Organic chemistry

Pharmaceutical organic chemistry

UNIT - 1st

Benzene & its derivative

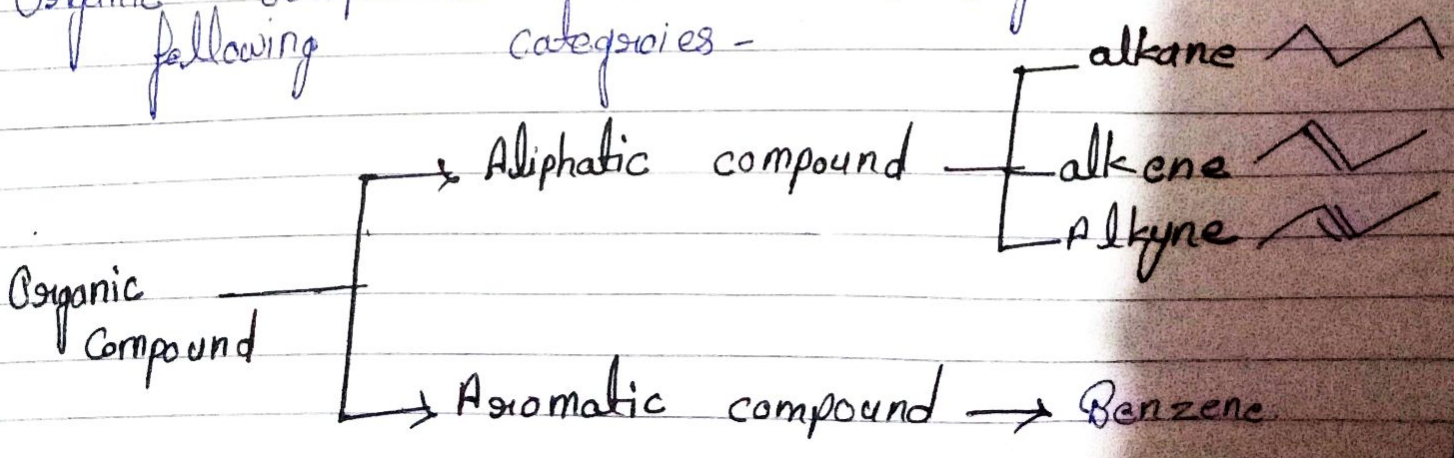
Organic compound

Those chemical compounds which is composed of carbon or which is derivative of carbon is called organic compound.

Eg- CH_4, CO_2, Benzene, C_2H_5OH,

Note HCN is the only compound in nature which contains carbon but it is inorganic in nature.

Organic compounds can be classified into following categories -



Aromatic compounds

Aromatic compounds are those organic compounds which follow the Huckle's rule of aromaticity.

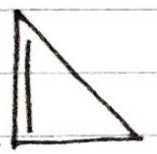
According to Huckle's rule -

(A) Compound should be cyclic

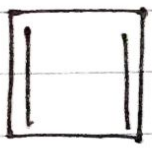
(B) Compound should show resonance it means single and double bond is present in alternet position.

(C) In the equation $4n + 2 = \pi e^-$ the value of n should be whole no.
[1, 2, 3, 4, 5 ---]

Eg -



[Non aromatic]



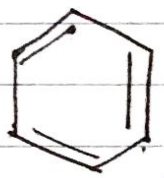
$4n + 2 = 4$

$4n = 4 - 2$

$n = \frac{2}{4}$

$n = \frac{1}{2}$

[Non aromatic]



$4n + 2 = 6$

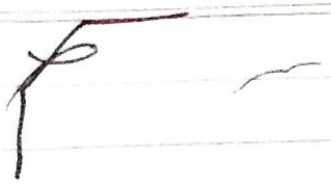
$4n = 6 - 2$

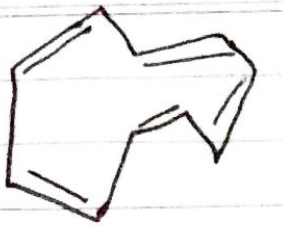
$4n = 4$

$n = \frac{4}{4}$

$n = 1$

[aromatic]





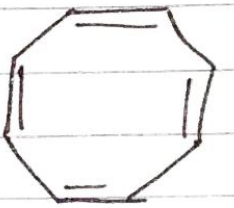
$4n + 2 = 10$

$4n = 10 - 2$

$4n = 8$

$n = \frac{8}{4}^{2}$

$n = 2$



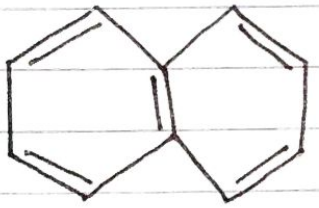
$4n + 2 = 8$

$4n = 8 - 2$

$4n = 6$

$n = \frac{6}{4}^{3}$

$n = \frac{3}{2}$



$4n + 2 = 10$

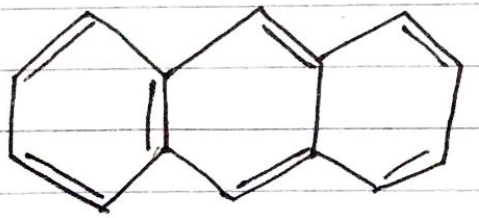
$4n = 10 - 2$

$4n = 8$

$n = \frac{8}{4}^{4}$

$n = \frac{4}{2}^{2}$

$n = 2$



~~Non~~ ~~aromatic~~

$4n + 2 = 14$

$4n = 14 - 2$

$4n = 12$

$n = \frac{12}{4}^{3}$

$n = 3$

Structure of Benzene

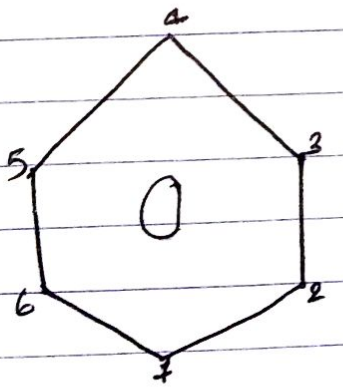
Benzene is a cyclic structure compound with molecular formula C_6H_6 and molecular weight is 84.

The structure of benzene can be categorise into 3 types -

[1] Kekule structure
[2] Chemical structure
[3] Resonating structure

[1] Kekule structure - Kekule explain that those compound in which 1st carbon is attached with last carbon then they form a cyclic structure

In the structure of benzene carbon no. is attach with carbon no. 6 and form a cyclic structure.



