Page No:

AMINES

Organic derivates of NH_3 are called amines.

* Classification of Amines.

1. Primary or 1° Amines → Only 1 H-atom of NH_3 is substituted by alkyl (R) or Aryl group (Ar).
   $R-NH_2$, $Ar-NH_2$.

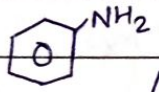
2. Secondary or 2° Amines → R_2NH, Ar_2NH, $RNHAr$.

3. Tertiary Amines or 3° Amines
   $R_2N\cdot Ar$, R_3N, $RNAr_2$, Ar_3N.

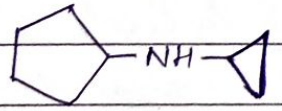
* IUPAC nomenclature

≈ $CH_3-CH_2-CH_2NH_2$.
common (n-propylamine)
IUPAC. Propan-1-amine

≈ $CH_3-\overset{2}{CH}(CH_3)-\overset{1}{CH_2}NH_2$
Isobutyl amine
2 methyl propan-1-amine

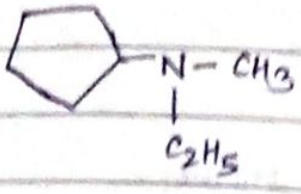
≈  Anniline (Benzenamine)

≈ $CH_3-CH_2-CH_2-NH-CH_2-CH_3$ Ethyl propyl amine (common).
IUPAC- N-ethyl propan-1-amine.

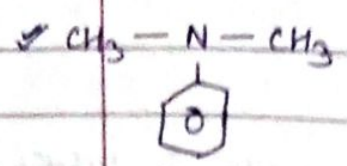
≈  (cyclopentyl cyclopropyl amine)
IUPAC. = N-cyclopropyl cyclopentanamine

≈  (Methyl Phenyl Amine)
IUPAC: N-methyl benzenamine

≈ $CH_3-\overset{2}{CH}(CH_3)-\overset{1}{CH_2}-N(CH_3)-CH_2CH_3$ | Ethyl methyl isobutyl amine)
IUPAC: N-Ethyl-N-methyl-2-methyl propan-1-amine

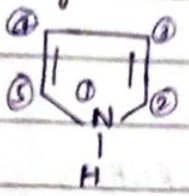


Ethyl methyl cyclopentyl amine.
IUPAC = N-Ethyl-N-methyl cyclopentanamine



N,N-dimethyl aniline
IUPAC: N,N dimethyl benzenamine

Heterocyclic Amines

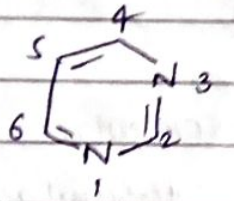


Pyridine

IUPAC
1 Aza benzene

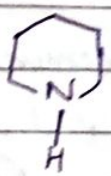
Common (Pyrroll)

IUPAC 1 Aza cyclopenta-2,4 diene

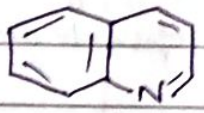


1,3 diaza benzene

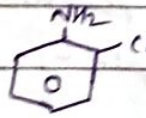
&



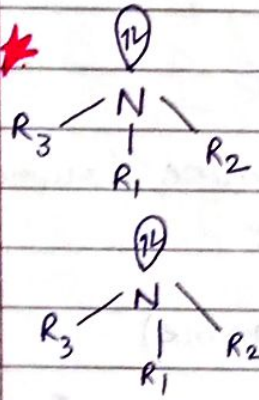
Peperidine



Quinoline
1,Aza Naphthalene



p-toluidene



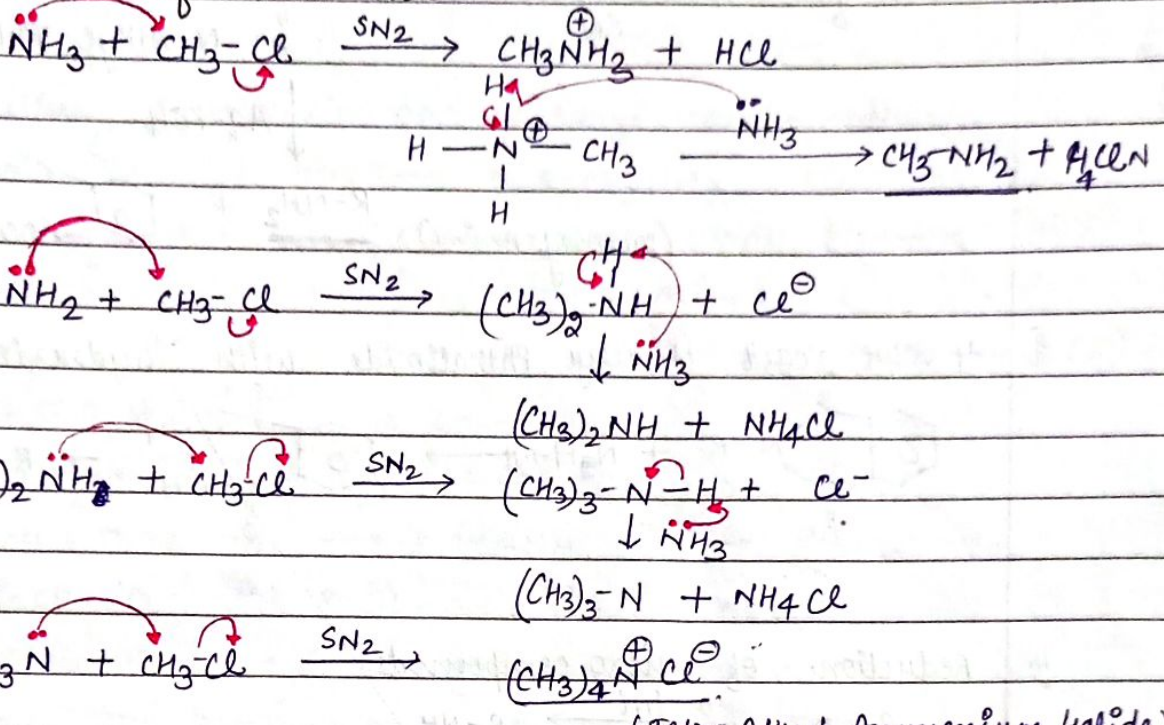
N atom is chiral. So, it should be optically active. but it isn't due to Amine Inversion.

The frequency of oscillation is so high that it ~~can~~ exist as a racemic mixture. optical Activity is thus not detected

Page No :

* Preparation of Amines.

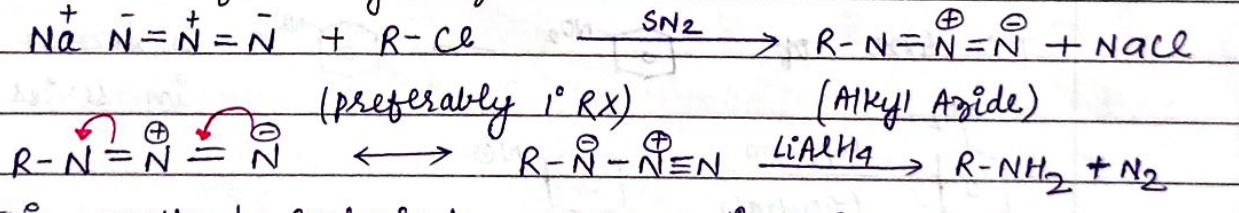
1. Alkylation of Ammonia



* If we use NH_3 in excess, primary Amine is major.
If we use CH_3-Cl in excess, Quarternary salt is major.
→ Rate of this reaction $\propto \frac{1}{\text{Steric Hindrance}}$.

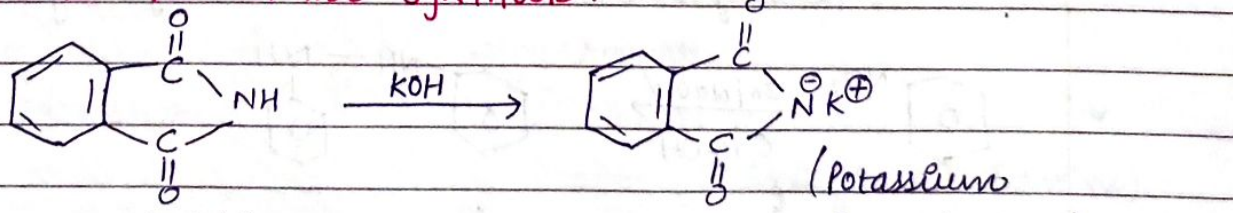
This rxn is called "HOFFMANN AMMONOLYSIS".

