III – B.Sc – CHEMISTRY

SEMESTER – V
SPECIAL TOPICS IN CHEMISTRY

UNIT –5: Molecular Rearrangements (10 hrs)

Types of rearrangements - mechanism of pinacol-pinacolone, benzyl-benzilic acid, bezindine, Favorski, dienone- phenol, Claisen, Fries, Hoffmann, Curtius, Schmidt and Beckmann rearrangements.

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Assistant Professor,
Dept.of Chemistry,
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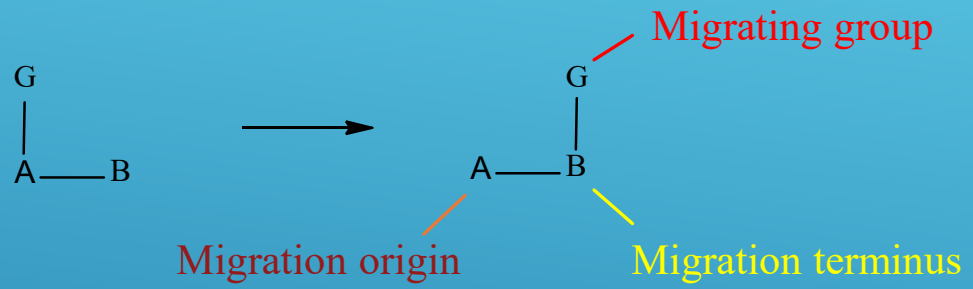
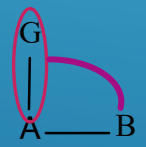
MOLECULAR REARRANGEMENTS

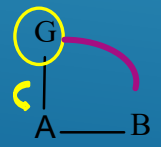
INTRODUCTION



Migrating group - G



G migrates with shared pair of electrons(bond),
as anion G- , electron-rich species
Anionotropic rearrangement



G migrates without shared pair of electrons(bond),
as cation G+ , electron-deficient species
Cationotropic rearrangement

CLASSIFICATION

(I) Based on migrating group G

(a) G as an anion – G^- - e^- rich , anionotropic rearrangement, migration to e^- deficient centre

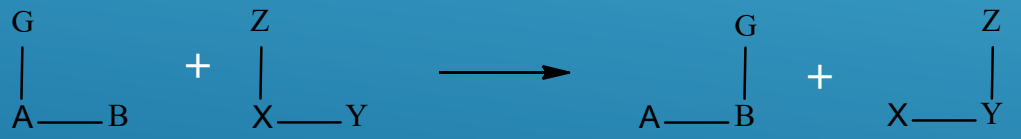
(b) G as a cation – G^+ - e^- deficient , cationic rearrangement , migration to e^- rich centre

(c) G as free radical – rare

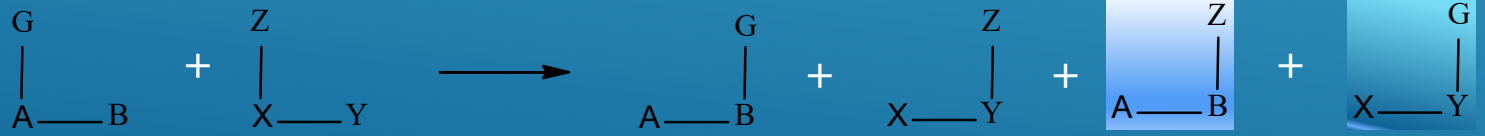
(II) Based on position of G – **Cross over experiment**

(a) Intra molecular - within same molecule – only 2 products

(b) Inter molecular – between 2 different molecules - 4 products



Intramolecular rearrangement



Intermolecular rearrangement

Migration or rearrangement to electron deficient Carbon

1. Pinacol-Pinacolone
2. Benzil-Benzilic acid

Migration or Rearrangement to electron deficient nitrogen

3. Beckmann
4. Hoffman
5. Cutius
6. Schmidt

Migration or Rearrangement to electron rich carbon-

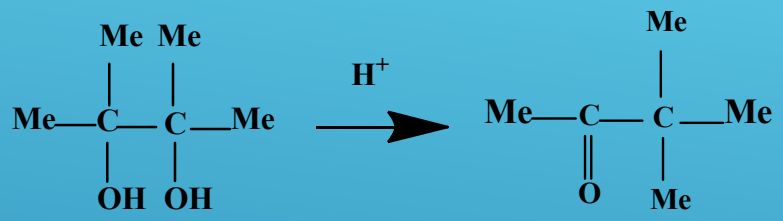
7. Favorski,

Aromatic Rearrangements

8. Fries
9. Claisen
10. Benzidine

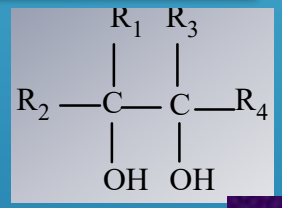
Migration or rearrangement to electron deficient Carbon

1. Pinacol-Pinacolone

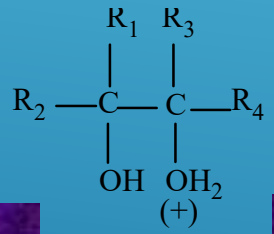


(2,3-ditertiary diol --------→ ketone/ aldehyde)

