3}{CH_2} - \overset{OCH_3}{\underset{2}{CH}} - \underset{1}{CH_2} - OH$$

2 methoxy 1-butanol or 2-meth

102. (b)



$$\overset{3}{CH_3} - \overset{2}{\underset{NH_2}{CH}} - \overset{1}{CH_3}$$

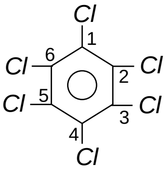
2-amino propane

103. (d) Propyne have the structure $CH_3 - C \equiv CH$.

It consist 2 primary carbon (a carbon to which single carbon is bonded) and one secondary carbon. Its structure show that it contain only primary hydrogen.

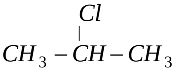
104. (c) $Fe_4[Fe(CN)_6]_3$ compound formed in the positive test for nitrogen with the lassaigne solution of an organic compounds.

105. (c)



1,2,3,4,5,6 hexachlorobenzene.

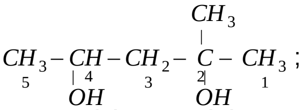
106. (a)



$$CH_3 - \overset{Cl}{CH} - CH_3$$

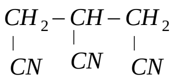
2 chloropropane

107. (c)



$$\underset{5}{CH_3} - \underset{OH}{\overset{}{CH}}_{4} - \underset{3}{CH_2} - \overset{CH_3}{\underset{OH}{C}}_{2} - \underset{1}{CH_3};$$

2 methyl 2,4-pentanedio l



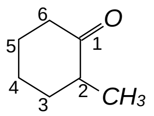
$$\underset{CN}{CH_2} - \underset{CN}{CH} - \underset{CN}{CH_2}$$

1, 2, 3 tricyanopropane

108. (a) $\underset{4}{CH_3} - \underset{3}{CH_2} - \underset{2}{C(Br)} = \underset{1}{CH} - Cl$

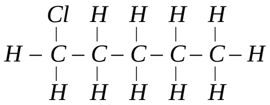
2-bromo 1-chloro butene

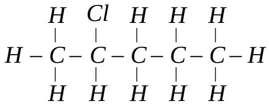
109. (b)

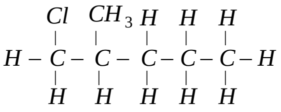


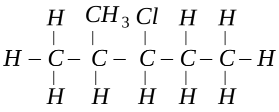
2 methyl cyclohexanone

110. (a) To be optically active the compound or structure should possess chiral or a symmetric centre but in the rest of the structures it is present.

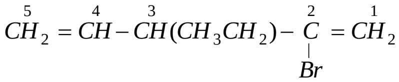

1 chloropentane


2 chloropentane


1 chloro -2 methyl pentane


3 chloro 2 methyl pentane

111. (b)



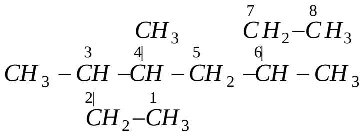
$$\overset{5}{CH_2}=\overset{4}{CH}-\overset{3}{CH}(CH_3CH_2)-\underset{Br}{\overset{2}{C}}=\overset{1}{CH_2}$$

2 bromo-3-ethyl-1, 4 pentadie ne

112. (d) $\underset{3}{CH_3}\,\underset{2}{CH_2}\,\overset{1}{COOH}$

Propanoic acid

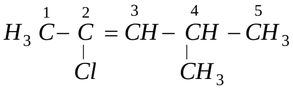
116. (b)



$$CH_3-\overset{3}{CH}-\overset{CH_3}{\overset{4}{CH}}-\overset{5}{CH_2}-\overset{\overset{7}{C}H_2-\overset{8}{C}H_3}{\overset{6}{CH}}-CH_3$$
$$\quad\;\; {}^{2}|\;\; {}^{1}$$
$$CH_2-CH_3$$

3,4 6-Trimethyloctane

117. (a)



$$\overset{1}{H_3C}-\underset{Cl}{\overset{2}{C}}=\overset{3}{CH}-\underset{CH_3}{\overset{4}{CH}}-\overset{5}{CH_3}$$

2-chloro-4-methyl-2-pentene

118. (d) $\overset{1}{CH_3}-\overset{2}{CO}-\overset{3}{CH_3}$

Ketones are named by adding the suffix '-one' in place of '–e' of alkane. Thus IUPAC name is propanone.

