# NEET | JEE ESSENTIALS

Class XI

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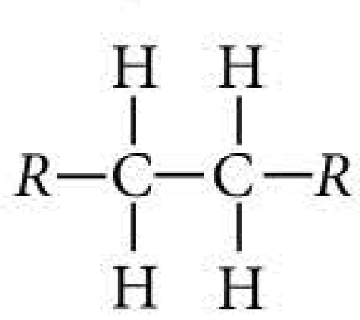
## Unit 7 ORGANIC CHEMISTRY – SOME BASIC PRINCIPLES AND TECHNIQUES

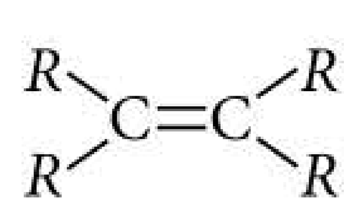
Organic chemistry deals with the study of hydrocarbons and their derivatives.

### Functional Groups in Organic Chemistry

- Functional groups are groups of atoms in organic compounds that are responsible for the characteristic chemical reactions of those compounds.



**Alkane**
Naming : -ane
*e.g.*, ethane



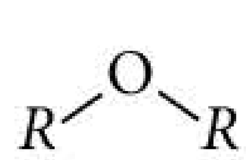
**Alkene**
Naming : -ene
*e.g.*, ethene

$R-C\equiv C-R$

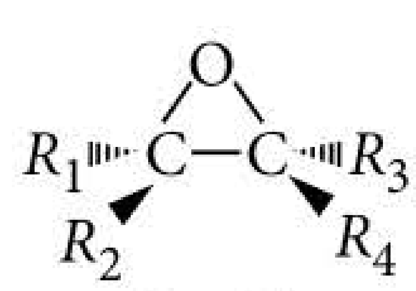
**Alkyne**
Naming : -yne
*e.g.*, ethyne

$R-OH$

**Alcohol**
Naming : -ol
*e.g.*, ethanol



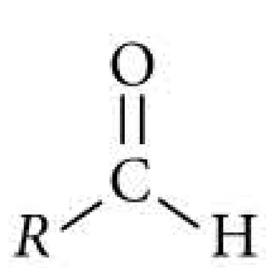
**Ether**
Naming : -oxy -ane
*e.g.*, methoxyethane



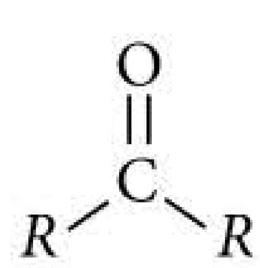
**Epoxide**
Naming : -ene oxide
*e.g.*, ethene oxide

$R-X$

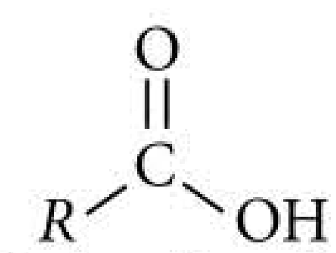
**Haloalkane**
Naming : halo-
*e.g.*, chloroethane



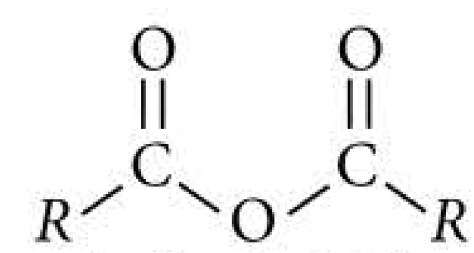
**Aldehyde**
Naming : -al
*e.g.*, ethanal



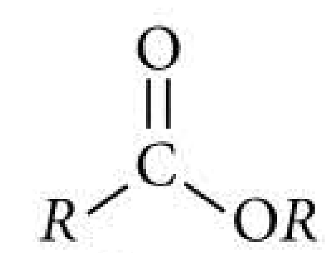
**Ketone**
Naming : -one
*e.g.*, propanone



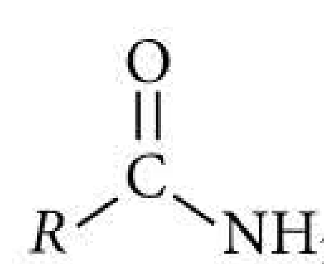
**Carboxylic acid**
Naming : -oic acid
*e.g.*, ethanoic acid



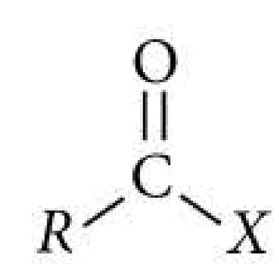
**Acid anhydride**
Naming : -oic anhydride
*e.g.*, ethanoic anhydride



**Ester**
Naming : -yl -oate
*e.g.*, ethyl ethanoate



**Amide**
Naming : -amide
*e.g.*, ethanamide



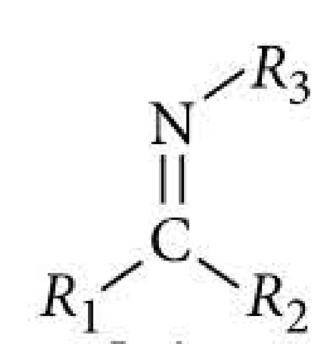
**Acyl halide**
Naming : -oyl halide
*e.g.*, ethanoyl chloride

$R-NH_2$

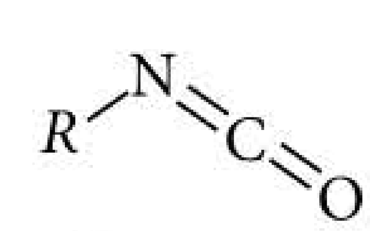
**Amine**
Naming : -amine
*e.g.*, ethanamine

$R-C\equiv N$

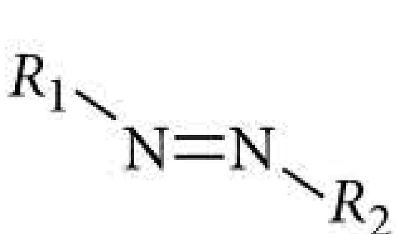
**Nitrile**
Naming : -nitrile
*e.g.*, ethanenitrile



**Imine**
Naming : -imine
*e.g.*, ethanimine



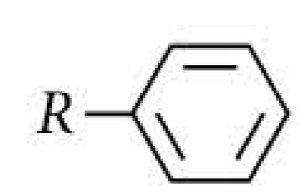
**Isocyanate**
Naming : -yl isocyanate
*e.g.*, ethyl isocyanate



**Azo compound**
Naming : azo-
*e.g.*, azoethane

$R-SH$

**Thiol**
Naming : -thiol
*e.g.*, methanethiol



**Arene**
Naming : -yl benzene
*e.g.*, ethyl benzene

Naming of all these organic compounds can be done by using IUPAC Nomenclature System.