Mechanism

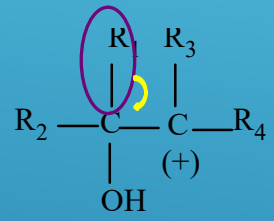


H^+ Step-1



Reversible protonation of –OH gp

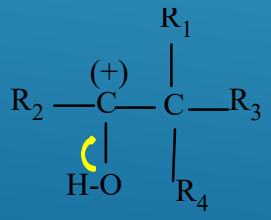
Step-2



Elimination of H2O , formation of electron-deficient carbocation

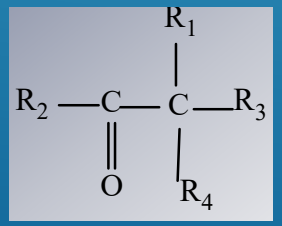
Step-3

Migration of migrating group, forms more stable carbocation

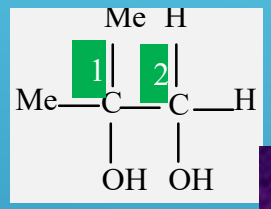


Step-4

Loss of proton

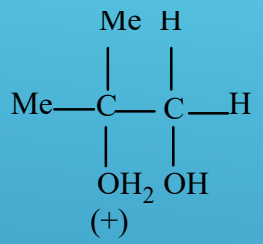


Example-1



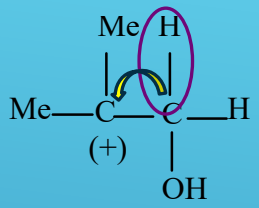
H^+ Step-1

OH attached to C1 will be protonated



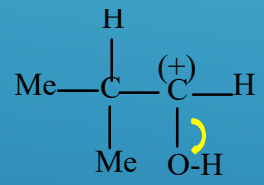
Step-2

Elimination of H2O , forms ter-carbocation



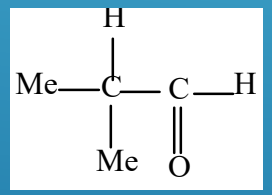
Step-3

Migration of migrating group - H



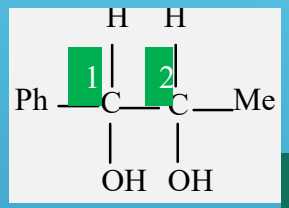
Step-4

Loss of proton



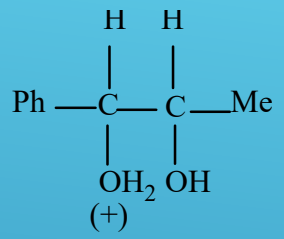
1.Which of the 2 –OH's will be protonated ?
-that –OH receives proton which produces more stable carbocation by elimination of water molecule

Example-2



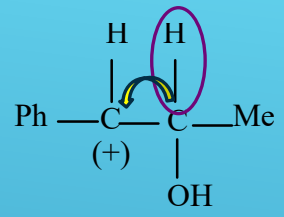
H^+ Step-1

OH attached to C1 will be protonated



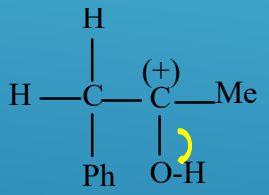
Step-2

Elimination of H2O , forms sec-carbocation which is stabilised by Ph group



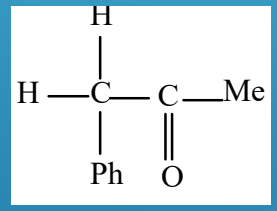
Step-3

Migration of migrating group - H



Step-4

Loss of proton

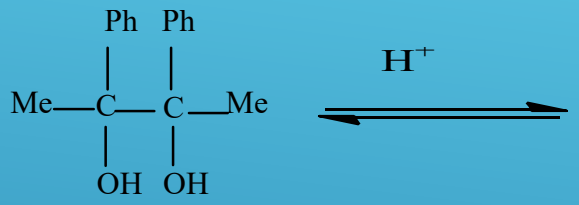


1.Which of the 2 –OH's will be protonated ?
-that –OH receives proton which produces more stable carbocation by elimination of water molecule

2. Migratory aptitude

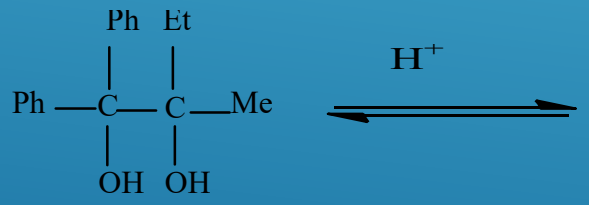
Ph > H > Me

Example-3

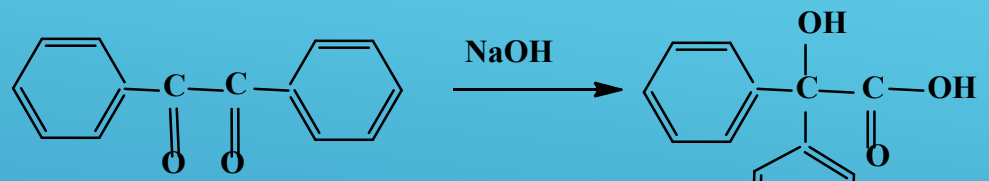


Try it yourself :