2. Reduction of Alkyl Azides.

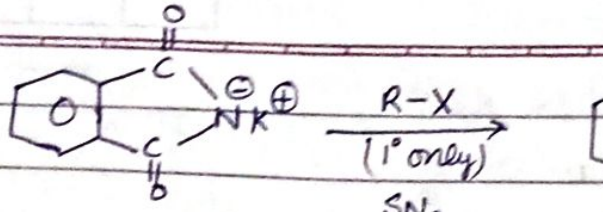


This method exclusively prepares 1° Amine.

3. GABRIEL PHTHALIMIDE SYNTHESIS.

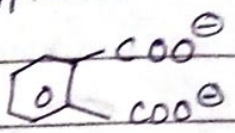


(Phthalimide) (Potassium Phthalimide)

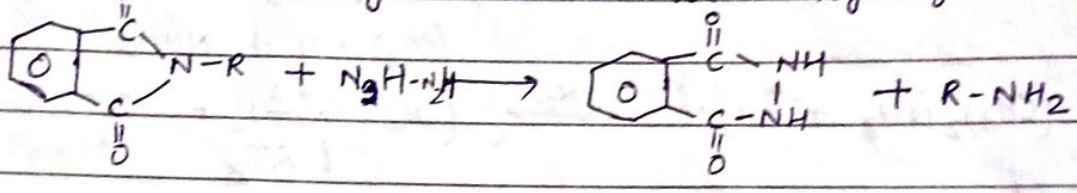


N-Alkyl Phthalimide.

↓ Aq KOH

(primary Amine) $R-NH_2$ + 

(#) If we react N-alkyl Phthalimide with hydrazine.

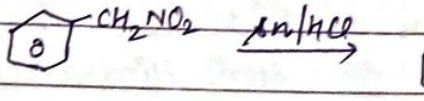


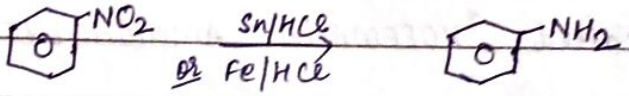
4. Reduction of nitro compounds.

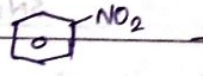
$R-NO_2 \xrightarrow{H_2/Ni} R-NH_2$

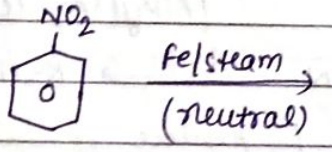
Other reducing agents are $LiAlH_4$; Sn/HCl.

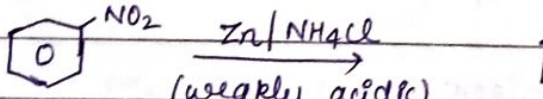
$CH_3CH_2NO_2 \xrightarrow{LiAlH_4} CH_3CH_2NH_2$.



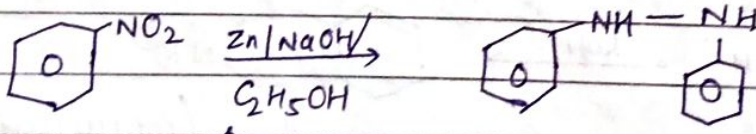


This rxn of  is ~~started~~ proceeded in series.

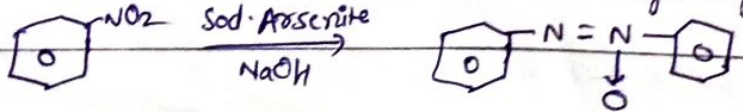




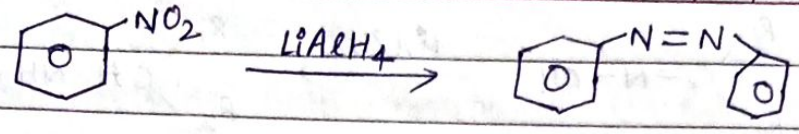
(N phenyl hydroxylamine).



(Phenyl hydrazine).



Azoxy benzene



(Azobenzene)

5. Reductive Amonolysis of carbonyl compounds.

$$R-\overset{O}{\overset{\|}{C}}-H + H_2 + NH_3 \longrightarrow R-CH_2NH_2 \quad (1^\circ)$$

$$R-CH=O + H_2NCH_2R \longrightarrow R-CH=NCH_2R \xrightarrow[\text{(Imine)}]{H_2/Pt} (RCH_2)_2NH \quad (2^\circ)$$

$$R-CH=O \xrightarrow{H_2/Pt} R-CH_2-OH$$

$$(R-CH_2)_2NH + HO-CH_2R \longrightarrow (RCH_2)_3N$$

$$R-CH=O + NH_3 \longrightarrow R-CH=NH \xrightarrow{H_2/Pt} R-CH_2-NH_2$$

$$R-CH=O \xrightarrow{H_2/Pt} R-CH_2-OH \xrightarrow{NH_3} R-CH_2-NH_2$$

There are two ways to produce 1° Amine.

6. Reduction of Cyanides, Isocyanides, Oximes & Amides.

$$R-C\equiv N + LiAlH_4 \longrightarrow R-CH_2NH_2$$

$$R-C\equiv N + H-AlH_3 \longrightarrow R-C(H)=N^{\ominus}-AlH_3$$

$$R-CH=N-AlH_2 \xrightarrow{H_2O} R-CH_2-NH_2 + AlH_3$$

$$R-C\equiv N \xrightarrow{Na-C_2H_5OH} R-CH_2-NH_2$$

"MENDIVER REACTION"

$$R-C\equiv N \xrightarrow{H_2/Ni} R-CH_2-NH_2$$

* Isocyanides give secondary Amine.

$$R-N^{\oplus}\equiv C^{\ominus} \xrightarrow[\text{or } H_2/Ni \text{ or } Na-C_2H_5OH]{LiAlH_4} R-NH-CH_3$$

(N-methyl Alkylamine).

Page No :

(*) Oximes : $R_1R_2C=N-OH \xrightarrow{LiAlH_4} R_1R_2CH-NH_2$

(*) Amides : $R-\overset{O}{\overset{\|}{C}}-NH_2 \xrightarrow{LiAlH_4} R-CH_2NH_2$ (1°)

7. HOFFMANN'S BROMAMIDE DEGRADATION REACTIONS.

$R-\overset{O}{\overset{\|}{C}}-NH_2 + Br_2 + 4KOH \longrightarrow R-NH_2 + 2KBr + K_2CO_3$

$R-\overset{O}{\overset{\|}{C}}-\underset{H}{N}-H + \bar{O}H \longrightarrow R-\overset{O}{\overset{\|}{C}}-\overset{\ominus}{\underset{H}{N}} \xrightarrow[-Br^-]{Br-Br} R-\overset{O}{\overset{\|}{C}}-\underset{H}{N}-Br$

$\downarrow \bar{O}H$

$R-N=C=O \xleftarrow{RDS} R-\overset{O}{\overset{\|}{C}}-\ddot{N}: \xleftarrow{-Br^\ominus} R-\overset{O}{\overset{\|}{C}}-\overset{\ominus}{N}-Br$

(Isocyanate) (Nitrene)

$R-N=C=O + \overset{\ominus}{O}H \longrightarrow R-\overset{\ominus}{N}=\underset{OH}{C}-\overset{\ominus}{O} \longleftrightarrow R-\overset{\ominus}{N}-\underset{OH}{C}=O$

$\downarrow H_2O, (-\bar{O}H)$

$\boxed{R-NH_2} + CO_2 \longleftarrow R-\overset{\oplus}{N}H_2-\underset{O^\ominus}{\underset{|}{C}}=O \longleftarrow R-NH-\underset{OH}{\underset{|}{C}}=O$

(carbamic acid) unstable

$CO_2 + 2KOH \longrightarrow K_2CO_3 + H_2O$

★ This is involving "Descent of chain".

* Chemical properties of Amine.