## IUPAC Nomenclature

IUPAC Name : 2° prefix + 1° prefix + root word + 1° suffix + 2° suffix

**Root word**

The root word indicates the number of carbon atoms in the parent chain.

For $C_1$-meth, $C_2$-eth, $C_3$-prop(*a*), $C_4$-but(*a*), $C_5$-pent(*a*), $C_6$-hex(*a*), $C_7$-hept(*a*), $C_8$-oct(*a*), $C_9$-non(*a*), $C_{10}$-dec(*a*), $C_{11}$-undec(*a*), $C_{12}$-dodec(*a*).

Extra '*a*' is added to root word if 1° suffix begins with a consonant. In general, the root word for any carbon chain is alk.

**Suffix**

A suffix designates the functional groups present in the compound. The suffix is again divided into primary and secondary.

**Prefix**

The parts of the name that precede the root word are called prefixes. The prefix is again divided into primary and secondary.

**Primary suffix**

- Primary suffix indicates the degree of saturation or unsaturation in the parent chain and is added immediately after the root word.
- Root word + Primary suffix → saturated or unsaturated carbon chain.
  - Single bonds only — ane, *e.g.*, $CH_3CH_2CH_3$, root word – prop primary suffix – ane
- 1(=) bond, – ene *e.g.*, $CH_3—CH=CH—CH_3$, root word : but primary suffix : -ene 2(=) bonds, – diene 3(=) bonds, – triene
- 1 (≡) bond, – yne *e.g.*, $CH≡C—CH_2—CH_3$, root word : but primary suffix : -yne 2(≡) bonds, – diyne

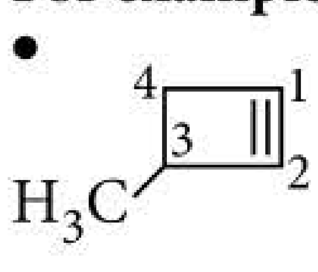
**Secondary suffix**

- A secondary suffix indicates the functional group present in the carbon compound.
- Functional group, —OH(-ol), —CHO(-al), >CO(-one), —COOH(-oic acid), $—CONH_2$ (-amide), —COCl (-oyl chloride), —COO*R* (oate), —CN (nitrile), —SH (thiol), $—NH_2$ (amine), $—SO_3H$ (sulphonic acid).
- If 2° suffix begins with a vowel, the terminal '*e*' is dropped otherwise it is retained.

**Primary prefix**

A primary prefix is used to differentiate acyclic and cyclic compounds. But the rules for using these are slightly different. *e.g.*, in cyclic compounds, the prefix cyclo is added before the root word.

**For example :**

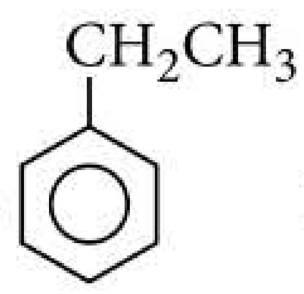
- 
  3-Methylcyclobutyne
- $CH_3-CH(Br)-CH_2COOH$
  3-Bromobutanoic acid

**Secondary prefix**

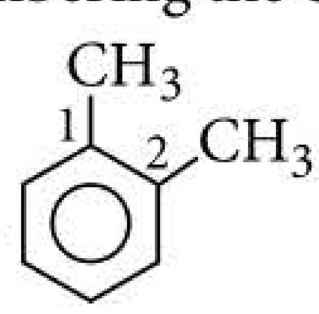
- Some functional groups are always treated as substituents whether organic compound is mono or polyfunctional *e.g.*, Fluoro (—F), Chloro (—Cl), Bromo (—Br), Iodo (—I), Nitro ($—NO_2$), Nitroso (—NO), Diazo ($—\overset{+}{N}≡N$), Alkoxy (—O*R*), Alkyl (—*R*), Phenyl ($—C_6H_5$), etc.
- When functional groups act as substituents in the presence of other principal functional group *e.g.*, Hydroxyl (—OH), Formyl (—CHO), Oxo or Keto (>CO), Cyano (—CN), Carboxy (—COOH), Alkoxycarbonyl (—COO*R*), Halocarbonyl (—CO*X*), Amino ($—NH_2$), Carbamoyl ($—CONH_2$), Sulpho ($—SO_3H$)

## IUPAC Nomenclature of Benzene Derivatives

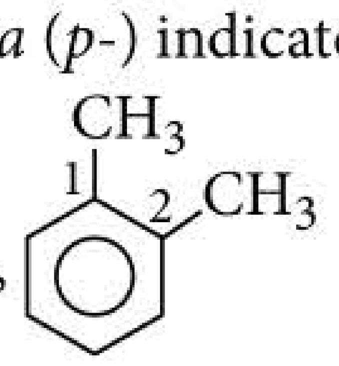
- For substituted benzene derivatives, the substituent is placed as prefix to the word benzene.

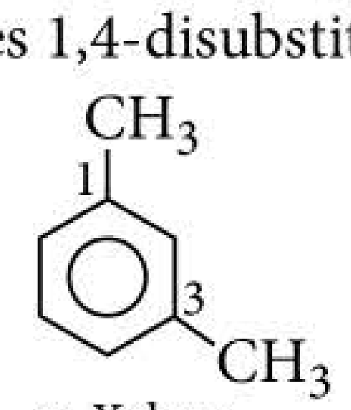
*e.g.*,  Ethyl benzene

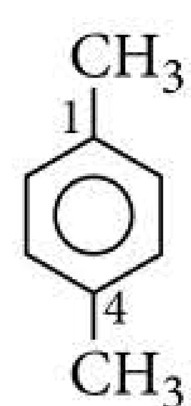
- In disubstituted benzene ring, the substituents are located at the lowest possible numbers while numbering the carbon atoms of the ring.

*e.g.*,  1,2-Dimethyl benzene

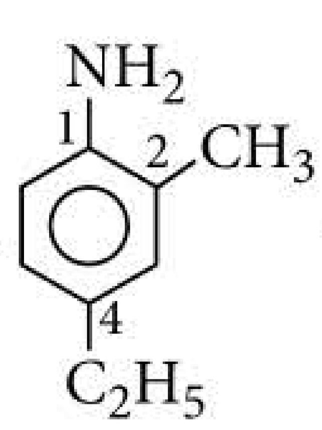
- In the trivial system of nomenclature, the prefix *ortho* (*o*-) indicates 1,2-*meta* (*m*-) indicates 1,3- and *para* (*p*-) indicates 1,4-disubstituted benzene ring.