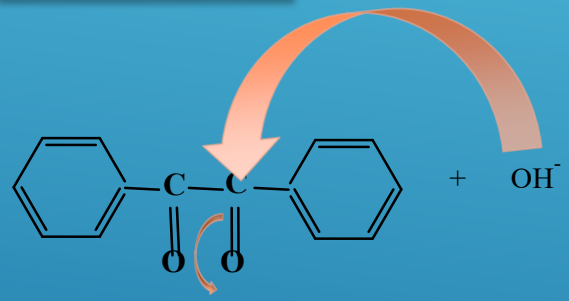
Example-4



2. BENZILIC ACID REARRANGEMENT



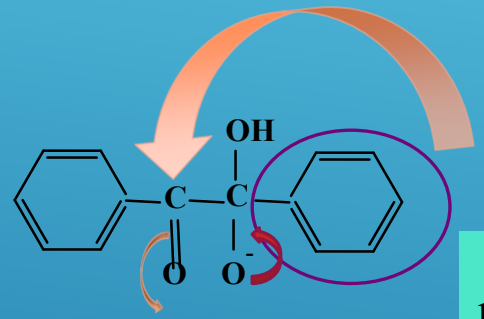
Mechanism



Aromatic diketones

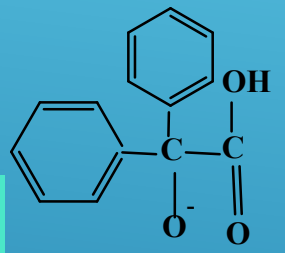
Step-1
Fast

Attack of OH ion on CO group



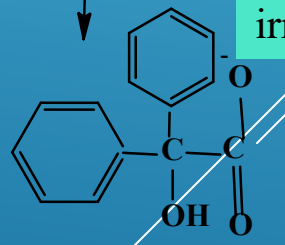
Step-2

Breakage of C=O bond



Step-3

Deprotonation of acid makes reaction irreversible

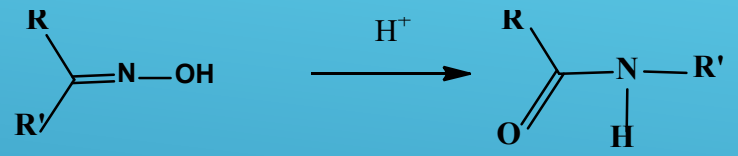


Acids

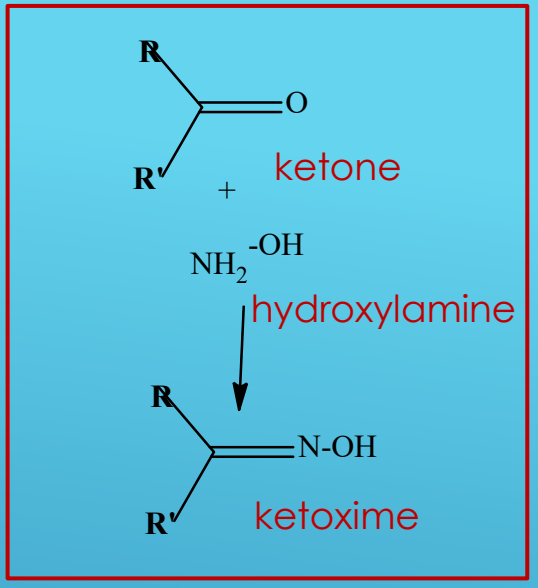
Try with (i) MeO-
(ii) t-BuO-

MIGRATION TO ELECTRON DEFICIENT NITROGEN

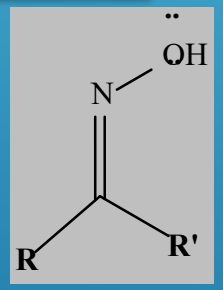
1. BECKMANN REARRANGEMENT



Oxime → Amide



Mechanism

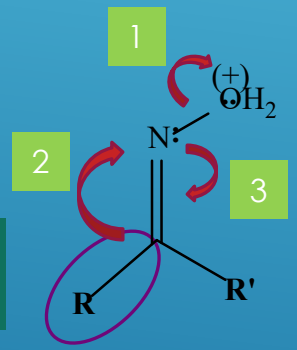


Oxime

Step-1

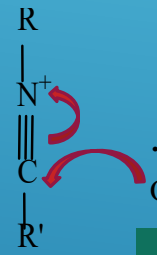
H^+

Protonation of OH group



Step-2

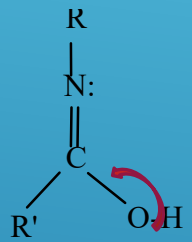
(1) Loss of H2O (N electron deficient)
(2) Migration of R towards electron deficient Nitrogen
(3) Lone pair e from N to C



Nitrilium ion

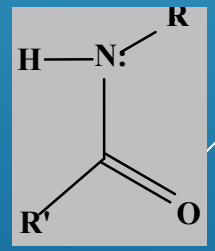
Step-3

attack of OH group to C



Step-4

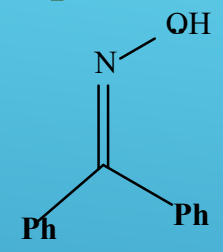
Tautomerisim (1,3-H shift)



Amide

+ H+

Example-1

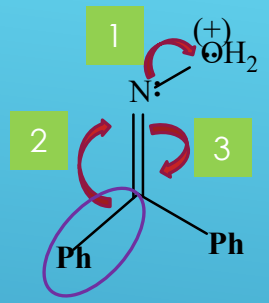


Benzophenone oxime

Step-1

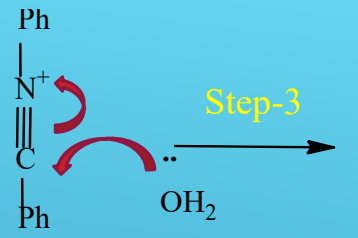
H^+

Protonation of OH group



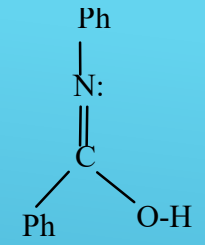
Step-2

(1) Loss of H2O (N electron deficient)
(2) Migration of Ph towards electron deficient Nitrogen
(3) Lone pair e from N to C



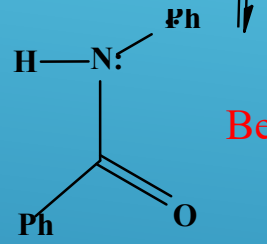
Step-3

attack of OH group to C



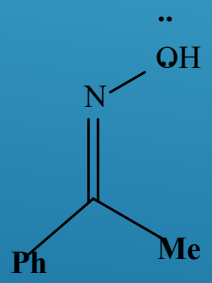
Step-4

Tautomerisim (1,3-H shift)



Benzanilide

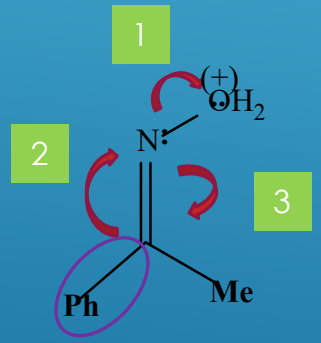
Example-2



Acetophenone oxime

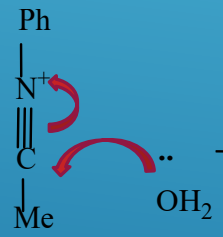
Step-1

H^+

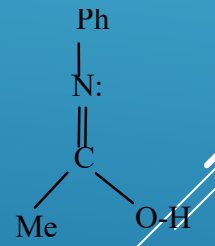


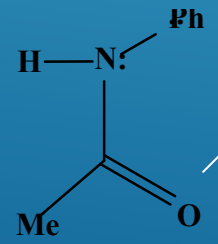
Step-2

Migratory aptitude
Group trans to the leaving group migrates



Step-3



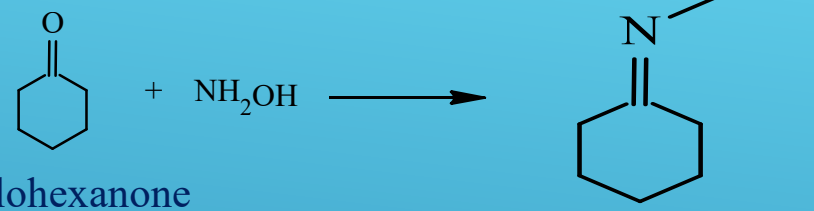


Acetanilide

Step-4

Tautomerisim (1,3-H shift)