1. CARBYLAMINE REACTION

$R-NH_2$ (or $Ar-NH_2$) $+ CHCl_3 + KOH \longrightarrow R-\overset{\oplus}{N}\equiv C^\ominus$ (or $Ar-\overset{\oplus}{N}\equiv C^\ominus$) $+ 3KCl + 3H_2O$

$CHCl_3 + \bar{O}H \longrightarrow \overset{\ominus}{C}Cl_3 + H_2O$

$\longrightarrow Cl^- + \ddot{C}Cl_2$ (Dichlorocarbene)

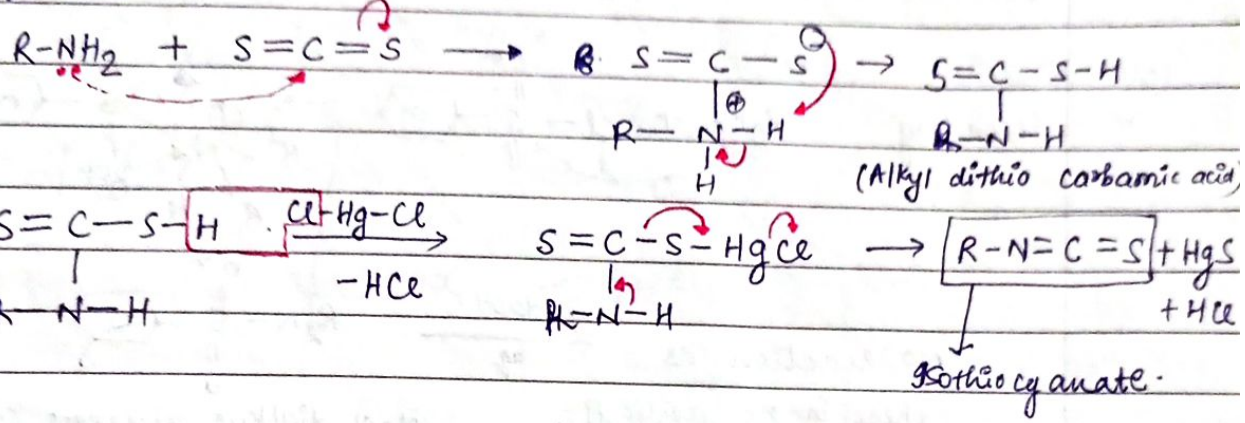
$R-\underset{H}{\overset{H}{\underset{|}{\overset{|}{N}}}}: + \ddot{C}Cl_2 \longrightarrow R-\overset{H}{\underset{H}{\overset{|}{\underset{|}{\overset{\oplus}{N}}}}}-\overset{\ominus}{C}(Cl)(Cl) \longrightarrow R-\overset{\oplus}{N}\equiv C-Cl$

→ $R-\overset{\oplus}{N}\equiv C^{\ominus}$ + HCl

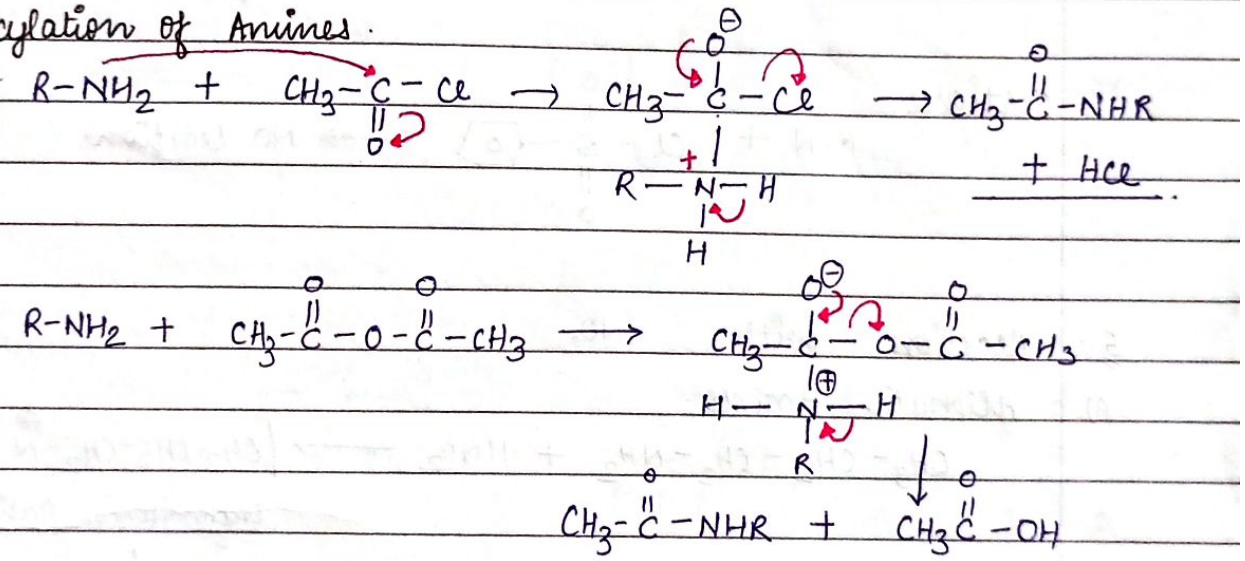
(bad smelling smell compound & hence used as a test for primary Amines).

2. **HOFFMANN MUSTARD OIL REACTION**

Primary Amines react with CS_2 & $HgCl_2$ to form Isothio cyanates.



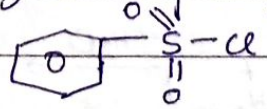
3. Acylation of Amines.



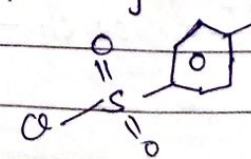
4. **HINSBERG REACTION**

It is used to differentiate b/w 1°, 2° & 3° Amine.

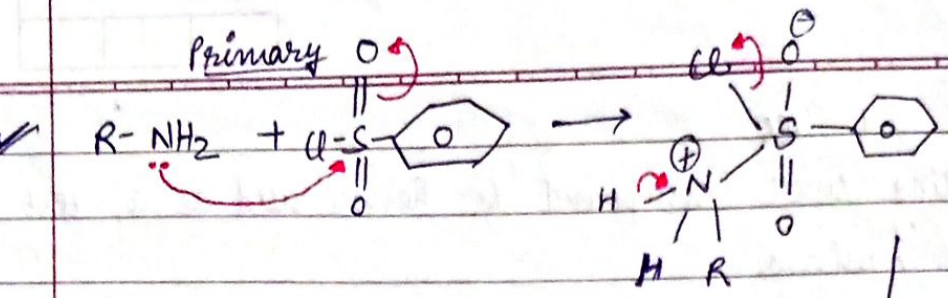
Hinsberg reagent = Benzene sulphonyl chloride

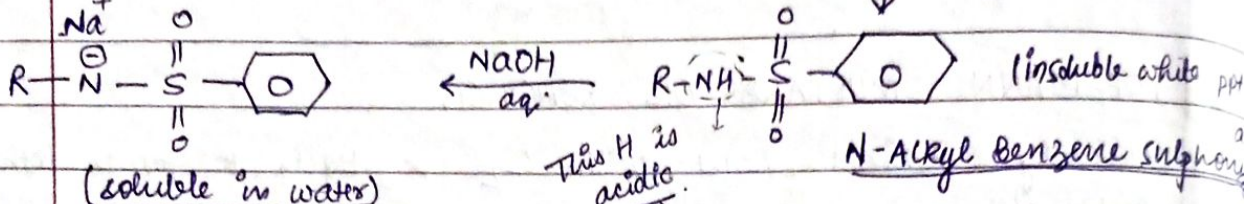


We can also use p-methyl benzene sulphonyl chloride



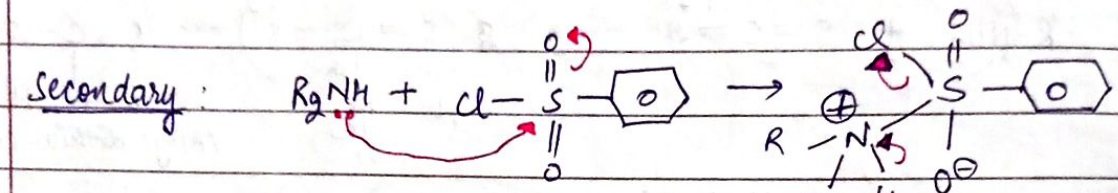
Primary

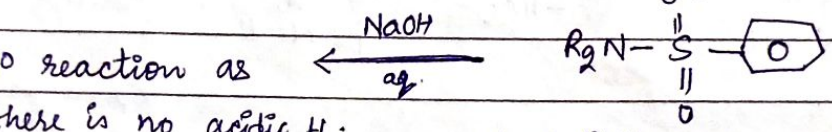




N-Alkyl Benzene sulphonamide

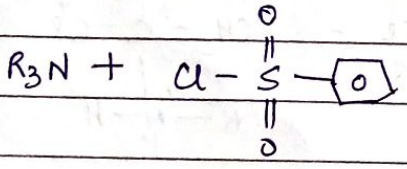
Secondary :





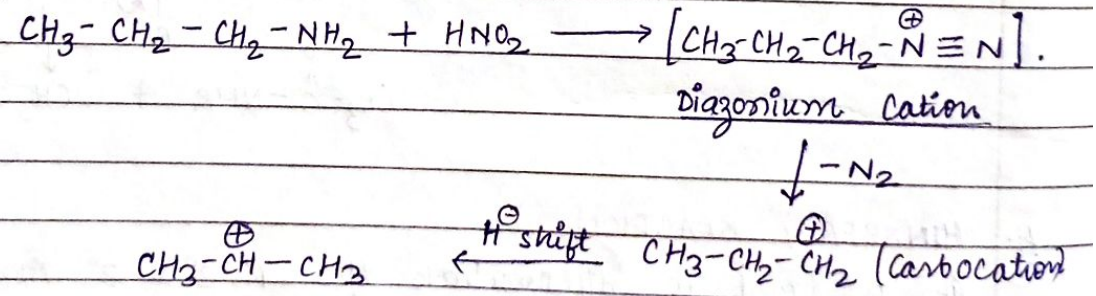
N-N dialkyl Benzene sulphonamide

Tertiary.