Critical Thinking Questions

1. (c) $116\,mg$ compounds means $116\times10^{-3}\,gm$ compound since $1mg$ contain $10^{-3}\,gm$

Mol. wt. of compound

$$=\frac{\text{mass of the substance}}{\text{volume of the vapour at S.T.P.}}\times22400$$

$$=\frac{116\times10^{-3}}{44.8}\times22400$$ =57.99% or 58.0%

2. (b)

Element.		No. of moles	Simple ratio
C	12	49.3/12 = 4.1	4.1/2.7 = 1.3 × 2 = 2.6 = 3
H	1	6.84/1= 6.84	6.84/2.7=2.5×2=5
O	16	43.86/16 = 2.7	2.7/2.7=1×2=2

Empirical formula = $C_3H_5O_2$

E.F. wt. = 12 × 3 + 1 × 5 + 16 ×2 = 73

Molecular wt = V.D. × 2 = 73 × 2 = 146

$$n=\frac{M.wt}{E.F.wt}=\frac{146}{73}=2$$

Molecular formula = (E.F)$_n$ $=(C_3H_5O_2)_2=C_6H_{10}O_4$.

3. (c) Mass of silver salt taken = 0.228 *gm*

Mass of silver left = 0.162 *gm*

Basicity of acid = 2

Step 1– To calculate the equivalent mass of the silver salt (E)

$$\frac{\text{Eq. mass of silver salt}}{\text{Eq. mass of silver}}=\frac{\text{Mass of Acid taken}}{\text{Mass of silver left}}$$

$$=\frac{E}{108}=\frac{0.228}{0.162}$$

$$=E=\frac{0.228}{0.162}\times108=152\,\text{(Eq. mass of silver salt)}$$

Step 2 – To calculate the eq. mass of acid.

Eq. mass of acid =

Eq. mass of silver salt – Eq. mass of *Ag* + Basicity

= 152 – 108 + 1 = 152 – 109 = 43 (Eq. mass of acid)

Step 3– To determine the molecular mass of acid.

Mol. mass of the acid = Eq. mass of acid × basicity = 45 × 2 = 90.

4. (d) $\because$ 0.0833 mole carbohydrate has hydrogen = $1g$

$\therefore$ 1 mole carbohydrate has hydrogen

$$=\frac{1}{0.0833}=12g$$

Empirical Formula (CH_2O) has hydrogen $=2g$

Hence $n=\frac{12}{2}=6$

Hence molecular formula of carbohydrate $=(CH_2O)_6$

$$=C_6H_{12}O_6$$

5. (e) Solution contain $He+CH_4$

Their mol. wt = $4+16=20$

% wt of CH_4 $=\frac{\text{wt of } CH_4}{\text{Total wt}}\times100=\frac{16}{20}\times100=80.0\%$

6. (b) % of *H* $=\frac{2}{18}\times\frac{\text{wt.of } H_2O}{\text{wt.of organic compound}}\times100$

$$=\frac{2}{18}\times\frac{0.9}{0.5}\times100=20\,\%$$

Since percentage of hydrogen is 20. Therefore, remaining is carbon *i.e.* 80 %.

7. (b) Some compound like hydrazine (NH_2NH_2) although contain nitrogen, they do not respond lassaigne's test because they do not have any carbon & hence $NaCN$ is not formed.

8. (a) Due to its volatile nature camphor is often used in molecular mass determination.