[2] Chemical structure of benzene - In the chemical structure of benzene -

[A] Six carban and six hydrogen is present.

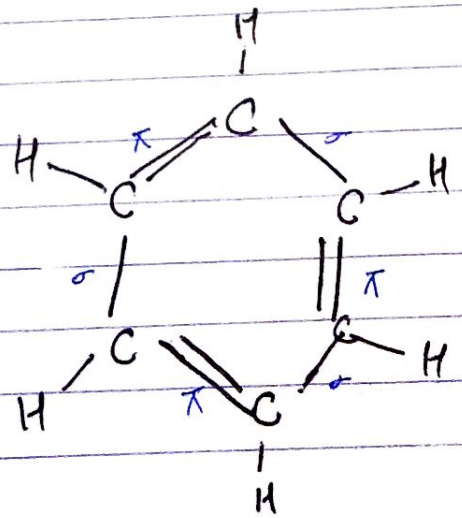
[B] All hydrogen is bonded with carban by sigma bond.

[C] In benzene b/w carban - carban sigma bond and Pi bond are attached ~~with~~ in alternet position.

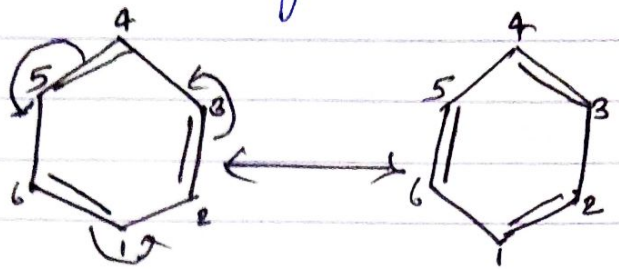
[D] Due to alternet position of sigma and Pi bond benzene show resonance.

[E] In the structure of benzene 3 type of bond of diffrent bond length is present.

C — H ⇒ 1.54 A°
C — C ⇒ 1.40 A°
C = C ⇒ 1.34 A°

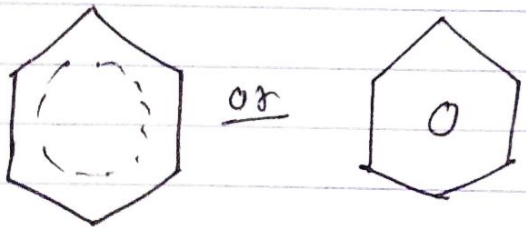


[3] Resonating structure - Due to alternet position sigma and Pi bond benzene shows 3 diffrent resonating structure -



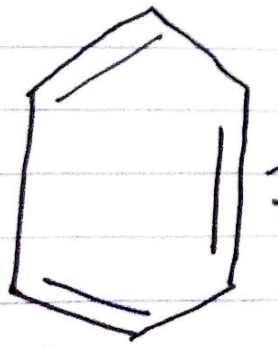
2 - 3
4 - 5
6 - 1

1 - 2
3 - 4
5 - 6



Derivative of Benzene

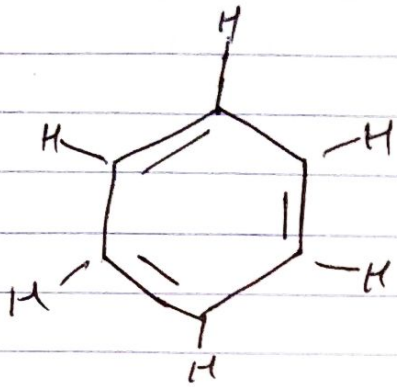
When any hydrogen atom of benzene ring is substituted with any other group/ an atom then it is called derivative of benzene.



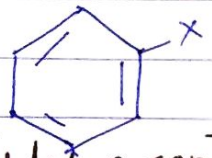
Benzene

- Monobenzene
  - Monosubstitution
  - Disubstitution
  - Polysubstitution
- Polybenzene
  - dicyclic
  - Tricyclic

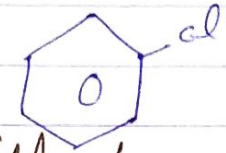
[1] Monobenzene derivative -



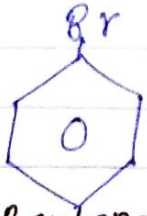
(A)



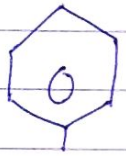
[Halobenzene]



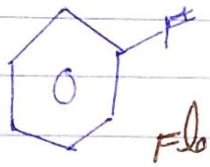
[Chlorobenzene]



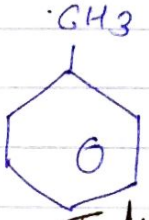
Bromobenzene



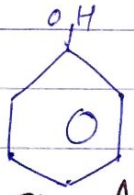
Idobenzene



Flurobenzene

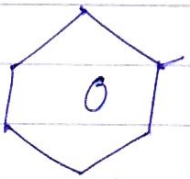


Toluene

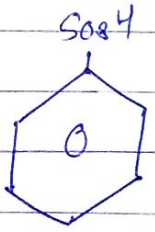


Phenol

Aniline

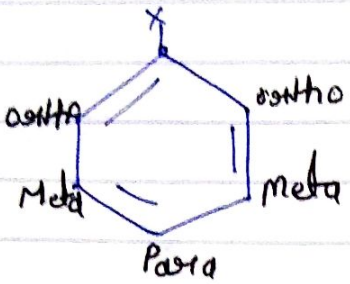


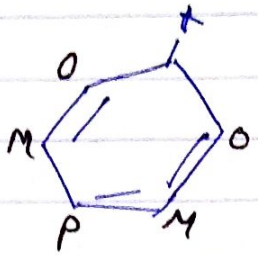
Nitrobenzene

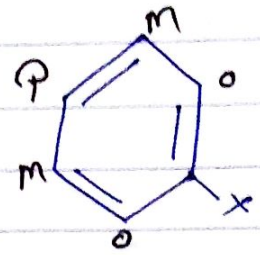


Sulphobenzene

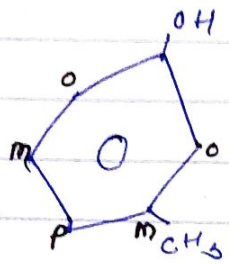
[2] Disubstitution -



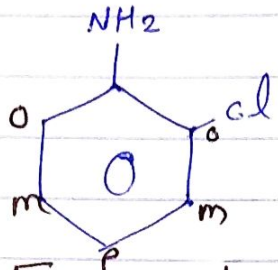




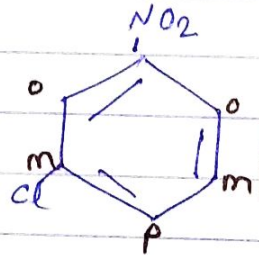
Eg -



[meta methyl phenal]