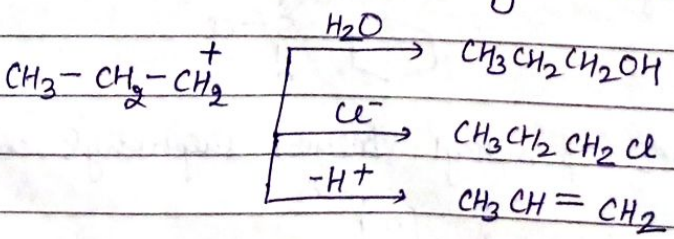


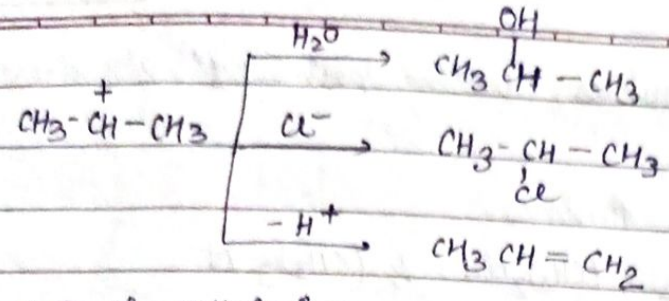
5. Reaction with HNO_2.

A) Aliphatic Amines.



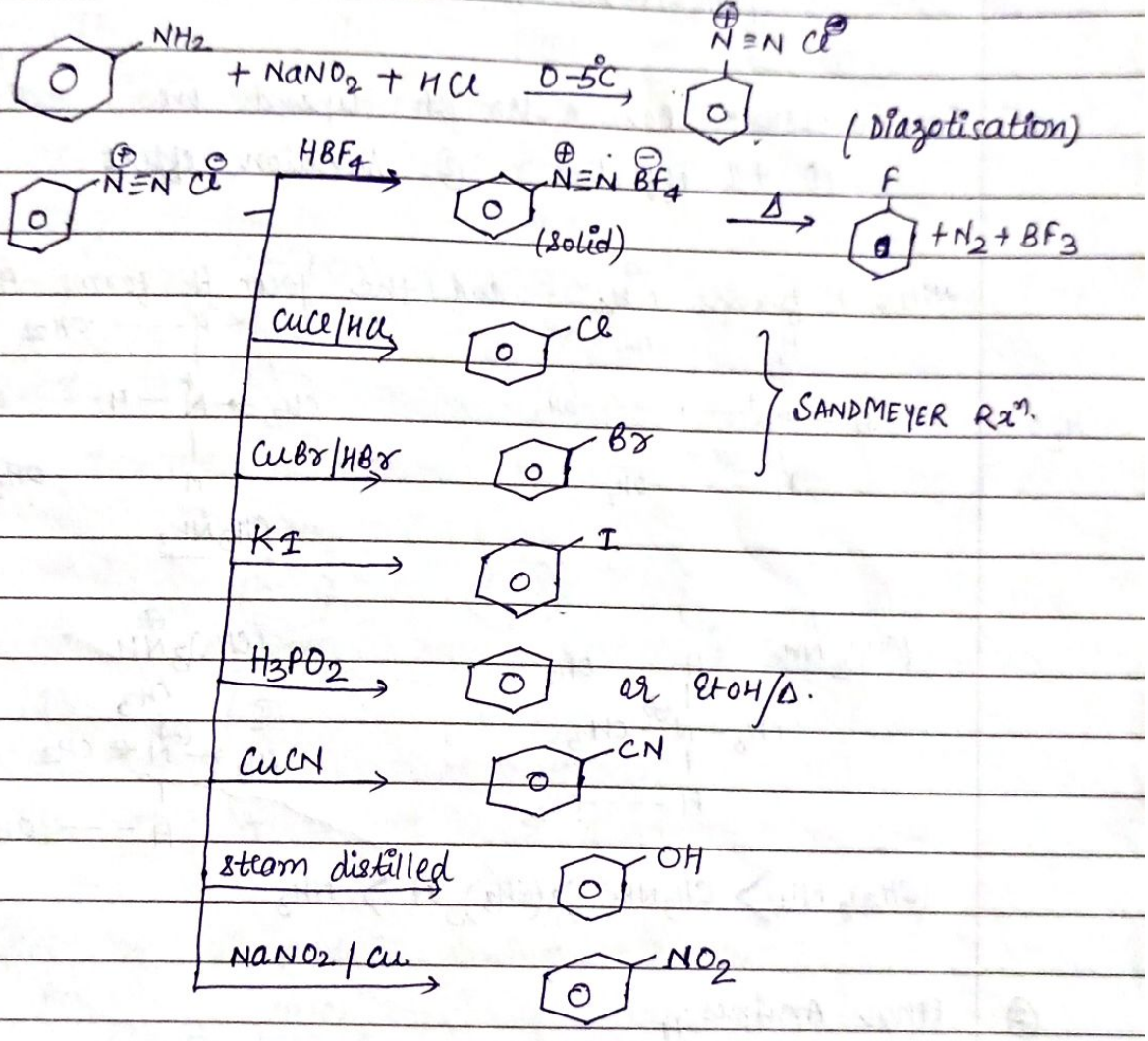
The carbocation can undergo elimination, substitution, etc..





* In case of methylamine, CH_3-OH isn't major product. ⇒ CH_3-O-CH_3 is formed

8) Aromatic Amines



6. CH_3-NH_2 and $C_2H_5-NH_2$ are gases at room temperature. Amines having 3 carbon atom & are are liquid at room temperature while high molecular mass amines are solid at room temperature.

Among isomeric amines, $1^\circ RNH_2 > 2^\circ R_2NH > 3^\circ R_3N$. (solubility in water). as hydrogen bond is $1^\circ > 2^\circ > 3^\circ$

In higher amines : steric effect dominates.

i.e. $(Pr)_2NH > PrNH > Pr_3N$.

Page No :

Among isomeric amines, boiling point $1° > 2° > 3°$.

Basic Nature of Amines

① NH_3, CH_3NH_2, $(CH_3)_2NH$ & $(CH_3)_3N$

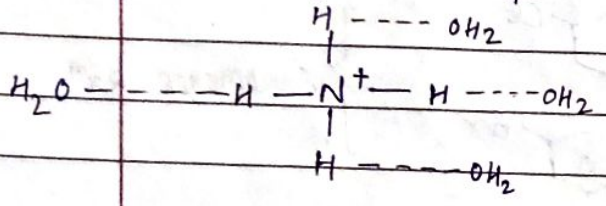
In non aqueous solvent, basic nature $\propto$ +I effect

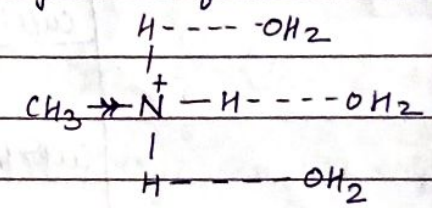
$(CH_3)_3N > (CH_3)_2NH > CH_3NH_2 > NH_3$

In water : Basic strength depends on

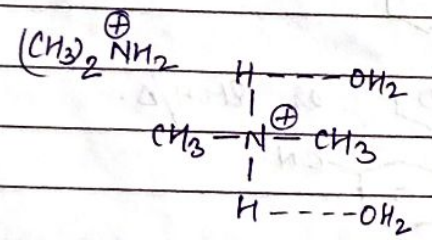
① +I effect ② Solvation effect

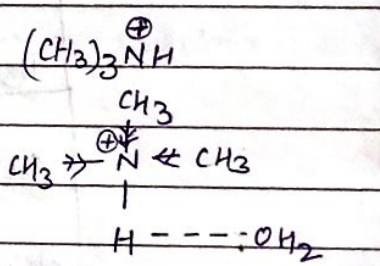
NH_3 → forms $\overset{\oplus}{N}H_4$ and the four H forms H-bonds.





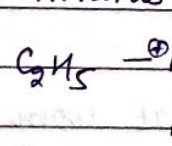
$CH_3\overset{+}{N}H_3$.





$(CH_3)_2NH > CH_3NH_2 > (CH_3)_3N > NH_3$.

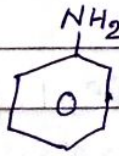
② Ethyl Amines.



$(C_2H_5)_2NH$, $(C_2H_5)_3N$.