9. (d) In Kjeldahl's method, the nitrogen is estimated in the form of ammonia, which is obtained by heating compounds with $NaOH$.

$$CH_3CONH_2 + NaOH \xrightarrow{\Delta} CH_3COONa + H_2O + NH_3$$

10. (d) Mol. wt of C_2H_5OH

$= 2 \times 12 + 5 + 16 + 1 = 64$

$\because$ $48 g\, C_2H_5OH$ has H atom $= 6 \times N_A$

$\therefore$ $0.046 g\ C_2H_5OH$ has H atoms

$$= \frac{6 \times 6.02 \times 10^{23} \times 0.046}{46} = 3.6 \times 10^{21}$$

11. (a) $C = 10.5\ gm = \frac{10.5}{12} mol = 0.87\ mol$

$H = 1\ gm = \frac{1}{1} = 1\ mol$

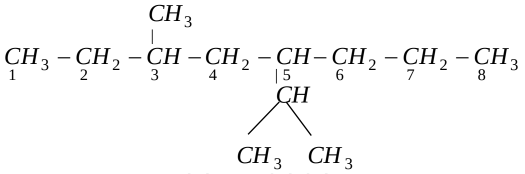
$\therefore (C_{0.87}H_1)_7 = C_{6.09}H_7 \approx C_6H_7$

$PV = nRT$; $PV = \frac{w}{m}RT$

$1 \times 1 = \frac{2.4}{m} \times 0.082 \times 400$

$m = 2.4 \times 0.082 \times 400 = 78.42 \approx 79$.

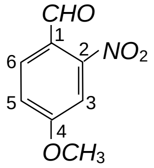
12. (b)



$$\underset{1}{CH_3} - \underset{2}{CH_2} - \underset{3}{\overset{CH_3}{\overset{|}{CH}}} - \underset{4}{CH_2} - \underset{5}{CH(CH(CH_3)_2)} - \underset{6}{CH_2} - \underset{7}{CH_2} - \underset{8}{CH_3}$$

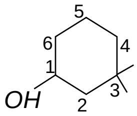
3, methyl-5 (1 methylethyl)octane

13. (a)



4, methoxy-2 nitrobenzaldehyde

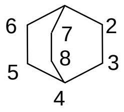
14. (a)



3, 3 dimethyl -1-cyclohexanol

15. (b) 4 ethyl, 3 methyl octane.

16. (a)



Bicyclo (2, 2, 2) octane.

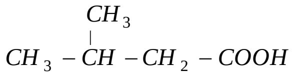
Assertion and Reason

1. (b) Chromatography is used to separate almost any given mixture. Whether coloured or colourless into its constituents and to test the purites of these constituents.

2. (e) Paper chromatography is a liquid-liquid partition chromatography in which the water is adsorbed or chemically bond to cellulose of paper which acts as the stationary phase while the mobile phase is another liquid which is usually a mixture of two or three solvents in which water is one of the components.

4. (b) On shaking with concentrated H_2SO_4 thiophene being more reactive undergoes sulphonation and the thiophene-2-sulphonic acid thus formed dissolves in concentrated H_2SO_4

5. (c) As, the functional group is $-COOH$, the numbering is done from RHS to give minimum number to carbon atom bearing the functional group. Rewriting the above structure



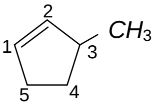
$CH_3 - \overset{CH_3}{\overset{|}{CH}} - CH_2 - COOH$. The chain consists of four carbon atoms. Hence it's a derivative of butane. The substituent is the methyl group. So the above compound is 3-methyl butanoic acid.

6. (b) Petroleum can be refined by fractional distillation since it separate crude petroleum into useful fractions such as gasoline, kerosine oil, disel oil, lubricating oil etc.,

7. (e) In lassaigne test potassium can not be used in place of sodium as potassium reacts vigorously and its use causes explosion.

8. (a) In naming cycloalkenes, number the ring to give the double bonded carbons 1 and 2 and choose the direction of numbering so that the substituents get the lowest numbers. The position of the double bond is not indicated because it is known to bond between *C*-1 and *C*-2 .