Example-3

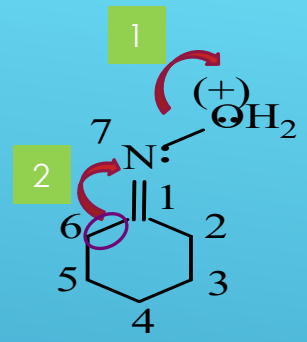


cyclohexanone

Cyclohexanone oxime

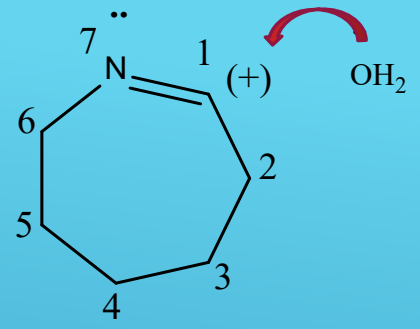
Step-1
H^+

Protonation of OH group

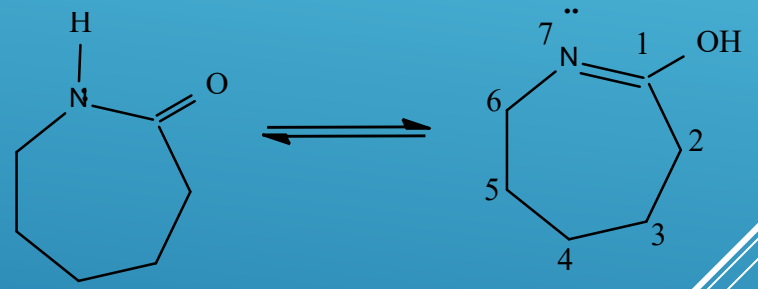


Step-2

(1) Loss of H2O
(2) Bond acts as migrating group (C6-C1 breaks)



Step-3



caprolactum

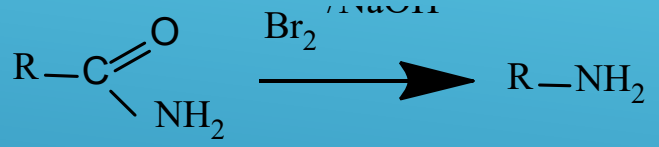
Beckmann rearrangement
Oxime ---- Anilide

Stereospecific – group trans/anti to the leaving group only migrates.

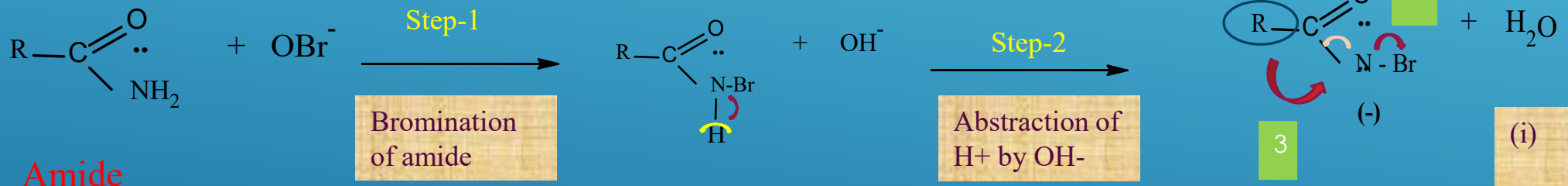
HOFMANN, CURTIUS AND SCHMIDT REARRANGEMENTS

Intermediate – R-N=C=O , Isocyanate
Product - R-NH2 , Primary amine

2. HOFMANN REARRANGEMENT

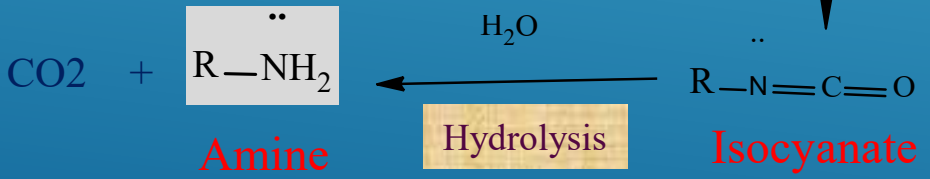


Mechanism



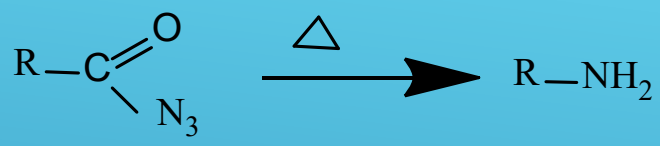
(i) Elimination of Br- (formation of e- deficient Nitrogen)
(ii) Rearrangement of R
(iii) l.p to b.p (stabilization)

Step-3



Try with
R – Me
- Ph

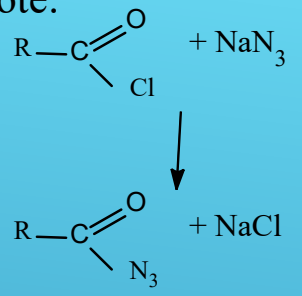
3. CURTIUS REARRANGEMENT



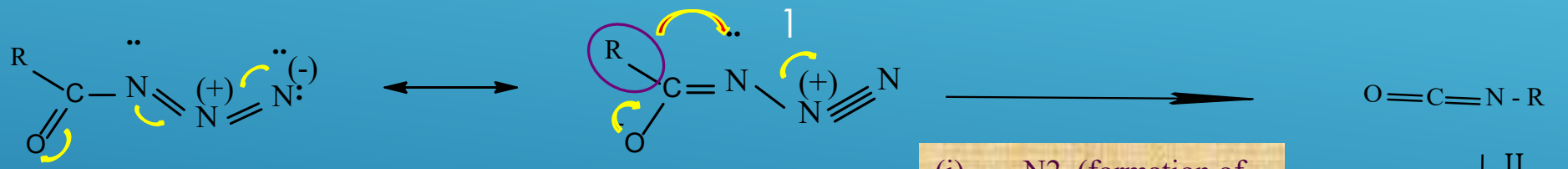
Acid azide

Amine

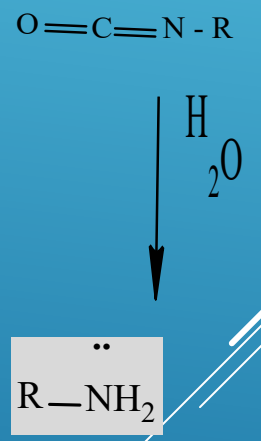
Note:



Mechanism

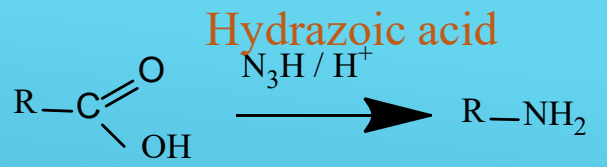


(i) - N2 (formation of e- deficientNitrogen)
(ii) Rearrangement of R
(iii) stabilization