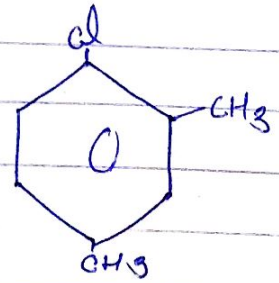


[ortho chloro aniline]

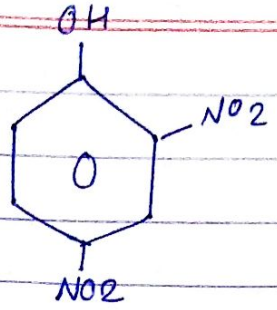


m [Metachloro nitro benzene]

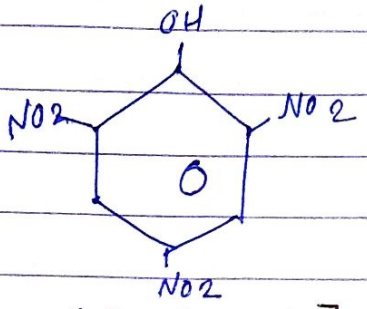
[3] Poly substitution -



[ortho para di methyl chloro Benzene]



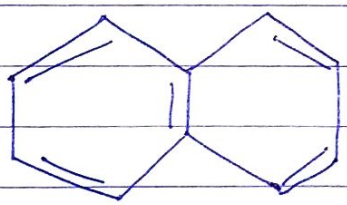
ortho Para di nitro phenol
or
2.4 di nitro phenol.



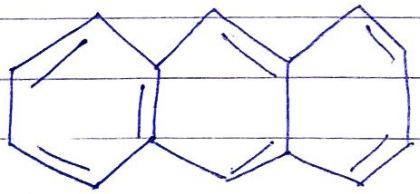
[Picric acid]

2.4.6 tri nitro phenol or
ortho para ortho nitro phenol.

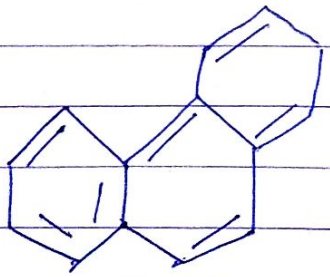
Polybenzene



[Napthalene]



[Anthracene]

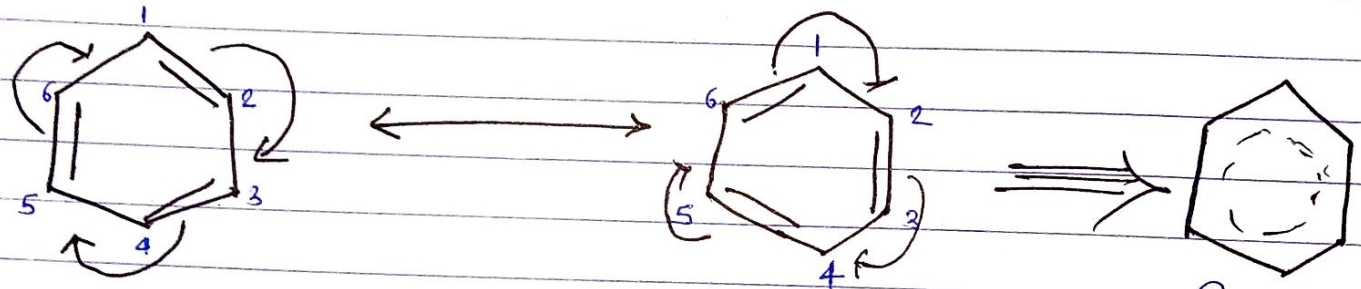


[Phenanthrene]

Resonance in Benzene

When in any compound single and double bond is present in alternet position so they can easily interchange their structure this is called resonance.

In benzene ring 3 double do bond is present in conjugation so they show resonance.



$C=C \Rightarrow C_1-C_2$
C_3-C_4
C_5-C_6

Structure - 1

$C=C \Rightarrow C_2-C_3$
C_4-C_5
C_6-C_1

Structure - 2

In structure 1 double bond is present b/w C_1-C_2, C_3-C_4, and C_5-C_6 but after resonce in by 2nd structure resonce double bond is present b/w C_2-C_3, C_4-C_5 and C_6-C_1.

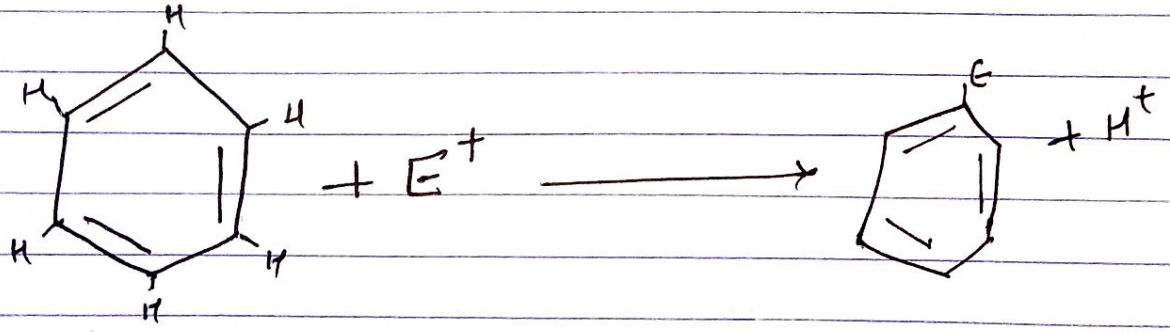
These structures are continiously change

from 1 form to another so the P_i bond is almost present b/w all carban so in resonce hybrid structure a ring is present b/w the benzene.

Electrophilic substitution reaction of Benzene

When benzene rings hydrogen atom is replace with any other electrophile molecule and form a new compound is called electrophilic substitution reaction.

Electrophile are those reaction intermediates which have [+] charge, they are e^- difficient so they attack on electron rich species.