*e.g.*, 
*o*-Xylene

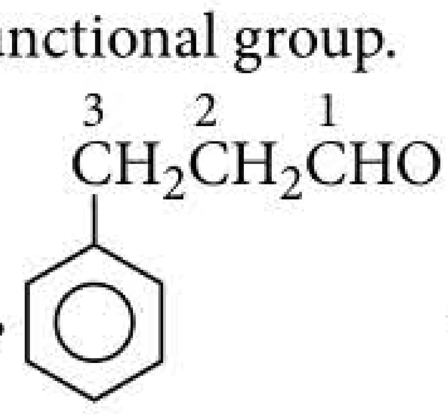

*m*-Xylene


*p*-Xylene

- In case of tri- or higher substituted benzene derivatives, common name of benzene derivatives is taken as the base compound. Number 1 position is assigned to the substituent of the base compound and lowest locant rule is followed for other substituents.

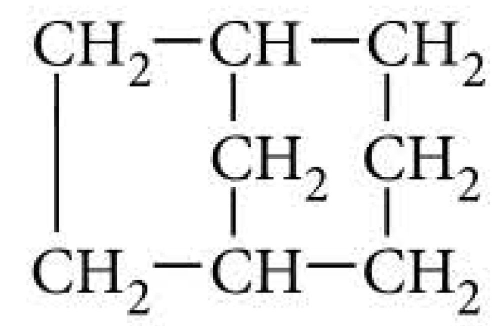
*e.g.*,  4-Ethyl-2-methylaniline

- Benzene ring is considered as substituent [Phenyl (Ph), $-C_6H_5$] when it is attached to an alkane with a functional group.

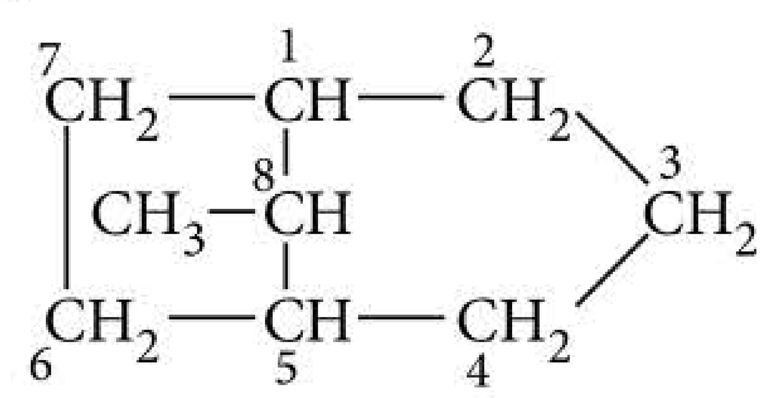
*e.g.*,  3-Phenylpropanal

## IUPAC Nomenclature of Bicyclic Compounds

- Bicyclic compounds are named by adding prefix bicyclo to the name of hydrocarbon corresponding to total number of carbon atoms in two rings. In between the words bicyclo and alkane, an expression in the square brackets is placed that represents the number of carbon atoms in each bridge connecting two bridge heads, in descending order separated from one another by full stop.

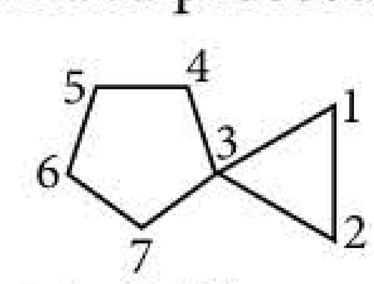

Bicyclo [3.2.1] octane

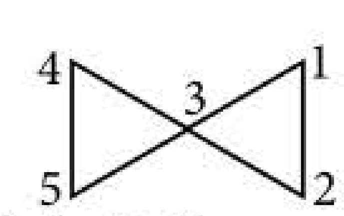
- If substituent is present, we number the bridged ring system beginning at one bridge head, proceeding first along the longest bridge to the other bridge head, then along the next longest bridge back to the first bridge head. The shortest bridge is numbered last.


8-Methyl bicyclo [3.2.1] octane

## IUPAC Nomenclature of Spiro Compounds

- Spiro compounds are named by adding prefix spiro followed by bracket containing the number of carbon atoms in each ring in ascending order and then by the name of hydrocarbon corresponding to total number of carbon atoms in two rings. The numbering starts from the atom next to the spiro atom and proceeds through the smaller ring first.


Spiro[2.4]heptane


Spiro[2.2]pentane

## Isomerism

- The phenomenon of existence of two or more compounds possessing the same molecular formula but different properties is known as *isomerism*.
- Isomerism in an organic compound can be classified broadly into structural and stereoisomerism.

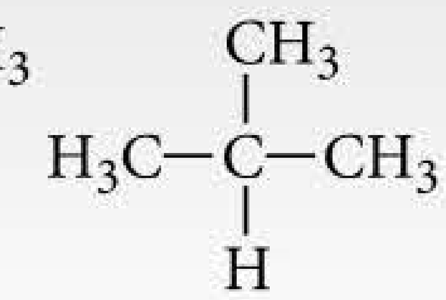
## Structural Isomerism

### Chain isomerim

Different arrangement of carbon atoms in a carbon skeleton. *e.g.*,

$H_3C-CH_2-CH_2-CH_3$

Butane



2-Methylpropane

### Position isomerism

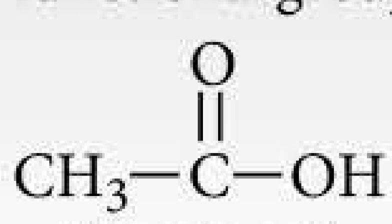
Different position of the same functional group in the molecule. *e.g.*,

$CH_3-CH=CH-CH_3$ — But-2-ene

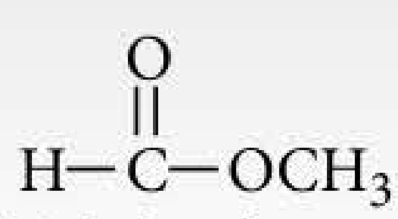
$CH_3-CH_2-CH=CH_2$ — But-1-ene

### Functional isomerism

Different positions of atoms give a different functional group. *e.g.*,



Ethanoic acid



Methyl methanoate

### Metamerism

Different alkyl groups are attached to the same polyvalent functional group. *e.g.*,

$H_3C-CH_2-O-CH_2-CH_3$

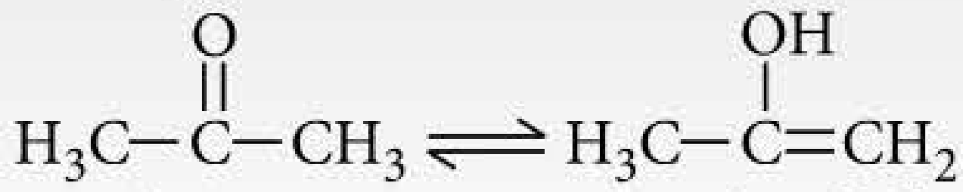
Diethyl ether or Ethoxyethane

$H_3C-O-CH_2-CH_2-CH_3$

Methyl propyl ether or 1-Methoxypropane

### Tautomerism

Tautomers have different functional groups and exist in dynamic equilibrium with each other due to a rapid interconversion from one form to another. *e.g.*,