$(C_2H_5)_2NH > (C_2H_5)_3N > (C_2H_5)NH_2 > NH_3$

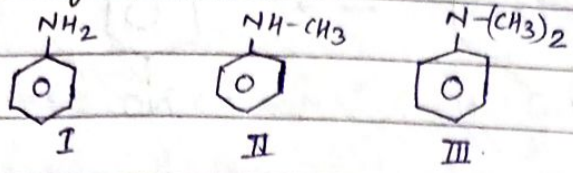
③ Aromatic Amines.



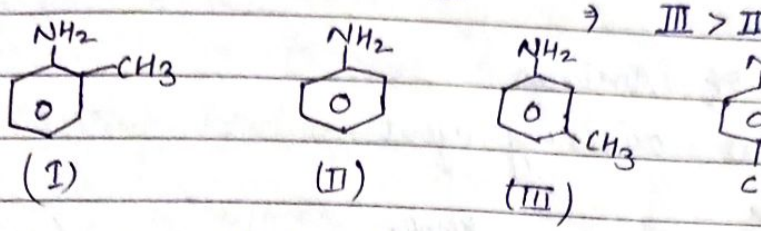
since the lone pair on Nitrogen is delocalised in resonance, they are much less basic than Aliphatic Amines.

Page No :

Effect Of Substituents.

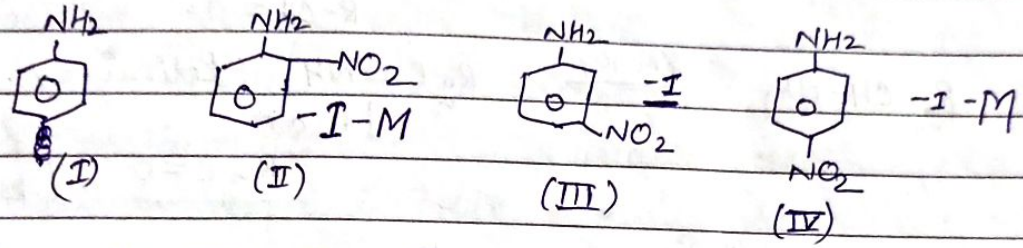
① 

→ III > II > I.

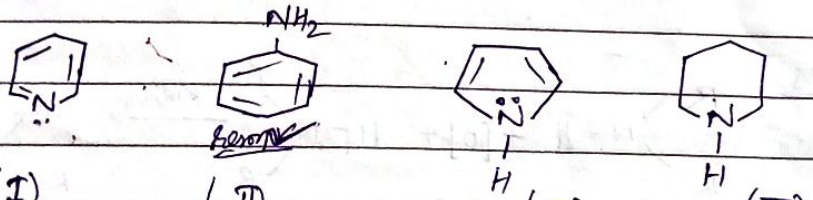
② 

Due to ORTHO EFFECT, I is least basic.

∴ IV > III > II > I.

③ 

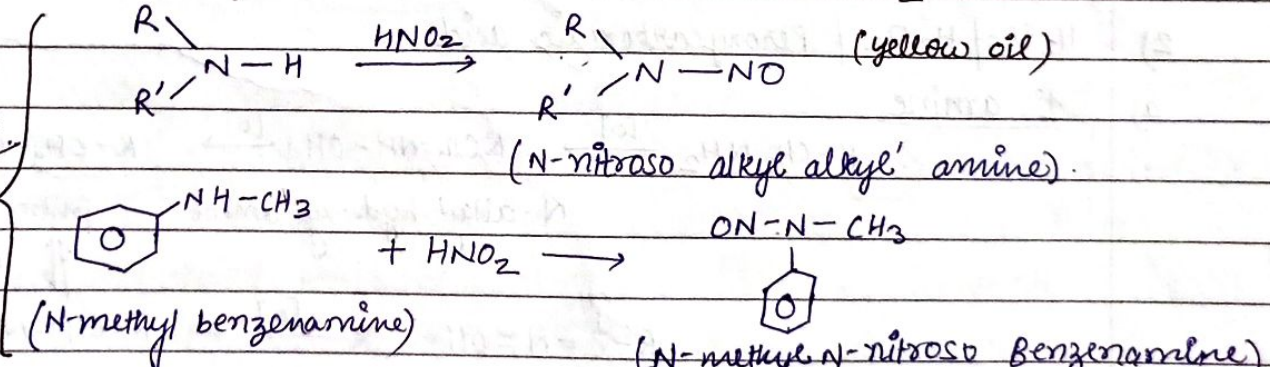
∴ I > III > IV > II

④ 

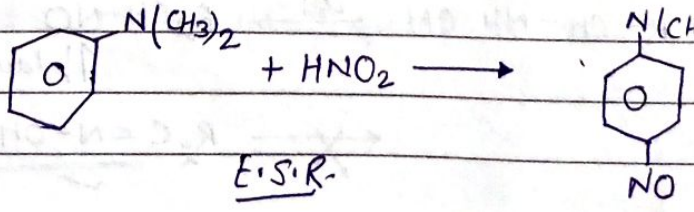
IV > I > II > III

I. Reaction of 2° and 3° Amines with HNO_2.

LIEBER MANN'S nitroso test.

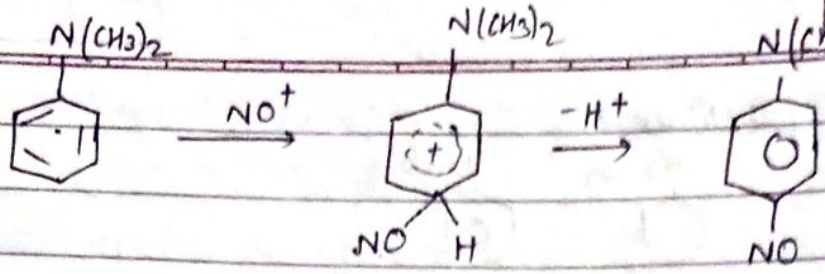


$R_3N + HNO_2 \longrightarrow$ No reaction.



p-nitroso N-N-dimethyl benzenamine

Phenol also gives secondary amine (red + blue)



8. Oxidation of Amines

1) $KMnO_4$ as oxidising agent :

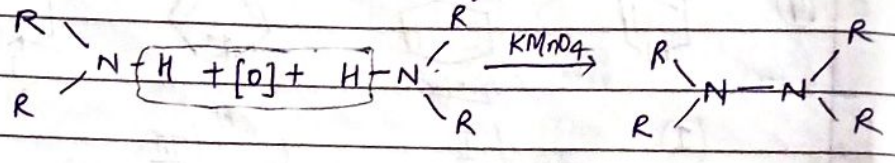
a) 1° amines.

$R-CH_2-NH_2 \xrightarrow{KMnO_4} R-CH=NH$ (Aldimine) $\xrightarrow{H_3O^+} R'-CH=O$

$R_2-CH-NH_2 \xrightarrow{KMnO_4} R_2C=NH$ (ketimine) $\xrightarrow{H_3O^+} R_2C=O$ (ketone)

$R_3C-NH_2 \xrightarrow{KMnO_4}$ No reaction

b) 2° Amines



(N-N tetra alkyl hydrazine)

c) 3° Amines :

$R_3N \xrightarrow{KMnO_4}$ No reaction

2) H_2SO_5 / H_2O_2 / Peroxycarboxylic acid.

a) 1° amine

$R-CH_2NH_2 \xrightarrow{[O]} RCH_2-NH-OH \xrightarrow{[O]} R-CH_2-NO$

N-alkyl hydroxyl amine (nitroso alkane)

$\rightleftharpoons$ Tautomer

$R-\overset{OH}{C}=N\overset{\alpha}{=}OH \xleftarrow{[O]} R-CH=NOH$

(Hydroxamic acid)

$R_2CH-NH_2 \xrightarrow{[O]} R_2-CH-NH-OH \xrightarrow{[O]} R_2CH-NO$

$\rightleftharpoons$ Tautomerise

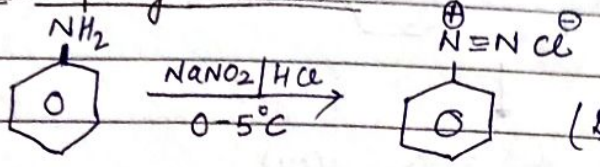
$\not\leftrightarrow R_2C=N-OH$ (ketoxime)

$R_3C-NH_2 \xrightarrow{[O]} R_3C-NH-OH \xrightarrow{[O]} R_3C-NO$

b) 2° Amine: $R\,CH_2\,NH\text{-}R' \xrightarrow{[O]} R-CH_2-\overset{OH}{\underset{|}{N}}-R'$

c) 3° Amines: $R_3N \xrightarrow{[O]} R_3\overset{\oplus}{N}-O^{\ominus}$ (oxo amines)

9. Azo Coupling Reactions

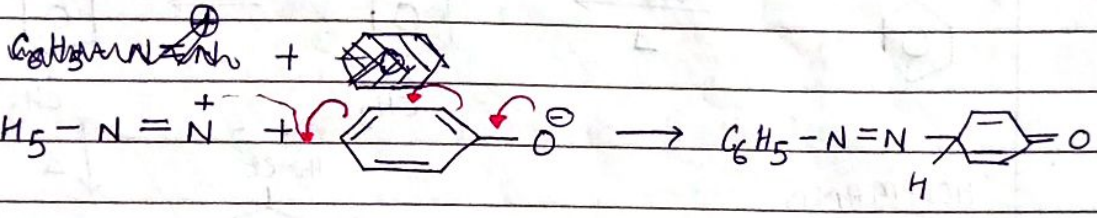


(Diazonium salts).