So,



is

cyclopentene

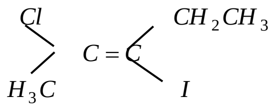
9. (a) On adding $FeCl_3$ solution to sodium extract during testing for nitrogen a red precipitate is obtained. It is due to the presence of sulphur also.

$$3NaCNS + FeCl_3 \longrightarrow \underset{\text{Red colour}}{Fe(CNS)_3} + 3NaCl$$

Purification, Classification and Nomenclature of Organic compounds

SET Self Evaluation Test -22

1. IUPAC name for the compound



[CBSE PMT 1998]

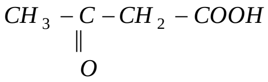
(a) *trans* 3 iodo, 4-chloro, 3-pentene

(b) *cis* 3 chloro, 3-iodo, 2-pentene

(c) *trans* 2 chloro, 3-iodo, 2-pentene

(d) *cis* 3 iodo, 4-chloro, 3-pentene

2. The IUPAC name of the following structure is



$CH_3-\underset{\underset{O}{\|}}{C}-CH_2-COOH$ **[RPMT 1997]**

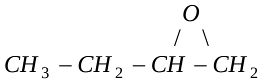
(a) 3-ketobutanoic acid

(b) 2-ketobutanoic acid

(c) 4-ketobutanoic acid

(d) 3-oxopropanoic acid

3. IUPAC name of the following compound



is **[UPSEAT 2001]**

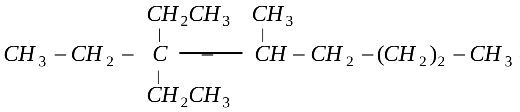
(a) 1, 2-epoxy butane

(b) Ethyl methyl ether

(c) Keto pentanone

(d) None of these

4. The IUPAC name of



$CH_3-CH_2-\underset{CH_2CH_3}{\overset{CH_2CH_3}{C}}-\overset{CH_3}{CH}-CH_2-(CH_2)_2-CH_3$ is

[CPMT 2000]

(a) 2, 2-diethyl-5-methyldecane

(b) 3, 3-ethyl-5-methyldecane

(c) 3, 3-diethyl-5-methylhexane

(d) 3,3-diethyl-4-methyl octane

5. The emperical formula of compound is CH_2O. If its molecular weight is 180. The molecular formula of the compound is

[AIIMS 1999; CPMT 1999; AFMC 1999; BHU 1999]

(a) $C_3H_6O_3$ (b) $C_4H_8O_4$

(c) $C_6H_{12}O_6$ (d) $C_5H_{10}O_5$

6. Accurate determination of atomic masses is done with the instrument called as **[Kerala (Med.) 2002]**

(a) Spectrophotometer

(b) Mass spectrometer

(c) Atomic absorption spectrometer

(d) Calorimeter

7. In a compound *C*, *H* and *N* atoms are present in 9 : 1 : 35 by weight. Molecular weight of compound is 108. Molecular formula of compound is**[AIEEE 2002]**

(a) $C_2H_6N_2$ (b) C_3H_4N

(c) $C_6H_8N_2$ (d) $C_9H_{12}N_3$

8. An alkane has a *C*/*H*-ratio (by mass) of 5.1428. Its molecular formula is **[KCET (Engg./Med.) 1999]**

(a) C_5H_{12} (b) C_6H_{14}

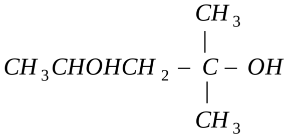
(c) C_8H_{18} (d) C_7H_{10}

9. 58 *ml* of $\frac{N}{5}H_2SO_4$ are used to neutralize ammonia given by 1 *g* of organic compound. Percentage of nitrogen in the compound is

(a) 34.3 (b) 82.7

(c) 16.2 (d) 21.6

10. The IUPAC name for



$CH_3CHOHCH_2-\underset{CH_3}{\overset{CH_3}{C}}-OH$ is

[AIIMS 1992; MNR 1992; JIPMER 1997]