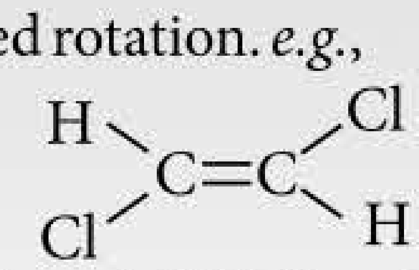
Acetone (Keto form) ⇌ Prop-1-en-2-ol (Enol form)

Keto-enol tautomerism

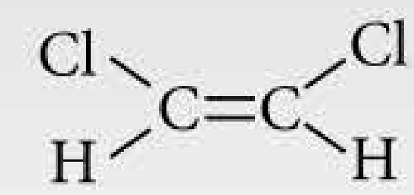
## Stereoisomerism

### Geometrical isomerism

Different arrangement of substituents around a bond with restricted rotation. *e.g.*,



(*E*) *trans*-1,2-Dichloroethene
*E* = High priority atoms or groups are on the opposite side

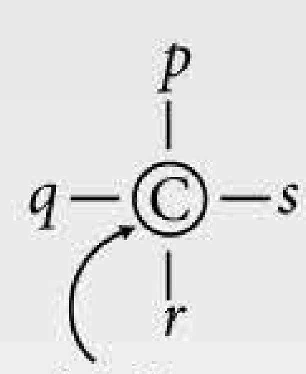


(*Z*) *cis*-1,2-Dichloroethene
*Z* = High priority atoms or groups are on the same side

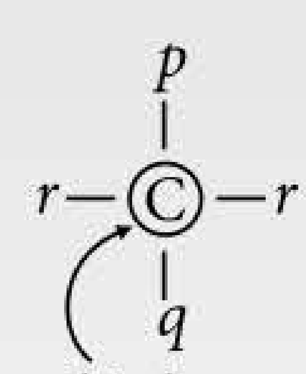
In addition to alkenes, compounds containing C=N (aldoxime and ketoxime) and N=N (azo compounds) bonds also show geometrical isomerism. However, in these cases, '*syn*' (for *cis*) and '*anti*' (for *trans*) are more commonly used.

### Optical isomerism

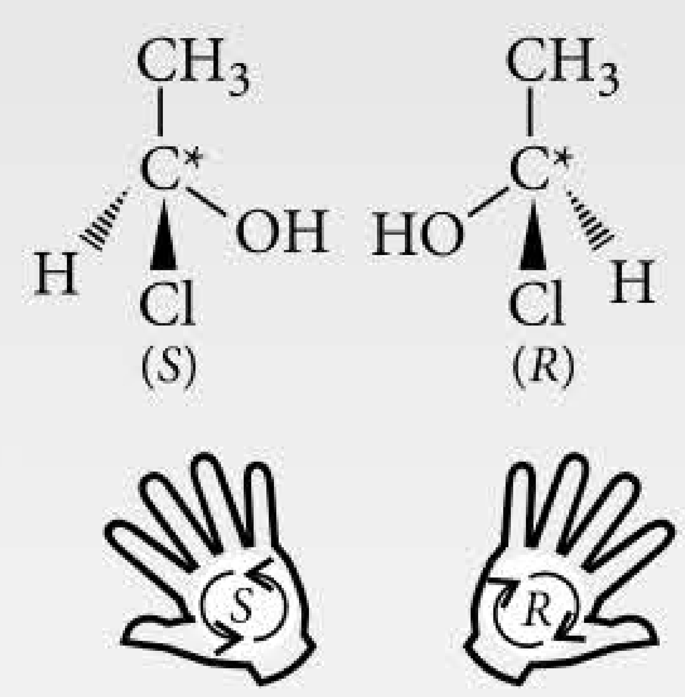
- In order to exhibit optical activity, an object must be *chiral*.
- The compound is said to have *chirality* if the central carbon atom is attached to four different groups and this centre is called *chiral* (*asymmetric*) *centre* or *stereogenic centre* or *stereocentre*.



chiral centre (asymmetric)



achiral centre (symmetric)




1-Chloroethanol

- *Enantiomers* or *d and l isomers* are the optical isomers which are non-superimposable mirror images (or dissymmetric) of each other.
- *Diastereomers* are the optical isomers which are not mirror images of each other. They have different physical properties and magnitude of specific rotation.
- *Meso compounds* are those compounds which have two or more even number of chiral carbon atoms and have an internal plane of symmetry. They are optically inactive due to *internal compensation*.

## Fission of a Covalent Bond

- **Homolytic fission**

$$R-X \xrightarrow{\text{Heat/Light}} \underset{\text{Alkyl free radical}}{R^{\bullet}} + X^{\bullet}$$

- **Heterolytic fission**

$$\underset{(X \text{ is more electronegative})}{CH_3-X} \longrightarrow \underset{\text{Carbocation}}{\overset{+}{C}H_3} + :X^-$$

$$\underset{(\text{C is more electronegative})}{CH_3-Z} \longrightarrow \underset{\text{Carbanion}}{:\overset{-}{C}H_3} + Z^+$$

## Reactions and Reaction Intermediates

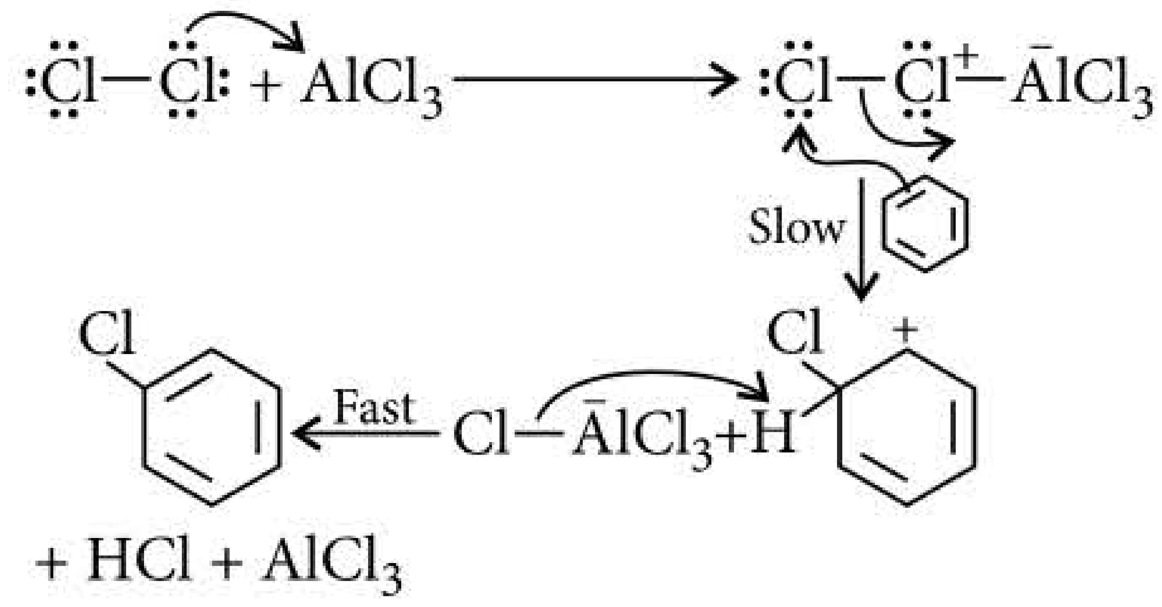
- **Substitution reactions**
  - **Free radical substitution reaction**