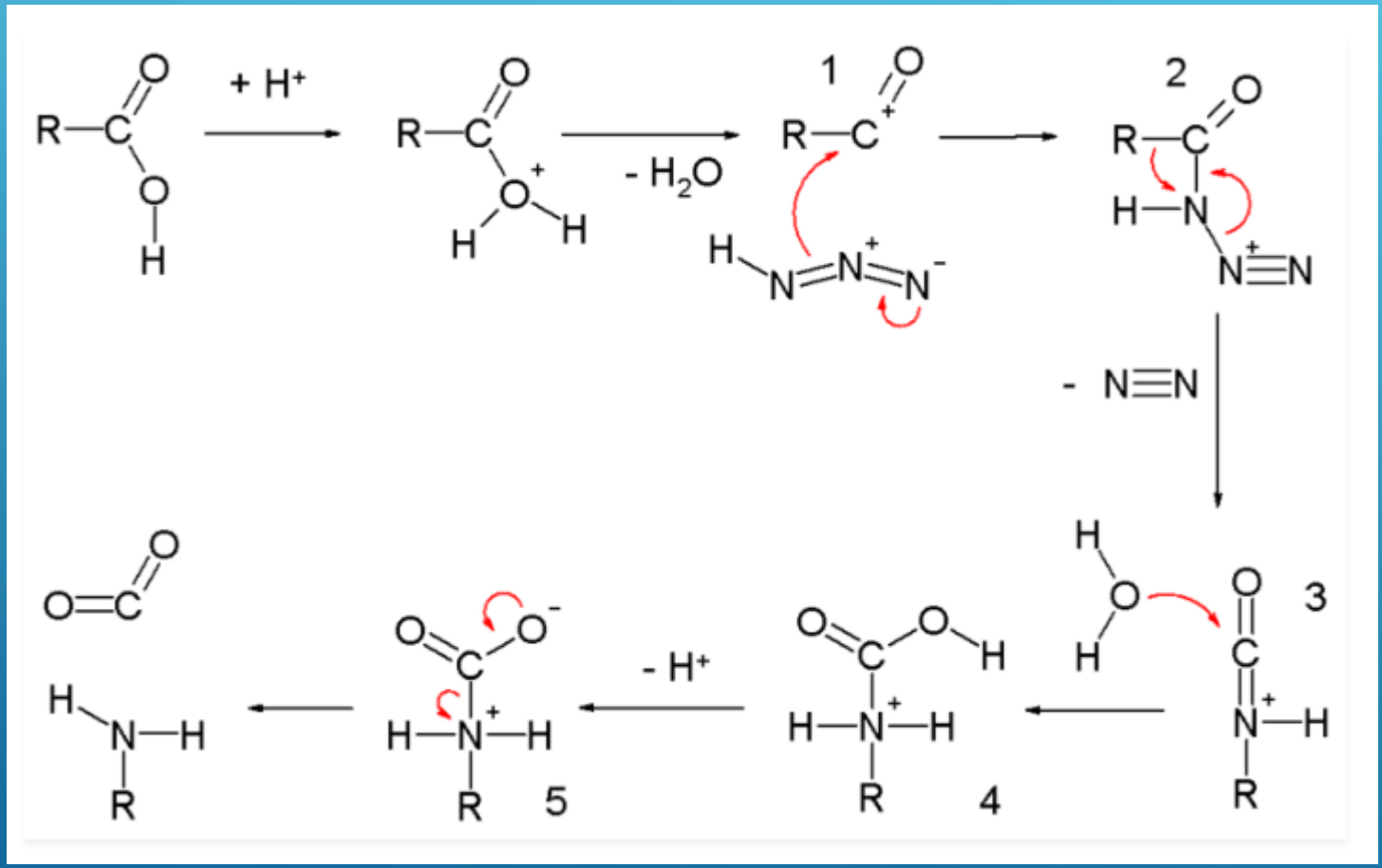


Amine

4. SCHMIDT REARRANGEMENT



Acid Amine

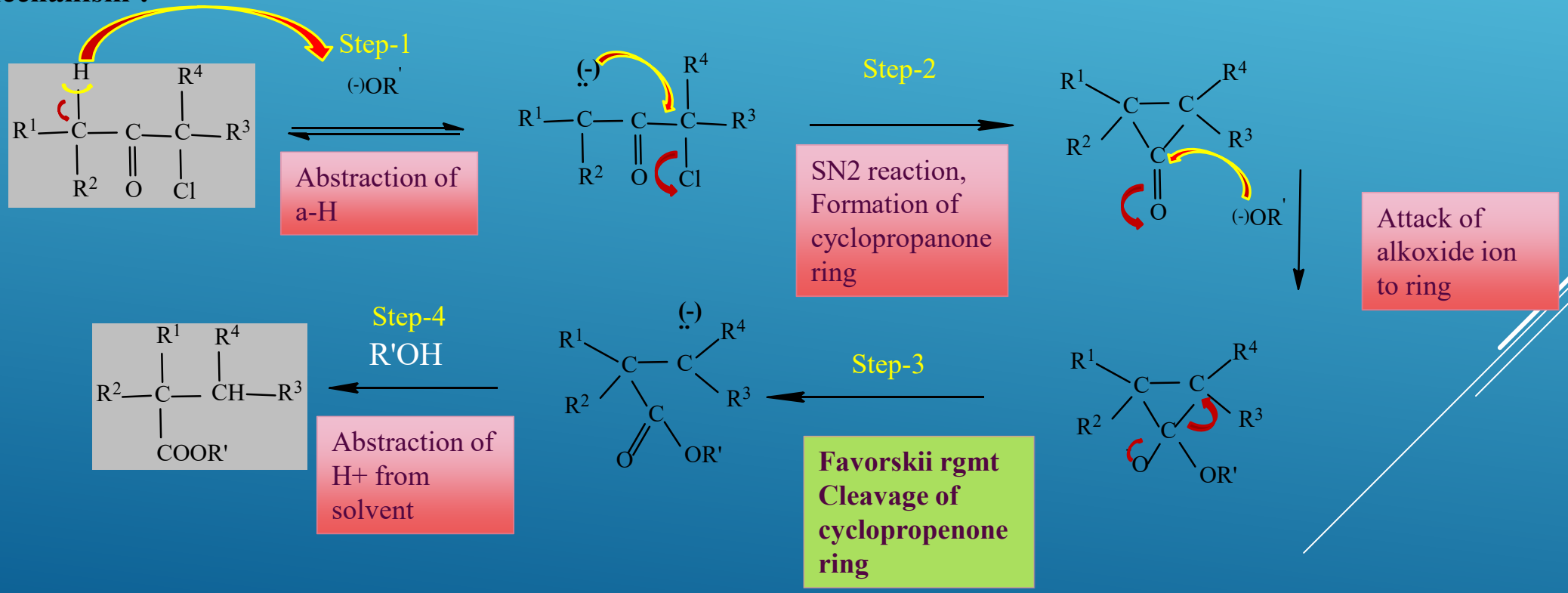


III. MIGRATION TO ELECTRON RICH CARBON - FAVORSKII REARRANGEMENT

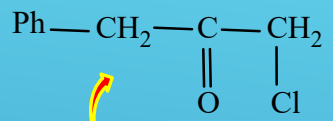
a - halo ketone

ester

Mechanism :