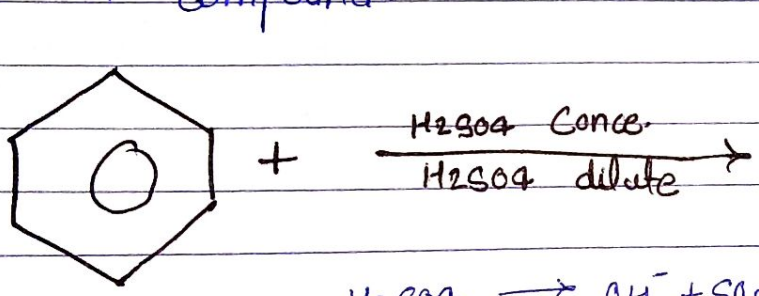


Example -

[1] Sulphonation - This reaction is perform with dilute sulphuric acid in the presence of concentrated sulphuric acid.

Generally sulphuric acids are acidic in nature but when this reaction is perform in the presence of concentrated sulphuric acid then it behaves like base and release OH^-.

The sulphone group is substituted with hydrogen atom and form sulpho benzene compound.



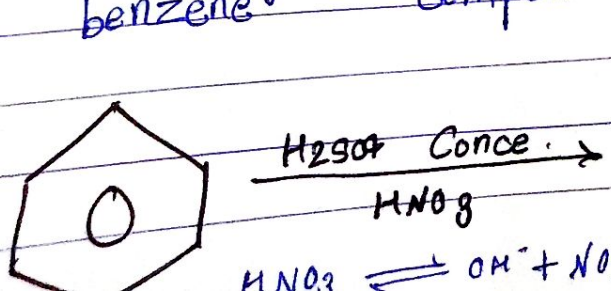
Sulphobenzene.

$H_2SO_4 \rightarrow OH^- + SO_3H^-$

[2] Nitration – This reaction is perform with nitric acid in the presence of concentrated sulphuric acid.

In the presence of strong acid nitric acid dissociate into OH^- and NO_2^+.

Now this electrophile nitro group attack on benzene ring and substituted the hydrogen atom and form nitro-benzene compound.



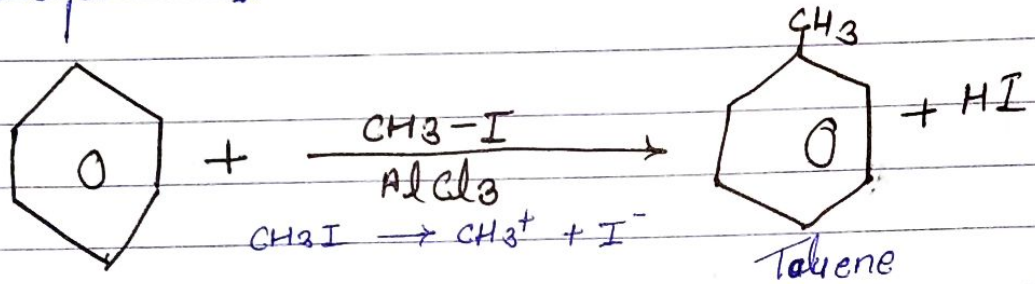
$HNO_3 \rightleftharpoons OH^- + NO_2^+$

Nitrobenzene.

[3] Friddle craft alkylation –

In this reactio The benzene ring reacts with methyl iodide in the presence of alumo aluminium tri chloride.

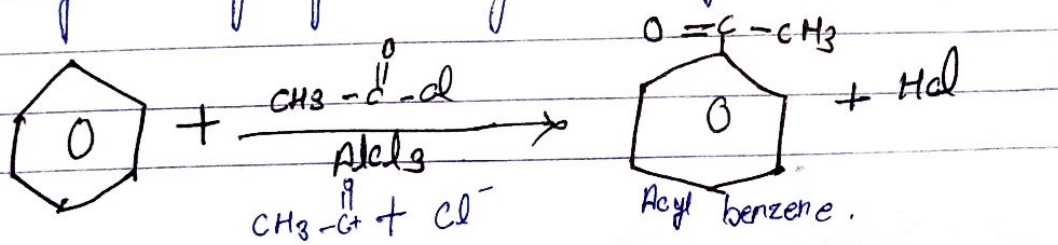
Methyl iodide dissociate into CH_3^+ and I^- and this iodide ion attack on benzen ring and after substitution with hydrogen it form toluene and released hydrogen Iodide.



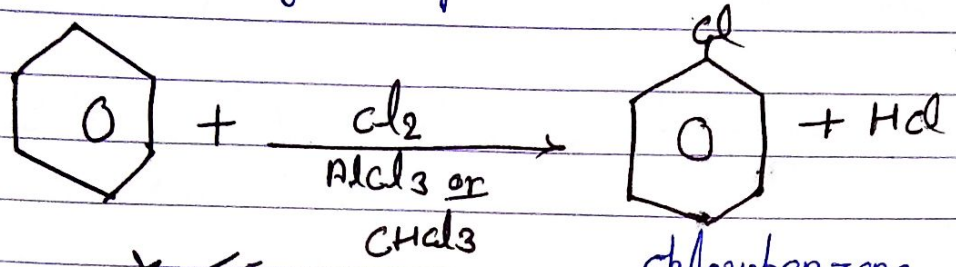
[4] Freedle craft acylation –

In this reaction benzene ring is react with acyl-chloride in the presence of aluminium tri chloride.

Acyl chloride after dissociation break into acyl ion and chloride ion. this acyl ion attacks on benzene ring and after substitution of hydrogen they form acyl benzene.



(5) Halogenation - When dihalogen molecule in the presence of chloroform attack on benzene then they form halo benzene product.



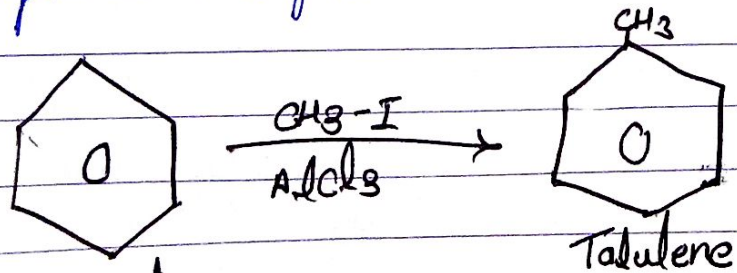
Chlorobenzene.