$$CH_4 + Cl_2 \xrightarrow[\text{or } 670\text{ K}]{h\nu} CH_3Cl + HCl$$

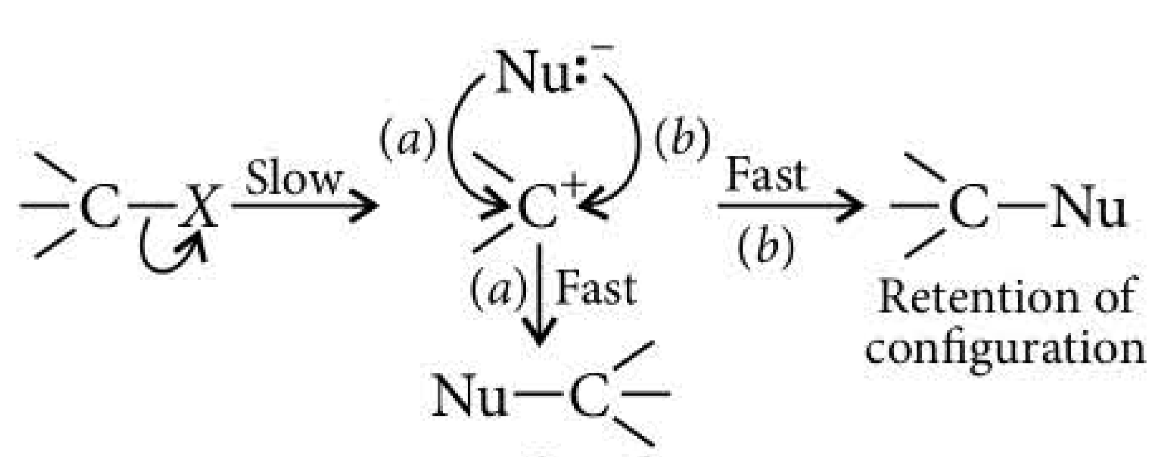
  - **Electrophilic substitution reaction ($S_E$)**
    - **Unimolecular ($S_E1$)**