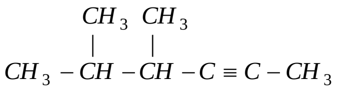
(a) 1, 1-dimethyl-1, 3-butanediol

(b) 2-methyl-2, 4-pentanediol

(c) 4-methyl-2, 4-pentanediol

(d) 1, 3, 3-trimethyl-1, 3-propanediol

11. Choose the correct IUPAC name of the compound



$CH_3-\overset{CH_3}{CH}-\overset{CH_3}{CH}-C\equiv C-CH_3$

(a) 2, 3-dimethyl-4-hexyne

(b) 4,5-dimethyl-2-hexyne

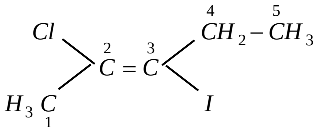
(c) 5-propyl-2-pentyne

(d) 2-propyl-3-pentyne

Answers and Solutions

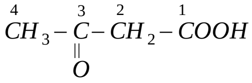
(SET -22)

1. (c)



Trans 2-chloro, 3-iodo, 2-pentene

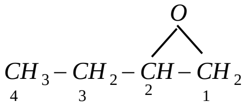
2. (a)



$\overset{4}{C}H_3-\overset{3}{\underset{\underset{O}{\|}}{C}}-\overset{2}{C}H_2-\overset{1}{C}OOH$

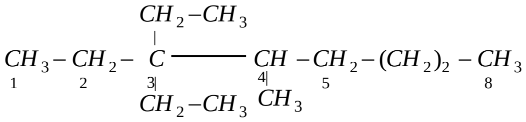
3-keto butanoic acid

3. (a)



1, 2 epoxy butane

4. (d)



$\underset{1}{CH_3}-\underset{2}{CH_2}-\overset{CH_2-CH_3}{\overset{|}{\underset{\underset{CH_2-CH_3}{3|}}{C}}}-\underset{\underset{CH_3}{4|}}{CH}-\underset{5}{CH_2}-(CH_2)_2-\underset{8}{CH_3}$

3, 3 di ethyl –4-methyl octane.

5. (c) Molecular formula = (Emperical formula)$_n$

$n=\frac{\text{Molecular weight}}{\text{Emperical formula wt.}}=\frac{180}{30}=6$

$=(CH_2O)_6=C_6H_{12}O_6$

6. (b) Atomic masses, determined by the mass spectrometer.

7. (c) Molecular weight of compound = 108

$C^{12}\rightarrow 12\times 6=72$

$H^{1}\rightarrow 1\times 8=8$

$N^{14}\rightarrow 14\times 2=28$

Total molecular weight = 108

∴ Molecualr formula $=C_6H_8N_2$

8. (b) The ratio of C/H in an alkane is 5.1428.

Alkanes have General formula C_nH_{2n+2}

The mass ratio of $\frac{C}{H}$ is $\frac{12n}{2n+2}$ or $\frac{6n}{n+1}$

$\frac{6n}{n+1}=5.1428$

$6n = 5.1428n + 5.1428 = 0.8572n + 5.1428$

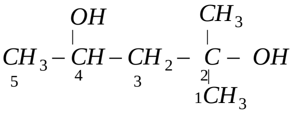
$n=\frac{5.1428}{0.8572}=6$

molecular formula $=C_6H_{2n+2}=C_6H_{14}$.

9. (c) % of $N=\frac{1.4\times\text{Normality of acid}\times\text{Volume of acid}}{\text{Mass of substance}}$

$=\frac{1.4\times 1\times 58}{1\times 5}=16.2$.

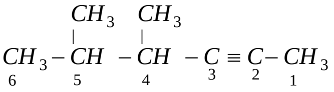
10. (b)



$\underset{5}{CH_3}-\overset{OH}{\overset{|}{\underset{4}{CH}}}-\underset{3}{CH_2}-\overset{CH_3}{\overset{|}{\underset{\underset{_1CH_3}{2|}}{C}}}-OH$

2-methyl –2, 4 – pentane diol

11. (b)



$\underset{6}{CH_3}-\overset{CH_3}{\overset{|}{\underset{5}{CH}}}-\overset{CH_3}{\overset{|}{\underset{4}{CH}}}-\underset{3}{C}\equiv\underset{2}{C}-\underset{1}{CH_3}$

4, 5-di methyl –2-hexyne

***