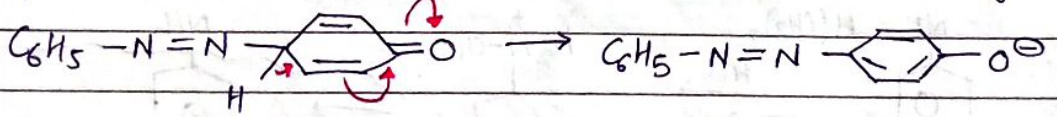
✓ Coupling reaction with phenol:

$C_6H_5-\overset{\oplus}{N}\equiv N \longleftrightarrow C_6H_5-N=\overset{\oplus}{N}$

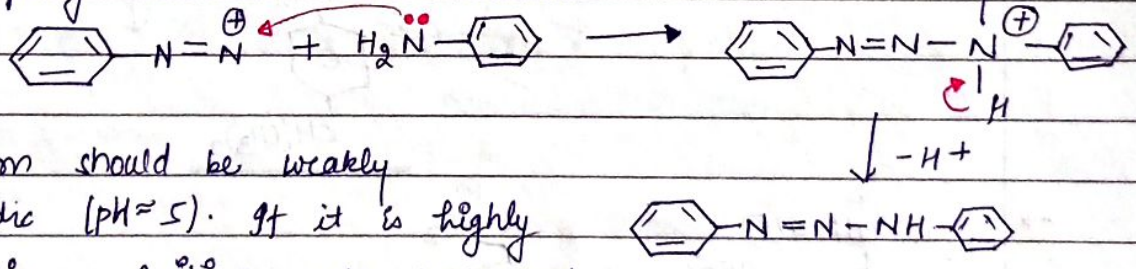
The medium should be weakly alkaline (pH ≈ 8). because as phenol is weak acid, substitution reaction can also take place. weakly alkaline medium neutralizes phenol.



para product is main due to steric hindrance at ortho position. If para is blocked, then ortho is major.



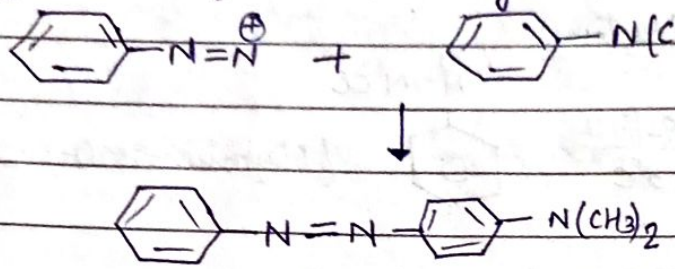
✓ Coupling reaction with Aniline



medium should be weakly acidic (pH ≈ 5). If it is highly acidic, Aniline gets protonated and no coupling reaction takes place.

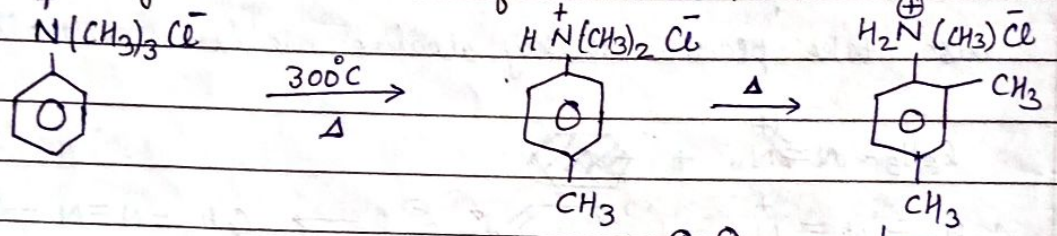
→ If secondary Aniline is used, steric hindrance increases at nitrogen. So, partial N-N coupling & partial N-C coupling will take place.

→ If tertiary aniline is used, steric hindrance increases largely at Nitrogen. So, only N-C coupling takes place.



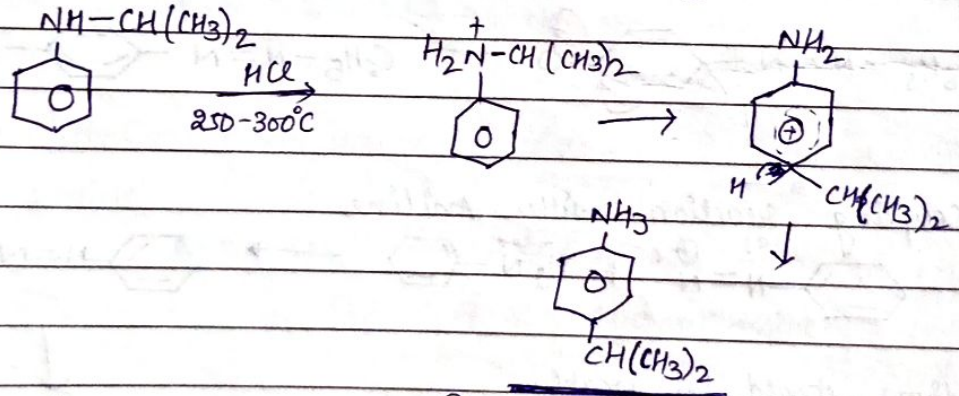
(N-C coupling product).

10. Rearrangement Reaction of Aromatic Amines.

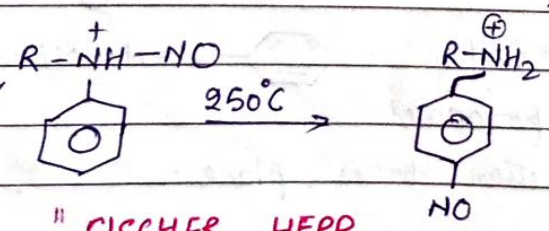


"HOFFMANN-MAURTIUS REARRANGEMENT REACTIONS"

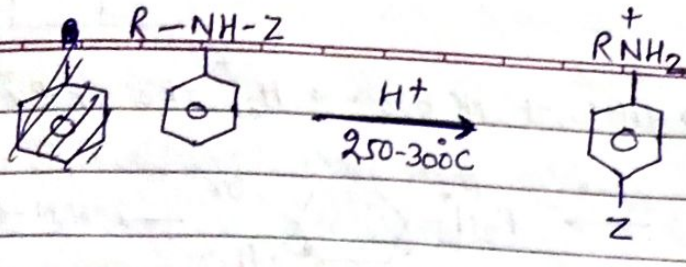
→



→

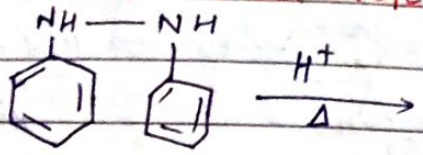


"FISCHER HEPP REARRANGEMENT"

→ 

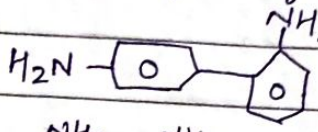
(Z = NO, NO2, NH2, OH, R, etc.)

11. BENZIDENE REARRANGEMENT

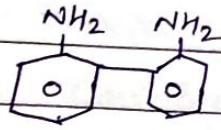


(major)

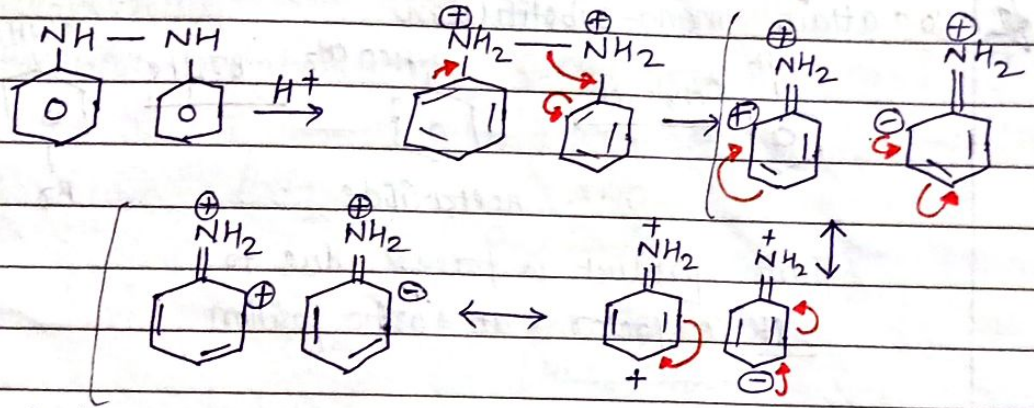
(p.p' benzidene) 70-90%

10-30% { + 

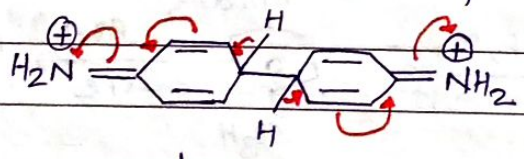
(o,p' benzidene)

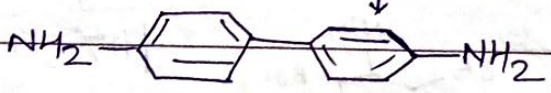
+ 

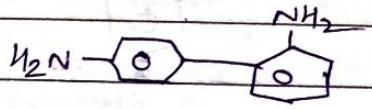
(o,o' benzidene)

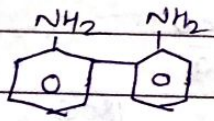
Mechanism 

(+) and (−) combine to form coupled product.