$$CH_3CH_2MgBr + HBr \longrightarrow CH_3CH_3 + MgBr_2$$

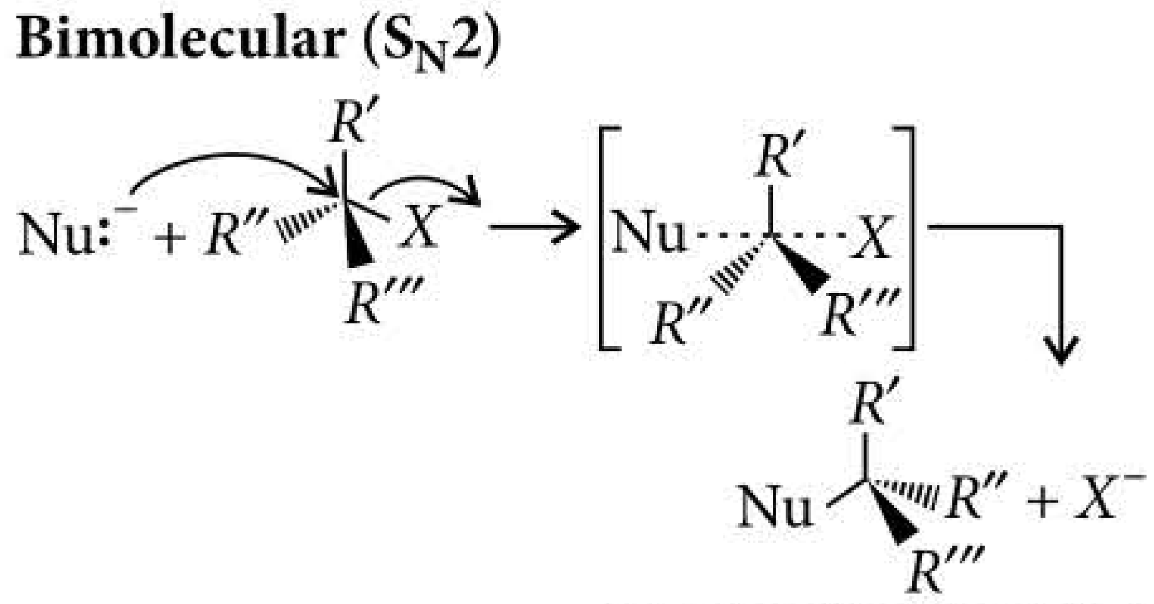
    - **Bimolecular ($S_E2$)**




  - **Nucleophilic substitution reaction ($S_N$)**
    - **Unimolecular ($S_N1$)**

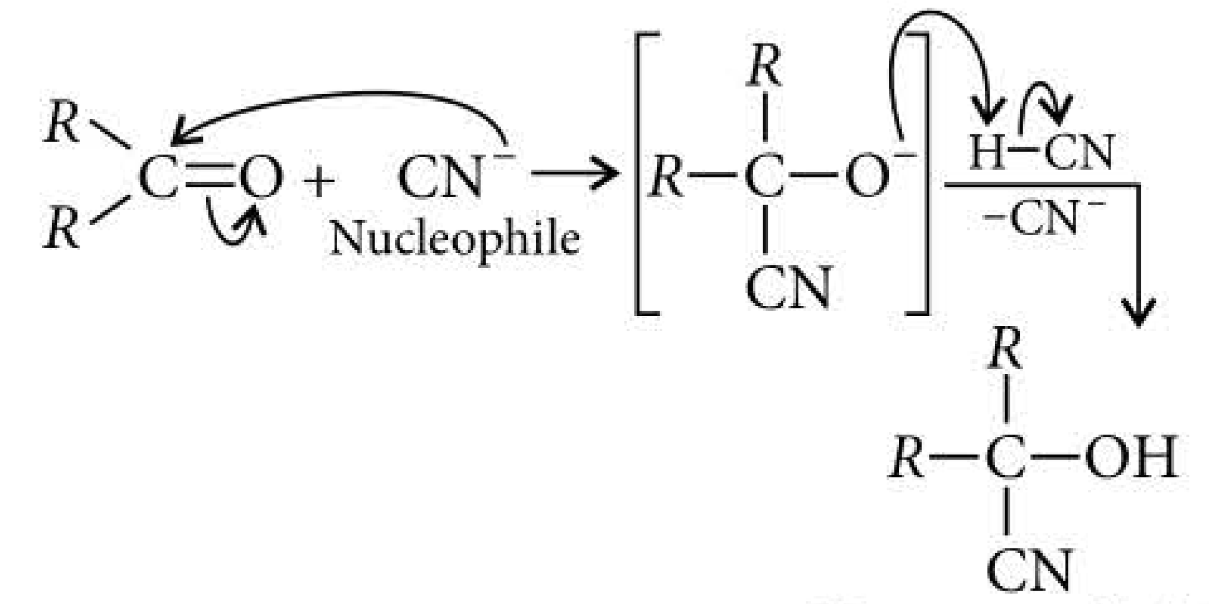



    - **Bimolecular ($S_N2$)**




- **Addition reactions**
  - **Nucleophilic addition reaction**

$$HO^- + H-CN \longrightarrow H_2O + \underset{\text{Nucleophile}}{CN^-}$$




  - **Electrophilic addition reaction**

$$\underset{\text{Propylene}}{CH_3CH{=}CH_2} + H^+ \xrightarrow{\text{Slow}} \underset{\text{Isopropyl carbocation (2°)}}{CH_3-\overset{+}{C}H-CH_3}$$

$$CH_3-\overset{+}{C}H-CH_3 + Br^- \xrightarrow{\text{Fast}} \underset{\substack{\text{2-Bromopropane}\\ \text{(Addition product)}}}{CH_3-\underset{Br}{CH}-CH_3}$$

  - **Free radical addition reaction**

$$\underset{\text{Propene}}{CH_3CH{=}CH_2} + HBr \xrightarrow{\text{Peroxides}} \underset{n\text{-Propyl bromide}}{CH_3-CH_2-CH_2Br}$$

- **Elimination reactions**
  - **α-Elimination**

$$HO^- + H(Cl)CCl_2 \longrightarrow :CCl_2 + H_2O + Cl^-$$

  - **β-Elimination**

$$H-\overset{\beta}{C}H_2-\overset{\alpha}{C}H_2-OH \xrightarrow{\text{Conc. } H_2SO_4} CH_2{=}CH_2 + H_2O$$

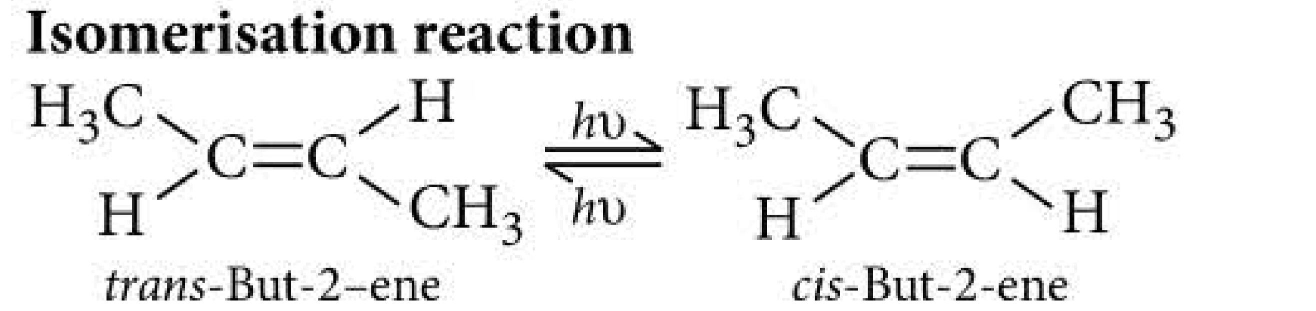
  - **γ-Elimination**

$$\underset{\text{1,3-Dibromopropane}}{BrCH_2-CH_2-CH_2Br} \xrightarrow{\text{Zn dust}} \text{Cyclopropane}$$

- **Condensation reaction**

$$\underset{\text{Two molecules of ethanal}}{CH_3-\overset{O}{\overset{\|}{C}}-H + CH_3CHO} \xrightarrow{\text{aq. NaOH}} \underset{\text{3-Hydroxybutanal}}{CH_3-\overset{OH}{\overset{|}{C}H}-CH_2CHO}$$

- **Isomerisation reaction**



## ATTACKING REAGENTS

| Electrophiles | Nucleophiles | Ambiphiles |
|---|---|---|
| They are positively charged or neutral molecules having electron deficient atom, seeking a site of high electron density to attack. Electrophiles have incomplete outer shells and are also called *Lewis acids* (electron-pair acceptors).<br>Charged : $H_3O^+$, $X^+$ (where $X$ = Cl, Br, I), $NO_2^+$, $NO^+$, $NH_4^+$, $\overset{+}{S}O_3H$, $C_6H_5\overset{+}{N}_2$, $R^+$, $RCO^+$.<br>Neutral : $BF_3$, $AlCl_3$, $FeCl_3$, $SiCl_4$, $BeCl_2$, $ZnCl_2$, $SO_3$, $CO_2$, $CS_2$, $CX_4$, $RCOCl$, $>C{=}O$, $:CCl_2$. | They are negatively charged or neutral molecules having electron-rich atom with unshared electron pair, seeking electron deficient site to attack. They are also called *Lewis bases* (electron-pair donors).<br>Charged : $H^-$, $OH^-$, $X^-$, $CN^-$, $N_3^-$, $RO^-$, $R^-$, $RS^-$, $SH^-$, $HSO_3^-$, $NO_2^-$, $NH_2^-$, $RCOO^-$, $HC{\equiv}C^-$.<br>Neutral : $\ddot{N}H_3$, $H_2\ddot{O}$, $R\ddot{O}H$, $R\ddot{O}R$, $R\ddot{S}H$, $RMgX$, $Ph_3\ddot{P}$, $RLi$, $LiAlH_4$, etc. | They behave both like electrophiles and nucleophiles hence, have dual nature.<br>$R\ddot{O}H$, $H\ddot{O}H$ and $R\ddot{P}H_2$ |

## ELECTRON DISPLACEMENT EFFECTS IN COVALENT BONDS

**Types of Electronic Displacement Effects**

### Inductive effect

Displacement of σ electrons along a saturated carbon chain when an electron donating (+*I* effect) or electron withdrawing (–*I* effect) group is attached at the end of the carbon chain.