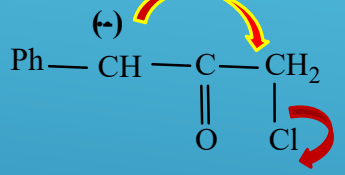
Example-1:



A

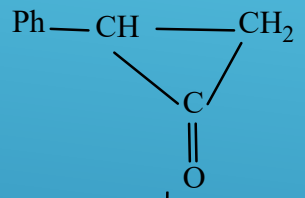
Step-1

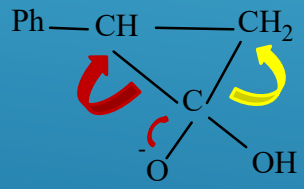
Abstraction of a-H



Step-2

SN2 reaction, Formation of cyclopropanone ring

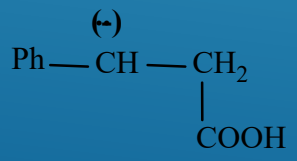




Step-3

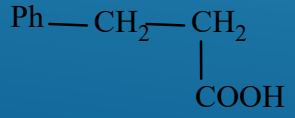
Step-3

Favorskii rgmt Cleavage of cyclopropanone ring

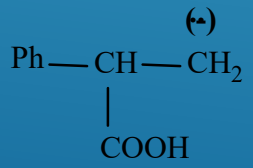


I

Step-4
H2O

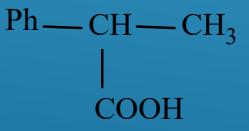


Major product



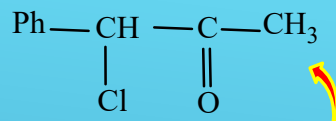
II

Step-4
H2O



Minor product

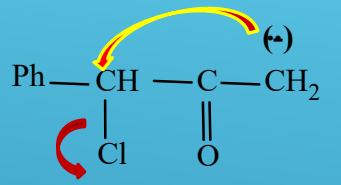
Example-2:



B

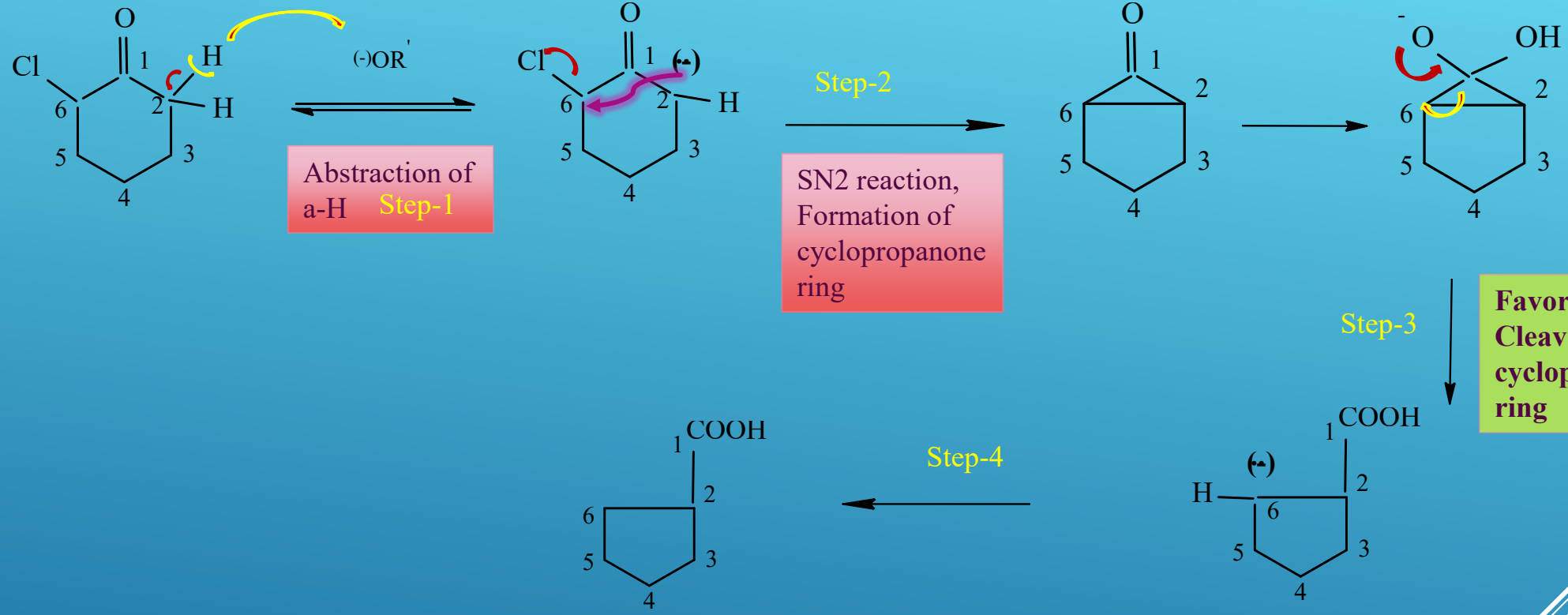
Step-1

Step-2



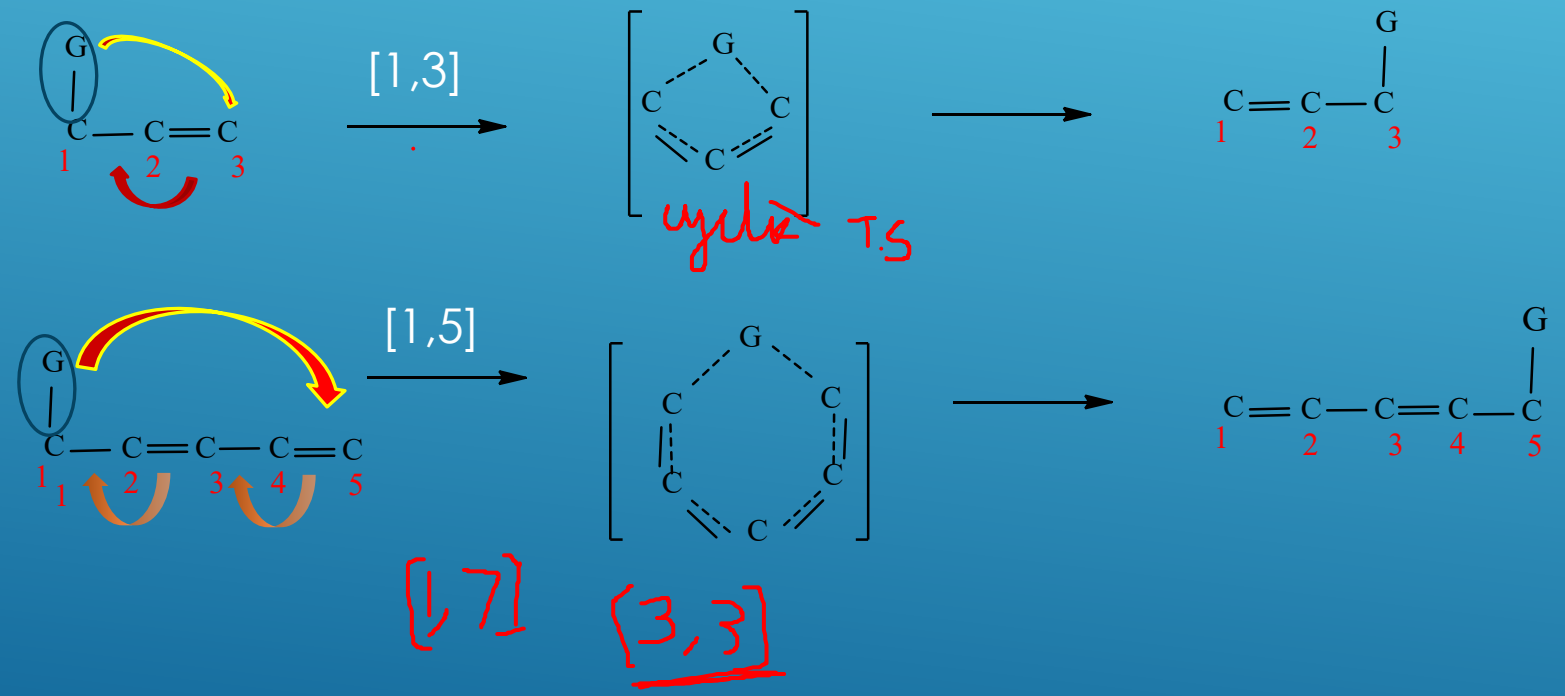
Step-2

Example-3:

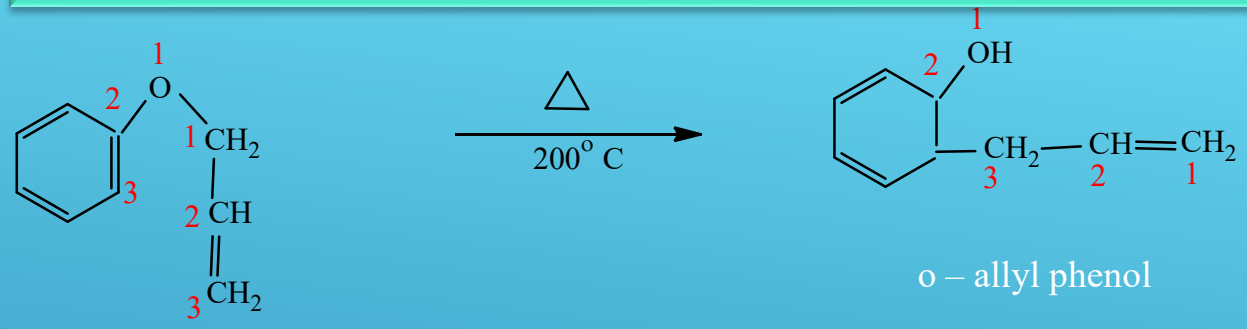

Cl
O
H
H
(-)OR'
Abstraction of a-H
Step-1
Step-2
SN2 reaction, Formation of cyclopropanone ring
OH
Step-3
Favorskii rgmt Cleavage of cyclopropanone ring
COOH
Step-4

IV. AROMATIC REARRANGEMENTS - CLAISEN
FRIES
BENZIDINE REARRANGEMENT

CLAISEN REARRANGEMENT (Sigmatropic rearrangement)



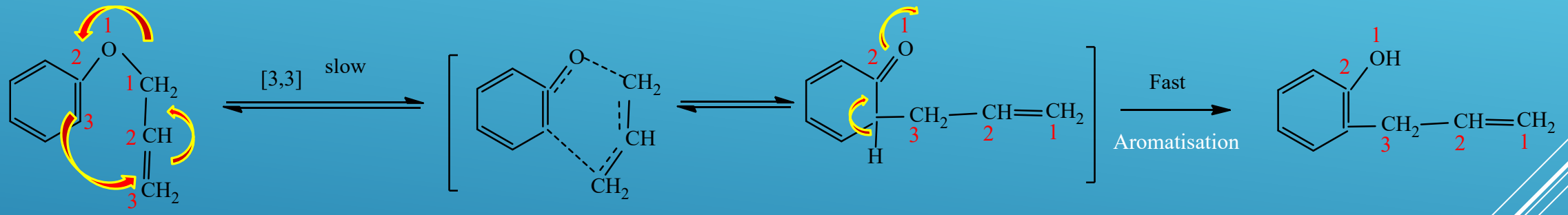
1.CLAISEN REARRANGEMENT (SIGMATROPIC REARRANGEMENT)