V.V. most

Freedal craft alkylation

In this reaction when aromatic compound react with methyl iodide or methyl chloride in the presence of alcls [aluminium tri chloride] they by electrophilic substitution reaction it gives ortho and para derrivative of aromatic compound.

This reaction is also known as feedle craft methylation.

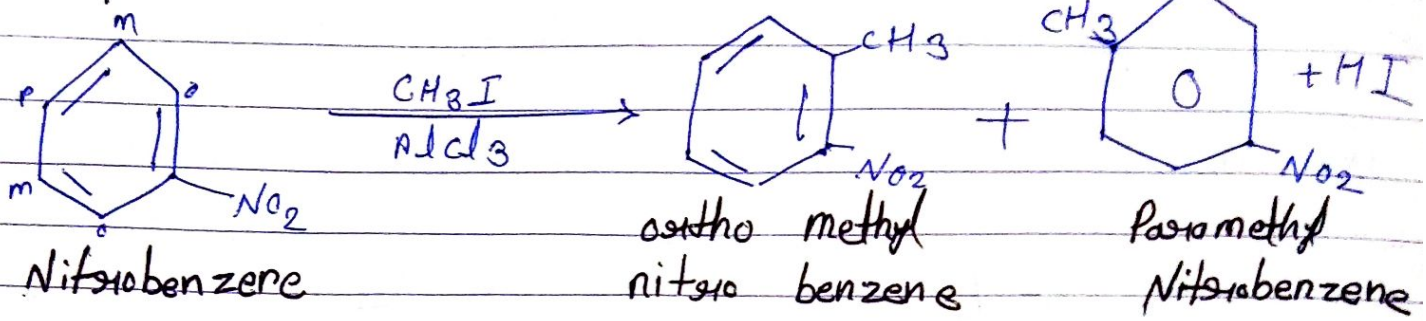


aromatic

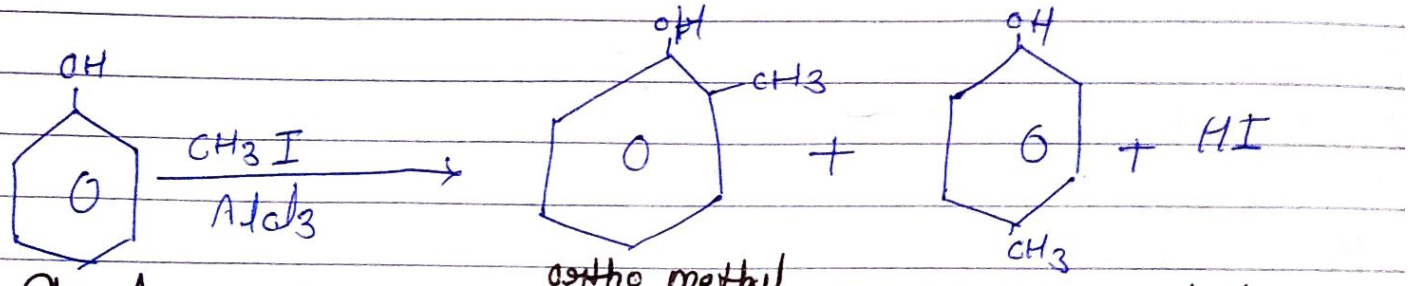
Hydrogen iodide.

Tolulene

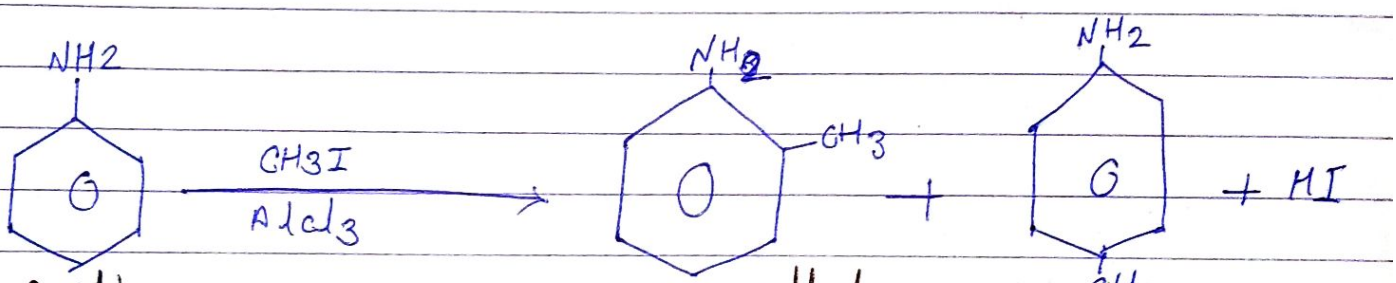
Example -



Nitrobenzene — ortho methyl nitro benzene — Para methyl Nitrobenzene



Phenol — ortho methyl phenol — Para methyl phenol



Aniline — ortho methyl aniline — Para methyl aniline.

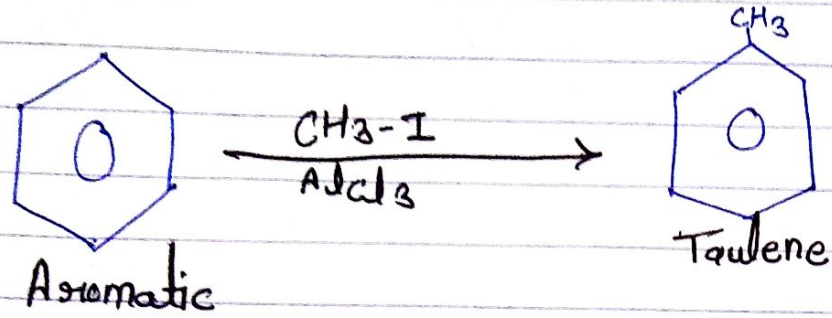
Reaction mechanism

When CH_3-I comes in contact with aluminium tri chloride then after dissociation of bond reaction intermediate carbocation $[CH_3^+]$ is form.