Case1 para & para : 

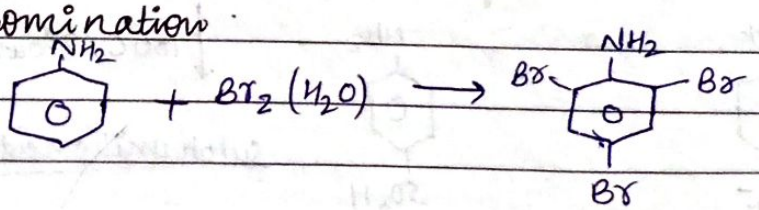


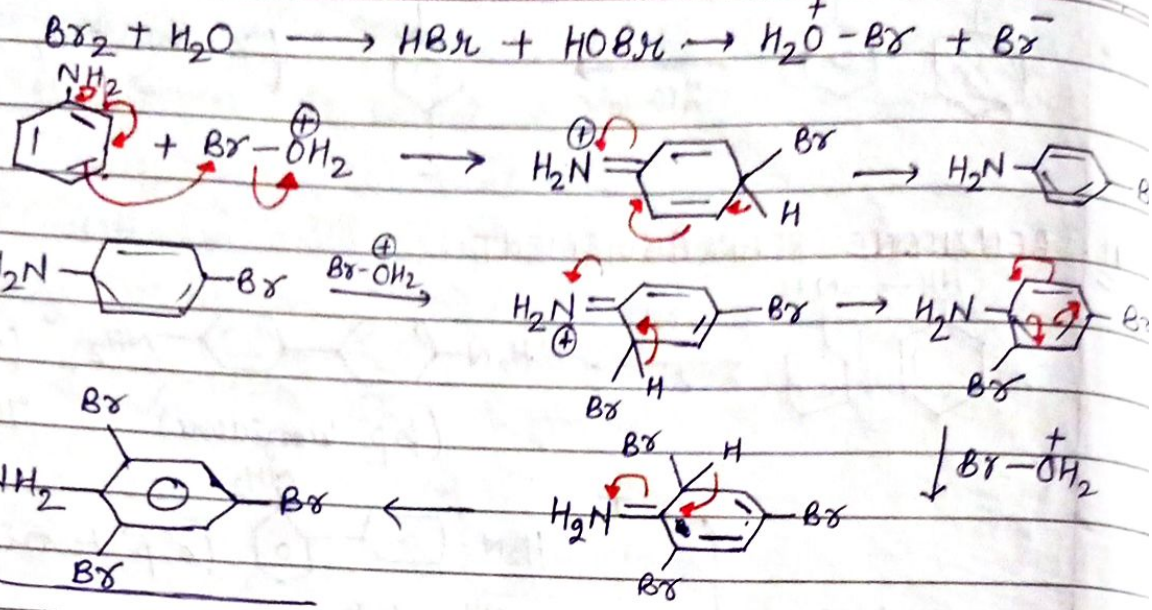
Case2 ortho & para. 

Case3 ortho & ortho 

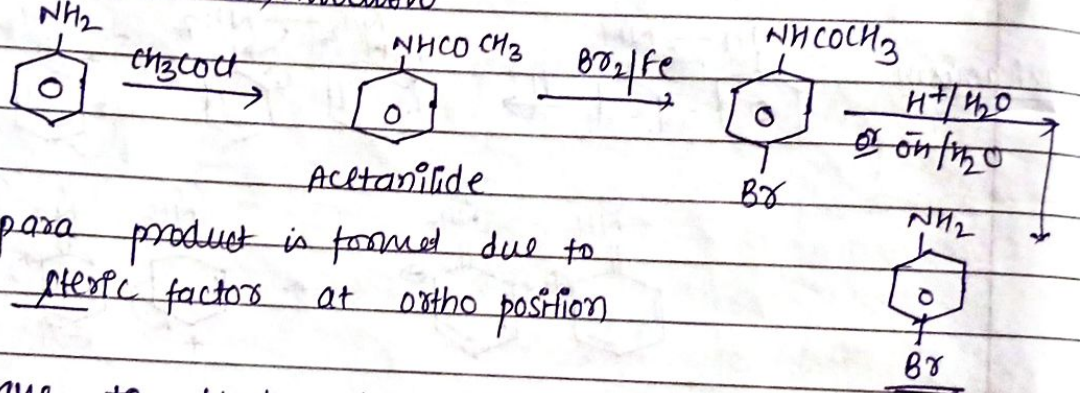
12. Electrophilic Aromatic Substitution Reactions

A) Bromination.





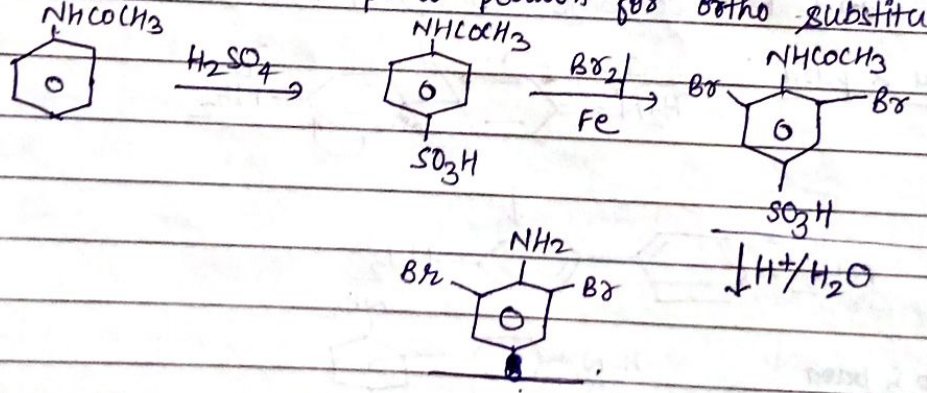
★ To attain mono-substitution



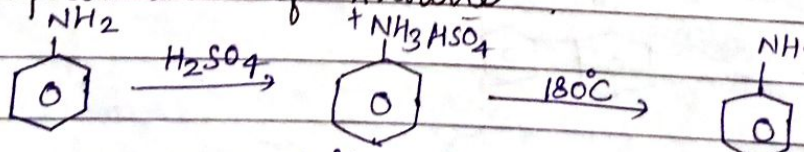
Acetanilide

para product is formed due to steric factors at ortho position

We have to block para position for ortho substitution.



B) Sulphonation of Aniline

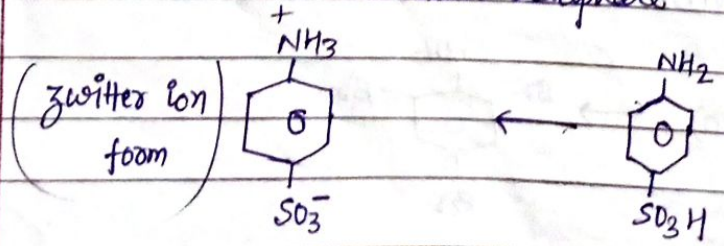


Anilium Bisulphate

Sulphamic Acid

↓ 180°C, 3 hours

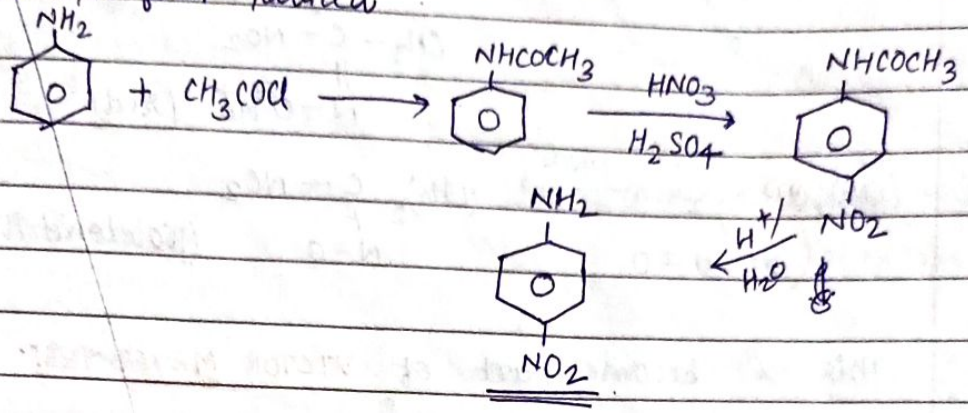
Sulphanilic acid



Page No :

c) Nitration

Direct Nitration may cause oxidising of Aniline so, reactivity of Aniline is first reduced

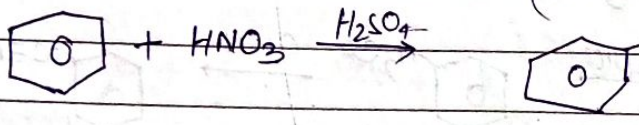


(#) Other organic Compounds Containing Nitrogen.