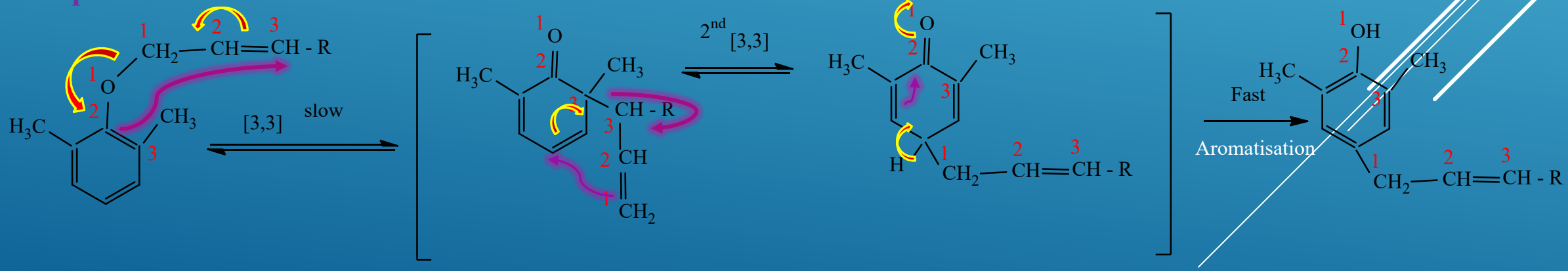
Allyl phenyl ether

o – allyl phenol

Example-1



Example-2

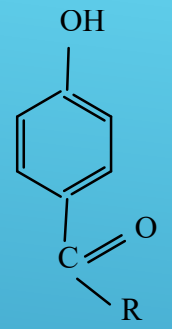


2. FRIES REARRANGEMENT

Ester

o – hydroxy ketone

+



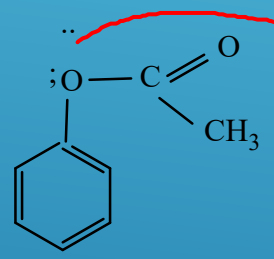
p– hydroxy ketone

PHOTO-FRIES

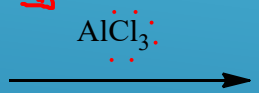
$h\nu$

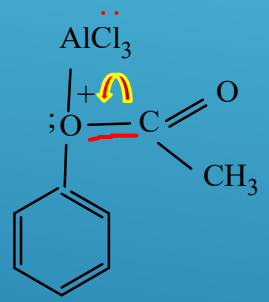
UV light
EtOH

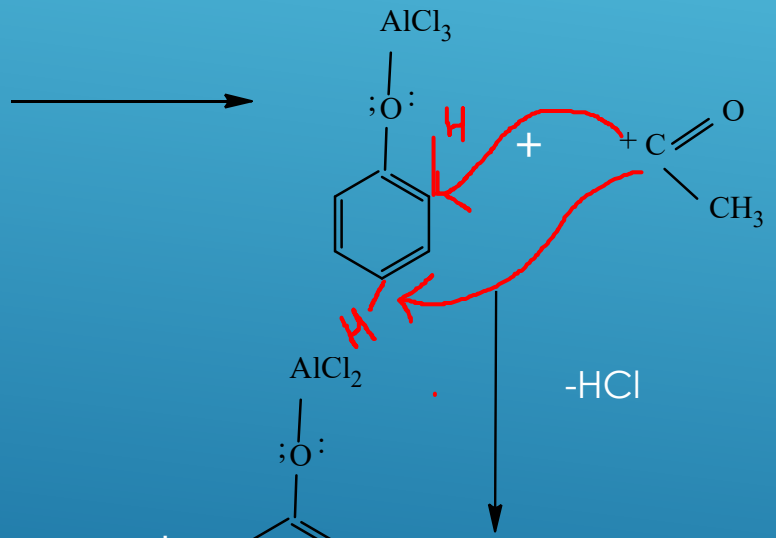
Example

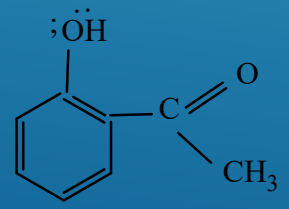


Acetophenone





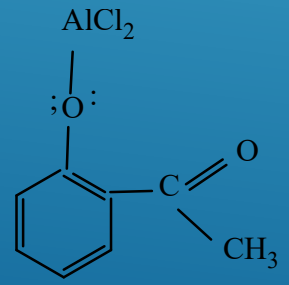




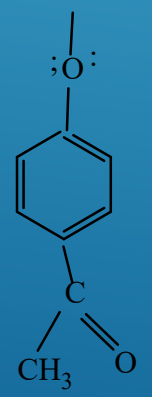
o-hydroxy
acetophenone

+

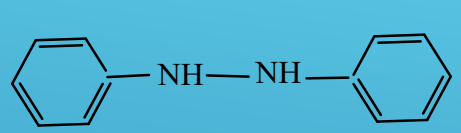
p-hydroxy
acetophenone



+



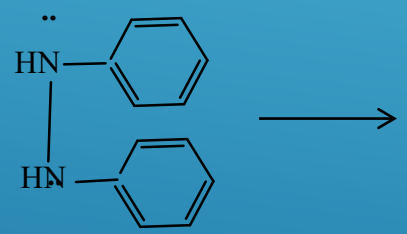
3. BENZIDINE REARRANGEMENT



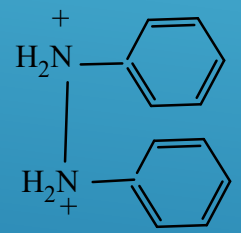
Hydrazobenzene

H^+

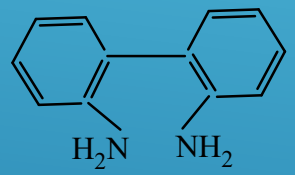
p-benzidine + o-benzidine + biphenylene + o-semidine + p-semidine



Hydrazobenzene
(I)



(II)

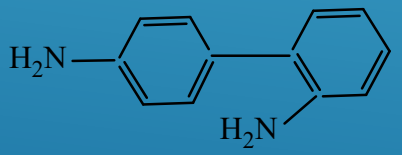


o-benzidine

+

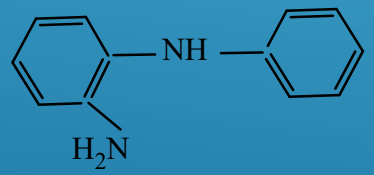
p-benzidine

+



biphenylene

+



o-semidine

Prepare a tabular column for all rearrangements as follows :

Name	Reactant	Product	Mechanism	Points to remember
Migration to electron deficient carbon				
1. P-P	diol	Ketone/ aldehyde	1. 2. 3. 4.	Which OH gets protonated Migratory aptitude
2.				
Migration to electron deficient nitrogen				
3.				
4				

THANK YOU