Now this carbocation attack on benzene ring

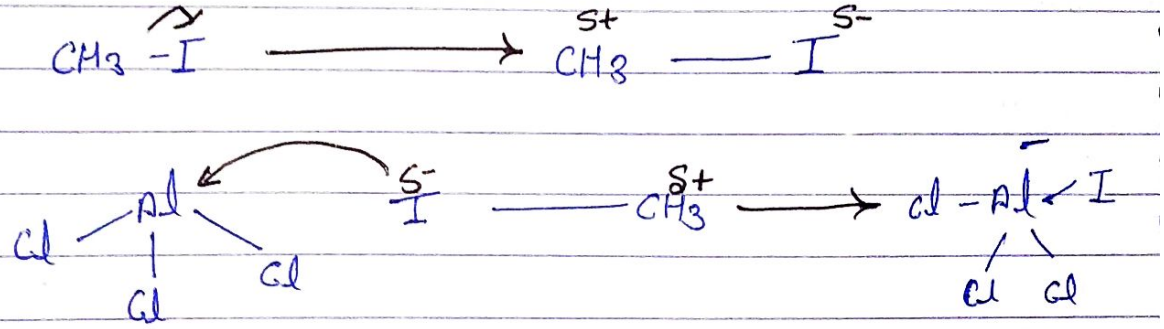
and replace the hydrogen and form electrophilic substitution product.

Reaction -

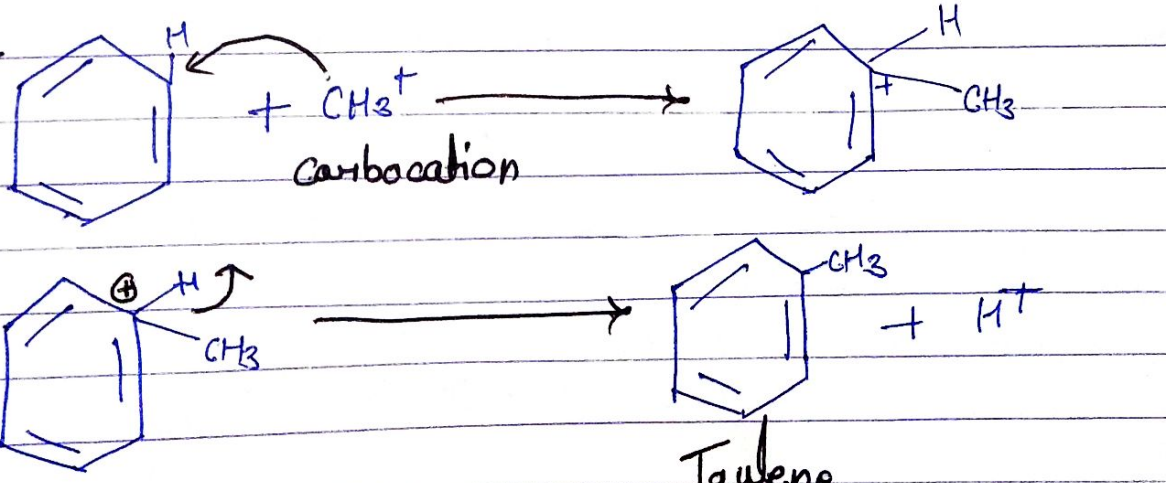


Mechanism -

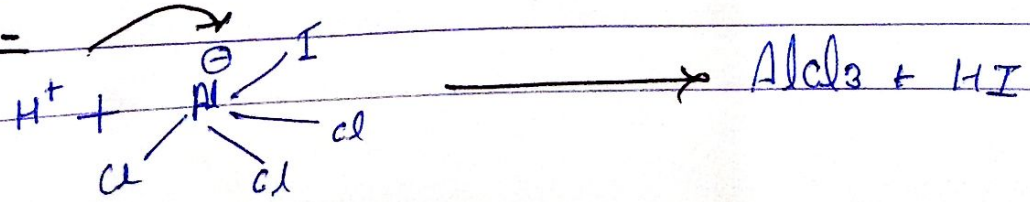
Initiation -



Elongation -

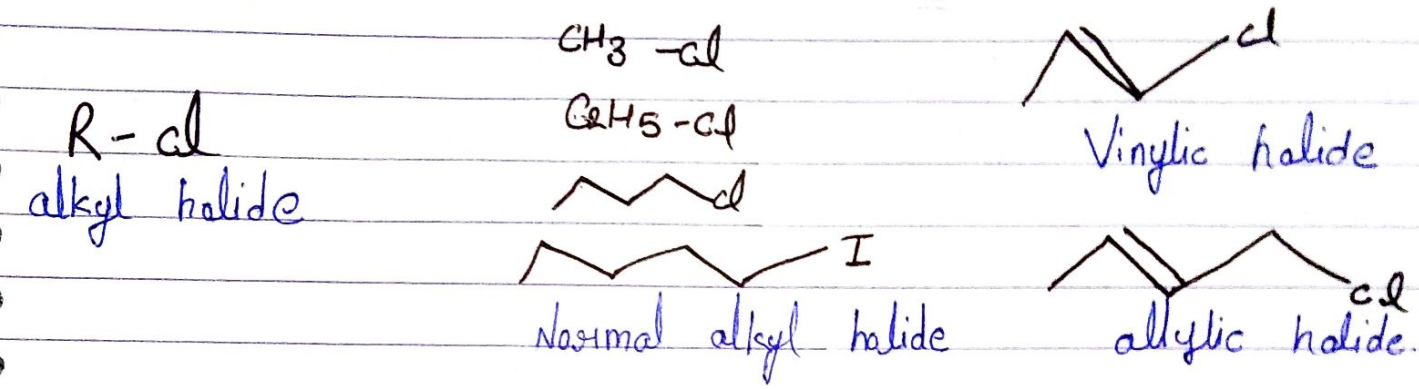


Termination -

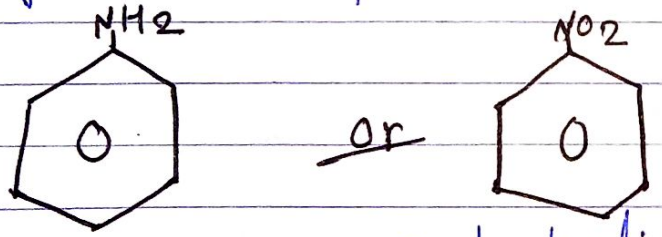


Limitation of Friedel Craft alkylation

[A] This reaction is suitable only for normal alkyl halides but it doesnot gives reaction with vinaylic halide and allylic halide.