* Nitro Compounds

Preparation $CH_3CH_2CH_2Br + AgNO_2 \longrightarrow CH_3CH_2CH_2-NO_2 + AgBr$

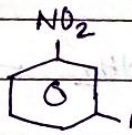
(1 nitro propane)



(nitrobenzene)

(brown liquid)

$\downarrow HNO_3 / H_2SO_4$



(yellow solid)

Properties:

① $CH_3-CH_2-\overset{\oplus}{N}(=O)-O^{\ominus} \leftrightarrow CH_3-CH_2-\overset{+}{N}(-O^{\ominus})=O$

② $CH_3-CH_2-\overset{+}{N}(=O)-O^{-}$ ⇌ (Tautomers) $CH_3-CH=\overset{+}{N}(-OH)-O^{-}$

(nitro form) (Acinitro form)

③ $CH_3CH_2NO_2 \xrightarrow[CH_3Br]{C_2H_5ONa} CH_3-\underset{CH_3}{CH}-NO_2$

$CH_3CH_2NO_2 + C_2H_5O^{-} \xrightarrow{-C_2H_5OH} CH_3-\overset{\ominus}{C}H-NO_2 \xrightarrow{\overset{\oplus}{CH_3}\,\overset{\ominus}{Br}} \underset{\text{(2 nitro propane)}}{CH_3-\underset{CH_3}{CH}-NO_2}$ (S_N2)

④ $CH_3-CH_2-NO_2 \xrightarrow{HNO_2}$ $CH_3-C(=N-OH)-NO_2$ (nitrolic acid)

$O=N-OH$

$\xrightarrow{NaOH}$ $CH_3-C(=N-O^{\ominus}Na^{\oplus})-NO_2$ (red)

$(CH_3)_2CH-NO_2 \xrightarrow{HNO_2}$ $(CH_3)_2C(N=O)-NO_2$ (pseudonitrole) · blue

$OH-N=O$

This rxn become part of VICTOR MEYER TEST.

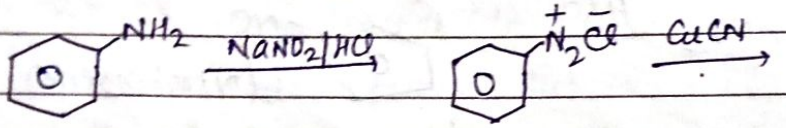
* Cyanides and Isocyanides

Preparation :

$CH_3-CH_2-Br + NaCN \xrightarrow{SN_2} CH_3-CH_2-CN$ (cyanide)

$CH_3-CH_2-Br + AgCN \xrightarrow{SN_2} CH_3-CH_2-\overset{\oplus}{N}\equiv C^{\ominus}$ (isocyanide)

$R-NH_2 + CHCl_3 + KOH \longrightarrow R-\overset{\oplus}{N}\equiv C^{\ominus} + KCl + H_2O$



Properties

$R-CN \xrightarrow[\text{or } \bar{O}H/H_2O]{H^+/H_2O} R-\overset{O}{\overset{\|}{C}}-NH_2 \xrightarrow{H^+/H_2O} R-COOH$

(partial hydrolysis) (complete hydrolysis)

$R-C\equiv N \xrightarrow[LiAlH_4]{H_2/Ni} RCH_2NH_2$

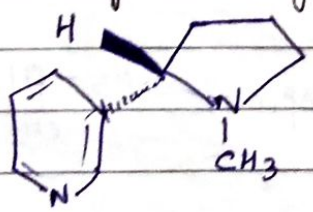
(Partial reduction) $R-C\equiv N \xrightarrow{SnCl_2/HCl} RCH=NH \xrightarrow{H^+/H_2O} R-CH=O.$

(Imine) (Stephen's reduction)

$R-\overset{+}{N}\equiv\bar{C} \xrightarrow{LiAlH_4} R-NH-CH_3$

$R-\overset{+}{N}\equiv\bar{C} \xrightarrow{H_2O} R-NH_2 + HCOOH$

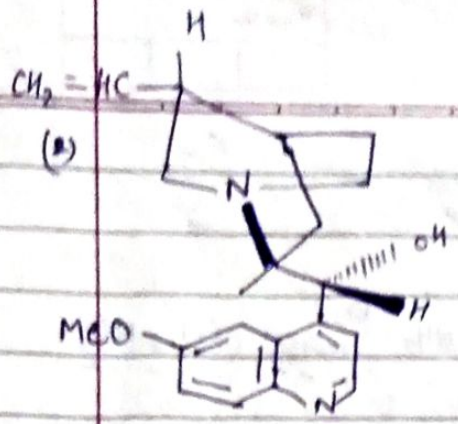
\# Naturally occuring Amines

1) 

Nicotine

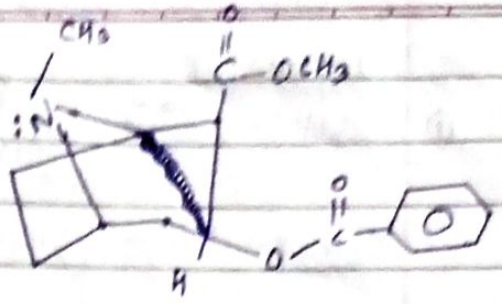
(Principal alkaloid from tobacco)

(2)



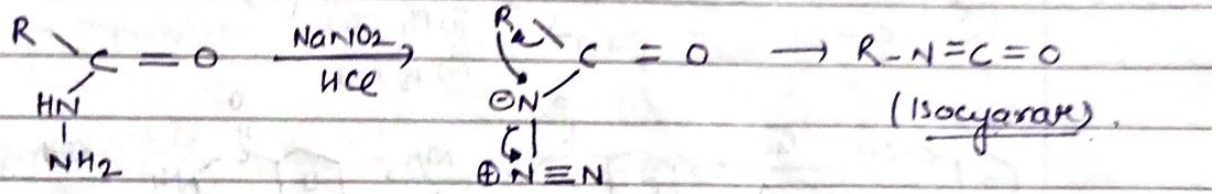
Quinine
(Anti malarial drug)

(3)

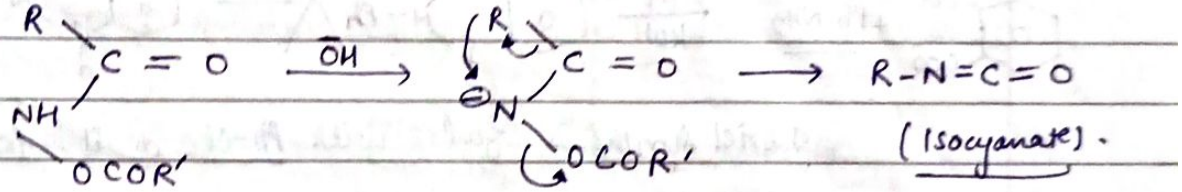


Cocaine (Stimulant of Central nervous System)

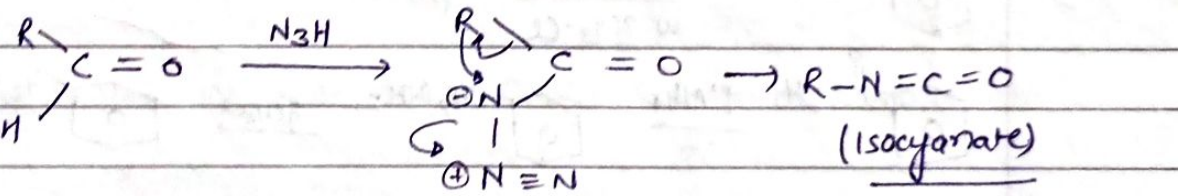
CURTIUS Reaction



LOSSEN reaction



SCHMIDT reaction



ZININ Reduction