- *Decreasing order of –I effect* :
  $-NO_2 > -CN > -COOH > -F > -Cl > -Br > -I > -H$
- *Decreasing order of +I effect* :
  $(CH_3)_3C- > (CH_3)_2CH- > CH_3CH_2- > CH_3- > D- > H-$

### Electromeric effect

It involves the complete transfer of π electrons of a multiple bond to one of the bonded atoms in presence of an attacking reagent.

- *+E effect* : When electron transfer takes place to the atom to which the attacking reagent gets finally attached.
- *–E effect* : When electron transfer takes place away from the atom to which the attacking reagent gets finally attached.

### Resonance or Mesomeric effect

It is defined as the polarity produced in the molecule by the interaction of two π bonds or between a π bond and a lone pair of electrons present on adjacent atom.

- *+R or +M effect* : $-OH$, $-OR$, $-SH$, $-SR$, $-NH_2$, $-NHR$, $-NR_2$, $-Cl$, $-Br$, $-I$, etc.
- *–R or –M effect* : $>C{=}O$, $-CHO$, $-COOR$, $-CN$, $-NO_2$, etc.
- In case of the elements of the second period in the periodic table, such resonance structures which violate octet rule should not be considered. *e.g.*,

$$\underset{\text{I}}{CH_2{=}CH-\overset{+}{N}H_3} \not\leftrightarrow \underset{\text{II}}{\overset{+}{C}H_2-CH{=}NH_3}$$

### Hyperconjugation

It involves delocalisation of σ electrons of C—H bond of an alkyl group directly attached to an atom of unsaturated system or to an atom with an unshared *p*-orbital. For an alkyl group attached to unsaturated system it decreases with decrease in number of α-hydrogens. Thus, the order of hyperconjugation effect decreases in the order :

$CH_3- > CH_3CH_2- > (CH_3)_2CH- > (CH_3)_3C-$

## Methods of Purification of Organic Compounds

**Methods**

**Distillation under reduced pressure :** It is used to purify liquids
- having very high boiling points.
- which decompose at or below their boiling points.
  *e.g.*, Glycerol is separated from spent-lye in soap industry.

**Crystallisation :** Differential solubilities of a given organic compound and its impurities in the same solvent.
- Crystallisation of sugar (containing an impurity of common salt) is achieved by shaking the impure solid with hot ethanol at 348 K (sugar dissolves whereas common salt remains insoluble).

**Steam distillation :** This method is used to separate substances which are steam volatile, insoluble in water, possess a vapour pressure of 10-15 mm Hg and contain non-volatile impurities.
- Aniline is separated from aniline-water mixture.
- Essential oils, *o*-nitrophenol, bromobenzene, nitrobenzene, etc. can be purified.

**Sublimation :** Some solid substances change from a solid to a vapour state without passing through the liquid state. Sublimable compounds get separated from non-sublimable impurities.
- Iodine from sodium chloride (as iodine sublimes readily leaving behind sodium chloride).
- Camphor, naphthalene, anthracene, benzoic acid, etc. are purified.

**Differential extraction :** This method involves the shaking of an aqueous solution of an organic compound with an organic solvent in which the organic compound is more soluble than in water. The organic solvent and the aqueous solution should be immiscible with each other so that they can form two distinct layers which can be separated by using separating funnel.
- Benzoic acid can be extracted from its water-benzoic acid mixture using benzene.

**Distillation :** It is used to separate
- volatile liquids from non-volatile impurities.
- liquids having sufficient difference in their boiling points.
- Hexane (b.p. 342 K) and toluene (b.p. 384 K)
- Chloroform (b.p. 334 K) and aniline (b.p. 457 K)

**Chromatography :** It involves differential movement of individual components of a mixture through a stationary phase under the influence of a mobile phase.
- Widely used for separation, purification, identification and characterisation of the components of a mixture, whether coloured or colourless.

**Fractional distillation :** If the difference in boiling points of two liquids is not much, this method is used.
- Crude oil in petroleum industry is separated into various useful fractions such as gasoline, kerosene oil, diesel oil, lubricating oil, etc.

**Adsorption chromatography (stationary phase is solid)**
- **Column chromatography :** It involves separation of a mixture over a column of adsorbent packed in a glass tube.
  Mixture of naphthalene and benzophenone can be separated by this.
- **Thin layer chromatography :** It involves the separation of substances of a mixture over a thin layer of an adsorbent coated on glass plate.
  Amino acids can be detected by spraying the plate with ninhydrin solution.

**Partition chromatography :** It is a liquid/liquid chromatography in which both the mobile phase and the stationary phase are liquids and used for the separation of sugars and amino acids.
- **Paper chromatography:** A special quality paper known as chromatographic paper is used. It contains water trapped in it, which acts as the stationary phase.

## Qualitative Analysis

**Detection of Elements and their Confirmatory Tests**

- **Carbon (Copper oxide test)**

$$2CuO + C \xrightarrow{\Delta} 2Cu + CO_2\uparrow$$

*Confirmatory test*

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

- **Hydrogen (Copper oxide test)**

$$CuO + 2H \xrightarrow{\Delta} Cu + H_2O$$

*Confirmatory test*

$$\underset{\text{White}}{CuSO_4} + 5H_2O \longrightarrow \underset{\text{Blue}}{CuSO_4\cdot 5H_2O}$$

- **Nitrogen**

$$Na + C + N \xrightarrow{\Delta} \underset{\text{(Lassaigne's extract)}}{NaCN}$$

*Confirmatory test*

$$FeSO_4 + 2NaOH \longrightarrow Fe(OH)_2 + Na_2SO_4$$

$$Fe(OH)_2 + 6NaCN \longrightarrow Na_4[Fe(CN)_6] + 2NaOH$$

$$3Na_4[Fe(CN)_6] + 4FeCl_3 \rightarrow \underset{\text{Prussian blue}}{Fe_4[Fe(CN)_6]_3} + 12NaCl$$

- **Sulphur**

$$2Na + S \xrightarrow{\Delta} \underset{\text{(Lassaigne's extract)}}{Na_2S}$$

*Confirmatory test*

$$Na_2S + \underset{\text{Sodium nitroprusside}}{Na_2[Fe(CN)_5NO]} \rightarrow \underset{\text{Deep violet}}{Na_4[Fe(CN)_5NOS]}$$

$$Na_2S + (CH_3COO)_2Pb \xrightarrow{CH_3COOH} \underset{\text{Black ppt.}}{PbS\downarrow} + 2CH_3COONa$$

- **Halogens**

$$Na + X \xrightarrow{\Delta} \underset{\text{(Lassaigne's extract)}}{NaX}$$

($X$ = Cl, Br or I)

*Confirmatory test*

$$NaX + AgNO_3 \xrightarrow{HNO_3} \underset{\text{ppt.}}{AgX\downarrow}$$

— White ppt. soluble in aqueous $NH_3$ (or $NH_4OH$) confirms Cl.

$$\underset{\text{White ppt.}}{AgCl\downarrow} + 2NH_{3(aq.)} \longrightarrow \underset{\text{Soluble}}{[Ag(NH_3)_2]Cl}$$

— Yellow ppt. partially soluble in aqueous $NH_3$ (or $NH_4OH$) confirms Br.