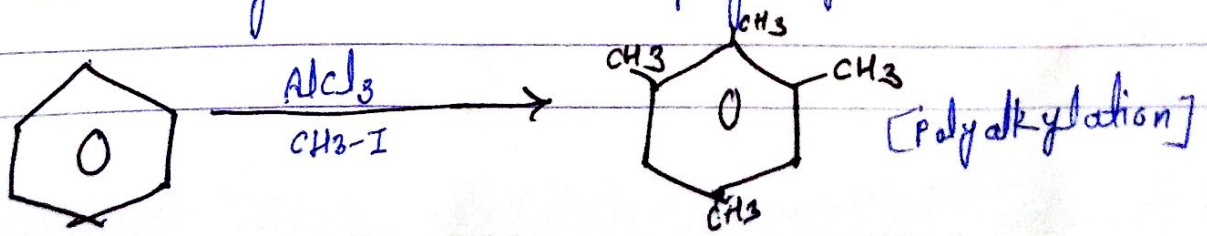


[B] If any e⁻ deactivating group like amine and nitro is attached with aromatic ring then it deactivates the aromatic ring and it doesnot gives friedel craft alkylation. reaction.



e⁻ deactivating group.

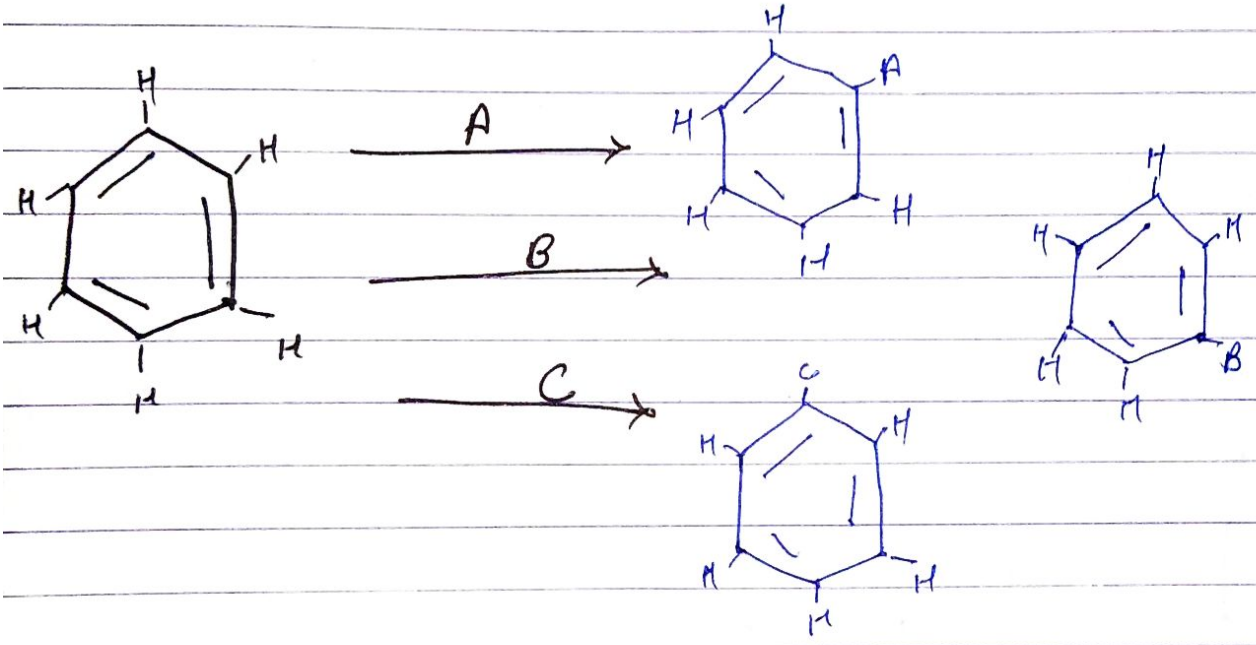
[C] When simple aromatic compounds like benzene gives friedel craft alkylation reaction then it goes under polyalkylation reaction.



Substituent effect

After electrophilic substitution reaction those group or molecule which replace the hydrogen and add on benzene ring is called substituent.

After addition of substituent the change in properties and structure of benzene ring is called substituent effect.



Here is a list of some substituent -

	Substituent	Name
[1]	CH_3 or R	Alkyl
[2]	X	Halo
[3]	R-O	Alkoxy

[4] R_2N — Amino

[5] HSO_3 — Sulphonic acid

[6] CN or NC — Cyno

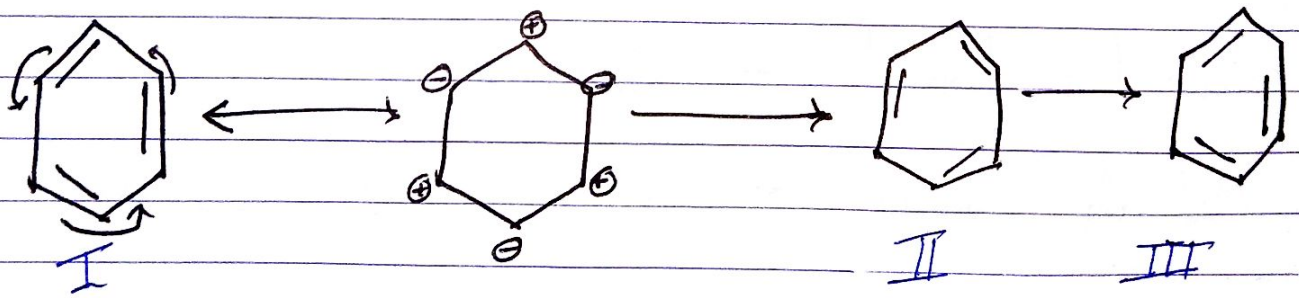
[7] NO_2 — Nitro

[8] $R-\overset{O}{\overset{\|}{C}}-$ — Acyl

On the basis of nature of substituent it is of 2 types -

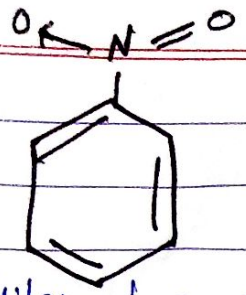
[1] Ring activating substituent - Those substituent which increase the no. of resonating structure and stability of the ring after addition is called ring activating substituent.

[2] Ring deactivating substituent - Those substituents which decrease the no. of resonating structure and stability of the ring is called ring deactivating substituents.



I II III

Total 3 resonating structure.



[Nitro benzene]

– Ring deactivating substituent ⇒ No. of resonating structure ↓

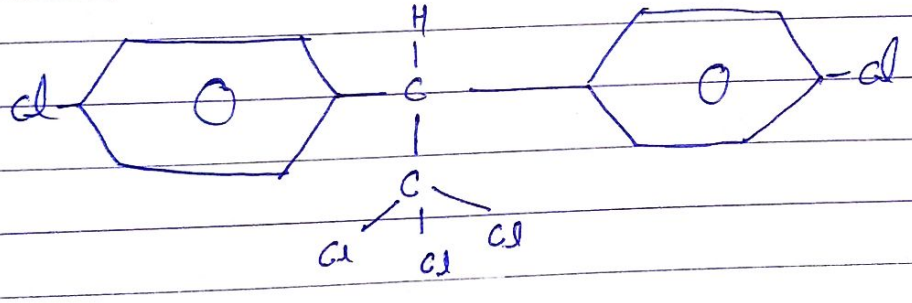
[Halo benzene]

– Ring activating substituent ⇒ No. of resonating structure ↑

DDT

[Dichloro diphenyl trichloro ethane]

Structure –



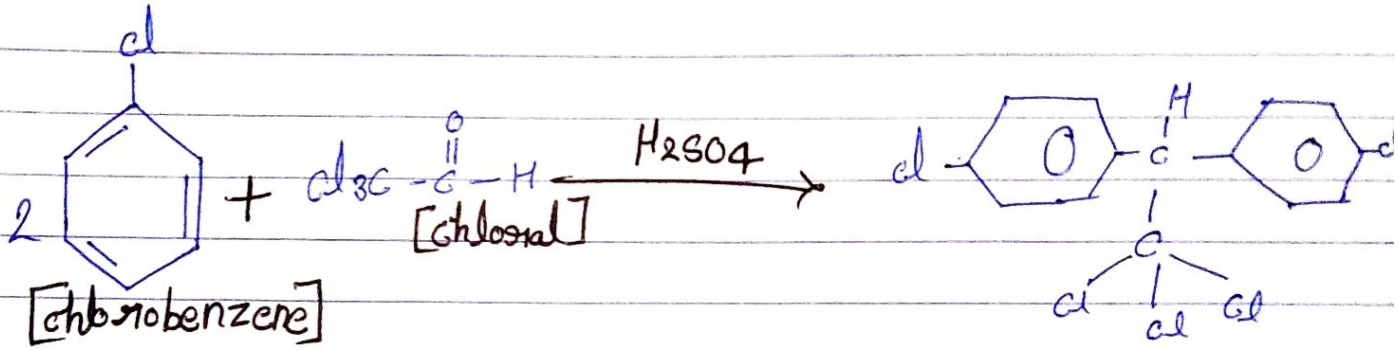
Molecular formula – $C_{14}H_9Cl_5$

Molecular weight – $12 \times 14 + 1 \times 9 + 35.5 \times 5$

$= 354.5$

Method of preparation -

It is prepared by the reaction of 2 molecule of chlorobenzene and 1 molecule of chloral, in the presence of sulphuric acid.



[DDT]

Properties -

DDT is an colourless white crystelline solid with melting point 109°C.

It is water insaluble but readialy saluble in benzene ketone and acetone.

DDT is a powerfull insectiside which is used to kill mosquito and insect.

DDT is non biodegradable in nature so it accumulates inside the plant.

It hasbeen provided a toxic effect in human beings and disturbed the production of the sex harmone in humans.

Now DDT is banned in many countries.

Saccharine

- Saccharine is an artifial sweetner.
- It is a non calorie sweetner.
- Saccharine is 300 - 400 times more sweeter than sugar.
- It is used for the manufacturing of drinks, candies, cookies, medicine and toothpaste.

History - Saccharine was discover by C. Fahlbere in 1879.

In 1885 it was 1st use as artificial sweetner.

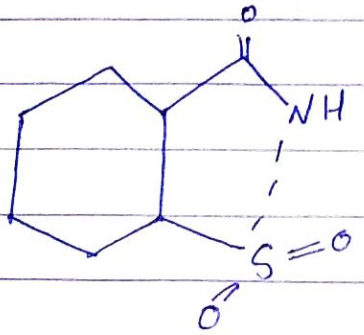
In 1960 Saccharine was used as sweetner for ~~antidiab~~ antidibetic product.

Chemistry of Saccharine - It is an aromatic compound.

and it is cyclic sulfimide.

The chemical name of saccharine is Benzoic sulfimit.

Structure of ~~Benzoic sulfimit~~ Saccharine -



- The mole. formula of saccharine is $C_7H_5NO_3S$
- and its molecular weight is 183.17 gm
- The ~~Pk~~ pK_a valve of saccharine is 1.6.
- It melting point is 228°C and its water solubility is 1 gm/270 ml of water.

Properties of saccharine -

It is odourless white crystelline power. It is intence - ज्यादा sweet so it gives unpleasent bitter taste.

It is slightly soluble in benzene, ethyl ether and chloroform and soluble in acetone and ethanol.

Use of saccharine -

Saccharine is used as sweetner for various vitamin supplements and medicine

It canbe used for the baking as a substitute of sugar.

Saccharine hasbeen used to sweeten food and beveregeस (पेयपदार्थ) without calorries.

Saccharine provide products with increase stability and inprove taste, low production caste and more choice for the consume.

Saccharine is very benificial for diabetes and ovese (मोटापे) patient.

Benzene Hexa chloride [BHC]

BHC was 1st discover by scientist Michan Faraday in 1825.

It is used as insectiside from 1933

Chemistry -

The molecular formula of BHC is C_6Cl_6 and mol. weight 285.

BHC is the substitution product of benzene

BHC is a white or chaclate colour powder

It is irritating to eye, nose and skin

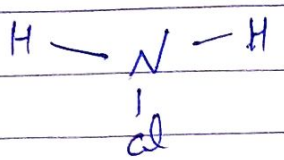
Use -

It is used to kill insectes by direct contact and it gives residual action for short diuration.

Chloramine

Chloramine

Chloro + amine



or NH_2Cl

Chloramine are the derrivative of ammonia by substitution of 1 hydrogen with chlorine.

The chemical formula of chloramine is NH_2Cl and mol. wt is ~~54~~ 51.46

It is a colourless gas with melting point $-66°C$.

It is used as disinfectant in water treatment, use to purified the drinking water.