— Yellow ppt. insoluble in aqueous $NH_3$ (or $NH_4OH$) confirms I.

- **Nitrogen and sulphur**

$$Na + C + N + S \xrightarrow{\Delta} \underset{\substack{\text{(Lassaigne's extract)}\\ \text{Sodium thiocyanate}}}{NaSCN}$$

*Confirmatory test*

$$3NaSCN + FeCl_3 \longrightarrow \underset{\text{Blood red colour}}{[Fe(SCN)_3]} + 3NaCl$$

- **Phosphorus**

$$P \xrightarrow[\Delta]{Na_2O_2,\ boil} Na_3PO_4$$

*Confirmatory test*

$$Na_3PO_4 + 3HNO_3 \xrightarrow{\Delta} H_3PO_4 + 3NaNO_3$$

$$H_3PO_4 + 12(NH_4)_2MoO_4 + 21HNO_3 \xrightarrow{\Delta} \underset{\substack{\text{Ammonium phosphomolybdate}\\ \text{(Yellow ppt.)}}}{(NH_4)_3PO_4\cdot 12MoO_3\downarrow} + 21NH_4NO_3 + 12H_2O$$

### INFOSHOTS

**Gas Chromatography(GC) – Sensor Can 'Smell' Prostate Cancer!**

A Research team from the University of Liverpool has reached an important milestone towards creating a urine diagnostic test for prostate cancer. The use of a gas chromatography (GC) – sensor system combined with advanced statistical methods towards the diagnosis of urological malignancies', which describes a diagnostic test using a special tool to 'smell' the cancer in men's urine. The GC sensor system is able to successfully identify different patterns of volatile compounds that allow classification of urine samples from patients with urological cancers. The research team used a gas chromatography sensor system called Odoreader that was developed by a team led by Professor Probert and Professor Norman Ratcliffe at UWE Bristol. The test involves inserting urine samples into the Odoreader that are then measured using algorithms developed by the research team at the University of Liverpool and UWE Bristol. "The Odoreader has a 30 metre column that enables the compounds in the urine to travel through at different rates thus breaking the sample into a readable format. This is then translated into an algorithm enabling detection of cancer by reading the patterns presented. The positioning of the prostate gland which is very close to the bladder gives the urine profile a different algorithm if the man has cancer."

# Quantitative Analysis

**Methods of Analysis**

## Estimation of carbon and hydrogen

**Liebig's combustion method :**

$$C_xH_y + \left(x+\frac{y}{4}\right)O_2 \xrightarrow{\Delta} xCO_2 + \frac{y}{2}H_2O$$

$$\%\text{ of C} = \frac{12}{44}\times\frac{\text{Mass of }CO_2\text{ formed}}{\text{Mass of compound taken}}\times 100,$$

$$\%\text{ of H} = \frac{2}{18}\times\frac{\text{Mass of }H_2O\text{ formed}}{\text{Mass of compound taken}}\times 100$$

## Estimation of nitrogen

**Dumas method :**

$$C_xH_yN_z + \left(2x+\frac{y}{2}\right)CuO \xrightarrow{\Delta}$$

$$xCO_2 + \frac{y}{2}H_2O + \frac{z}{2}N_2 + \left(2x+\frac{y}{2}\right)Cu$$

$$\%\text{ of N} = \frac{28}{22400}\times\frac{\text{Vol. of }N_2\text{ at STP}}{\text{Mass of compound taken}}\times 100,$$

$$\text{Vol. of }N_2\text{ at STP} = \frac{P_1V_1\times 273}{760\times T_1}$$

**Kjeldahl's method :**

$$\text{Organic compound} + H_2SO_{4\,(conc.)} \xrightarrow{\Delta}$$

$$(NH_4)_2SO_4 \xrightarrow[\Delta]{2NaOH} Na_2SO_4 + 2NH_3 + 2H_2O$$

$$2NH_3 + H_2SO_4 \longrightarrow (NH_4)_2SO_4$$

$$\%\text{ of N} = \frac{1.4\times\text{Molarity of acid}\times\text{Vol. of acid used}\times\text{Basicity of acid}}{\text{Mass of compound taken}},$$

$$\%\text{ of N} = \frac{1.4\times\text{Normality of acid}\times\text{Vol. of acid used}}{\text{Mass of compound taken}}$$

(for monobasic acid)

## Estimation of halogen

**Carius method :**

$$X \xrightarrow[AgNO_3]{HNO_3,\ \Delta} AgX\downarrow$$

$$\%\text{ of Cl} = \frac{35.5}{143.5}\times\frac{\text{Mass of AgCl formed}}{\text{Mass of compound taken}}\times 100$$

$$\%\text{ of Br} = \frac{80}{188}\times\frac{\text{Mass of AgBr formed}}{\text{Mass of compound taken}}\times 100$$

$$\%\text{ of I} = \frac{127}{235}\times\frac{\text{Mass of AgI formed}}{\text{Mass of compound taken}}\times 100$$

## Estimation of sulphur

**Carius method :**

$$S \xrightarrow[\text{(ii) }BaCl_2]{\text{(i) }HNO_3,\ \Delta} \underset{\text{White ppt.}}{BaSO_4\downarrow}$$

$$\%\text{ of S} = \frac{32}{233}\times\frac{\text{Mass of }BaSO_4\text{ formed}}{\text{Mass of compound taken}}\times 100$$

## Estimation of phosphorus

**Ignition method :**

$$P \xrightarrow[\text{Heat}]{HNO_3} H_3PO_4$$

$$H_3PO_4 + Mg^{2+} + NH_4Cl \xrightarrow{\Delta} \underset{\text{Magnesium ammonium phosphate (white ppt.)}}{MgNH_4PO_4} + HCl$$

$$2MgNH_4PO_4 \xrightarrow{\Delta} \underset{\text{Magnesium pyrophosphate}}{Mg_2P_2O_7} + 2NH_3 + H_2O$$

$$\%\text{ of P} = \frac{62}{222}\times\frac{\text{Mass of }Mg_2P_2O_7\text{ formed}}{\text{Mass of compound taken}}\times 100$$

## Estimation of carbon, hydrogen and nitrogen

The elements carbon, hydrogen and nitrogen present in a compound can be determined by an apparatus known as CHN elemental analyser. It requires only 1-3 mg of the compound and displays the values of the element on the screen. The results are accurate within ±0.03% error.

## Estimation of oxygen

% of oxygen in a compound = 100 – (Sum of the % of all other elements present in the compound).